



TEST REPORT

APPLICANT : Thundercomm Technology Co., Ltd.
PRODUCT NAME : Thundersoft TurboX S820 SOM
MODEL NAME : S820
BRAND NAME : TurboX
FCC ID : 2AOHHTURBOXSOMS820
STANDARD(S) : 47 CFR Part 15 Subpart C
TEST DATE : 2017-12-05 to 2018-01-15
ISSUE DATE : 2018-01-18

Tested by: Tu Ya'nan
Tu Ya'nan (Test Engineer)
Approved by: Andy Yeh
Andy Yeh (Technical Director)

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Change History		
Issue	Date	Reason for change
1.0	2017-12-29	First edition
2.0	2018-01-18	Second edition



1. Technical Information

Note: Provide by applicant.

1.1. Applicant and Manufacturer Information

Applicant:	Thundercomm Technology Co., Ltd.
Applicant Address:	4F, Taixiang Building, 1A Longxiang Rd., Haidian Dist., Beijing, 100191, P.R.China
Manufacturer:	Thundercomm Technology Co., Ltd.
Manufacturer Address:	4F, Taixiang Building, 1A Longxiang Rd., Haidian Dist., Beijing, 100191, P.R.China

1.2. Equipment Under Test (EUT) Description

Product Name:	Thundersoft TurboX S820 SOM
Serial No:	(N/A, marked #1 by test site)
Hardware Version:	Dolphin_V23
Software Version:	N/A
Modulation Type:	DSSS, OFDM
Operating Frequency Range:	802.11b/g/n-20MHz: 2.412GHz - 2.462GHz 802.11n-40MHz: 2.422GHz - 2.452GHz
Channel Number:	802.11b/g/n-20MHz: 11 802.11n-40MHz: 7
Modulation Type:	DSSS, OFDM
Antenna Type:	FPC Antenna <small>Note6</small>
Antenna Gain:	Ant0: 4 dBi; Ant1: 4 dBi <small>Note6</small>
Directional Gain:	7.01dBi <small>Note 3</small>

Note 1: The EUT is operating at 2.4GHz ISM; it supports 802.11b, 802.11g, 802.11n and they are all tested in this report.

For 802.11b/g/n HT20, the frequencies allocated is $F \text{ (MHz)} = 2412 + 5 * (n - 1)$ ($1 \leq n \leq 11$). The lowest, middle, highest channel numbers of the EUT used and tested in this report are separately 1 (2412MHz), 6 (2437MHz) and 11 (2462MHz).

For 802.11n HT40, the frequencies allocated is $F \text{ (MHz)} = 2412 + 5 * (n - 1)$ ($3 \leq n \leq 9$). The lowest, middle, highest channel numbers of the EUT used and tested in this report are separately 3 (2422MHz), 6 (2437MHz) and 9 (2452MHz).



Note 2: The EUT has two antenna ports and the two antenna ports have the same characteristics, only 802.11n modulation mode supports a MIMO function.

Modulation Mode:	TX Function	Relationship between the two output signals
802.11b	1TX	Uncorrelated
802.11g	1TX	Uncorrelated
802.11n	2TX	Correlated

Note 3: According to KDB 662911 D01, the directional gain = $G_{ANT} + 10\log(N_{ANT})$ dBi, where G_{ANT} is the antenna gain in dBi, N_{ANT} is the number of outputs.

Note 4: For conducted test item Peak Power and Power spectral density of each modulation mode, we recorded the test result of two antenna ports separately, for other conducted test items both of the two antennas were tested separately, we only recorded the worst test result(ANT0) in this report.

Note 5: All radiation test items for 802.11n modulation mode operate at MIMO mode during the test. Other modulation mode operate at SISO mode, both of the two antennas were tested separately, we only recorded the worst test result(ANT0) in this report.

Note 6: The product will not sell with antenna. The antennas we use for all radiated test were just for test, the antenna type is FPC antenna and the antenna gain is 4 dBi. For more detailed, please refer to the Internal Photos.

Note 7: The EUT connected to the serial port of the computer with a serial communication cable, we use the dedicated software to control the EUT continuous transmission.

Note 8: For a more detailed description, please refer to Specification or User's Manual supplied by the applicant and/or manufacturer.



1.3. Test Standards and Results

The objective of the report is to perform testing according to 47 CFR Part 15 Subpart C (Bluetooth, 2.4GHz ISM band radiators) for the EUT FCC ID Certification:

No	Identity	Document Title
1	47 CFR Part 15 (10-1-15 Edition)	Radio Frequency Devices

Test detailed items/section required by FCC rules and results are as below:

No.	Section	Description	Test Date	Test Engineer	Result
1	15.203	Antenna Requirement	N/A	N/A	PASS
2	15.247(b)	Peak Output Power	Dec 05, 2017	Tu Ya'nan	PASS
3	15.247(a)	Bandwidth	Jan 15, 2018	Tu Ya'nan	PASS
4	15.247(d)	Conducted Spurious Emission and Band Edge	Dec 05, 2017	Tu Ya'nan	PASS
5	15.247(d)	Restricted Frequency Bands	Dec 07&28, 2017	Wang Dalong	PASS
6	15.207	Conducted Emission	Dec 12, 2017	Wang Dalong	PASS
7	15.209, 15.247(d)	Radiated Emission	Dec 13, 2017	Wang Dalong	PASS
8	15.247(e)	Power spectral density	Jan 15, 2018	Tu Ya'nan	PASS

Note1: The tests of Conducted Emission and Radiated Emission were performed according to the method of measurements prescribed in ANSI C63.10 2013.

Note2: These RF tests were performed according to the method of measurements prescribed in KDB558074 D01 DTS Meas Guidance v03r05, KDB662911 D01 Multiple Transmitter Output v02r01.

1.4. Environmental Conditions

During the measurement, the environmental conditions were within the listed ranges:

Temperature (°C):	15 - 35
Relative Humidity (%):	30 -60
Atmospheric Pressure (kPa):	86-106



2. 47 CFR Part 15C Requirements

2.1. Antenna requirement

2.1.1. Applicable Standard

According to FCC 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

2.1.2. Result: Compliant

The EUT has a permanently and irreplaceable attached antenna. Please refer to the EUT internal photos.

2.2. Peak Output Power

2.2.1. Requirement

According to FCC section 15.247(b)(3), For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: The maximum peak conducted output power of the intentional radiator shall not exceed 1 Watt.

2.2.2. Test Description

The measured output power was calculated by the reading of the USB Wideband Power Sensor and calibration.

A. Test Setup:



The EUT (Equipment under the test) which is coupled to the USB Wideband Power Sensor; the RF load attached to the EUT antenna terminal is 50Ohm; the path loss as the factor is calibrated to correct the reading, all test result in power meter.

B. Equipments List:

Please reference ANNEX A(1.5).



2.2.3. Test Result

The lowest, middle and highest channels are selected to perform testing to verify the conducted RF output peak power of the Module.

2.2.3.1 802.11b Test Mode

Channel	Frequency (MHz)	ANT0 Measured Peak Power		ANT1 Measured Peak Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
1	2412	16.63	0.04603	16.53	0.04498	30	1	PASS
6	2437	16.51	0.04477	16.47	0.04436			PASS
11	2462	16.72	0.04699	16.63	0.04603			PASS

Channel	Frequency (MHz)	ANT0 Average Power		ANT1 Average Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
1	2412	13.88	0.02443	13.53	0.02254	30	1	PASS
6	2437	13.87	0.02438	13.47	0.02223			PASS
11	2462	13.94	0.02477	13.62	0.02301			PASS

2.2.3.2 802.11g Test mode

Channel	Frequency (MHz)	ANT0 Measured Peak Power		ANT1 Measured Peak Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
1	2412	19.51	0.08933	19.53	0.08974	30	1	PASS
6	2437	19.53	0.08974	19.37	0.08650			PASS
11	2462	19.57	0.09057	19.48	0.08872			PASS

Channel	Frequency (MHz)	ANT0 Average Power		ANT1 Average Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
1	2412	13.31	0.02143	13.41	0.02193	30	1	PASS
6	2437	13.21	0.02094	13.34	0.02158			PASS
11	2462	13.27	0.02123	13.15	0.02065			PASS



2.2.3.3 802.11n-20MHz Test mode

Channel	Frequency (MHz)	ANT0 Measured Peak Power		ANT1 Measured Peak Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
1	2412	19.85	0.09661	19.78	0.09506	30	1	PASS
6	2437	19.83	0.09616	19.83	0.09616			PASS
11	2462	19.78	0.09506	19.75	0.09441			PASS

Channel	Frequency (MHz)	ANT0 Average Power		ANT1 Average Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
1	2412	13.12	0.02051	13.01	0.02000	30	1	PASS
6	2437	13.04	0.02014	13.06	0.02023			PASS
11	2462	13.09	0.02037	13.07	0.02028			PASS

Total Peak Power (ANT0+ANT1)

Channel	Frequency (MHz)	Total Peak Power (W)	Total Peak Power (dBm)	Limit		Verdict
				dBm	W	
1	2412	0.1917	22.83	28.99	0.79	PASS
6	2437	0.1923	22.84			PASS
11	2462	0.1895	22.78			PASS

Note: Directional gain = 4.0dBi + 10log(2) = 7.01dBi > 6dBi, so the power limit shall be reduced to 30-(7.01-6) = 28.99dBm.



2.2.3.4 802.11n-40MHz Test mode

Channel	Frequency (MHz)	ANT0 Measured Peak Power		ANT1 Measured Peak Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
3	2422	20.27	0.10641	20.21	0.10495	30	1	PASS
6	2437	20.53	0.11298	20.47	0.11143			PASS
9	2452	20.18	0.10423	20.46	0.11117			PASS

Channel	Frequency (MHz)	ANT0 Average Power		ANT1 Average Power		Limit		Verdict
		dBm	W	dBm	W	dBm	W	
3	2422	13.26	0.02118	13.32	0.02148	30	1	PASS
6	2437	13.18	0.02080	13.24	0.02109			PASS
9	2452	13.15	0.02065	13.18	0.02080			PASS

Total Peak Power (ANT0+ANT1)

Channel	Frequency (MHz)	Total Peak Power (W)	Total Peak Power (dBm)	Limit		Verdict
				dBm	W	
1	2412	0.2114	23.25	28.99	0.79	PASS
6	2437	0.2244	23.51			PASS
11	2462	0.2154	23.33			PASS

Note: Directional gain = 4.0dBi + 10log(2) = 7.01dBi > 6dBi, so the power limit shall be reduced to 30-(7.01-6) = 28.99dBm.

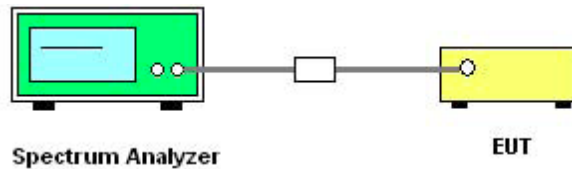
2.3. Bandwidth

2.3.1. Requirement

According to FCC section 15.247(a) (2), Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

2.3.2. Test Description

A. Test Set:



The EUT is coupled to the Spectrum Analyzer; the RF load attached to the EUT antenna terminal is 50Ohm; the path loss as the factor is calibrated to correct the reading.

Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. In order to make an accurate measurement, set the span greater than RBW.

KDB 558074 Section 8.1 Option 1 was used in order to prove compliance.

B. Equipments List:

Please reference ANNEX A(1.5).

2.3.3. Test Result

The lowest, middle and highest channels are selected to perform testing to record the 6 dB bandwidth of the Module.

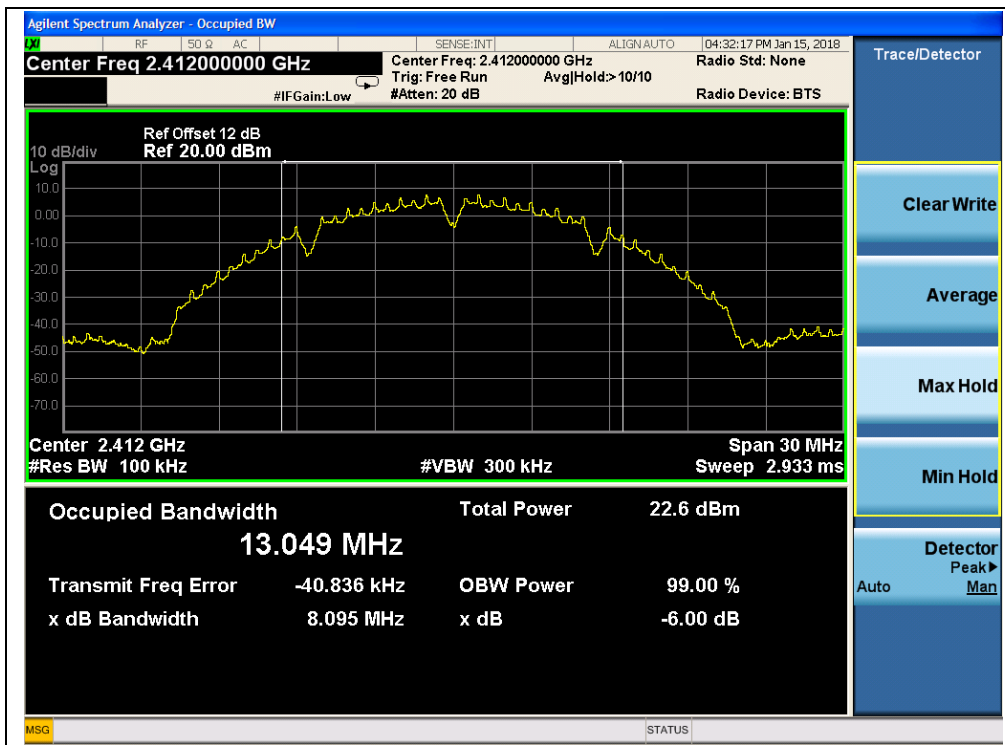


2.3.3.1 802.11b Test mode

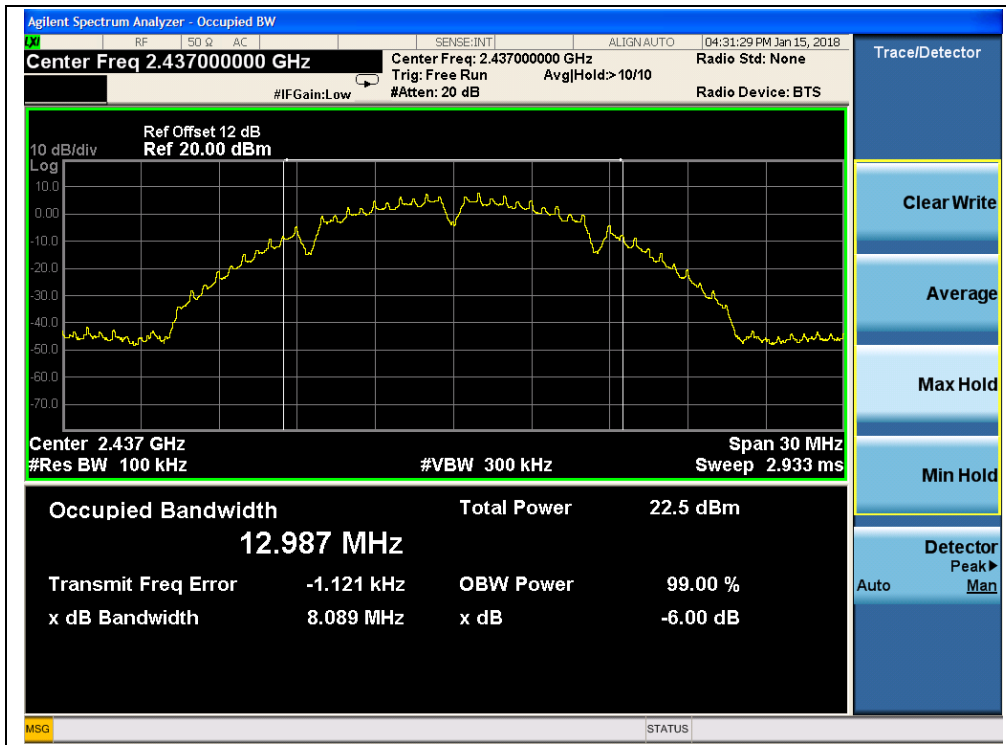
A. Test Verdict:

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Limits(kHz)	Result
1	2412	8.095	≥500	PASS
6	2437	8.089	≥500	PASS
11	2462	8.082	≥500	PASS

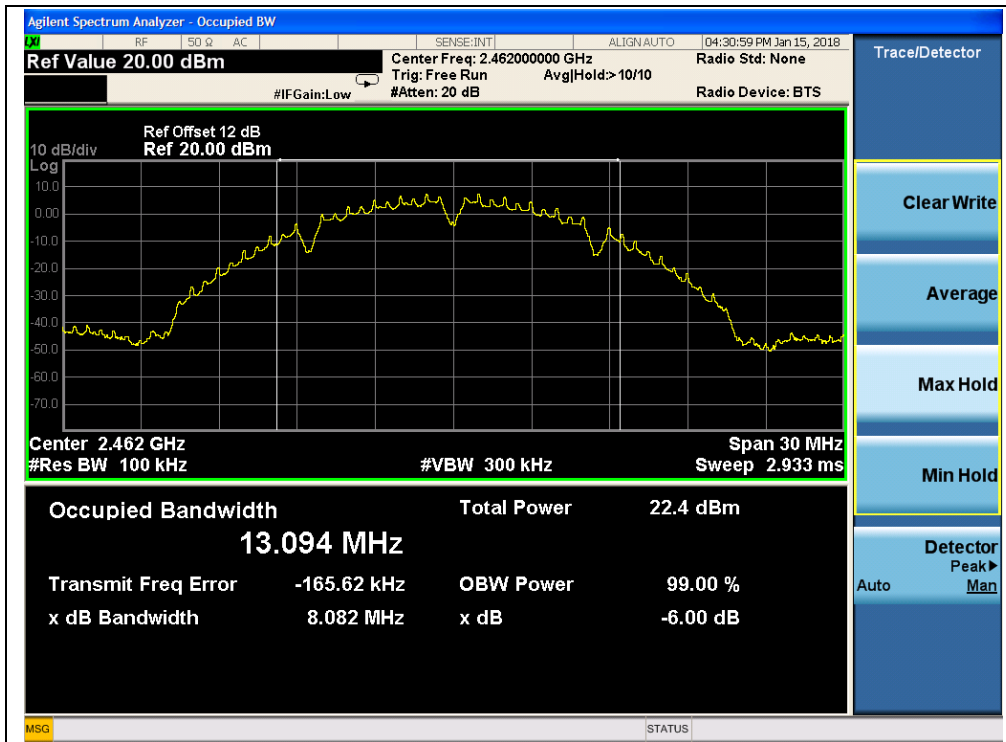
B. Test Plots



(Channel 1: 2412MHz @ 802.11b)



(Channel 6: 2437 MHz @ 802.11b)



(Channel 11: 2462MHz @ 802.11b)

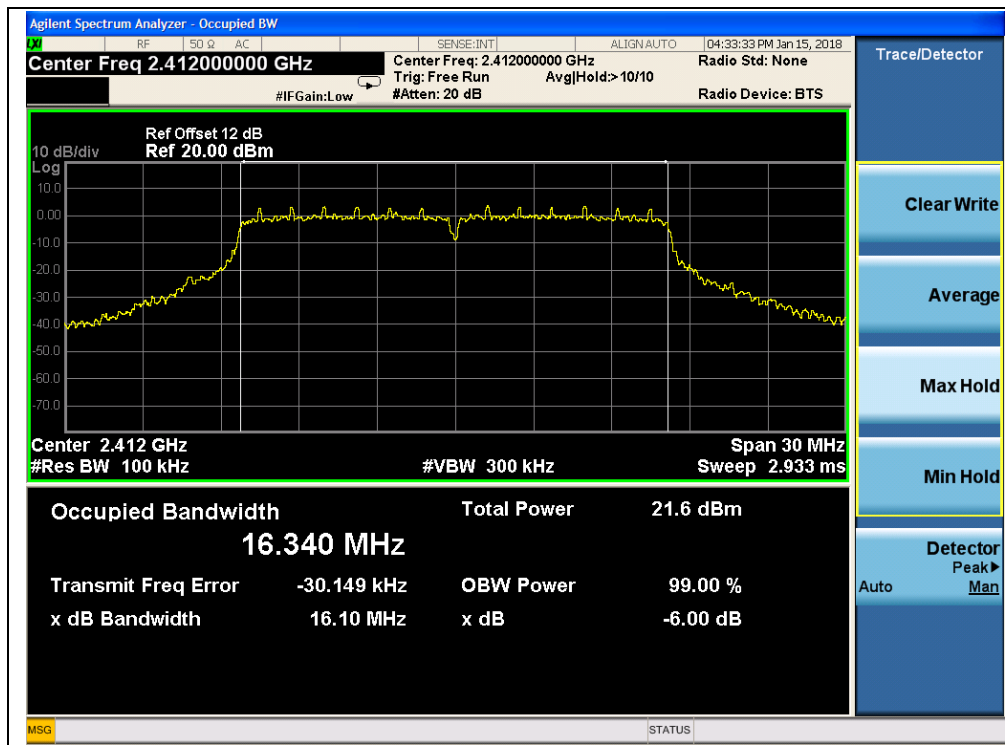


2.3.3.2 802.11g Test mode

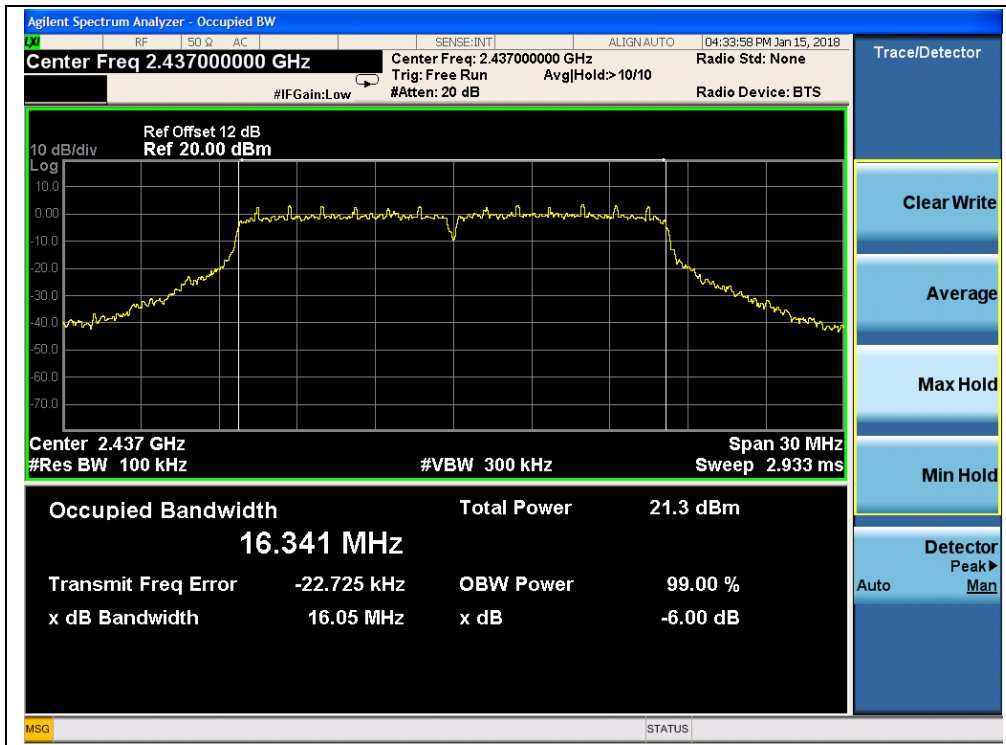
A. Test Verdict:

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Limits (kHz)	Result
1	2412	16.10	≥500	PASS
6	2437	16.05	≥500	PASS
11	2462	15.95	≥500	PASS

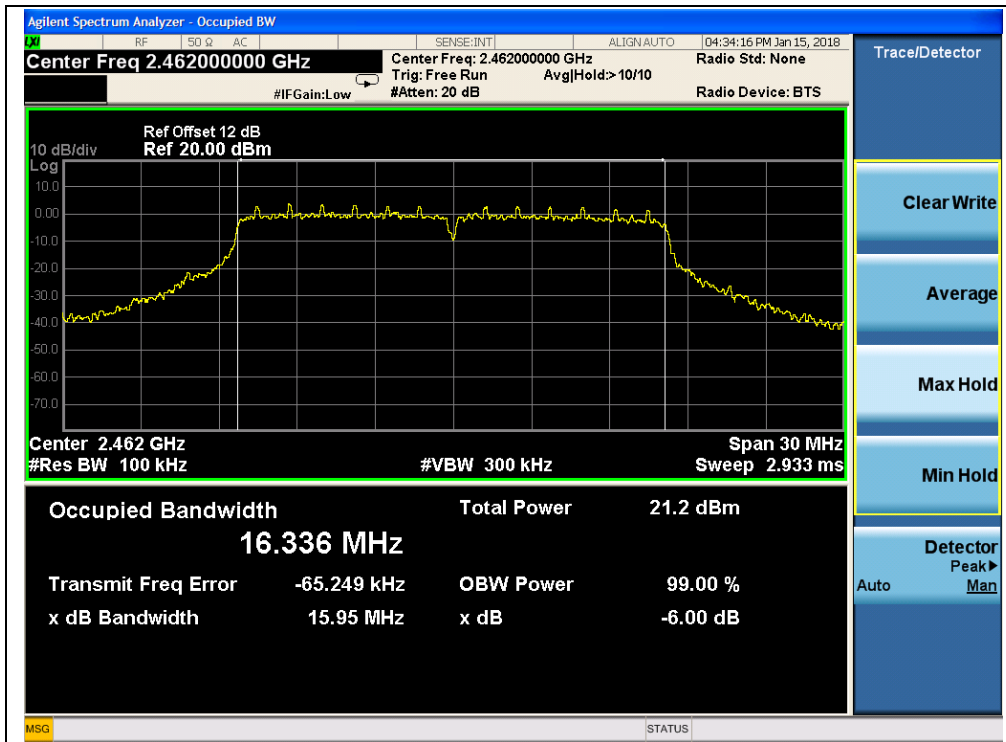
B. Test Plots:



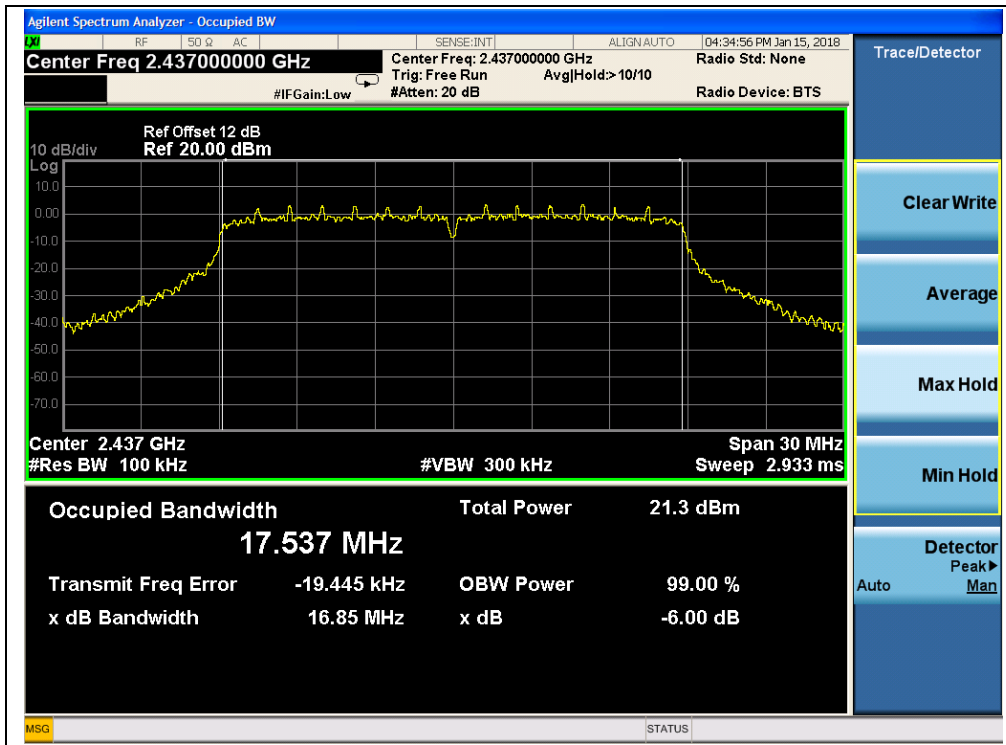
(Channel 1: 2412MHz @ 802.11g)



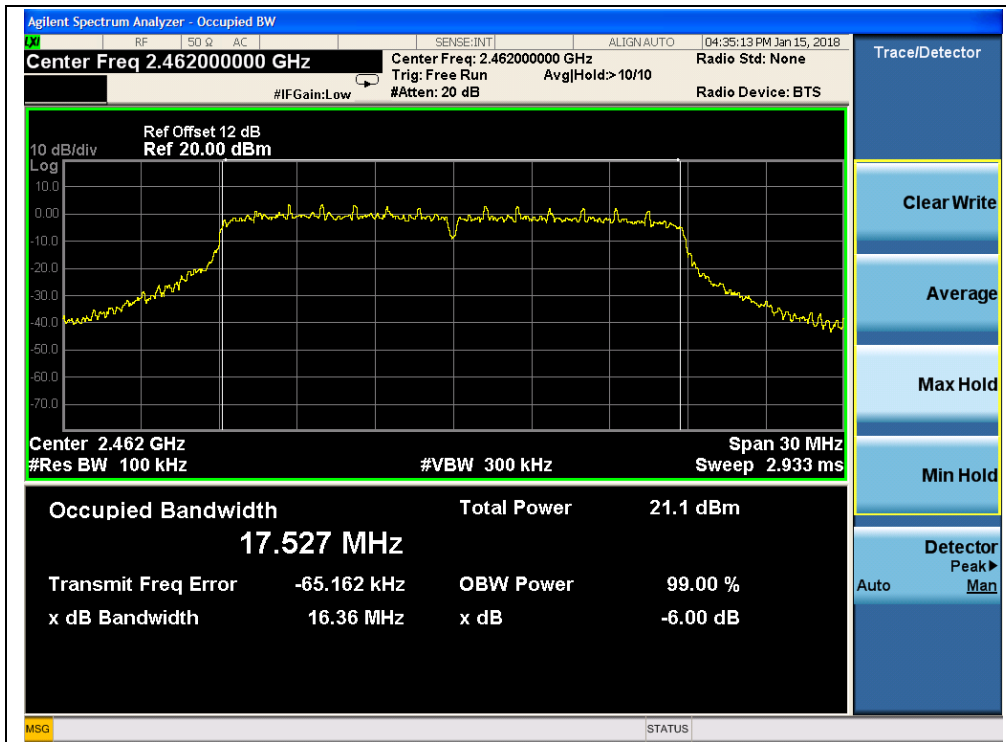
(Channel 6: 2437MHz @ 802.11g)



