MEASUREMENT REPORT

FCC PART 15.247 WLAN 802.11b/g/n

FCC ID:	2AD8UFZCWMBOM2
APPLICANT:	Nokia Solutions and Networks, OY
Application Type:	Certification
Product:	AC220m Wi-Fi module OD US
Model No.:	FZCWMBOM2
Trademark:	Nokia
FCC Rule Part(s):	Part15 Subpart C (Section 15.247)
Test Procedure(s):	ANSI C63.10-2013, KDB 558074 D01v04 KDB 662911 D01v02r01
Test Date:	December 04 ~ 18, 2017

Reviewed : Paddy Chen
(Paddy Chen)

Approved By : Chenz Ker
(Chenz Ker)

Testing Laboratory
3261

The test results relate only to the samples tested.
This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2013. Test results reported herein relate only to the item(s) tested.
The test report shall not be reproduced except in full without the written approval of MRT Technology (Taiwan) Co., Ltd.

Revision History

Report No.	Version	Description	Issue Date	Note
1712TW0104-U1	Rev. 01	Initial Report	01-30-2018	Valid

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§2.1033 General Information

Applicant:	Nokia Solutions and Networks, OY
Applicant Address:	2000 W. Lucent Lane, Naperville, Illinois, United States, 60563
Manufacturer:	Nokia Solutions and Networks, OY
Manufacturer Address:	2000 W. Lucent Lane, Naperville, Illinois, United States, 60563
Test Site:	MRT Technology (Taiwan) Co., Ltd
Test Site Address:	No. 38, Fuxing Second Rd., Guishan Dist., Taoyuan City 333, Taiwan (R.O.C)
FCC Registration No.:	153292
FCC Rule Part(s):	Part15 Subpart C (Section 15.247)
Test Device Serial No.:	N/A ☐ Production ☒ Pre-Production ☐ Engineering

Test Facility / Accreditations

Measurements were performed at MRT Laboratory located in Fuxing Rd., Taoyuan, Taiwan (R.O.C)

- **MRT facility is a FCC registered (Reg. No. 153292) test facility with the site description report on file and is designated by the FCC as an Accredited Test Film.**
- **MRT facility is an IC registered (MRT Reg. No. 21723-1) test laboratory with the site description on file at Industry Canada.**
- **MRT Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (TAF) under the American Association for Laboratory Accreditation Program (TAF Cert. No. 3261) in EMC, Telecommunications and Radio testing for FCC, Industry Taiwan, EU and TELEC Rules.**

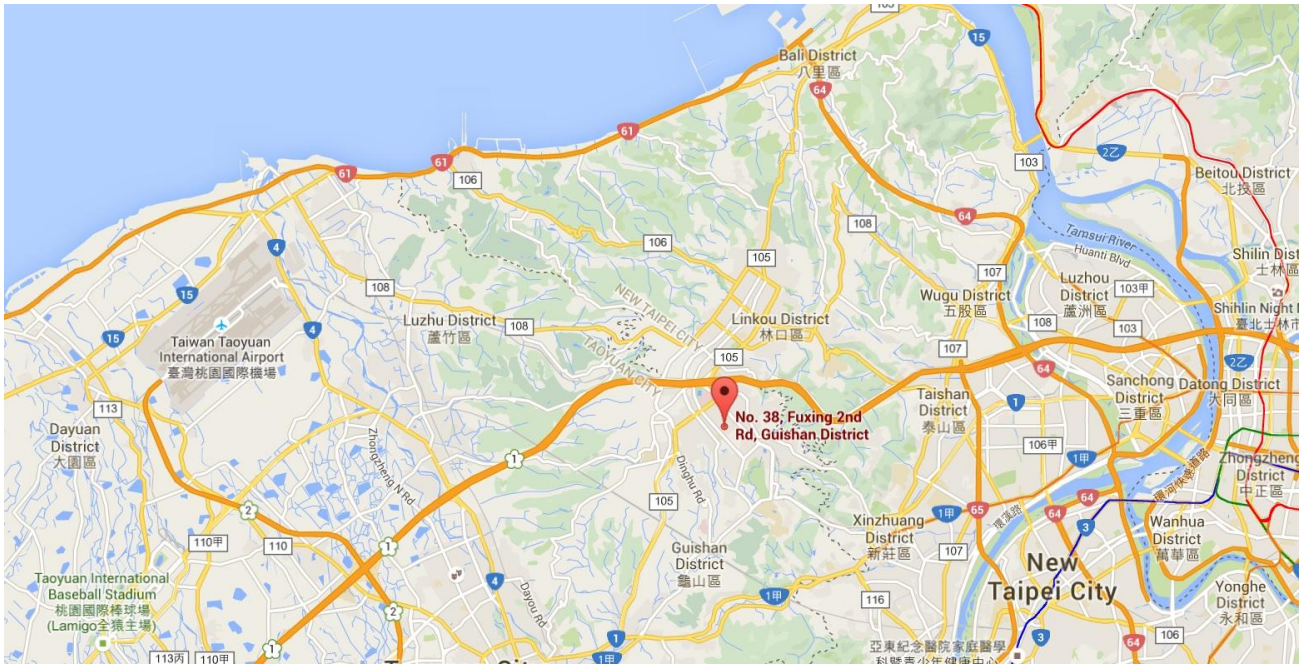
1. INTRODUCTION

1.1. Scope

Measurement and determination of electromagnetic emissions (EMC) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission and the Industry Canada Certification and Engineering Bureau.

1.2. MRT Test Location

The map below shows the location of the MRT LABORATORY, its proximity to the Taoyuan City. These measurement tests were conducted at the MRT Technology (Taiwan) Co., Ltd. Facility located at No.38, Fuxing 2nd Rd., Guishan Dist., Taoyuan City 33377, Taiwan (R.O.C).



2. PRODUCT INFORMATION

2.1. Equipment Description

Product Name:	AC220m Wi-Fi module OD US
Model No.:	FZCWMBOM2
Brand Name:	Nokia
Wi-Fi Specification	802.11a/b/g/n/ac
Frequency Range	**2.4GHz:** For 802.11b/g/n-HT20: 2412 ~ 2462 MHz For 802.11n-HT40: 2422 ~ 2452 MHz **5GHz:** For 802.11a/n-HT20/ac-VHT20: 5180~5240MHz, 5745~5825MHz For 802.11n-HT40/ac-VHT40: 5190~5230MHz, 5755~5795MHz For 802.11ac-VHT80: 5210MHz, 5775MHz
2.4GHz Maximum Average Output Power	**CDD Mode:** 802.11b: 29.32dBm; 802.11g: 25.71dBm 802.11n-HT20: 24.76dBm; 802.11n-HT40: 18.47dBm **Beam-Forming Mode:** 802.11n-HT20: 27.97dBm; 802.11n-HT40: 23.62dBm
Type of Modulation	802.11b: DSSS 802.11g/n/ac: OFDM
Modulation Technology	CCK, DQPSK, DBPSK for DSSS 16QAM, 64QAM, 256QAM, QPSK, BPSK for OFDM

2.2. Operating Frequencies and Channel List

802.11b/g/n-HT20

Channel	Frequency	Channel	Frequency	Channel	Frequency
01	2412 MHz	02	2417 MHz	03	2422 MHz
04	2427 MHz	05	2432 MHz	06	2437 MHz
07	2442 MHz	08	2447 MHz	09	2452 MHz
10	2457 MHz	11	2462 MHz	--	--

802.11n-HT40

Channel	Frequency	Channel	Frequency	Channel	Frequency
03	2422 MHz	04	2427 MHz	05	2432 MHz
06	2437 MHz	07	2442 MHz	08	2447 MHz
09	2452 MHz	--	--	--	--

2.3. Description of Available Antennas

Antenna	Manufacturer	Frequency Band (GHz)	Antenna Name	Tx Paths
	Nokia	2.4	473171A / FAWH (WiFi Omni Ant)	2
		5		2

Note: The manufacture has provided an antenna cable to connect WiFi Omni Antenna with EUT, and the cable loss is: 0.45dB Max @ 0~3 GHz; 0.75dB Max @ 0~6 GHz

Antenna Name	Frequency Band (MHz)	Tx Paths	Per Chain Max Antenna Gain (dBi)		Beam Forming Directional Gain (dBi)		CDD Directional Gain (dBi)	
			Ant 0	Ant 1	For Power	For PSD	For Power	For PSD
473171A / FAWH (WiFi Omni Ant)	2412 ~2462	2	4.00	4.00	7.01	7.01	4.00	7.01
	5150 ~ 5250	2	7.00	7.00	10.01	10.01	7.00	10.01
	5725 ~ 5850	2	7.00	7.00	10.01	10.01	7.00	10.01

Note1: The EUT supports Cyclic Delay Diversity (CDD) technology for 802.11a/b/g mode, and CDD signals are correlated.

Note 2: The EUT supports Beam Forming technology for 802.11n/ac mode.

Note 3: For CDD transmissions, directional gain is calculated as follows, N_{ANT} = 2, N_{SS} = 1.

Two antennas have the same gain, G_{ANT}, Directional gain = G_{ANT} + Array Gain, where Array Gain is as follows.

- For power spectral density (PSD) measurements on all devices,

Array Gain = 10 log (N_{ANT}/ N_{SS}) dB = 3.01;

- For power measurements on IEEE 802.11 devices,

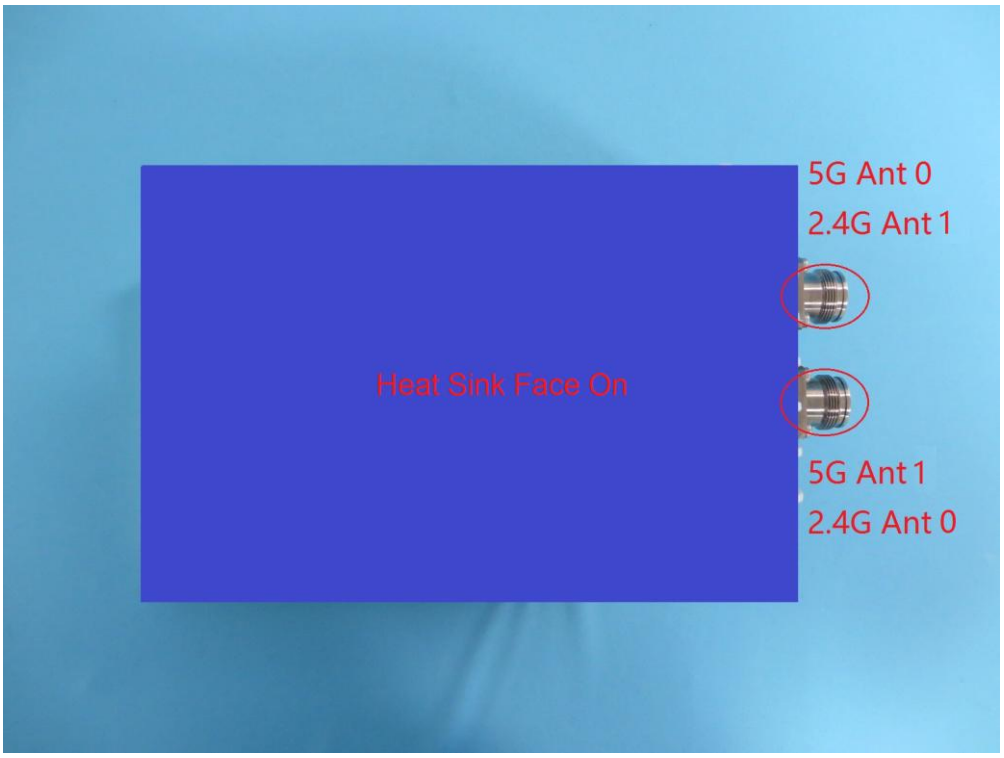
Array Gain = 0 dB for $N_{ANT} \leq 4$;

Note 4: For Beam Forming transmissions, Two antennas have the same gain, G_{ANT}:

Directional gain = G_{ANT} + 10 log (N_{ANT}/N_{SS}) dBi, where N_{SS} = the number of independent spatial streams of data and G_{ANT} is the antenna gain in dBi.

