FCC Certification Test Report

WELOTEC GMBH

LTE-ROUTER

MODEL: TK8X2L, TK8X5L(X = 0-9)

FCC ID: 2AJGHTK800

REPORT# **17WB0301245F-01 Rev. 0**
Feb. 16, 2017

Prepared for:

Welotec GmbH
Zum Hagenbach 7, Laer, Germany, 48366

Prepared By:

Washington International Technology Limited

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For the

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Prepared by:

Steven yang

Reviewed by:

Herve Idoko

Abstract

This report has been prepared on behalf of Welotec GmbH to support the attached Application for Equipment Authorization. The test report and application are submitted for a Spread Spectrum Transceiver under Part 15.247 of the FCC Rules and Regulations. This Federal Communication Commission (FCC) Certification Test Report documents the test configuration and test results for a Welotec GmbH LTE-Router.

And Testing was performed by:

Compliance Certification Services (Shenzhen) Inc. has been accepted by the FCC, the FCC Registration Number is 441872.

Shenzhen UnionTrust Quality and Technology Co., Ltd. the test facility is accredited by the CNAS, CNAS-Lab Code: L9069.

The LTE-Router is an IEEE 802.11b/802.11g/802.11n compliant device and complies with the limits for a Direct Sequence Spread Spectrum Transmitter device under Part 15.247 of the FCC Rules and Regulations.

Revision History	Reason	Date
Rev 0	Initial Release	Feb. 16, 2017
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Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

After the modifications listed in Section 2.7 were installed:

The Welotec GmbH LTE-Router complies with the limits for a Spread Spectrum Transceiver device under Part 15.247 of the FCC Rules and Regulations.

1.2 Test Scope Summary

Tests for radiated and conducted emissions were performed. All measurements were performed according to the 2013 version of ANSI C63.10

Test Specification	Specific Description	Result	Modifications (Y/N)	Test Location
47 CFR Part 15 Subpart C Section 15.207	Conducted Emissions – AC Power Ports	N/A	N	N/A
47 CFR Part 15 Subpart C Section 15.247 (b)(3)	RF Output Power	Complied	N	Shenzhen UnionTrust Quality and Technology Co., Ltd.
47 CFR Part 15 Subpart C Section 15.247 (e)	RF Power Spectral Density	Complied	N	Shenzhen UnionTrust Quality and Technology Co., Ltd.
47 CFR Part 15 Subpart C Section 15.247(d)	Conducted Out of Band Emission	Complied	N	Shenzhen UnionTrust Quality and Technology Co., Ltd.
47 CFR Part 15 Subpart C Section 15.205/15.209	Radiated spurious emissions	Complied	N	Compliance Certification Services (Shenzhen) Inc.
47 CFR Part 15 Subpart C Section 15.247 (a)(2)	Occupied Bandwidth	Complied	N	Shenzhen UnionTrust Quality and Technology Co., Ltd.
47 CFR Part 15 Subpart C Section 15.205/15.209	Band Edge Measurements (Radiated)	Complied	N	Compliance Certification Services (Shenzhen) Inc.
NOTE: The EUT is also considered as a kind of other class A digital device it has been verified to comply with the requirements of FCC Part 15B Class A(Verification) the test report has been issued by Washington Technology International Limited				

1.3 Contract Information

Customer:	Welotec GmbH
	Zum Hagenbach 7, Laer, Germany, 48366

1.4 Test and Support Personnel

Paul Pan	Compliance Certification Services (Shenzhen) Inc.
	No.10-1 Mingkeda Logistics Park, No.18 Huanguan South RD. Guan lan Town, Baoan Distr, Shenzhen, Guangdong, China.
	Project Leader
Tiny You	Shenzhen UnionTrust Quality and Technology Co., Ltd.
	Address: 16/F, Block A, Building 6, Baoneng Science and Technology Park, Qingxiang Road No.1, Longhua New District, Shenzhen, China 518109
	Engineer

1.5 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**eres
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**C**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**decibel**
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga - prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo - prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega - prefix for 10^6 multiplier
m	**M**eter
µ	**m**icro - prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

2 Equipment Under Test

2.1 EUT Identification

The results obtained relate only to the item(s) tested.

Table 1: Overview of LTE-Router, Equipment Under Test

ITEM	DESCRIPTION
Manufacturer:	Welotec GmbH
FCC ID Number:	2AJGHTK800
Trade Mark:	N/A
EUT Name:	LTE-Router
Test Model:	TK815L
FCC Rule Parts:	§15.247
Frequency Range:	IEEE 802.11b/g/n(HT20): 2412 – 2462MHz IEEE 802.11n (HT40): 2422 – 2452 MHz
Maximum Output Power:	IEEE 802.11b: 21.63dBm IEEE 802.11g: 22.80dBm IEEE 802.11n (HT20): 22.88dBm IEEE 802.11n (HT40): 22.31dBm
Modulation:	Direct Sequence Spread Spectrum & Orthogonal Frequency Division Multiplexing
Necessary Bandwidth:	IEEE 802.11b/g/n(HT20): 20 MHz IEEE 802.11n (HT40): 40 MHz
Keying:	Automatic
Type of Information:	IEEE 802.11b: DSSS(CCK,DQPSK,DBPSK) IEEE 802.11g: OFDM(64QAM, 16QAM, QPSK, BPSK) IEEE 802.11n (HT20), HT40: OFDM (64QAM, 16QAM, QPSK,BPSK)
Number of Channels:	IEEE 802.11b/g/n(HT20): 11 IEEE 802.11n (HT40): 7
Antenna Type	Sucker antenna see the PCB Photo
Frequency Tolerance:	N/A
Emission Type(s):	N/A
Interface Cables:	None
Power Source & Voltage:	12-48V
Sample Received Date:	Dec. 26, 2016
Sample tested Date:	Dec. 26, 2016 ~ Feb. 10, 2017

2.2 EUT Description

The LTE-Router is a network Router for household users. By connecting it to IP network through Ethernet interface or Wi-Fi, it can stream videos over the network to TV display panel via RSS 485 cable connection.

Product Name: LTE-Router

Model No. : TK8X2L, TK8X5L(X = 0-9) (The series model are the same in these: appearance, PCB layout, and basic software function; the differences are the software function and the numbers of Ethernet ports. X means different software functions. TK8X5L have five Ethernet ports; TK8x2L have two Ethernet ports.)

Tested Model No.: TK815L

EUT Rated Voltage: 12-48V

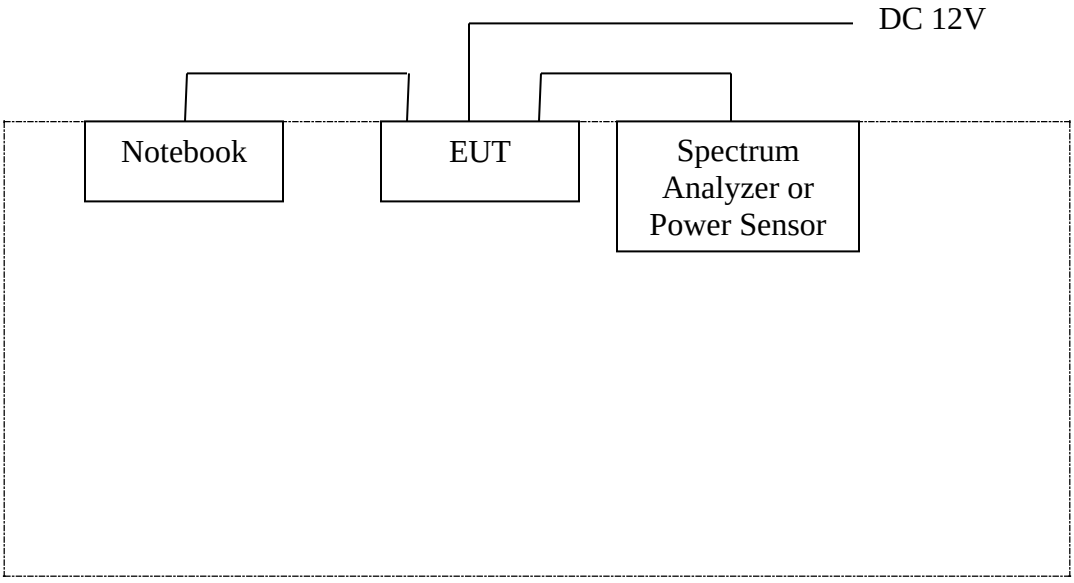
I/O Ports: Front Side: (1) RJ-45 Port*5; (2) SMA connection Port*5

2.3 Test Configuration

The Welotec GmbH LTE-Router, Equipment Under Test (EUT), was operated by 12-48VDC power supply.

The EUT was configured with DC power supply, an antenna, a support NB with RSS485 cable. The EUT firmware/software was set up to control power, bit rate, and channel selection.

RF test setup



Radiated test setup:

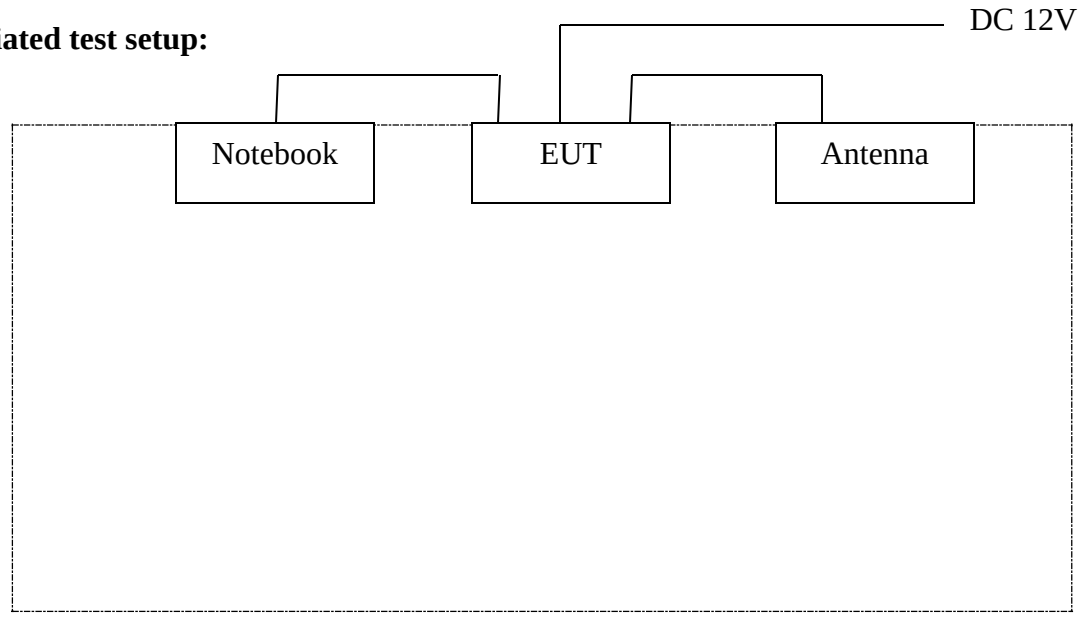


Figure 1: Test Configuration

2.4 Equipment Configuration

The EUT was set up as outlined in Radiated Emission Test Configuration photo. The EUT was comprised of the following equipment. (All Modules, PCBs, etc. listed were considered as part of the EUT, as tested.)

Table 2: Equipment Configuration

Name / Description	Model Number	Part Number	Serial Number	Revision
LTE-Router	TK815L	N/A	RF91516135343045	N/A

2.5 Interface Cables

Table 3: Interface Cables

Port Identification	Connector Type	Cable Length	Shielded (Y/N)	Termination Point
Antenna cable	SMA	2.0m	N	N/A
Antenna cable	SMA	2.0m	N	N/A
Antenna cable	SMA	0.3m	Y	N/A
Antenna cable	SMA	0.3m	Y	N/A

2.6 Support Equipment

The following support equipment was used during testing:

No.	Support Equipment	Model/Part Number	Serial Number
1	Lenovo Notebook	Thinkpad E450	SL10G10780
2	DC Power	N/A	N/A

2.7 EUT Modifications

No modifications were performed in order to meet the test requirements:

2.8 Testing Algorithm

The TK815L LTE-Router was operated using and drivers.

2.9 Test Location

1. RF measurements herein were performed at Shenzhen UnionTrust Quality and Technology Co., Ltd.
2. Radiated measurements herein were performed at Compliance Certification Services (Shenzhen) Inc.

2.10 Measurements

2.10.1 Measurement Method

All measurements were performed according to the 2013 version of ANSI C63.10 for testing compliance of a wide variety of unlicensed wireless devices

2.11 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{div_a{}^2} + \frac{b^2}{div_b{}^2} + \frac{c^2}{div_c{}^2} + ...}$$

where u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$div_{a,\ b,\ c}$ = the individual uncertainty element divisor based on the probability distribution

divisor = 1.732 for rectangular distribution

divisor = 2 for normal distribution

divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

where U = expanded uncertainty

k = coverage factor

k ≤ 2 for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 4 below.

Table 4: Expanded Uncertainty List

Scope	Expanded Uncertainty
Uncertainty for Radiation Emission test in 3m chamber	±3.8928dB(30~200MHz)
	±3.8753dB(200~1000MHz)
	±5.3112dB(1000~8000MHz)
	±5.3493dB(8000~18000MHz)

3 Test Equipment

Table 5 shows a list of the test equipment used for measurements along with the calibration information.

Table 5: Test Equipment List

Radiated Test Equipment List (CCS)

Item	Instrument	Manufacturer	Type No./Serial No	Last Cal.	Calibration interval
1	PSA Series Spectrum Analyzer	Agilent	E4446A/US44300399	02-20-2017	1 Year
2	Turn Table	N/A	N/A	N.C.R	N.C.R
3	Controller	Sunol Sciences	SC104V/022310-1	N.C.R	N.C.R
4	Controller	CT	N/A	N.C.R	N.C.R
5	Bilog Antenna	SCHAFFNER	CBL6143/5063	02-21-2017	1 Year
6	Horn Antenna	SCHWARZBECK	BBHA9120/D286	02-20-2017	1 Year
7	Loop Antenna	COM-POWER	AL-130/121044	02-20-2017	1 Year
8	High Noise Amplifier	Agilent	8449B/3008A01838	02-21-2017	1 Year
9	Horn Antenna	Schwarzbeck	BBHA9120/ D286	02-21-2017	1 Year
10	Temp. / Humidity Meter	Anymetre	JR913/N/A	02-21-2017	N.C.R
11	Antenna Tower	SUNOL	TLT2/N/A	N.C.R	N.C.R
12	Test S/W	FARAO	LZ-RF / CCS-SZ-3A2		

RF Test Equipment List (UnionTrust)

Item	Instrument	Manufacturer	Type No./Serial No	Last Cal.	Calibration interval
1	EXA Spectrum Analyzer	KEYSIGHT	N9010A/ MY51440197	12-22-2017	1 Year
2	USB Wideband Power Sensor	KEYSIGHT	U2021XA/ MY55430035	12-22-2017	1 Year
3	USB Wideband Power Sensor	KEYSIGHT	U2021XA/ MY55430023	12-22-2017	1 Year

4 System Test Configuration

For emissions testing, the equipment under test (EUT) setup to transmit continuously to simplify the measurement methodology. Care was taken to ensure proper power supply voltages during testing. During testing, radiated emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario. It was powered by a 12~24Vdc DC power. Only the worst case data were recorded in this test report.

For STBC modes (2Tx), there are two transmission antennas. Both Chain 1 and Chain 2 used at the same time and antenna ports have uniform output powers. The Chain 1 and Chain 2 antenna ports cannot be used alone.

The signal is maximized through rotation and placement in the three orthogonal axes. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters. Radiated emissions are taken at three meters unless the signal level is too low for measurement at that distance. If necessary, a pre-amplifier is used and/or the test is conducted at a closer distance. Therefore, all final radiated testing was performed with the EUT in (see table below) orientation.

Frequency Band(GHz)	Mode	Antenna Port	Worst-case Orientation
2.4~2.4835	1TX SISO	Chain 1	Y-Portrait
		Chain 2	Y-Portrait
	2TX STBC	Chain 1 + Chain 2	Y-Portrait

Worst-case data rates see table below:

Mode	Worst-case data rates		
	SISO Mode		STBC Mode
	Chain 1	Chain 2	Chain 1+2
802.11b	1 Mbps	1 Mbps	1 Mbps
802.11g	6 Mbps	6 Mbps	6 Mbps
802.11n HT20	MCS 0	MCS 0	MCS 0
802.11n HT40	MCS 0	MCS 0	MCS 0

All readings are extrapolated back to the equivalent three meter reading using inverse scaling with distance. Analyzer resolution is 100 kHz or greater for frequencies below 1000MHz. The resolution is 1 MHz or greater for frequencies above 1000MHz. The spurious emissions more than 20 dB below the permissible value are not reported.

Radiated emission measurement were performed from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

5 Duty Cycle of Test Signal and Measurement Methods

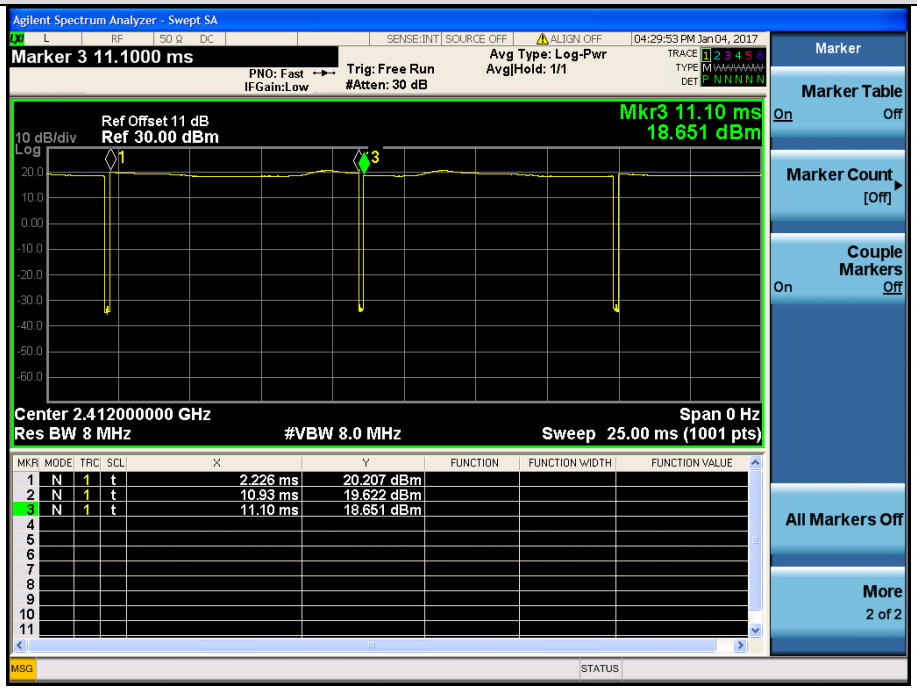
5.1 Duty Cycle

Mode	Data rates (Mbps)	Transmission Duration T (msec)	Period (msec)	Duty Cycle (linear)	Duty Cycle (%)	Duty Cycle Factor (dB)	1/ T Minimum VBW (kHz)
802.11b	1Mbps	8.7040	8.8740	0.98	98.08	0.00	0.01
802.11g	1Mbps	1.4425	1.6385	0.88	88.04	0.55	0.69
802.11n(HT20)	MCS0	1.3665	1.5625	0.87	87.46	0.58	0.73
802.11n(HT40)	MCS0	0.6673	0.8690	0.77	76.79	1.15	1.50

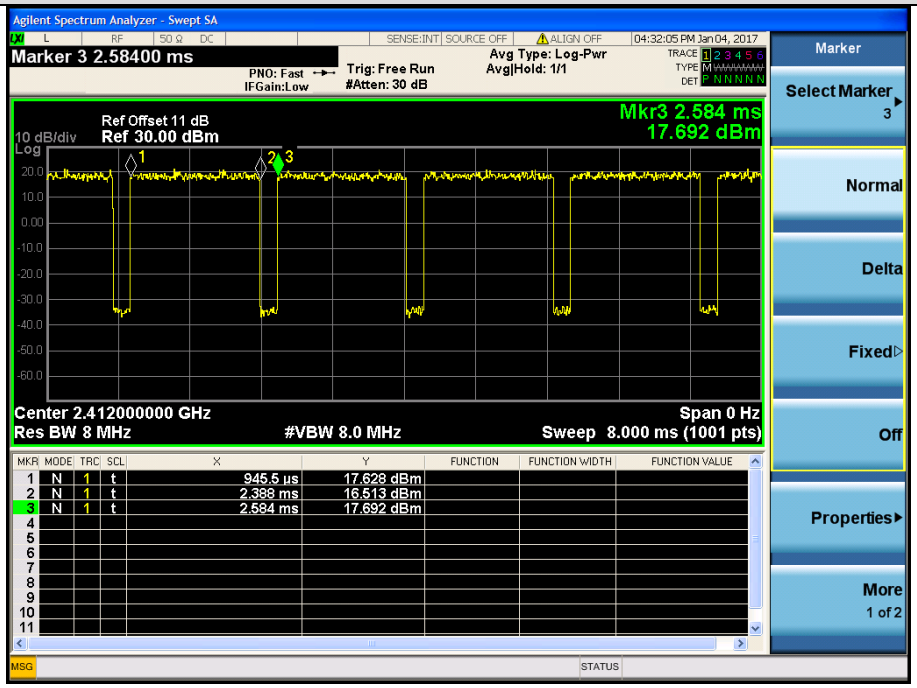
Remark:

1. Duty cycle = On Time/ Period;
2. Duty Cycle factor = 10 * log(1/ Duty cycle)
3. Period = Mkr3 - Mkr1
4. Transmission Duration = Mkr2 - Mkr1

