



**FCC CFR47 PART 15 SUBPART C
CERTIFICATION
TEST REPORT**

FOR

**802.11ag /DRAFT 802.11n
WIRELESS LAN PCI-E MINI CARD**

MODEL NUMBER: BCM94321MC

FCC ID: QDS-BRCM1022HR1

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: BROADCOM CORP.
190 MATHILDA PLACE
SUNNYVALE, CA 94086, USA

EUT DESCRIPTION: 802.11 AG /DRAFT 802.11n WIRELESS LAN PCI-E MINI CARD

MODEL: BCM94321MC

SERIAL NUMBER: 6F632058LWQXE & 6F634002HWQXE

DATE TESTED: NOVEMBER 10, 2006 TO MAY 03, 2007

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
FCC PART 15 SUBPART C	NO NON-COMPLIANCE NOTED

Compliance Certification Services, Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by Compliance Certification Services and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Compliance Certification Services will constitute fraud and shall nullify the document. No part of this report may be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any government agency.

Approved & Released For CCS By:

Tested By:



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EMC ENGINEER
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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4-2003, FCC CFR 47 Part 2 and FCC CFR 47 Part 15.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 561F Monterey Road, Morgan Hill, California, USA and 47173 Benicia Street, Fremont, California, USA. The sites are constructed in conformance with the requirements of ANSI C63.4, ANSI C63.7 and CISPR Publication 22. All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://www.ccsemc.com>.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Radiated Emission, 30 to 200 MHz	+/- 3.3 dB
Radiated Emission, 200 to 1000 MHz	+4.5 / -2.9 dB
Radiated Emission, 1000 to 2000 MHz	+4.5 / -2.9 dB
Power Line Conducted Emission	+/- 2.9 dB

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is an 802.11n MIMO transceiver chipset. The chipset is installed on a Mini PCI-E card, model number BCM94321MC.

Broadcom Corp manufactures the radio module.

5.2. WORST CASE DATA RATES

The worst-case data rate in each mode is based on investigations of PSD, peak power, average power, conducted emissions, plus bandedge and 2nd harmonic (5GHz only) radiated emissions across all the data rates, bandwidths, modulations and spatial stream modes.

Based upon pre-testing across all transmit modes, the worst case data rates are as follows:

For the Legacy Mode, the worst case is 1Mb/s @ 11b mode & 6Mb/s @ 11ag mode.

For MCS Index and MIMO operation modes covered under this evaluation it was determined that MCS Index 0 is worst case for all 20MHz bandwidth modes.

MCS Index 32 is worst case for 40MHz mode.

Both MCS 0 and MCS 32 were set to CDD mode.

Based on the preliminary test results, the following modes were tested:

2.4 GHz DTS BAND

1/ LEGACY MODE:

- _ 802.11b Legacy Mode
- _ 802.11g Legacy Mode
- _ 802.11n Mode 20 MHz SISO is covered by the worst case 802.11g Mode Legacy testing
- _ 802.11n Mode 40 MHz SISO

2/ MIMO MODE:

- _ 802.11g Mode Legacy CDD is covered by the worst case 802.11n Mode 20 MHz CDD MCS0.
- _ 802.11n Mode 20 MHz CDD MCS 0:
- _ 802.11n 40 MHz CDD MCS 32
- _ 802.11n 40 MHz SDM MCS 15

5.8 GHz DTS BAND

1/ LEGACY MODE:

- _ 802.11a Legacy Mode
- _ 802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing
- _ 802.11n Mode 40 MHz SISO

2/ MIMO MODE:

- _ 802.11a Mode CDD is covered by the worst case 802.11n Mode 20 MHz CDD MCS0.
- _ 802.11n Mode 20 MHz CDD MCS 0
- _ 802.11n 40 MHz CDD MCS 32

Comparative test results for Output Power and PPSD in the MIMO modes demonstrated close correlation (on the order of +/- 0.1 to 0.4 dB) between the mathematical addition of Chain 0 and Chain 1 (using linear units), as compared to measurements made using an RF combiner. Therefore all results presented in this report for the above parameters are Chain 0, Chain 1, and the mathematical sum of Chain 0 + Chain 1.

Comparative test results for Conducted Spurious in the MIMO modes demonstrated close correlation (on the order of +/- 1 dB) between individual chain and measurements made using an RF combiner. Therefore all results presented in this report for the above parameter is Chain 0 and Chain 1.

5.3. MAXIMUM OUTPUT POWER

The transmitter has a maximum peak conducted output power as follows:

2400 to 2483.5 MHz Authorized Band

Frequency Range (MHz)	Mode	Peak Power Chain 0 (dBm)	Peak Power Chain 1 (dBm)	Total Peak Power (dBm)	Output Power (mW)
2412 - 2462	802.11b Legacy	N/A	N/A	23.19	208.45
2412 - 2462	802.11g Legacy	N/A	N/A	25.7	371.54
2412 - 2462	802.11n 20MHz SISO	covered by the worst case 802.11g Mode Legacy testing			
2422 - 2452	802.11n 40MHz SISO	N/A	N/A	23.19	208.45
2412 - 2462	802.11g Legacy CDD	covered by the worst case 802.11n 20MHz CDD			
2412 - 2462	802.11n 20MHz CDD	26.02	26.2	29.12	816.58
2422 - 2452	802.11n 40MHz CDD	21.77	21.61	24.7	295.12
2422 - 2452	802.11n 40MHz SDM	22.88	22.69	25.8	380.19

5725 to 5850 MHz Authorized Band

Frequency Range (MHz)	Mode	Peak Power Chain 0 (dBm)	Peak Power Chain 1 (dBm)	Total Peak Power (dBm)	Output Power (mW)
5745 - 5825	802.11a Legacy	N/A	N/A	24.23	264.85
5745 - 5825	802.11n 20MHz SISO	covered by the worst case 802.11a Mode Legacy testing			
5755 - 5795	802.11n 40MHz SISO	N/A	N/A	25.28	337.29
5745 - 5825	802.11a Mode CDD	covered by the worst case 802.11n 20MHz CDD			
5745 - 5825	802.11n 20MHz CDD	24.38	24.36	27.38	547.02
5755 - 5795	802.11n 40MHz CDD	24.33	24.36	27.36	544.50

5.4. DESCRIPTION OF AVAILABLE ANTENNAS

The EUT has 2 Tx/Rx antennas that are automatically selected for use as per the MCS index and STF mode selections. The EUT was tested with PCB antennas described below:

Band	Ant Main	Ant Aux	$10^{*}(\text{Ant Main}/10)$	$10^{*}(\text{Ant Aux}/10)$	$10^{*}(\text{ant main}/10)+10^{*}(\text{ant aux}/10)$	$10^{*}\log[10^{*}(\text{ant main}/10)+10^{*}(\text{ant aux}/10)]$ (dBm)
Acon						
2.4-2.4835GHz	3.36	2.89	2.168	1.945	4.113	6.142
5.4-5.725GHz	6.02	5.44	3.999	3.499	7.499	8.750
5.725-5.825GHz	6.02	5.01	3.999	3.170	7.169	8.555
Foxconn						
5.15-5.25GHz	3.74	4.37	2.366	2.735	5.101	7.077
5.25-5.35GHz	6.23	5.02	4.198	3.177	7.374	8.677

5.5. SOFTWARE AND FIRMWARE

The EUT was tested in the following manner:

- “epi_tcp.exe” was used to transmit UDP packets to a broadcast IP address (192.168.66.255) – i.e. no ACK required. This test mode sends a continuous packetized data stream with duty cycles that vary dependant upon data rate/MCS Index selected.
- “wl_ampdu” and “frameburst” were enabled to ensure worst case data packet transfer and duty cycle.
- Worst case packet length have also been used to ensure max duty cycle

5.6. CONFIGURATION AND MODE

Operating modes were changed directly in software with no other changes to the set up. Power levels were verified across all the MCS Index at the start of test and as required throughout testing.

Prior to each test a power meter was used to tune the gated average power within a Tx packet. The channel gates on the meter were set to ensure that, at the time of recording, only packet power was captured without including duty cycle off time.

Power was tuned for different modes, channels and antennas based on the power tuning table contained in the Operational Description submitted under the same filing.

5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop PC	Dell	Inspiron 0000	CN-901014-70166-57K-01JT	DOC
AC Adapter	Dell	PA-1600-06D1	F9710	DOC

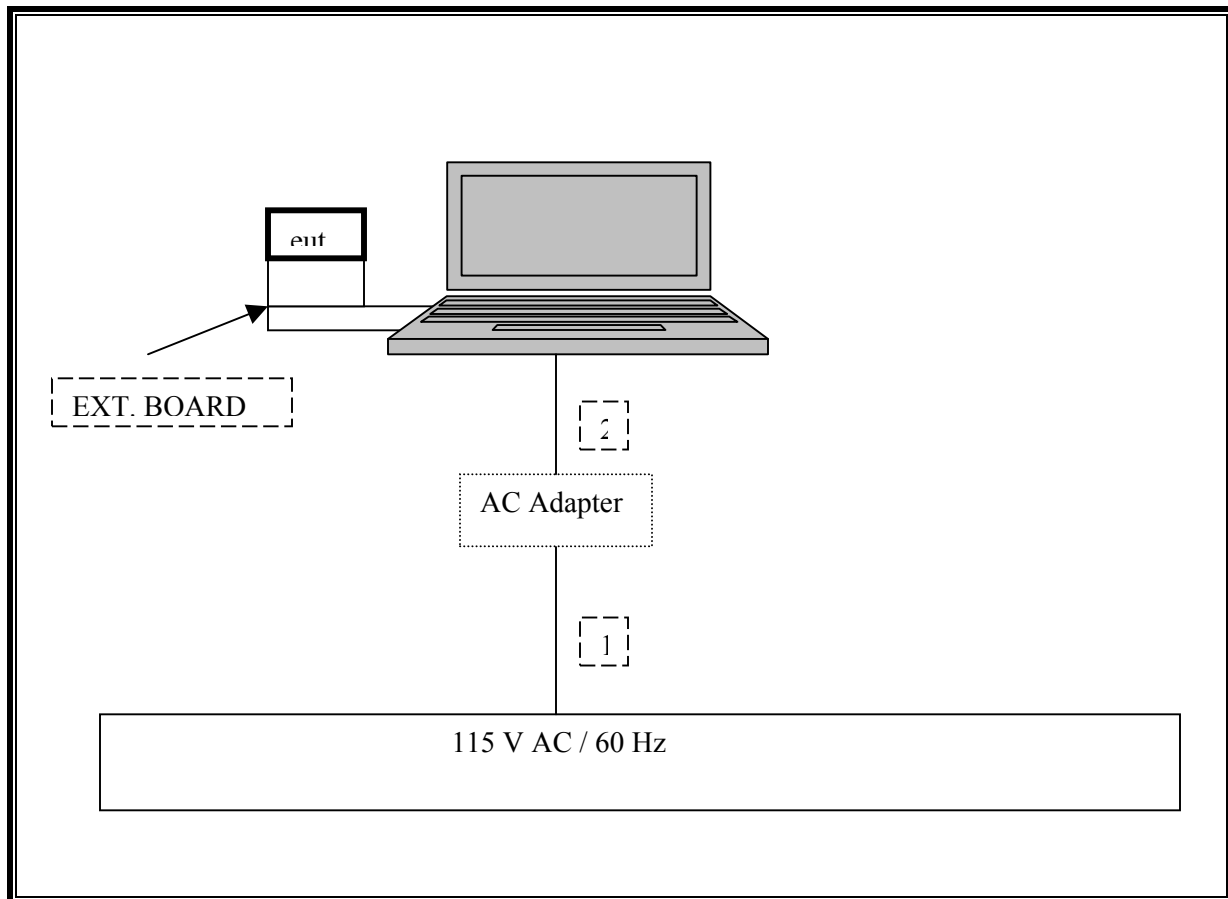
I/O CABLES

I/O CABLE LIST						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length	Remarks
1	AC	1	AC	Unshielded	1.2 m	N/A
2	DC	1	DC	Unshielded	1.2 m	N/A

TEST SETUP

The EUT is installed in a host laptop computer via Express card to MiniPCI-E adapter boards during the tests. Test software exercised the radio card.

SETUP DIAGRAM



6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST				
Description	Manufacturer	Model	Serial Number	Cal Due
Spectrum Analyzer 3 Hz ~ 44 GHz	Agilent / HP	E4446A	US42510266	10/19/2007
Antenna, Horn 1 ~ 18 GHz	EMCO	3115	2238	4/15/2008
Preamplifier, 1 ~ 26.5 GHz	Agilent / HP	8449B	3008A00561	10/3/2007
Preamplifier, 26 ~ 40 GHz	Miteq	NSP4000-SP2	924343	8/18/2007
LISN, 10 kHz ~ 30 MHz	FCC	LISN-50/250-25-2	2023	8/30/2007
LISN, 10 kHz ~ 30 MHz	Solar	8012-50-R-24-BNC	8379443	8/30/2007
EMI Test Receiver	R & S	ESHS 20	827129/006	11/3/2007
AC Power Source, 10 kVA	ACS	AFC-10K-AFC-2	J1568	CNR
Quasi-Peak Adaptor	Agilent / HP	85650A	2521A01038	01/11/08
SA Display Section 2	Agilent / HP	85662A	2816A16696	04/07/08
SA RF Section, 1.5 GHz	Agilent / HP	85680B	2814A04227	01/07/08
Preamp 30-1000MHz	Sonoma Instrument	310N	185623	01/20/08
Antenna, Bilog 30 MHz ~ 2 Ghz	Sunol Sciences	JB1	A121003	08/13/07
EMI Receiver, 9 kHz ~ 2.9 GHz	Agilent / HP	8542E	3942A00286	6/12/2008
RF Filter Section	Agilent / HP	85420E	3705A00256	6/12/2008
4.0 High Pass Filter	Micro Tronics	HPM13351	3	N/A
2.4 - 2.5 Band Reject Filter	Micro Tronics	N/A	1	N/A
2.0 - 4.2 GHz Combiner	Mini-Circuits	ZA4PD-4	SF380100518	N/A
4.6 - 5.8 GHz Combiner	Mini-Circuits	ZB4PD1-5.8	SN649900514	N/A
Peak Power Meter	Agilent / HP	E4416A	GB41291160	12/2/2007
Antenna, Horn, 18 ~ 26 GHz	ARA	MWH-1826/B	1013	8/6/2007
Antenna, Horn 26 ~ 40 GHz	ARA	MWH-2640/B	1029	4/11/2008
4.0 GHz High Pass Filter	Micro Tronics	HPM13351	3	N/A
2.4 - 2.5 Reject Filter	Micro Tronics	BRM50702	3	N/A
7.6 GHz High Pass Filter	Micro Tronics	HPM13350	1	N/A
5.75 - 5.8 Reject Filter	Micro Tronics	BRC13192	2	N/A

7. LIMITS AND RESULT

LEGACY MODE

7.1. CHANNEL TESTS FOR THE 2400 TO 2483.5 MHz BAND

7.1.1. 6 dB BANDWIDTH

LIMIT

§15.247 (a) (2) For direct sequence systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 100 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

RESULTS

No non-compliance noted:

6 dB BANDWIDTH - LEGACY

802.11b Legacy Mode

Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2412	10170	500	9670
Middle	2437	10170	500	9670
High	2462	10170	500	9670

802.11g Legacy Mode

Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2412	16330	500	15830
Middle	2437	16330	500	15830
High	2462	16330	500	15830

802.11n Mode 20 MHz SISO is covered by the worst case 802.11g mode Legacy testing.