(Channel 11: 2462MHz @ 802.11g)



(Channel 6: 2437MHz @ 802.11n-20)



(Channel 11: 2462MHz @ 802.11n-20)

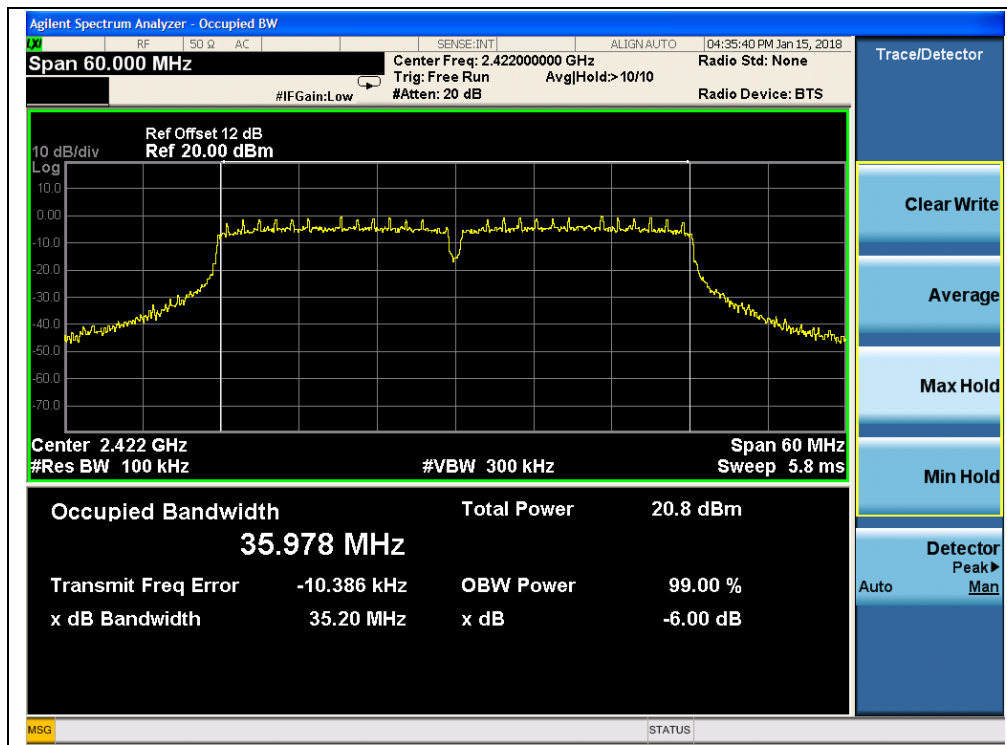


2.3.3.4 802.11n-40 Test mode

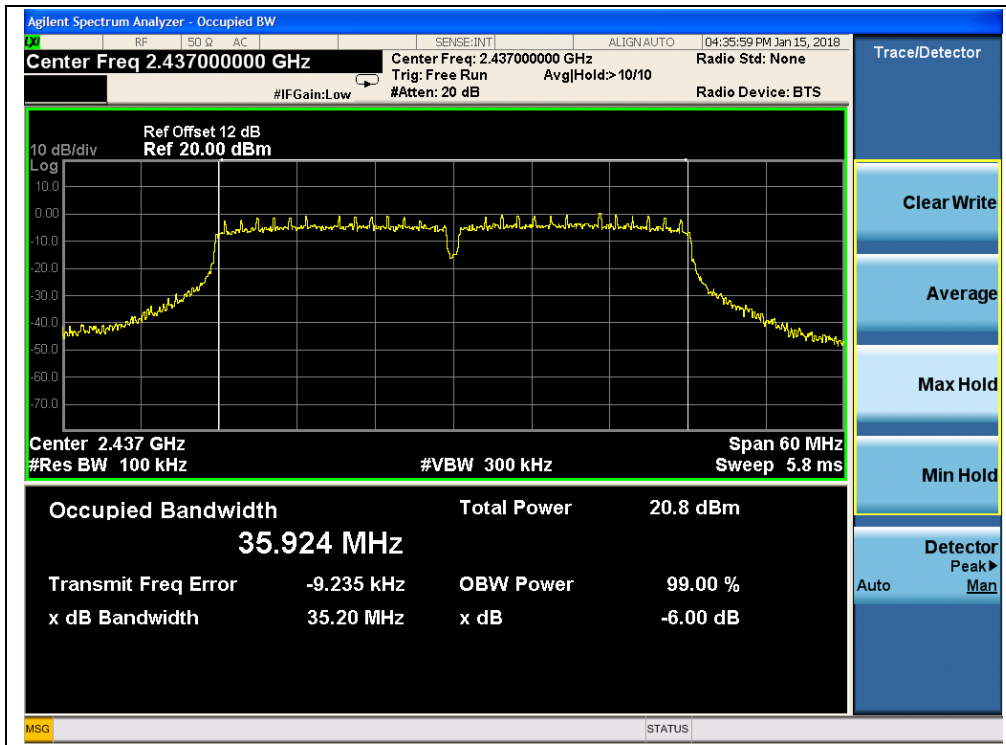
A. Test Verdict:

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Limits (kHz)	Result
3	2422	35.20	≥500	PASS
6	2437	35.20	≥500	PASS
9	2452	35.17	≥500	PASS

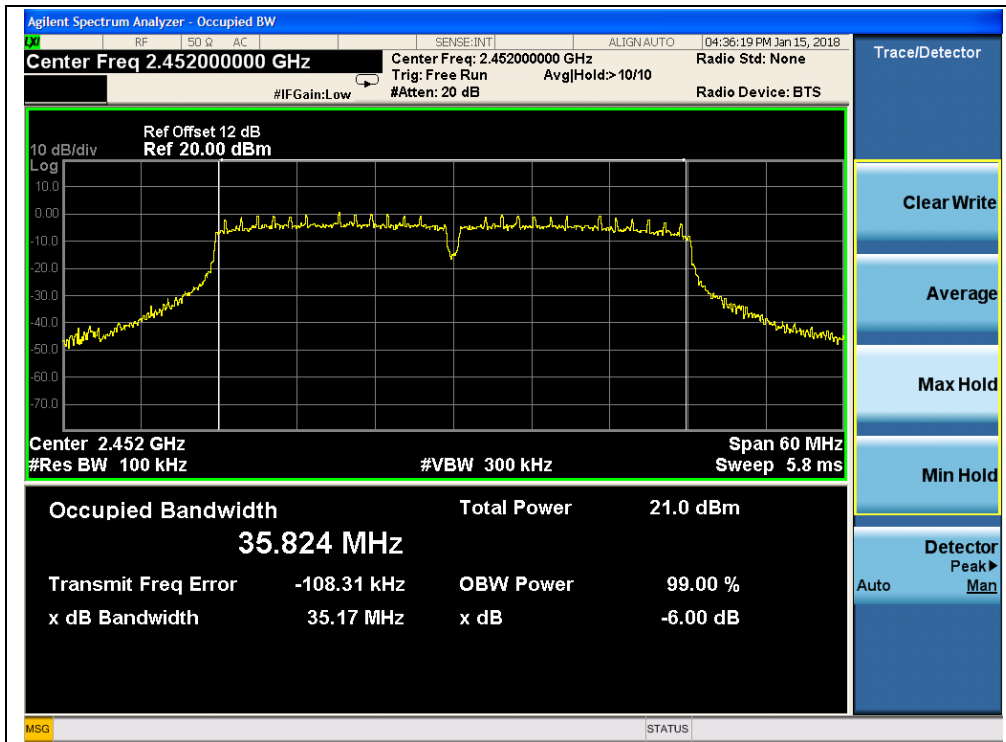
B. Test Plots:



(Channel 3: 2422Mz @ 802.11n-40)



(Channel 6: 2437MHz @ 802.11n-40)



(Channel 9: 2452MHz @ 802.11n-40)

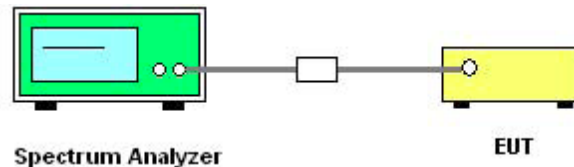
2.4. Conducted Spurious Emissions and Band Edge

2.4.1. Requirement

According to FCC section 15.247(c), in any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

2.4.2. Test Description

A. Test Set:



The EUT is coupled to the Spectrum Analyzer; the RF load attached to the EUT antenna terminal is 50Ohm; the path loss as the factor is calibrated to correct the reading.

Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. In order to make an accurate measurement, set the span greater than RBW.

KDB 558074 Section 11.0 was used in order to prove compliance.

B. Equipments List:

Please reference ANNEX A(1.5).

2.4.3. Test Result

The measurement frequency range is from 30MHz to the 10th harmonic of the fundamental frequency. The lowest, middle and highest channels are tested to verify the spurious emissions.



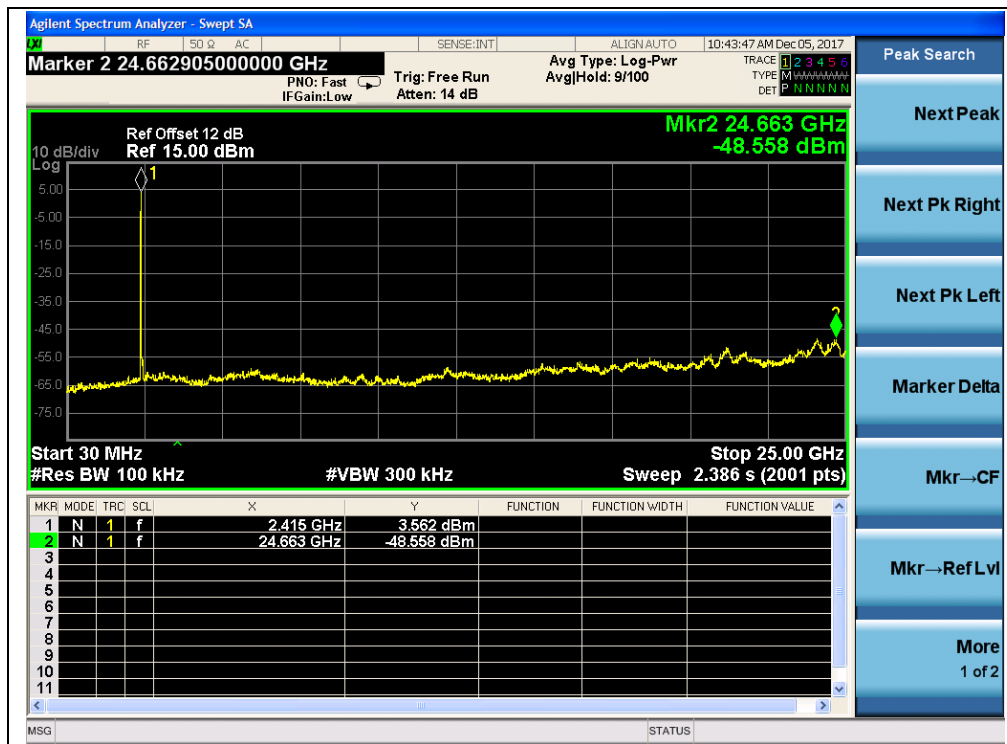
2.4.3.1 802.11b Test mode

A. Test Verdict:

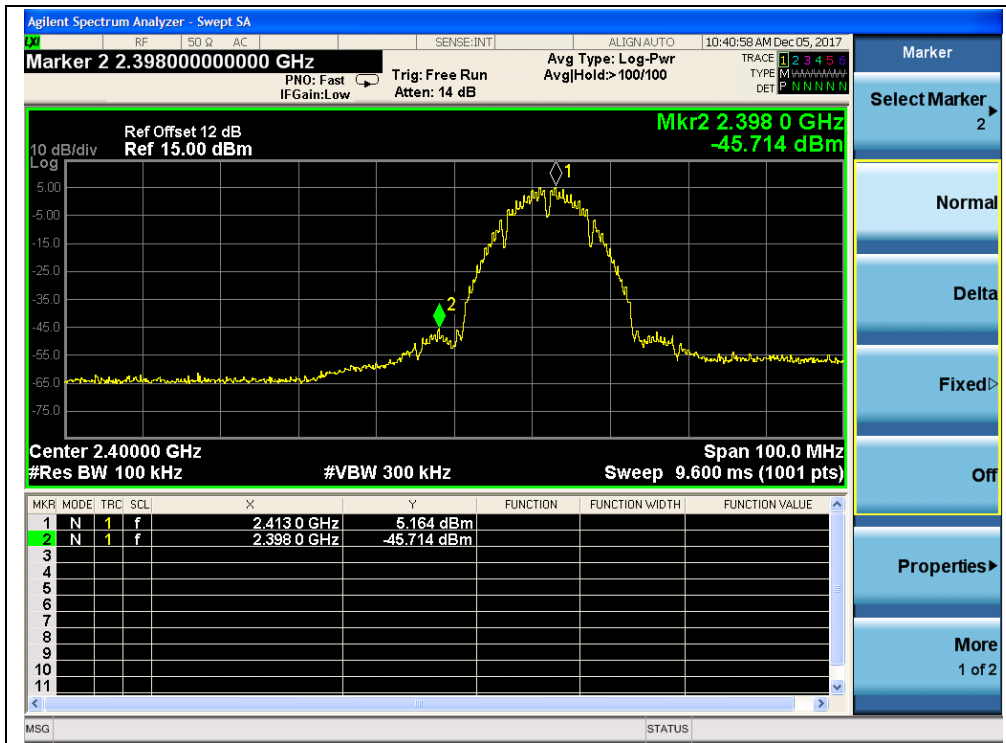
Channel	Frequency (MHz)	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
			Carrier Level	Calculated -20dBc Limit	
1	2412	-48.56	3.56	-16.44	PASS
6	2437	-48.93	2.93	-17.07	PASS
11	2462	-48.98	3.30	-16.70	PASS

B. Test Plots:

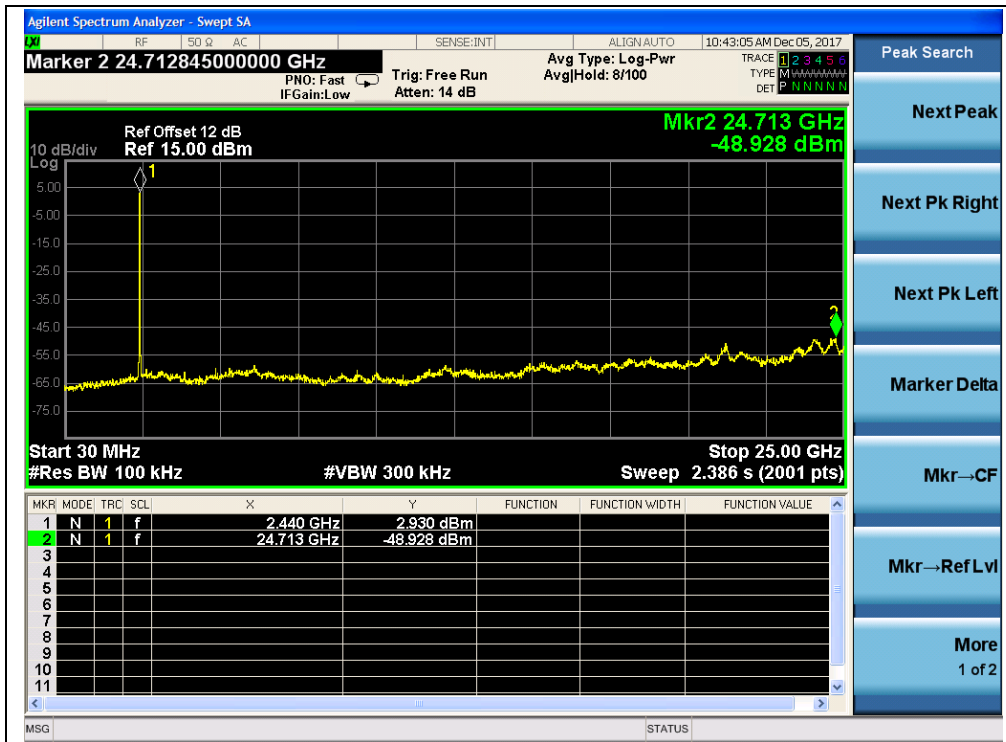
Note: the power of the Module transmitting frequency should be ignored.



(Channel = 1, 30MHz to 25GHz)



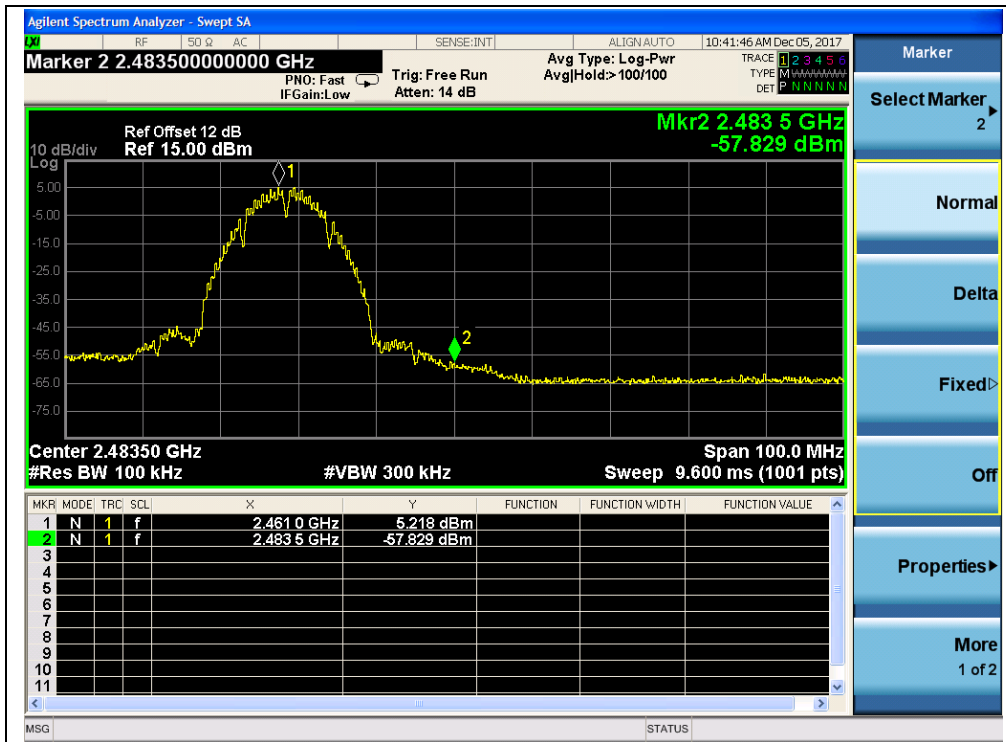
(Band Edge @ Channel = 1)



(Channel = 6, 30MHz to 25GHz)



(Channel = 11, 30MHz to 25GHz)



(Band Edge @ Channel = 11)



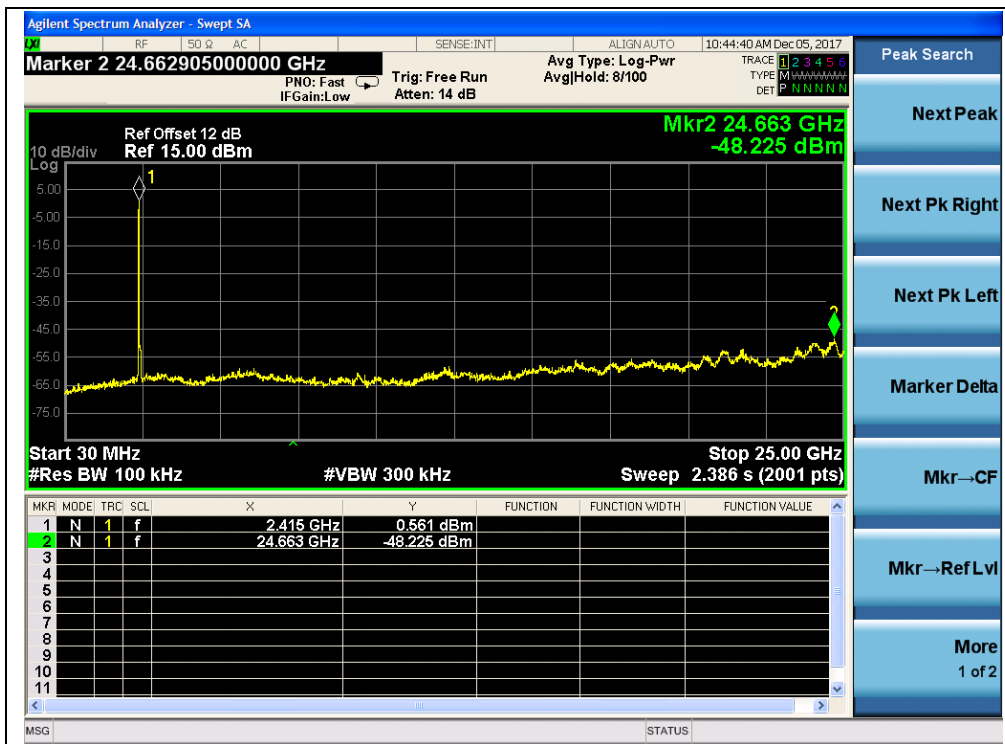
2.4.3.2 802.11g Test mode

A. Test Verdict:

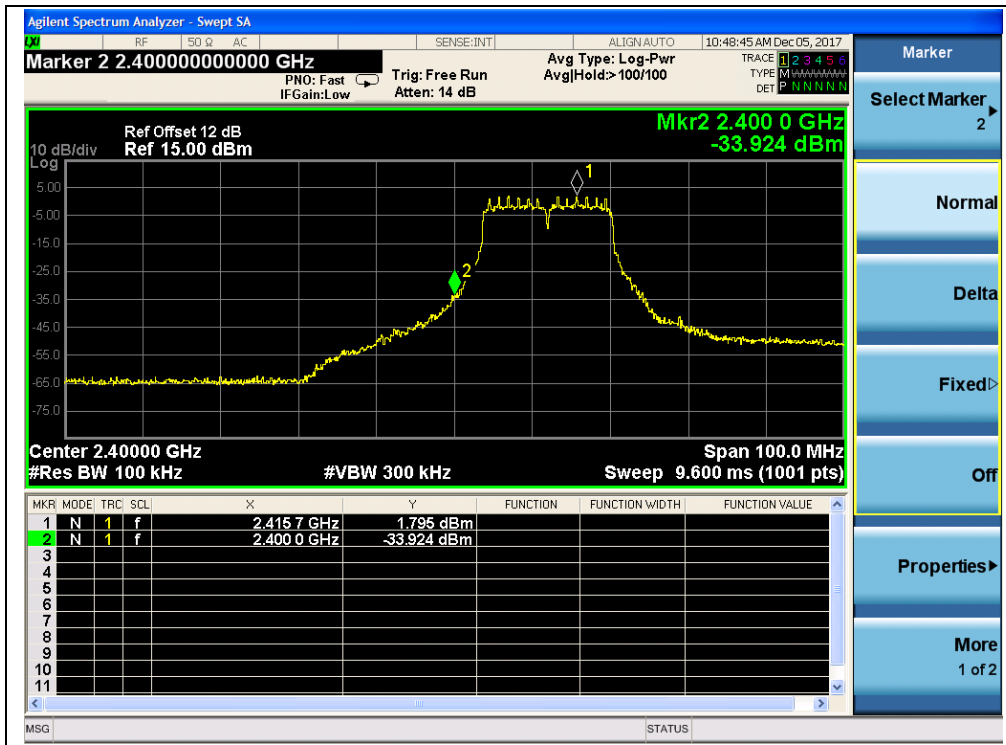
Channel	Frequency (MHz)	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
			Carrier Level	Calculated -20dBc Limit	
1	2412	-48.23	0.56	-19.44	PASS
6	2437	-50.74	1.14	-18.86	PASS
11	2462	-51.04	-1.37	-21.37	PASS

B. Test Plots:

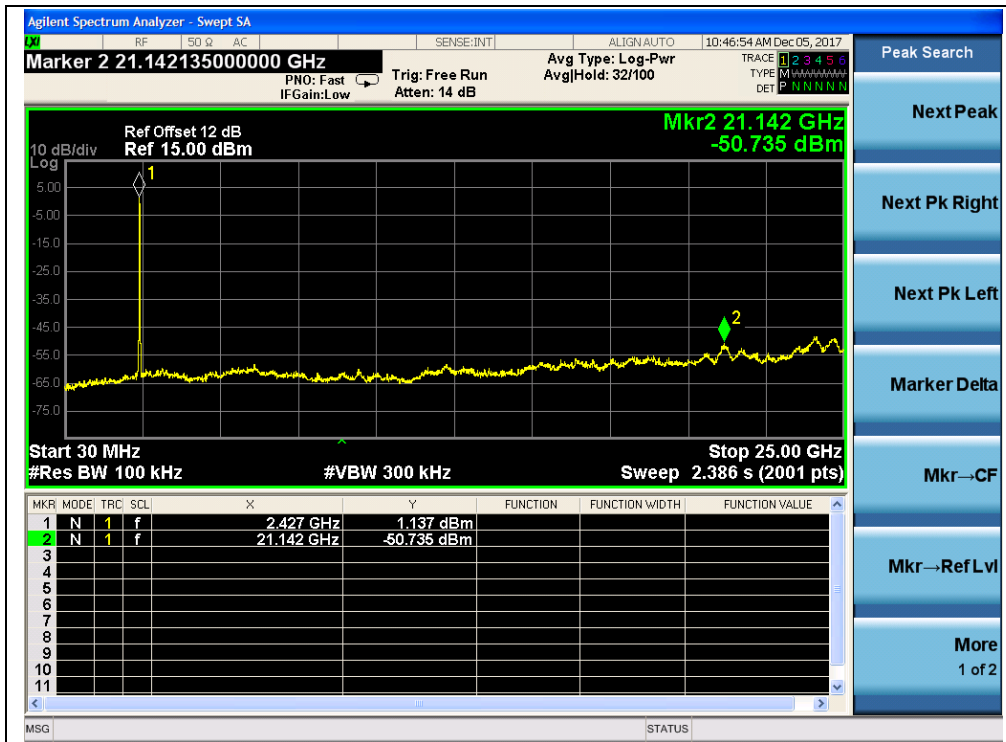
Note: the power of the Module transmitting frequency should be ignored.