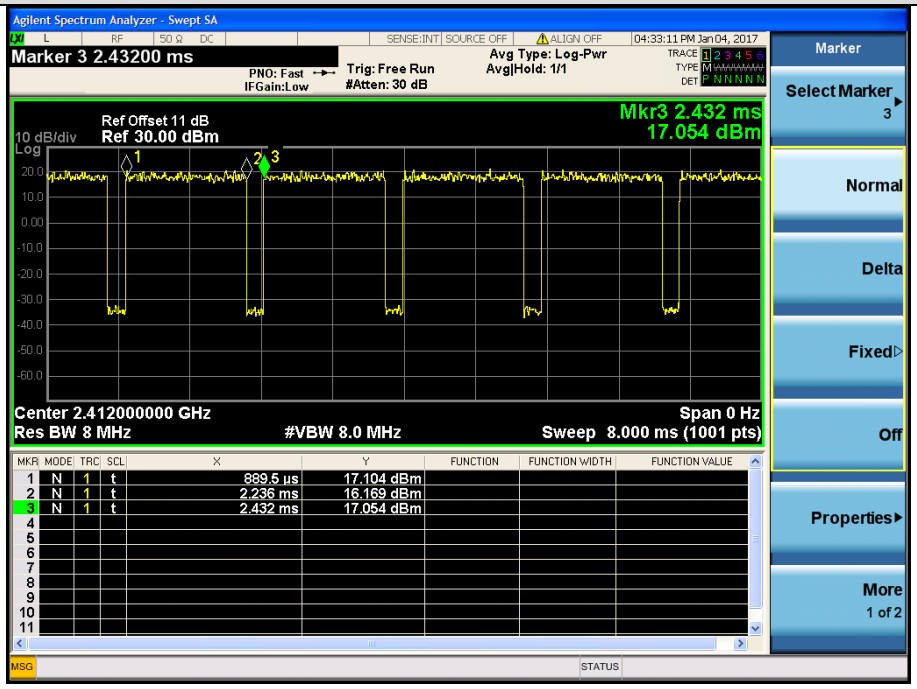
Test Mode: 802.11b_ 1Mbps



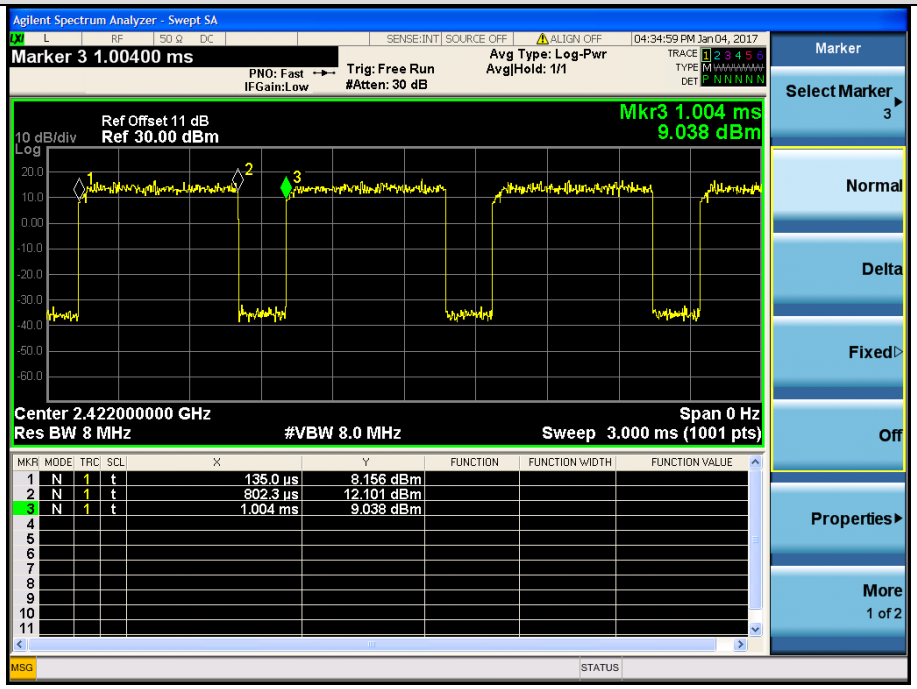
Test Mode: 802.11g_6Mbps



Test Mode: 802.11n(HT20)_MCS0



Test Mode: 802.11n(HT40) _MCS0



5.2 Measurement Methods

KDB 558074 D01 DTS Meas Guidance v03r05

KDB 662911 D01 Multiple Transmitter Output v02r01

ANSI C63.10-2013

6 Test Results

6.1 RF Power Output

To measure the output power the unit was set to transmit on a low, high and middle channel. The output from the transmitter was connected to an attenuator and then to the input of a detector diode. The output of the detector diode was displayed on an oscilloscope. The trace deflection was recorded and the transmitter was replaced with a signal generator at the same frequency. The output of the signal generator was increased until the trace deflection was the same as it was with the transmitter. The signal from the generator was then connected to a power meter and the level was taken.

6.1.1 Limit

For systems using digital modulation in the 2400—2483.5MHz, The Peak output Power shall not exceed 1W (30dBm)

6.1.2 Test Procedure(KDB 558074 D01 v03r05, Section 9.1.2)

1, Connected the EUT's antenna port to measure device by 10dB attenuator.

2, For IEEE 802.11b/g and IEEE802.11n HT20 and HT40 mode, use a PK or Average power meter which's bandwidth is 20MHz up to 40MHz and above 6dB bandwidth of signal to measure out each test modes' PK or Average output power.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

6.1.3 Test Data

The EUT complied with the FCC Part 15.247 RF Power Output requirements.

Table 6 provides the test results for RF Power Output. (All the data attached was use the worst case data rate data)

6.1.4 Areas of Concern

None.

Table 6: RF Output Peak Power

Chain 1 and Chain 2 (SISO Mode)-Test Data

IEEE 802.11b

Channel	Freq. (MHz)	Chain	RF Output Peak Power (dBm)			
			DSSS Data Rate			
			1 Mbps	2 Mbps	5.5Mbps	11 Mbps
1	2412	1	**18.51**	18.41	18.34	18.32
		2	**18.23**	18.15	18.07	18.01
6	2437	1	**18.66**	18.56	18.48	18.34
		2	**18.57**	18.46	18.38	18.25
11	2462	1	**18.16**	18.12	18.10	18.11
		2	**18.18**	18.14	18.06	18.03

IEEE 802.11g

Channel	Freq. (MHz)	Chain	RF Output Peak Power (dBm)							
			OFDM Data Rate							
			6 Mbps	9 Mbps	12 Mbps	18 Mbps	24 Mbps	36 Mbps	48 Mbps	54 Mbps
1	2412	1	**19.43**	19.32	19.25	19.21	19.14	18.79	16.03	16
		2	**19.51**	19.45	19.36	19.25	19.14	18.65	16.36	16.29
6	2437	1	**19.56**	19.55	19.42	19.33	19.25	18.88	16.14	16.09
		2	**19.78**	19.64	19.57	19.41	19.36	18.71	16.75	16.63
11	2462	1	**19.75**	19.64	19.58	19.34	19.21	18.89	16.12	16.1
		2	**19.83**	19.76	19.54	19.34	19.21	18.97	16.65	16.51

IEEE 802.11n (HT20)

Channel	Freq. (MHz)	Chain	RF Output Peak Power (dBm)							
			OFDM Data Rate							
			MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
1	2412	1	**19.68**	19.53	19.45	19.38	19.23	19.08	16.53	16.33
		2	**19.38**	19.28	19.17	19.09	18.95	18.28	16.08	16.02
6	2437	1	**19.53**	19.43	19.37	19.28	19.13	19.05	16.49	16.24
		2	**19.56**	19.47	19.31	19.22	19.17	18.56	16.38	16.31
11	2462	1	**19.81**	19.74	19.64	19.51	19.32	19.12	16.74	16.23
		2	**19.93**	19.75	19.67	19.52	19.41	18.86	16.97	16.74

IEEE 802.11(HT40)

Channel	Freq. (MHz)	Chain	RF Output Peak Power (dBm)							
			OFDM Data Rate							
			MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
3	2422	1	**18.54**	18.47	18.33	18.24	18.13	18.07	16.08	15.39
		2	**18.73**	18.64	18.58	18.41	18.39	18.25	16.17	16.04
6	2437	1	**18.86**	18.74	18.66	18.52	18.45	18.36	16.04	15.63
		2	**18.89**	18.77	18.69	18.54	18.46	18.37	16.22	15.79
9	2452	1	**19.23**	19.12	18.97	18.95	18.87	18.75	16.63	15.89
		2	**19.36**	19.23	19.18	19.14	18.97	18.87	16.78	15.93

Chain 1 + Chain 2 (STBC Mode)-Test Data

Mode	Channel /Freq. (MHz)	RF Output Peak Power (dBm)			Limit (dBm)	Pass/Fail
		Chain 1 Power	Chain 2 Power	Total Power (Chain 1+2)		
IEEE 802.11b	1/2412	18.51	18.23	21.38	30	Pass
	6/2437	18.66	18.57	**21.63**	30	Pass
	11/2462	18.16	18.18	21.18	30	Pass
IEEE 802.11g	1/2412	19.43	19.51	22.48	30	Pass
	6/2437	19.56	19.78	22.68	30	Pass
	11/2462	19.75	19.83	**22.80**	30	Pass
IEEE 802.11n (HT20)	1/2412	19.68	19.38	22.54	30	Pass
	6/2437	19.53	19.56	22.56	30	Pass
	11/2462	19.81	19.93	**22.88**	30	Pass
IEEE 802.11n (HT40)	3/2422	18.54	18.73	21.65	30	Pass
	6/2437	18.86	18.89	21.89	30	Pass
	9/2452	19.23	19.36	**22.31**	30	Pass

Remark:

1. According exploratory test, EUT will have maximum output power as above bolded data rate, so those data rate were used for all test.
2. Total Power (Chain 1+2) = $10*\log[(10^{\text{Chain 1}/10})+(10^{\text{Chain 2}/10})]$
3. Directional gain and the maximum conducted output power see table below:

Frequency	Chain 1 Antenna Gain (dBi)	Chain 2 Antenna Gain (dBi)	Directional gain (dBi)	Peak Power Limits (dBm)
2.4 GHz	2	2	5	30
NOTE: All transmit signals are correlated with each other. The directional gain = G_{ANT} + 10 log(N) dBi = 2 + 10 log(2) = 5dBi				

RF Output Average Power

Mode	Channel /Freq. (MHz)	RF Output Average Power (dBm)				
		Measured Power		Power with Duty Factor		Total Power
		Chain 1	Chain 2	Chain 1	Chain 2	(Chain 1+2)
IEEE 802.11b	1/2412	14.68	14.53	14.68	14.53	17.62
	6/2437	14.74	14.78	14.74	14.78	**17.77**
	11/2462	14.41	14.33	14.41	14.33	17.38
IEEE 802.11g	1/2412	10.44	10.51	10.99	11.06	14.04
	6/2437	10.46	10.60	11.01	11.15	14.09
	11/2462	10.58	11.12	11.13	11.67	14.42
IEEE 802.11n (HT20)	1/2412	10.17	10.13	10.75	10.71	13.74
	6/2437	10.23	10.35	10.81	10.93	13.88
	11/2462	10.26	10.81	10.84	11.39	14.13
IEEE 802.11n (HT40)	3/2422	9.71	9.79	10.86	10.94	13.91
	6/2437	9.72	9.82	10.87	10.97	13.93
	9/2452	9.90	10.32	11.05	11.47	14.28

Remark:

1. All the data attached was use the worst case data rate.
2. Power with Duty Factor = Measured Power + Duty Cycle Factor.(The Duty Cycle Factor See Section 5.1)
3. Total Power (Chain 1+2) = $10*\log[(10^{\text{Chain 1}/10})+(10^{\text{Chain 2}/10})]$.

6.2 RF Power Spectral Density

The output from the transmitter was connected to an attenuator and then to the input of the RF Spectrum Analyzer. The analyzer offset was adjusted to compensate for the attenuator and other losses in the system.

6.2.1 Limit

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

6.2.2 Test Procedure(KDB 558074 D01 v03r05, Section 10.2)

This procedure shall be used if maximum peak conducted output power was used to demonstrate compliance, and is optional if the maximum conducted (average) output power was used to demonstrate compliance.

a) Set analyzer center frequency to DTS channel center frequency.
b) Set the span to 1.5 times the DTS bandwidth.
c) Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
d) Set the VBW ≥ 3 x RBW.
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.

If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

6.2.3 Test Data

The EUT complied with the FCC Part 15.247 RF Power Spectral Density requirements.

Table 7 provides the test results for RF Power Spectral Density. (All the data attached was use the worst case data rate data)

6.2.4 Areas of Concern

None.

Table 7: RF Power Spectral Density

Mode	Channel /Freq. (MHz)	PSD (dBm)			Limit (dBm)	Pass/Fail
		SISO Mode		STBC Mode		
		Chain 1 PSD	Chain 2 PSD	Total PSD (Chain 1+2)		
IEEE 802.11b	1/2412	-14.360	-14.239	-11.289	8	Pass
	6/2437	-14.290	-14.039	-11.152	8	Pass
	11/2462	-13.236	-13.664	-10.434	8	Pass
IEEE 802.11g	1/2412	-16.303	-15.175	-12.692	8	Pass
	6/2437	-15.497	-16.122	-12.788	8	Pass
	11/2462	-15.905	-15.700	-12.791	8	Pass
IEEE 802.11n (HT20)	1/2412	-15.782	-14.775	-12.239	8	Pass
	6/2437	-15.501	-14.825	-12.140	8	Pass
	11/2462	-16.119	-14.518	-12.235	8	Pass
IEEE 802.11n (HT40)	3/2422	-18.828	-17.258	-14.962	8	Pass
	6/2437	-19.284	-18.222	-15.710	8	Pass
	9/2452	-19.118	-18.620	-15.852	8	Pass

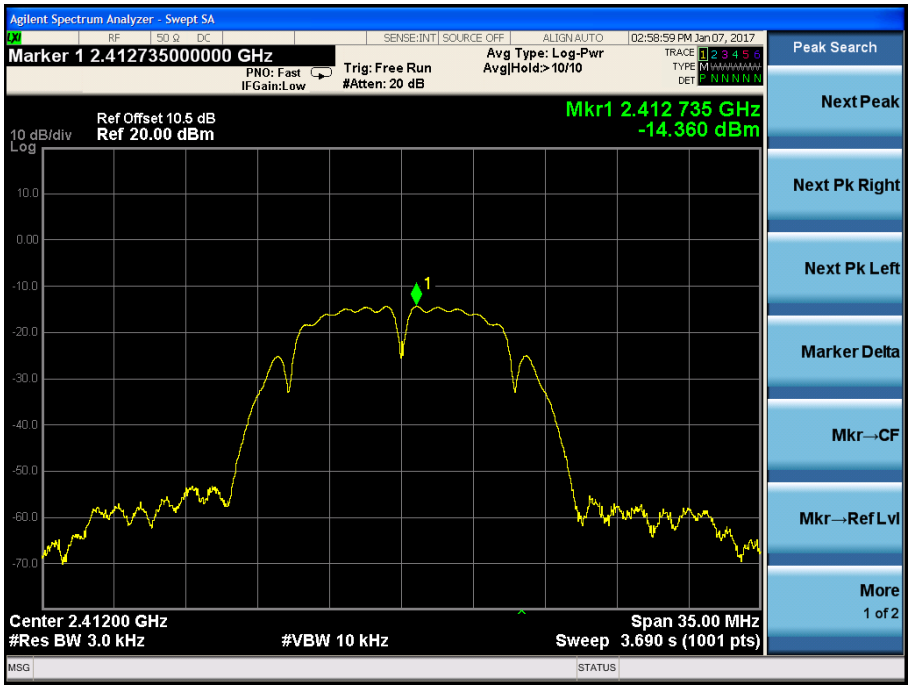
Remark:

1. All the data attached was use the worst case data rate.
2. Total PSD (Chain 1+2) = $10*\log[(10^{\text{Chain 1}/10})+(10^{\text{Chain 2}/10})]$