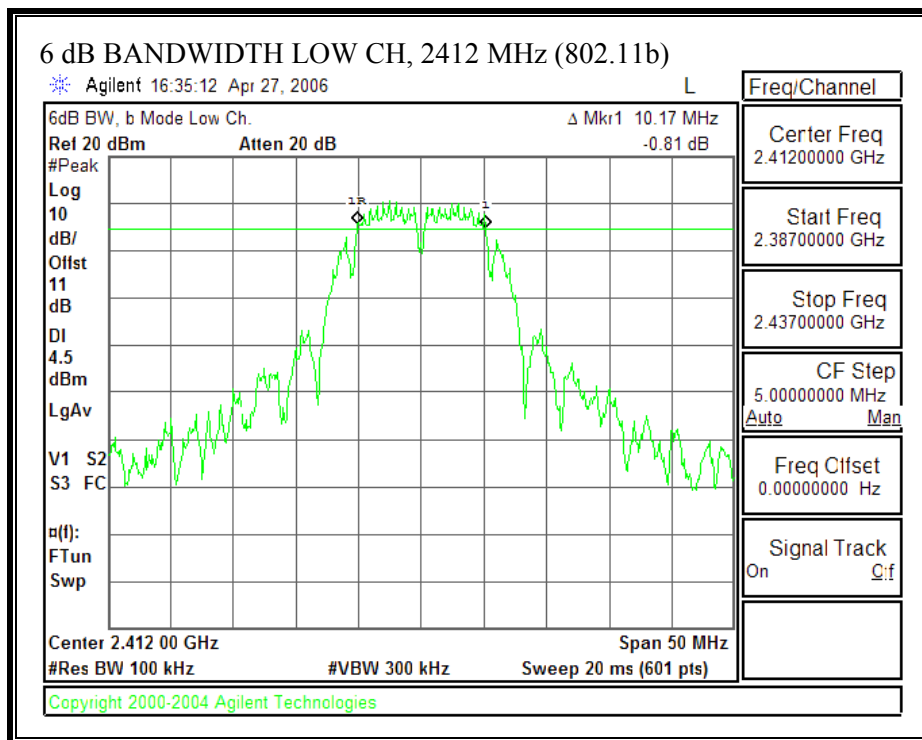
802.11n 40 MHz SISO Mode

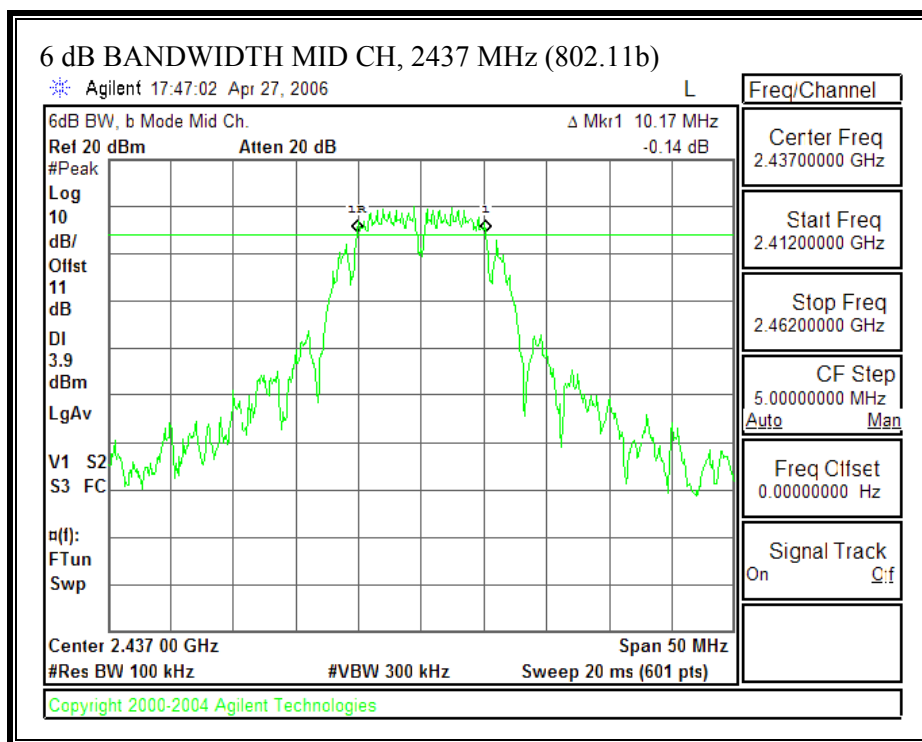
Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2422	35330	500	34830
Middle	2437	35070	500	34570
High	2452	32670	500	32170