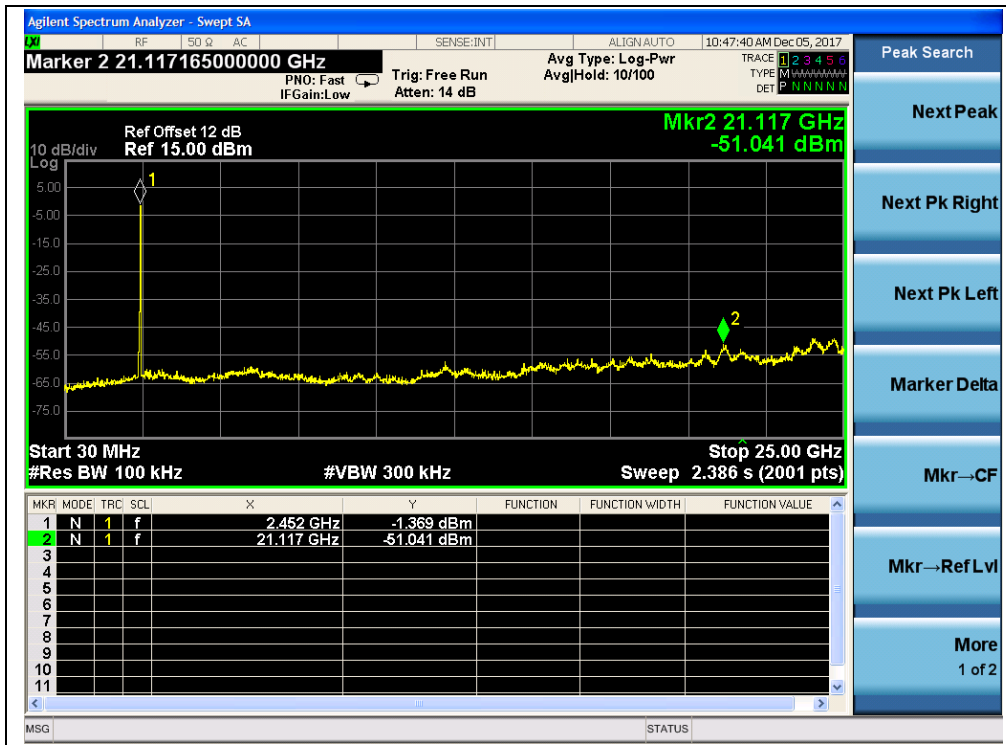
(Channel = 1, 30MHz to 25GHz)



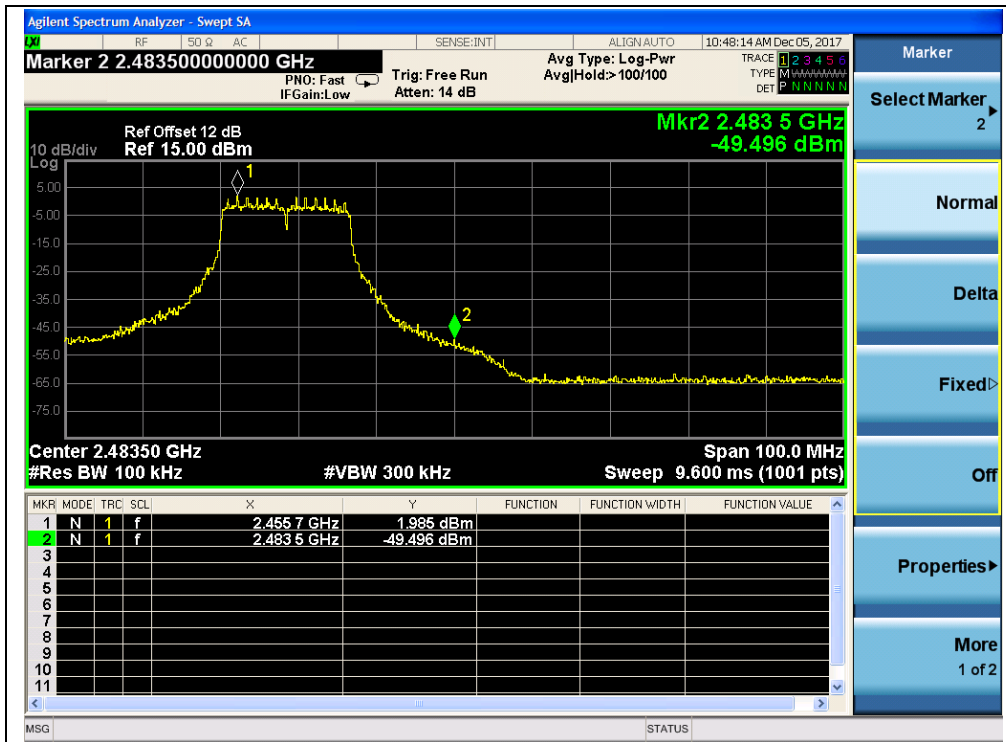
(Band Edge @ Channel = 1)



(Channel = 6, 30MHz to 25GHz)



(Channel = 11, 30MHz to 25GHz)



(Band Edge @ Channel = 11)



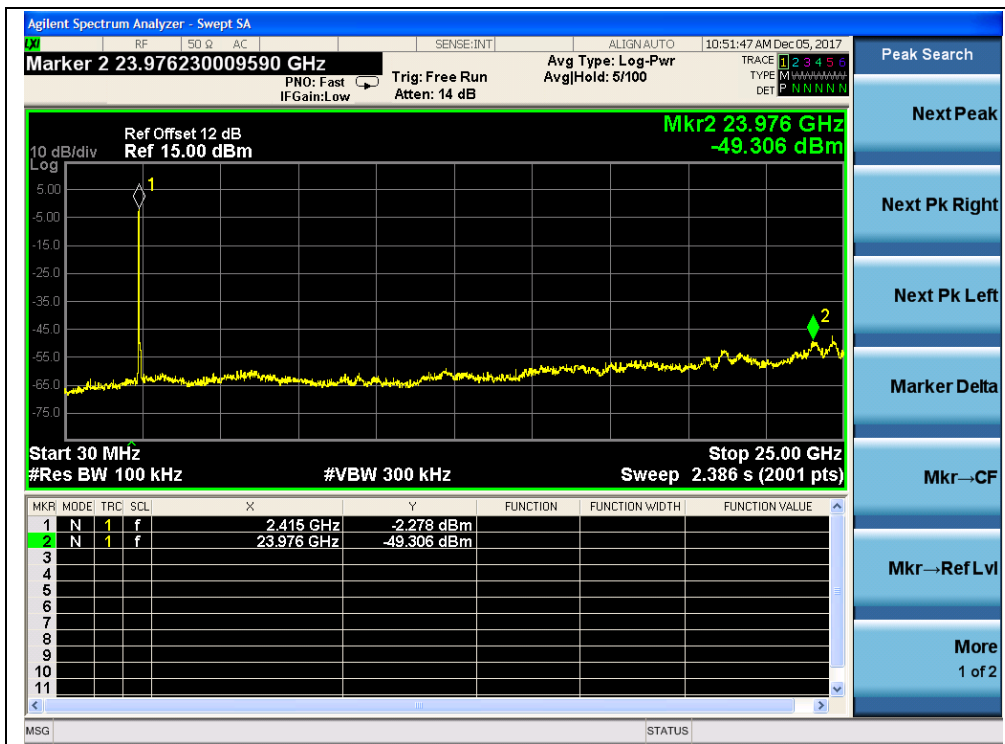
2.4.3.3 802.11n -20MHz Test mode

A. Test Verdict:

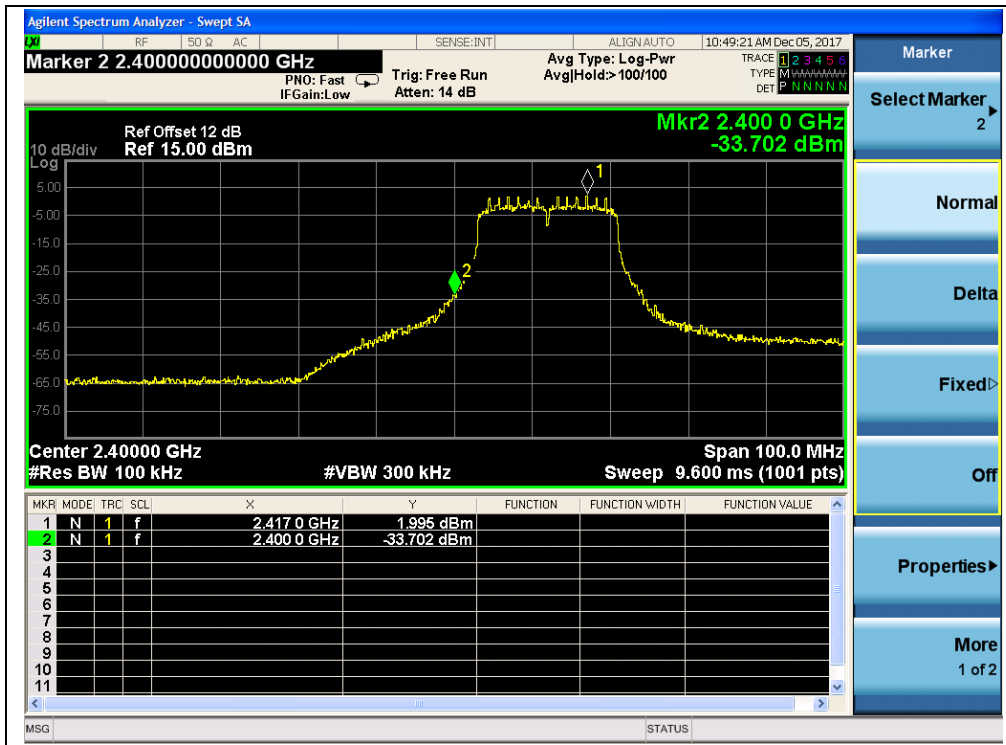
Channel	Frequency (MHz)	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
			Carrier Level	Calculated -20dBc Limit	
1	2412	-49.31	-2.28	-22.28	PASS
6	2437	-48.74	0.56	-19.44	PASS
11	2462	-48.38	1.09	-18.91	PASS

B. Test Plots:

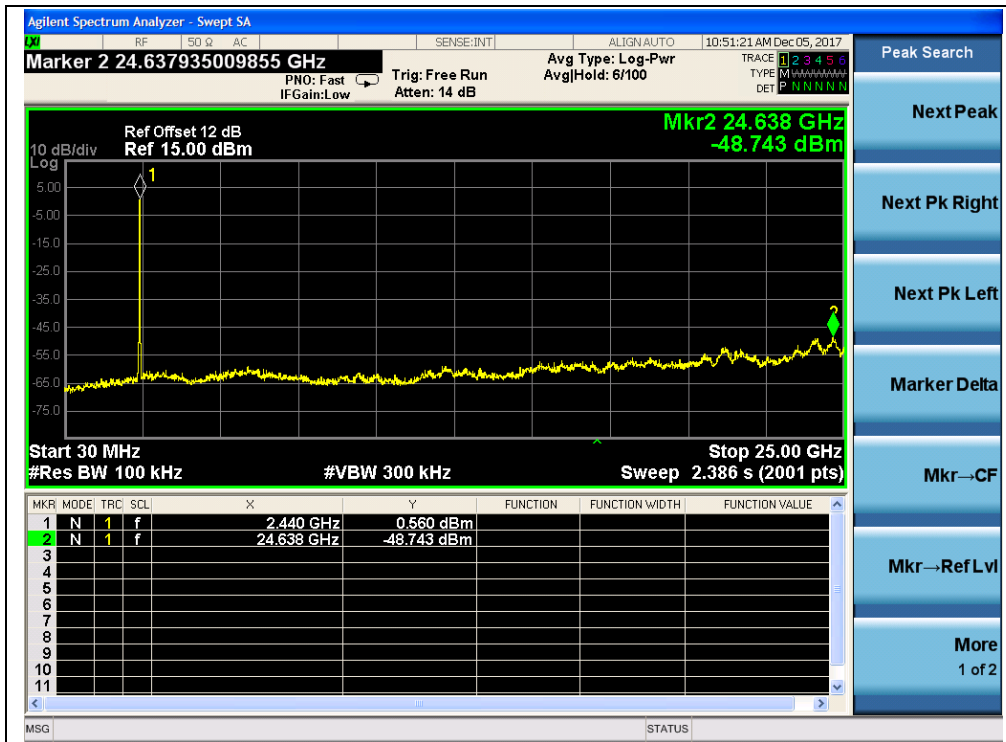
Note: the power of the Module transmitting frequency should be ignored.



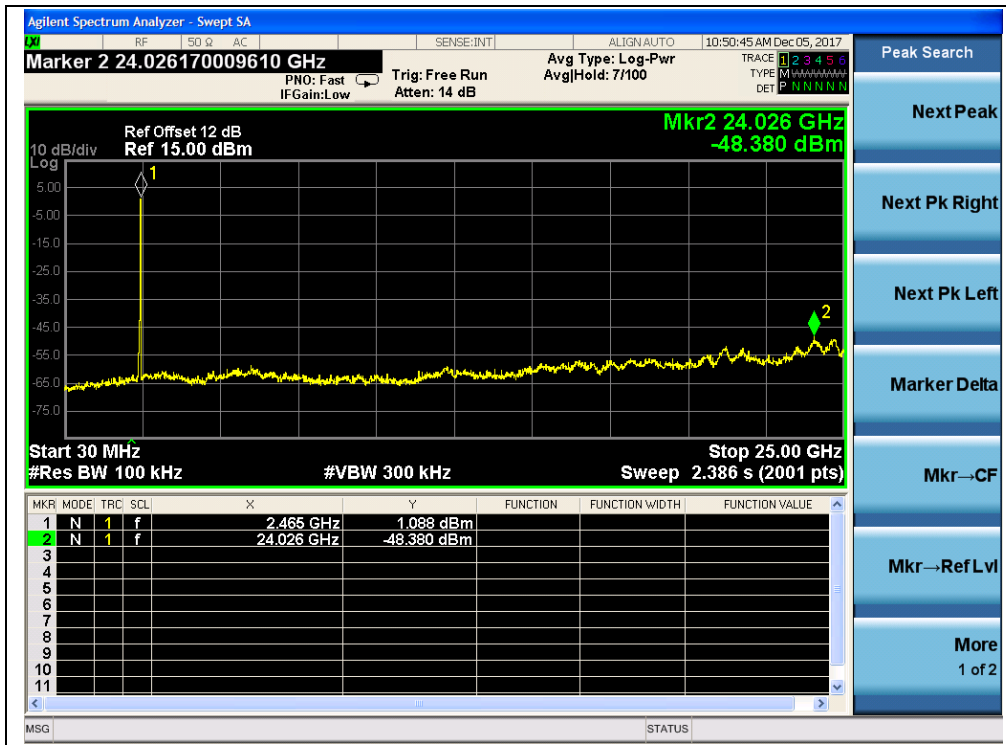
(Channel = 1, 30MHz to 25GHz)



(Band Edge @ Channel = 1)



(Channel = 6, 30MHz to 25GHz)



(Channel = 11, 30MHz to 25GHz)



(Band Edge @ Channel = 11)



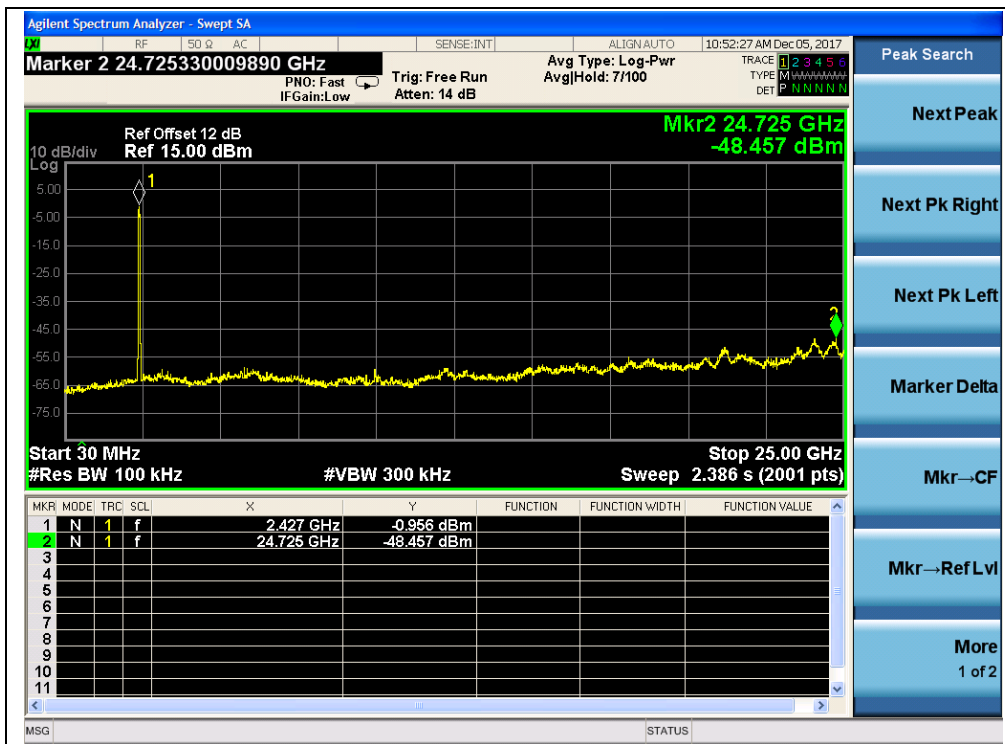
2.4.3.4 802.11n -40MHz Test mode

A. Test Verdict:

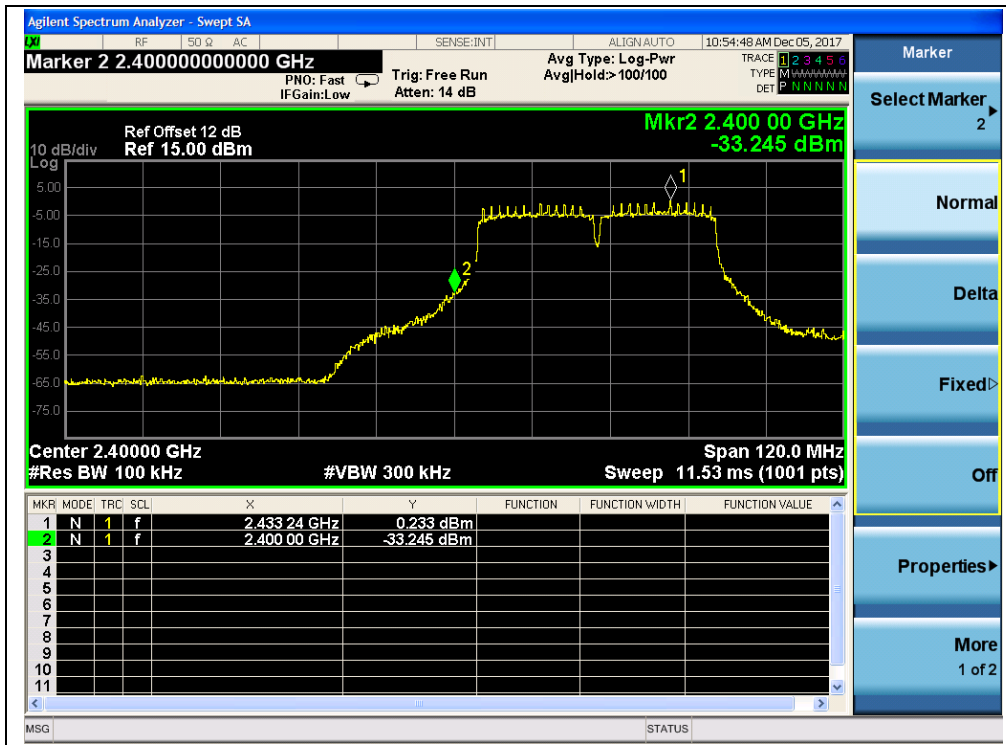
Channel	Frequency (MHz)	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
			Carrier Level	Calculated -20dBc Limit	
3	2422	-48.46	-0.96	-20.96	PASS
6	2437	-48.58	-3.68	-23.68	PASS
9	2452	-48.33	-1.09	-21.09	PASS

B. Test Plots:

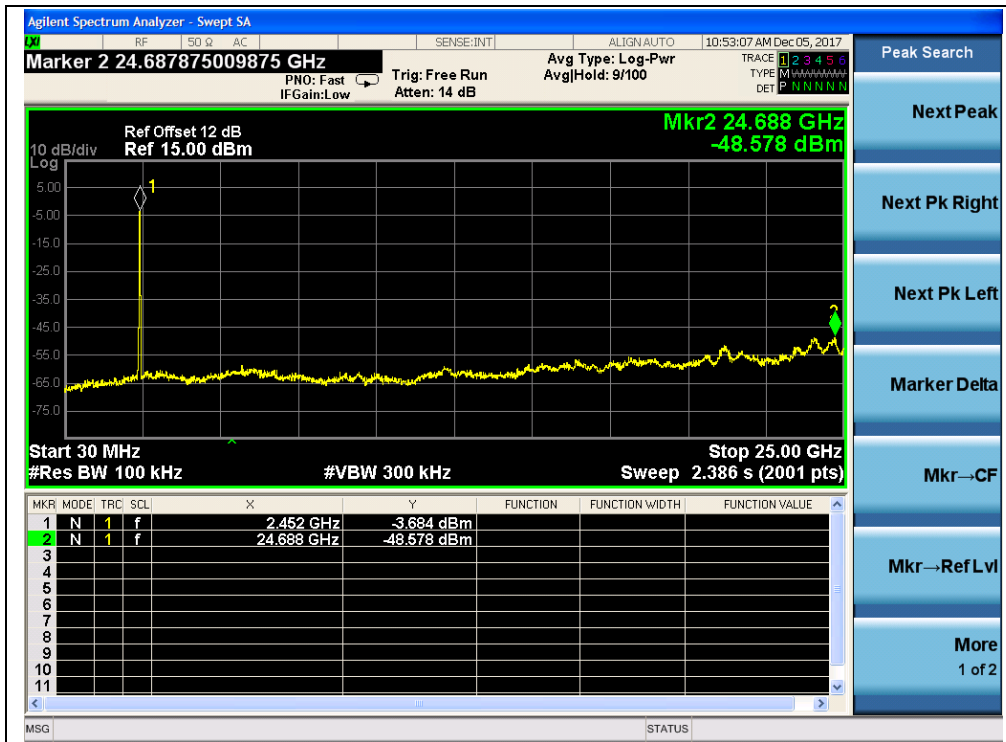
Note: the power of the Module transmitting frequency should be ignored.



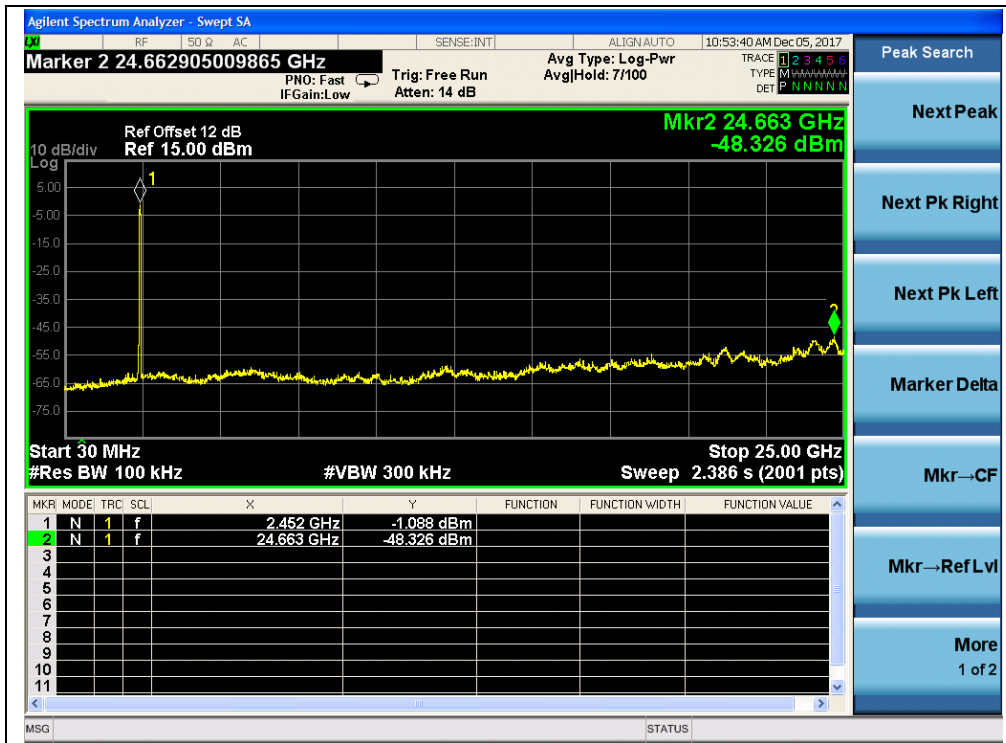
(Channel = 3, 30MHz to 25GHz)



(Band Edge @ Channel = 3)



(Channel = 6, 30MHz to 25GHz)



(Channel = 9, 30MHz to 25GHz)



(Band Edge @ Channel = 9)

2.5. Power spectral density (PSD)

2.5.1. Requirement

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

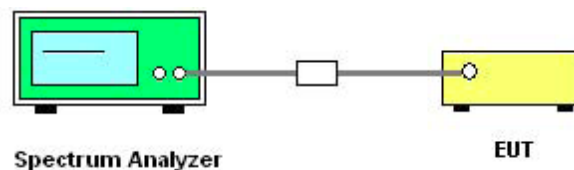
2.5.2. Test Description

A. Test procedure

The measured power spectral density was calculated by the reading of the spectrum analyzer and calibration. Following is the test procedure for PSD test:

- a) Set analyzer center frequency to channel center frequency.
- b) Set the span to 1.5 times DTS bandwidth
- c) Set the RBW to 3 kHz
- d) Set the VBW to 10 kHz
- e) Detector = peak.
- f) Sweep time = auto couple.
- g) Trace mode = max hold.
- h) Allow trace to fully stabilize.
- i) Use the peak marker function to determine the maximum amplitude level within the RBW.

B. Test Set:



The EUT is coupled to the Spectrum Analyzer; the RF load attached to the EUT antenna terminal is 50Ohm; the path loss as the factor is calibrated to correct the reading.

KDB 558074 Section 10.2 was used in order to prove compliance.

C. Equipments List:

Please reference ANNEX A(1.5).



2.5.3. Test Result

2.5.3.1 802.11b Test mode

A. Test Verdict:

Channel	Frequency (MHz)	ANT0 Measured PSD (dBm/3kHz)	ANT1 Measured PSD (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
1	2412	-8.69	-9.27	8	PASS
6	2437	-9.30	-8.28	8	PASS
11	2462	-9.85	-10.61	8	PASS

B. Test Plots:



(Channel = 1 @ 802.11b, ANT0)



(Channel = 6 @ 802.11b, ANT0)



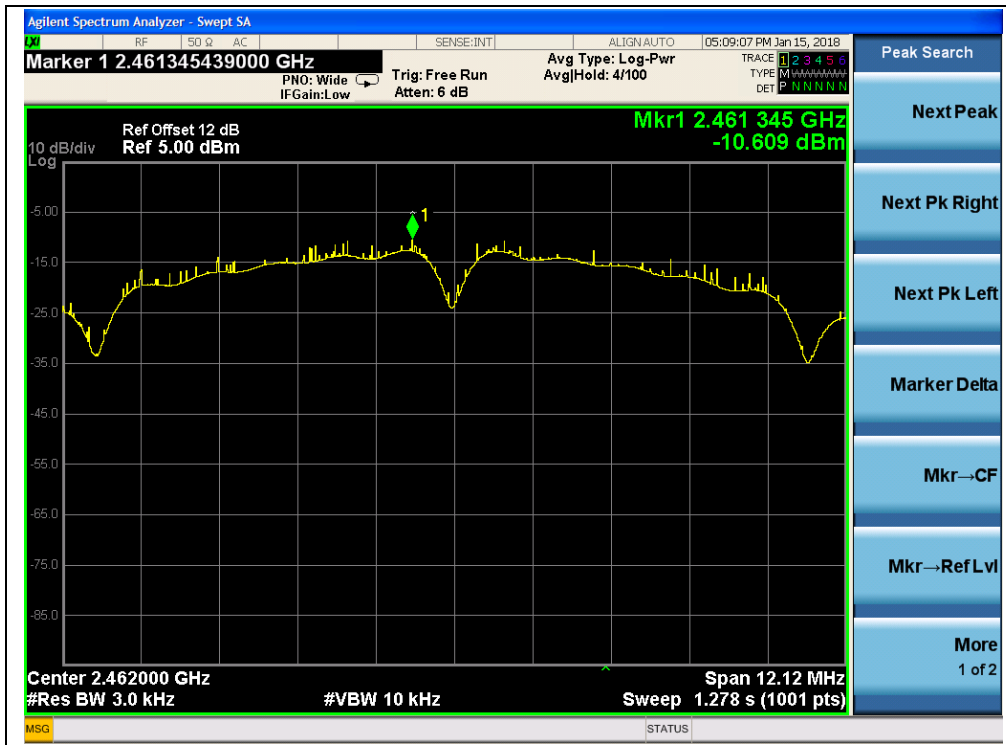
(Channel = 11 @ 802.11b, ANT0)



(Channel = 1 @ 802.11b, ANT1)



(Channel = 6 @ 802.11b, ANT1)



(Channel = 11 @ 802.11b, ANT1)

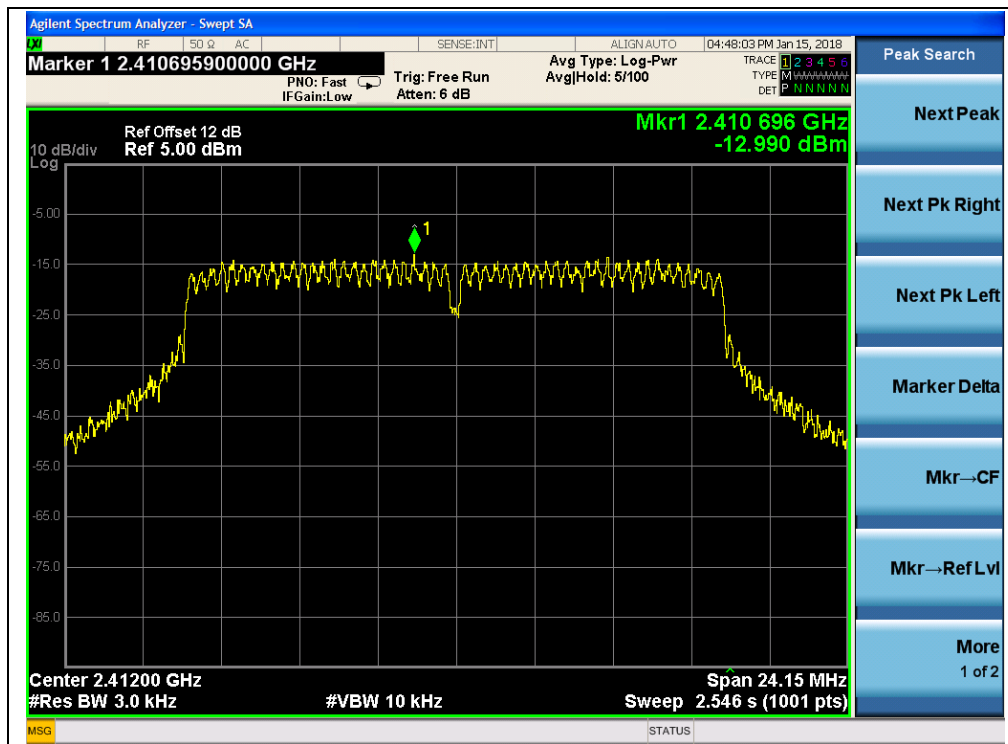


2.5.3.2 802.11g Test mode

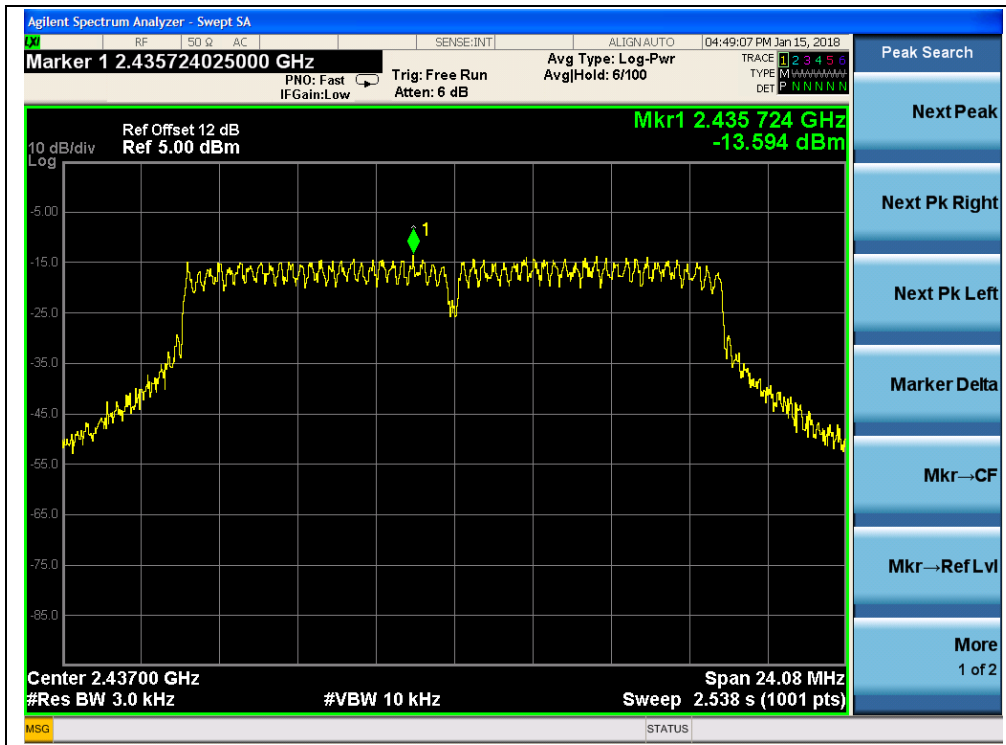
A. Test Verdict:

Channel	Frequency (MHz)	ANT0 Measured PSD (dBm/3kHz)	ANT1 Measured PSD (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
1	2412	-12.99	-13.76	8	PASS
6	2437	-13.59	-13.50	8	PASS
11	2462	-13.65	-13.45	8	PASS