2.4. Description of Antenna RF Port

Antenna RF Port				
---	2.4GHz RF Port		5GHz RF Port	
Software Control Port	Ant 0	Ant 1	Ant 0	Ant 1



2.5. Test Mode

Test Mode	Mode 1: Transmit by 802.11b (1Mbps)
	Mode 2: Transmit by 802.11g (6Mbps)
	Mode 3: Transmit by 802.11n-HT20 (MCS0)
	Mode 4: Transmit by 802.11n-HT40 (MSC0)

2.4GHz Test Mode	Ant 0 + 1	
	CDD	Beam-Forming
802.11b	√	×
802.11g	√	×
802.11n-HT20	√	√
802.11n-HT40	√	√

2.6. Device Capabilities

This device contains the following capabilities:

2.4GHz WLAN (DTS) & 5GHz WLAN (NII).

Note: 2.4GHz WLAN (DTS) operation is possible in 20MHz, and 40MHz channel bandwidths. The maximum achievable duty cycles for all modes were determined based on measurements performed on a spectrum analyzer in zero-span mode with RBW = 8MHz, VBW = 50MHz. The RBW and VBW were both greater than 50/T, where T is the minimum transmission duration, and the number of sweep points across T was greater than 100. The duty cycles are as follows:

Test Mode	Duty Cycle
802.11b	98.56%
802.11g	95.58%
802.11n-HT20	97.83%
802.11n-HT40	94.96%

2.7. Test Configuration

The device was tested per the guidance of KDB 558074 D01v04. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing.

2.8. EMI Suppression Device(s)/Modifications

No EMI suppression device(s) were added and/or no modifications were made during testing.

2.9. Labeling Requirements

Per 2.1074 & 15.19; Docket 95-19

The label shall be permanently affixed at a conspicuous location on the device; instruction manual or pamphlet supplied to the user and be readily visible to the purchaser at the time of purchase. However, when the device is so small wherein placement of the label with specified statement is not practical, only the FCC ID must be displayed on the device per Section 15.19(a)(5). Please see attachment for FCC ID label and label location.

3. DESCRIPTION of TEST

3.1. Evaluation Procedure

The measurement procedures described in the American National Standard for Testing Unlicensed Wireless Devices (ANSI C63.10-2013), and the guidance provided in KDB 558074 D01v04 were used in the measurement.

Deviation from measurement procedure…….....None

3.2. AC Line Conducted Emissions

The line-conducted facility is located inside an 8'x4'x4' shielded enclosure. A 1m x 2m wooden table 80cm high is placed 40cm away from the vertical wall and 80cm away from the sidewall of the shielded room. Two 10kHz-30MHz, 50Ω/50uH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room floor. Power to the LISNs is filtered by external high-current high-insertion loss power line filters. These filters attenuate ambient signal noise from entering the measurement lines. These filters are also bonded to the shielded enclosure.

The EUT is powered from one LISN and the support equipment is powered from the second LISN. All interconnecting cables more than 1 meter were shortened to a 1 meter length by non-inductive bundling (serpentine fashion) and draped over the back edge of the test table. All cables were at least 40cm above the horizontal reference ground-plane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the receiver and exploratory measurements were made to determine the frequencies producing the maximum emission from the EUT. The receiver was scanned from 150kHz to 30MHz. The detector function was set to peak mode for exploratory measurements while the bandwidth of the analyzer was set to 9kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Each emission was also maximized by varying: power lines, the mode of operation or data exchange speed, or support equipment which determined the worst-case emission. Once the worst case emissions have been identified, the one EUT cable configuration/arrangement and mode of operation that produced these emissions are used for final measurements on the same test site. The analyzer is set to CISPR quasi-peak and average detectors with a 9kHz resolution bandwidth for final measurements.

An extension cord was used to connect to a single LISN which powered by EUT. The extension cord was calibrated with LISN, the impedance and insertion loss are compliance with the requirements as stated in ANSI C63.10-2013.

3.3. Radiated Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. For measurements above 1GHz absorbers are arranged on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1GHz, the absorbers are removed. A turntable is used for radiated measurement. It is a continuously rotatable, remote controlled, metallic turntable and 2 meters (6.56 ft.) in diameter. The turn table is flush with the raised floor of the chamber in order to maintain its function as a ground plane. An 80cm high PVC support structure is placed on top of the turntable.

For all measurements, the spectrum was scanned through all EUT azimuths and from 1 to 4 meter receive antenna height using a broadband antenna from 30MHz up to the upper frequency shown in 15.33(b)(1) depending on the highest frequency generated or used in the device or on which the device operates or tunes. For frequencies above 1GHz, linearly polarized double ridge horn antennas were used. For frequencies below 30MHz, a calibrated loop antenna was used. When exploratory measurements were necessary, they were performed at 1 meter test distance inside the semi-anechoic chamber using broadband antennas, broadband amplifiers, and spectrum analyzers to determine the frequencies and modes producing the maximum emissions. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The test set-up for frequencies below 1GHz was placed on top of the 0.8 meter high, 1 x 1.5 meter table; and test set-up for frequencies 1-40GHz was placed on top of the 1.5 meter high, 1 x 1.5 meter table. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Appropriate precaution was taken to ensure that all emissions from the EUT were maximized and investigated. The system configuration, clock speed, mode of operation or video resolution, if applicable, turntable azimuth, and receive antenna height was noted for each frequency found.

Final measurements were made in the semi-anechoic chamber using calibrated, linearly polarized broadband and horn antennas. The test setup was configured to the setup that produced the worst case emissions. The spectrum analyzer was set to investigate all frequencies required for testing to compare the highest radiated disturbances with respect to the specified limits. The turntable containing the EUT was rotated through 360 degrees and the height of the receive antenna was varied 1 to 4 meters and stopped at the azimuth and height producing the maximum emission. Each emission was maximized by changing the orientation of the EUT through three orthogonal planes and changing the polarity of the receive antenna, which produced the worst-case emissions. According to 3dB Beam-Width of horn antenna, the horn antenna should be always directed to the EUT when rising height.

4. ANTENNA REQUIREMENTS

Excerpt from §15.203 of the FCC Rules/Regulations:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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."

- There are provisions for special connecter (4.3_10 connecter) to an external antenna.

Conclusion:

The device unit complies with the requirement of §15.203.

5. TEST EQUIPMENT CALIBRATION DATE

Conducted Emissions

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
EMI Test Receiver	R&S	ESR3	MRTTWA00045	1 year	2018/03/17
Two-Line V-Network	R&S	ENV216	MRTTWA00019	1 year	2018/03/23
Two-Line V-Network	R&S	ENV216	MRTTWA00020	1 year	2018/03/23
Temperature/Humidity Meter	TFA	35.1078.10.IT	MRTTWA00033	1 year	2018/06/08

Radiated Emissions

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
Signal Analyzer	R&S	FSV40	MRTTWA00007	1 year	2018/03/02
EMI Test Receiver	R&S	ESR3	MRTTWA00009	1 year	2018/03/16
Broadband Preamplifier	SCHWARZBECK	BBV 9718	MRTTWA00005	1 year	2018/04/06
Broadband Amplifier	SCHWARZBECK	BBV 9721	MRTTWA00006	1 year	2018/04/06
Acitve Loop Antenna	SCHWARZBECK	FMZB 1519B	MRTTWA00002	1 year	2018/04/06
Broadband TRILOG Antenna	SCHWARZBECK	VULB 9162	MRTTWA00001	1 year	2018/04/06
Broadband Hornantenna	SCHWARZBECK	BBHA 9120D	MRTTWA00003	1 year	2018/04/06
Breitband Hornantenna	SCHWARZBECK	BBHA 9170	MRTTWA00004	1 year	2018/04/06
Temperature/Humidity Meter	TFA	35.1078.10.IT	MRTTWA00033	1 year	2018/06/08

Conducted Test Equipment

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
EXA Signal Analyzer	KEYSIGHT	N9010A	MRTTWA00012	1 year	2018/07/10
X-Series USB Peak and Average Power Sensor	KEYSIGHT	U2021XA	MRTTWA00014	1 year	2018/03/18
X-Series USB Peak and Average Power Sensor	KEYSIGHT	U2021XA	MRTTWA00015	1 year	2018/03/18
Programmable Temperature & Humidity Chamber	TEN BILLION	TTH-B3UP	MRTTWA00036	1 year	2018/05/11
Temperature/Humidity Meter	TFA	35.1078.10.IT	MRTTWA00033	1 year	2018/06/08

Software	Version	Function
EMI Software	V3	EMI Test Software

6. MEASUREMENT UNCERTAINTY

Where relevant, the following test uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k = 2.

AC Conducted Emission Measurement
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 150kHz~30MHz: 3.46dB
Radiated Emission Measurement
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 9kHz ~ 1GHz: 4.18dB 1GHz ~ 25GHz: 4.76dB

7. TEST RESULT

7.1. Summary

Product Name: **Nokia Solutions and Networks, OY**

FCC ID: **2AD8UFZCWMBOM2**

Data Rate / MCS Tested: **1Mbps ~ 11Mbps (b); 6Mbps ~ 54Mbps (g);**
MCS0 for 802.11n-HT20MHz; MCS0 for 802.11n-HT40MHz.

FCC Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
15.247(a)(2)	6dB Bandwidth	≥ 500kHz	Conducted	Pass	Section 7.2
15.247(b)(3)	Output Power	Refer to Section 7.3		Pass	Section 7.3
15.247(e)	Power Spectral Density	Refer to Section 7.4		Pass	Section 7.4
15.247(d)	Band Edge / Out-of-Band Emissions	≥ 30dBc(Average)		Pass	Section 7.5
15.205 15.209	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in 15.209	Radiated	Pass	Section 7.6 & 7.7
15.207	AC Conducted Emissions 150kHz - 30MHz	< FCC 15.207 limits	Line Conducted	Pass	Section 7.8

Notes:

1) The analyzer plots shown in this section were all taken with a correction table loaded into the analyzer. The correction table was used to account for the losses of the cables and attenuators used as part of the system to connect the EUT to the analyzer at all frequencies of interest.
2) Test Items “6dB Bandwidth” & “Band Edge / Out-of-Band Emissions” have been assessed single and MIMO transmission, and showed the worst test data in this report.