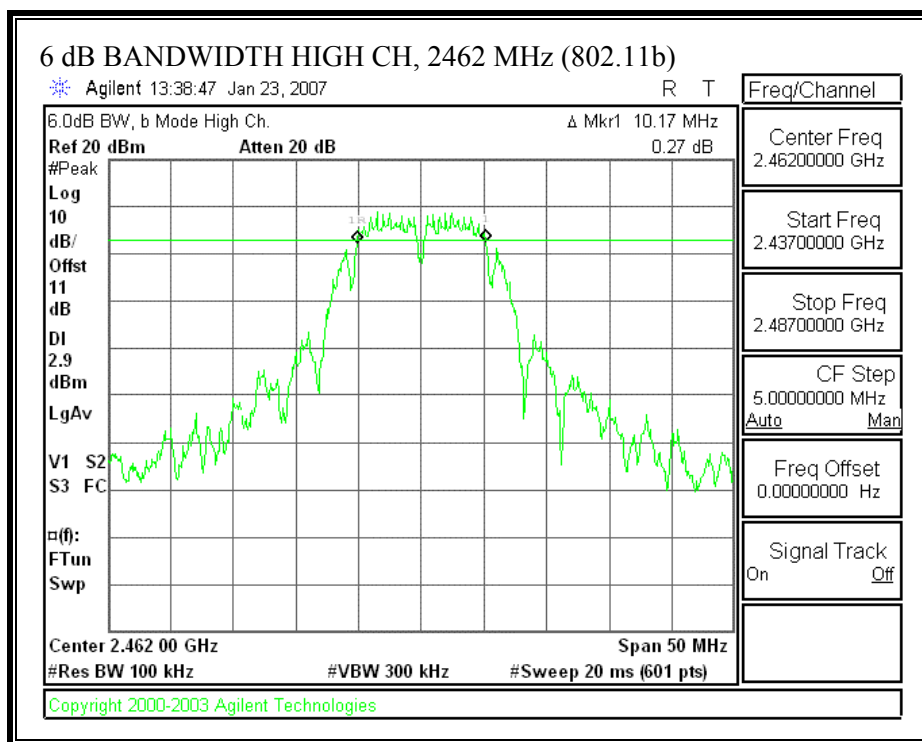
802.11b Legacy Mode

2.4 GHz BAND

6 dB BANDWIDTH – 11b Mode

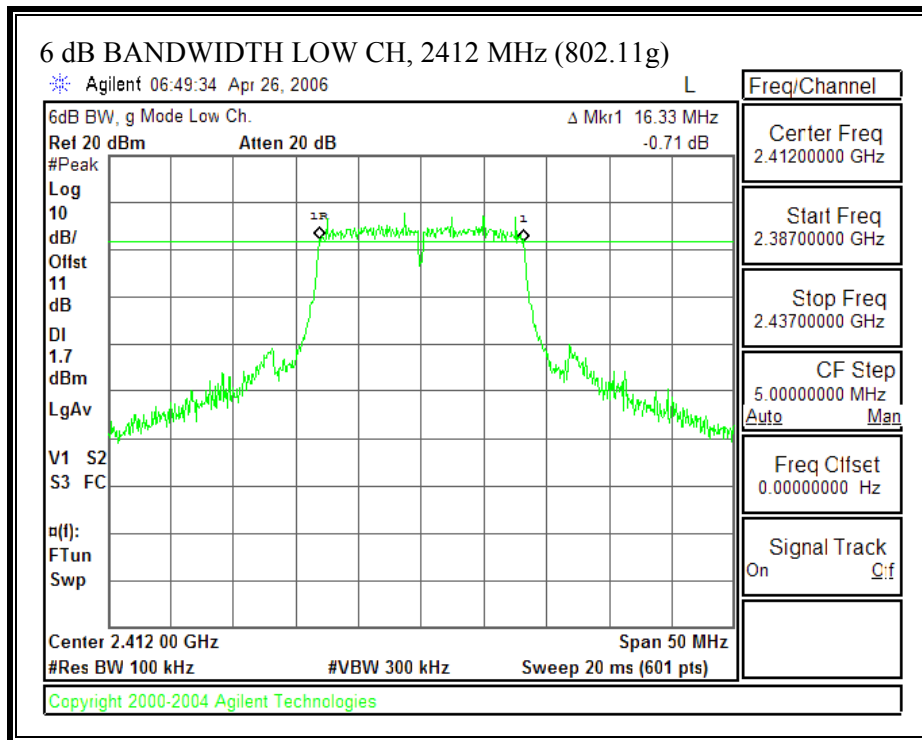


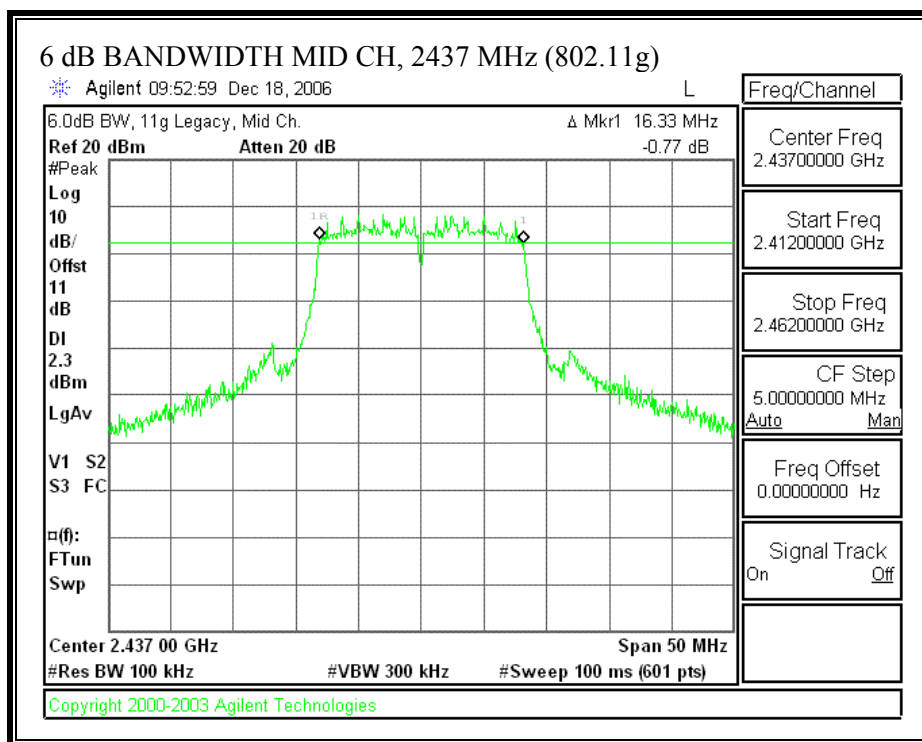


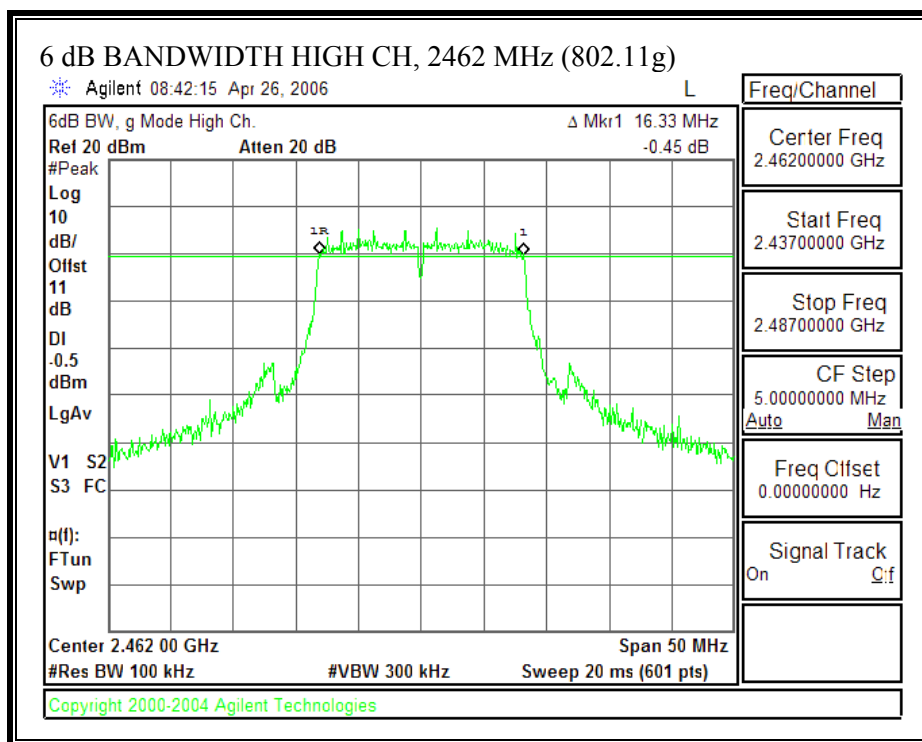


802.11g Legacy Mode

6 dB BANDWIDTH – 11g Mode

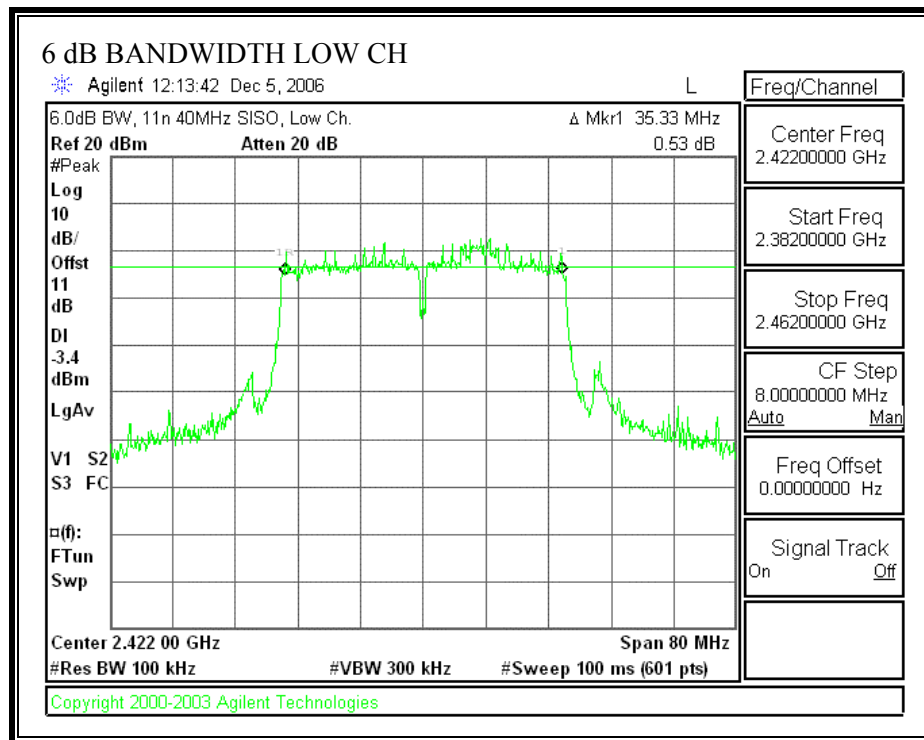


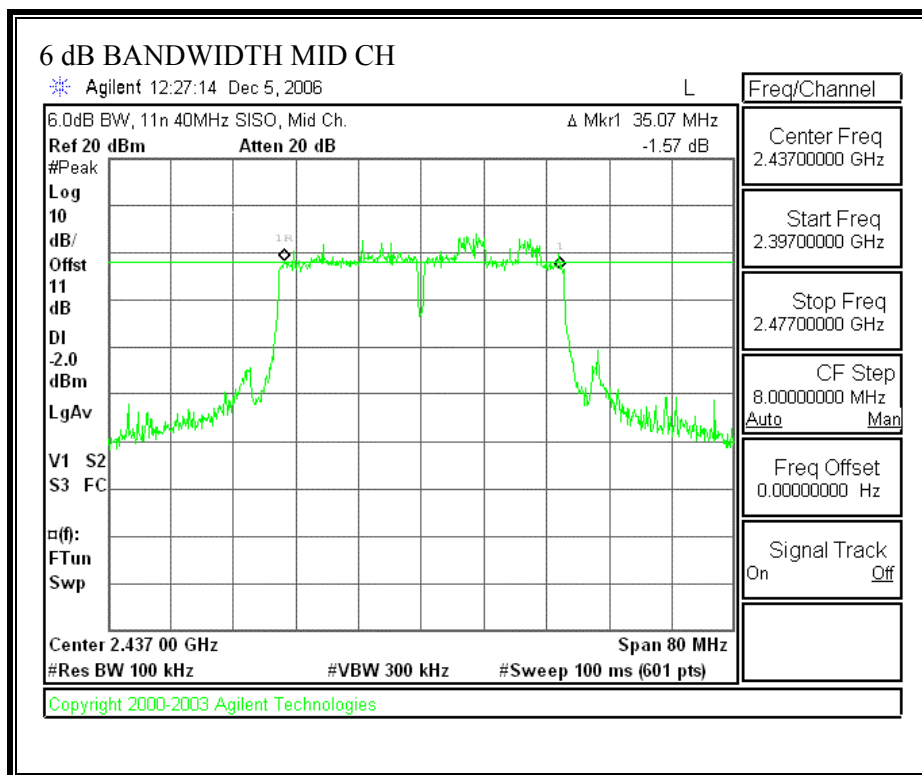


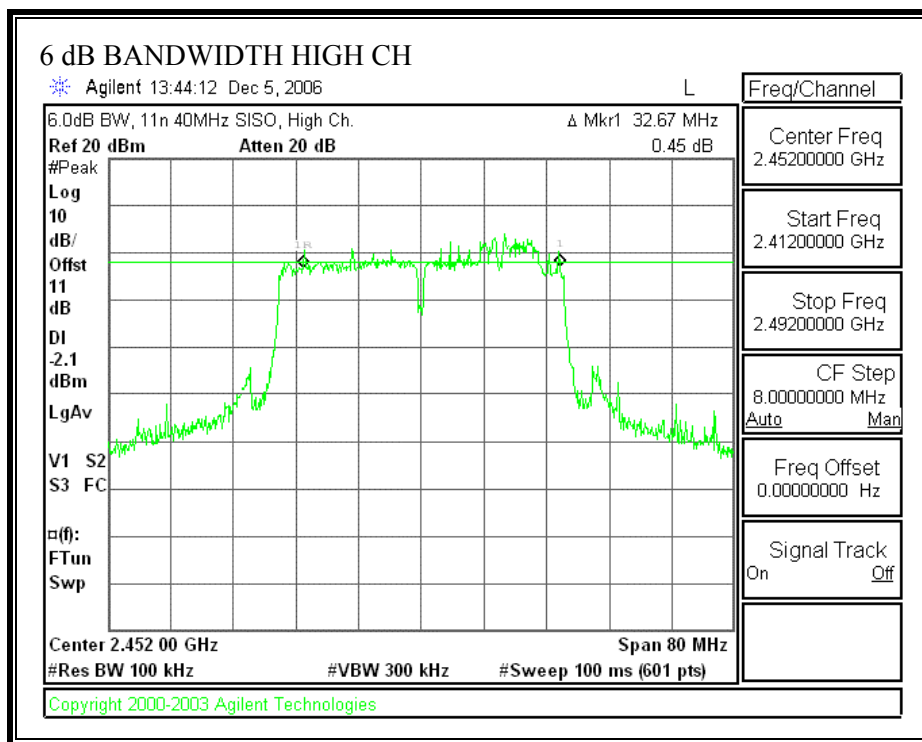


802.11n Mode 40 MHz SISO

6 dB BANDWIDTH (802.11n 40 MHz SISO MODE)







7.1.2. 99% BANDWIDTH

LIMIT

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

RESULTS

No non-compliance noted:

802.11b Legacy Mode

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2412	13.1316
Middle	2437	13.9032
High	2462	13.0540

802.11g Legacy Mode

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2412	16.4843
Middle	2437	16.4156
High	2462	16.4633

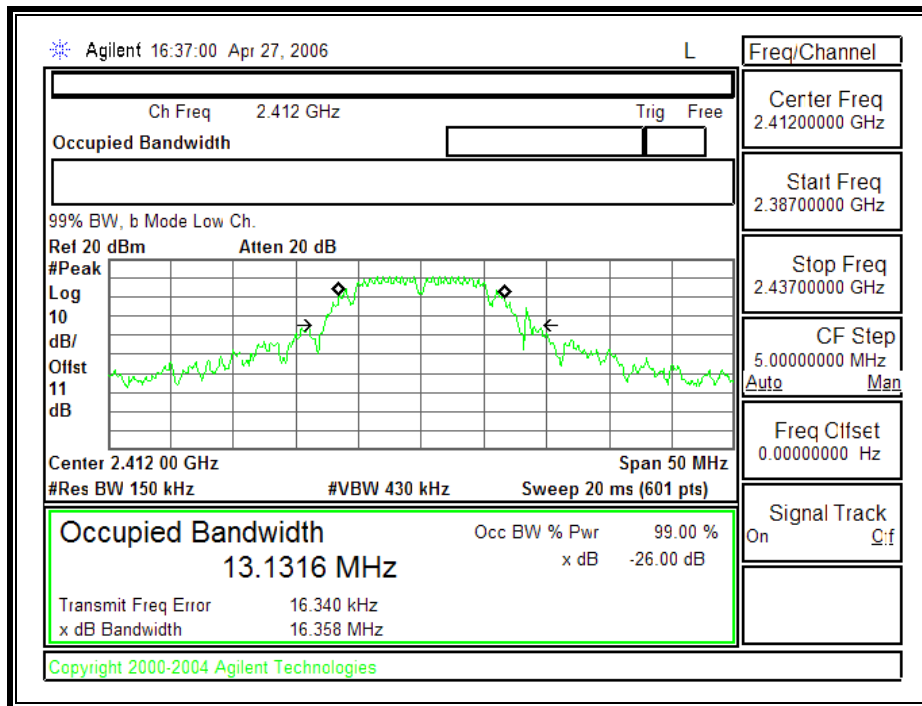
802.11n Mode 20 MHz SISO is covered by the worst case 802.11g Mode Legacy testing.

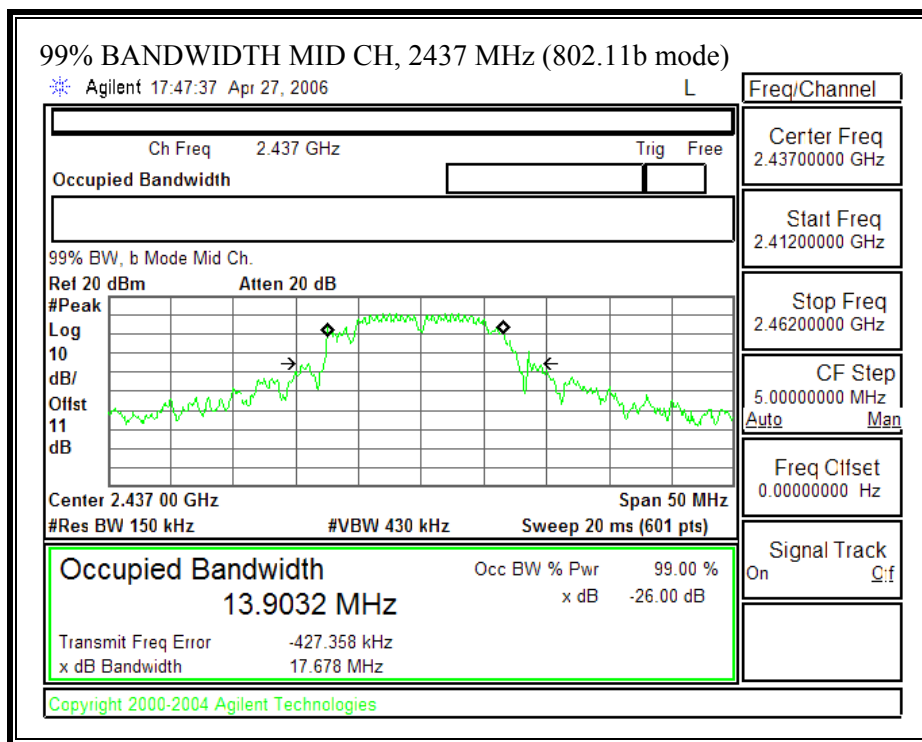
802.11n Mode 40 MHz SISO

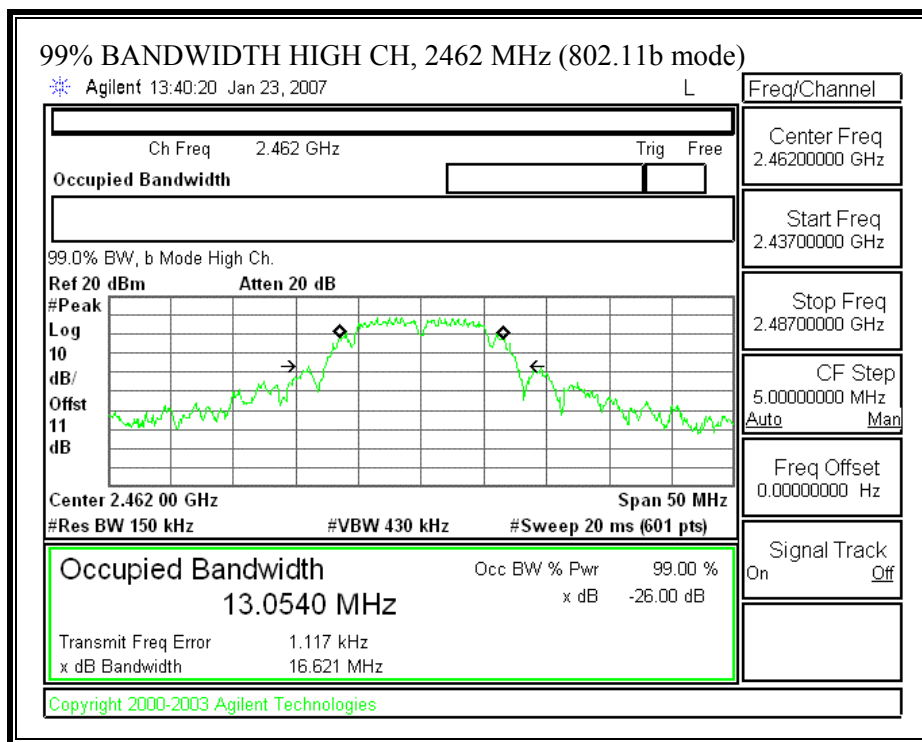
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	2422	36.0504
Middle	2437	36.2982
High	2452	36.0834

802.11b Legacy Mode

99% BANDWIDTH (802.11b MODE)

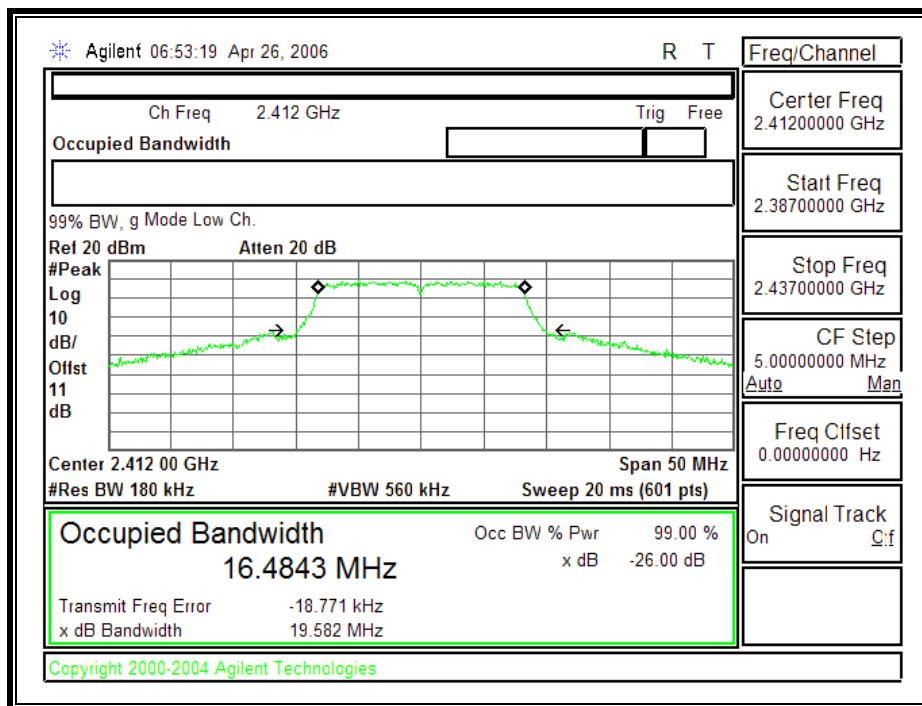


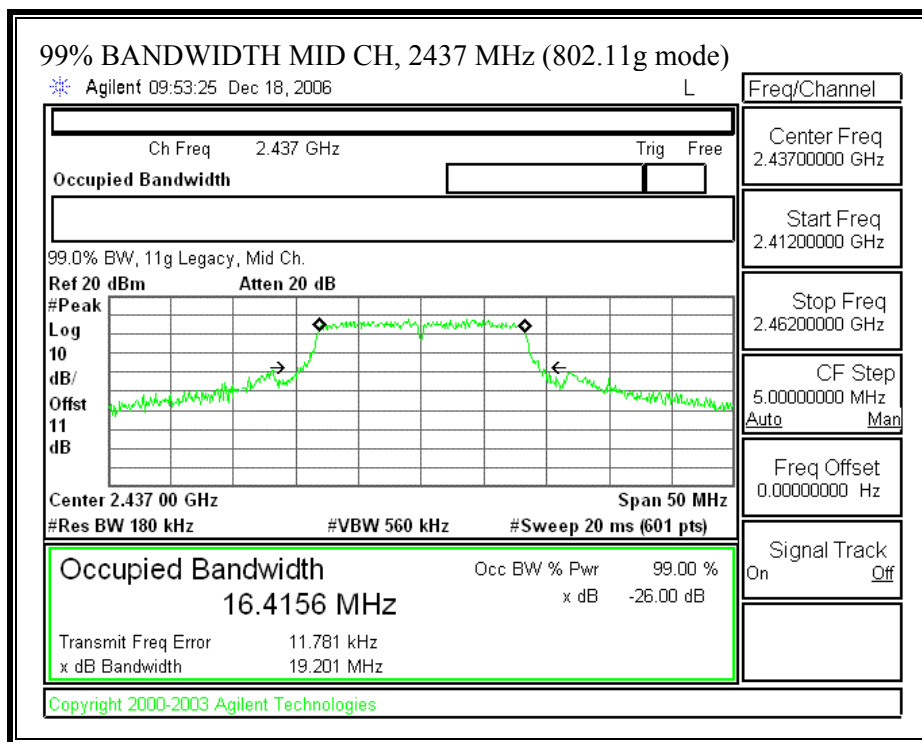


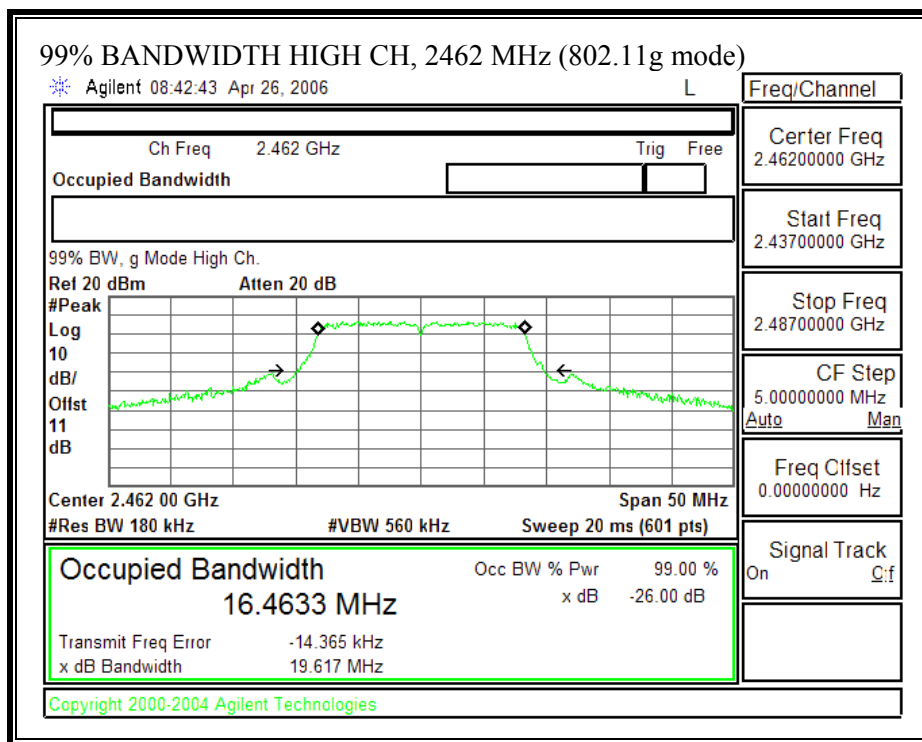


802.11g Legacy Mode

99% BANDWIDTH (802.11g MODE)