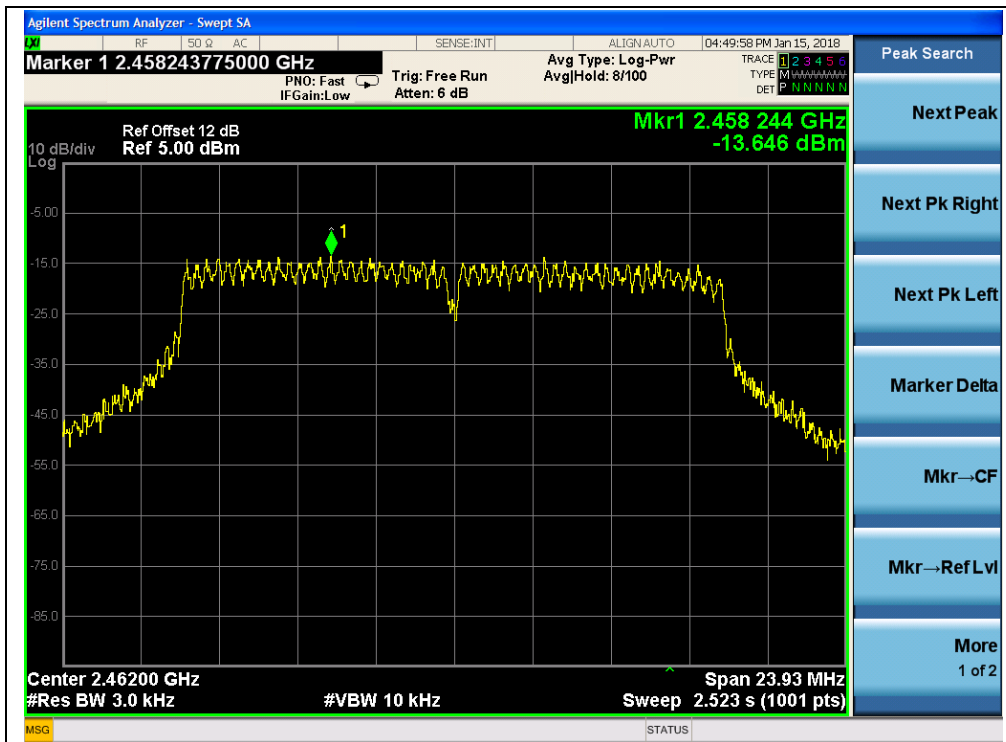
B. Test Plots:



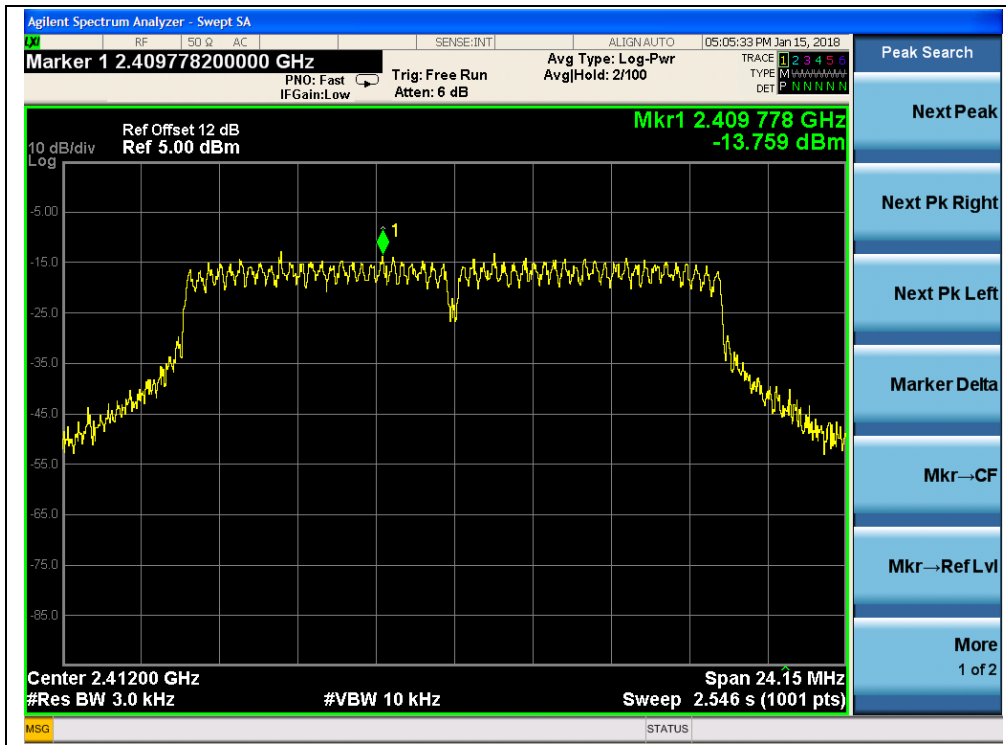
(Channel = 1 @ 802.11g, ANT0)



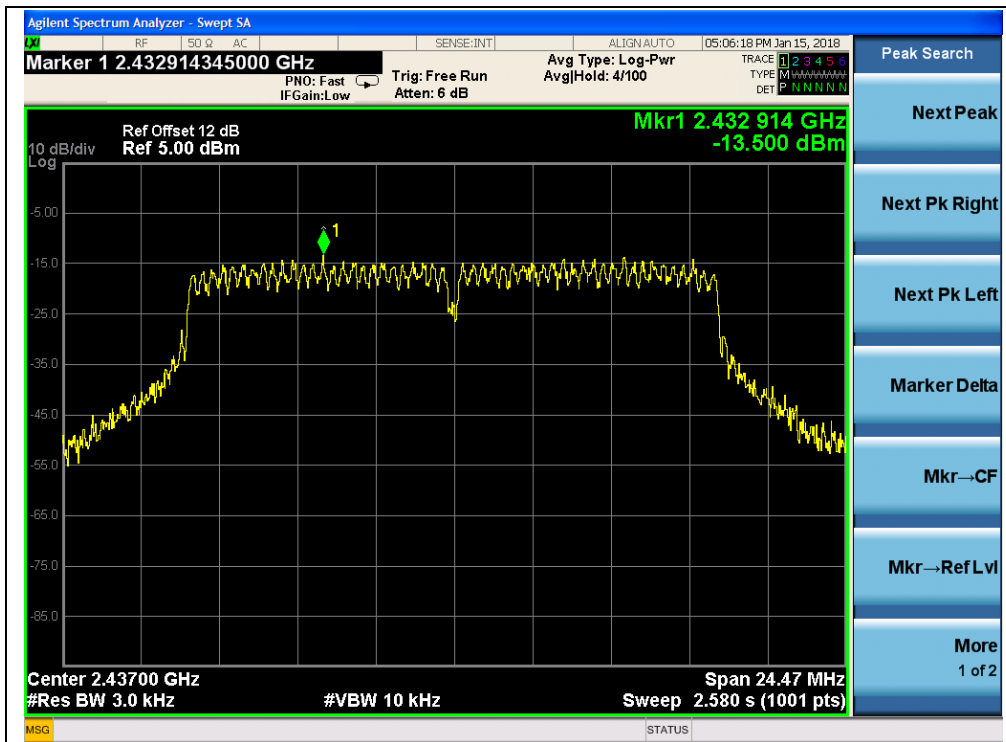
(Channel = 6 @ 802.11g, ANT0)



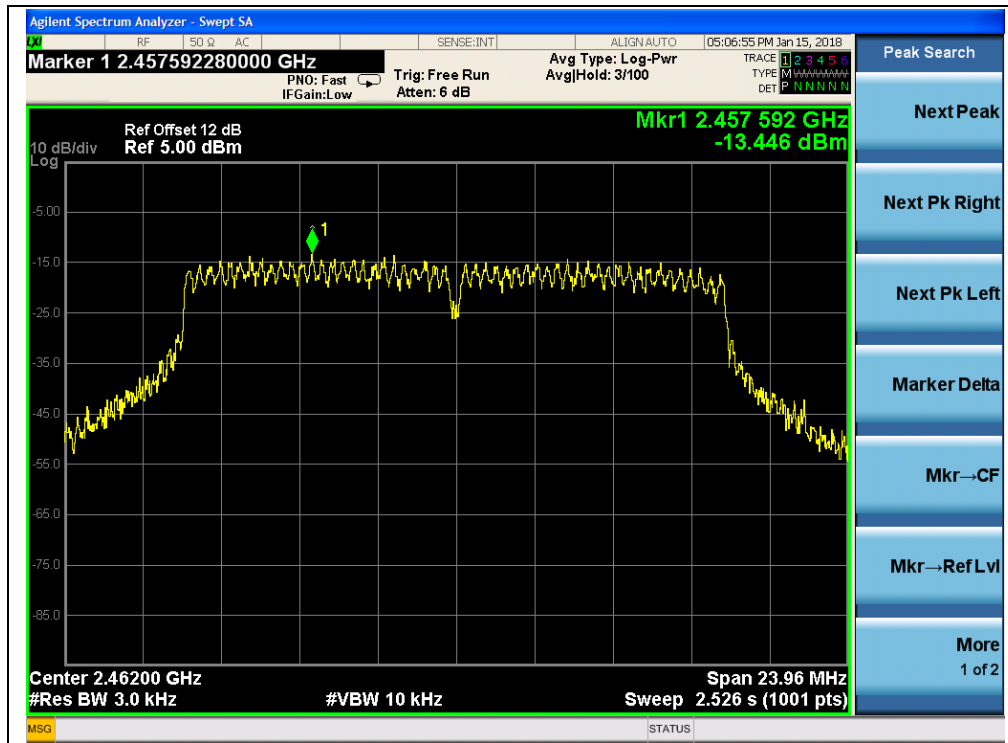
(Channel = 11 @ 802.11g, ANT0)



(Channel = 1 @ 802.11g, ANT1)



(Channel = 6 @ 802.11g, ANT1)



(Channel = 11 @ 802.11g, ANT1)



2.5.3.3 802.11n-20MHz Test mode

A. Test Verdict:

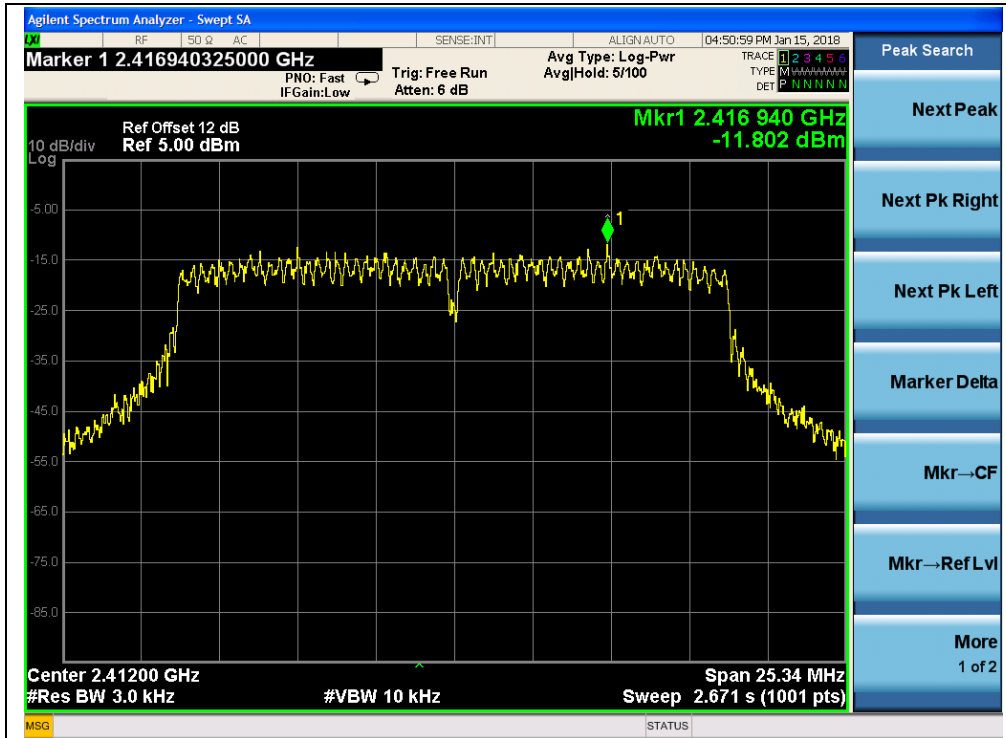
Channel	Frequency (MHz)	ANT0 Measured PSD (dBm/3kHz)	ANT1 Measured PSD (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
1	2412	-11.80	-13.17	8	PASS
6	2437	-13.40	-13.20	8	PASS
11	2462	-11.97	-13.79	8	PASS

Total Power spectral density (ANT0+ANT1)

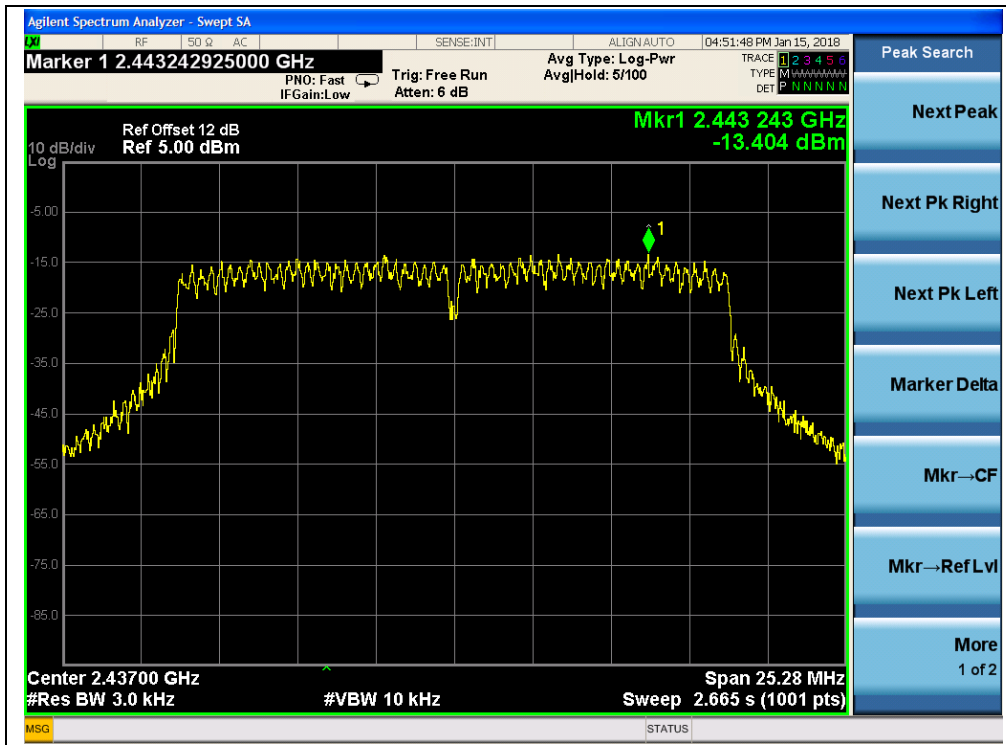
Channel	Frequency (MHz)	Total PSD (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
1	2412	-9.42	6.99	PASS
6	2437	-10.29	6.99	PASS
11	2462	-9.78	6.99	PASS

Note: Directional gain = 4.0dBi + 10log(2) = 7.01dBi > 6dBi, so the power limit shall be reduced to 8-(7.01-6) = 6.99dBm.

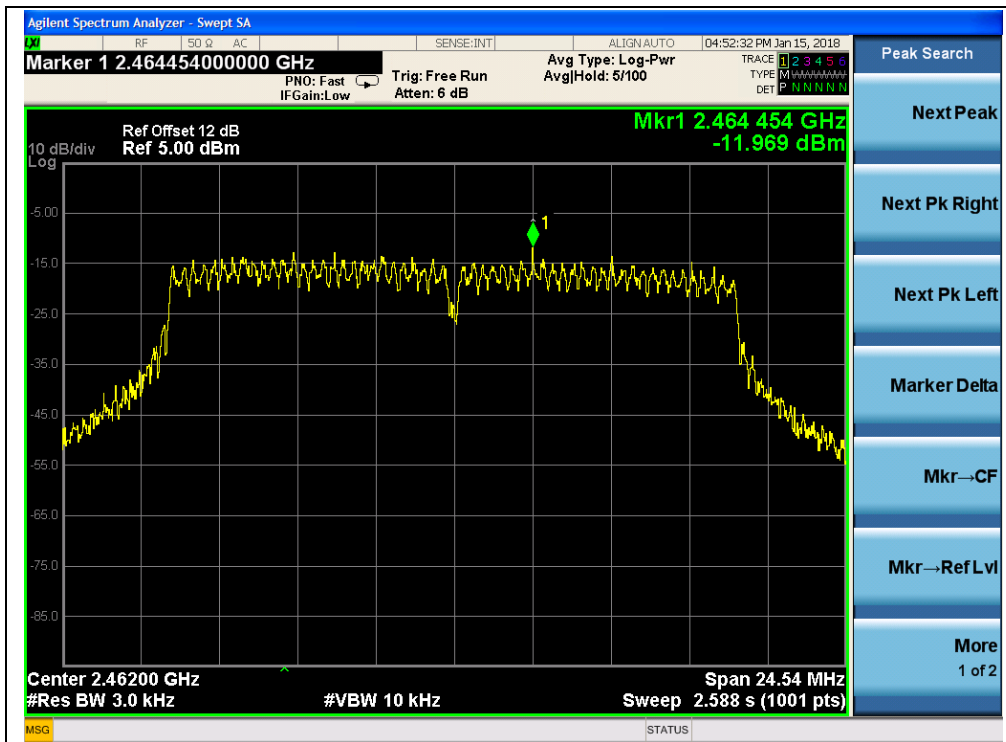
B. Test Plots:



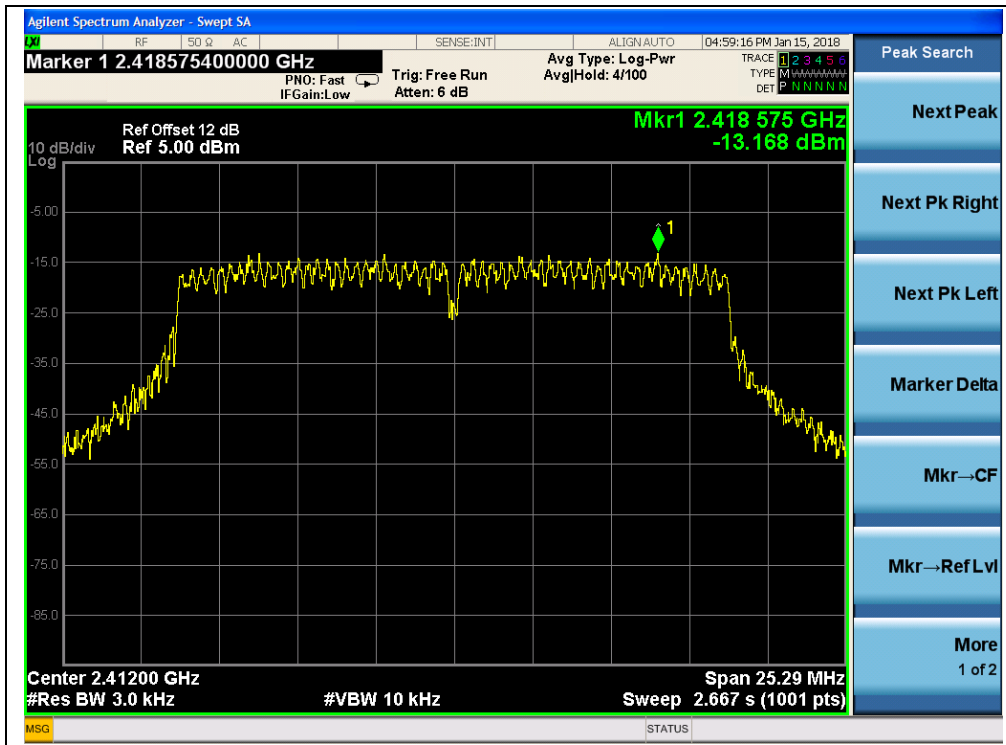
(Channel = 1 @ 802.11n-20MHz, ANT0)



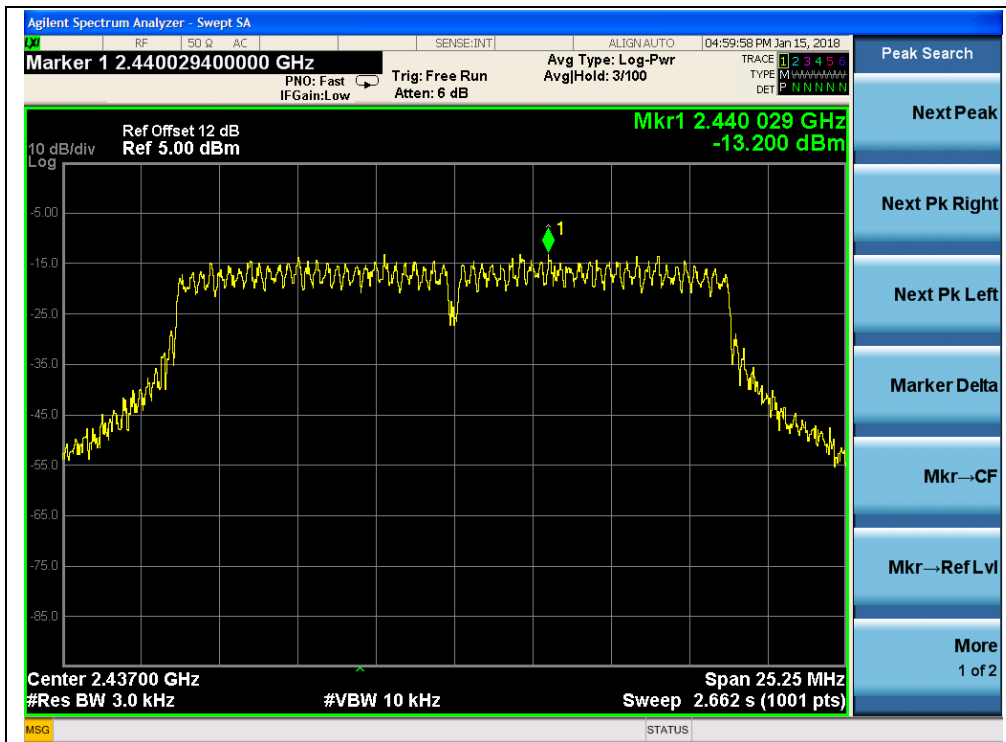
(Channel = 6 @ 802.11n-20MHz, ANT0)



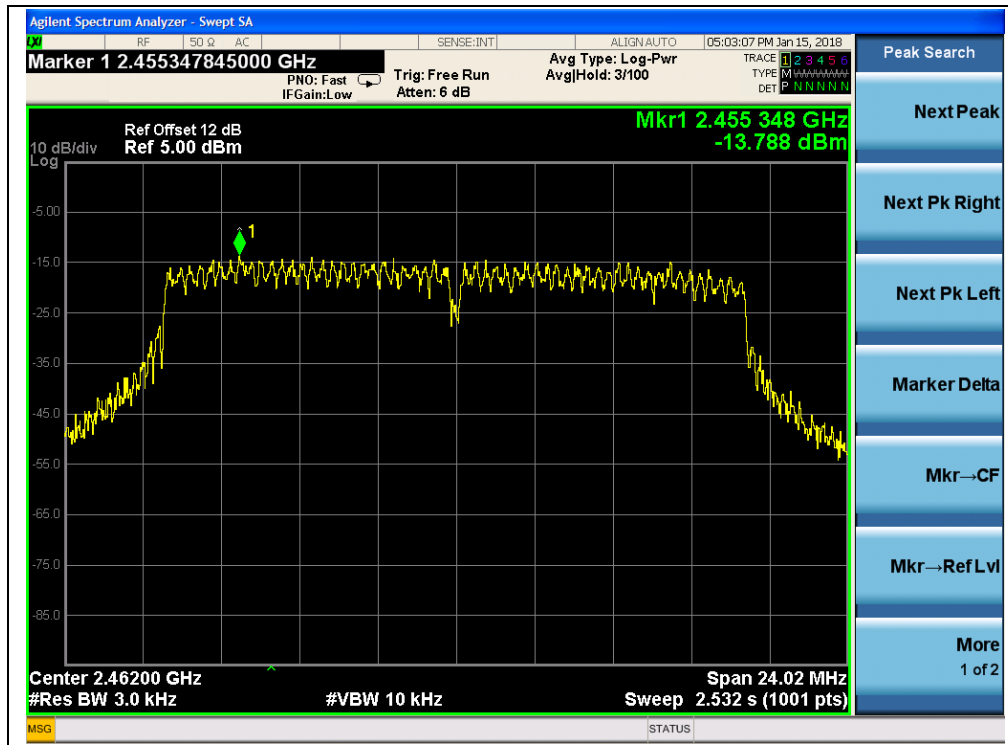
(Channel = 11 @ 802.11n-20MHz, ANT0)



(Channel = 1 @ 802.11n-20MHz, ANT1)



(Channel = 6 @ 802.11n-20MHz, ANT1)



(Channel = 11 @ 802.11n-20MHz, ANT1)



2.5.3.4 802.11n-40MHz Test mode

A. Test Verdict:

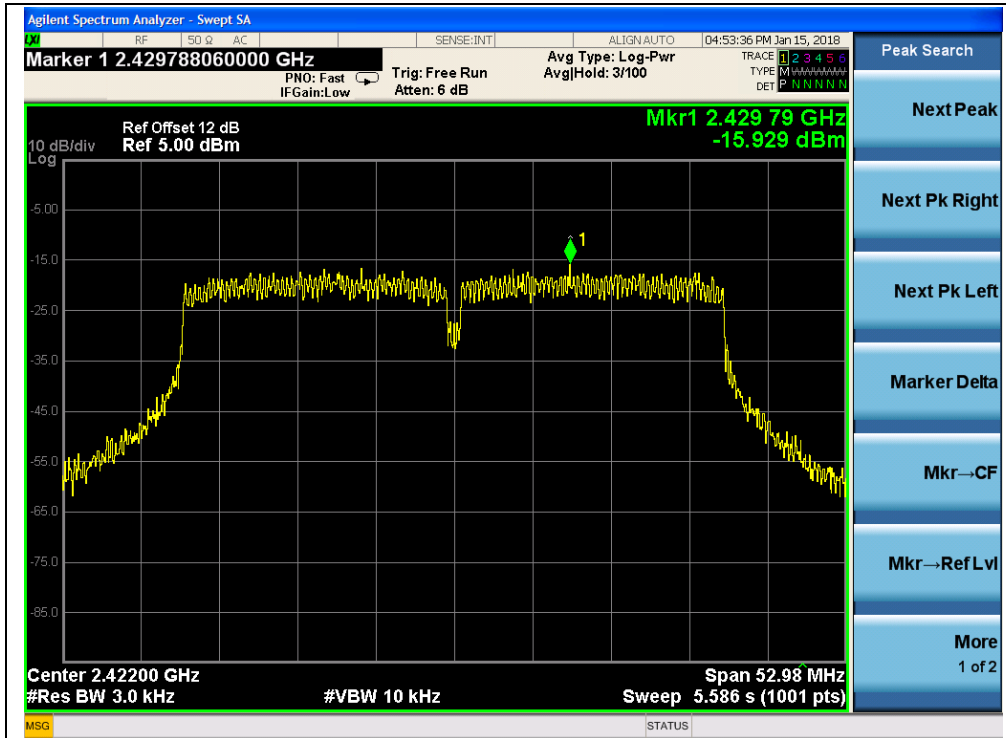
Channel	Frequency (MHz)	ANT0 Measured PSD (dBm/3kHz)	ANT1 Measured PSD (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
3	2422	-15.93	-14.80	8	PASS
6	2437	-15.17	-15.85	8	PASS
9	2452	-15.79	-16.47	8	PASS

Total Power spectral density (ANT0+ANT1)

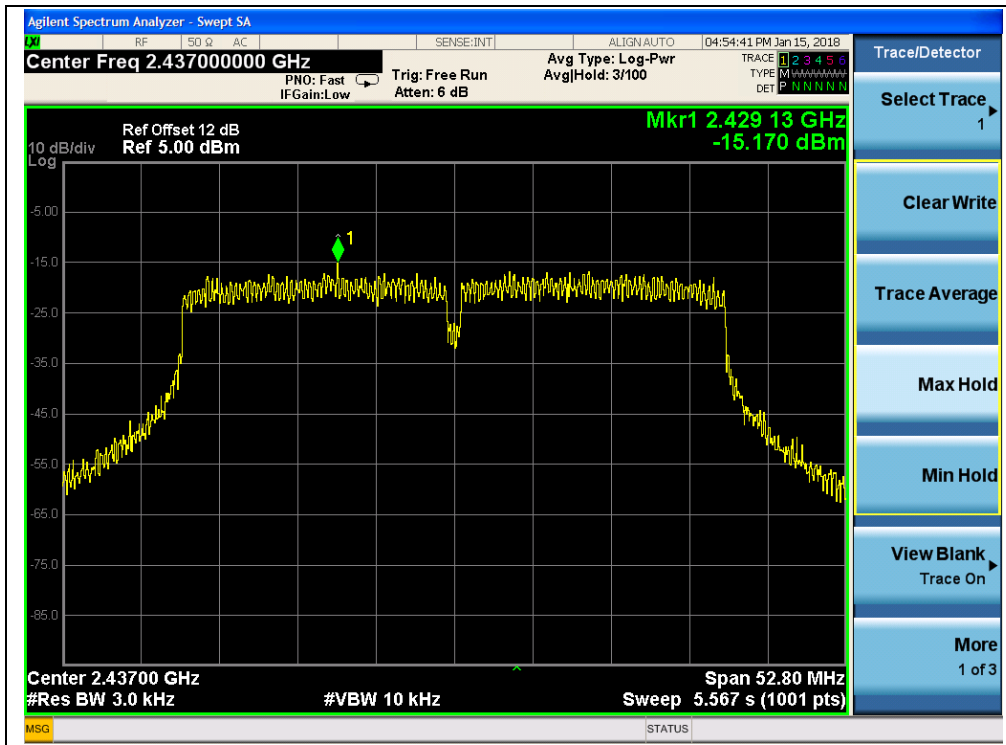
Channel	Frequency (MHz)	Total PSD (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
3	2422	-12.32	6.99	PASS
6	2437	-12.49	6.99	PASS
9	2452	-13.11	6.99	PASS

Note: Directional gain = 4.0dBi + 10log(2) = 7.01dBi > 6dBi, so the power limit shall be reduced to 8-(7.01-6) = 6.99dBm.