7.2. 6dB Bandwidth Measurement

7.2.1.Test Limit

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

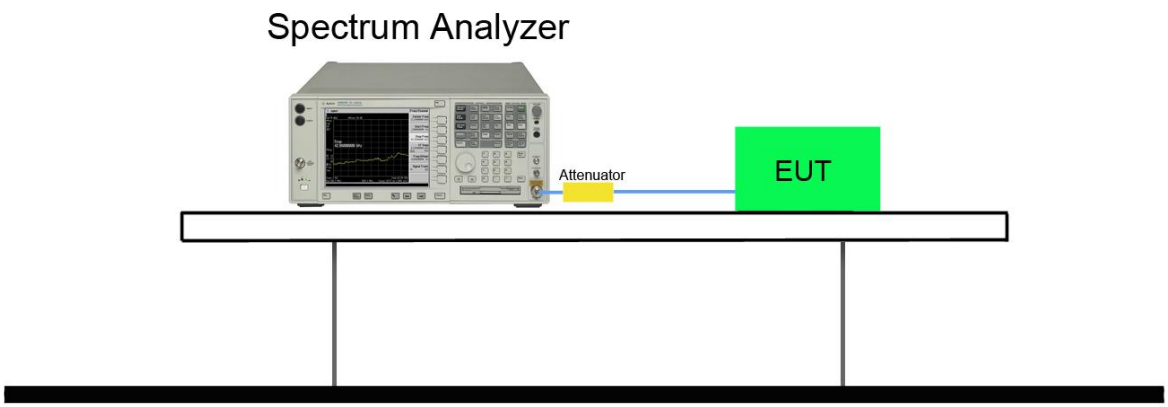
7.2.2.Test Procedure used

KDB 558074 D01v04 - Section 8.2 Option 2

7.2.3.Test Setting

1. The Spectrum's automatic bandwidth measurement capability was used to perform the 6dB bandwidth measurement. The "X" dB bandwidth parameter was set to X = 6. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. Set RBW = 100 kHz
3. VBW ≥ 3 × RBW
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. Allow the trace was allowed to stabilize

7.2.4.Test Setup



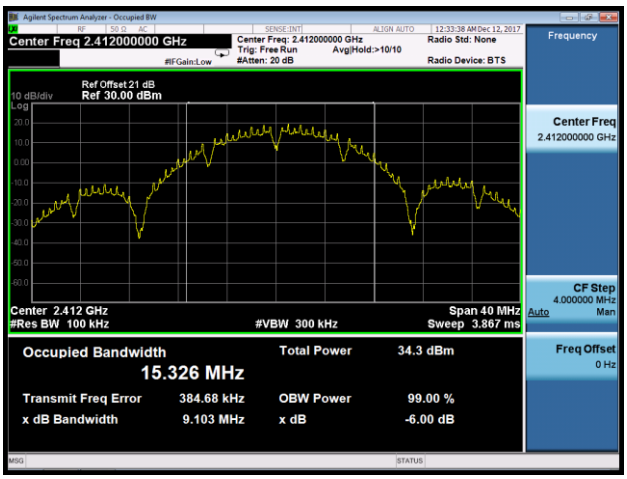
7.2.5.Test Result

Product	AC220m Wi-Fi module OD US	Test Engineer	Peter Xu
Test Site	SR2	Test Date	2017/12/12
Test Item	6dB Bandwidth		

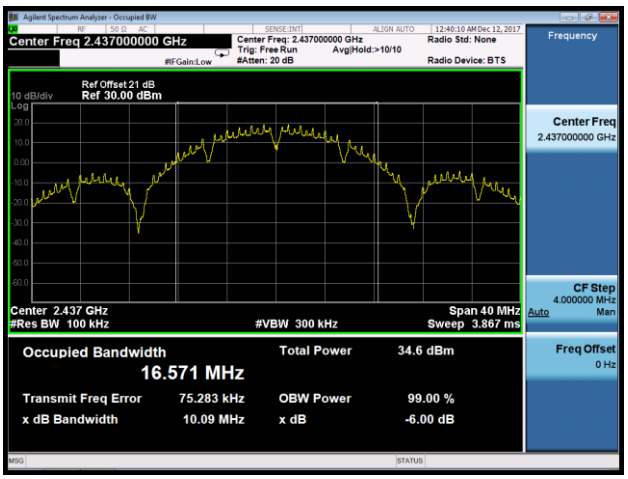
Test Mode	Data Rate/ MCS	Channel No.	Frequency (MHz)	6dB Bandwidth (MHz)	Limit (MHz)	Result
Ant 0						
802.11b	1Mbps	01	2412	9.10	≥ 0.5	Pass
802.11b	1Mbps	06	2437	10.09	≥ 0.5	Pass
802.11b	1Mbps	11	2462	8.08	≥ 0.5	Pass
802.11g	6Mbps	01	2412	15.73	≥ 0.5	Pass
802.11g	6Mbps	06	2437	16.53	≥ 0.5	Pass
802.11g	6Mbps	11	2462	15.75	≥ 0.5	Pass
802.11n-HT20	MCS0	01	2412	16.37	≥ 0.5	Pass
802.11n-HT20	MCS0	06	2437	17.60	≥ 0.5	Pass
802.11n-HT20	MCS0	11	2462	16.36	≥ 0.5	Pass
802.11n-HT40	MCS0	03	2422	35.11	≥ 0.5	Pass
802.11n-HT40	MCS0	06	2437	35.74	≥ 0.5	Pass
802.11n-HT40	MCS0	09	2452	31.31	≥ 0.5	Pass
Ant 1						
802.11b	1Mbps	01	2412	9.09	≥ 0.5	Pass
802.11b	1Mbps	06	2437	10.11	≥ 0.5	Pass
802.11b	1Mbps	11	2462	8.09	≥ 0.5	Pass
802.11g	6Mbps	01	2412	15.73	≥ 0.5	Pass
802.11g	6Mbps	06	2437	16.35	≥ 0.5	Pass
802.11g	6Mbps	11	2462	15.75	≥ 0.5	Pass
802.11n-HT20	MCS0	01	2412	16.38	≥ 0.5	Pass
802.11n-HT20	MCS0	06	2437	17.61	≥ 0.5	Pass
802.11n-HT20	MCS0	11	2462	16.33	≥ 0.5	Pass
802.11n-HT40	MCS0	03	2422	30.04	≥ 0.5	Pass
802.11n-HT40	MCS0	06	2437	36.01	≥ 0.5	Pass
802.11n-HT40	MCS0	09	2452	26.34	≥ 0.5	Pass

802.11b 6dB Bandwidth - Ant 0

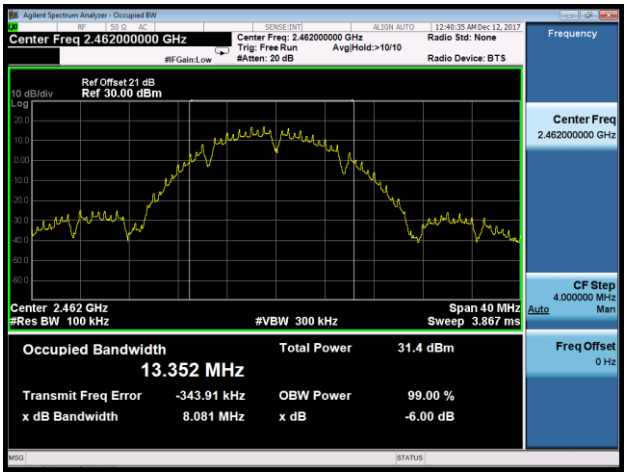
Channel 01 (2412MHz)

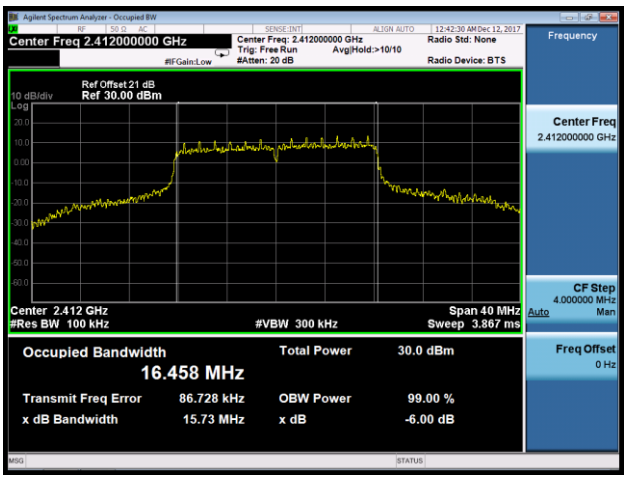
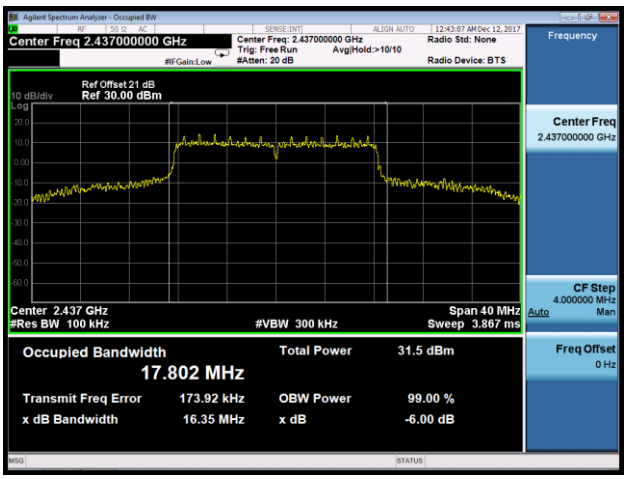
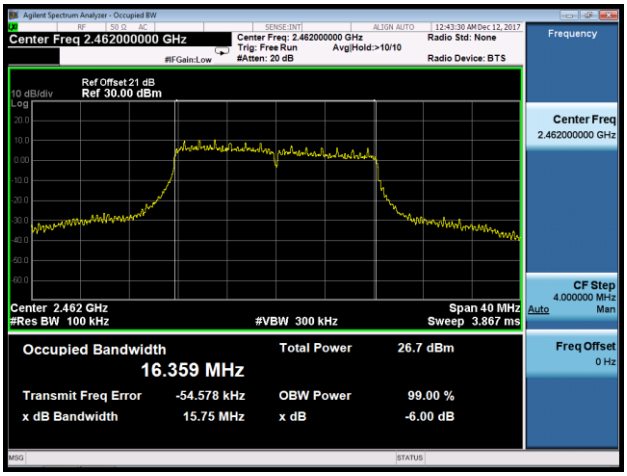


Channel 06 (2437MHz)



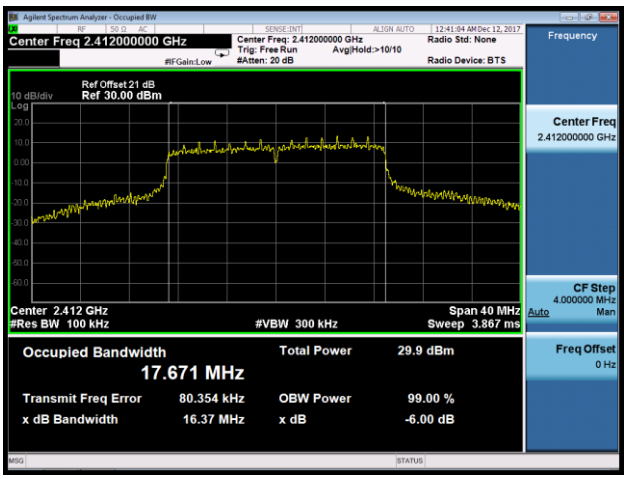
Channel 11 (2462MHz)



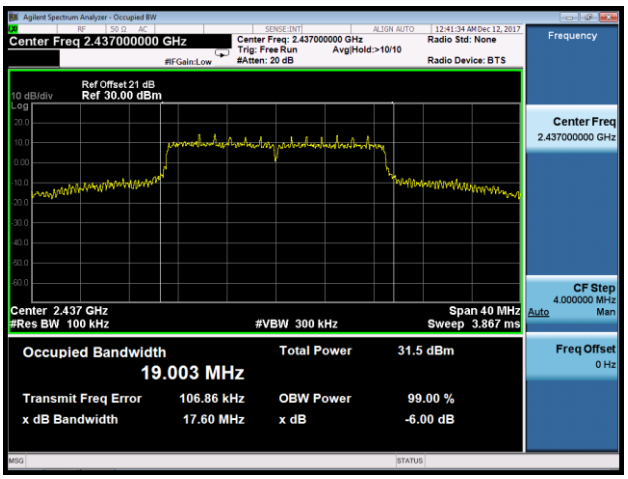
802.11g 6dB Bandwidth - Ant 0	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT20 6dB Bandwidth - Ant 0

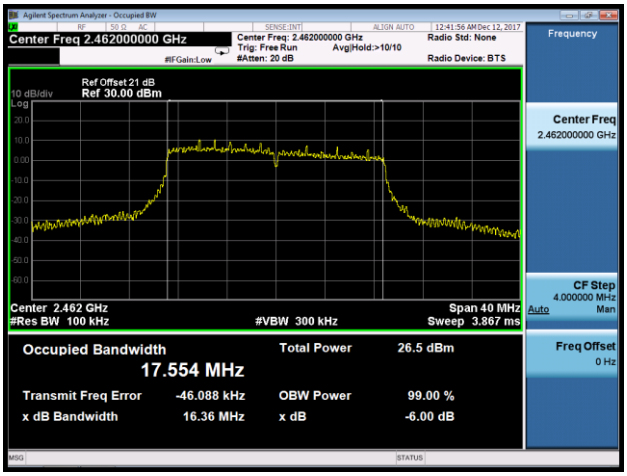
Channel 01 (2412MHz)



Channel 06 (2437MHz)