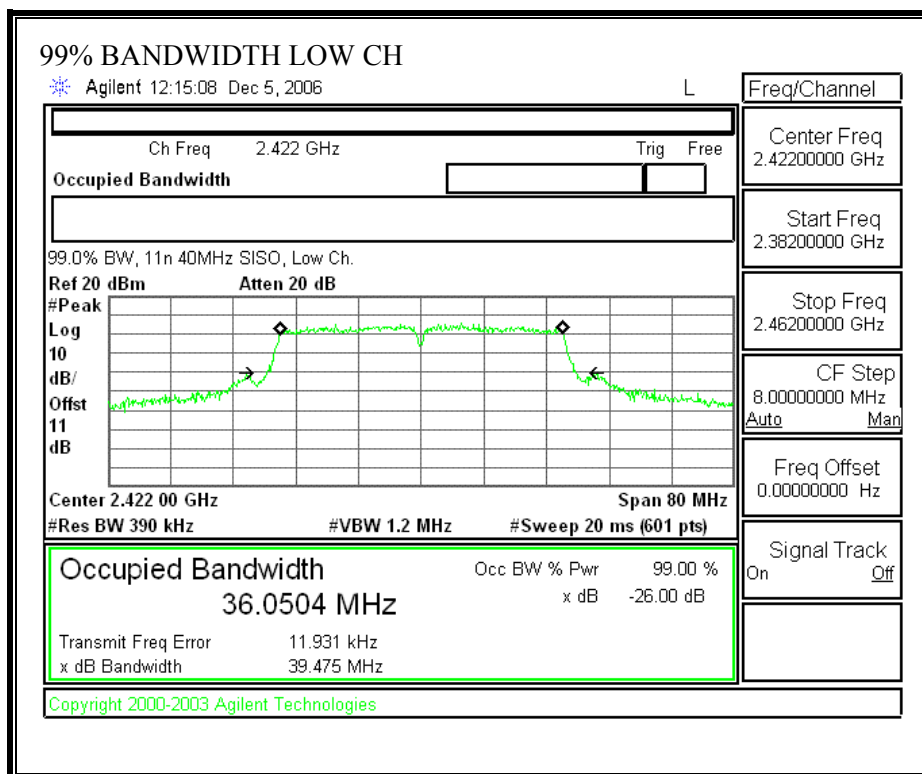


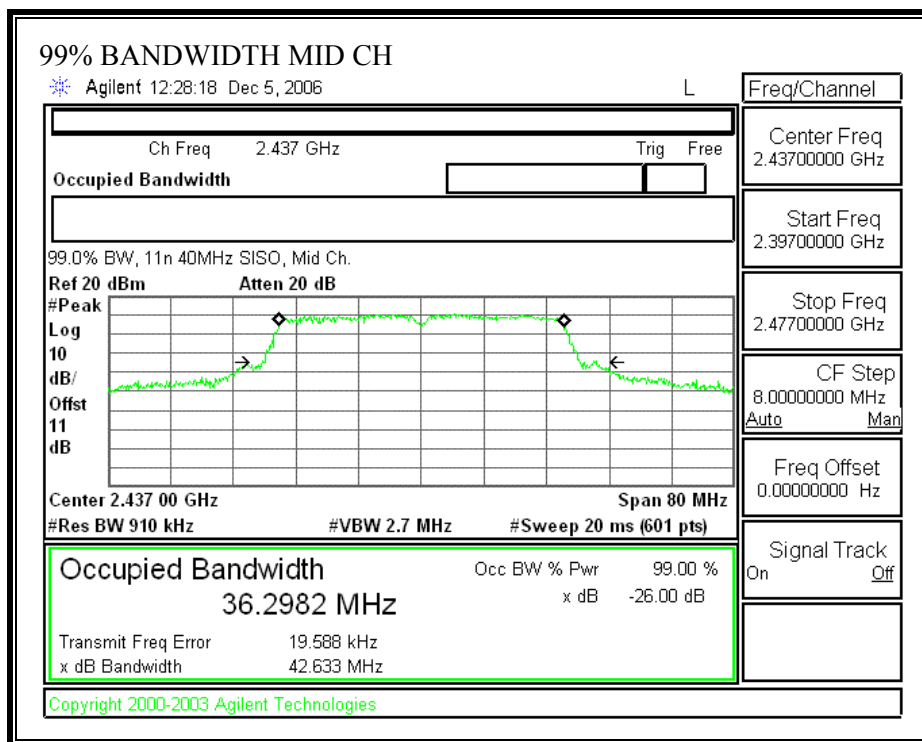


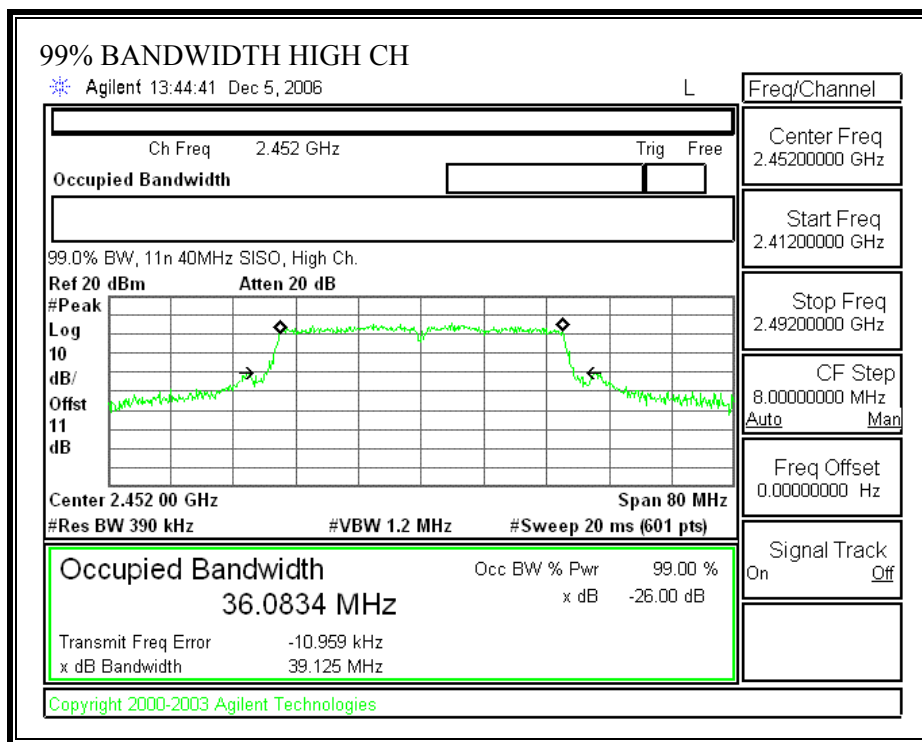


802.11n Mode 40 MHz SISO

99% BANDWIDTH (802.11n 40 MHz SISO MODE)







7.1.3. PEAK OUTPUT POWER

PEAK POWER LIMIT

§15.247 (b) The maximum peak output power of the intentional radiator shall not exceed the following:

§15.247 (b) (3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz , and 5725-5850 MHz bands: 1 watt.

§15.247 (b) (4) Except as shown in paragraphs (b)(4) (i), (ii) and (iii) of this section, if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1) or (b)(2) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

§15.247 (b) (4) (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer and the analyzer's internal channel power integration function is used to integrate the power over a bandwidth greater than or equal to the 99% bandwidth.

ANTENNA GAIN

2.4GHz band: 3.36 dBi

5.8GHz band: 6.02 dBi

RESULTS

The maximum antenna gain is 3.36dBi @ 2.4GHz for other than fixed, point-to-point operations, therefore the limit is still 30 dBm for 2.4GHz band.

No non-compliance noted:

802.11b Legacy Mode

Channel	Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
1	2412	22.32	30	-7.68
2	2417	23.19	30	-6.81
6	2437	23.01	30	-6.99
10	2457	22.56	30	-7.44
11	2462	21.86	30	-8.14

802.11g Legacy

Channel	Frequency (MHz)	Peak (dBm)	Limit (dBm)	Margin (dB)
1	2412	23.15	30	-6.85
2	2417	24.29	30	-5.71
6	2437	25.70	30	-4.30
10	2457	24.40	30	-5.60
11	2462	22.10	30	-7.90

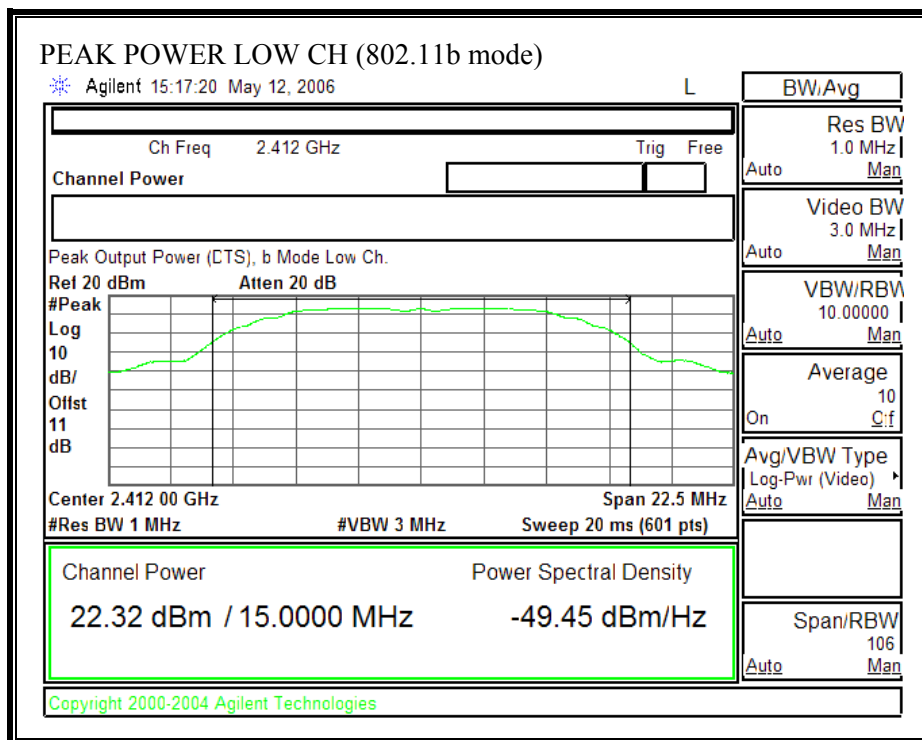
802.11n Mode 20 MHz SISO is covered by the worst case 802.11g Mode Legacy testing.

802.11n Mode 40 MHz SISO

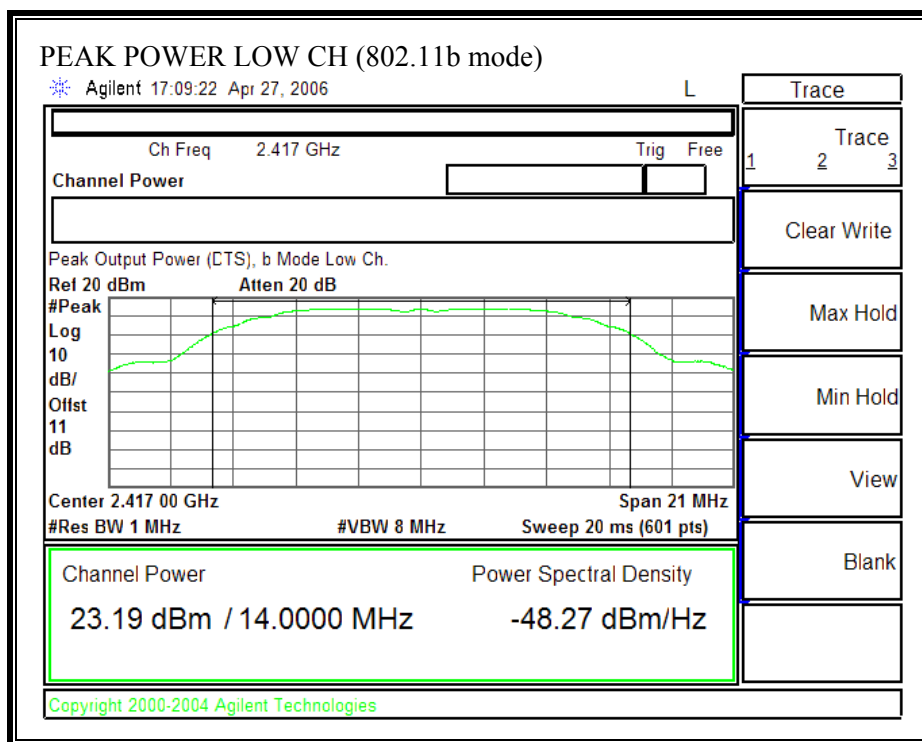
Channel	Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
Low	2422	22.34	30	-7.66
Low	2427	23.19	30	-6.81
Middle	2437	23.06	30	-6.94
High	2447	22.26	30	-7.74
High	2452	21.19	30	-8.81