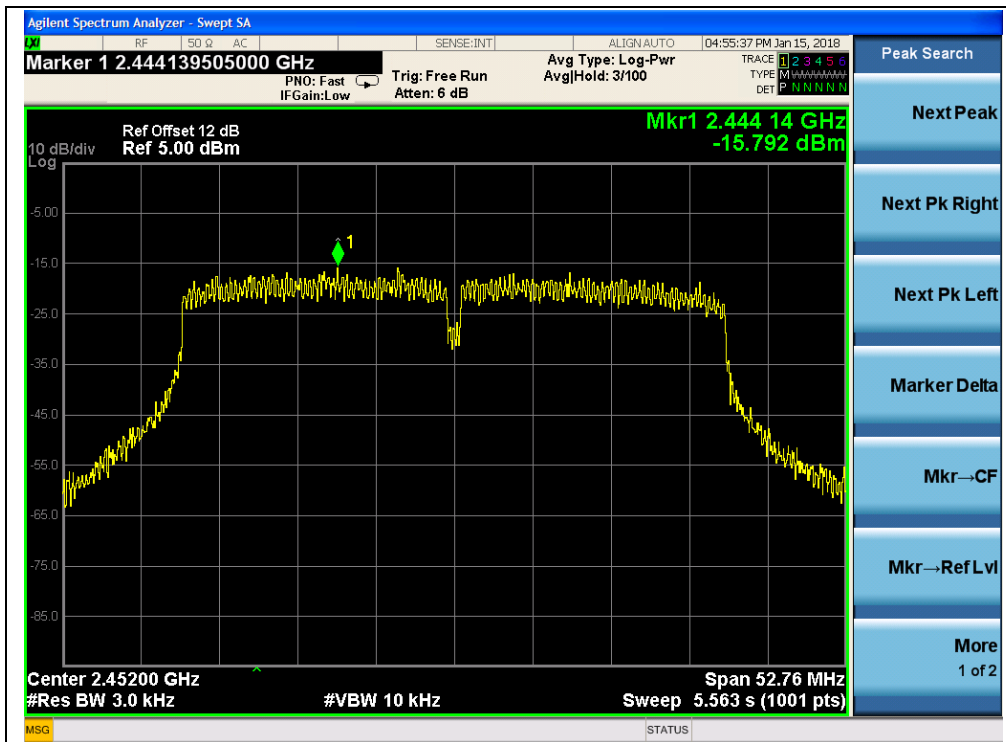
B. Test Plots:



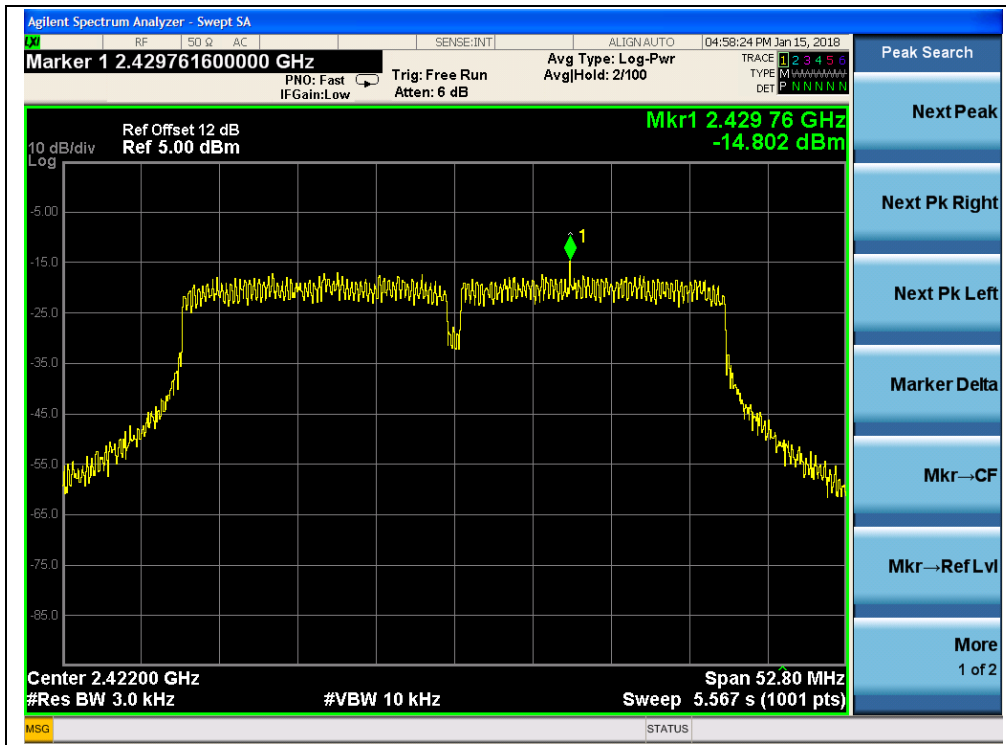
(Channel = 3 @ 802.11n-40MHz, ANT0)



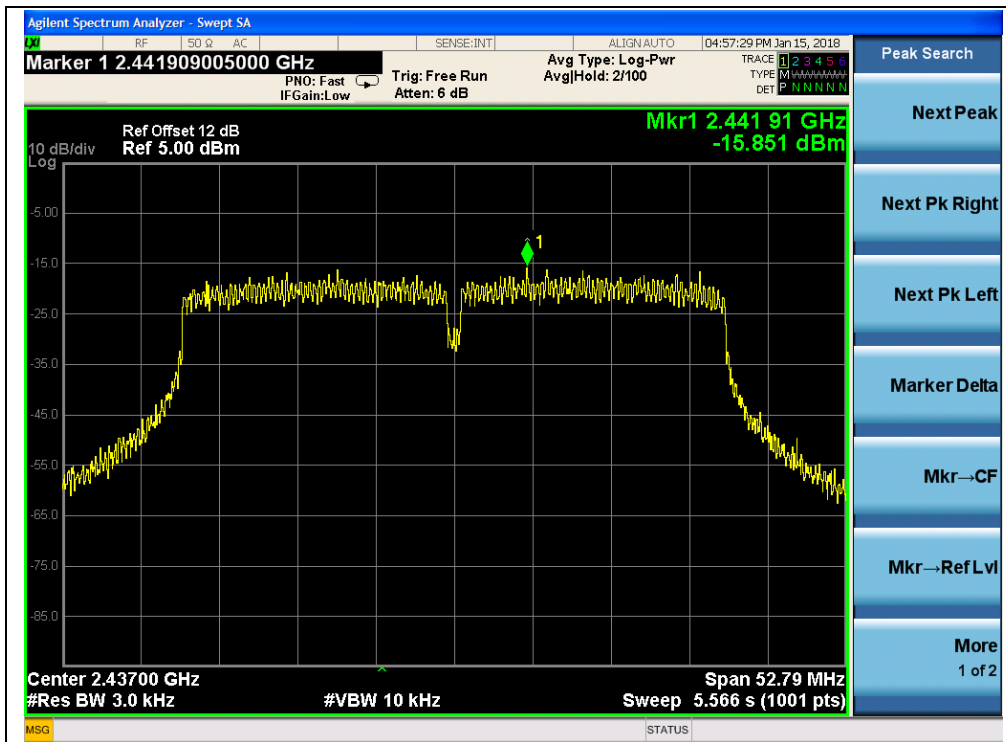
(Channel = 6 @ 802.11n-40MHz, ANT0)



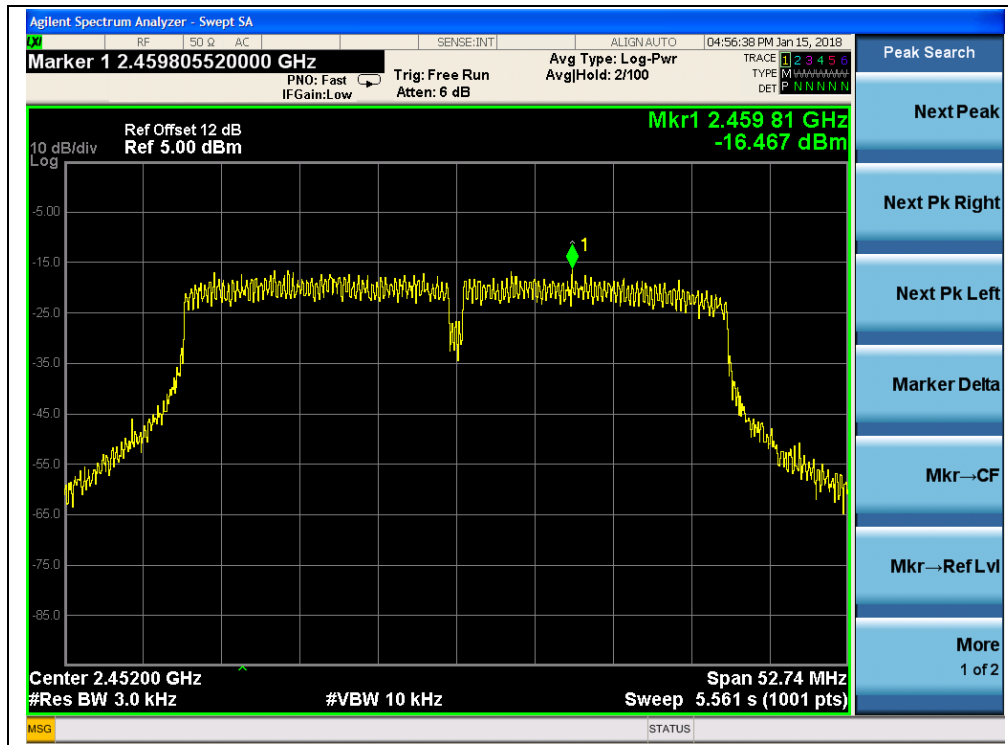
(Channel = 9 @ 802.11n-40MHz, ANT0)



(Channel = 3 @ 802.11n-40MHz, ANT1)



(Channel = 6 @ 802.11n-40MHz, ANT1)



(Channel = 9 @ 802.11n-40MHz, ANT1)

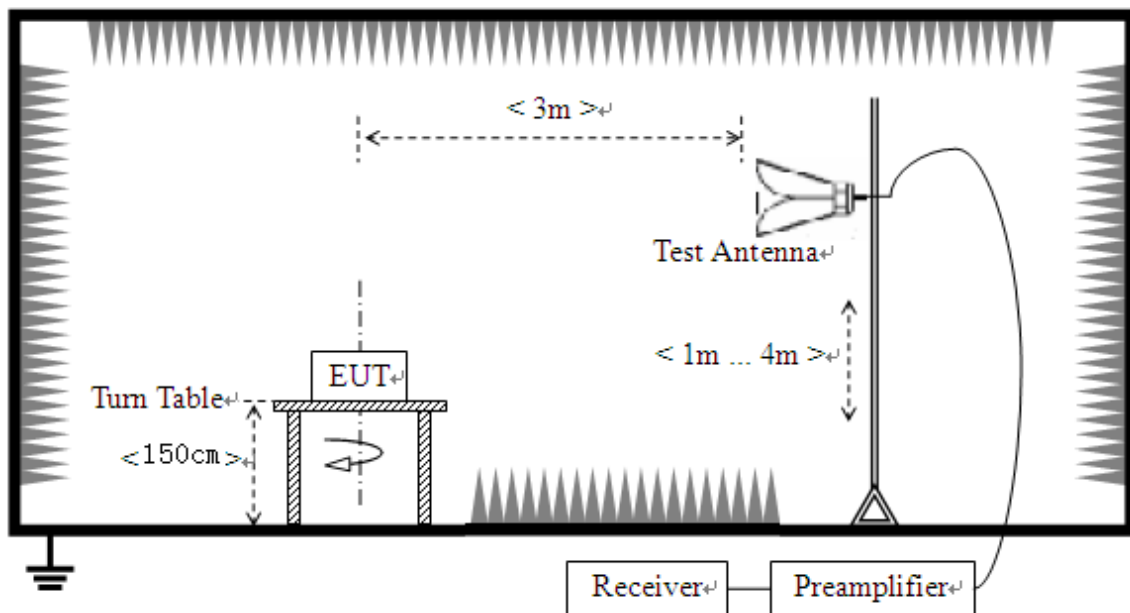
2.6. Restricted Frequency Bands

2.6.1. Requirement

According to FCC section 15.247(d), in any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power. In addition, radiated emissions which fall in the restricted bands, as defined in 15.205(a), must also comply with the radiated emission limits specified in 15.209(a).

2.6.2. Test Description

A. Test Setup



The EUT is located in a 3m Semi-Anechoic Chamber; the antenna factors, cable loss and so on of the site as factors are calculated to correct the reading.

For the Test Antenna:

Test Antenna is 3m away from the EUT. Test Antenna height is varied from 1m to 4m above the ground to determine the maximum value of the field strength.

KDB 558074 Section 12.1 was used in order to prove compliance.

**B. Equipments List:**

Please reference ANNEX A(1.5).

2.6.3. Test Result

The lowest and highest channels are tested to verify Restricted Frequency Bands.

The measurement results are obtained as below:

$$E \text{ [dB}\mu\text{V/m]} = U_R + A_T + A_{\text{Factor}} \text{ [dB]}; A_T = L_{\text{Cable loss}} \text{ [dB]} - G_{\text{preamp}} \text{ [dB]}$$

 A_T : Total correction Factor except Antenna U_R : Receiver Reading G_{preamp} : Preamplifier Gain A_{Factor} : Antenna Factor at 3m

Note: Restricted Frequency Bands were performed when antenna was at vertical and horizontal polarity, and only the worse test condition (vertical) was recorded in this test report.

2.6.3.1 802.11b Test mode

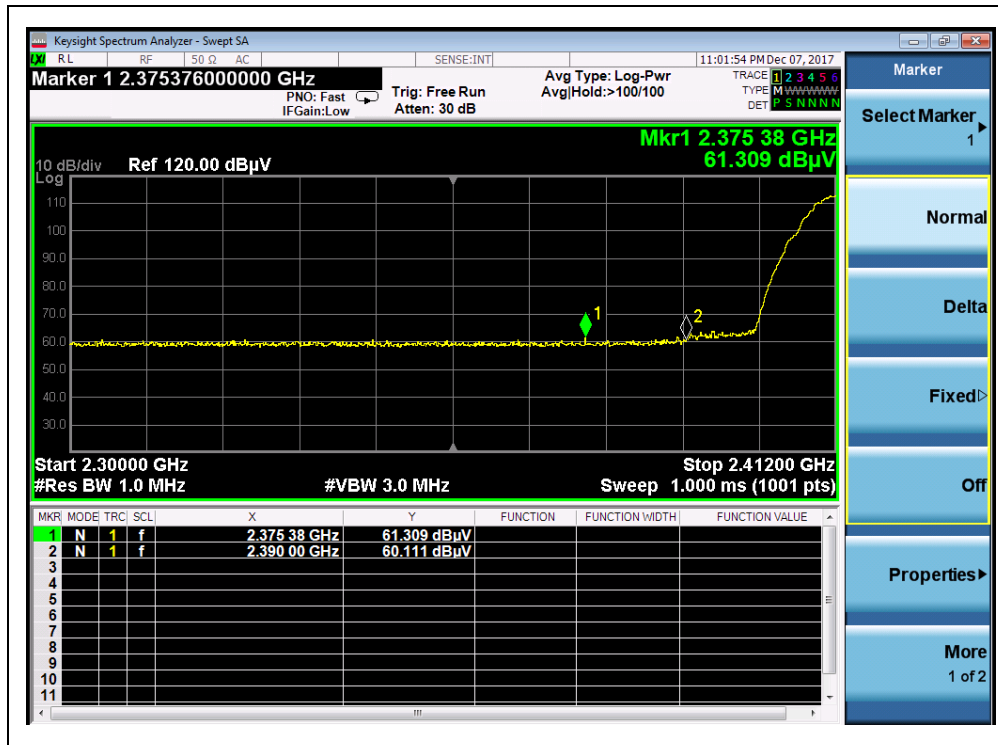
The lowest and highest channels are tested to verify the band edge emissions.

A. Test Verdict:

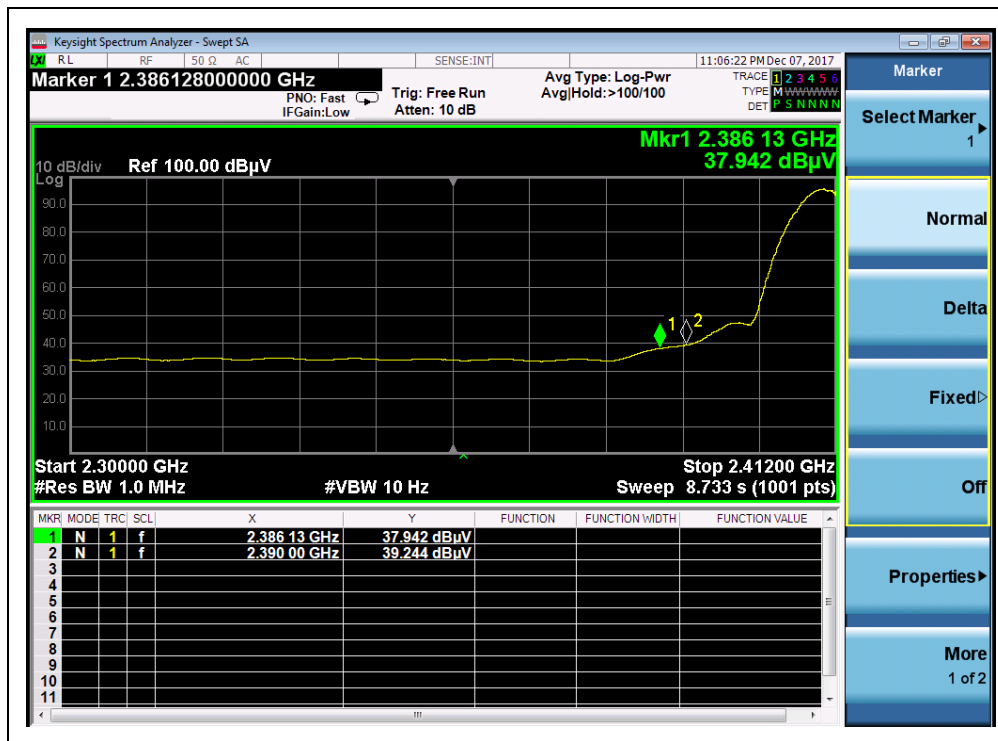
Channel	Frequency (MHz)	Detector	Receiver Reading U_R (dBuV)	A_T (dB)	A_{Factor} (dB@3m)	Max. Emission E (dB μ V/m)	Limit (dB μ V/m)	Verdict
		PK/ AV						
1	2375.38	PK	61.31	-32.81	40.30	68.80	74	Pass
1	2386.13	AV	37.94	-32.81	40.30	45.43	54	Pass
11	2484.18	PK	57.74	-32.81	40.30	65.23	74	Pass
11	2484.18	AV	38.18	-32.81	40.30	45.67	54	Pass



B. Test Plots:



(Channel = 1 PEAK @ 802.11b)



(Channel = 1 AVG @ 802.11b)



(Channel = 11 PEAK @ 802.11b)



(Channel = 11 AVG @ 802.11b)



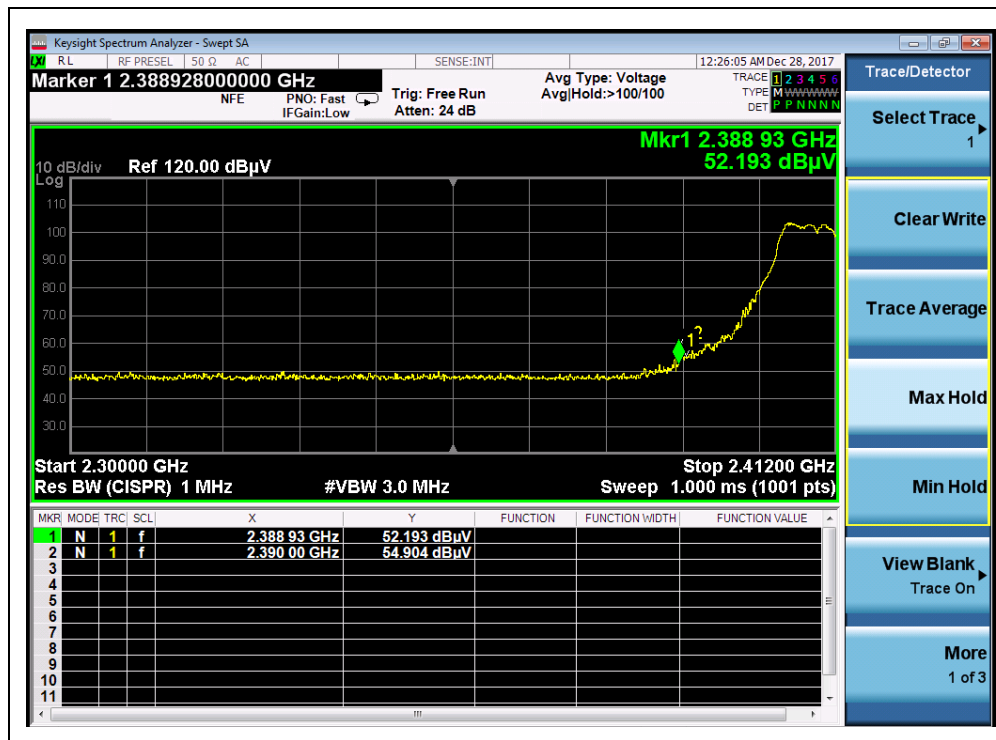
2.6.3.2 802.11g Test mode

The lowest and highest channels are tested to verify the band edge emissions.

A. Test Verdict:

Channel	Frequency (MHz)	Detector	Receiver Reading	A _T (dB)	A _{Factor} (dB@3m)	Max. Emission E (dBμV/m)	Limit (dBμV/m)	Verdict
		PK/ AV	U _R (dBuV)					
1	2388.93	PK	52.19	-32.81	40.30	59.68	74	Pass
1	2388.93	AV	37.67	-32.81	40.30	45.16	54	Pass
11	2484.18	PK	63.83	-32.81	40.30	71.32	74	Pass
11	2484.18	AV	40.65	-32.81	40.30	48.14	54	Pass

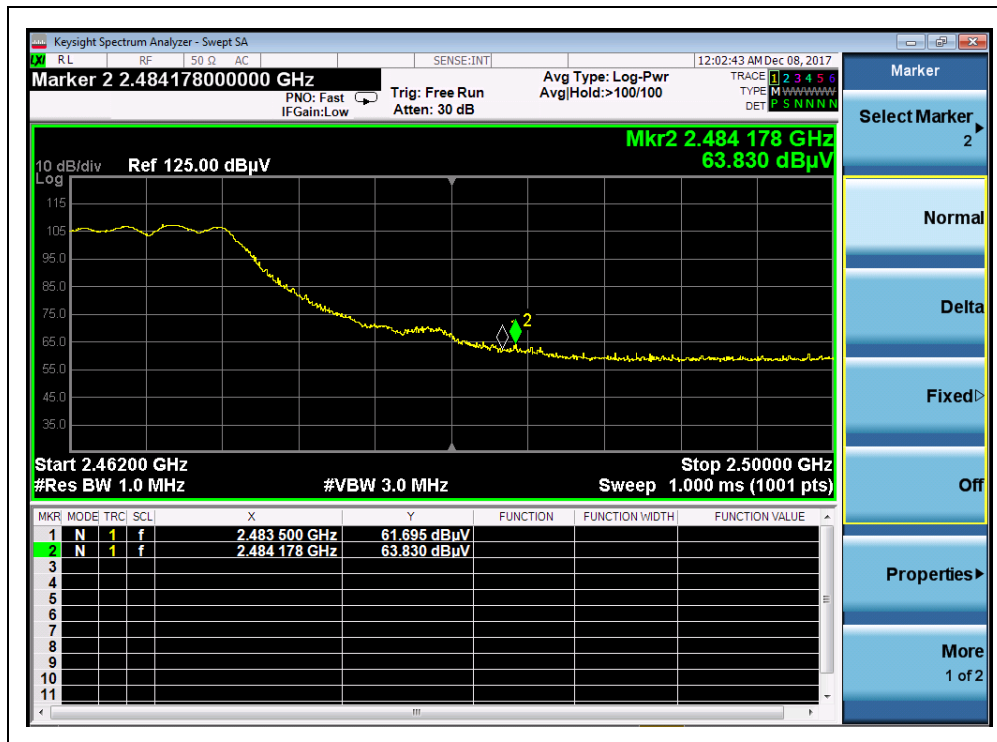
B. Test Plots:



(Channel = 1 PEAK @ 802.11g)



(Channel = 1 AVG @ 802.11g)



(Channel = 11 PEAK @ 802.11g)



(Channel = 11 AVG @ 802.11g)

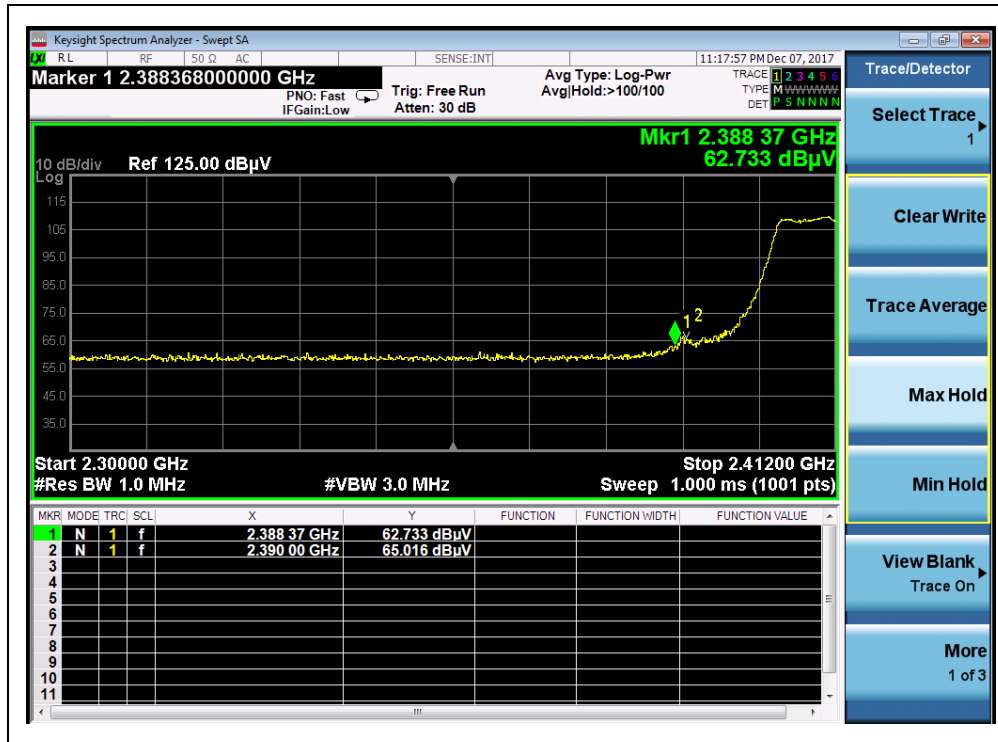
2.6.3.3 802.11n-20MHz Test mode

The lowest and highest channels are tested to verify the band edge emissions.

A. Test Verdict:

Channel	Frequency (MHz)	Detector	Receiver Reading	A_T	A_{Factor}	Max. Emission	Limit (dBμV/m)	Verdict
		PK/ AV	U_R (dBuV)	(dB)	(dB@3m)	E (dBμV/m)		
1	2388.37	PK	62.73	-32.81	40.30	70.22	74	Pass
1	2388.37	AV	44.90	-32.81	40.30	52.39	54	Pass
11	2484.71	PK	59.62	-32.81	40.30	67.11	74	Pass
11	2484.71	AV	41.58	-32.81	40.30	49.07	54	Pass

B. Test Plots:



(Channel = 1 PEAK @ 802.11n-20)



(Channel = 1 AVG @ 802.11n-20)



(Channel = 11 PEAK @ 802.11n-20)



(Channel = 11 AVG @ 802.11n-20)

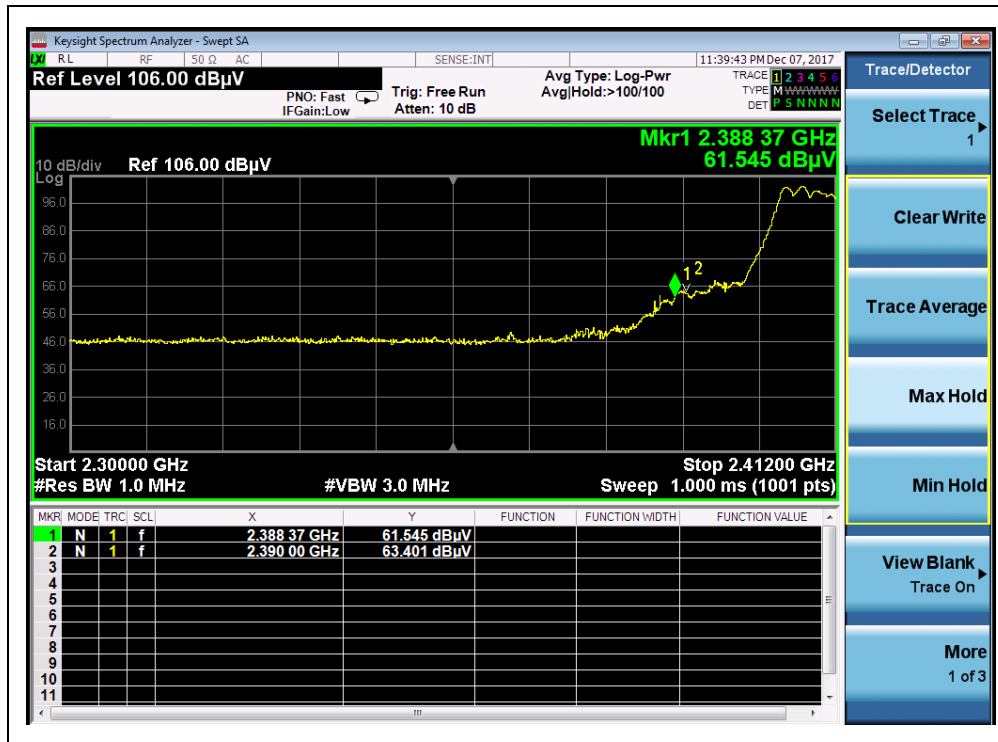
2.6.3.4 802.11n-40MHz Test mode

The lowest and highest channels are tested to verify the band edge emissions.

A. Test Verdict:

Channel	Frequency (MHz)	Detector	Receiver Reading	A _T (dB)	A _{Factor} (dB@3m)	Max. Emission E (dBμV/m)	Limit (dBμV/m)	Verdict
		PK/ AV	U _R (dBuV)					
3	2388.37	PK	61.55	-32.81	40.30	69.04	74	Pass
3	2388.37	AV	40.85	-32.81	40.30	48.34	54	Pass
9	2484.82	PK	60.89	-32.81	40.30	68.38	74	Pass
9	2484.82	AV	39.32	-32.81	40.30	46.81	54	Pass

B. Test Plots:



(Channel = 3 PEAK @ 802.11n-40)



(Channel = 3 AVG @ 802.11n-40)



(Channel = 9 PEAK @ 802.11n-40)



(Channel = 9 AVG @ 802.11n-40)

2.7. Conducted Emission

2.7.1. Requirement

According to FCC section 15.207, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency within the band 150kHz to 30MHz shall not exceed the limits in the following table, as measured using a 50 μ H/50 Ω line impedance stabilization network (LISN).