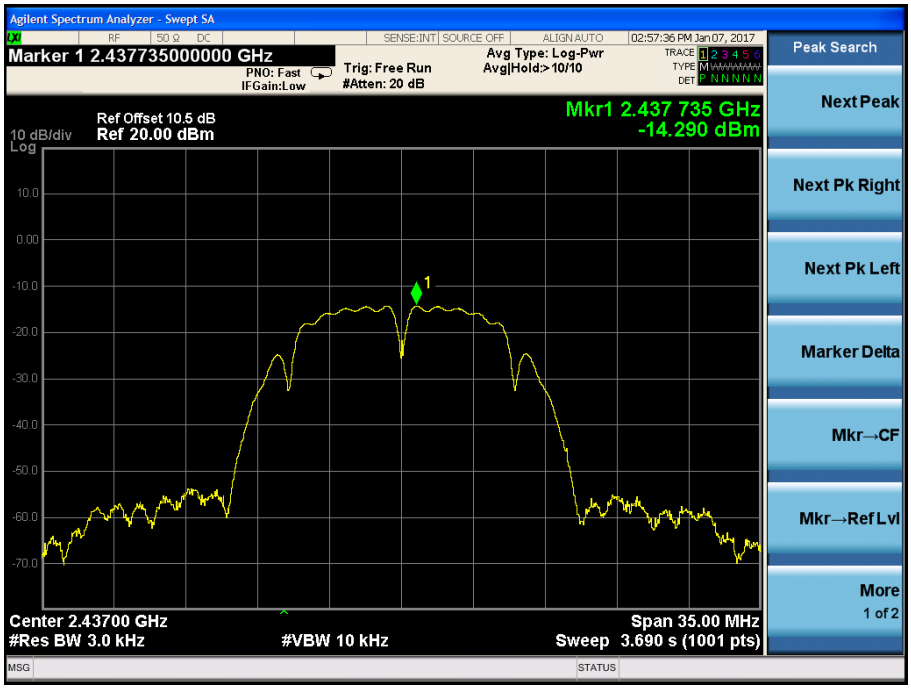
Chain 1-Test plot as follows

Test Mode: IEEE 802.11b TX

Test CH1: 2412MHz



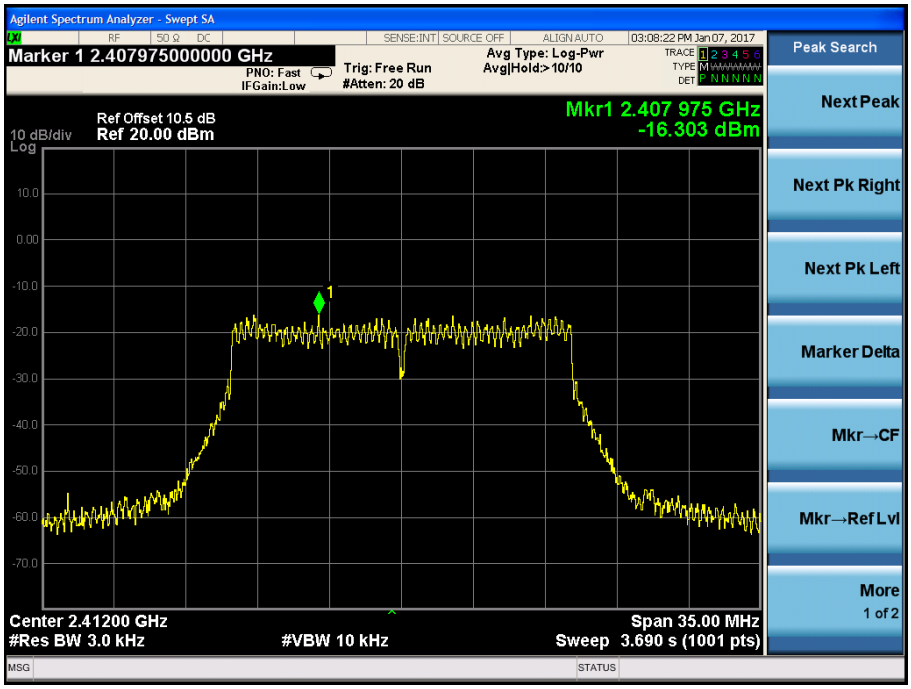
Test CH6: 2437MHz



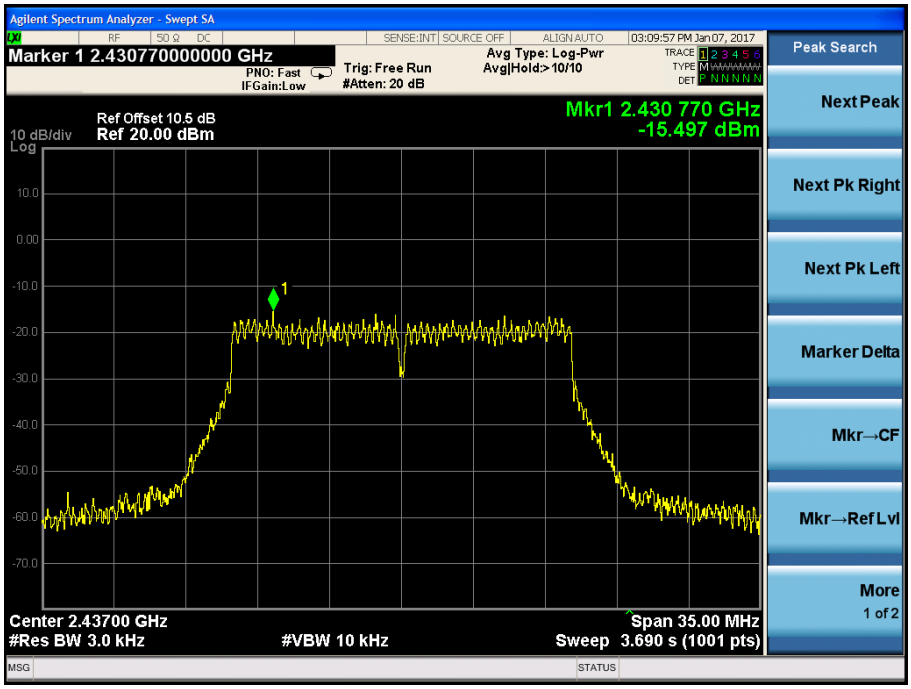
Test CH11: 2462MHz

Test Mode: IEEE 802.11g TX

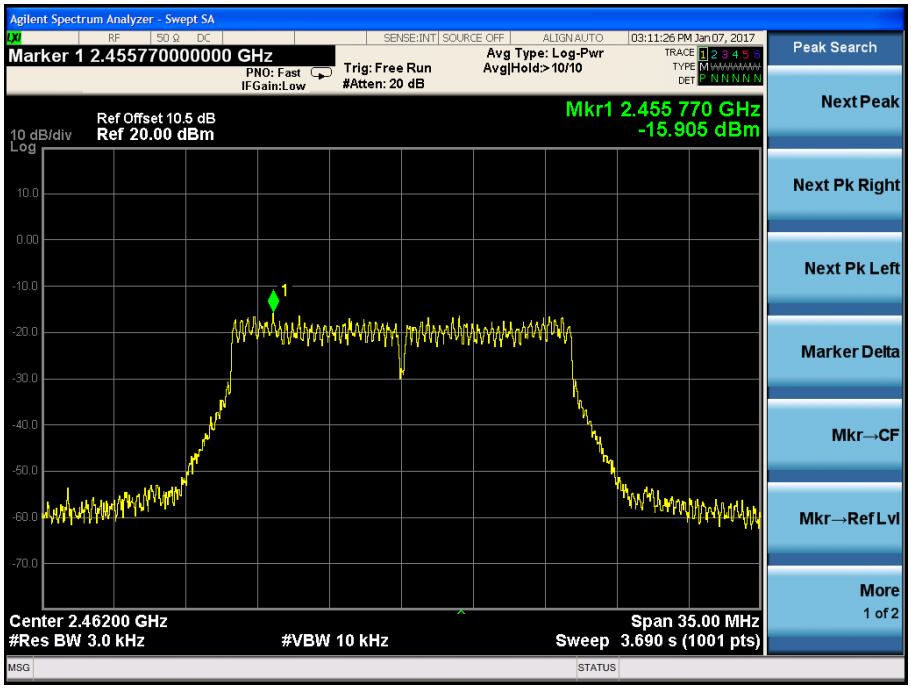
Test CH1: 2412MHz



Test CH6: 2437MHz

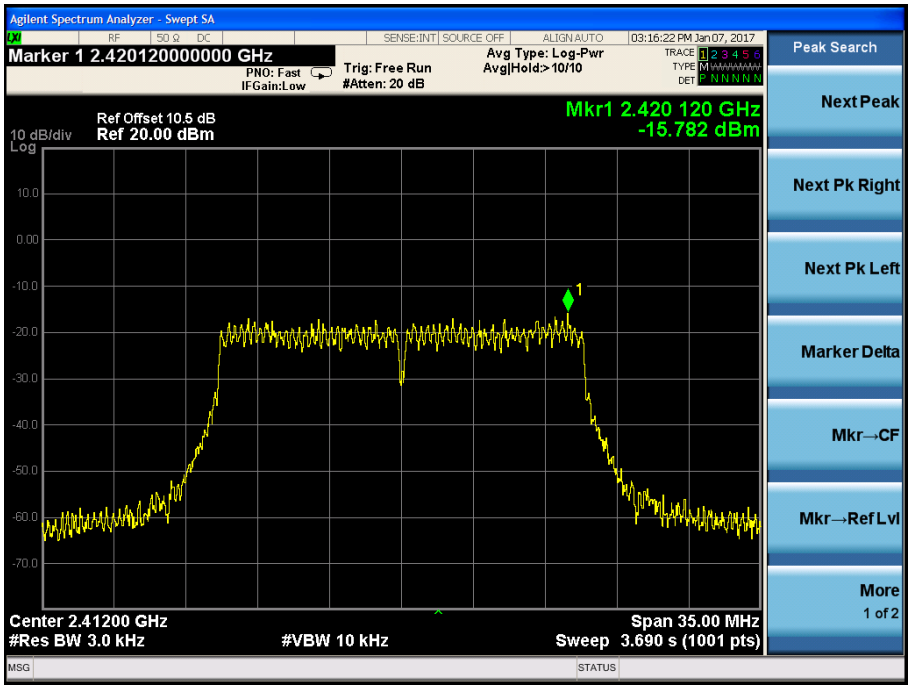


Test CH11: 2462MHz

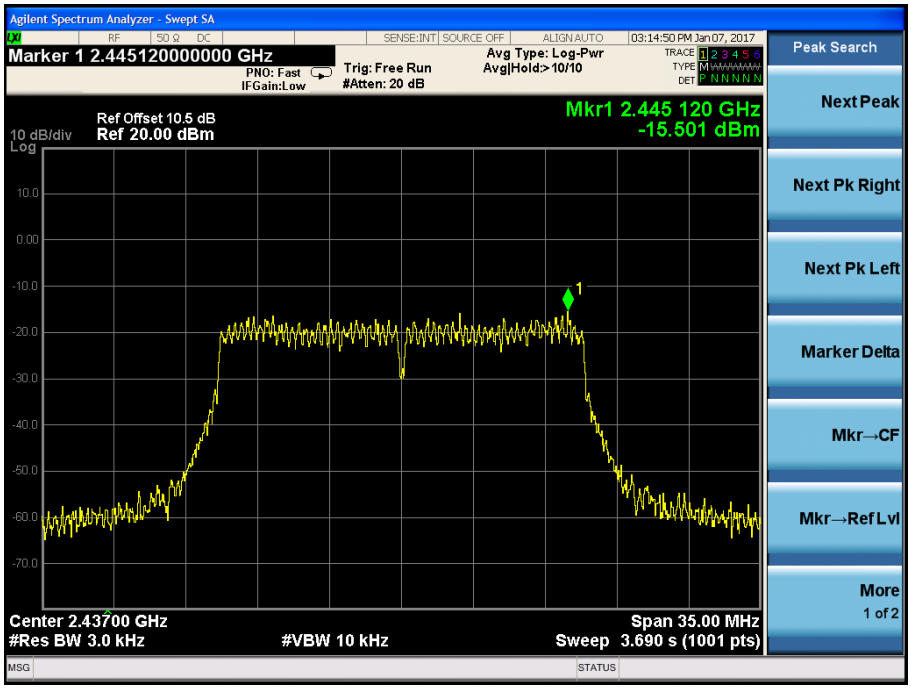


Test Mode: IEEE 802.11n (HT20) TX

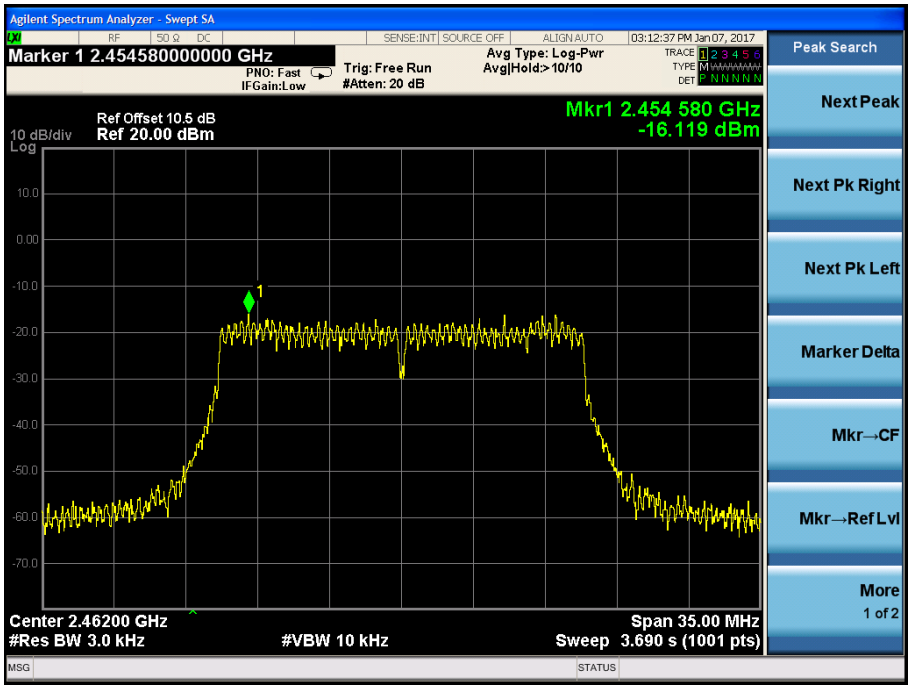
Test CH1: 2412MHz



Test CH6: 2437MHz

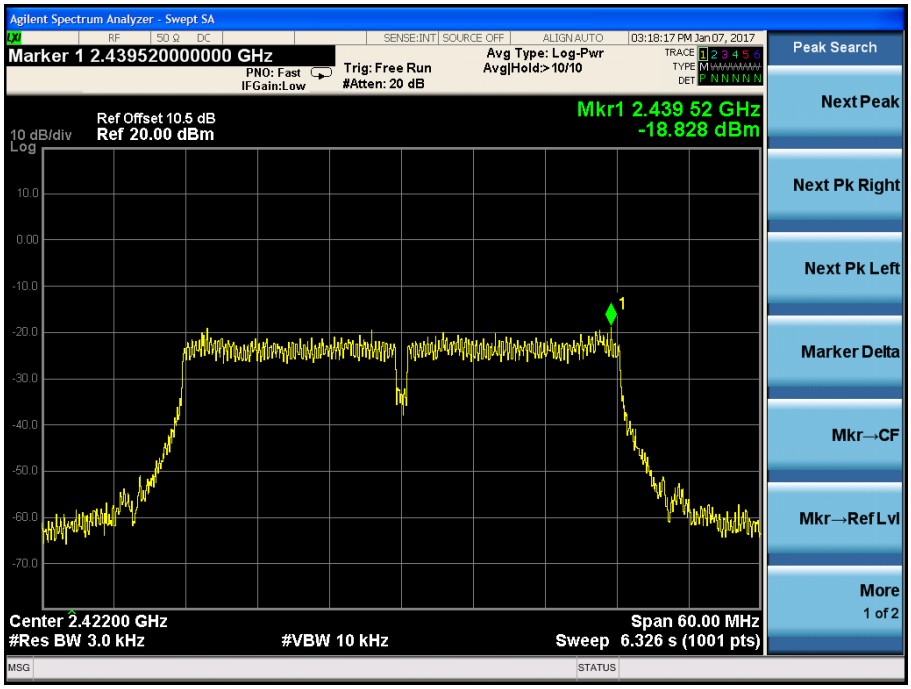


Test CH11: 2462MHz

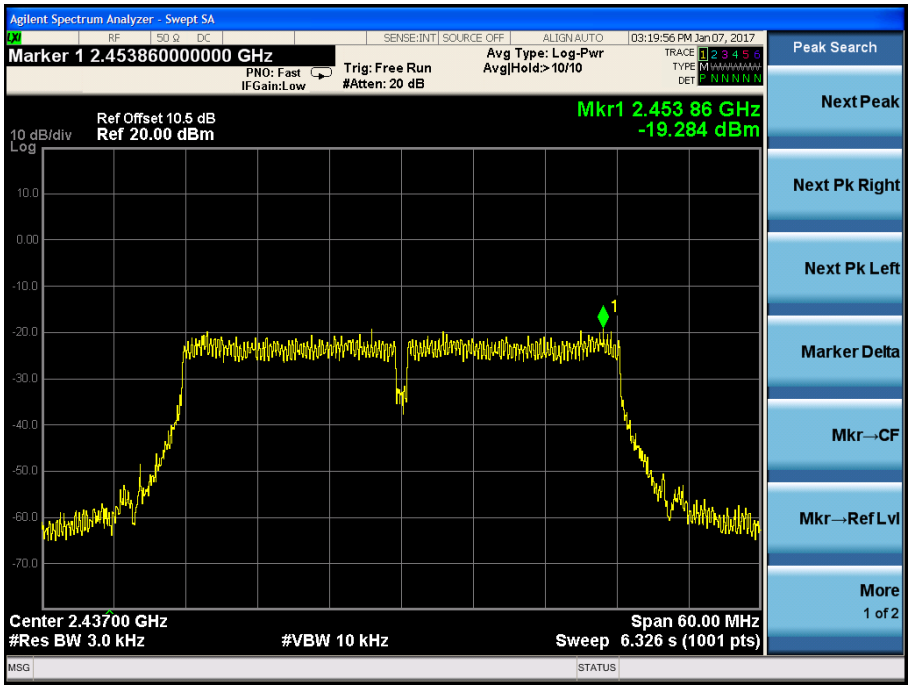


Test Mode: IEEE 802.11n (HT40) TX

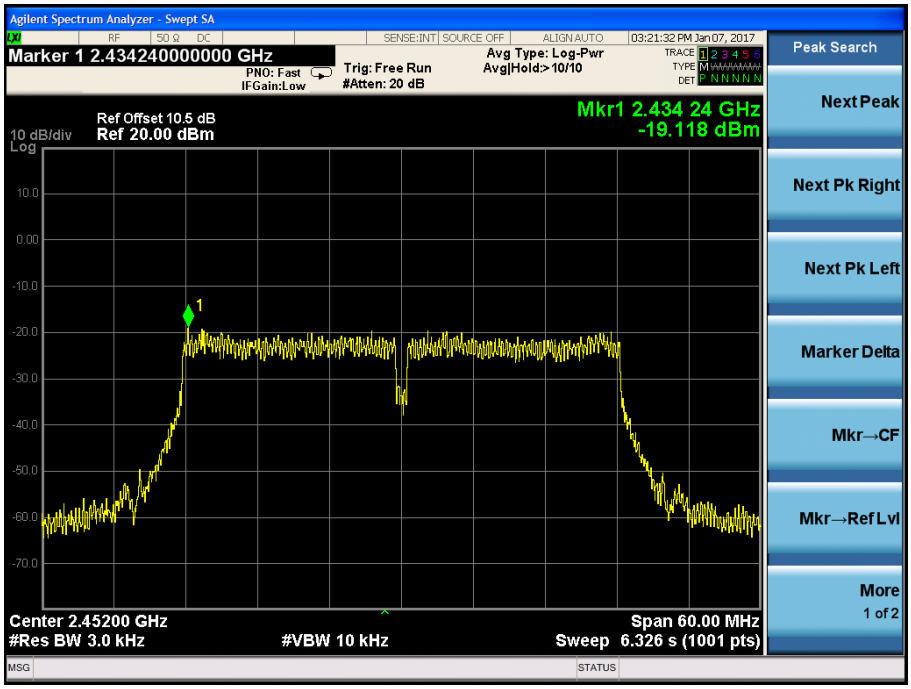
Test CH3: 2422MHz



Test CH6: 2437MHz



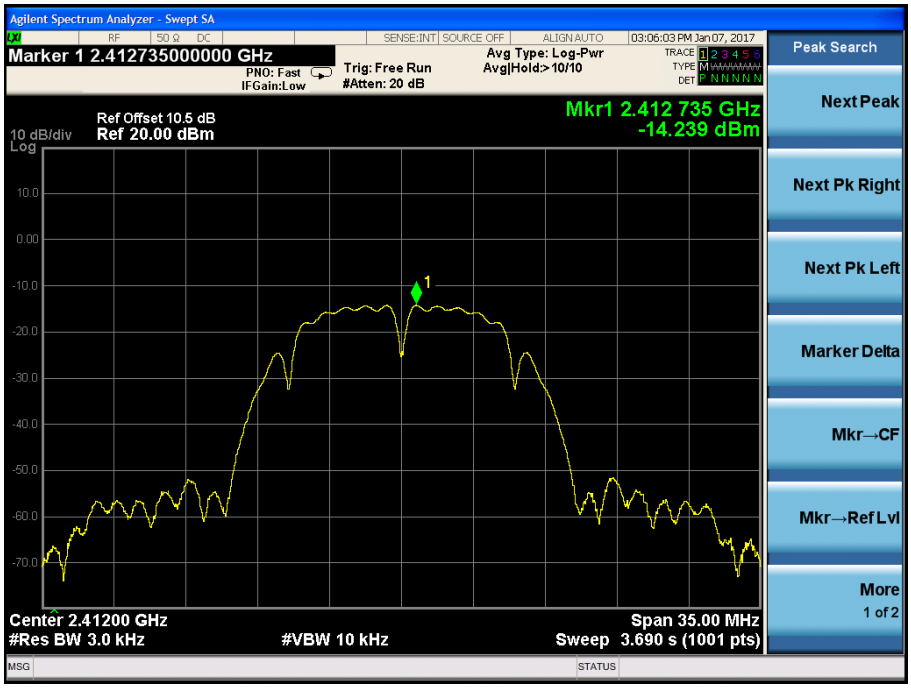
Test CH9: 2452MHz



Chain 2-Test plot as follows

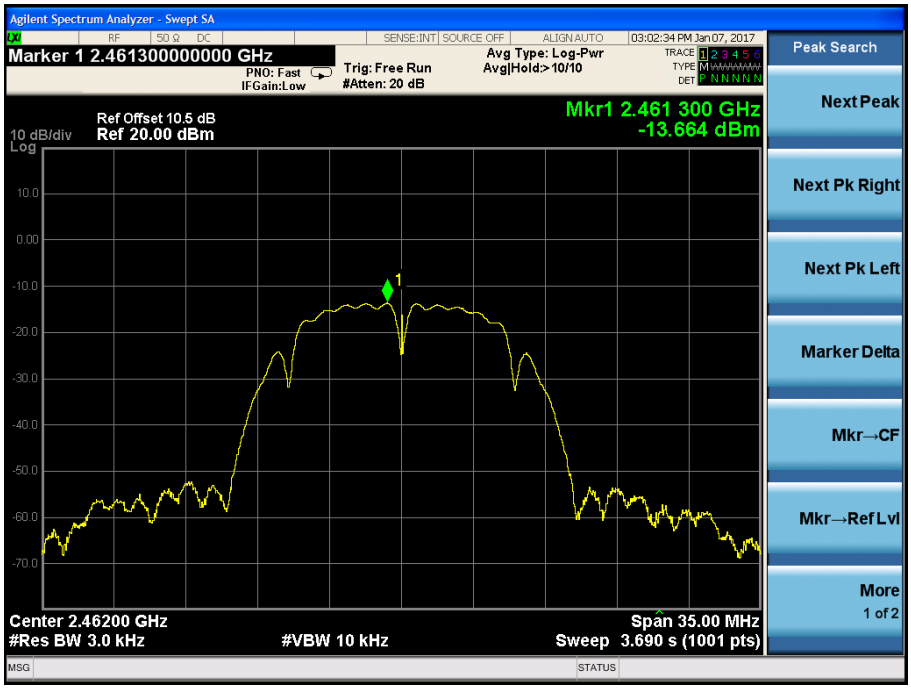
Test Mode: IEEE 802.11b TX

Test CH1: 2412MHz

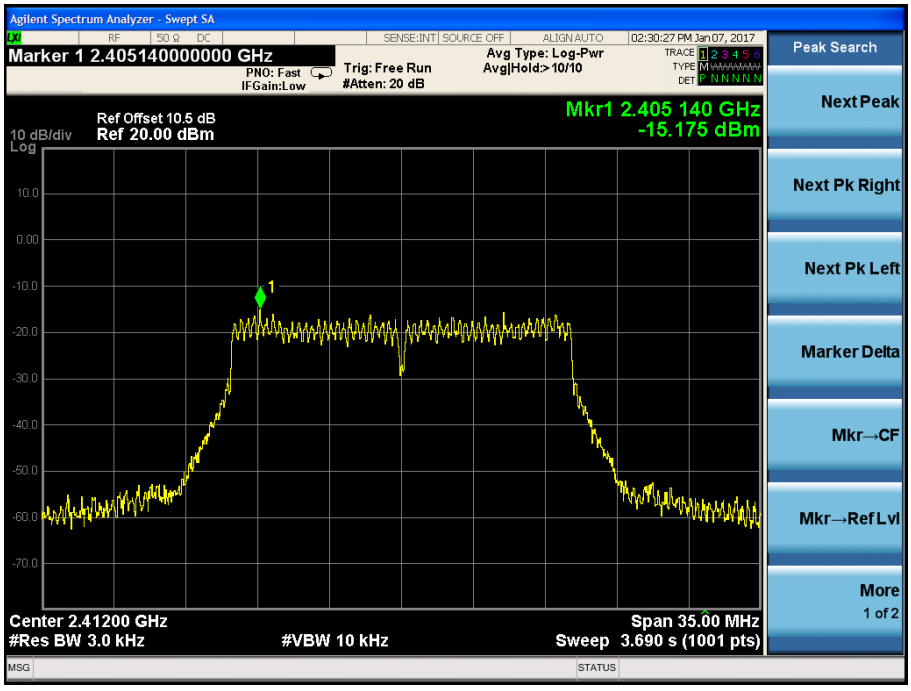


Test CH6: 2437MHz

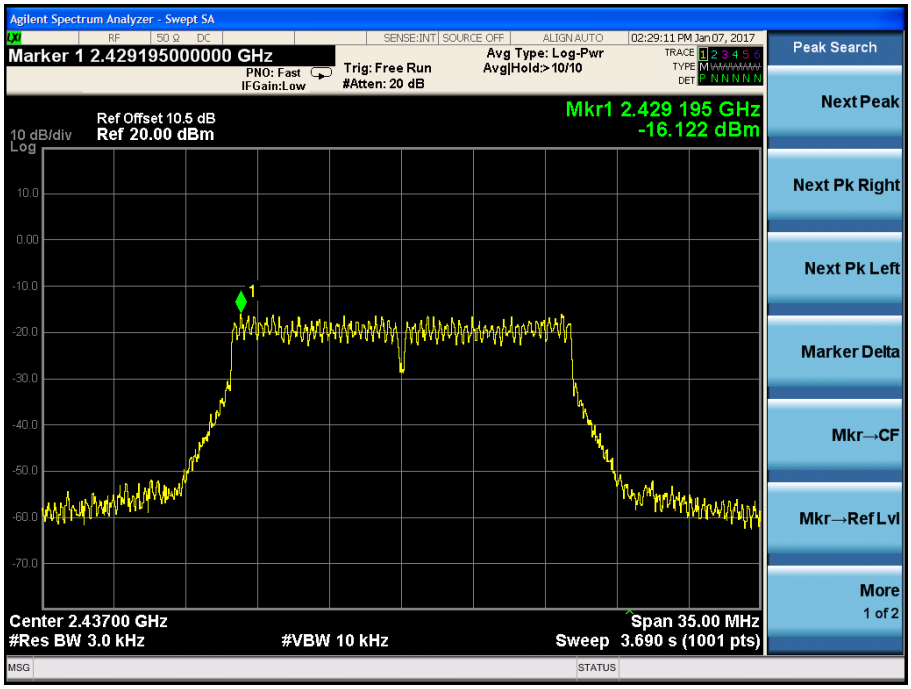
Test CH11: 2462MHz



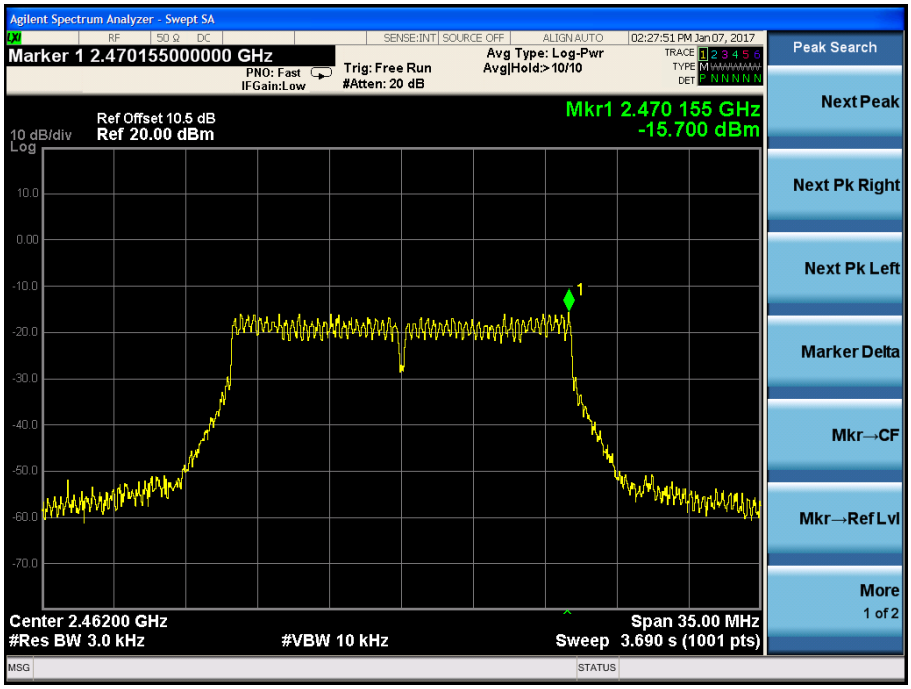
Test Mode: IEEE 802.11g TX Test CH1: 2412MHz