802.11b Legacy Mode

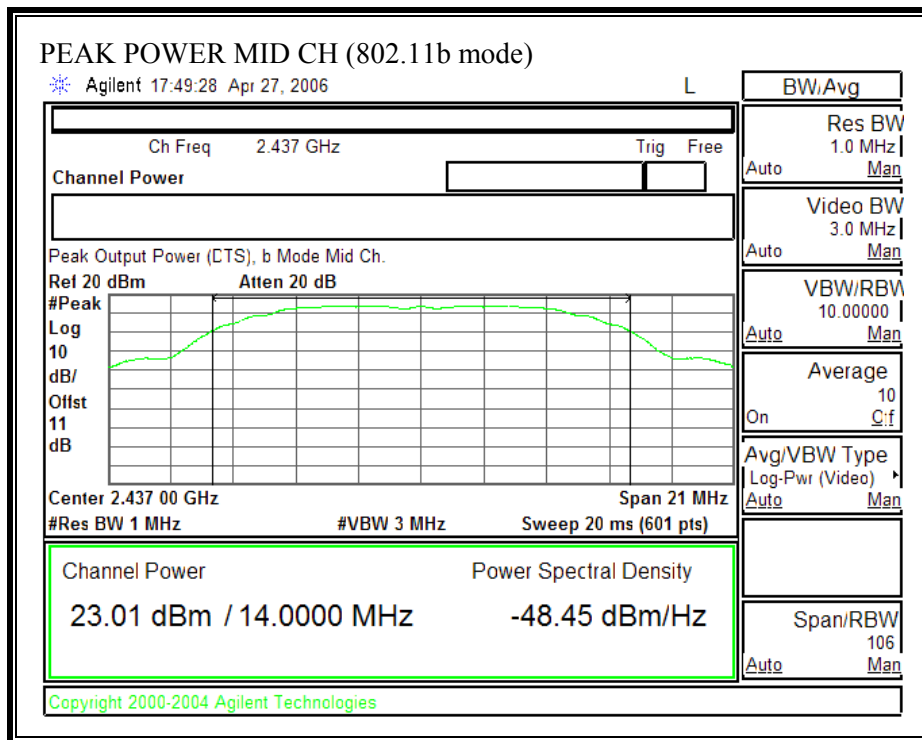
CHANNEL 1, 2412 MHz



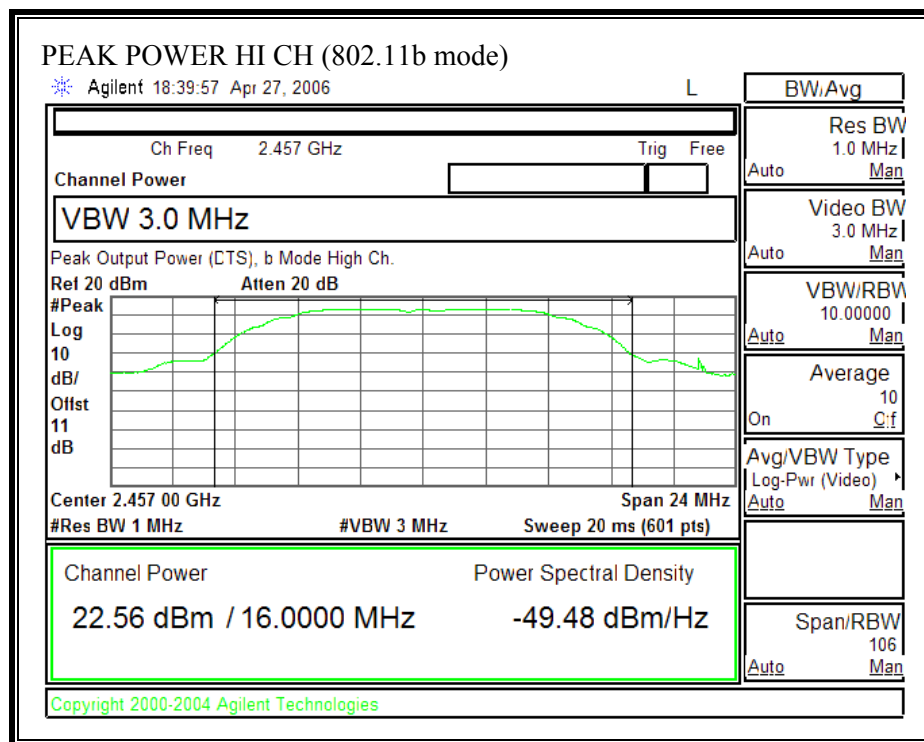
CHANNEL 2, 2417 MHz



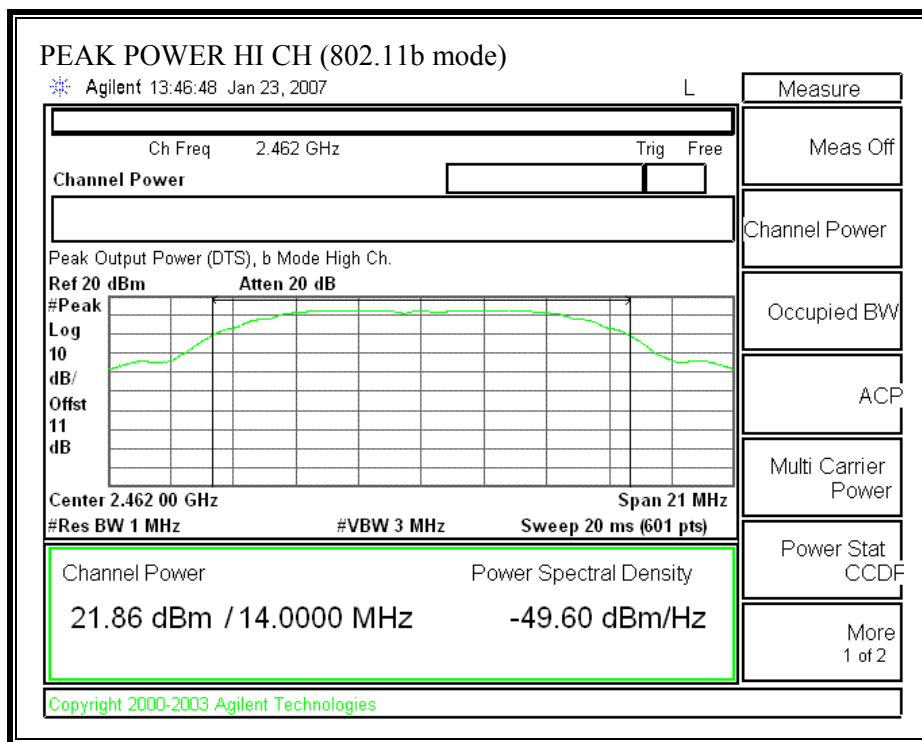
CHANNEL 2, 2437 MHz



CHANNEL 10, 2457 MHz



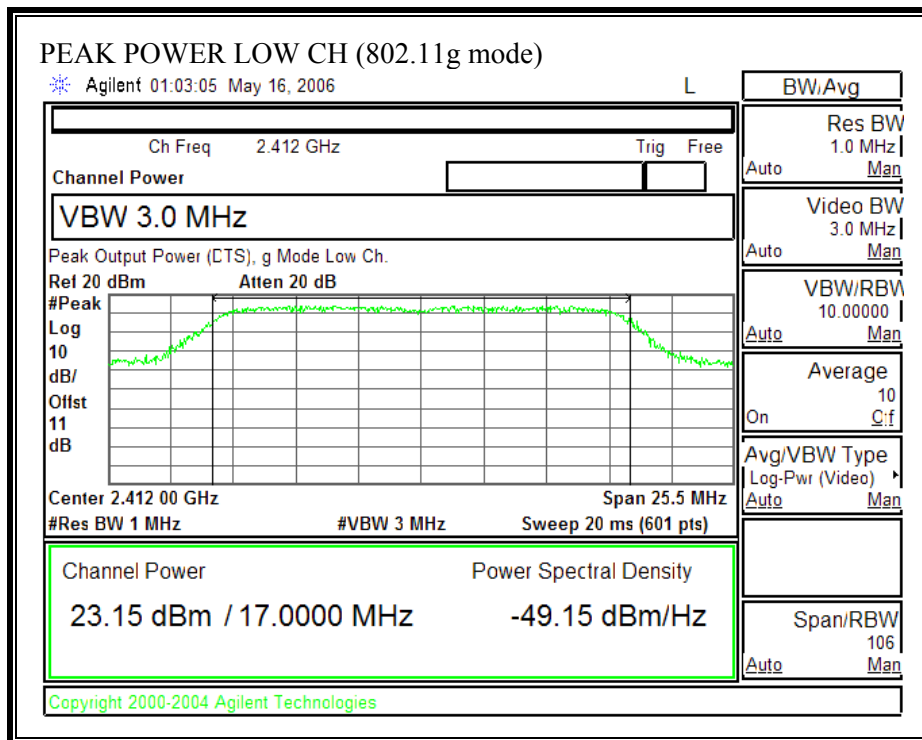
CHANNEL 11, 2462 MHz



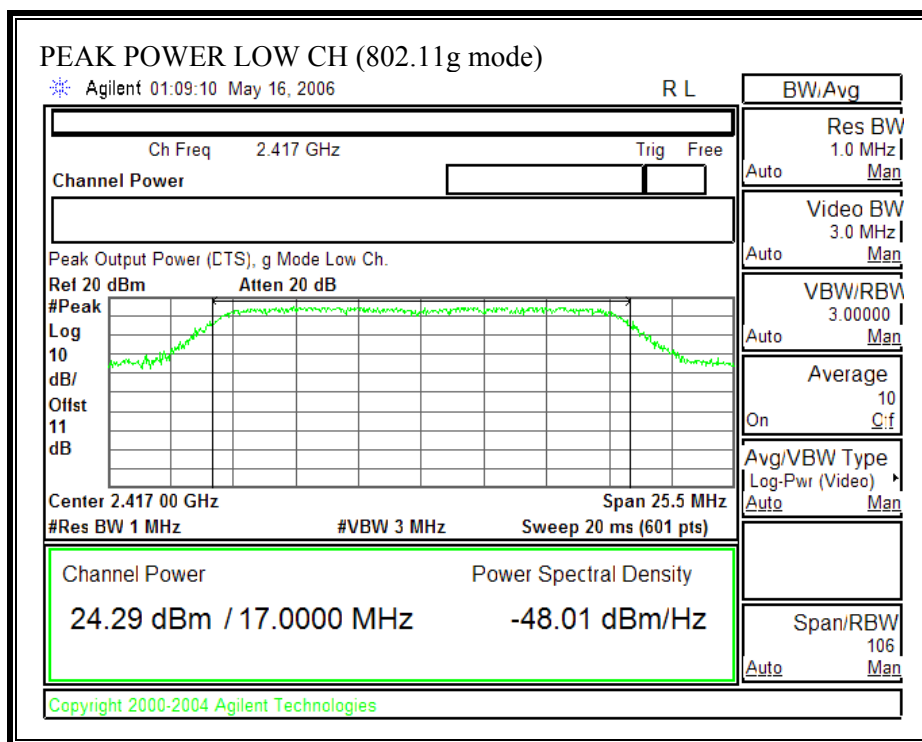
802.11g Legacy Mode

OUTPUT POWER (802.11g MODE)