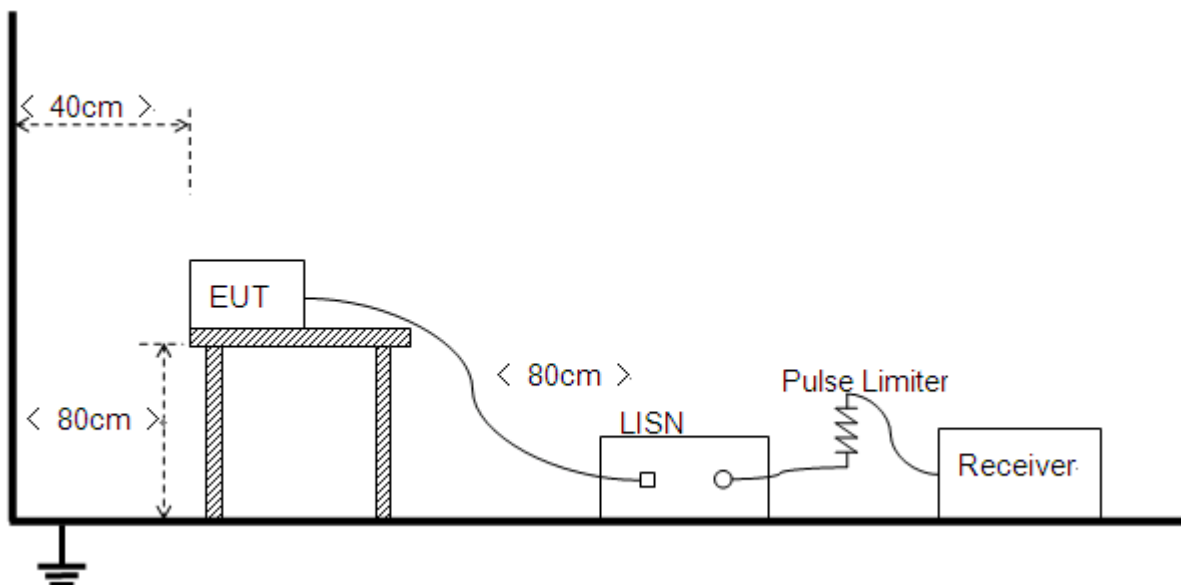
Frequency range (MHz)	Conducted Limit (dB μ V)	
	Quai-peak	Average
0.15 - 0.50	66 to 56	56 to 46
0.50 - 5	56	46
5 - 30	60	50

NOTE:

- (a) The lower limit shall apply at the band edges.
- (b) The limit decreases linearly with the logarithm of the frequency in the range 0.15 - 0.50MHz.

2.7.2. Test Description

A. Test Setup:



The Table-top EUT was placed upon a non-metallic table 0.8m above the horizontal metal reference ground plane. EUT was connected to LISN and LISN was connected to reference Ground Plane. EUT was 80cm from LISN. The set-up and test methods were according to ANSI C63.10 2013.

B. Equipments List:

Please reference ANNEX A(1.5).

2.7.3. Test Result

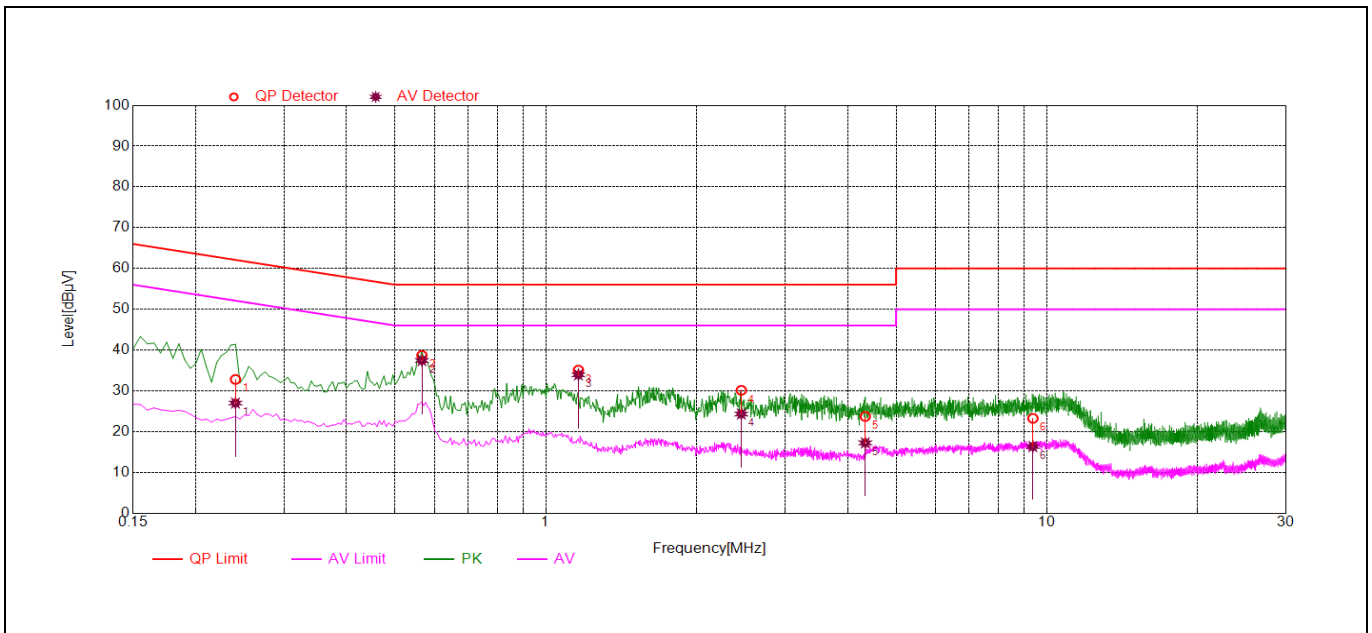
The maximum conducted interference is searched using Peak (PK), if the emission levels more than the AV and QP limits, and that have narrow margins from the AV and QP limits will be re-measured with AV and QP detectors. Tests for both L phase and N phase lines of the power mains connected to the EUT are performed. Refer to recorded points and plots below.

A. Test setup:

The EUT configuration of the emission tests is EUT + Link.

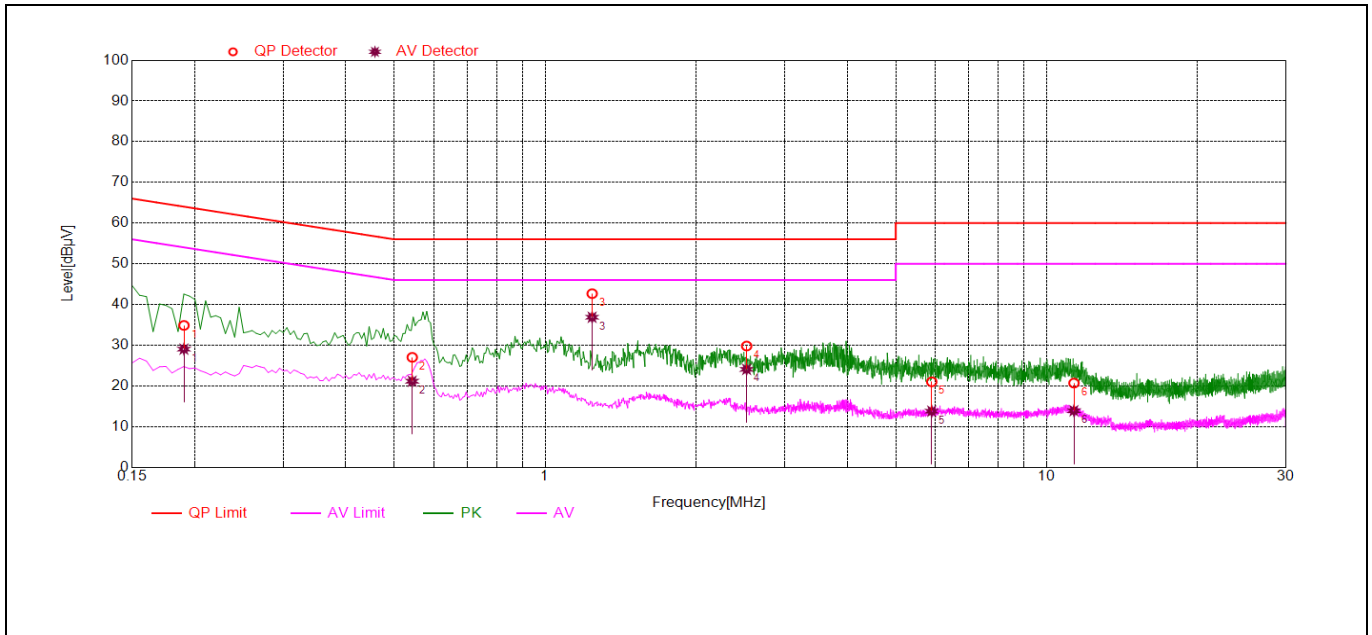
Note: The test voltage is AC 120V/60Hz.

B. Test Plots:



(Plot A: L Phase)

NO.	Fre. (MHz)	Emission Level (dBµV)		Limit (dBµV)		Power-line	Verdict
		Quai-peak	Average	Quai-peak	Average		
1	0.24	32.79	27.00	62.10	52.10	Line	PASS
2	0.57	38.67	37.42	56.00	46.00		PASS
3	1.16	35.08	33.91	56.00	46.00		PASS
4	2.45	30.12	24.31	56.00	46.00		PASS
5	4.34	23.71	17.22	56.00	46.00		PASS
6	9.38	23.24	16.33	60.00	50.00		PASS



(Plot B: N Phase)

NO.	Fre. (MHz)	Emission Level (dBµV)		Limit (dBµV)		Power-line	Verdict
		Quai-peak	Average	Quai-peak	Average		
1	0.19	34.86	29.03	64.03	54.03	Neutral	PASS
2	0.54	27.02	21.15	56.00	46.00		PASS
3	1.24	42.66	36.86	56.00	46.00		PASS
4	2.52	29.79	24.06	56.00	46.00		PASS
5	5.90	21.00	13.78	60.00	50.00		PASS
6	11.34	20.69	13.89	60.00	50.00		PASS



2.8. Radiated Emission

2.8.1. Requirement

According to FCC section 15.247(d), radiated emission outside the frequency band at attenuation below the general limits specified in FCC section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in FCC section 15.205(a), must also comply with the radiated emission limits specified in FCC section 15.209(a).

According to FCC section 15.209 (a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength ($\mu\text{V}/\text{m}$)	Measurement Distance (m)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

Note:

For Above 1000M Hz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20dB above the maximum permitted average limit.

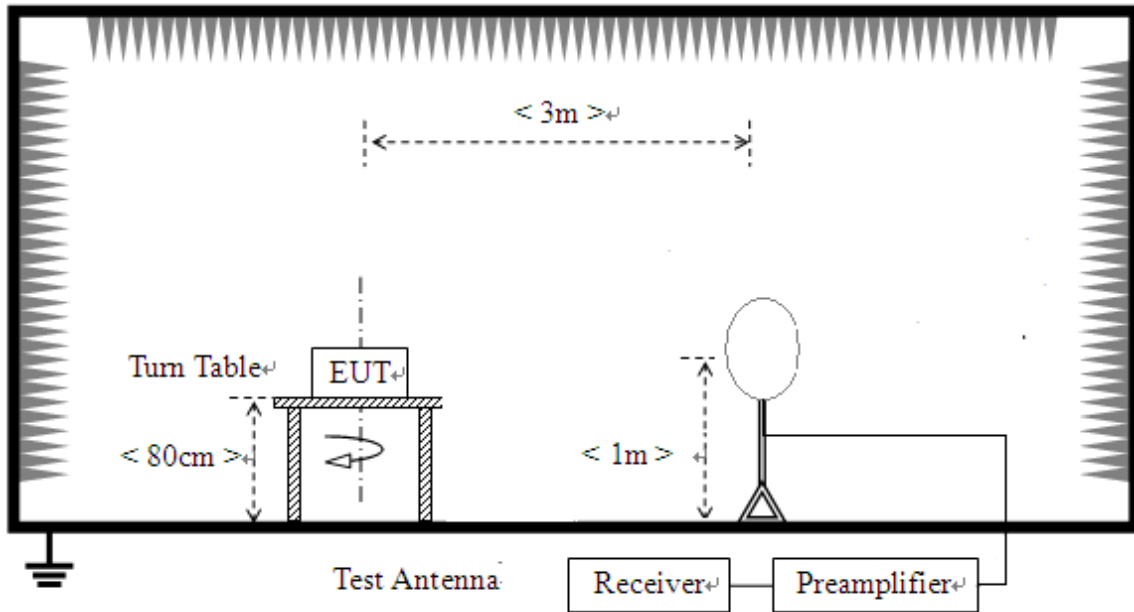
For above 1000M Hz, limit field strength of harmonics: 54dB $\mu\text{V}/\text{m}@3\text{m}$ (AV) and 74dBuV/m@3m (PK)

In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), also should comply with the radiated emission limits specified in Section 15.209(a)(above table)

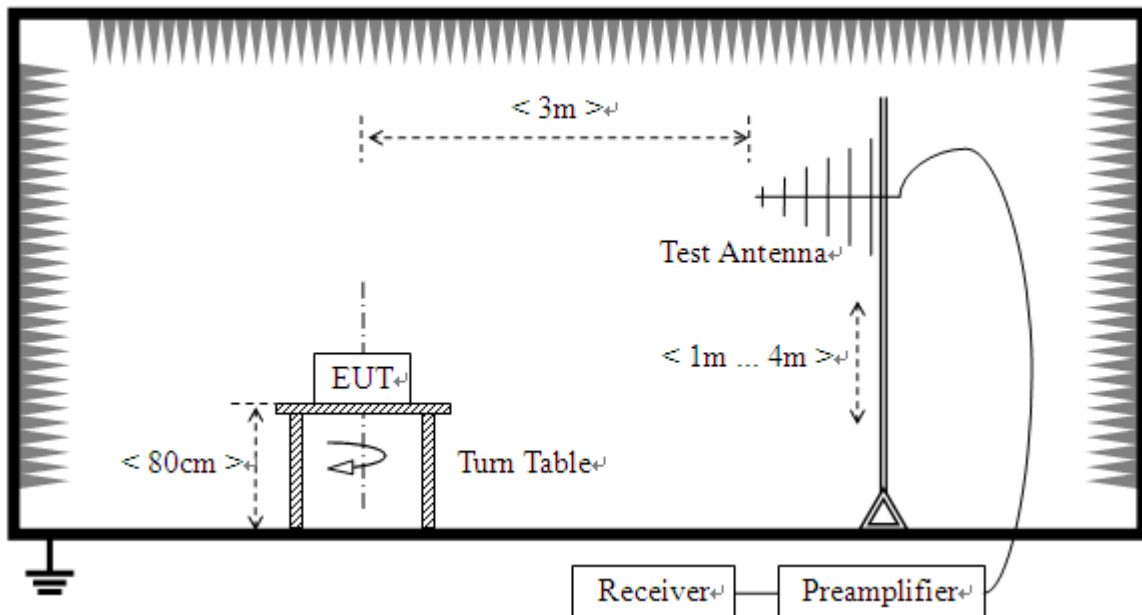
2.8.2. Test Description

A. Test Setup:

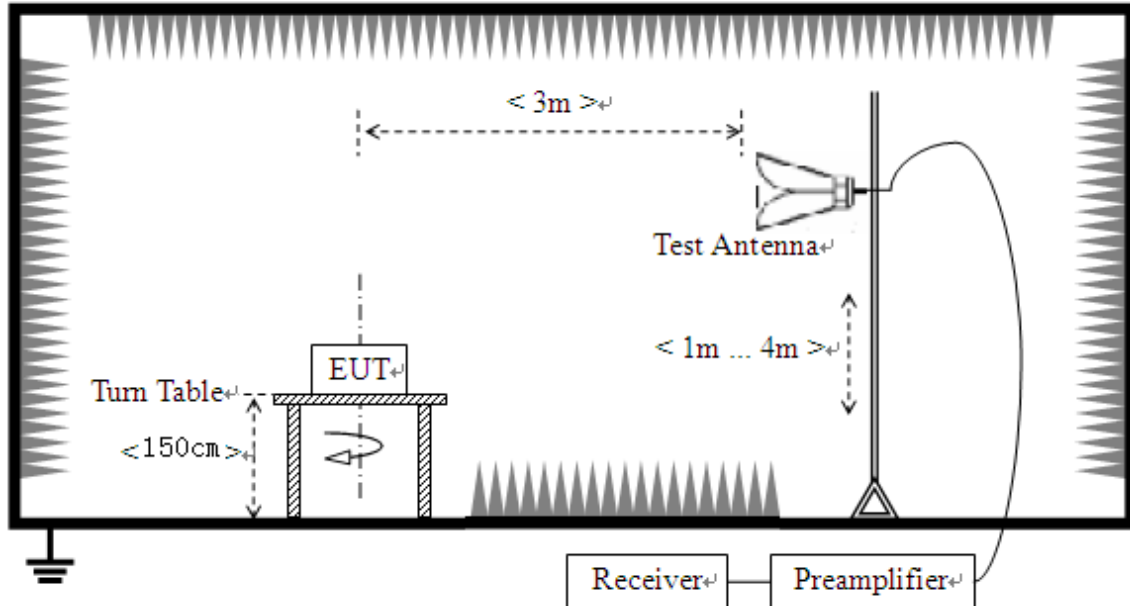
- 1) For radiated emissions from 9kHz to 30MHz



- 2) For radiated emissions from 30MHz to 1GHz



3) For radiated emissions above 1GHz



The RF absorbing material used on the reference ground plane and on the turntable have a maximum height (thickness) of 30 cm (12 in) and have a minimum-rated attenuation of 20 dB at all frequencies from 1 GHz to 18 GHz.

The test site semi-anechoic chamber has met the requirement of NSA tolerance 4dB according to the standards: ANSI C63.10 (2013). For radiated emissions below or equal to 1GHz, The EUT was set-up on insulator 80cm above the Ground Plane, For radiated emissions above 1GHz, The EUT was set-up on insulator 150cm above the Ground Plane. The set-up and test methods were according to ANSI C63.10

For the radiated emission test above 1GHz:

Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final measurement antenna elevations shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane.

The EUT is located in a 3m Semi-Anechoic Chamber; the antenna factors, cable loss and so on of the site as factors are calculated to correct the reading



For the Test Antenna:

(a) In the frequency range of 9kHz to 30MHz, magnetic field is measured with Loop Test Antenna. The Test Antenna is positioned with its plane vertical at 1m distance from the EUT. The center of the Loop Test Antenna is 1m above the ground. During the measurement the Loop Test Antenna rotates about its vertical axis for maximum response at each azimuth about the EUT.

(b) In the frequency range above 30MHz, Bi-Log Test Antenna (30MHz to 1GHz) and Horn Test Antenna (above 1GHz) are used. Place the test antenna at 3m away from area of the EUT, while keeping the test antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The test antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final test antenna elevation shall be that which maximizes the emissions. The test antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane. The emission levels at both horizontal and vertical polarizations should be tested.

A. Equipments List:

Please reference ANNEX A(1.5).

2.8.3. Test Result

According to ANSI C63.10, because of peak detection will yield amplitudes equal to or greater than amplitudes measured with the quasi-peak (or average) detector, the measurement data from a spectrum analyzer peak detector will represent the worst-case results, if the peak measured value complies with the quasi-peak limit, it is unnecessary to perform an quasi-peak measurement.

The measurement results are obtained as below:

$$E [\text{dB}\mu\text{V}/\text{m}] = U_R + A_T + A_{\text{Factor}} [\text{dB}]; A_T = L_{\text{Cable loss}} [\text{dB}] - G_{\text{preamp}} [\text{dB}]$$

A_T : Total correction Factor except Antenna

U_R : Receiver Reading

G_{preamp} : Preamplifier Gain

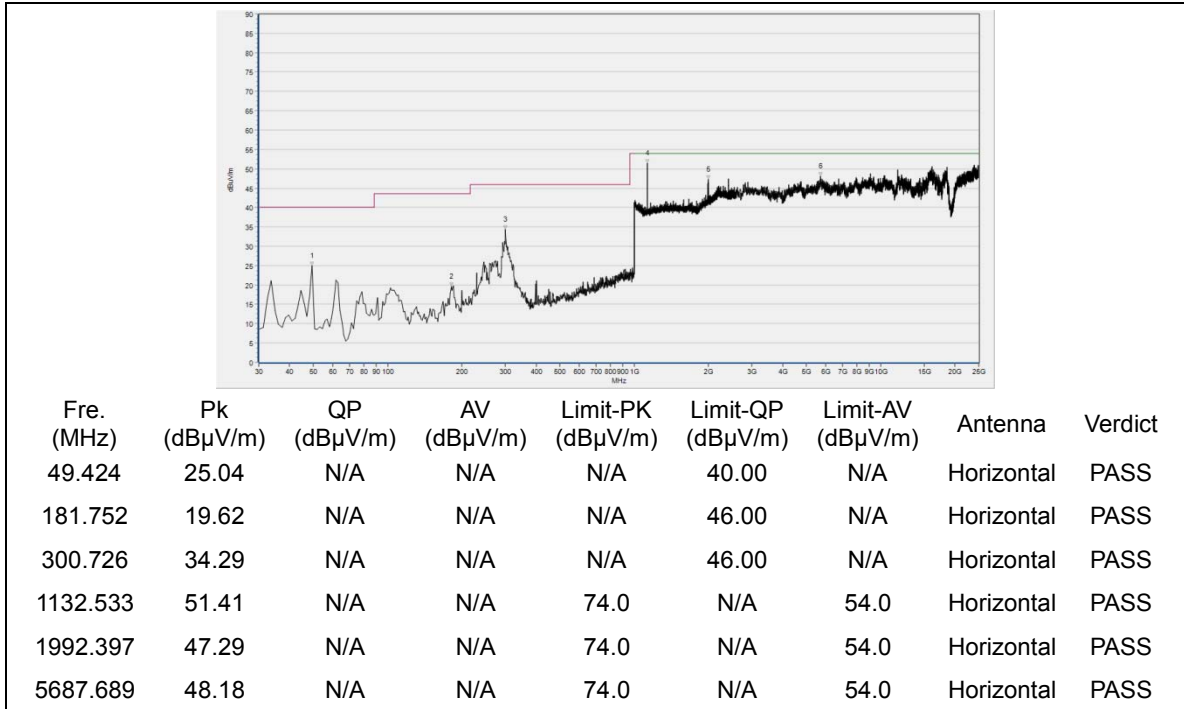
A_{Factor} : Antenna Factor at 3m

During the test, the total correction Factor A_T and A_{Factor} were built in test software.

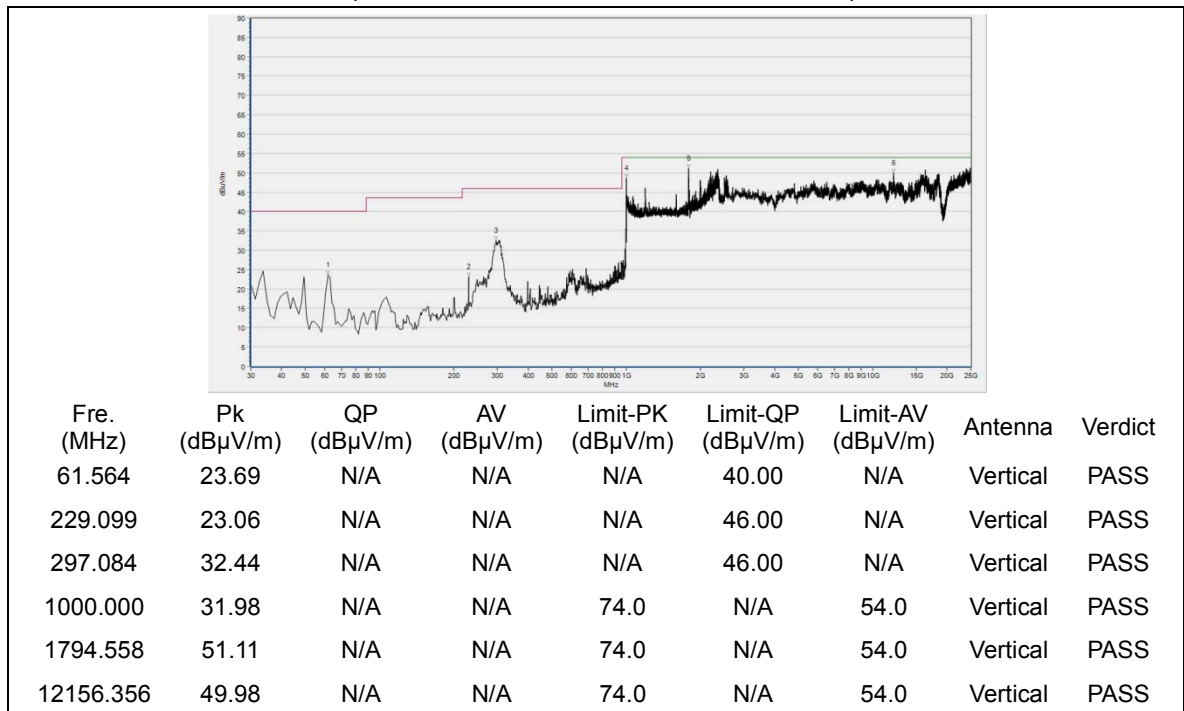
The low frequency, which started from 9KHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

2.8.3.1 802.11b Test mode

Plots for Channel = 1

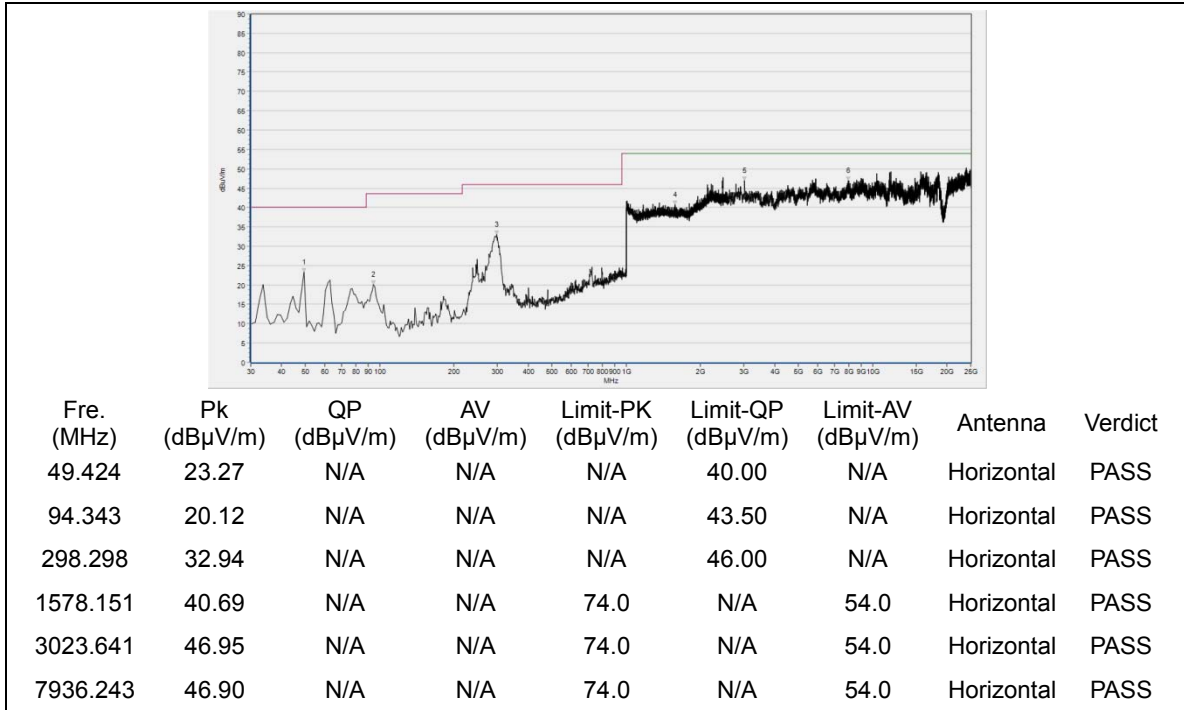


(Antenna Horizontal, 30MHz to 25GHz)

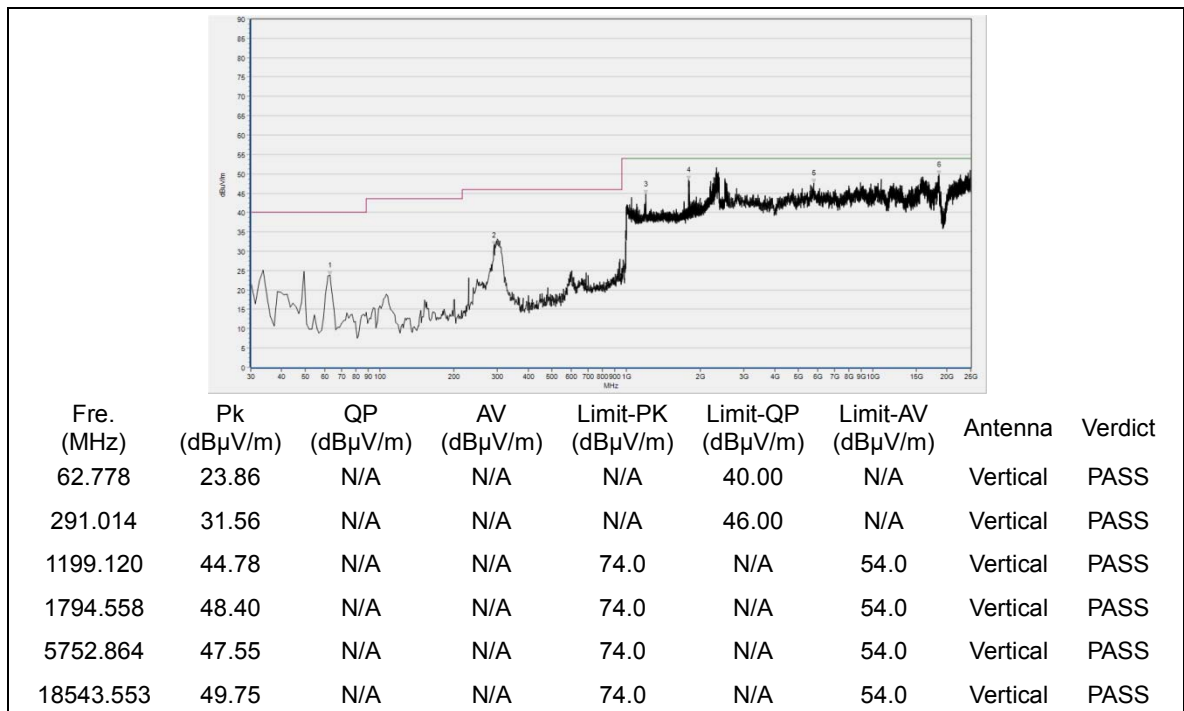


(Antenna Vertical, 30MHz to 25GHz)