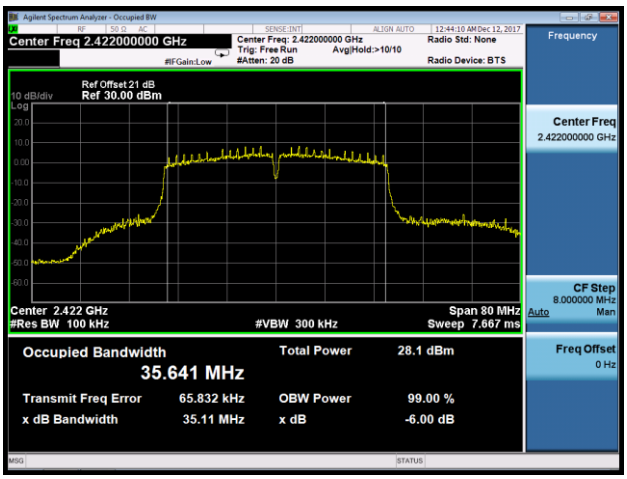


Channel 11 (2462MHz)

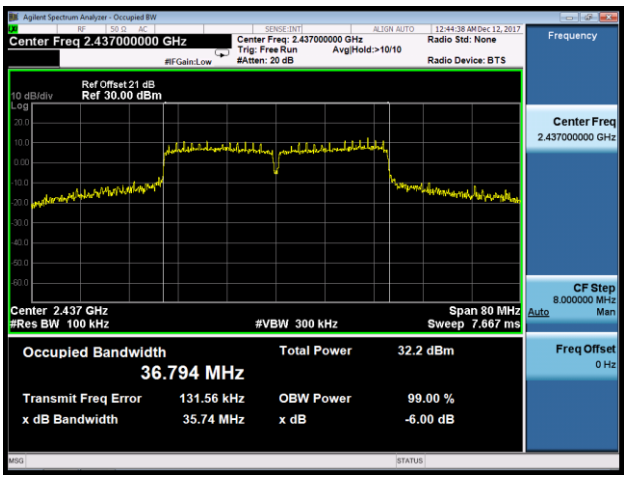


802.11n-HT40 6dB Bandwidth - Ant 0

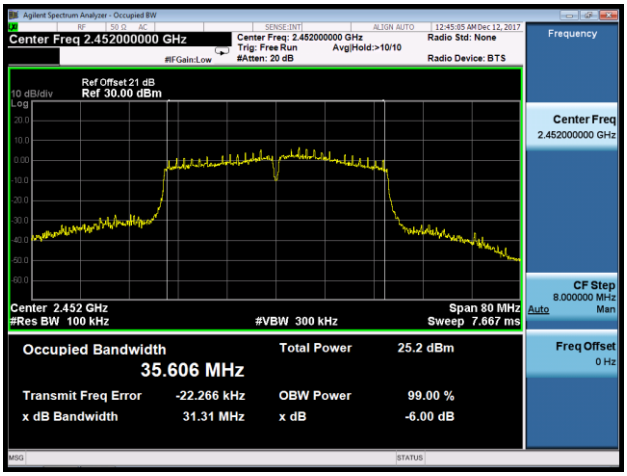
Channel 03 (2422MHz)



Channel 06 (2437MHz)

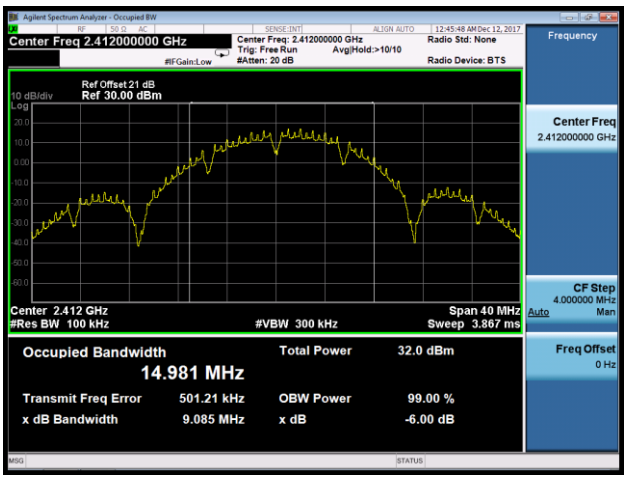


Channel 09 (2452MHz)

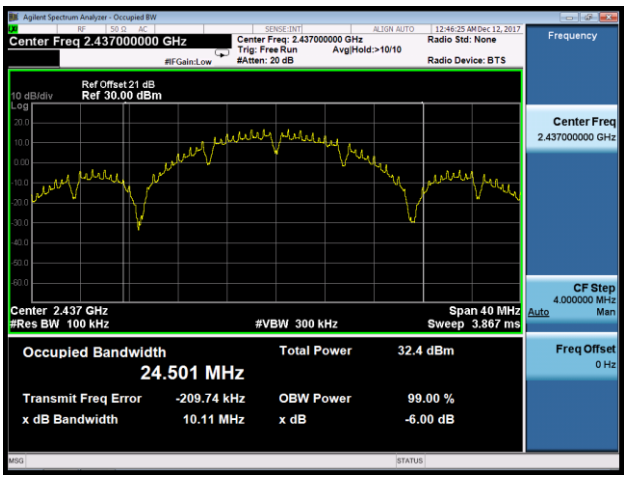


802.11b 6dB Bandwidth - Ant 1

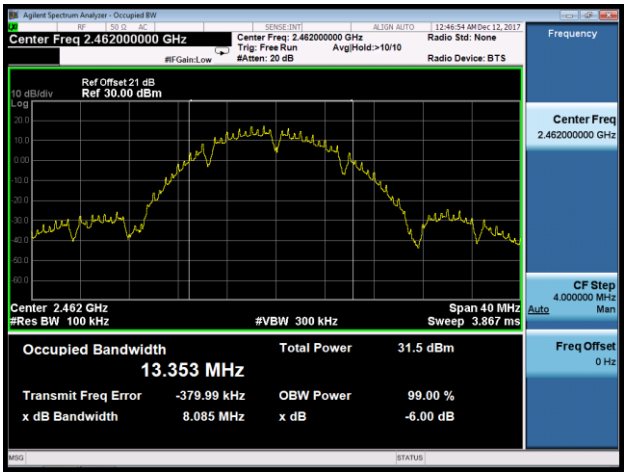
Channel 01 (2412MHz)

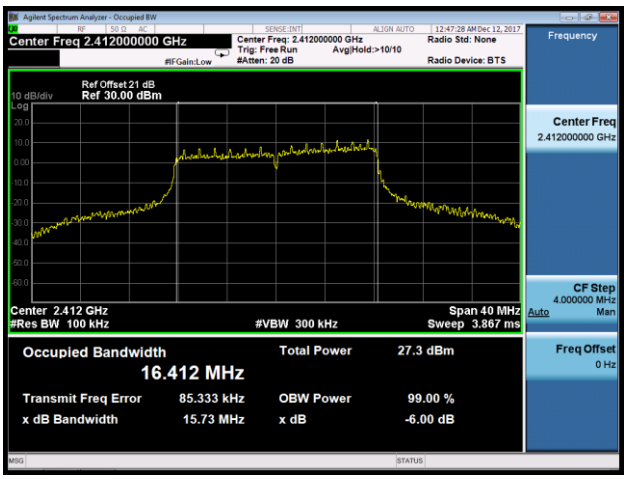
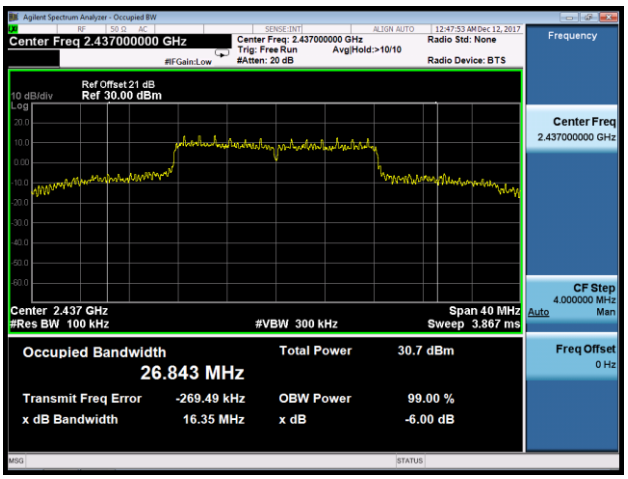
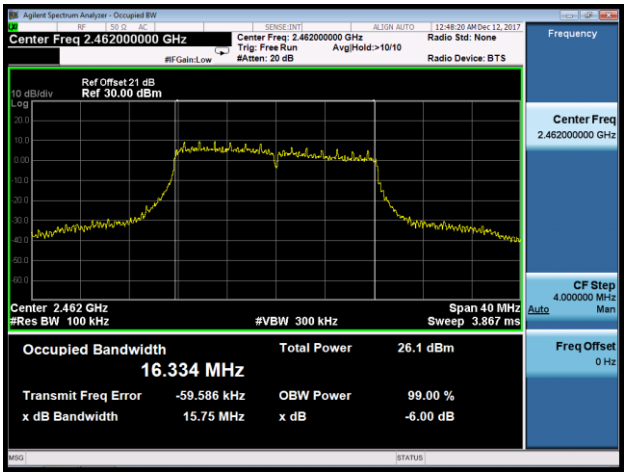


Channel 06 (2437MHz)



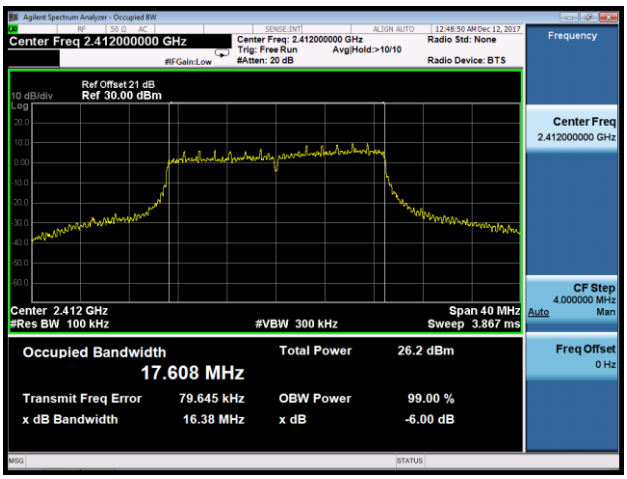
Channel 11 (2462MHz)



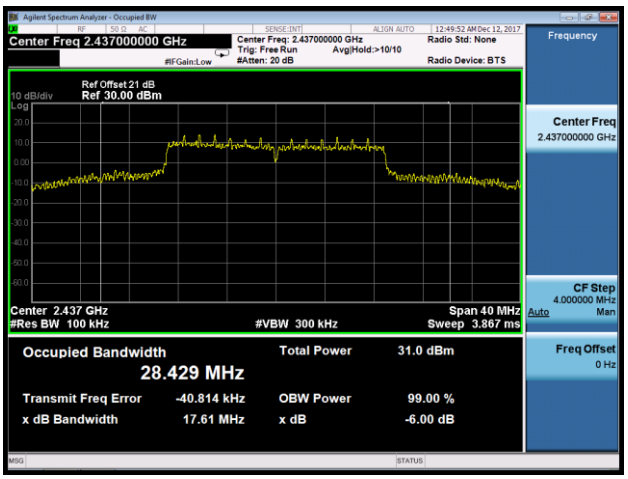
802.11g 6dB Bandwidth - Ant 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT20 6dB Bandwidth - Ant 1