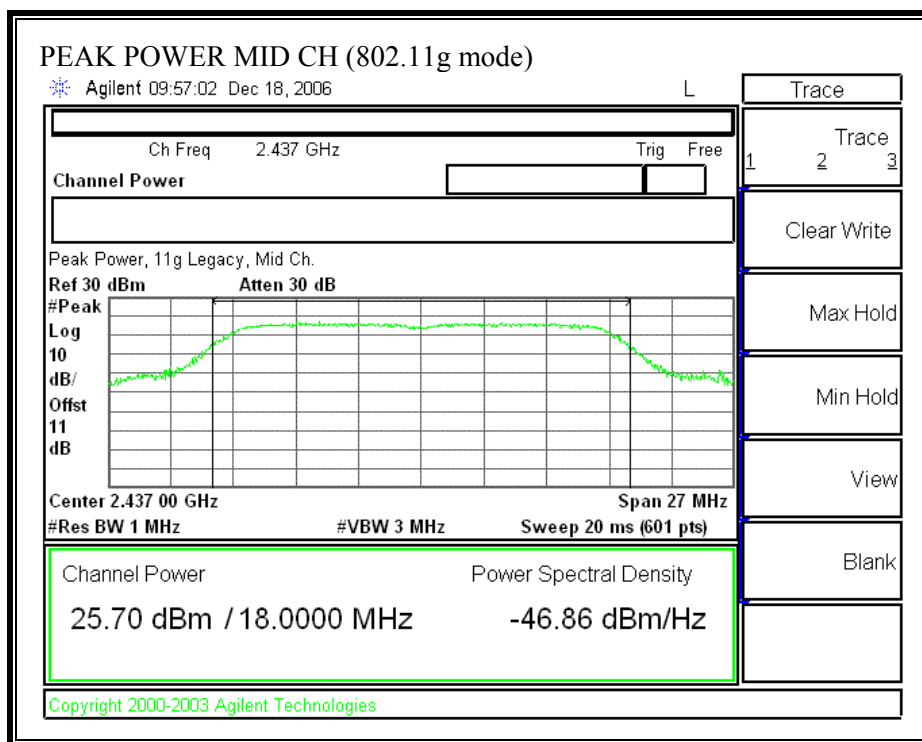
CHANNEL 1, 2412 MHz



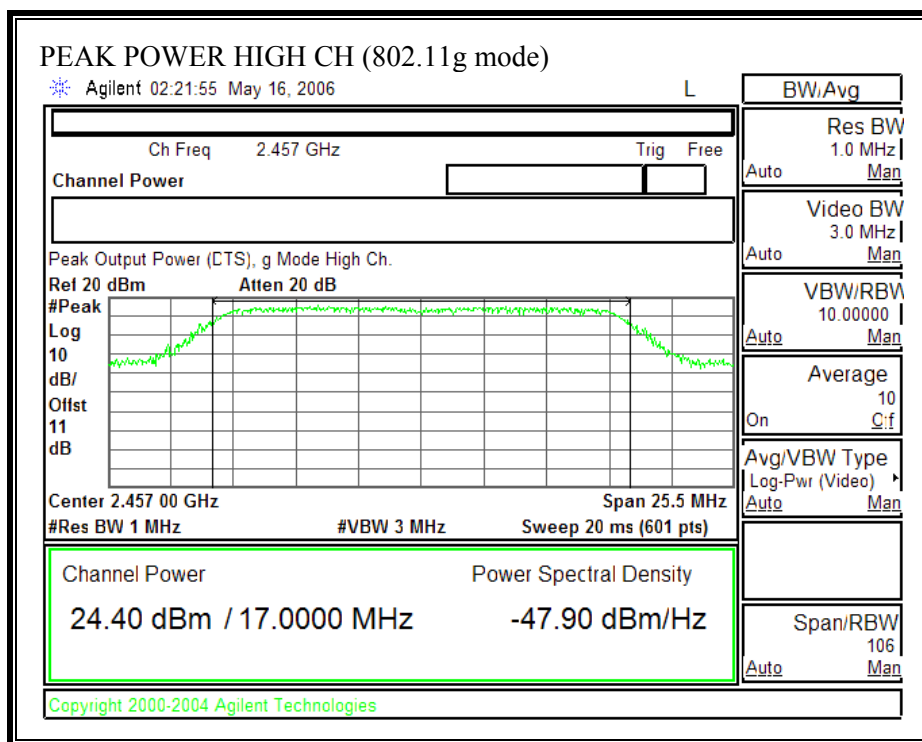
CHANNEL 2, 2417 MHz



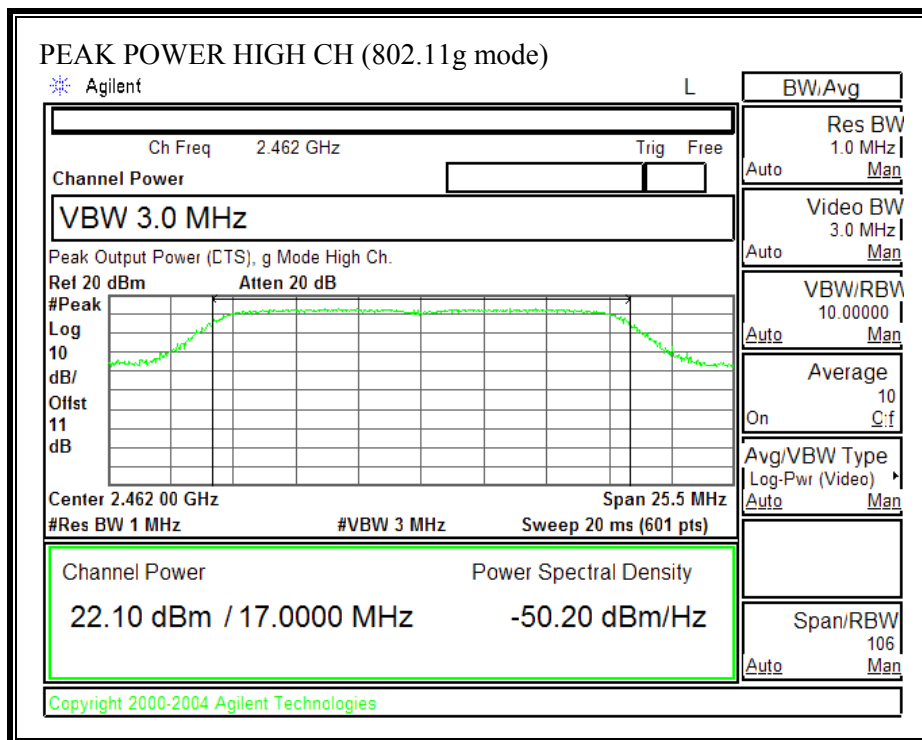
CHANNEL 6, 2437 MHz



CHANNEL 10, 2457 MHz

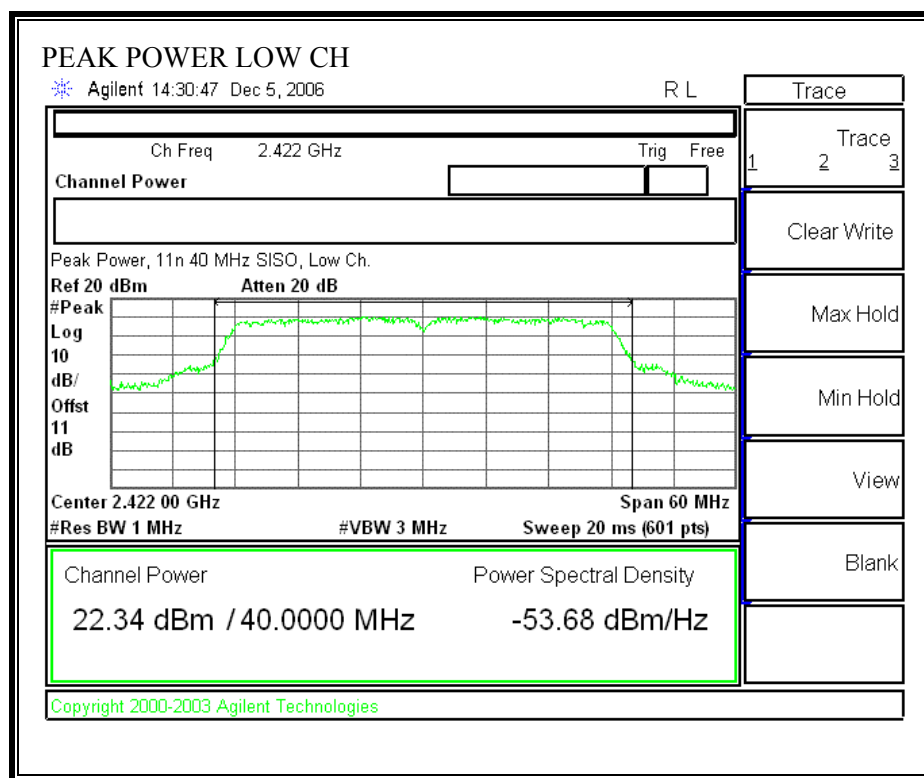


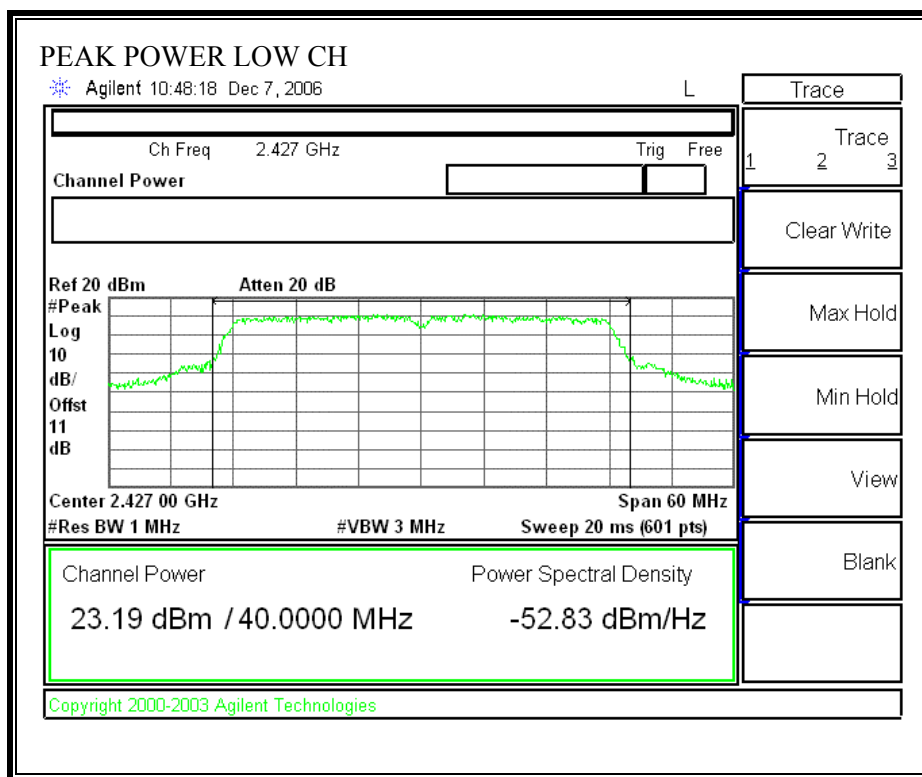
CHANNEL 11, 2462 MHz

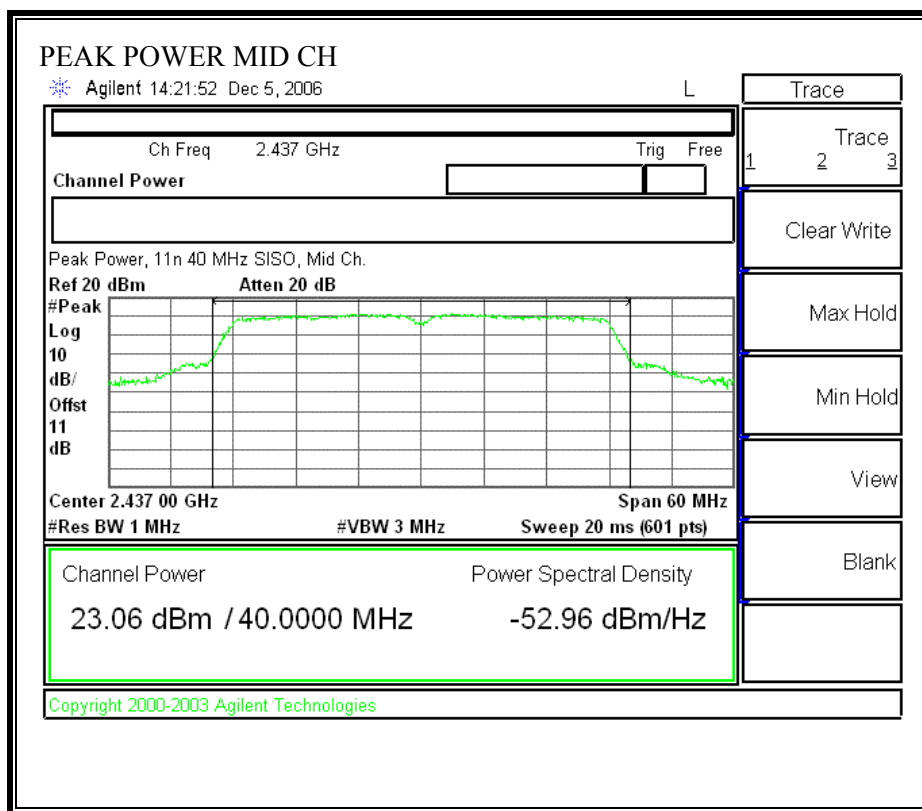


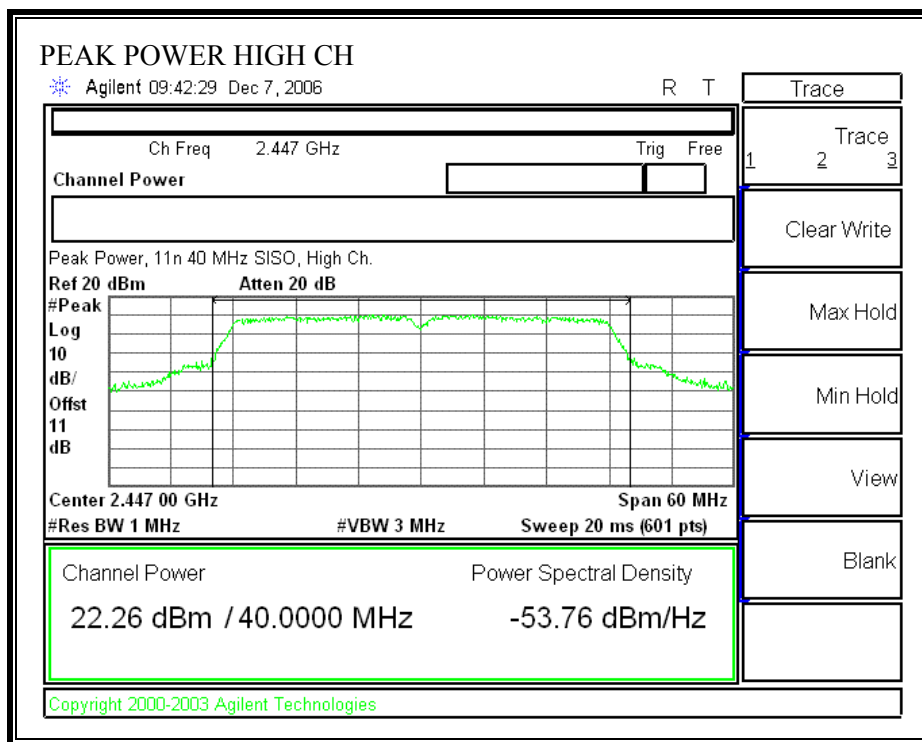
802.11n Mode 40 MHz SISO

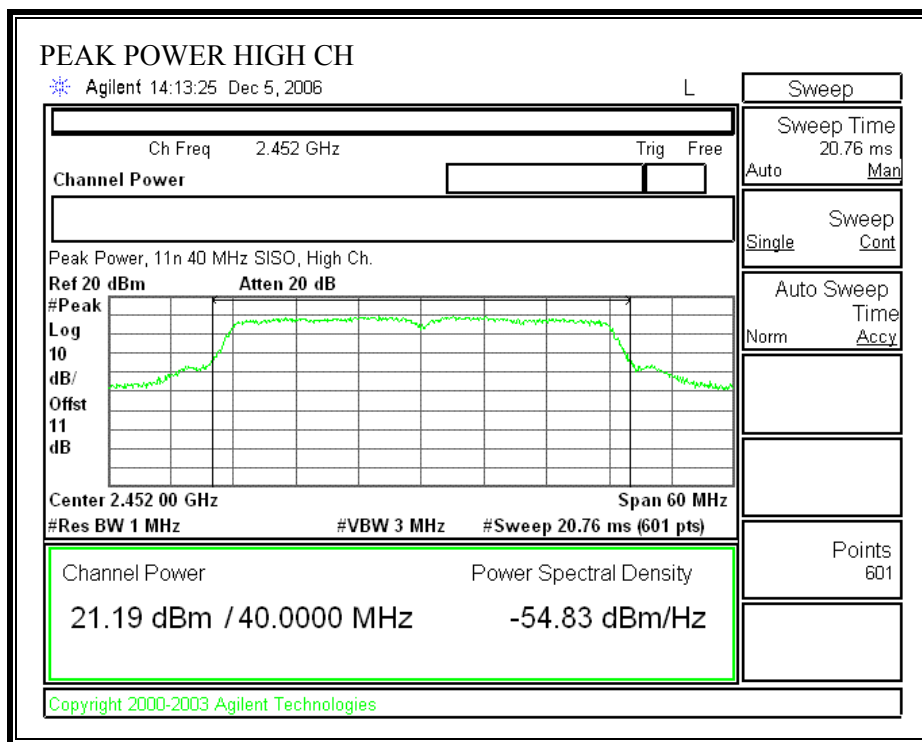
OUTPUT POWER (802.11n 40 MHz SISO MODE)











7.1.4. MAXIMUM PERMISSIBLE EXPOSURE

LIMITS

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f ²)	6
30–300	61.4	0.163	1.0	6
300–1500 .....	.....	.....	f/300	6
1500–100,000 .....	.....	.....	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f ²)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500 .....	.....	.....	f/1500	30
1500–100,000 .....	.....	.....	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

CALCULATIONS

Given

$$E = \sqrt{(30 * P * G) / d}$$

and

$$S = E^2 / 3770$$

where

E = Field Strength in Volts/meter

P = Power in Watts

G = Numeric antenna gain

d = Distance in meters

S = Power Density in milliwatts/square centimeter

Combining equations and rearranging the terms to express the distance as a function of the remaining variables yields:

$$d = \sqrt{((30 * P * G) / (3770 * S))}$$

Changing to units of Power to mW and Distance to cm, using:

$$P \text{ (mW)} = P \text{ (W)} / 1000 \text{ and}$$

$$d \text{ (cm)} = 100 * d \text{ (m)}$$

yields

$$d = 100 * \sqrt{((30 * (P / 1000) * G) / (3770 * S))}$$

$$d = 0.282 * \sqrt{(P * G / S)}$$

where

d = distance in cm

P = Power in mW

G = Numeric antenna gain

S = Power Density in mW/cm²

Substituting the logarithmic form of power and gain using:

$$P \text{ (mW)} = 10^{(P \text{ (dBm)} / 10)} \text{ and}$$

$$G \text{ (numeric)} = 10^{(G \text{ (dBi)} / 10)}$$

yields

$$d = 0.282 * 10^{((P + G) / 20)} / \sqrt{S} \quad \text{Equation (1)}$$

where

d = MPE distance in cm

P = Power in dBm

G = Antenna Gain in dBi

S = Power Density Limit in mW/cm²

Equation (1) and the measured peak power is used to calculate the MPE distance.

LIMITS

From §1.1310 Table 1 (B), $S = 1.0 \text{ mW/cm}^2$ in the 2.4 GHz band.

RESULTS

No non-compliance noted:

802.11b Legacy Mode

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm ²)
802.11b Mode Legacy	20.0	23.19	3.36	0.09

802.11g Legacy Mode

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm ²)
802.11g	20.0	25.70	3.36	0.16

802.11n Mode 20 MHz SISO is covered by the worst case 802.11g Mode Legacy testing.

802.11n Mode 40 MHz SISO

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm ²)
802.11n 40 MHz SISO	20.0	23.19	3.36	0.09

NOTE: For mobile or fixed location transmitters, the minimum separation distance is 20 cm, even if calculations indicate that the MPE distance would be less.

7.1.5. PEAK POWER SPECTRAL DENSITY

LIMIT

§15.247 (d) For direct sequence systems, the peak 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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer, the maximum level in a 3 kHz bandwidth is measured with the spectrum analyzer using RBW = 3 kHz and VBW > 3 kHz, sweep time = span / 3 kHz, and video averaging is turned off. The PPSD is the highest level found across the emission in any 3 kHz band.

RESULTS

No non-compliance noted:

802.11b Mode Legacy

Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	2412	-1.75	8	-9.75
Low	2417	-3.52	8	-11.52
Middle	2437	-2.01	8	-10.01
High	2457	-2.35	8	-10.35
High	2462	-3.04	8	-11.04

802.11g Mode Legacy

Channel	Frequency (MHz)	PPSD Chain0 (dBm)	Limit (dBm)	Margin (dB)
Low	2412	-5.60	8	-13.60
Low	2417	-5.62	8	-13.62
Middle	2437	-4.60	8	-12.60
High	2457	-5.70	8	-13.70
High	2462	-8.36	8	-16.36

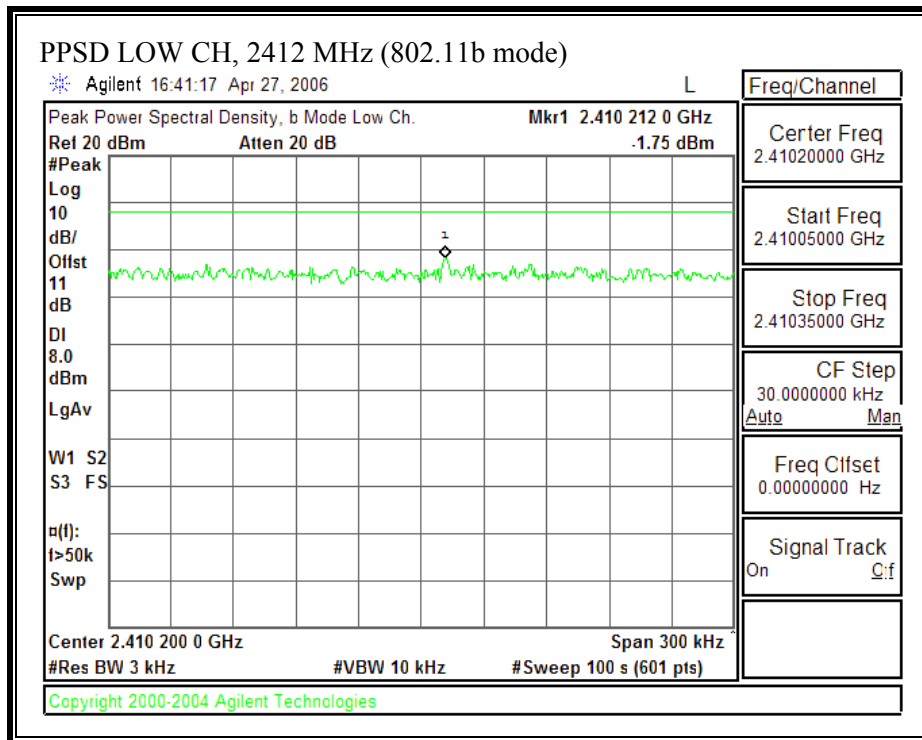
802.11n Mode 20 MHz SISO is covered by the worst case 802.11g Mode Legacy testing.