Plot for Channel = 6

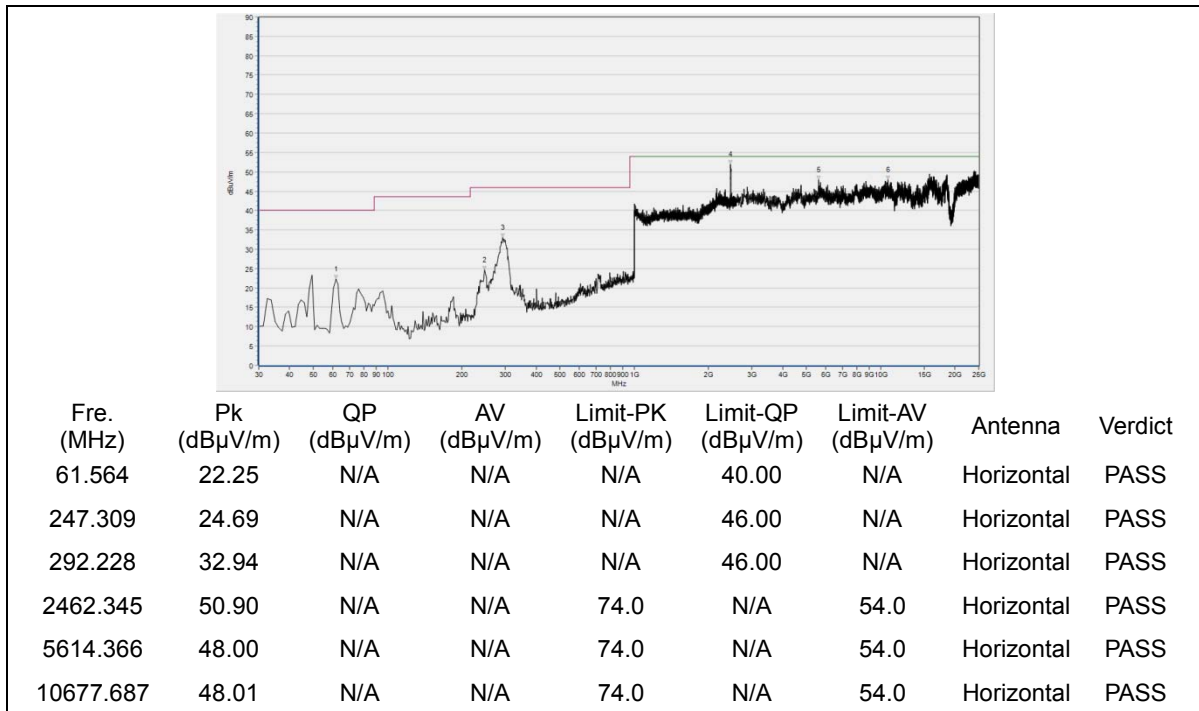


(Antenna Horizontal, 30MHz to 25GHz)

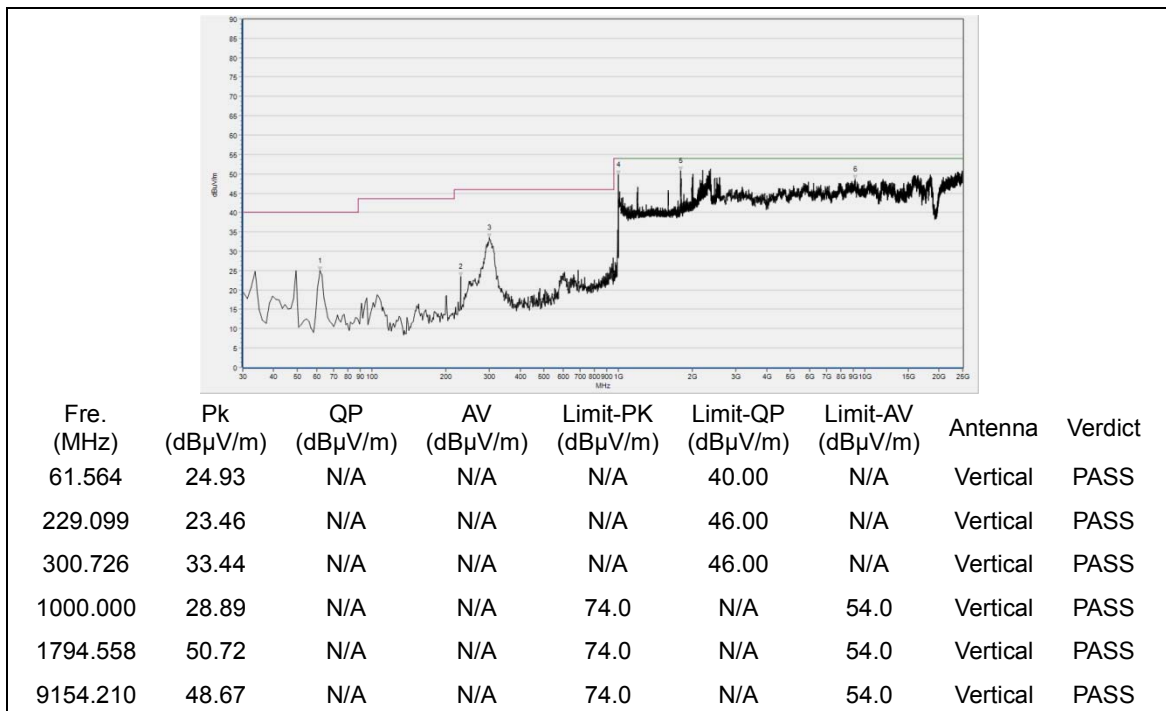


(Antenna Vertical, 30MHz to 25GHz)

Plot for Channel = 11



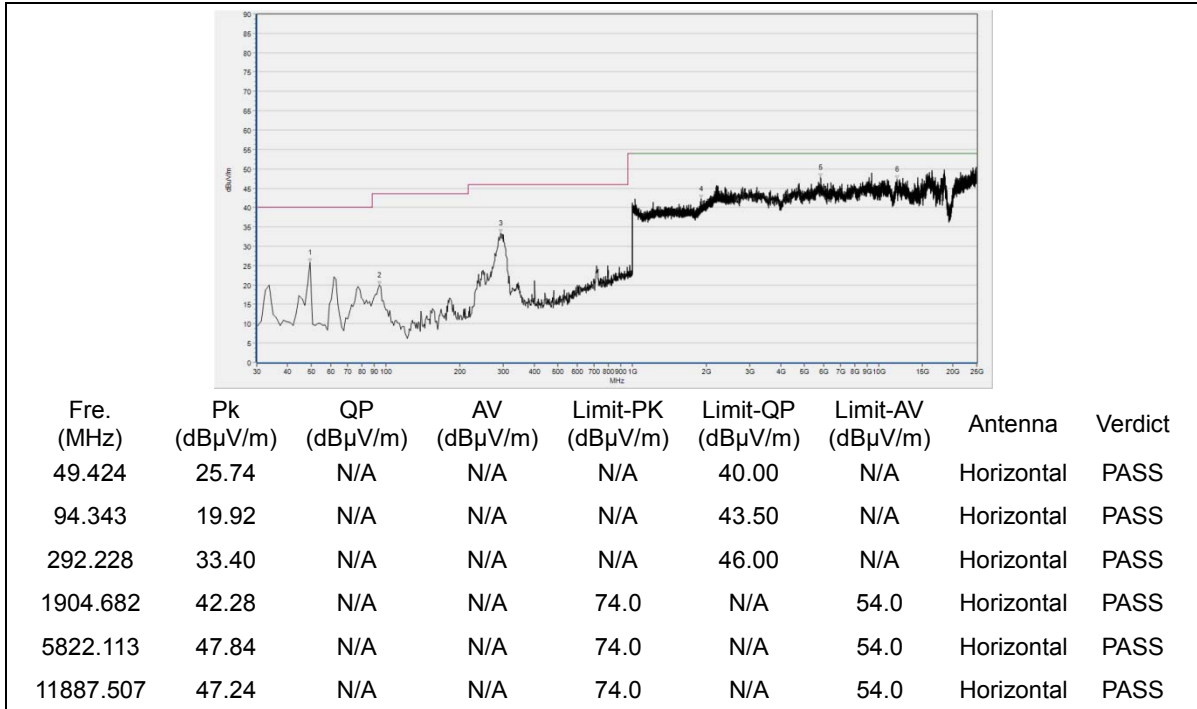
(Antenna Horizontal, 30MHz to 25GHz)



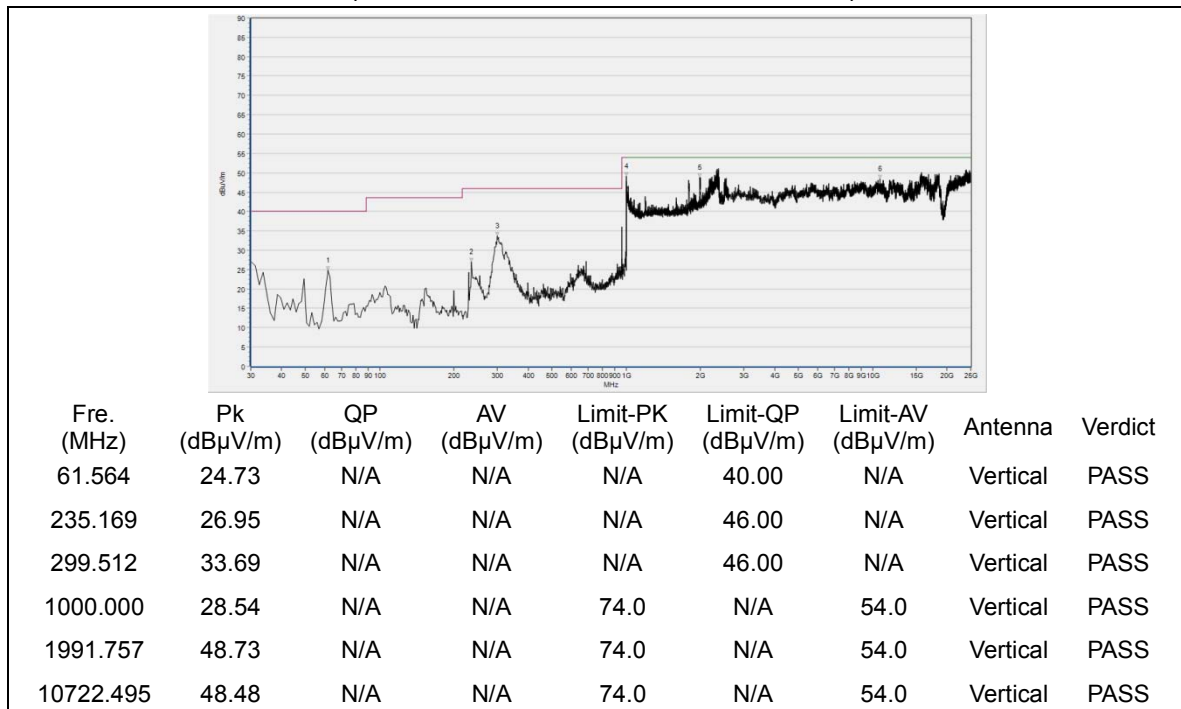
(Antenna Vertical, 30MHz to 25GHz)

2.8.3.2 802.11g Test mode

Plots for Channel = 1

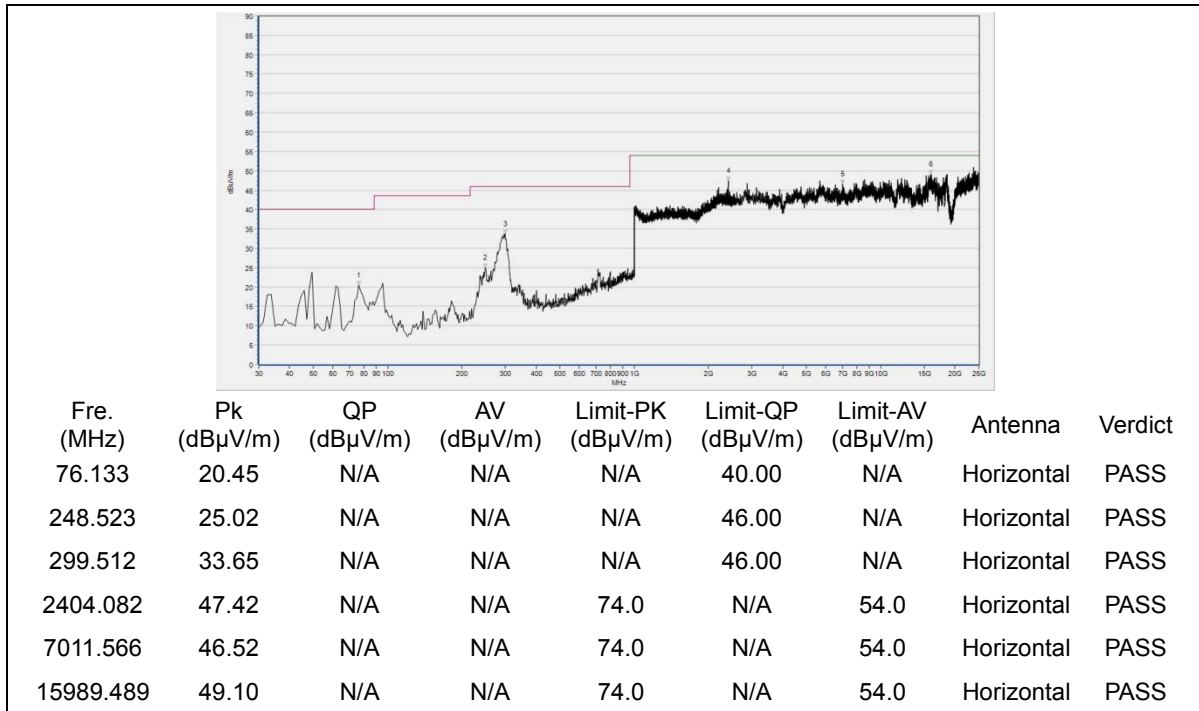


(Antenna Horizontal, 30MHz to 25GHz)

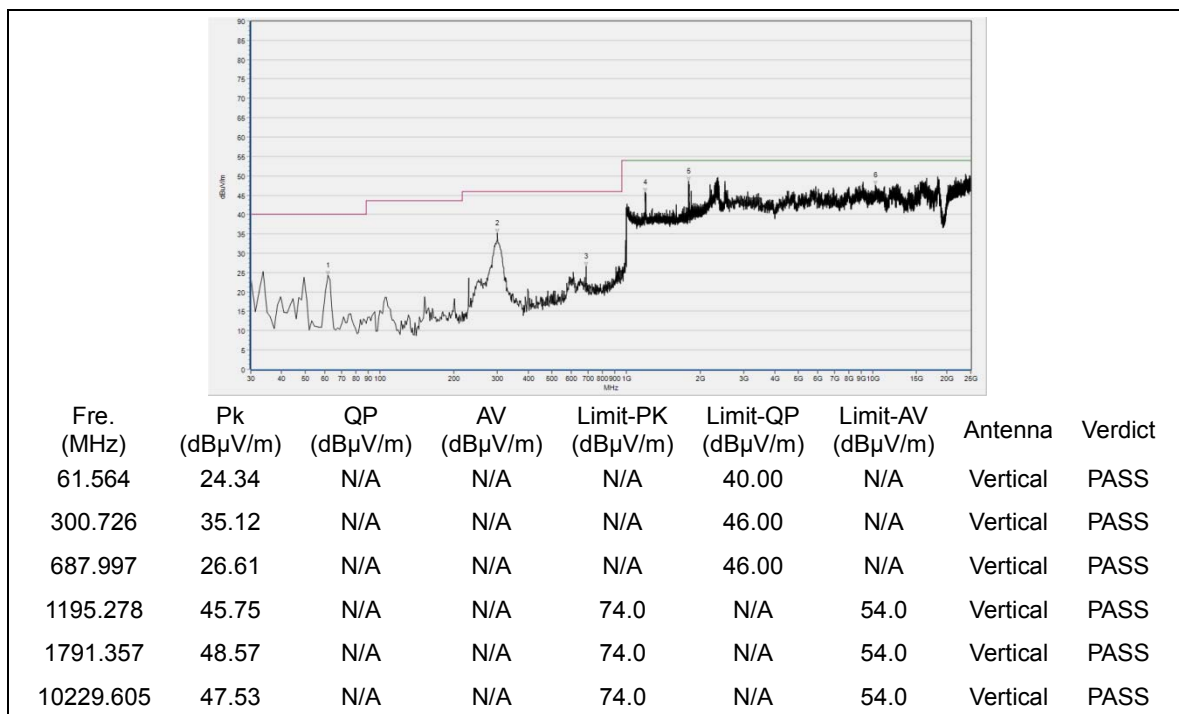


(Antenna Vertical, 30MHz to 25GHz)

Plot for Channel = 6

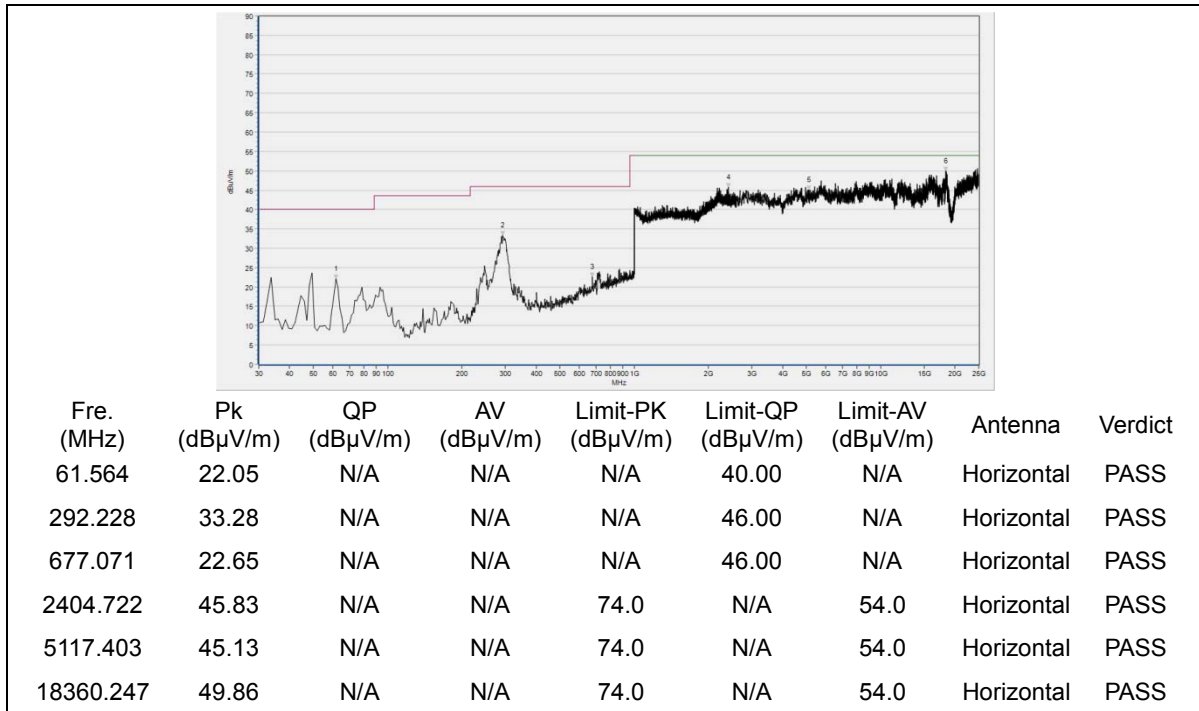


(Antenna Horizontal, 30MHz to 25GHz)

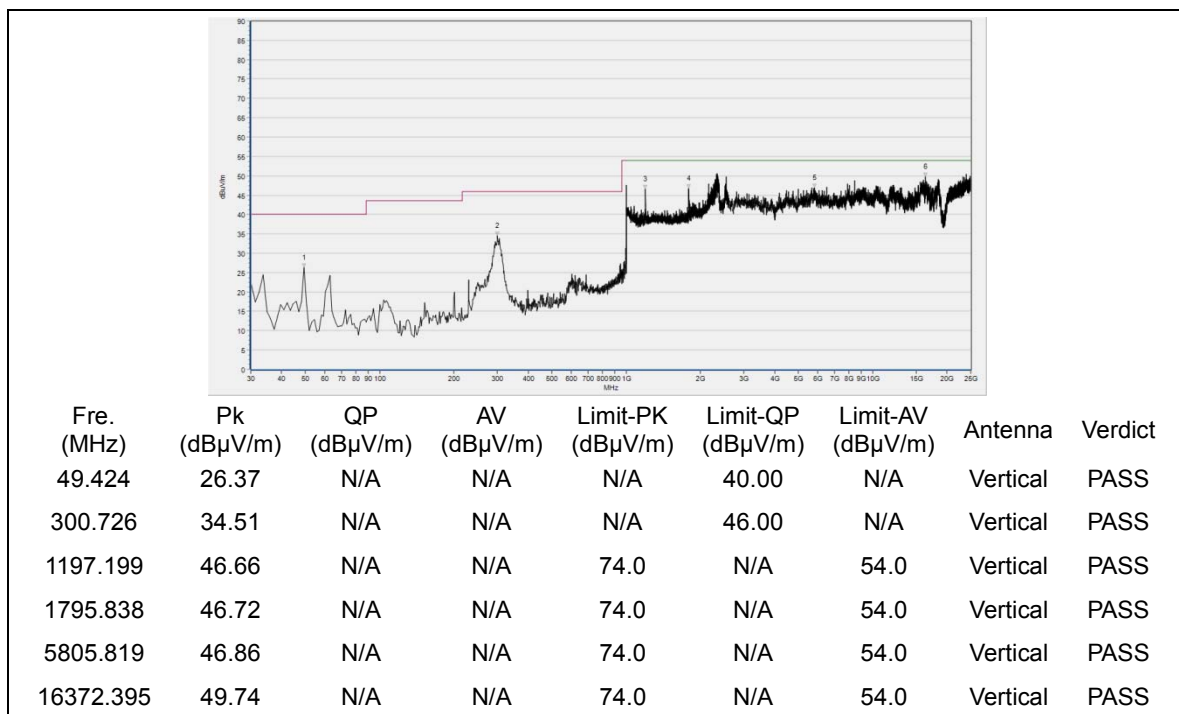


(Antenna Vertical, 30MHz to 25GHz)

Plot for Channel = 11



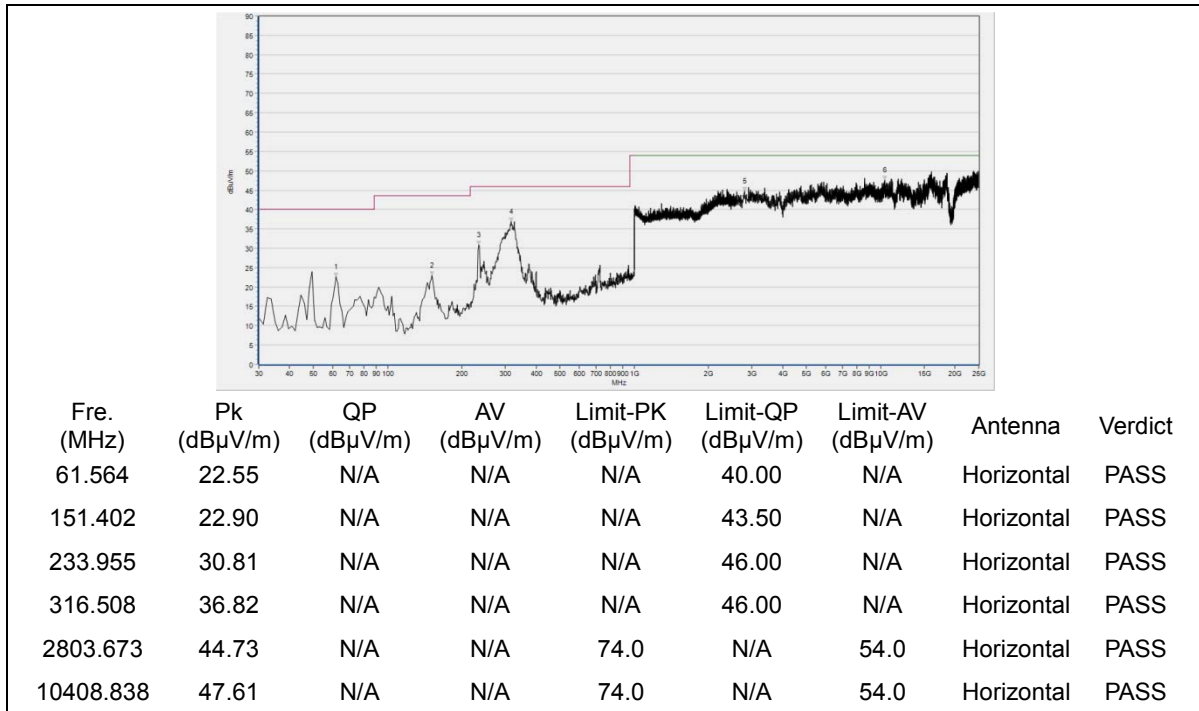
(Antenna Horizontal, 30MHz to 25GHz)



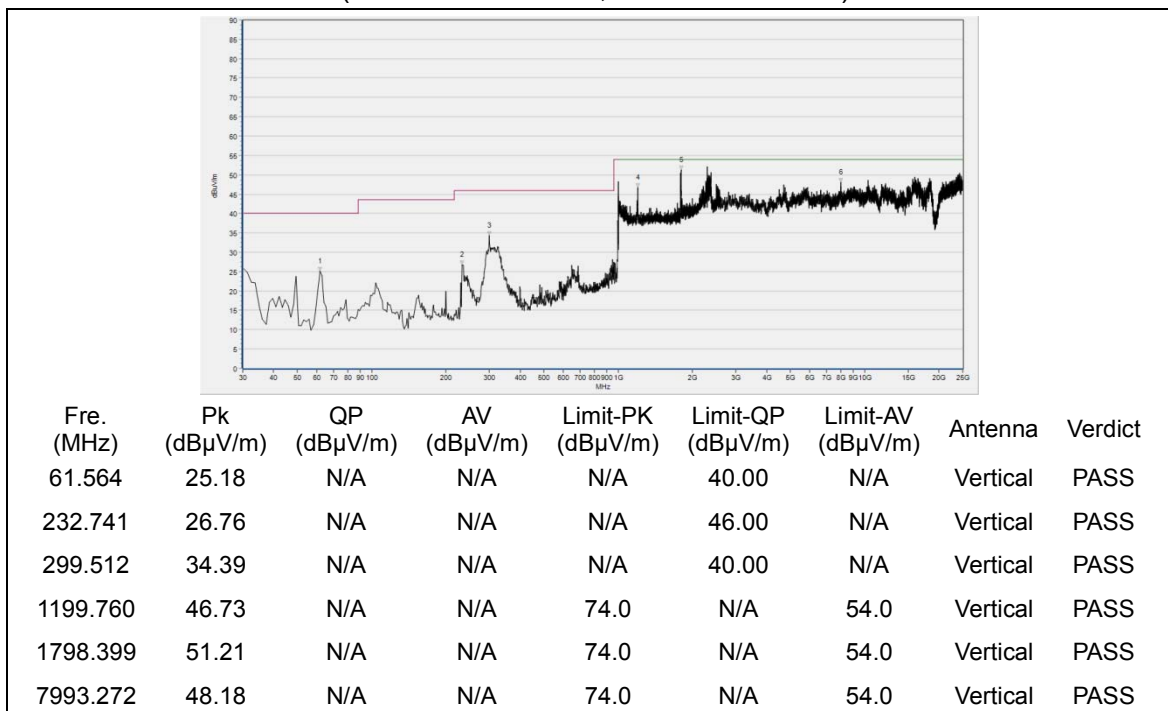
(Antenna Vertical, 30MHz to 25GHz)

2.8.3.3 802.11n-20MHz Test mode

Plots for Channel = 1

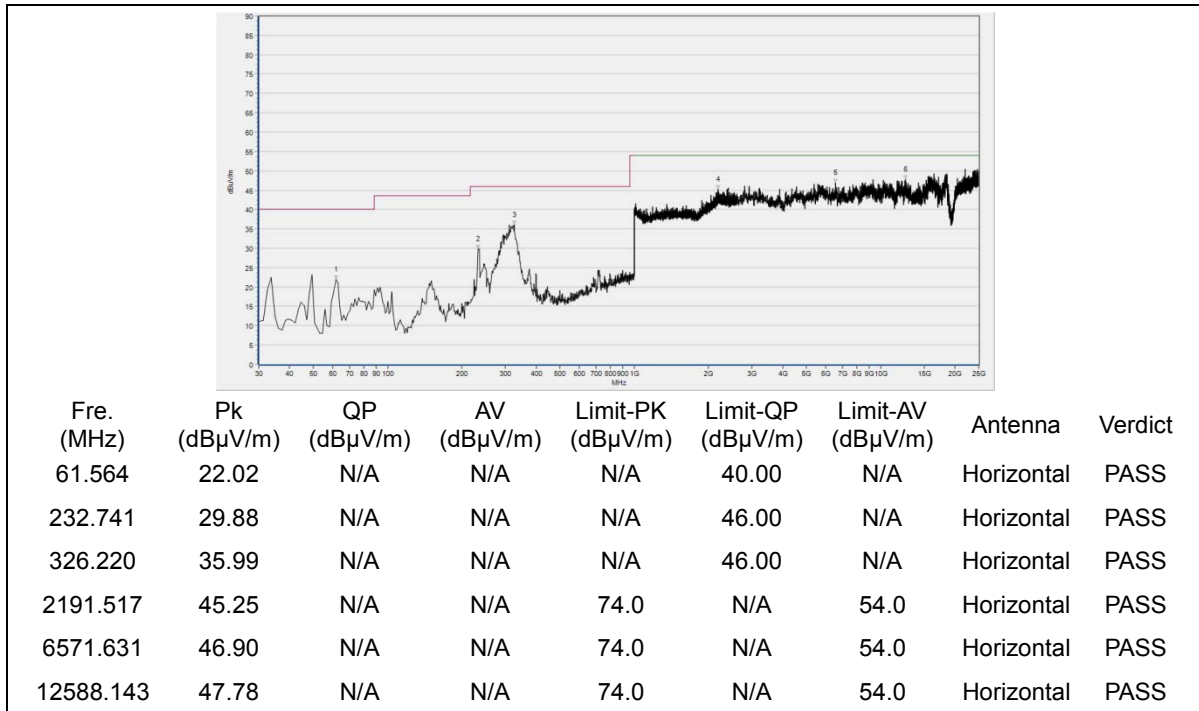


(Antenna Horizontal, 30MHz to 25GHz)