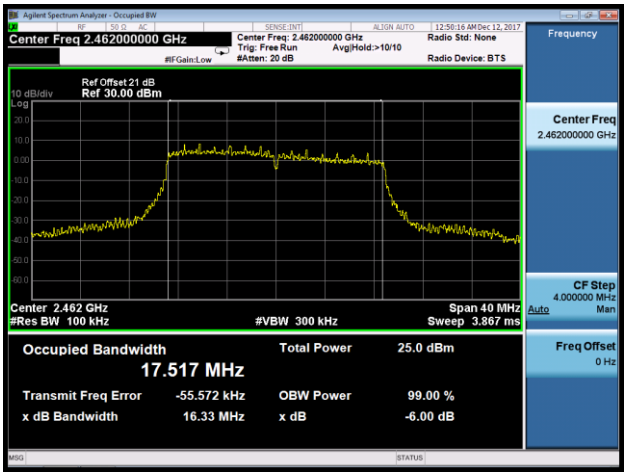
Channel 01 (2412MHz)



Channel 06 (2437MHz)

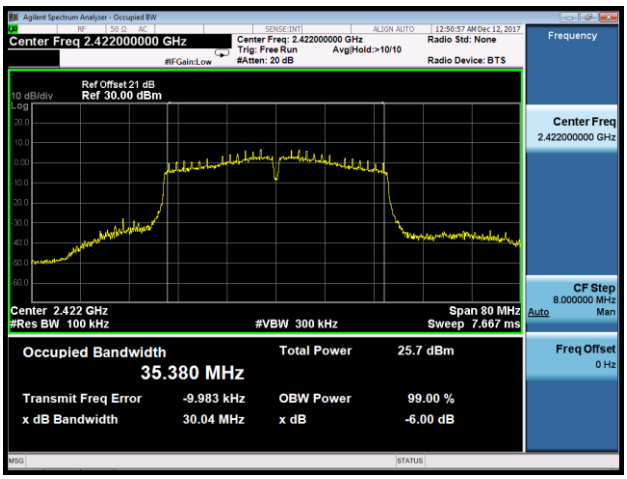


Channel 11 (2462MHz)

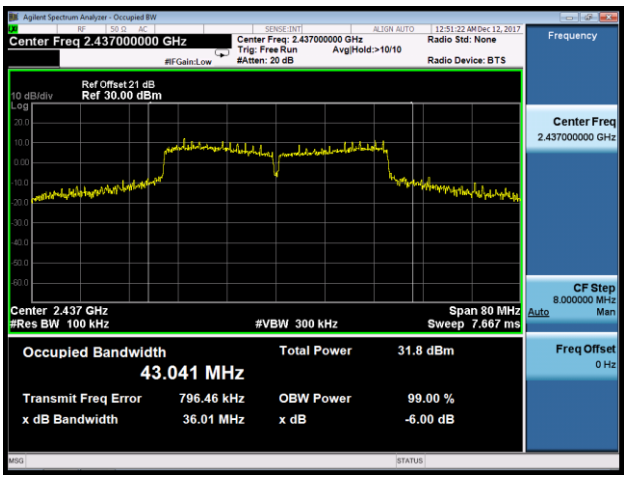


802.11n-HT40 6dB Bandwidth - Ant 1

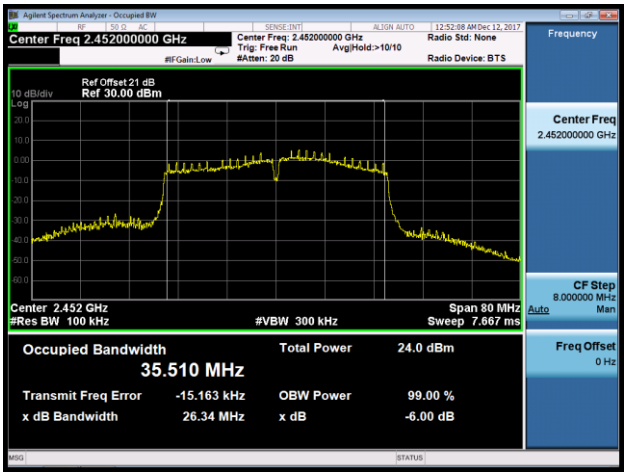
Channel 03 (2422MHz)



Channel 06 (2437MHz)



Channel 09 (2452MHz)



7.3. Output Power Measurement

7.3.1.Test Limit

The maximum out power shall be less 1 Watt (30dBm) and the E.I.R.P shall not exceed 4 Watt (36dBm). The total conducted output power shall be reduced by 1 dB below the specified limits for each dB that the directional gain of the antenna / antenna array exceeds 6 dBi

Frequency Band (MHz)	Per Chain Max Antenna Gain (dBi)		Beam Forming Directional Gain (dBi)	Limit of SISO (dBm)		Limit of MIMO (dBm)
	Ant 0	Ant 1		Ant 0	Ant 1	Ant 0 + 1
WiFi Omni Ant						
2412 ~2462	4.00	4.00	7.01	30.00	30.00	28.99

Note: For CDD mode, the output power limit should be 30dBm

7.3.2.Test Procedure Used

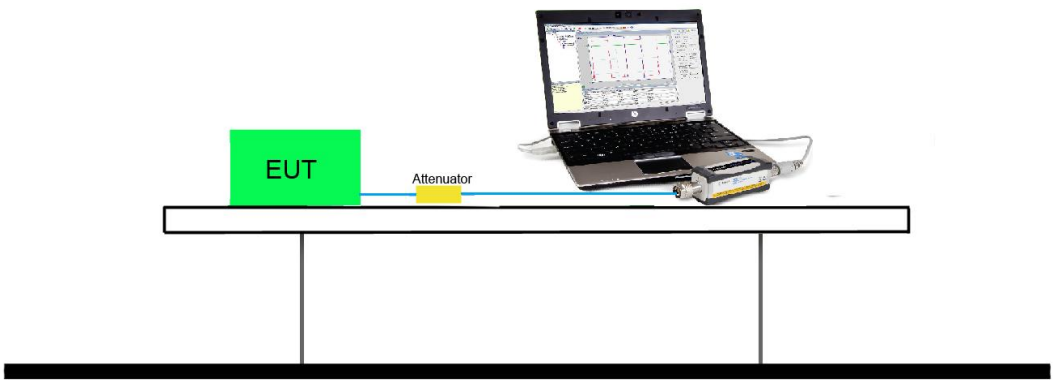
KDB 558074 D01v04 - Section 9.2.3.2 AVGPM-G Average Power Method

7.3.3.Test Setting

Average Power Measurement

Average power measurements were perform only when the EUT was transmitting at its maximum power control level using a broadband power meter with a pulse sensor. The power meter implemented triggering and gating capabilities which were set up such that power measurements were recorded only during the ON time of the transmitter.

7.3.4.Test Setup



7.3.5.Test Rate Assessment

Power output test was verified over all data rates of each mode shown as below, and then choose the maximum power output (gray marker) for final test of each channel.

N_{TX}	Data Rate (Mbps)						
	802.11b	802.11g	MCS Index for 802.11n	20MHz Bandwidth		40MHz Bandwidth	
				800ns GI	400ns GI	800ns GI	400ns GI
1	1	6	0	6.5	7.2	13.5	15.0
1	2	9	1	13.0	14.4	27.0	30.0
1	5.5	12	2	19.5	21.7	40.5	45.0
1	11	18	3	26.0	28.9	54.0	60.0
1	--	24	4	39.0	43.3	81.0	90.0
1	--	36	5	52.0	57.8	108.0	120.0
1	--	48	6	58.5	65.0	121.5	135.0
1	--	54	7	65.0	72.2	135.0	150.0
2	--	--	12.0	13.0	14.4	27.0	30.0
2	--	--	12.5	26.0	28.9	54.0	60.0
2	--	--	13.0	39.0	43.3	81.0	90.0
2	--	--	13.5	52.0	57.8	108.0	120.0
2	--	--	14.0	78.0	86.7	162.0	180.0
2	--	--	14.5	104.0	115.6	216.0	240.0
2	--	--	15.0	117.0	130.0	243.0	270.0
2	--	--	15.5	130.0	144.0	270.0	300.0

Output power at various data rates for Ant 0:

Test Mode	Bandwidth (MHz)	Channel No.	Frequency (MHz)	Data Rate (Mbps)	Average Power (dBm)
802.11b	20	6	2437	1	27.98
				5.5	27.82
				11	27.71
802.11g	20	6	2437	6	23.82
				24	23.69
				54	23.53
802.11n	20	6	2437	6.5	24.28
				52	24.12
				65	24.00
802.11n	40	6	2437	13.5	18.27
				54	17.92
				135	17.83

7.3.6.Test Result

Product	AC220m Wi-Fi module OD US	Test Engineer	Peter Xu
Test Site	SR2	Test Date	2017/12/10
Test Item	Output Power		

Test Mode	Data Rate/ MCS	Channel No.	Freq. (MHz)	Average Power (dBm)	Limit (dBm)	EIRP Average Power (dBm)	EIRP Limit (dBm)	Result
Ant 0								
11b	1Mbps	1	2412	27.34	≤ 30.00	31.34	≤ 36.00	Pass
11b	1Mbps	6	2437	27.98	≤ 30.00	31.98	≤ 36.00	Pass
11b	1Mbps	11	2462	24.46	≤ 30.00	28.46	≤ 36.00	Pass
11g	6Mbps	1	2412	22.82	≤ 30.00	26.82	≤ 36.00	Pass
11g	6Mbps	6	2437	23.82	≤ 30.00	27.82	≤ 36.00	Pass
11g	6Mbps	11	2462	19.74	≤ 30.00	23.74	≤ 36.00	Pass
11n-HT20	MCS0	1	2412	22.01	≤ 30.00	26.01	≤ 36.00	Pass
11n-HT20	MCS0	6	2437	24.28	≤ 30.00	28.28	≤ 36.00	Pass
11n-HT20	MCS0	11	2462	19.43	≤ 30.00	23.43	≤ 36.00	Pass
11n-HT40	MCS0	3	2422	20.78	≤ 30.00	24.78	≤ 36.00	Pass
11n-HT40	MCS0	6	2437	18.27	≤ 30.00	22.27	≤ 36.00	Pass
11n-HT40	MCS0	9	2452	17.93	≤ 30.00	21.93	≤ 36.00	Pass
Ant 1								
11b	1Mbps	1	2412	25.07	≤ 30.00	29.07	≤ 36.00	Pass
11b	1Mbps	6	2437	25.73	≤ 30.00	29.73	≤ 36.00	Pass
11b	1Mbps	11	2462	24.58	≤ 30.00	28.58	≤ 36.00	Pass
11g	6Mbps	1	2412	20.16	≤ 30.00	24.16	≤ 36.00	Pass
11g	6Mbps	6	2437	23.27	≤ 30.00	27.27	≤ 36.00	Pass
11g	6Mbps	11	2462	19.07	≤ 30.00	23.07	≤ 36.00	Pass
11n-HT20	MCS0	1	2412	19.33	≤ 30.00	23.33	≤ 36.00	Pass
11n-HT20	MCS0	6	2437	23.38	≤ 30.00	27.38	≤ 36.00	Pass
11n-HT20	MCS0	11	2462	18.34	≤ 30.00	22.34	≤ 36.00	Pass
11n-HT40	MCS0	3	2422	18.36	≤ 30.00	22.36	≤ 36.00	Pass
11n-HT40	MCS0	6	2437	17.55	≤ 30.00	21.55	≤ 36.00	Pass
11n-HT40	MCS0	9	2452	16.67	≤ 30.00	20.67	≤ 36.00	Pass

Note: EIRP Average Power (dBm) = Average Power (dBm) + Ant Gain (dBi)