Test CH6: 2437MHz

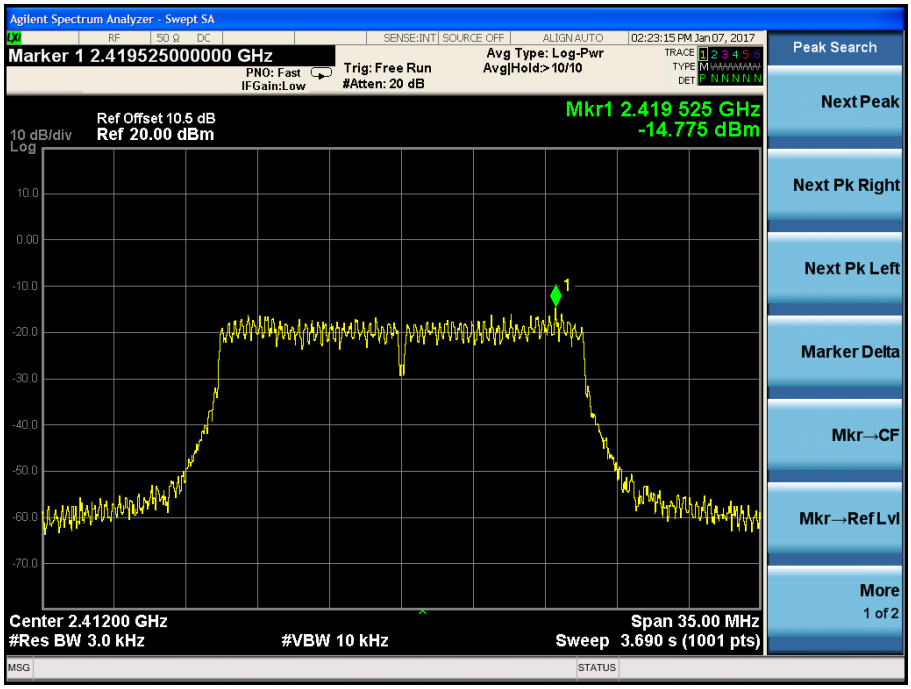


Test CH11: 2462MHz

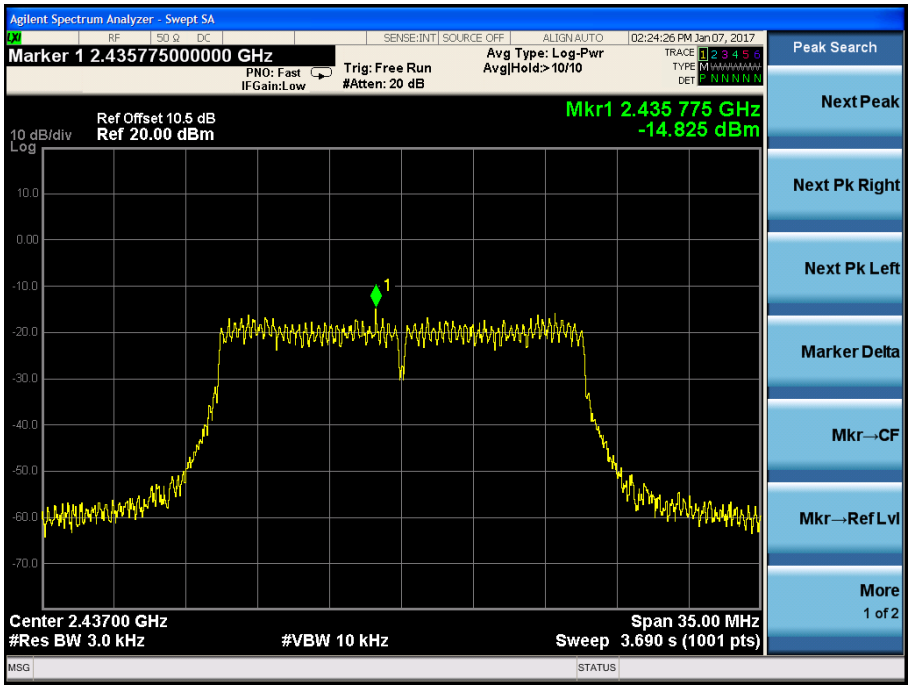


Test Mode: IEEE 802.11n (HT20) TX

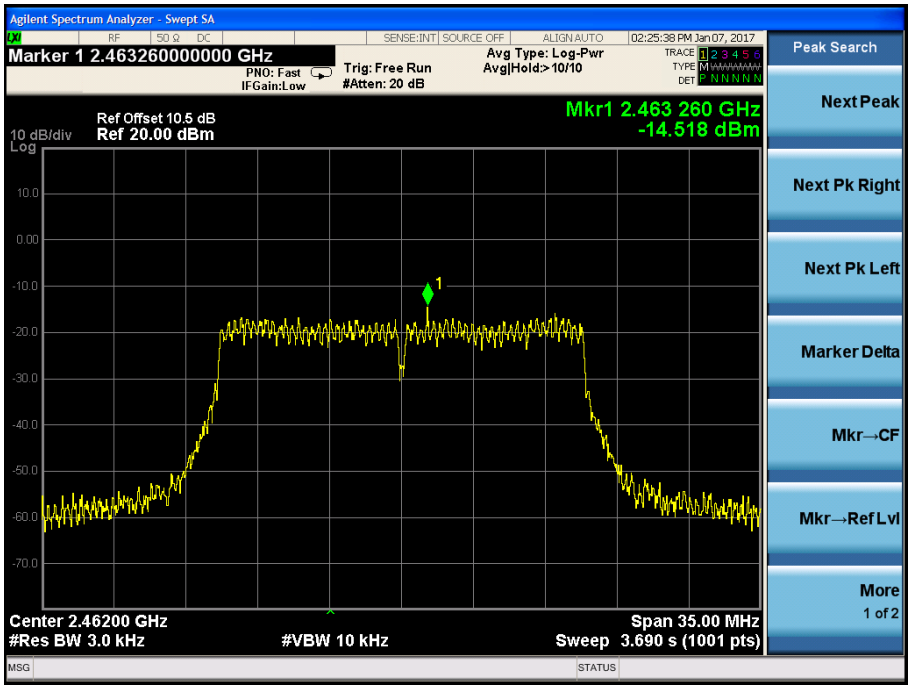
Test CH1: 2412MHz



Test CH6: 2437MHz

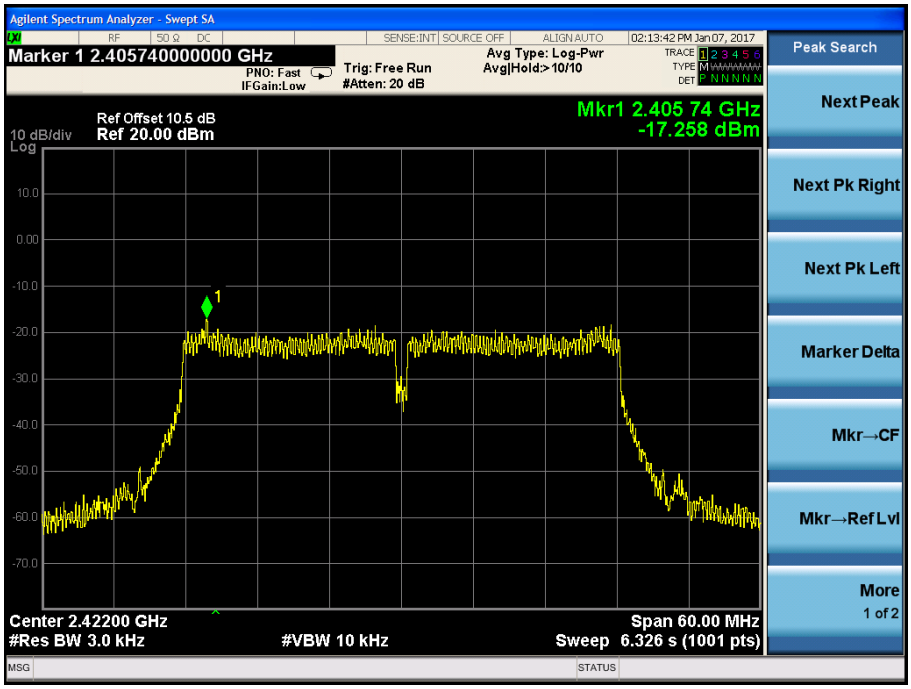


Test CH11: 2462MHz

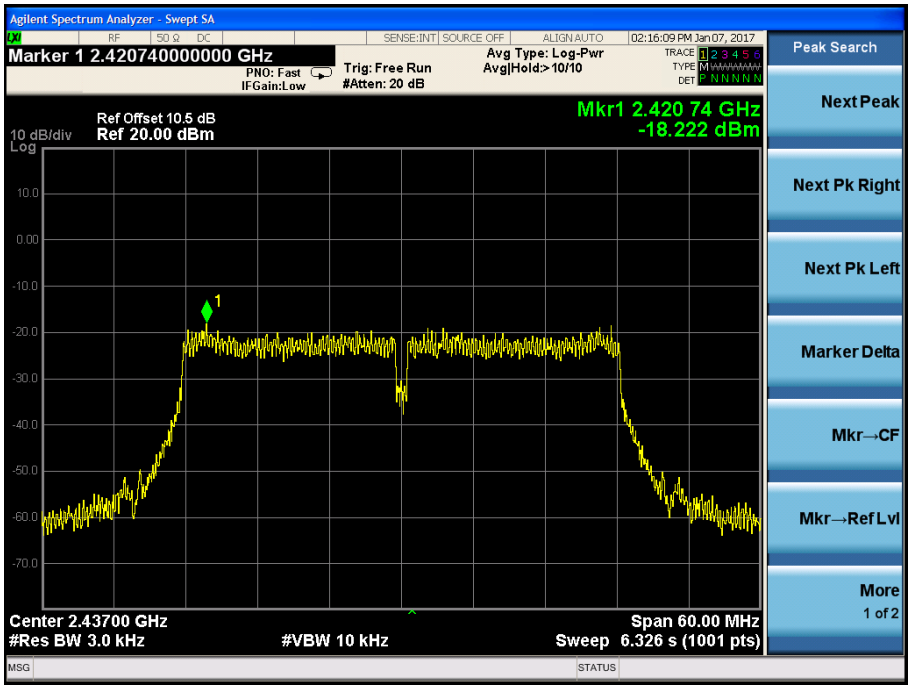


Test Mode: IEEE 802.11n (HT40) TX

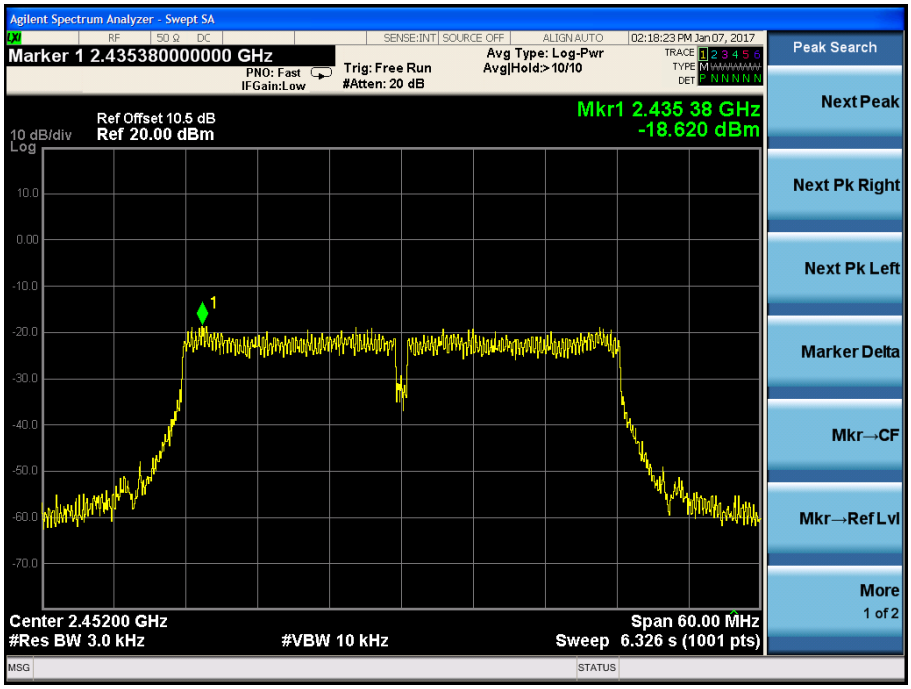
Test CH3: 2422MHz



Test CH6: 2437MHz



Test CH9: 2452MHz



6.3 Occupied Bandwidth

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer.

6.3.1 Limit

For direct sequence systems, the minimum 6dB bandwidth shall be at least 500 kHz

6.3.2 Test Procedure(KDB 558074 D01 v03r05, Section 8.1)

a) Set RBW = 100 kHz.

b) Set the video bandwidth (VBW) ≥ 3 x RBW.

c) Detector = Peak.

d) Trace mode = max hold.

e) Sweep = auto couple.

f) Allow the trace to stabilize.

g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

6.3.3 Test Data

The EUT complied with the FCC Part 15.247 Occupied bandwidth requirements.

Table 8 provides the test results for occupied bandwidth. (All the data attached was use the worst case data rate as in table 6)

6.3.4 Areas of Concern

None.

Table 8: Occupied Bandwidth Results

Mode	Channel /Freq. (MHz)	6dB BW (MHz)		OBW (MHz)		6dB BW Limit	Pass/Fail
		Chain 1	Chain 2	Chain 1	Chain 2		
IEEE 802.11b	1/2412	10.04	10.07	12.337	12.368	> 500 kHz	Pass
	6/2437	9.756	10.07	12.326	12.392	> 500 kHz	Pass
	11/2462	10.07	10.07	12.355	12.306	> 500 kHz	Pass
IEEE 802.11g	1/2412	16.37	16.37	16.483	16.473	> 500 kHz	Pass
	6/2437	16.38	16.38	16.476	16.481	> 500 kHz	Pass
	11/2462	16.38	16.38	16.478	16.478	> 500 kHz	Pass
IEEE 802.11n (HT20)	1/2412	17.29	17.28	17.569	17.575	> 500 kHz	Pass
	6/2437	17.54	17.32	17.572	17.579	> 500 kHz	Pass
	11/2462	17.32	17.54	17.589	17.583	> 500 kHz	Pass
IEEE 802.11n (HT40)	3/2422	36.36	36.31	36.183	36.183	> 500 kHz	Pass
	6/2437	36.34	36.30	36.178	36.183	> 500 kHz	Pass
	9/2452	36.32	36.31	36.188	36.189	> 500 kHz	Pass

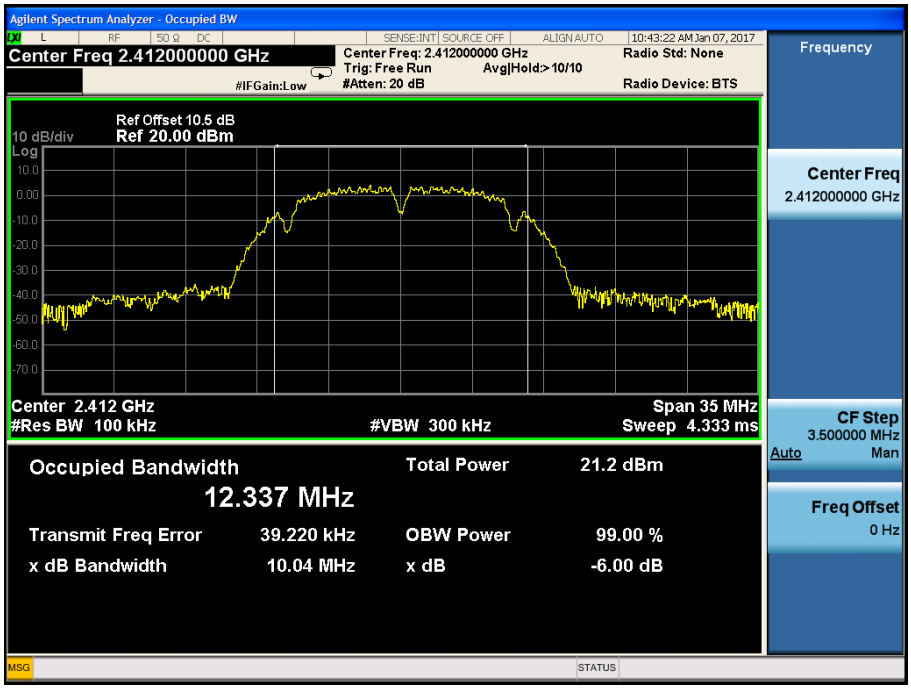
Remark:

1. All the data attached was use the worst case data rate.

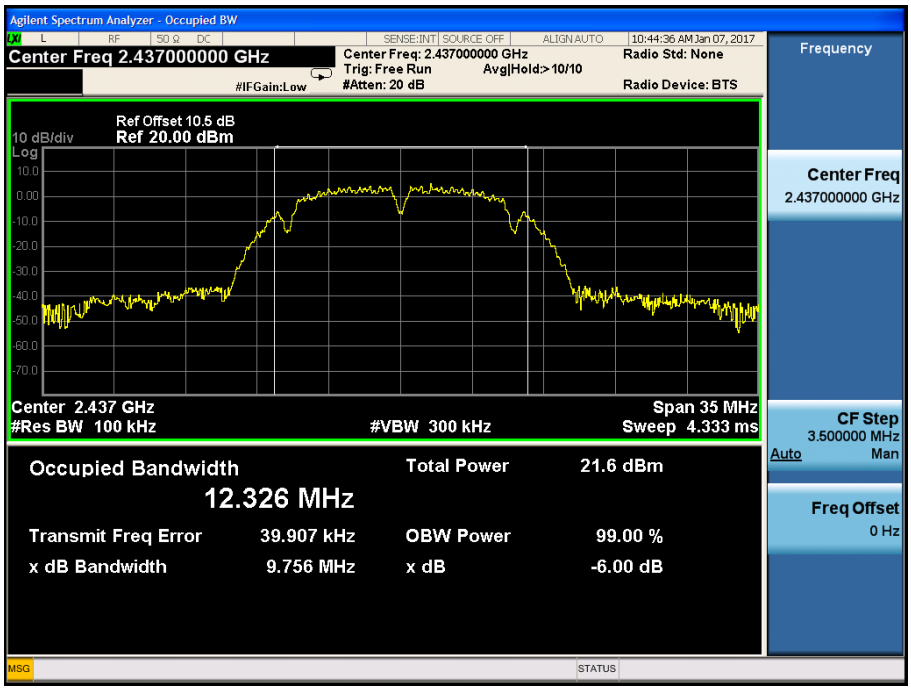
Chain 1-Test plot as follows

Test Mode: IEEE 802.11b TX

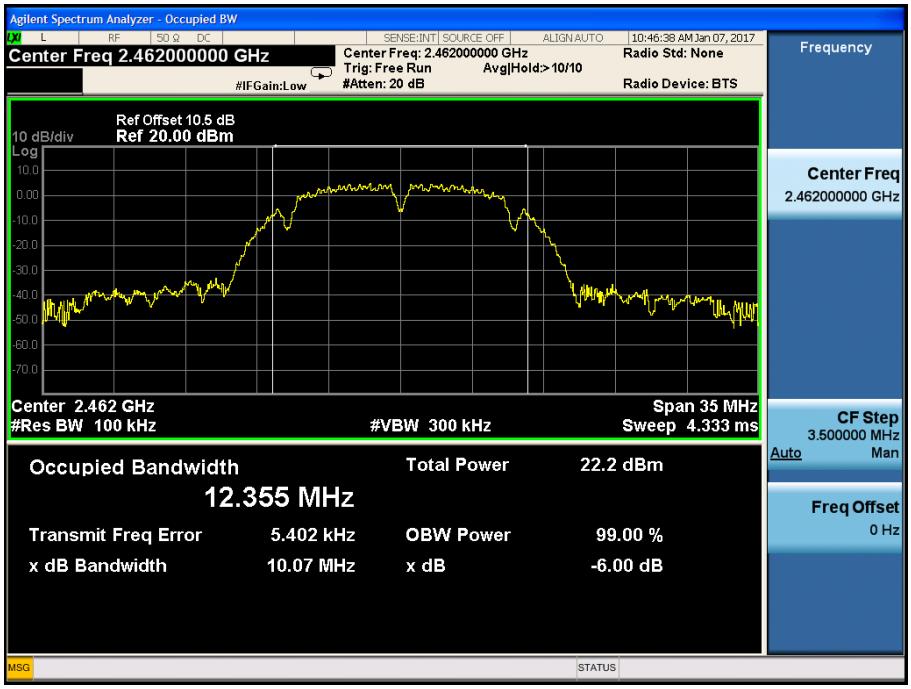
Test CH1: 2412MHz



Test CH6: 2437MHz

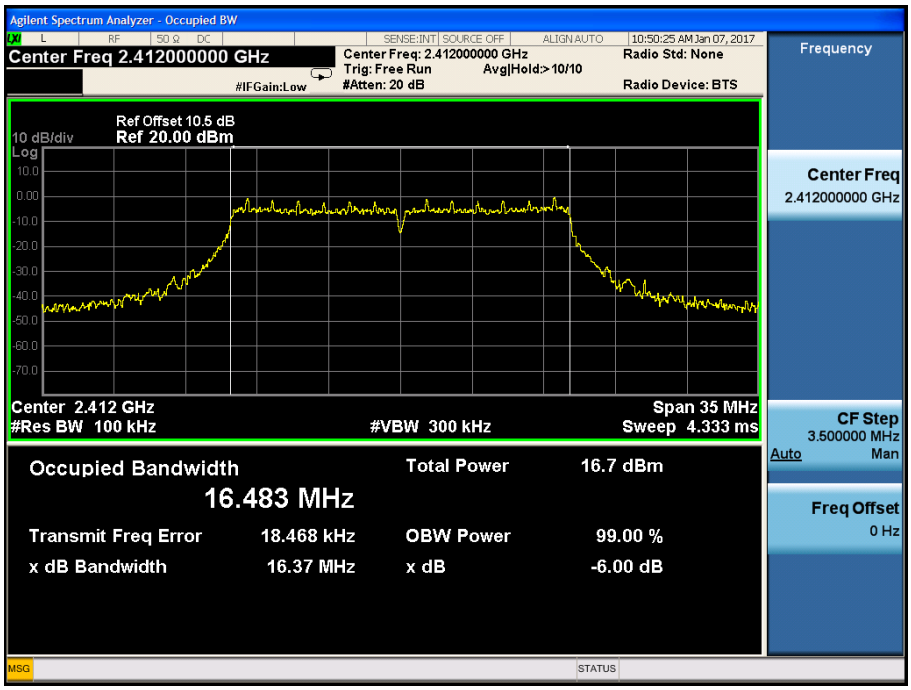


Test CH11: 2462MHz

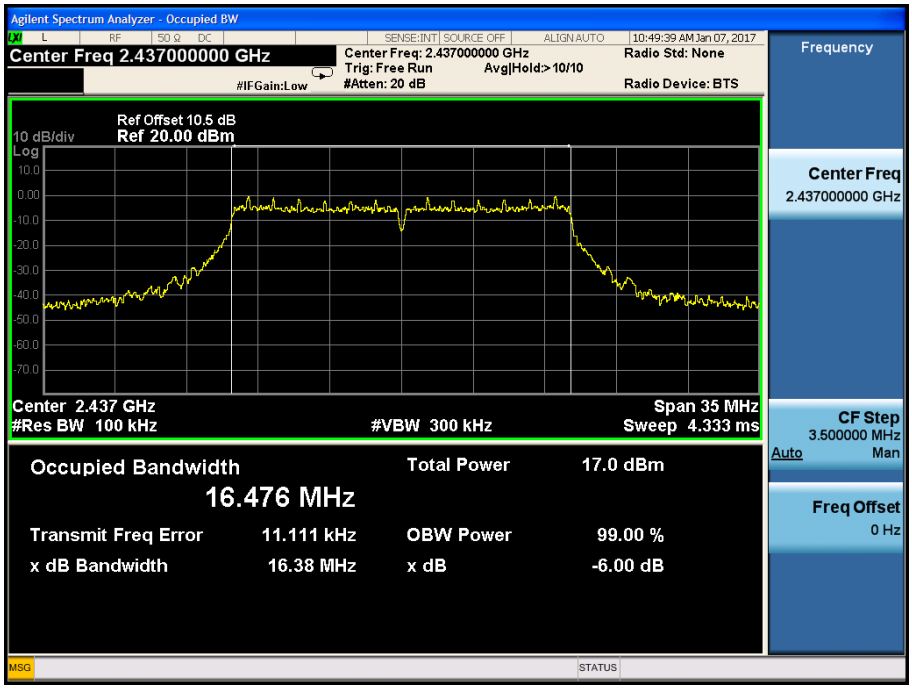


Test Mode: IEEE 802.11g TX

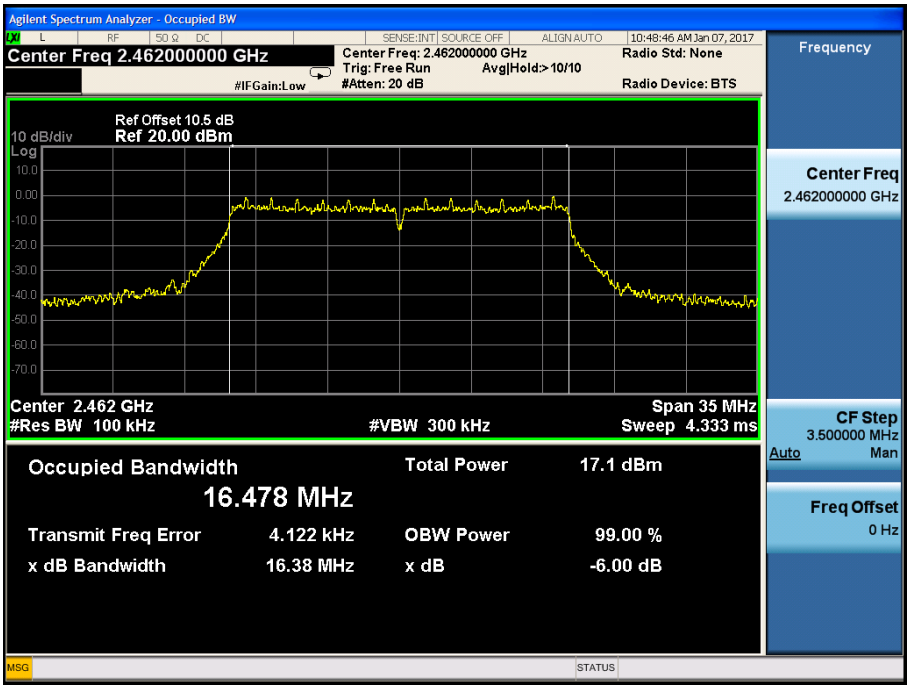
Test CH1: 2412MHz



Test CH6: 2437MHz

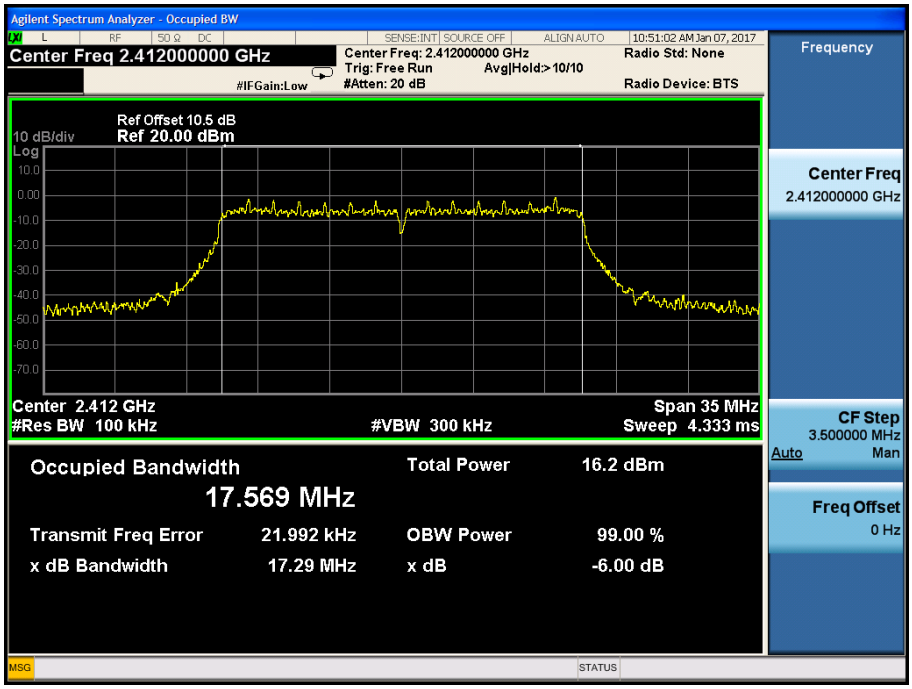


Test CH11: 2462MHz

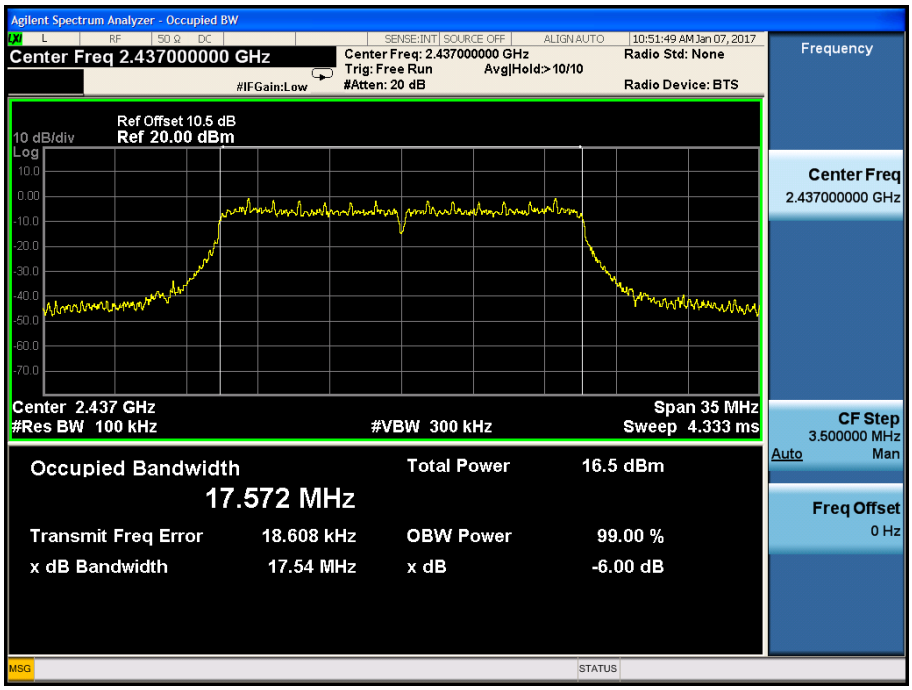


Test Mode: IEEE 802.11n (HT20) TX Test

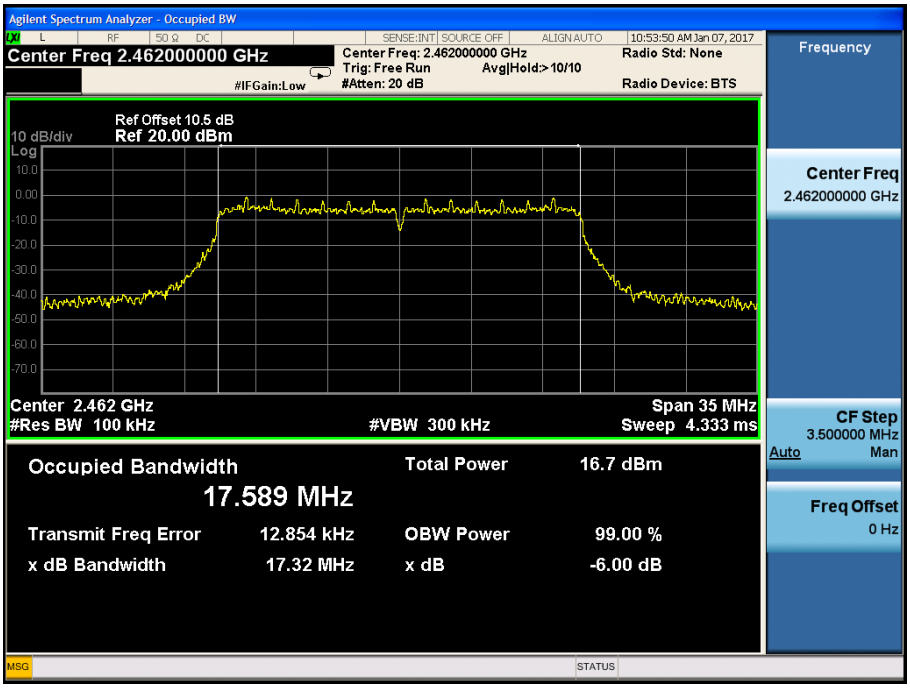
CH1: 2412MHz



Test CH6: 2437MHz

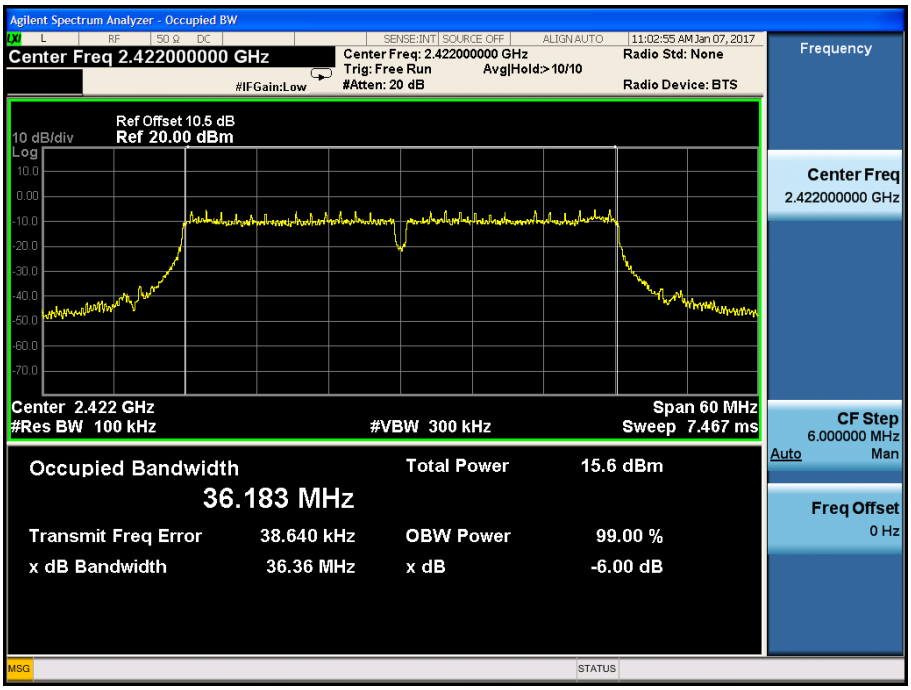


Test CH11: 2462MHz

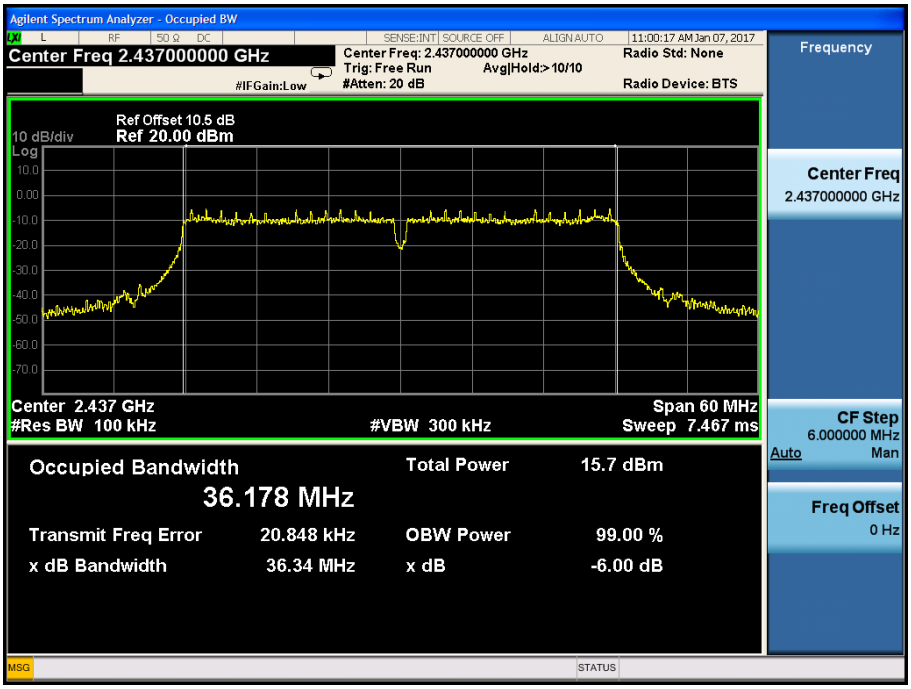


Test Mode: IEEE 802.11n (HT40) TX

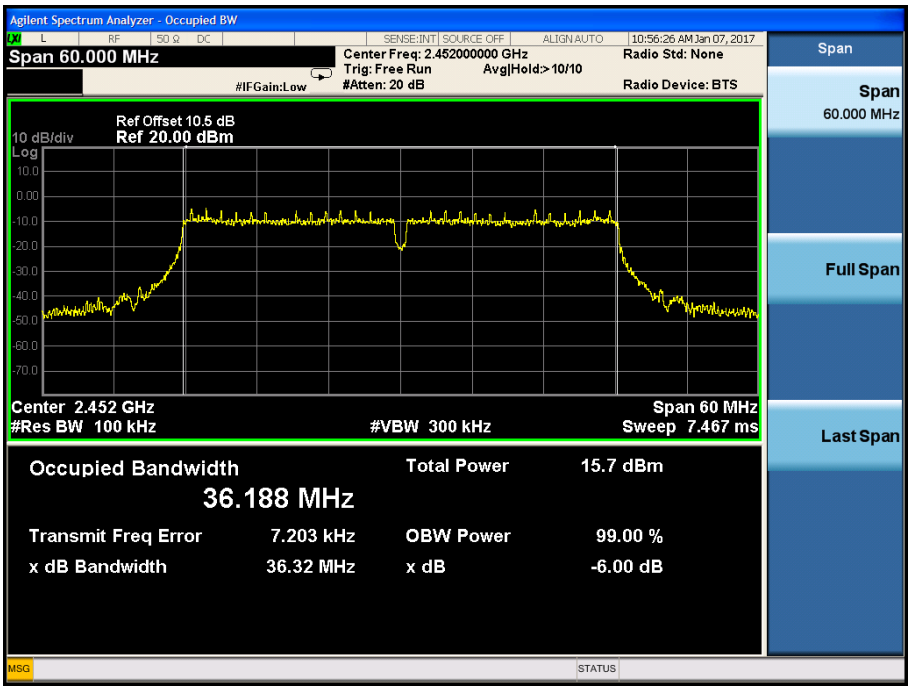
Test CH3: 2422MHz



Test CH6: 2437MHz



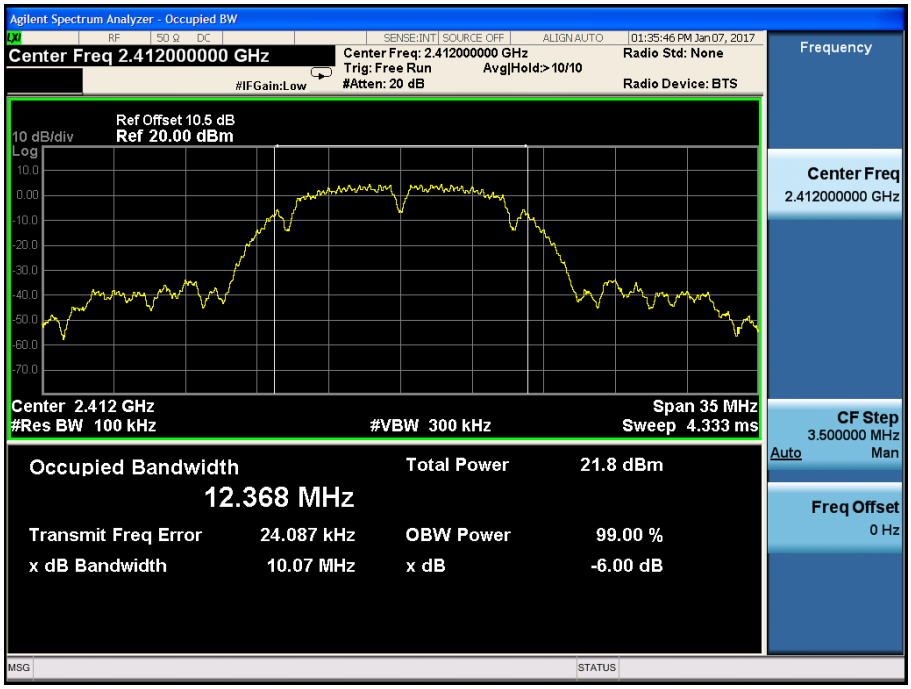
Test CH9: 2452MHz



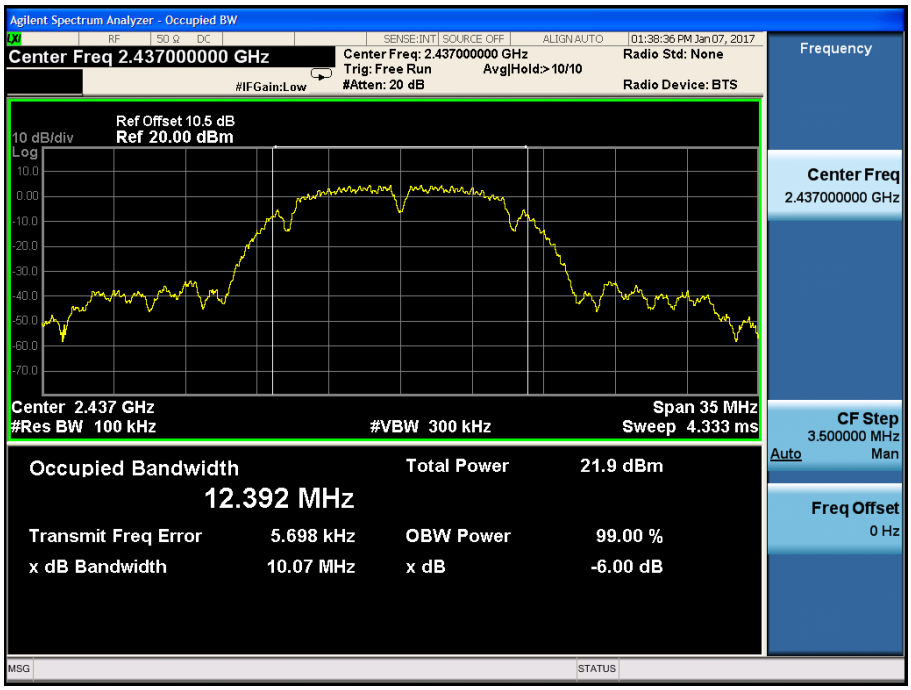
Chain 2-Test plot as follows

Test Mode: IEEE 802.11b TX

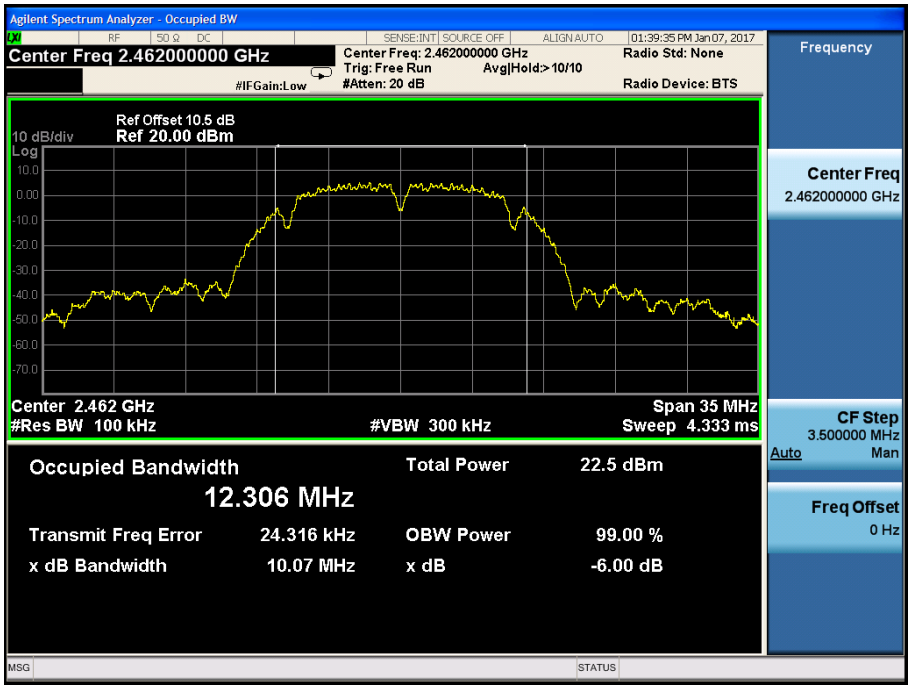
Test CH1: 2412MHz



Test CH6: 2437MHz

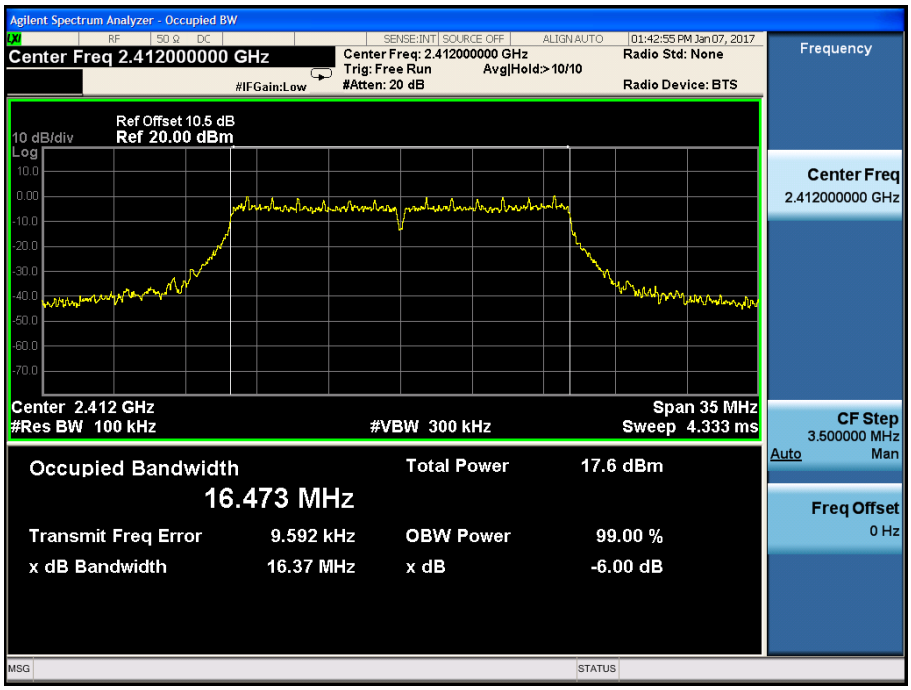


Test CH11: 2462MHz

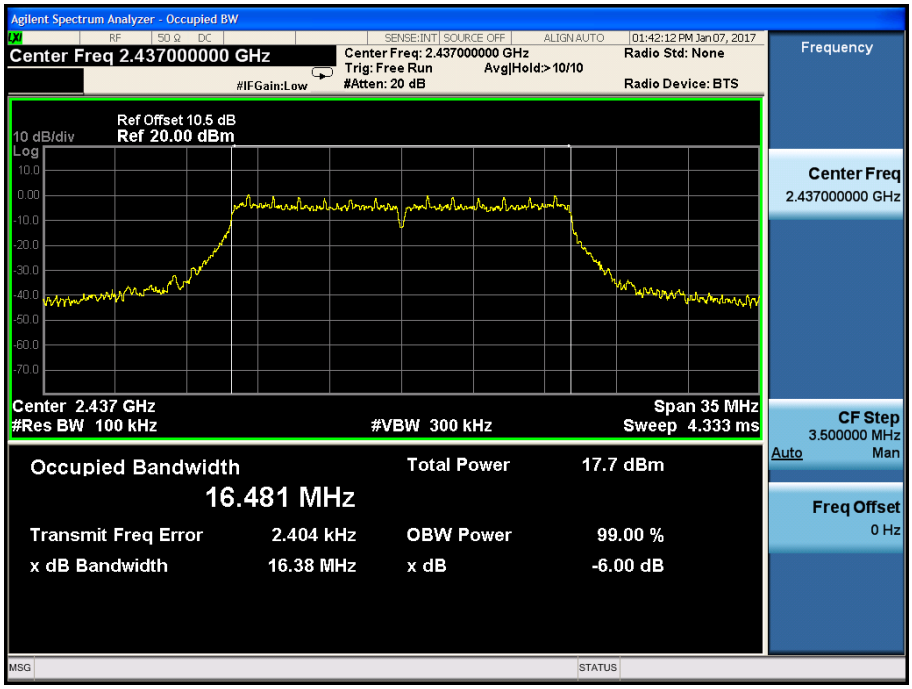


Test Mode: IEEE 802.11g TX

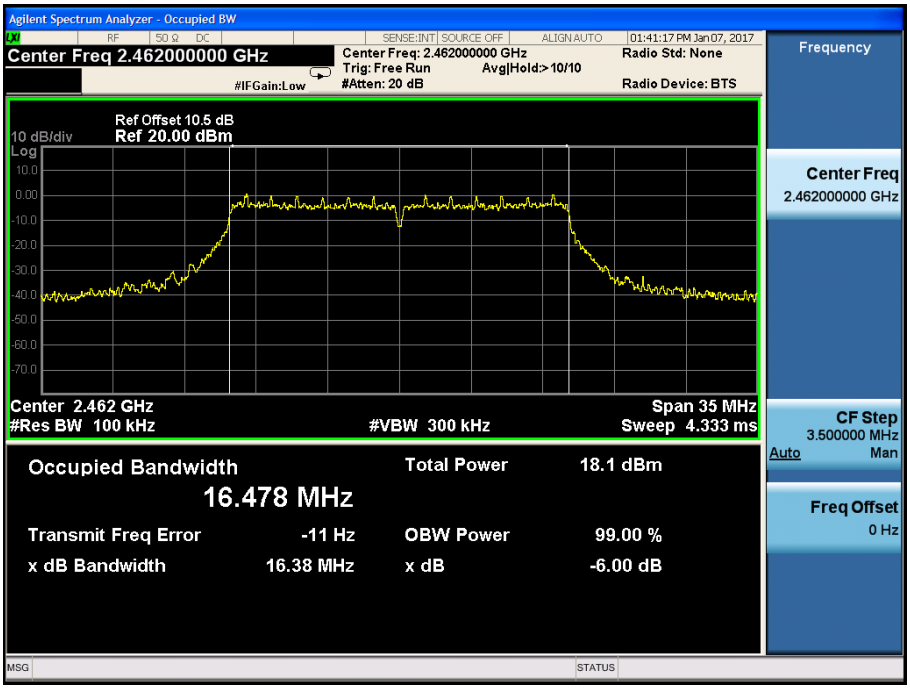
Test CH1: 2412MHz



Test CH6: 2437MHz

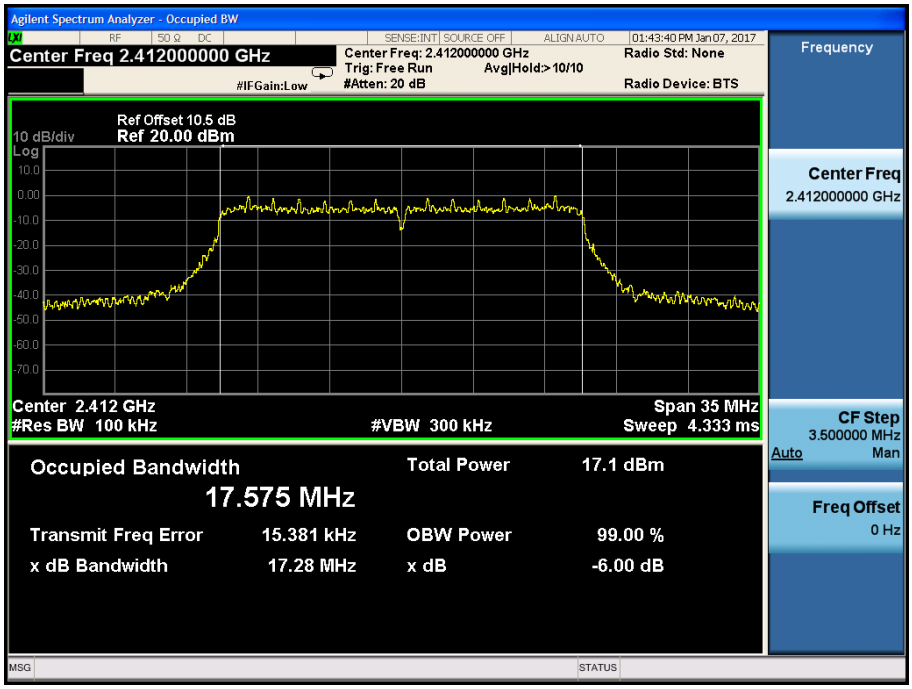


Test CH11: 2462MHz

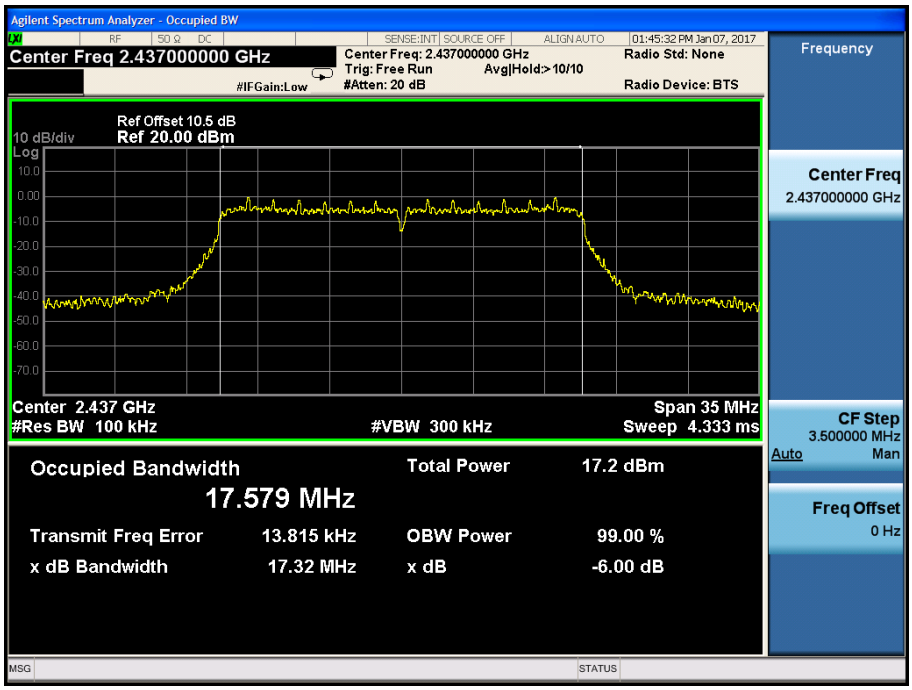


Test Mode: IEEE 802.11n (HT20) TX Test

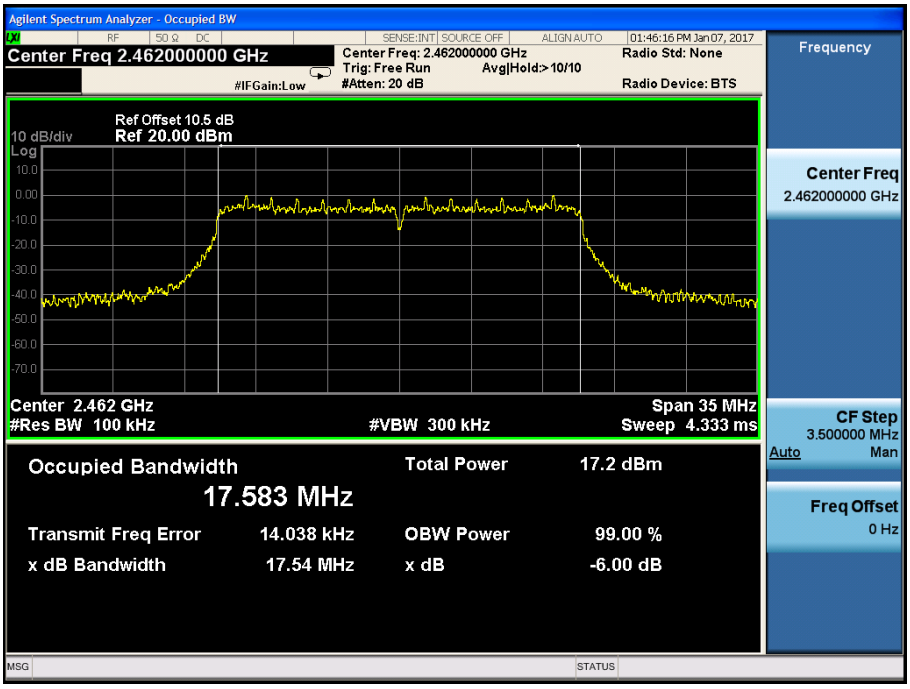
CH1: 2412MHz



Test CH6: 2437MHz

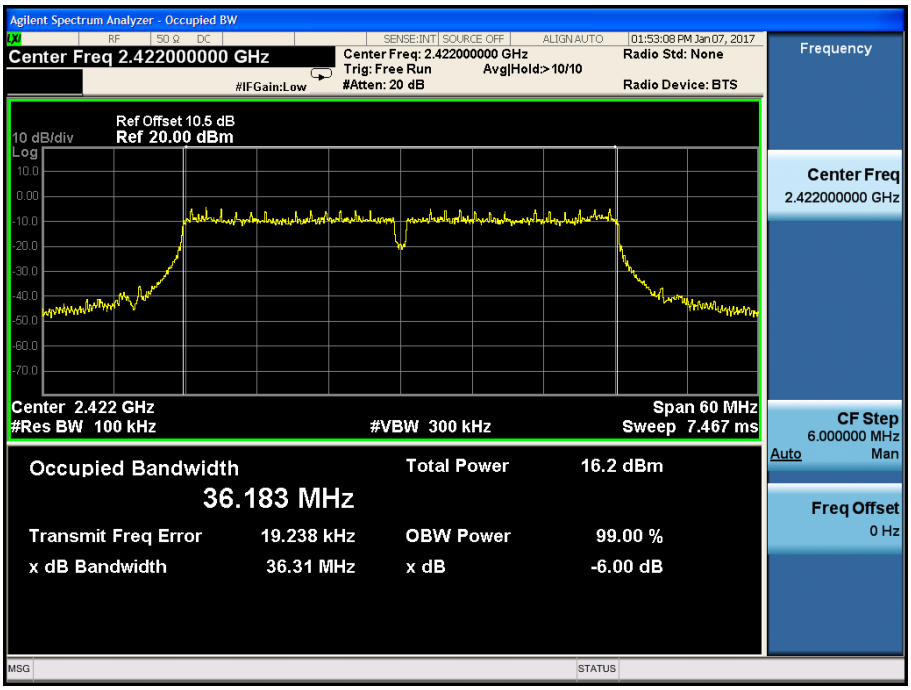


Test CH11: 2462MHz

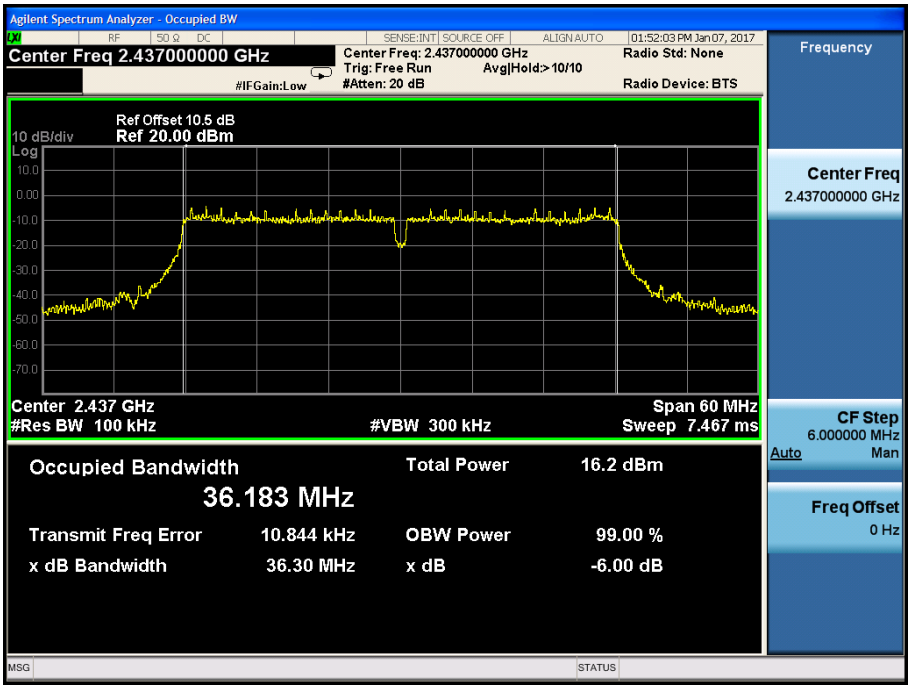


Test Mode: IEEE 802.11n (HT40) TX

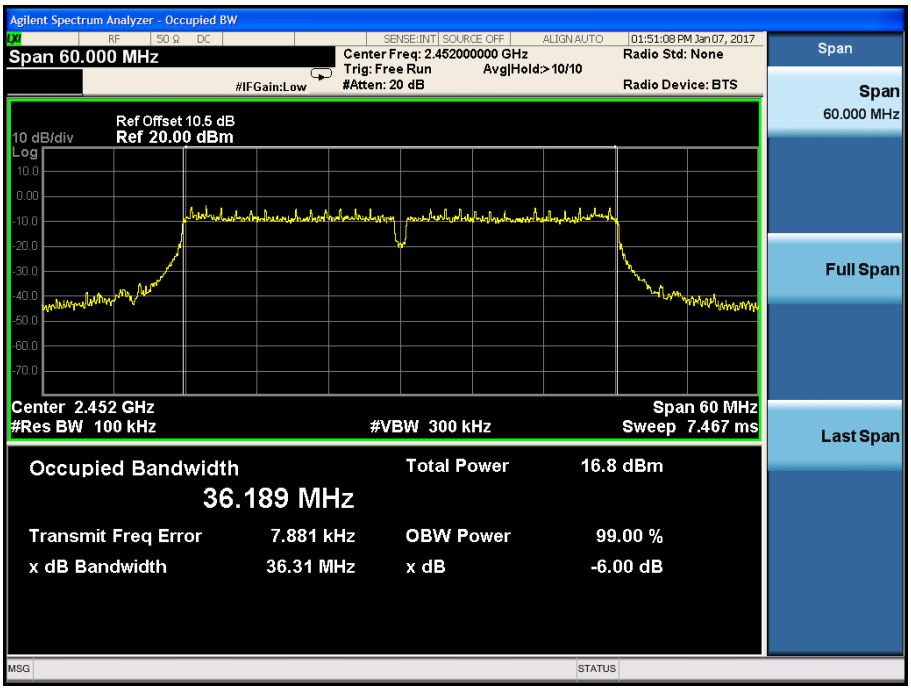
Test CH3: 2422MHz



Test CH6: 2437MHz



Test CH9: 2452MHz



6.4 Radiated Spurious Emissions

6.4.1 Limits