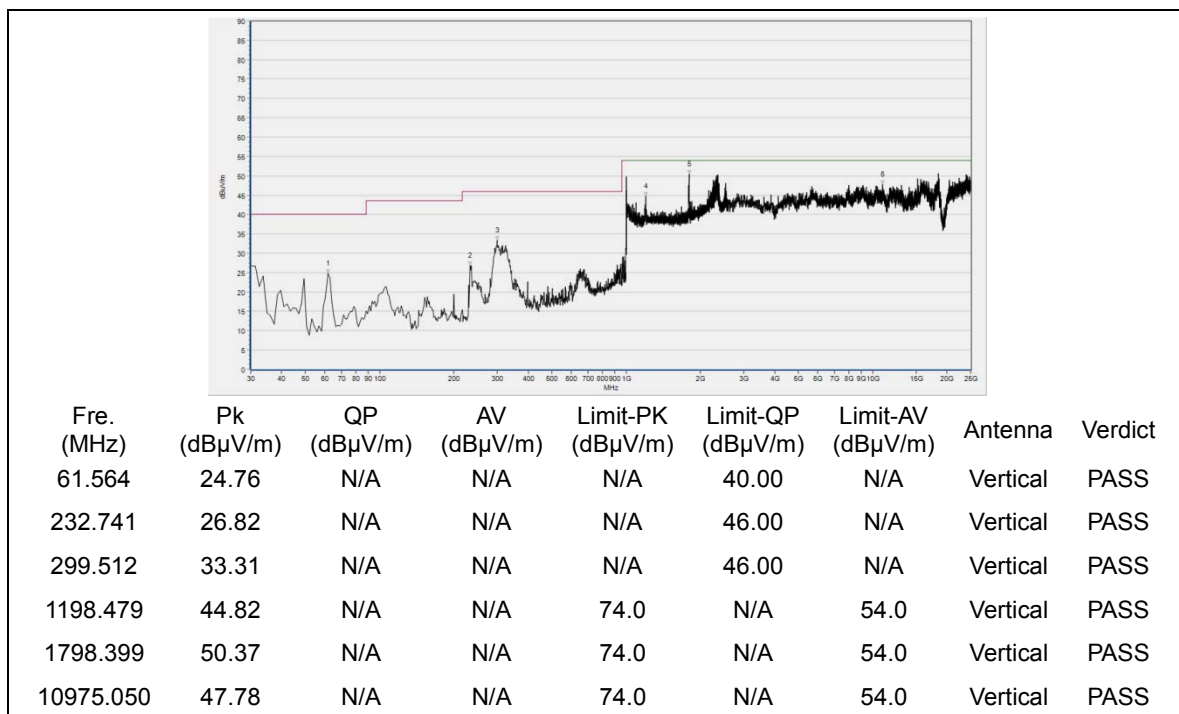


(Antenna Vertical, 30MHz to 25GHz)

Plot for Channel = 6

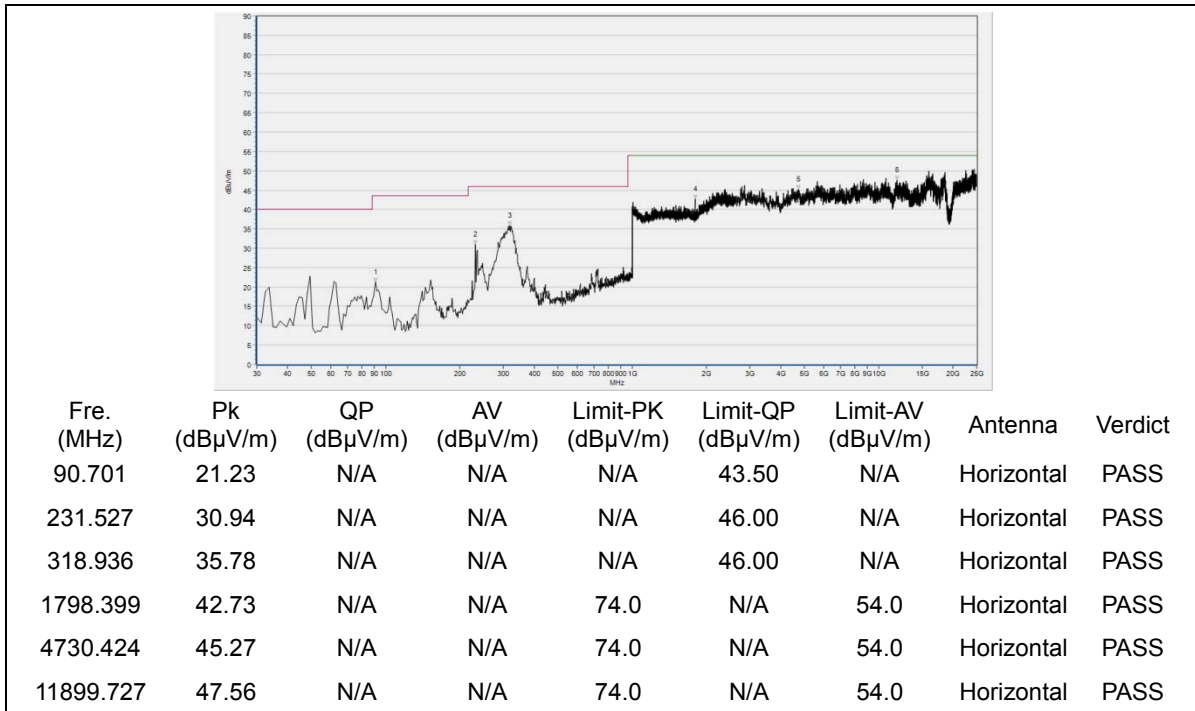


(Antenna Horizontal, 30MHz to 25GHz)

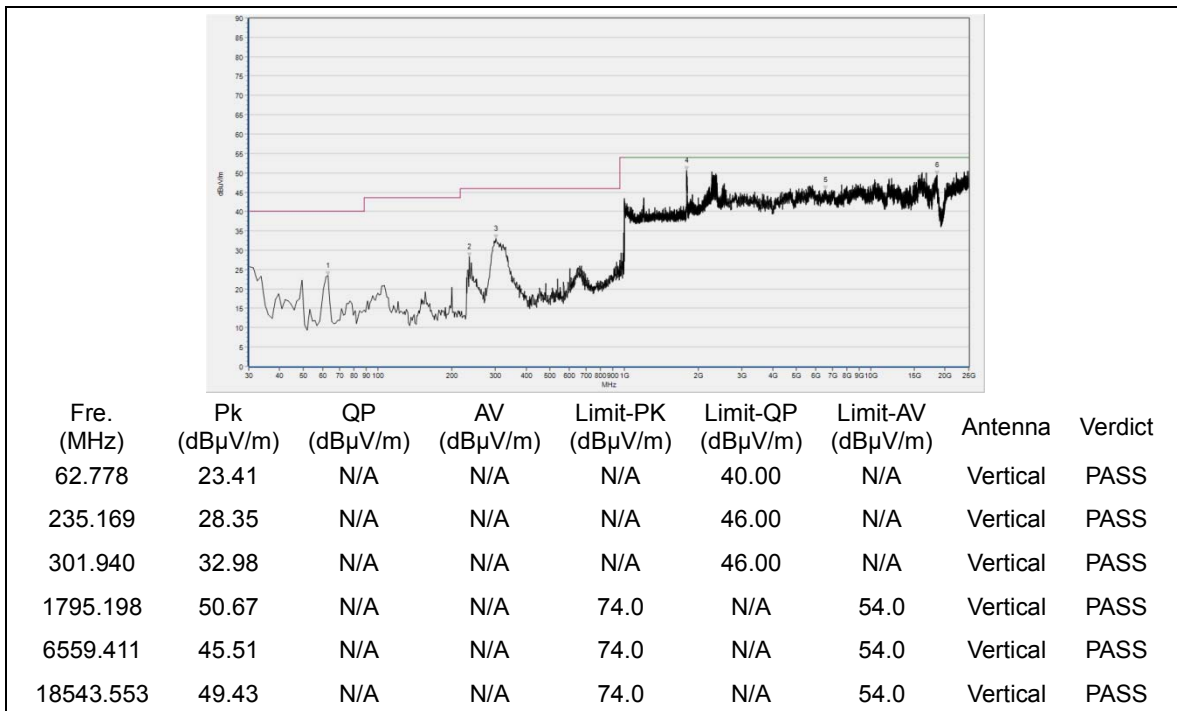


(Antenna Vertical, 30MHz to 25GHz)

Plot for Channel = 11



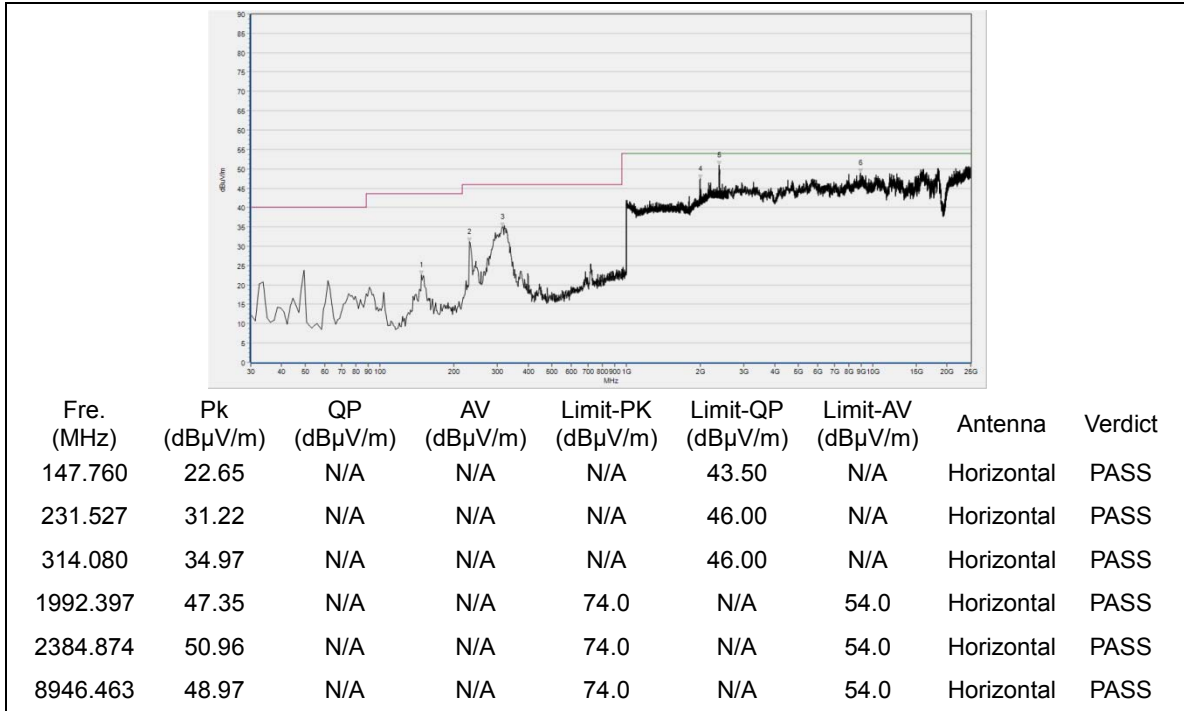
(Antenna Horizontal, 30MHz to 25GHz)



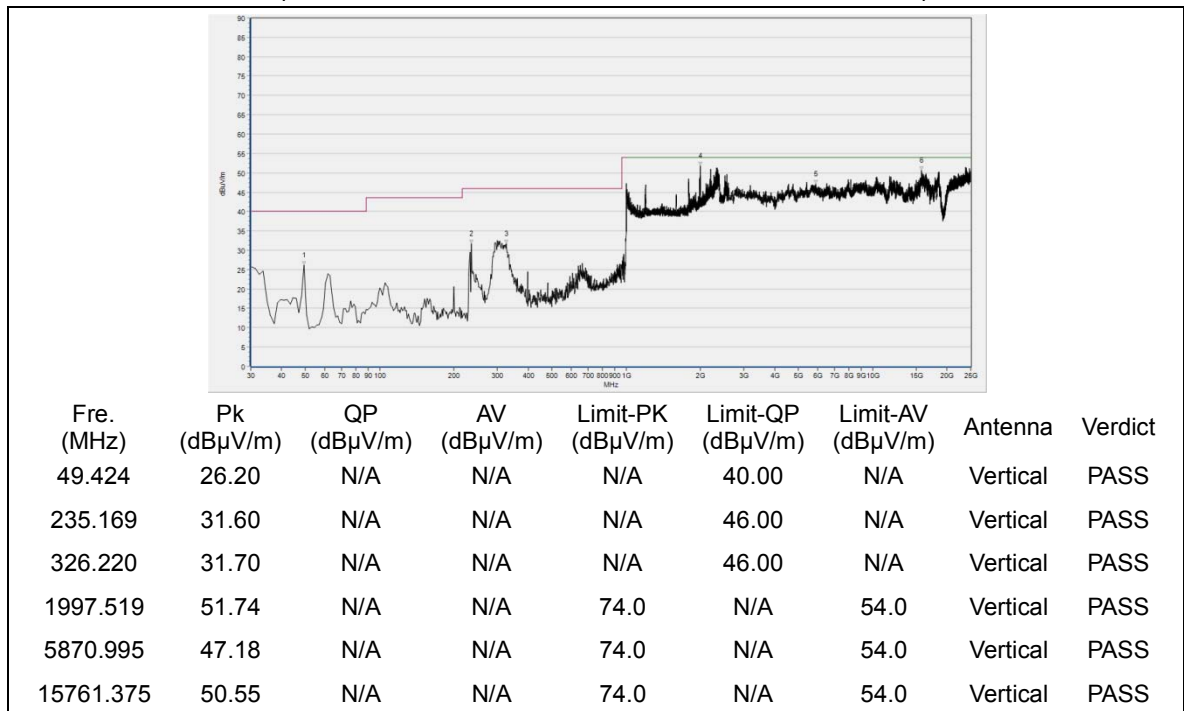
(Antenna Vertical, 30MHz to 25GHz)

2.8.3.4 802.11n-40MHz Test mode

Plots for Channel = 3

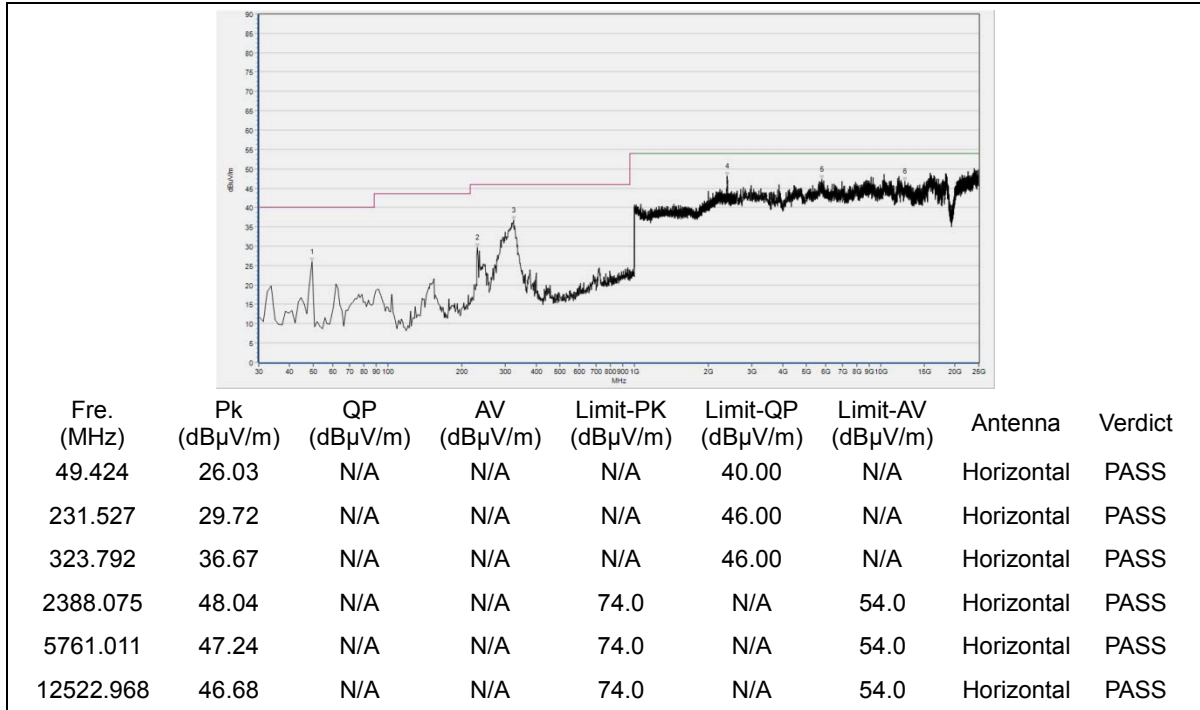


(Plot A.2: Antenna Horizontal, 30MHz to 25GHz)

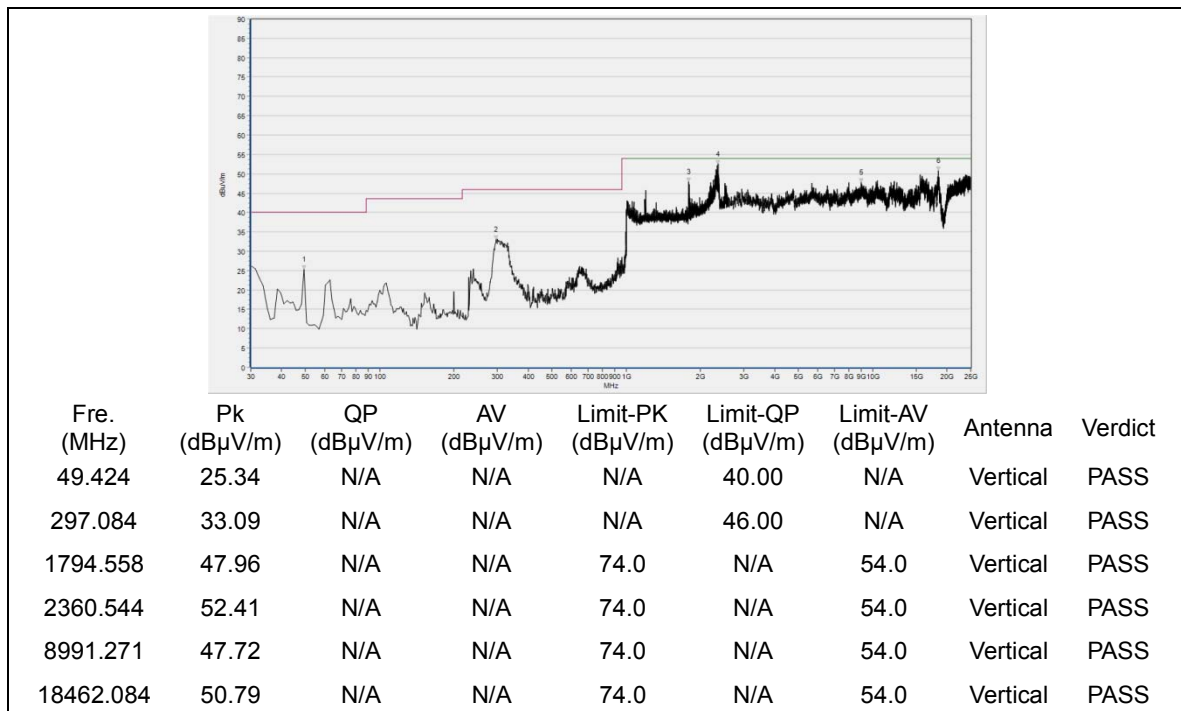


(Plot A.3: Antenna Vertical, 30MHz to 25GHz)

Plots for Channel = 6

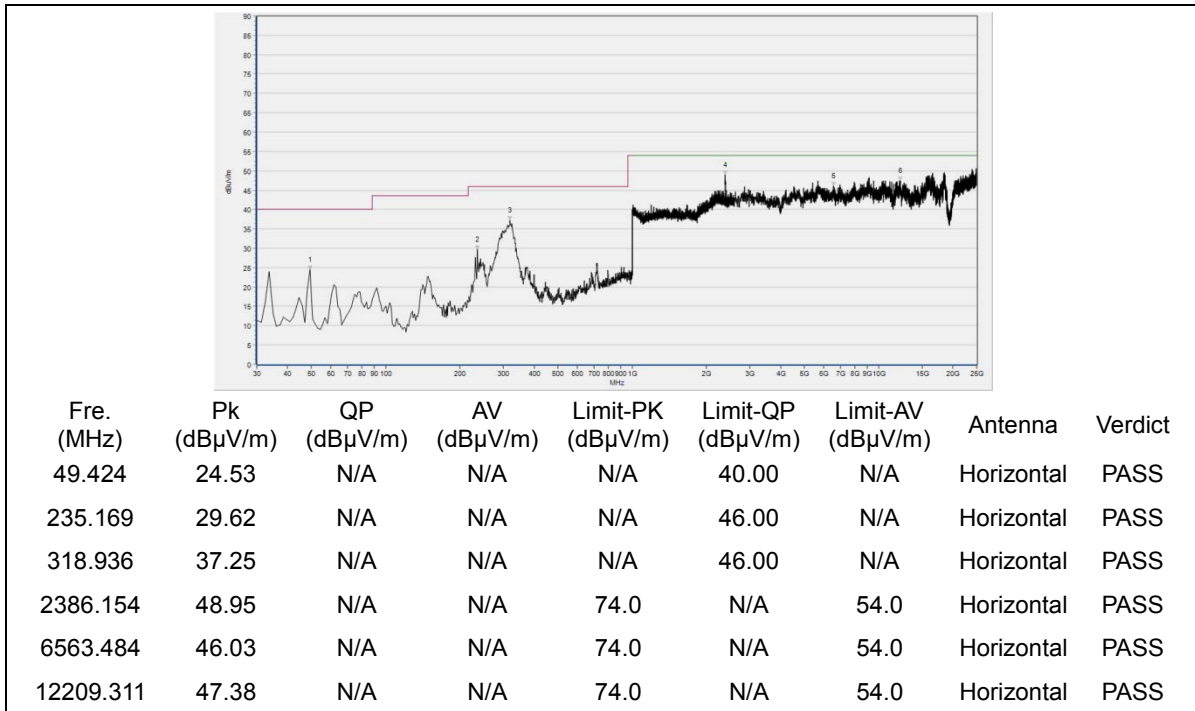


(Plot B.2: Antenna Horizontal, 30MHz to 25GHz)

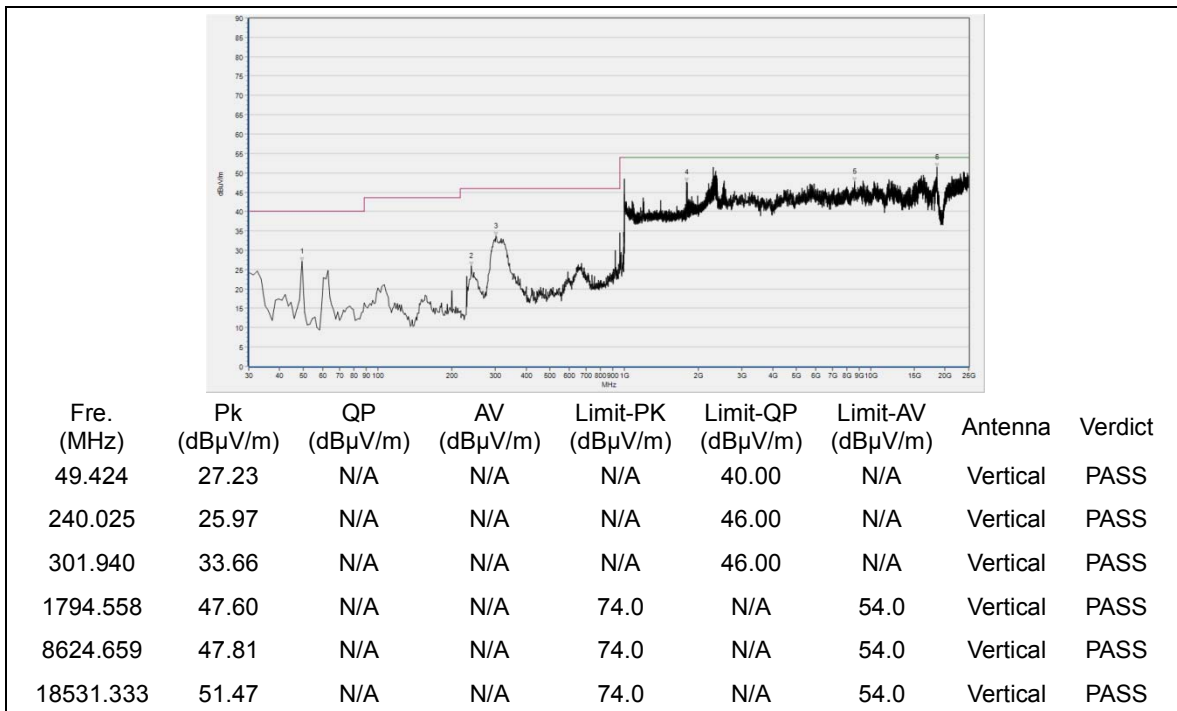


(Plot B.3: Antenna Vertical, 30MHz to 25GHz)

Plots for Channel = 9



(Plot C.2: Antenna Horizontal, 30MHz to 25GHz)



(Plot C.3: Antenna Vertical, 30MHz to 25GHz)



Annex A Test Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for test performed on the EUT as specified in CISPR 16-1-2:

Test items	Uncertainty
Peak Output Power	$\pm 2.22\text{dB}$
Power spectral density (PSD)	$\pm 1.3\text{dB}$
Bandwidth	$\pm 5\%$
Conducted Spurious Emission	$\pm 2.77\text{ dB}$
Restricted Frequency Bands	$\pm 5\%$
Radiated Emission	$\pm 2.95\text{dB}$
Conducted Emission	$\pm 2.44\text{dB}$

This uncertainty represent an expanded uncertainty expressed at a approximately the 95% confidence level using a coverage factor of $k=2$



Annex B Testing Laboratory Information

1. Identification of the Responsible Testing Laboratory

Company Name:	Shenzhen Morlab Communications Technology Co., Ltd.
Department:	Morlab Laboratory
Address:	FL.3, Building A, Fei Yang Science Park, No.8 LongChang Road, Block 67, BaoAn District, Shenzhen, Guangdong Province, P. R. China
Responsible Test Lab Manager:	Mr. Su Feng
Telephone:	+86 755 36698555
Facsimile:	+86 755 36698525

2. Identification of the Responsible Testing Location

Name:	Shenzhen Morlab Communications Technology Co., Ltd. Morlab Laboratory
Address:	FL.3, Building A, Fei Yang Science Park, No.8 LongChang Road, Block 67, BaoAn District, Shenzhen, Guangdong Province, P. R. China

3. Facilities and Accreditations

All measurement facilities used to collect the measurement data are located at FL.3, Building A, FeiYang Science Park, Block 67, BaoAn District, Shenzhen, 518101 P. R. China. The test site is constructed in conformance with the requirements of ANSI C63.10-2013 and CISPR Publication 22; the FCC designation number is CN1192.



4. Test Equipments Utilized

4.1 Conducted Test Equipments

Equipment Name	Serial No.	Type	Manufacturer	Cal. Date	Cal. Due
Power Splitter	NW521	1506A	Weinschel	2017.05.24	2018.05.23
Attenuator 1	(N/A.)	10dB	Resnet	2017.05.24	2018.05.23
Attenuator 2	(N/A.)	3dB	Resnet	2017.05.24	2018.05.23
EXA Signal Analyzer	MY53470836	N9010A	Agilent	2017.12.03	2018.12.02
USB Wideband Power Sensor	MY54210011	U2021XA	Agilent	2017.05.24	2018.05.23
RF cable (30MHz-26GHz)	CB01	RF01	Morlab	N/A	N/A
Coaxial cable	CB02	RF02	Morlab	N/A	N/A
SMA connector	CN01	RF03	HUBER-SUHNER	N/A	N/A

4.2 Conducted Emission Test Equipments

Equipment Name	Serial No.	Type	Manufacturer	Cal. Date	Cal. Due
Receiver	MY56400093	N9038A	KEYSIGHT	2017.07.13	2018.07.12
LISN	812744	NSLK 8127	Schwarzbeck	2017.05.17	2018.05.16
Pulse Limiter (20dB)	9391	VTSD 9561-D	Schwarzbeck	2017.05.17	2018.05.16
Coaxial cable(BNC) (30MHz-26GHz)	CB01	EMC01	Morlab	N/A	N/A

4.3 Auxiliary Test Equipment

Equipment Name	Model No.	Brand Name	Manufacturer	Cal. Date	Cal. Due
Computer	T430i	Think Pad	Lenovo	N/A	N/A

**4.4 Radiated Test Equipments**

Equipment Name	Serial No.	Type	Manufacturer	Cal. Date	Cal. Due
Receiver	MY54130016	N9038A	Agilent	2017.05.17	2018.05.16
Test Antenna - Bi-Log	9163-519	VULB 9163	Schwarzbeck	2017.05.14	2018.05.13
Test Antenna - Horn	9170C-531	BBHA9170	Schwarzbeck	2017.09.13	2018.09.12
Test Antenna - Loop	1519-022	FMZB1519	Schwarzbeck	2017.03.07	2018.03.06
Test Antenna - Horn	01774	BBHA 9120D	Schwarzbeck	2017.09.13	2018.09.12
Coaxial cable (N male) (9KHz-30MHz)	CB04	EMC04	Morlab	N/A	N/A
Coaxial cable (N male) (30MHz-26GHz)	CB02	EMC02	Morlab	N/A	N/A
Coaxial cable (N male) (30MHz-26GHz)	CB03	EMC03	Morlab	N/A	N/A
1-18GHz pre-Amplifier	MA02	TS-PR18	Rohde& Schwarz	2017.05.17	2018.05.16
18-26.5GHz pre-Amplifier	MA03	TS-PR18	Rohde& Schwarz	2017.05.17	2018.05.16
Anechoic Chamber	N/A	9m*6m*6m	CRT	2017.11.19	2020.11.18

————— END OF REPORT —————