Test Mode	Data Rate/ MCS	Channel No.	Freq. (MHz)	Ant 0 Average Power (dBm)	Ant 1 Average Power (dBm)	Total Average Power (dBm)	Limit (dBm)	EIRP Average Power (dBm)	EIRP Limit (dBm)	Result
Ant 0 + 1 (CDD Mode)										
11b	1Mbps	1	2412	24.52	23.95	27.25	≤ 30.00	31.25	≤ 36.00	Pass
11b	1Mbps	6	2437	27.05	25.41	29.32	≤ 30.00	33.32	≤ 36.00	Pass
11b	1Mbps	11	2462	23.33	23.47	26.41	≤ 30.00	30.41	≤ 36.00	Pass
11g	6Mbps	1	2412	18.61	18.12	21.38	≤ 30.00	25.38	≤ 36.00	Pass
11g	6Mbps	6	2437	23.27	22.05	25.71	≤ 30.00	29.71	≤ 36.00	Pass
11g	6Mbps	11	2462	15.78	15.87	18.84	≤ 30.00	22.84	≤ 36.00	Pass
11n-HT20	MCS0	1	2412	18.13	17.77	20.96	≤ 30.00	24.96	≤ 36.00	Pass
11n-HT20	MCS0	6	2437	22.37	21.03	24.76	≤ 30.00	28.76	≤ 36.00	Pass
11n-HT20	MCS0	11	2462	14.52	14.63	17.59	≤ 30.00	21.59	≤ 36.00	Pass
11n-HT40	MCS0	3	2422	15.21	15.02	18.13	≤ 30.00	22.13	≤ 36.00	Pass
11n-HT40	MCS0	6	2437	15.72	15.18	18.47	≤ 30.00	22.47	≤ 36.00	Pass
11n-HT40	MCS0	9	2452	13.53	13.44	16.50	≤ 30.00	20.50	≤ 36.00	Pass
Ant 0 + 1 (Beam-Forming Mode)										
11n-HT20	MCS0	1	2412	20.07	19.69	22.89	≤ 28.99	29.90	≤ 36.00	Pass
11n-HT20	MCS0	6	2437	25.48	24.37	27.97	≤ 28.99	34.98	≤ 36.00	Pass
11n-HT20	MCS0	11	2462	15.16	14.73	17.96	≤ 28.99	24.97	≤ 36.00	Pass
11n-HT40	MCS0	3	2422	20.67	20.55	23.62	≤ 28.99	30.63	≤ 36.00	Pass
11n-HT40	MCS0	6	2437	18.41	18.19	21.31	≤ 28.99	28.32	≤ 36.00	Pass
11n-HT40	MCS0	9	2452	16.96	16.97	19.98	≤ 28.99	26.99	≤ 36.00	Pass

Note 1: Total Average Power (dBm) = $10*\log\{10^{(\text{Ant 0 Average Power /10})} + 10^{(\text{Ant 1 Average Power /10})}\}$ (dBm).

Note 2: EIRP Average Power (dBm) = Total Average Power (dBm) + Directional Gain (dBi).

7.4. Power Spectral Density Measurement

7.4.1.Test Limit

The maximum permissible power spectral density is 8dBm in any 3 kHz band. The total power spectral density shall be reduced by 1 dB below the specified limits for each dB that the directional gain of the antenna / antenna array exceeds 6 dBi

Frequency Band (MHz)	Per Chain Max Antenna Gain (dBi)		CDD & Beam Forming Directional Gain (dBi)	Limit of SISO (dBm)		Limit of MIMO (dBm)
	Ant 0	Ant 1		Ant 0	Ant 1	Ant 0 + 1
Wi-Fi Omni Ant						
2412 ~2462	4.00	4.00	7.01	8.00	8.00	6.99

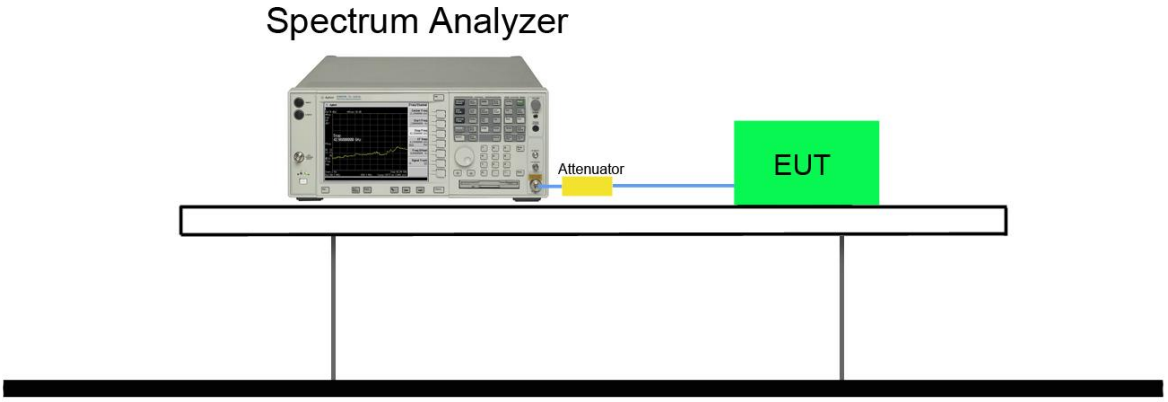
7.4.2.Test Procedure Used

KDB 558074 D01v04 - Section 10.5 Method AVGPSD

7.4.3.Test Setting

1. Measure the duty cycle (x) of the transmitter output signal
2. Set instrument center frequency to DTS channel center frequency.
3. Set span to at least 1.5 times the OBW.
4. RBW = 10kHz
5. VBW = 30kHz
6. Detector = RMS
7. Ensure that the number of measurement points in the sweep ≥ 2 x span/RBW.
8. Sweep time = auto couple
9. Don’t use sweep triggering. Allow sweep to “free run”.
10. Employ trace averaging (RMS) mode over a minimum of 100 traces.
11. Use the peak marker function to determine the maximum amplitude level.
12. Add 10 log (1/x), where x is the duty cycle measured in step (a, to the measured PSD to compute the average PSD during the actual transmission time.
13. Add Constant Factor = 10*log(3kHz / 10kHz) = -5.23

7.4.4.Test Setup



7.4.5.Test Result

Product	AC220m Wi-Fi module OD US	Test Engineer	Peter Xu
Test Site	SR2	Test Date	2017/12/12
Test Item	Power Spectral Density		

Test Mode	Data Rate/ MCS	Channel No.	Freq. (MHz)	AVGPSD (dBm / 10kHz)	Duty Cycle (%)	Constant Factor	Total AVGPSD (dBm / 3kHz)	Limit (dBm / 3kHz)	Result
Ant 0									
11b	1Mbps	1	2412	0.61	98.56	-5.23	-4.62	≤ 8.00	Pass
11b	1Mbps	6	2437	0.87	98.56	-5.23	-4.36	≤ 8.00	Pass
11b	1Mbps	11	2462	-0.73	98.56	-5.23	-5.96	≤ 8.00	Pass
11g	6Mbps	1	2412	-5.35	95.58	-5.23	-10.38	≤ 8.00	Pass
11g	6Mbps	6	2437	-4.55	95.58	-5.23	-9.58	≤ 8.00	Pass
11g	6Mbps	11	2462	-7.61	95.58	-5.23	-12.64	≤ 8.00	Pass
11n-HT20	MCS0	1	2412	-5.63	97.83	-5.23	-10.76	≤ 8.00	Pass
11n-HT20	MCS0	6	2437	-4.10	97.83	-5.23	-9.23	≤ 8.00	Pass
11n-HT20	MCS0	11	2462	-7.48	97.83	-5.23	-12.61	≤ 8.00	Pass
11n-HT40	MCS0	3	2422	-9.76	94.96	-5.23	-14.77	≤ 8.00	Pass
11n-HT40	MCS0	6	2437	-12.83	94.96	-5.23	-17.84	≤ 8.00	Pass
11n-HT40	MCS0	9	2452	-11.59	94.96	-5.23	-16.60	≤ 8.00	Pass

Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	AVGPSD (dBm / 10kHz)	Duty Cycle (%)	Constant Factor	Total AVGPSD (dBm / 3kHz)	Limit (dBm / 3kHz)	Result
Ant 1									
11b	1Mbps	1	2412	-1.58	98.56	-5.23	-6.81	≤ 8.00	Pass
11b	1Mbps	6	2437	-2.09	98.56	-5.23	-7.32	≤ 8.00	Pass
11b	1Mbps	11	2462	-1.69	98.56	-5.23	-6.92	≤ 8.00	Pass
11g	6Mbps	1	2412	-7.22	95.58	-5.23	-12.25	≤ 8.00	Pass
11g	6Mbps	6	2437	-4.56	95.58	-5.23	-9.59	≤ 8.00	Pass
11g	6Mbps	11	2462	-7.92	95.58	-5.23	-12.95	≤ 8.00	Pass
11n-HT20	MCS0	1	2412	-7.40	97.83	-5.23	-12.53	≤ 8.00	Pass
11n-HT20	MCS0	6	2437	-3.91	97.83	-5.23	-9.04	≤ 8.00	Pass
11n-HT20	MCS0	11	2462	-8.56	97.83	-5.23	-13.69	≤ 8.00	Pass
11n-HT40	MCS0	3	2422	-11.04	94.96	-5.23	-16.05	≤ 8.00	Pass
11n-HT40	MCS0	6	2437	-12.81	94.96	-5.23	-17.82	≤ 8.00	Pass
11n-HT40	MCS0	9	2452	-12.88	94.96	-5.23	-17.89	≤ 8.00	Pass

Note 1: When EUT duty cycle < 98%, the total AVGPSD = Ant AVGPSD + 10*log(1/duty cycle) + Constant Factor.

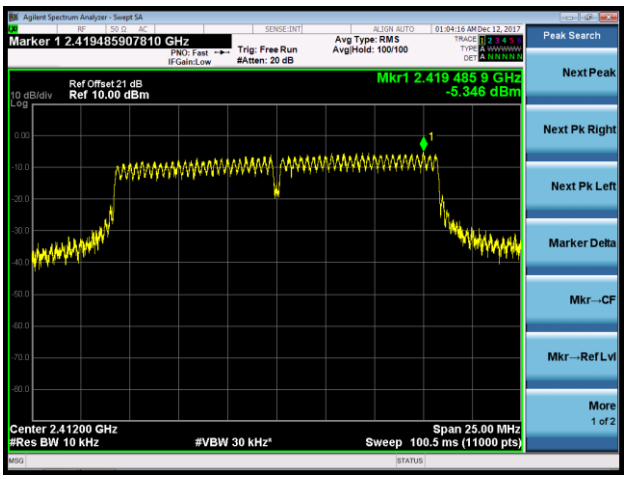
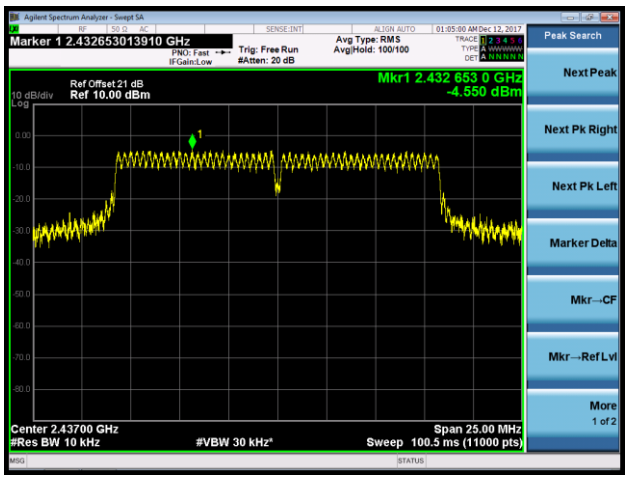
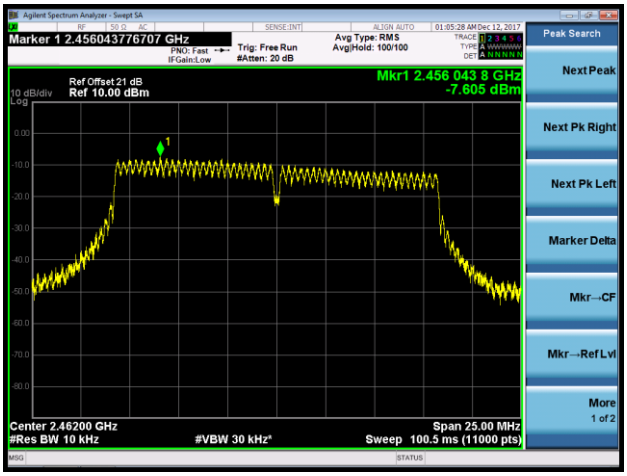
Note 2: When EUT duty cycle > 98%, the total AVGPSD = Ant AVGPSD + Constant Factor.