Radiated emissions that fall in the restricted bands must comply with the general emissions limits in 15.209(a) as below table. Other emissions shall be at least 20 dB below the highest level of the desired power.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Remark:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 log Emission level (uV/m).
3. For frequencies above 1000 MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20 dB under any condition of modulation.

The emissions were measured using the following resolution bandwidths:

Frequency Range	Resolution Bandwidth	Video Bandwidth
30MHz-1000 MHz	120kHz	>30 kHz
>1000 MHz	1 MHz	<30 Hz

Harmonic and Spurious emissions that were identified as coming from the EUT were checked in Peak and in Average Mode. The high frequency, which started from 10 to26.5GHz, which above 10GHz are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured was not reported.

Peak measurements and average measurements are made. All emissions were determined to have a peak-to-average ratio of less than 20dB.

6.4.2 Test Procedure(KDB 558074 D01 v03r05, Section 12.1 and Section12.2.5.3)

The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.10-2013. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

6.4.3 Test Data

The EUT complied with the FCC Part 15.247 Radiated Spurious Emissions requirements. Table 9 provide the test results for Radiated Spurious Emissions. (All the data attached was use the worst case data rate as in table 6)

6.4.4 Areas of Concern

None

Table 9: Radiated Emission Test Data

Radiated Emission Test Data (Below 30 MHz)

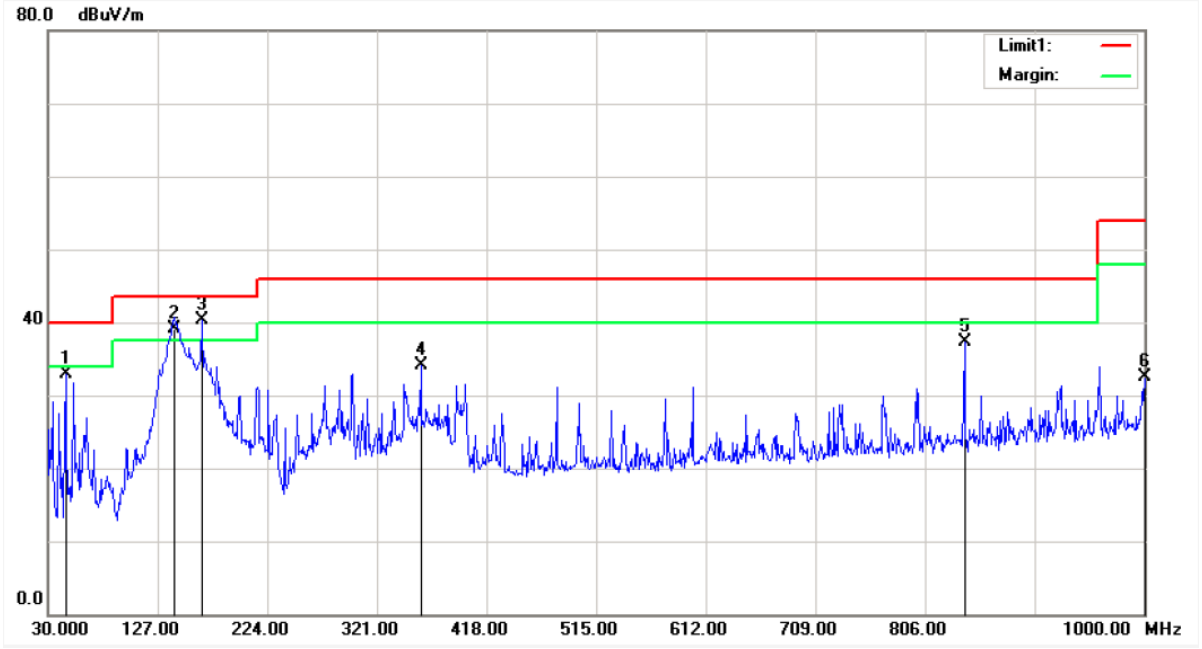
The amplitude of spurious emissions attenuated more than 20 dB below the permissible value is not required to be report.

Radiated Emission Test Data (Above 10 GHz)

The amplitude of spurious emissions attenuated more than 20 dB below the permissible value is not required to be report.