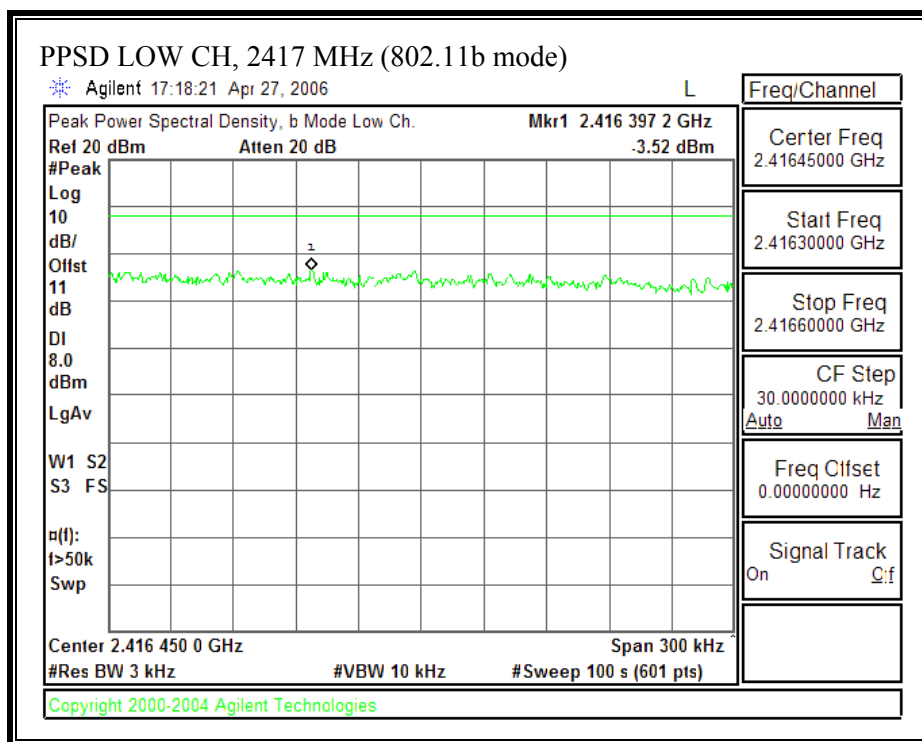
802.11n Mode 40 MHz SISO

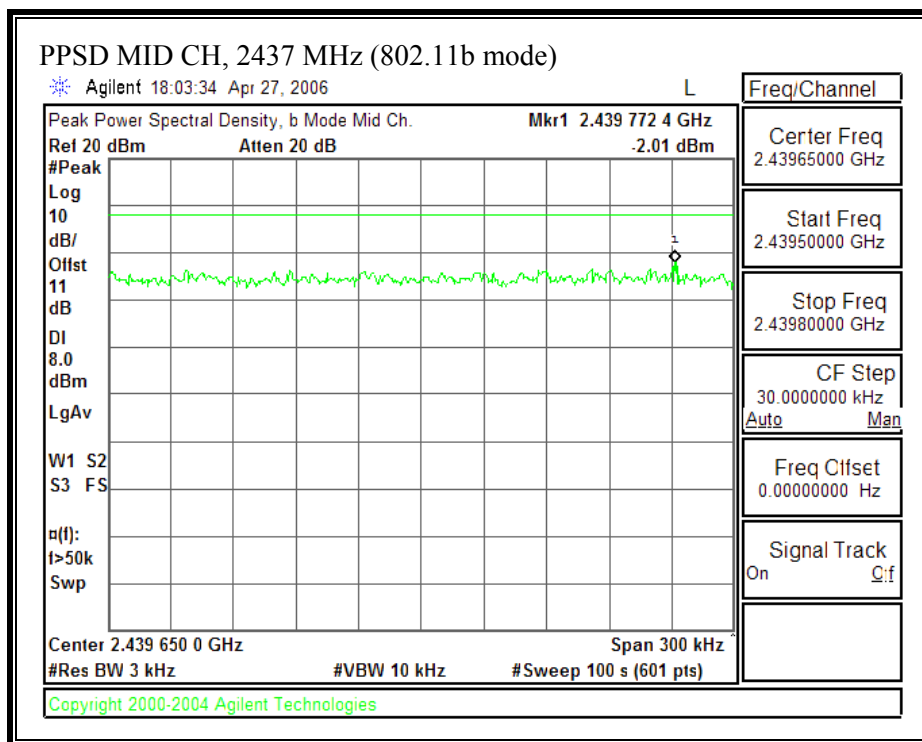
Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	2422	-9.77	8	-17.77
Low	2427	-8.70	8	-16.70
Middle	2437	-6.54	8	-14.54
High	2447	-8.29	8	-16.29
High	2452	-8.20	8	-16.20

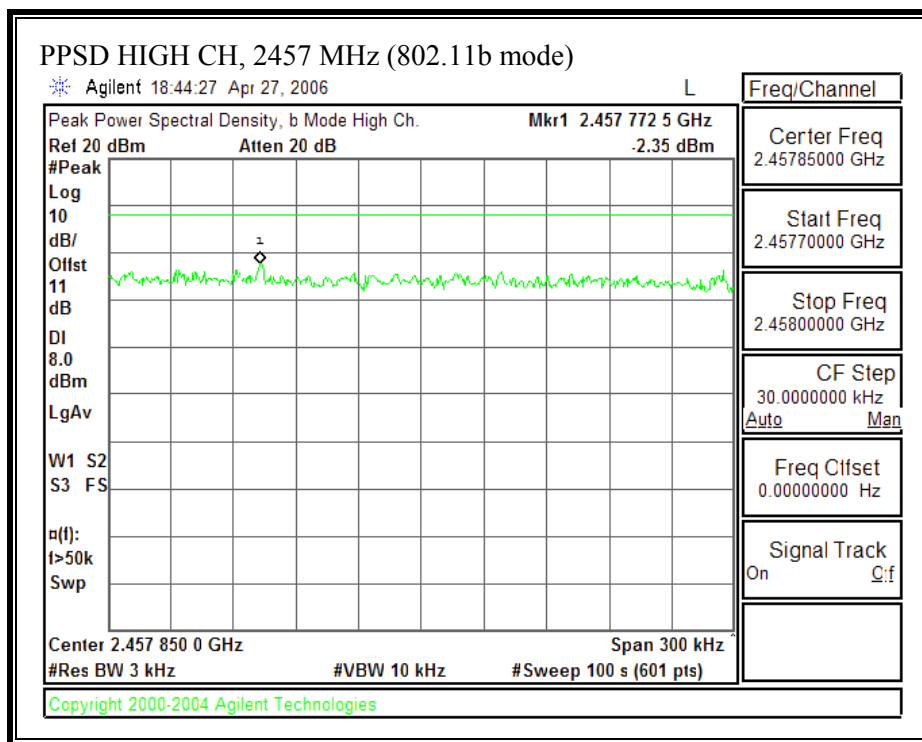
802.11b Legacy Mode

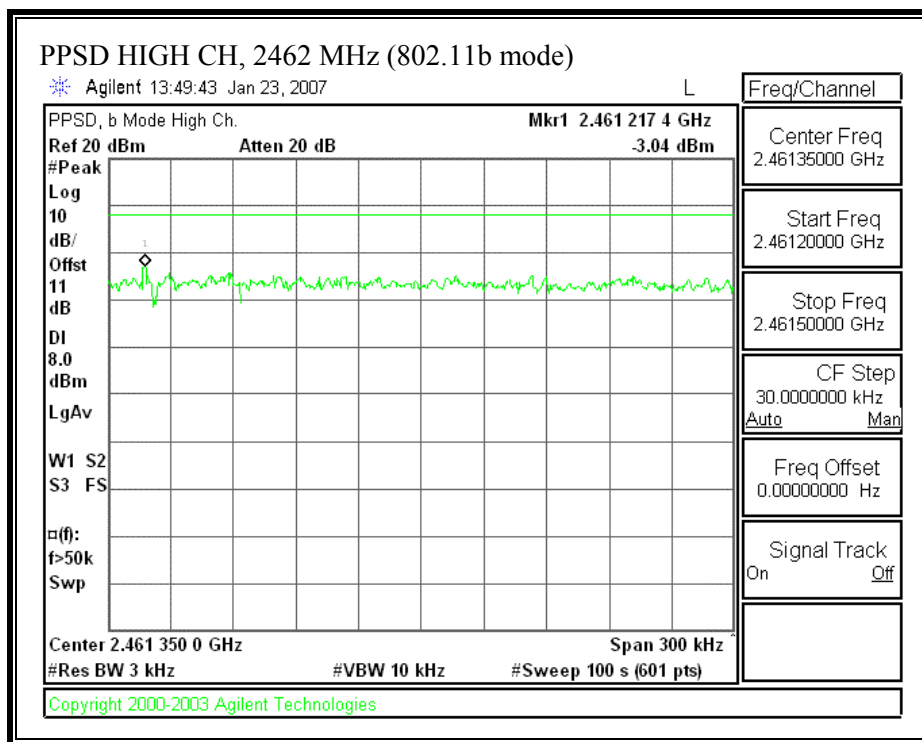
PEAK POWER SPECTRAL DENSITY (802.11b MODE)