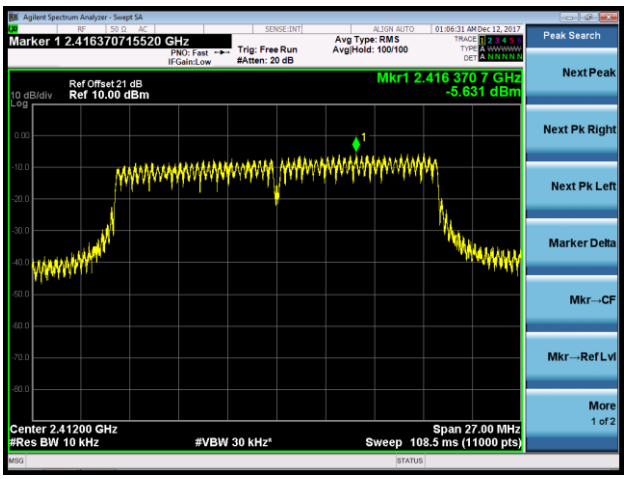
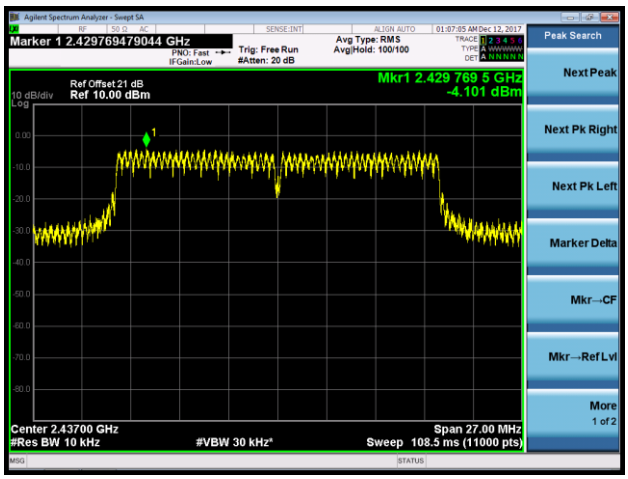
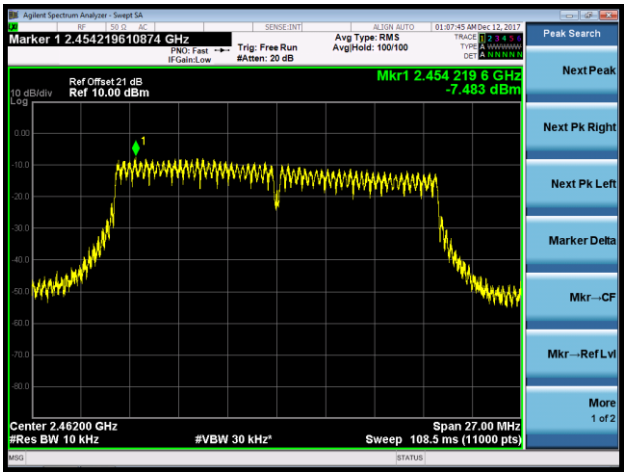
Test Mode	Data Rate (Mbps)	Channel No.	Freq. (MHz)	Ant 0 AVGPSD (dBm / 10kHz)	Ant 1 AVGPSD (dBm / 10kHz)	Duty Cycle (%)	Total AVGPSD (dBm / 10kHz)	Limit (dBm / 3kHz)	Result
Ant 0 + 1 (CDD Mode)									
11b	1Mbps	1	2412	-2.53	-0.07	98.56	-3.35	≤ 6.99	Pass
11b	1Mbps	6	2437	-2.75	-4.68	98.56	-5.83	≤ 6.99	Pass
11b	1Mbps	11	2462	-2.05	-3.73	98.56	-5.03	≤ 6.99	Pass
11g	6Mbps	1	2412	-9.77	-9.35	95.58	-11.78	≤ 6.99	Pass
11g	6Mbps	6	2437	-5.90	-6.11	95.58	-8.22	≤ 6.99	Pass
11g	6Mbps	11	2462	-12.12	-11.91	95.58	-14.23	≤ 6.99	Pass
11n-HT20	MCS0	1	2412	-9.97	-9.33	97.83	-11.85	≤ 6.99	Pass
11n-HT20	MCS0	6	2437	-5.46	-7.72	97.83	-8.57	≤ 6.99	Pass
11n-HT20	MCS0	11	2462	-13.29	-12.87	97.83	-15.29	≤ 6.99	Pass
11n-HT40	MCS0	3	2422	-16.34	-15.22	94.96	-17.96	≤ 6.99	Pass
11n-HT40	MCS0	6	2437	-15.66	-15.14	94.96	-17.39	≤ 6.99	Pass
11n-HT40	MCS0	9	2452	-16.56	-15.69	94.96	-18.32	≤ 6.99	Pass
Ant 0 + 1 (Beam-Forming Mode)									
11n-HT20	MCS0	1	2412	-7.85	-6.86	97.83	-9.45	≤ 6.99	Pass
11n-HT20	MCS0	6	2437	-2.89	-3.61	97.83	-5.36	≤ 6.99	Pass
11n-HT20	MCS0	11	2462	-12.52	-11.71	97.83	-14.22	≤ 6.99	Pass
11n-HT40	MCS0	3	2422	-10.05	-9.04	94.96	-11.51	≤ 6.99	Pass
11n-HT40	MCS0	6	2437	-13.11	-12.58	94.96	-14.83	≤ 6.99	Pass
11n-HT40	MCS0	9	2452	-12.27	-12.02	94.96	-14.14	≤ 6.99	Pass

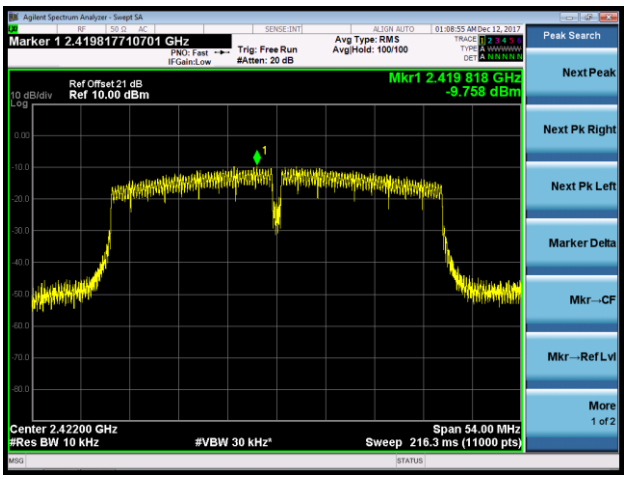
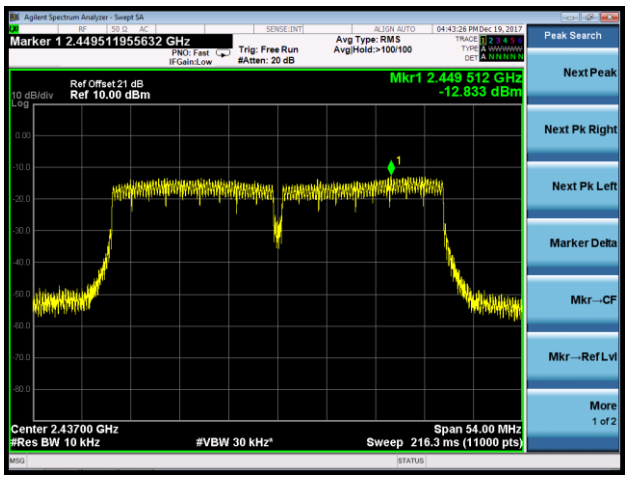
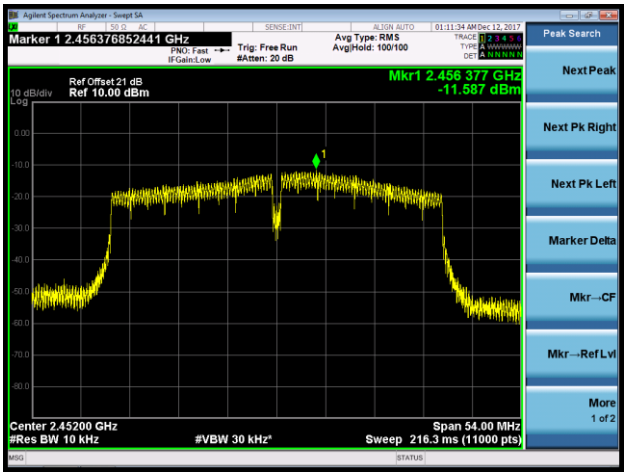
Note 1: When EUT duty cycle < 98%, the total AVGPSD = $10*\log\{10^{(\text{Ant 0 AVGPSD}/10)}+10^{(\text{Ant 1 AVGPSD}/10)}\}+10*\log(1/\text{duty cycle})$.

Note 2: When EUT duty cycle > 98%, the total AVGPSD = $10*\log\{10^{(\text{Ant 0 AVGPSD}/10)}+10^{(\text{Ant 1 AVGPSD}/10)}\}$.

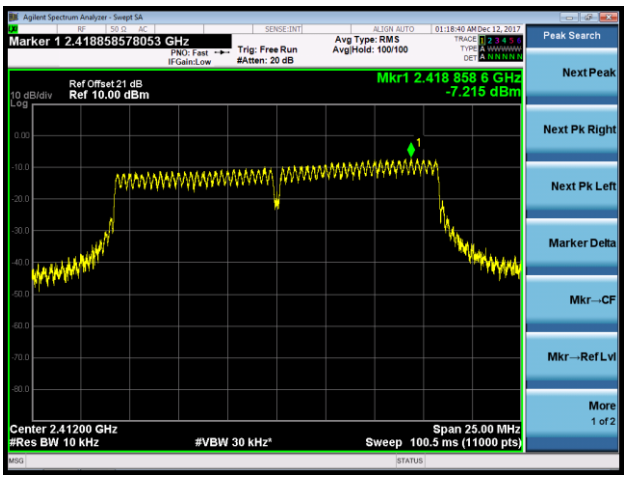
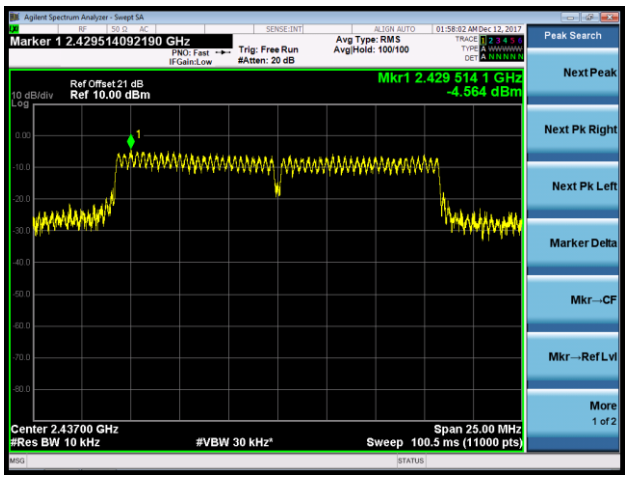
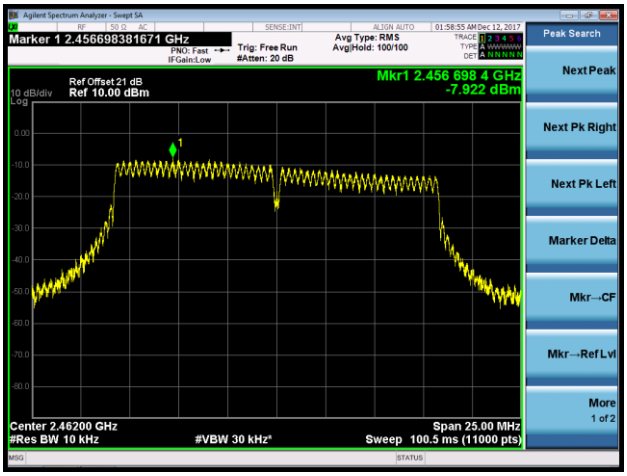
802.11b AVGPSD - Ant 0	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
Channel 11 (2462MHz)	