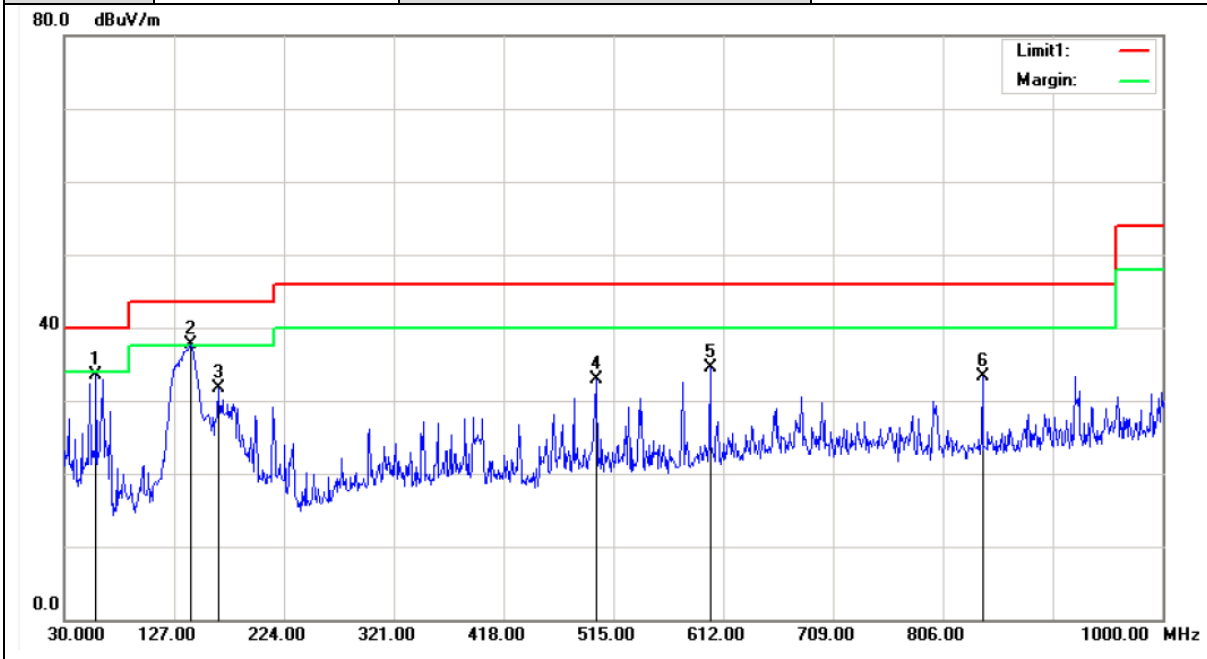
Radiated Emission Test Data (30 MHz~1 GHz Worst Case)

Mode	802.11n(HT20)	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	1



.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	45.52	44.72	-11.83	32.89	40.00	7.11	QP
2	141.55	51.15	-11.95	39.20	43.50	4.30	QP
3*	165.80	52.60	-12.34	40.26	43.50	3.24	QP
4	359.80	43.25	-9.19	34.06	46.00	11.94	QP
5	840.92	40.12	-2.87	37.25	46.00	8.75	QP
6	1000.00	31.59	0.89	32.48	54.00	21.52	QP

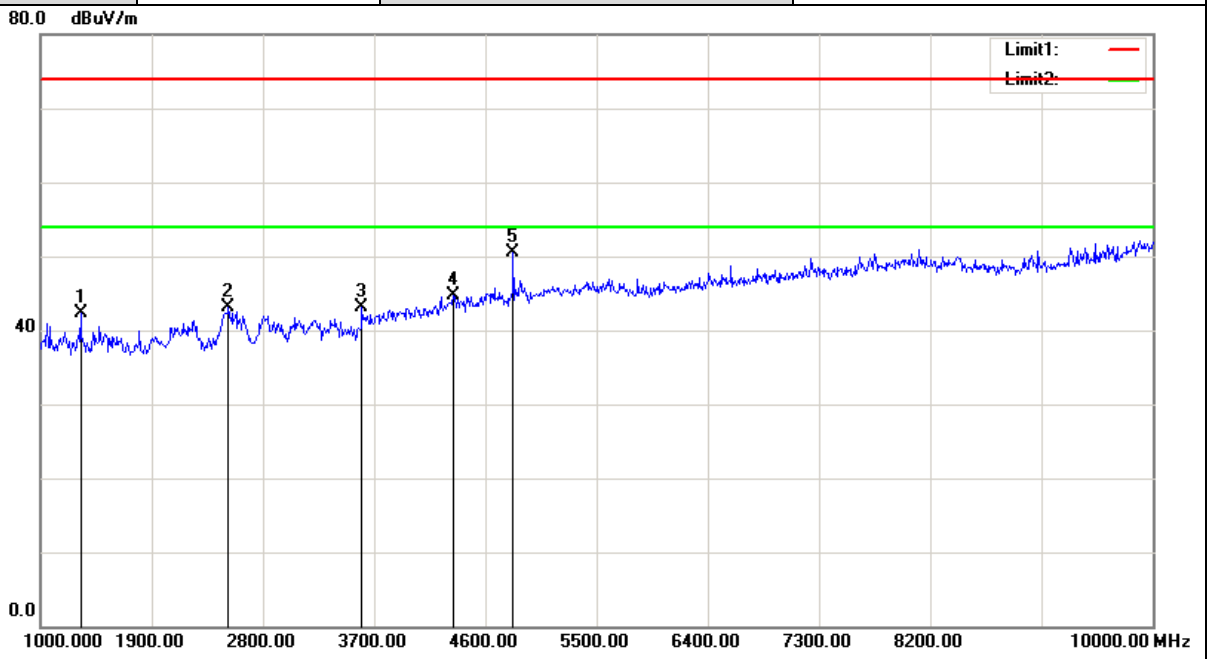
Mode	802.11n(HT20)	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	1



.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	58.13	46.68	-13.09	33.59	40.00	6.41	QP
2*	141.55	49.70	-11.95	37.75	43.50	5.75	QP
3	165.80	43.98	-12.34	31.64	43.50	11.86	QP
4	500.45	39.86	-6.88	32.98	46.00	13.02	QP
5	600.36	40.25	-5.84	34.41	46.00	11.59	QP
6	840.92	36.08	-2.87	33.21	46.00	12.79	QP

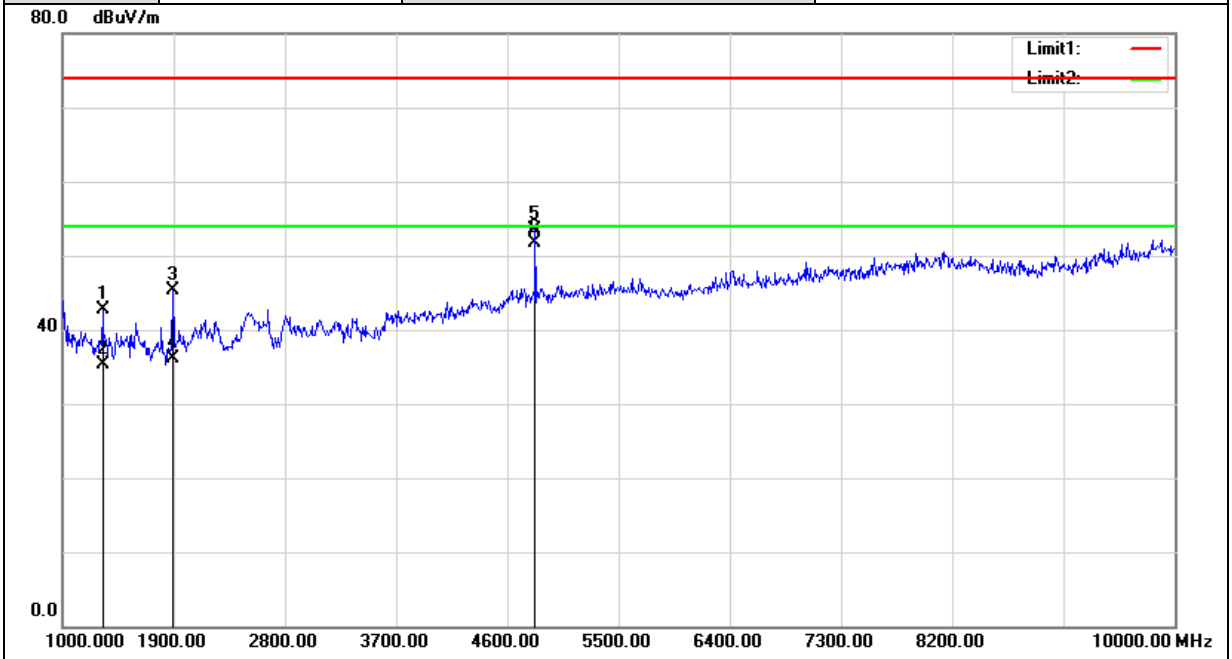
Radiated Emission Test Data (Above 1GHz)

Mode	802.11b	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	1



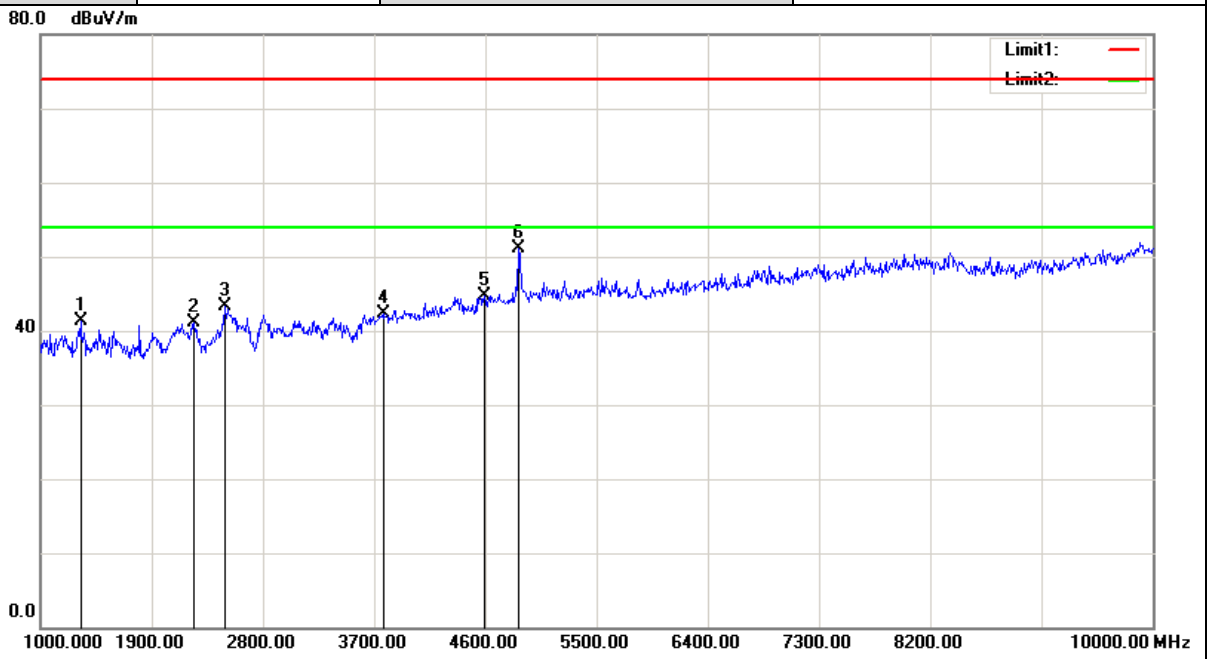
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	49.65	-7.34	42.31	74.00	31.69	peak
2	2521.000	45.36	-2.22	43.14	74.00	30.86	peak
3	3601.000	43.18	-0.09	43.09	74.00	30.91	peak
4	4339.000	41.84	2.78	44.62	74.00	29.38	peak
5*	4825.000	46.02	4.41	50.43	74.00	23.57	peak

Mode	802.11b	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	1



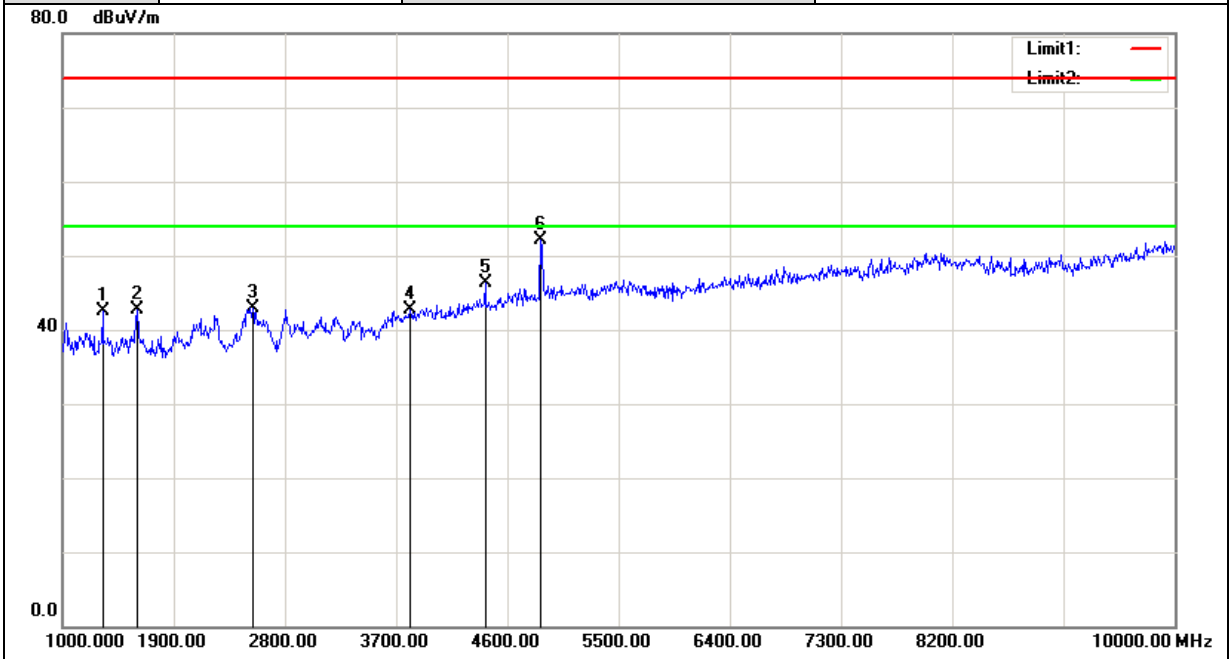
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	50.08	-7.34	42.74	74.00	31.26	peak
2	1324.000	42.55	-7.34	35.21	54.00	18.79	AVG
3	1891.000	51.07	-5.69	45.38	74.00	28.62	peak
4	1891.000	41.89	-5.69	36.20	54.00	17.80	AVG
5	4825.000	49.17	4.41	53.58	74.00	20.42	peak
6*	4825.000	47.36	4.41	51.77	54.00	2.23	AVG

Mode	802.11b	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	6



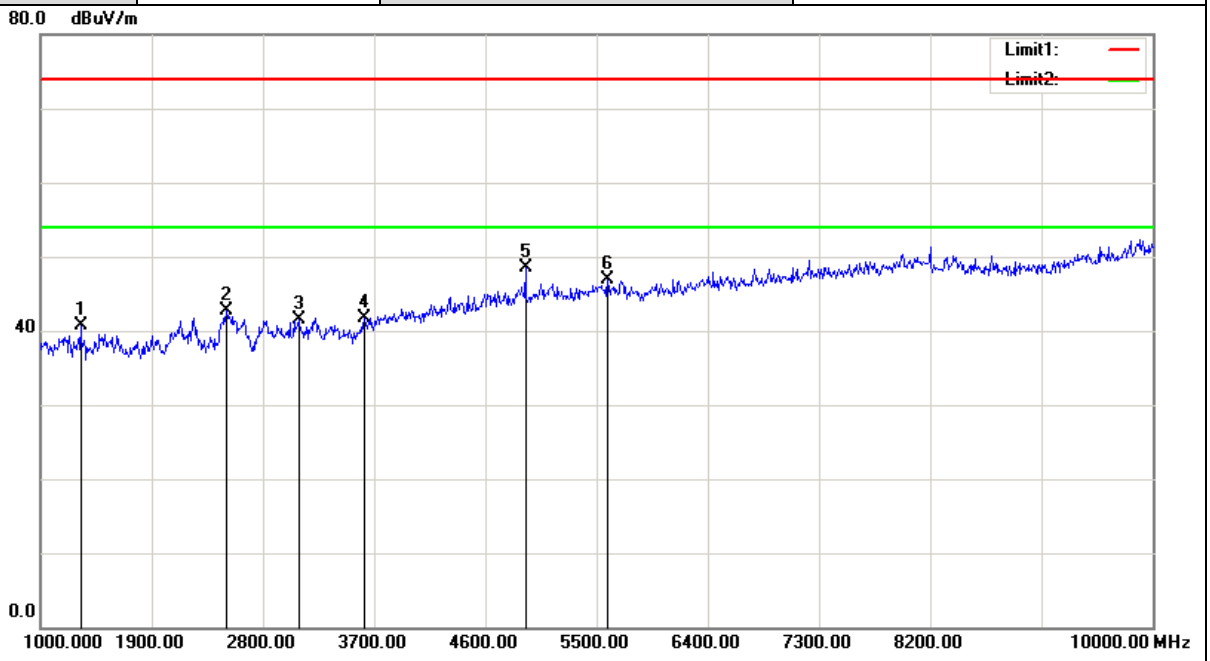
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	48.57	-7.34	41.23	74.00	32.77	peak
2	2242.000	44.75	-3.67	41.08	74.00	32.92	peak
3	2494.000	45.60	-2.29	43.31	74.00	30.69	peak
4	3772.000	41.60	0.63	42.23	74.00	31.77	peak
5	4591.000	41.10	3.65	44.75	74.00	29.25	peak
6*	4870.000	46.63	4.56	51.19	74.00	22.81	peak

Mode	802.11b	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	6



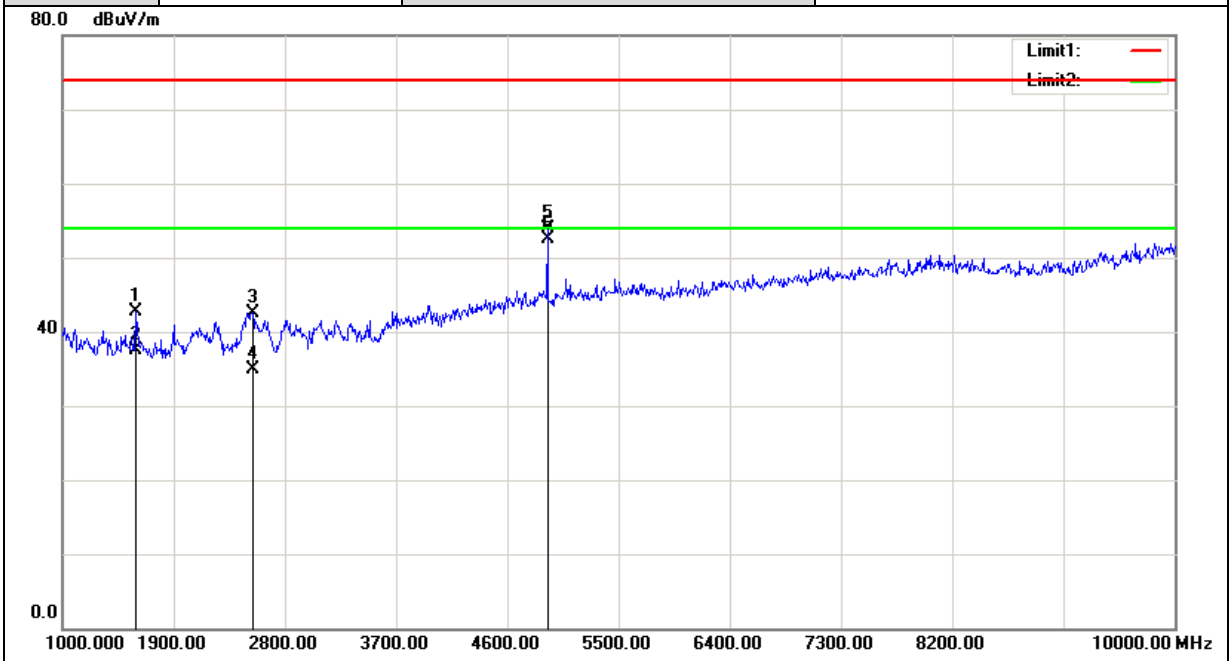
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	49.79	-7.34	42.45	74.00	31.55	peak
2	1603.000	49.38	-6.69	42.69	74.00	31.31	peak
3	2539.000	45.13	-2.19	42.94	74.00	31.06	peak
4	3817.000	41.98	0.82	42.80	74.00	31.20	peak
5	4420.000	43.19	3.07	46.26	74.00	27.74	peak
6*	4870.000	47.64	4.56	52.20	74.00	21.80	peak

Mode	802.11b	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	11



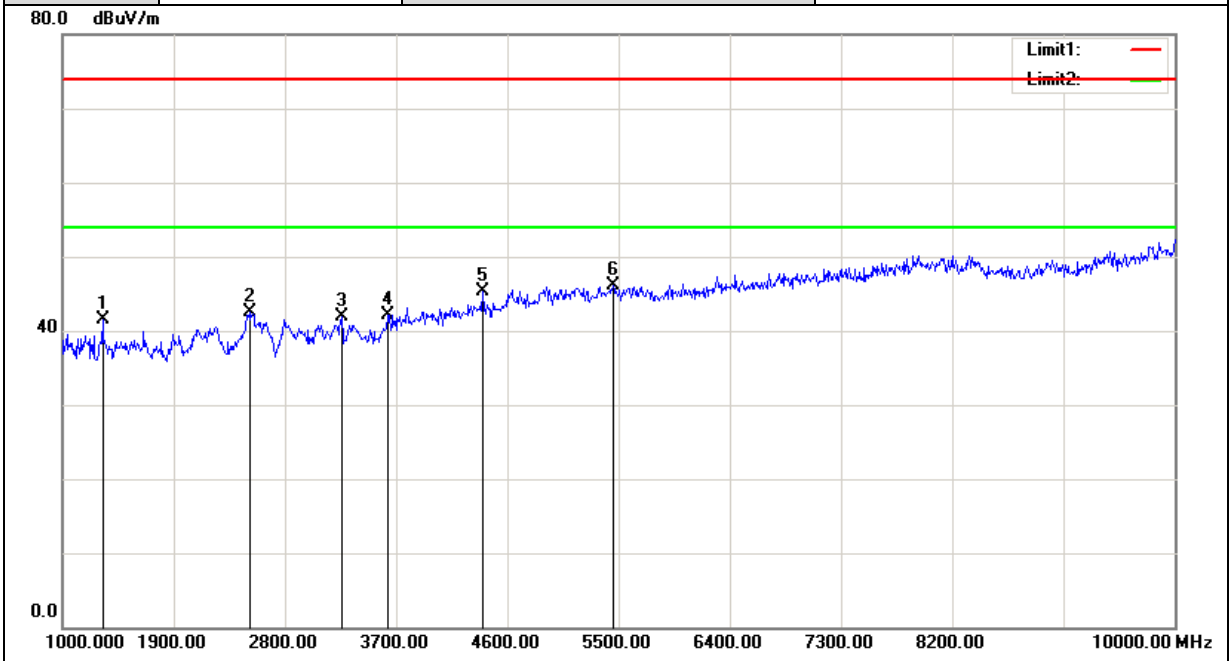
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	47.96	-7.34	40.62	74.00	33.38	peak
2	2503.000	44.93	-2.25	42.68	74.00	31.32	peak
3	3088.000	42.70	-1.21	41.49	74.00	32.51	peak
4	3619.000	41.80	-0.02	41.78	74.00	32.22	peak
5*	4924.000	43.69	4.73	48.42	74.00	25.58	peak
6	5590.000	40.97	5.91	46.88	74.00	27.12	peak