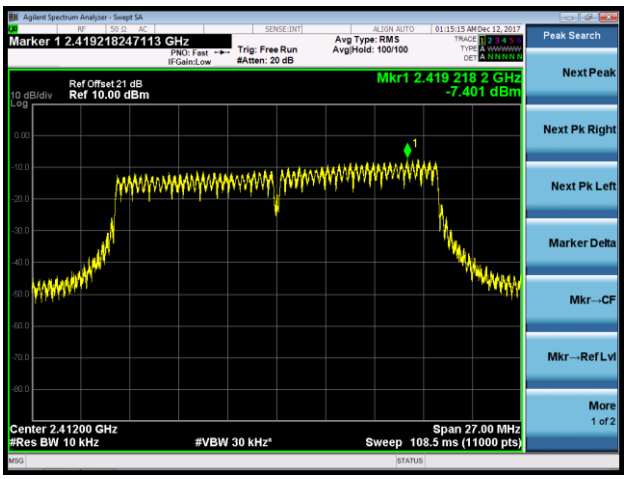
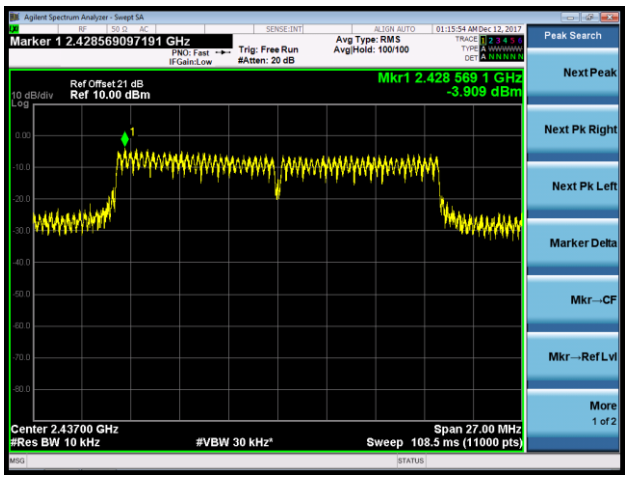
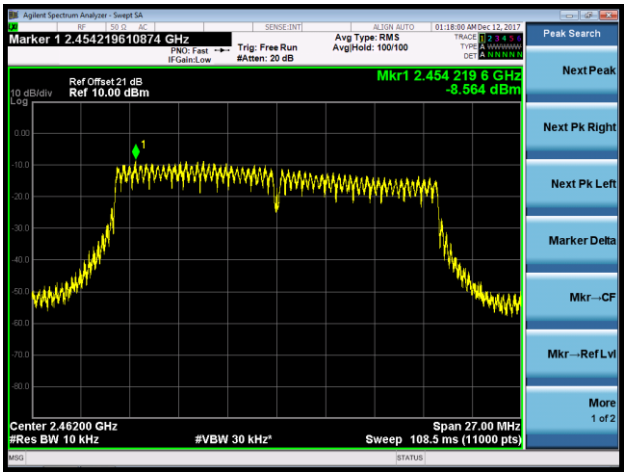
802.11g AVGPSD - Ant 0	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

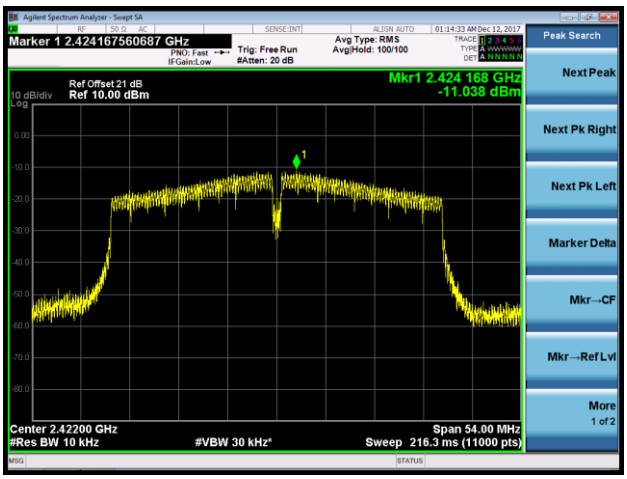
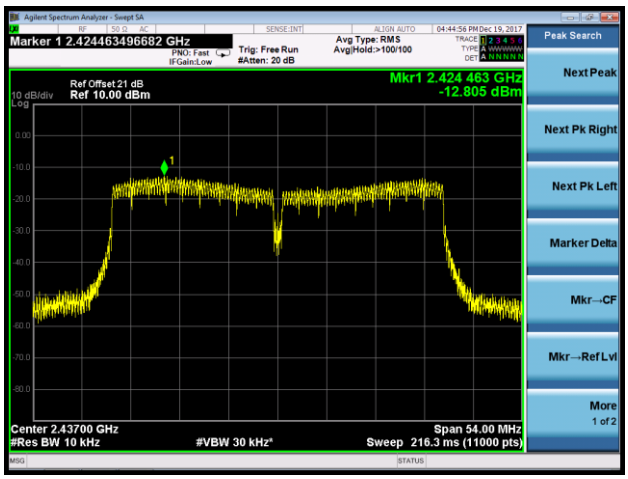
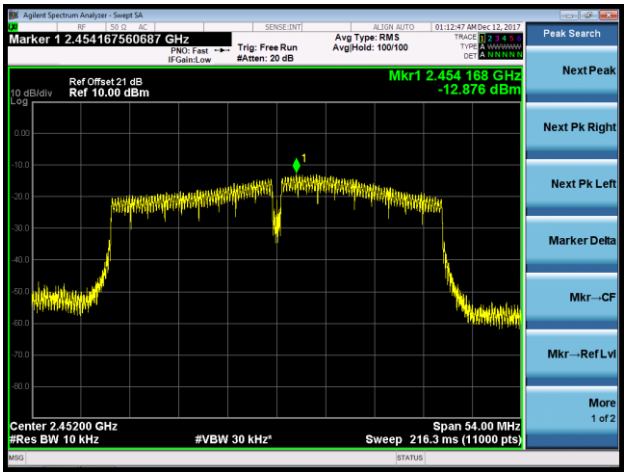
802.11n-HT20 AVGPSD - Ant 0	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT40 AVGPSD - Ant 0	
Channel 03 (2422MHz)	Channel 06 (2437MHz)
	
Channel 09 (2452MHz)	
	

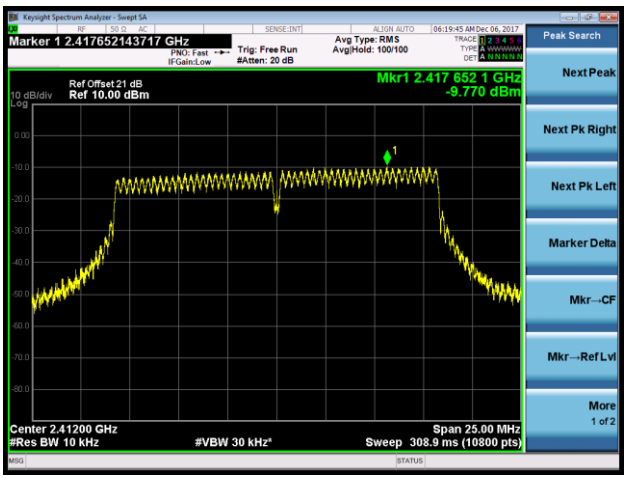
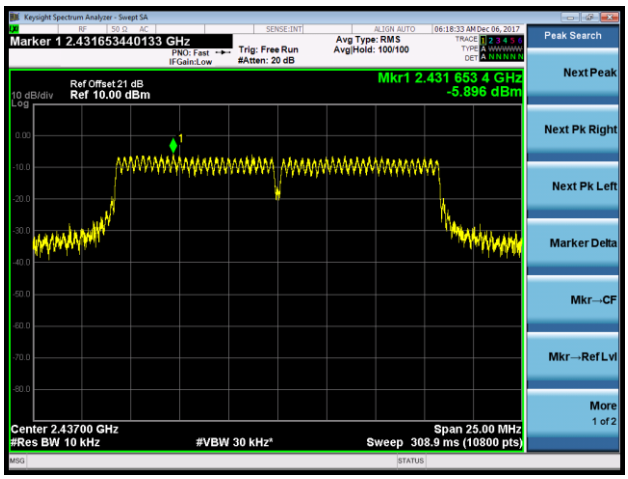
802.11b AVGPSD - Ant 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
Channel 11 (2462MHz)	

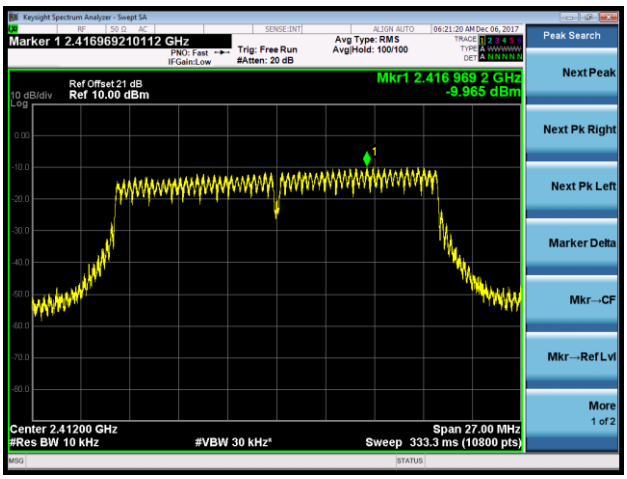
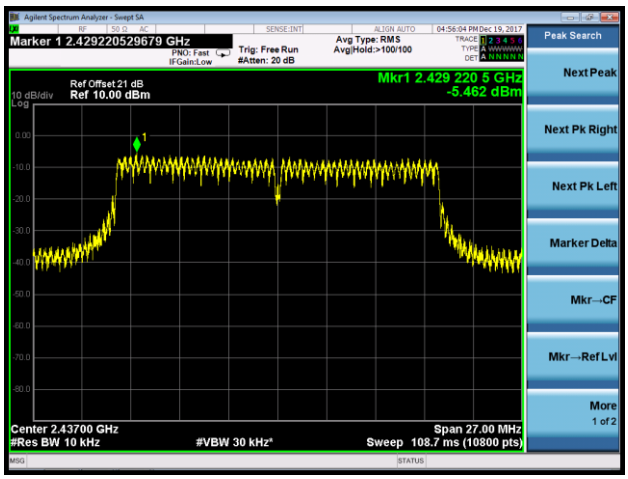
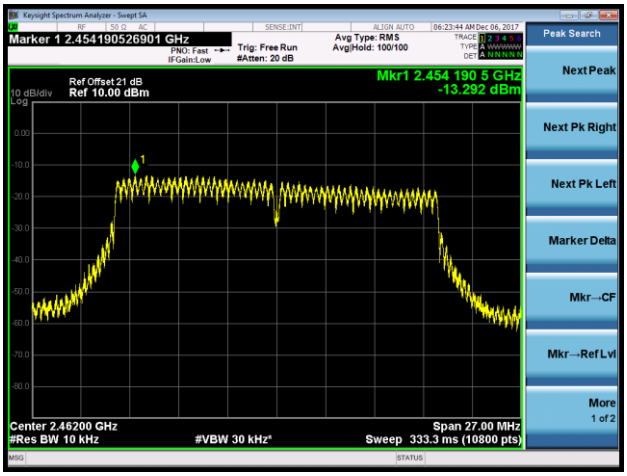
802.11g AVGPSD - Ant 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT20 AVGPSD - Ant 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT40 AVGPSD - Ant 1	
Channel 03 (2422MHz)	Channel 06 (2437MHz)
	
Channel 09 (2452MHz)	
	

802.11b AVGPSD - Ant 0 / Ant 0 + 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
Channel 11 (2462MHz)	

802.11g AVGPSD - Ant 0 / Ant 0 + 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	

802.11n-HT20 AVGPSD - Ant 0 / Ant 0 + 1 (CDD Mode)	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)