Mode	802.11b	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	11



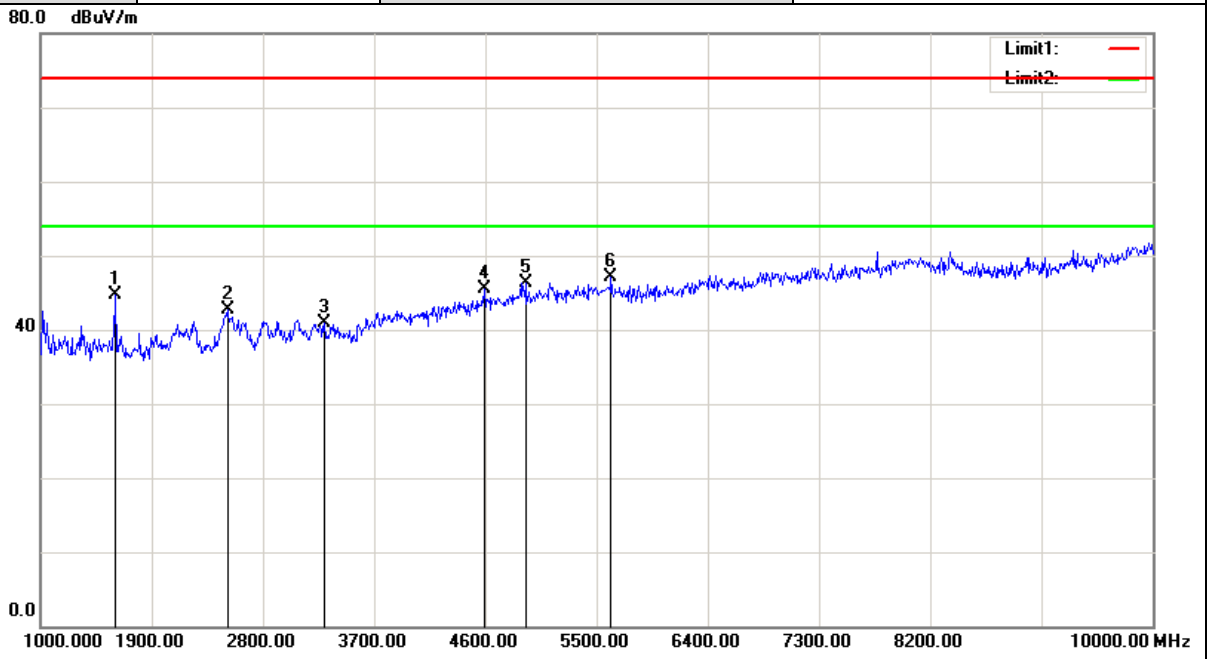
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1594.000	49.46	-6.71	42.75	74.00	31.25	peak
2	1594.000	44.25	-6.71	37.54	54.00	16.46	AVG
3	2539.000	44.75	-2.19	42.56	74.00	31.44	peak
4	2539.000	37.18	-2.19	34.99	54.00	19.01	AVG
5	4924.000	49.10	4.73	53.83	74.00	20.17	peak
6*	4924.000	47.70	4.73	52.43	54.00	1.57	AVG

Mode	802.11g	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	1



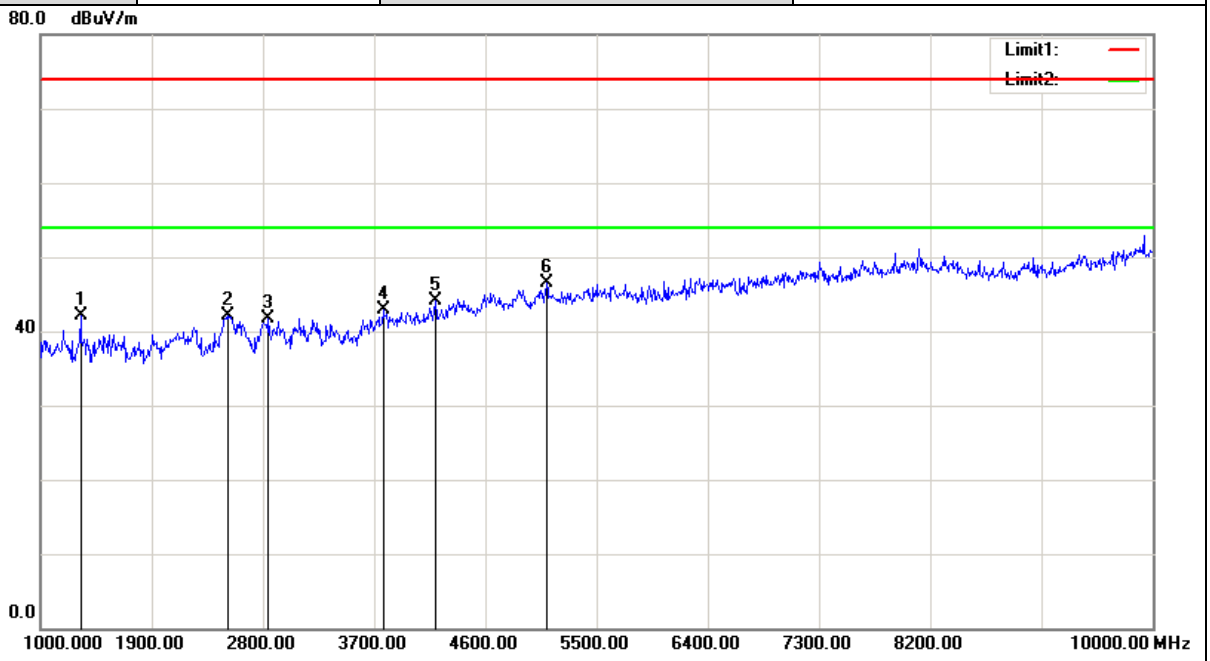
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	48.80	-7.34	41.46	74.00	32.54	peak
2	2512.000	44.74	-2.24	42.50	74.00	31.50	peak
3	3259.000	42.82	-0.92	41.90	74.00	32.10	peak
4	3628.000	42.05	0.02	42.07	74.00	31.93	peak
5	4402.000	42.25	3.01	45.26	74.00	28.74	peak
6*	5455.000	40.29	5.79	46.08	74.00	27.92	peak

Mode	802.11g	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	1



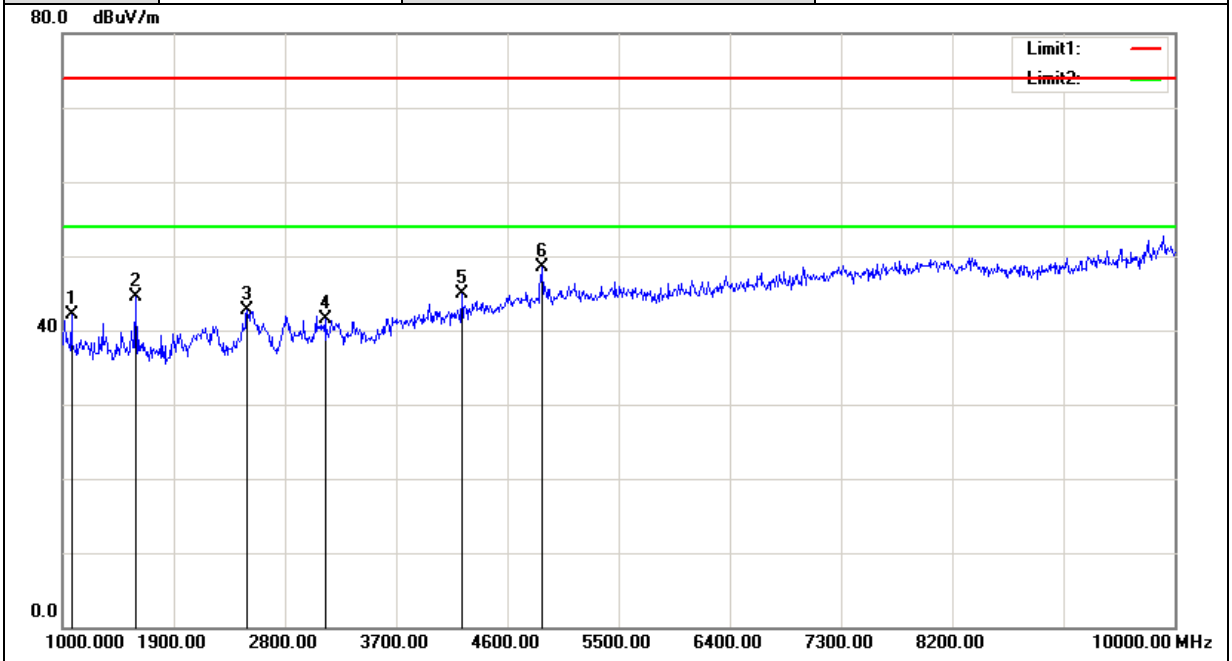
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1603.000	51.44	-6.69	44.75	74.00	29.25	peak
2	2512.000	45.01	-2.24	42.77	74.00	31.23	peak
3	3295.000	41.68	-0.86	40.82	74.00	33.18	peak
4	4591.000	41.94	3.65	45.59	74.00	28.41	peak
5	4924.000	41.62	4.73	46.35	74.00	27.65	peak
6*	5617.000	41.12	5.92	47.04	74.00	26.96	peak

Mode	802.11g	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	6



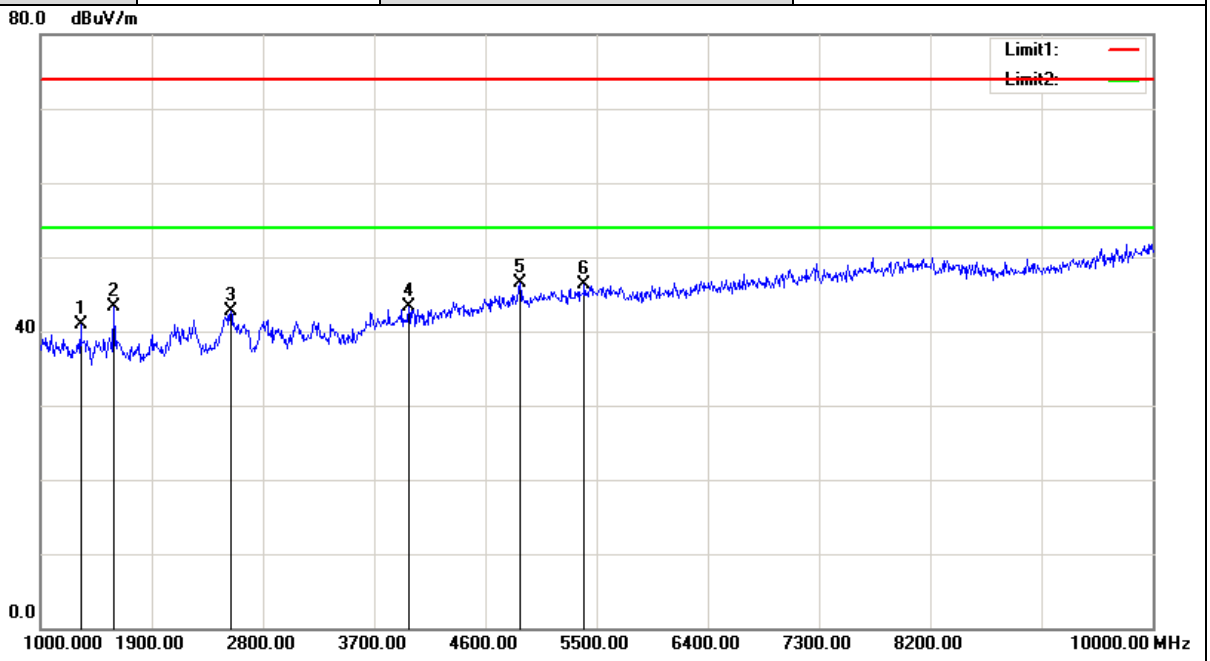
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	49.44	-7.34	42.10	74.00	31.90	peak
2	2512.000	44.25	-2.24	42.01	74.00	31.99	peak
3	2845.000	43.37	-1.64	41.73	74.00	32.27	peak
4	3772.000	42.22	0.63	42.85	74.00	31.15	peak
5	4195.000	41.79	2.28	44.07	74.00	29.93	peak
6*	5095.000	41.35	5.15	46.50	74.00	27.50	peak

Mode	802.11g	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	6



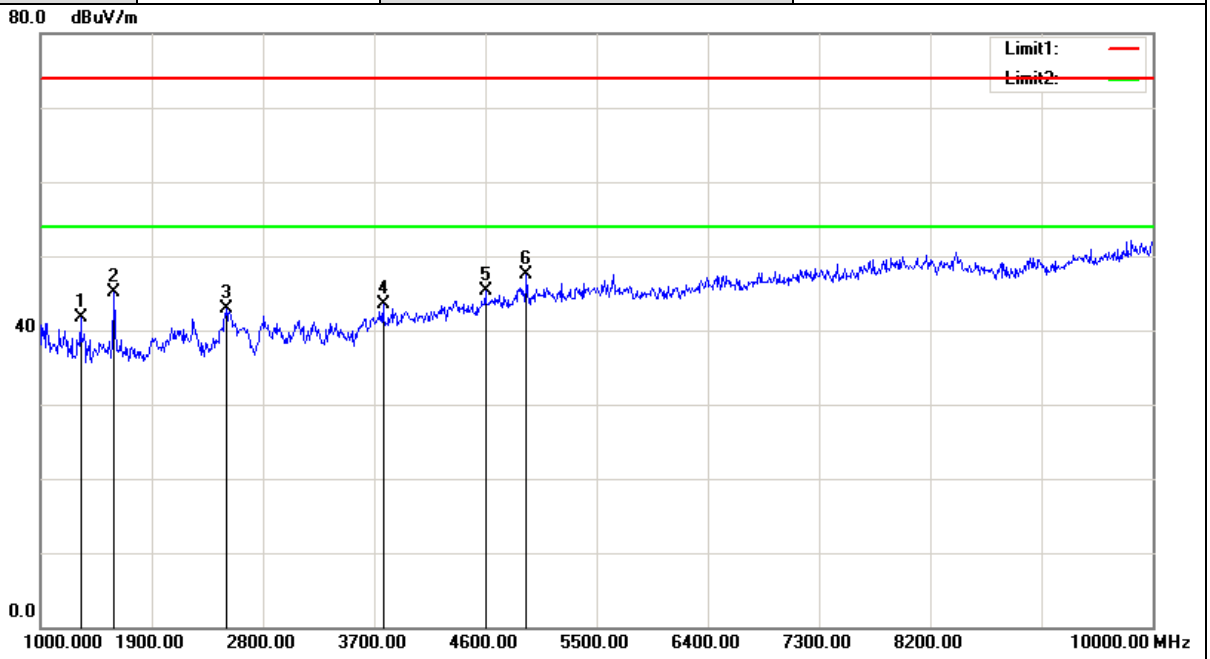
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1072.000	50.35	-8.28	42.07	74.00	31.93	peak
2	1594.000	51.22	-6.71	44.51	74.00	29.49	peak
3	2494.000	45.02	-2.29	42.73	74.00	31.27	peak
4	3124.000	42.62	-1.15	41.47	74.00	32.53	peak
5	4231.000	42.52	2.40	44.92	74.00	29.08	peak
6*	4879.000	43.97	4.59	48.56	74.00	25.44	peak

Mode	802.11g	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	11



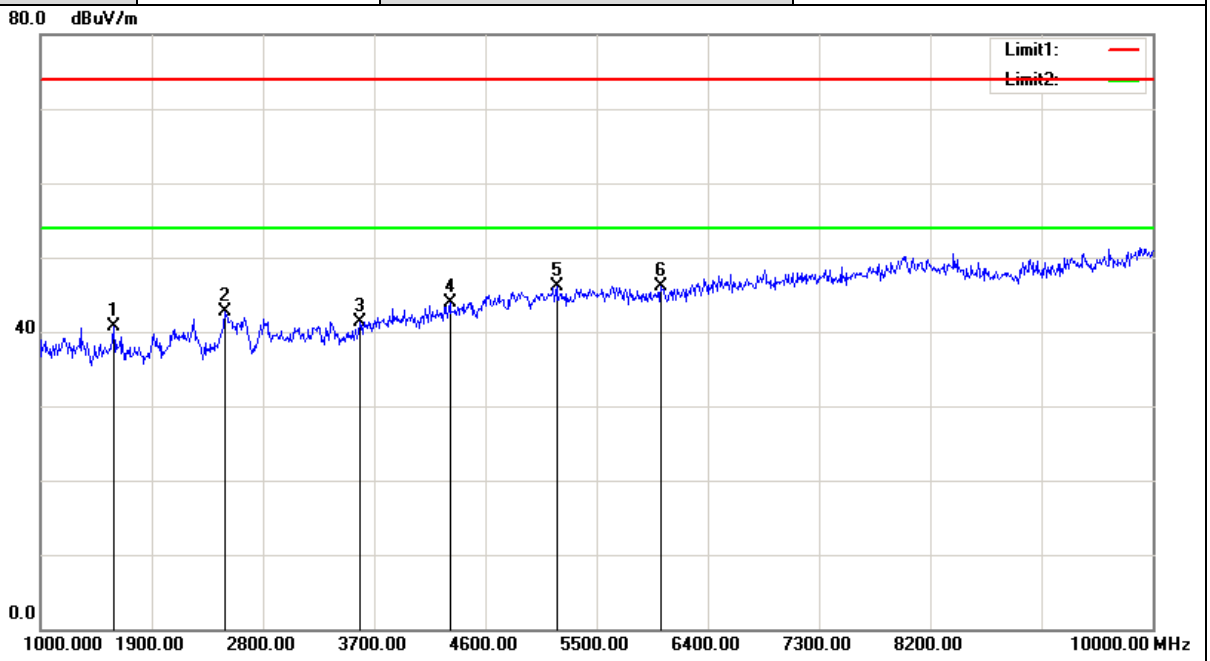
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	48.19	-7.34	40.85	74.00	33.15	peak
2	1594.000	50.00	-6.71	43.29	74.00	30.71	peak
3	2539.000	44.99	-2.19	42.80	74.00	31.20	peak
4	3979.000	41.76	1.50	43.26	74.00	30.74	peak
5*	4879.000	41.83	4.59	46.42	74.00	27.58	peak
6	5401.000	40.63	5.69	46.32	74.00	27.68	peak

Mode	802.11g	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	11



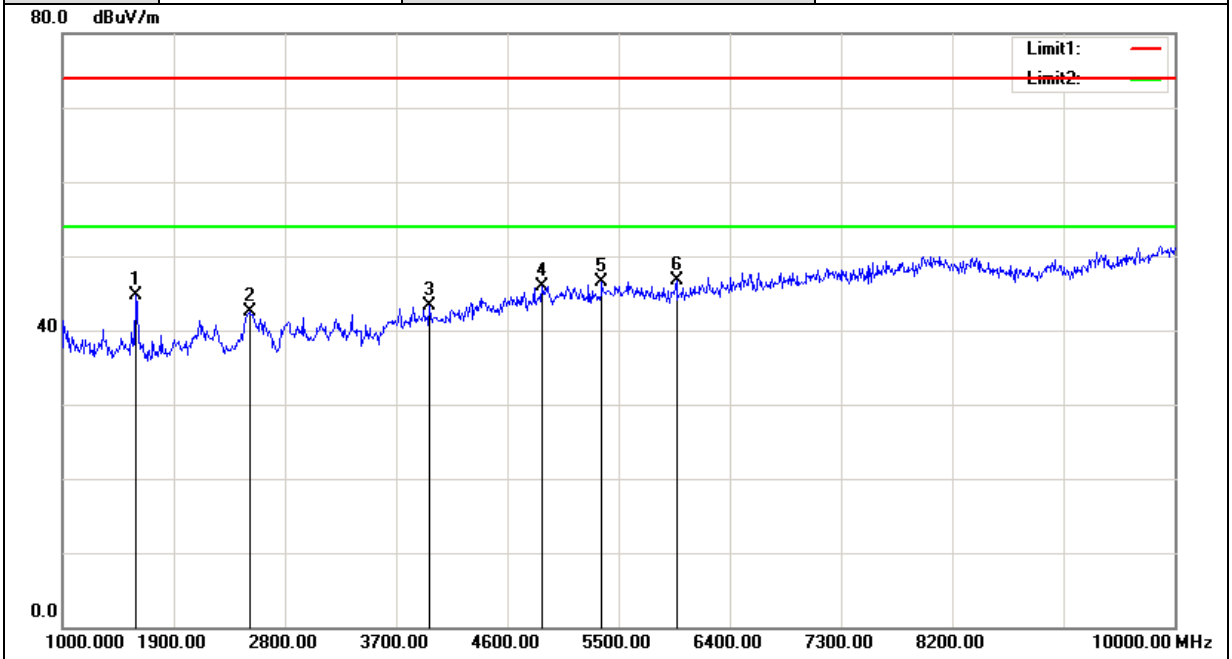
.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1324.000	48.96	-7.34	41.62	74.00	32.38	peak
2	1594.000	51.73	-6.71	45.02	74.00	28.98	peak
3	2503.000	45.09	-2.25	42.84	74.00	31.16	peak
4	3772.000	42.87	0.63	43.50	74.00	30.50	peak
5	4600.000	41.53	3.68	45.21	74.00	28.79	peak
6*	4933.000	42.66	4.76	47.42	74.00	26.58	peak

Mode	802.11n(HT20)	Ant. Polar.	Horizontal
Antenna	Chain 1+2	Channel	1



.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1594.000	47.50	-6.71	40.79	74.00	33.21	peak
2	2494.000	44.98	-2.29	42.69	74.00	31.31	peak
3	3583.000	41.53	-0.17	41.36	74.00	32.64	peak
4	4312.000	41.15	2.69	43.84	74.00	30.16	peak
5	5176.000	40.73	5.29	46.02	74.00	27.98	peak
6*	6022.000	40.01	6.12	46.13	74.00	27.87	peak

Mode	802.11n(HT20)	Ant. Polar.	Vertical
Antenna	Chain 1+2	Channel	1



.No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	1594.000	51.41	-6.71	44.70	74.00	29.30	peak
2	2512.000	44.69	-2.24	42.45	74.00	31.55	peak
3	3970.000	41.93	1.46	43.39	74.00	30.61	peak
4	4879.000	41.37	4.59	45.96	74.00	28.04	peak
5	5365.000	40.84	5.63	46.47	74.00	27.53	peak
6*	5968.000	40.57	6.07	46.64	74.00	27.36	peak