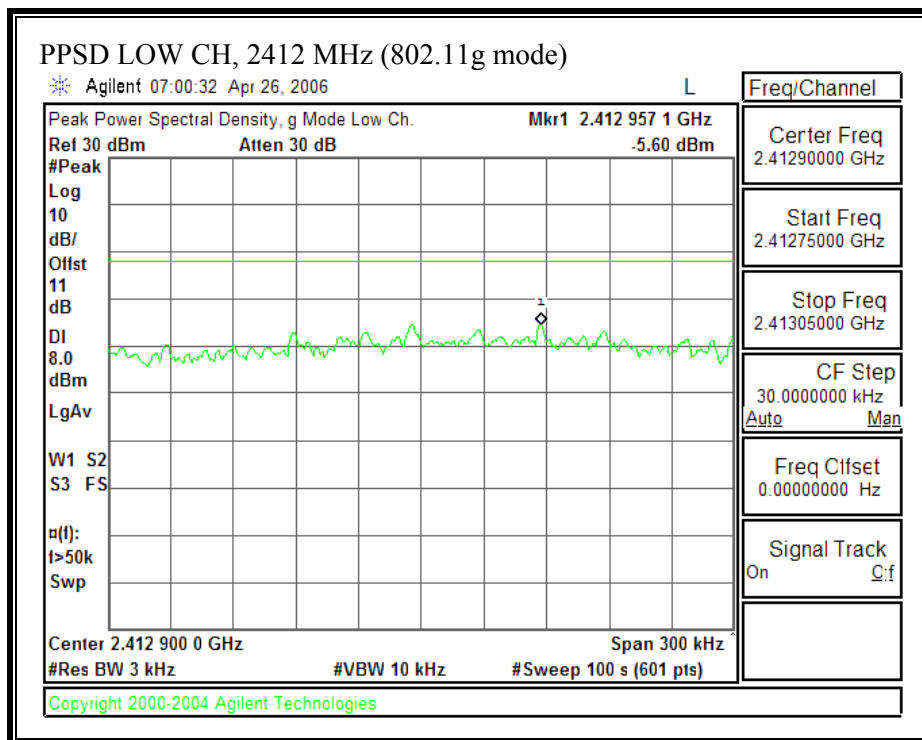


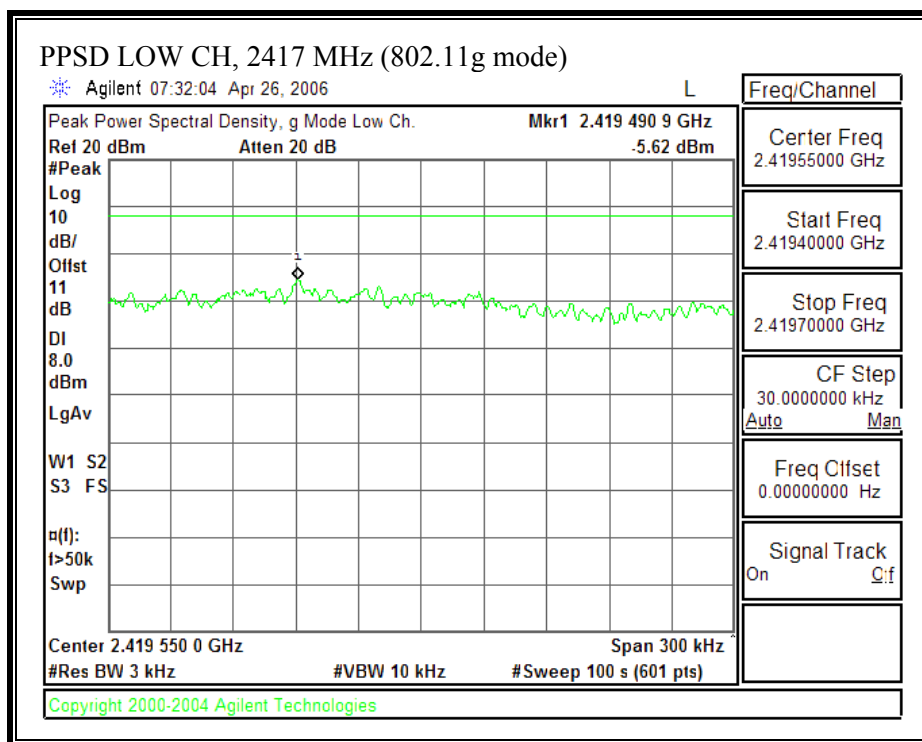


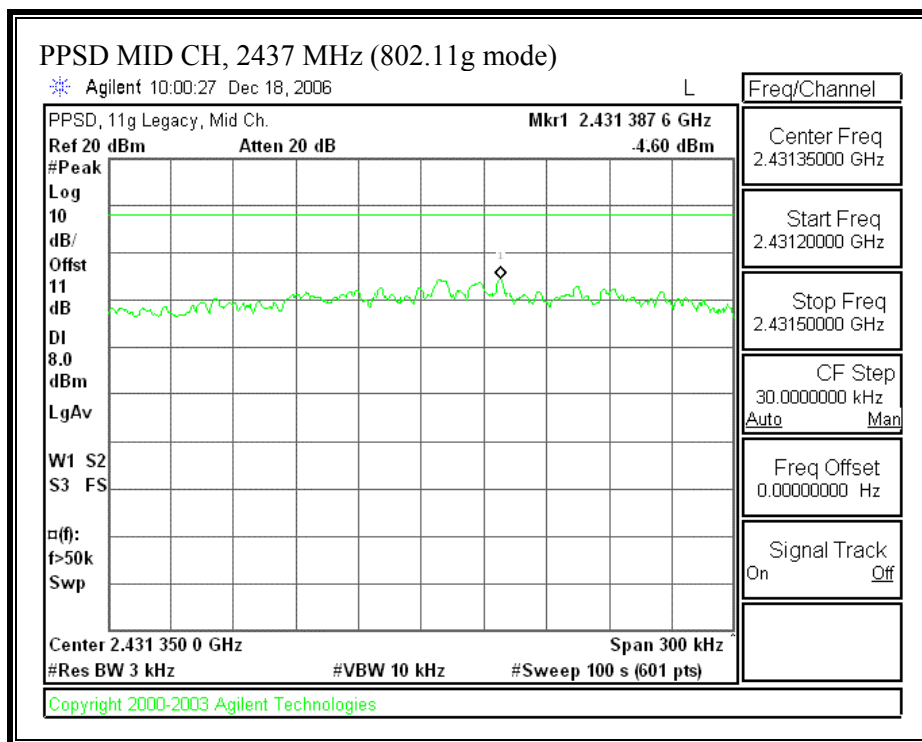


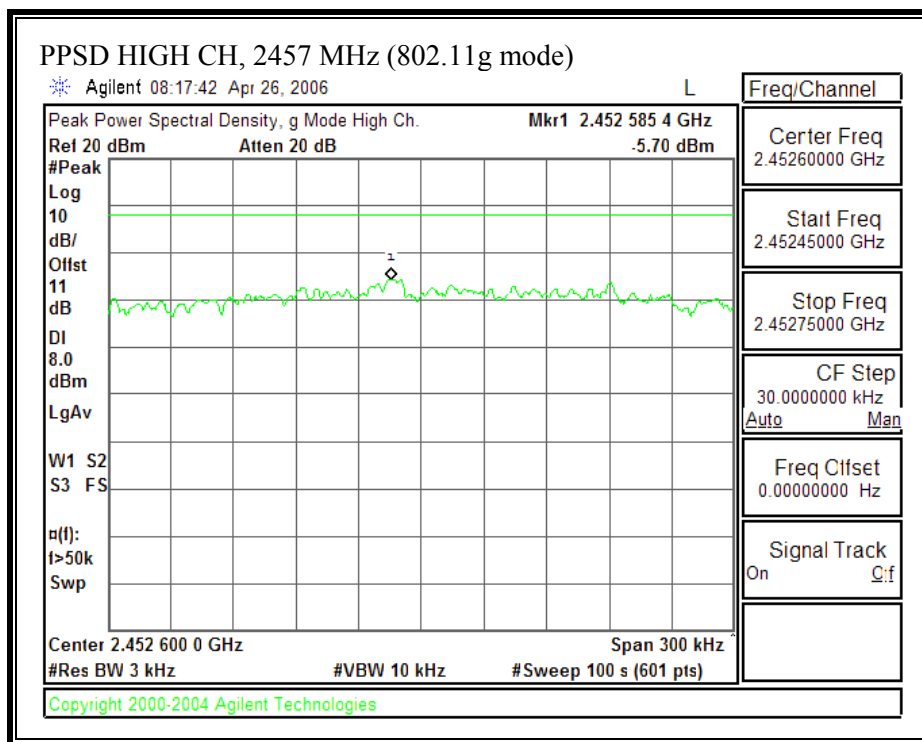
802.11g Legacy Mode

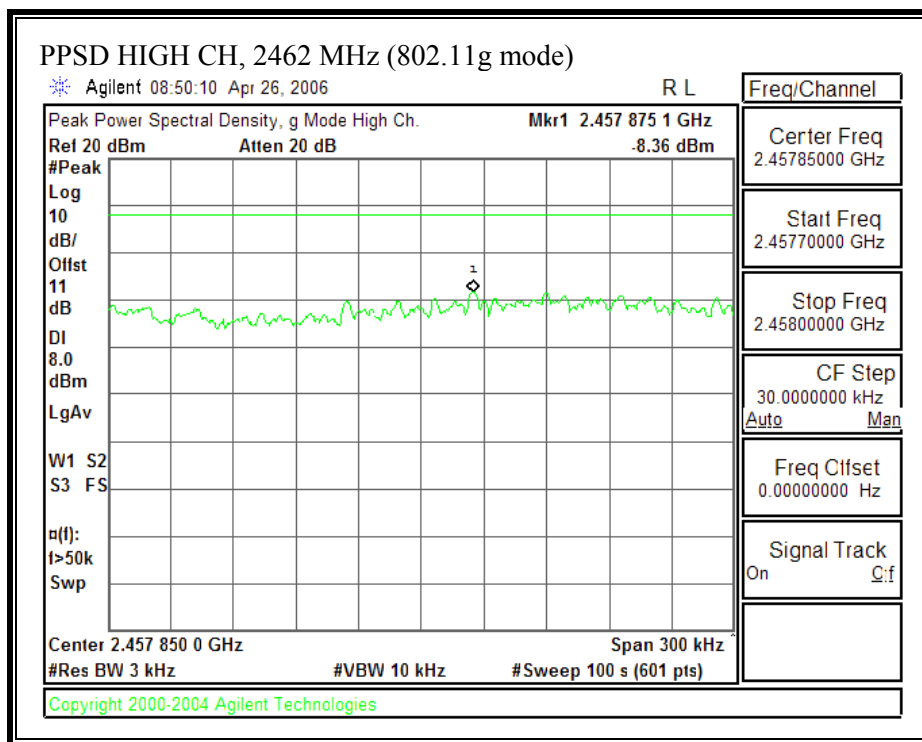
PEAK POWER SPECTRAL DENSITY (802.11g MODE))





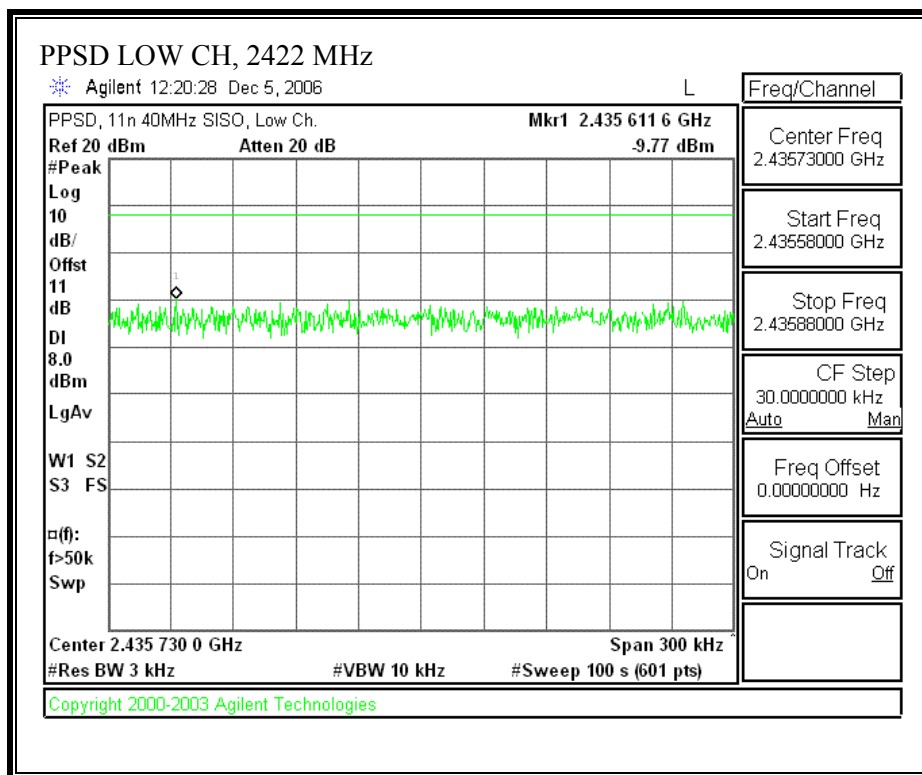


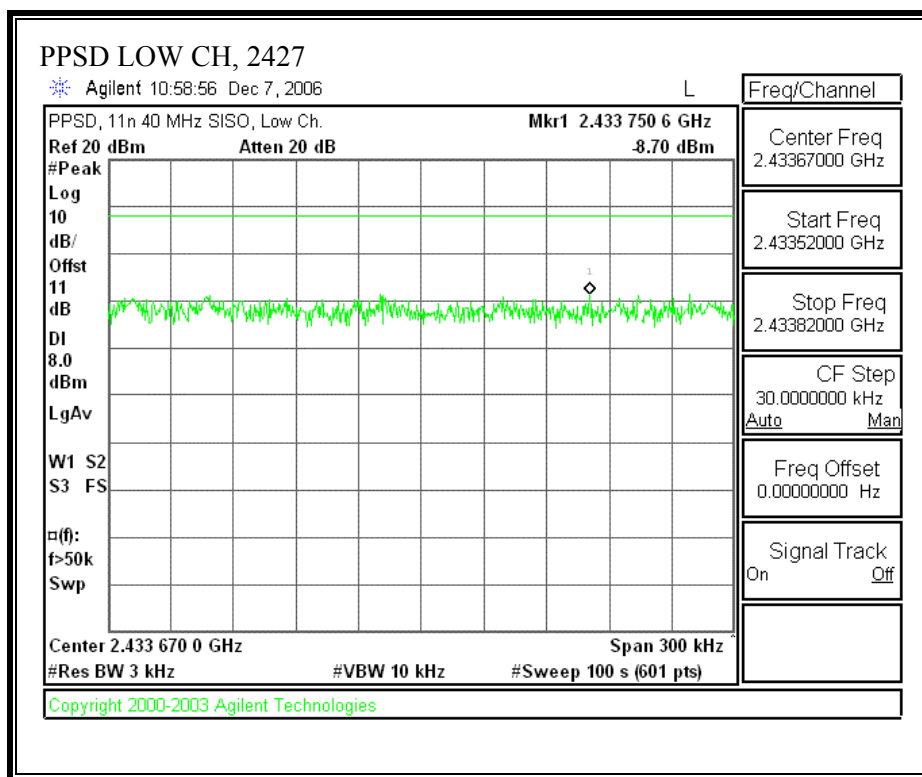


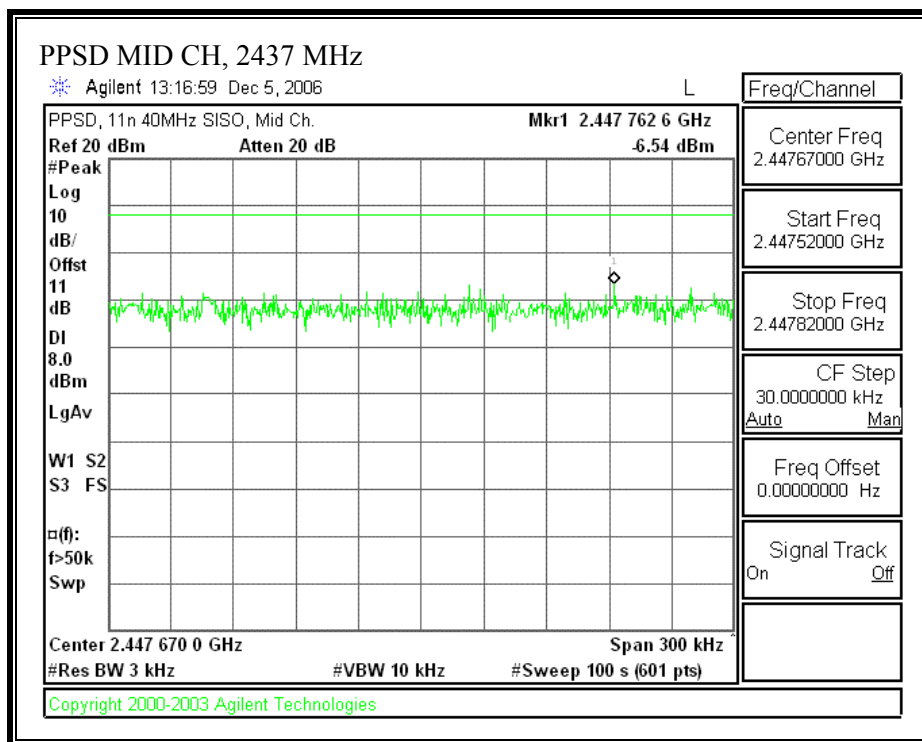


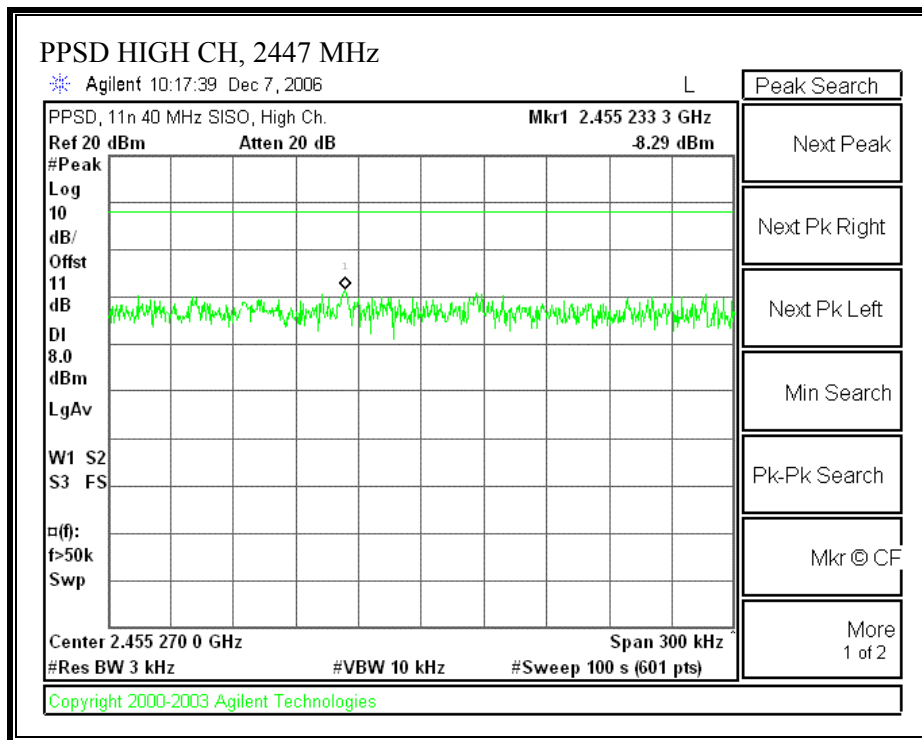
802.11n Mode 40 MHz SISO

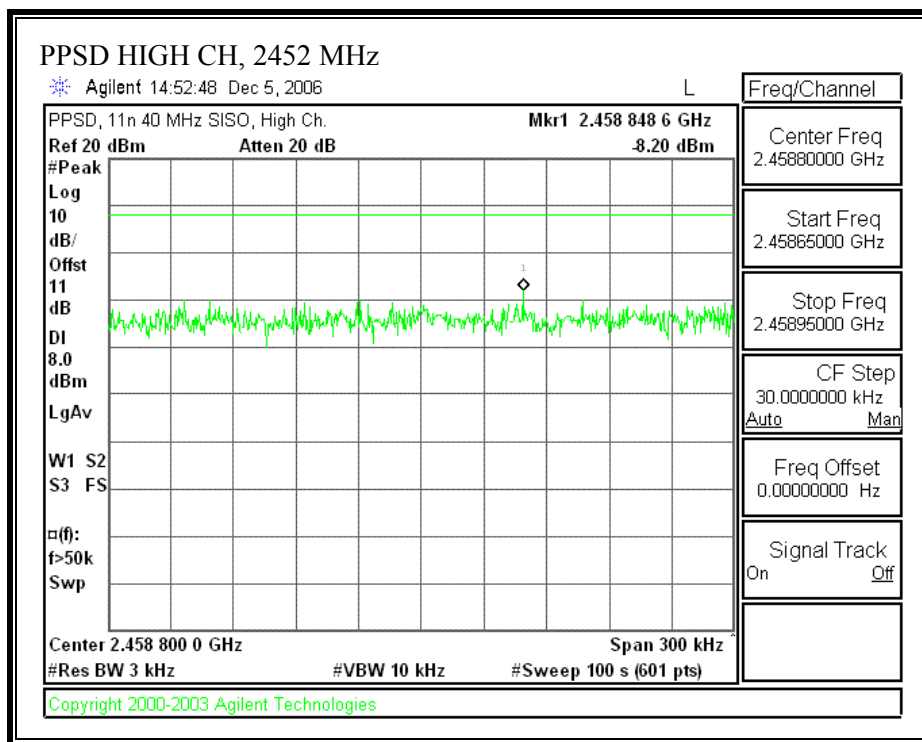
PEAK POWER SPECTRAL DENSITY (802.11n 40 MHz SISO MODE)











7.1.6. CONDUCTED SPURIOUS EMISSIONS

LIMITS

§15.247 (c) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in §15.209(a) is not required. 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) (see §15.205(c)).

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

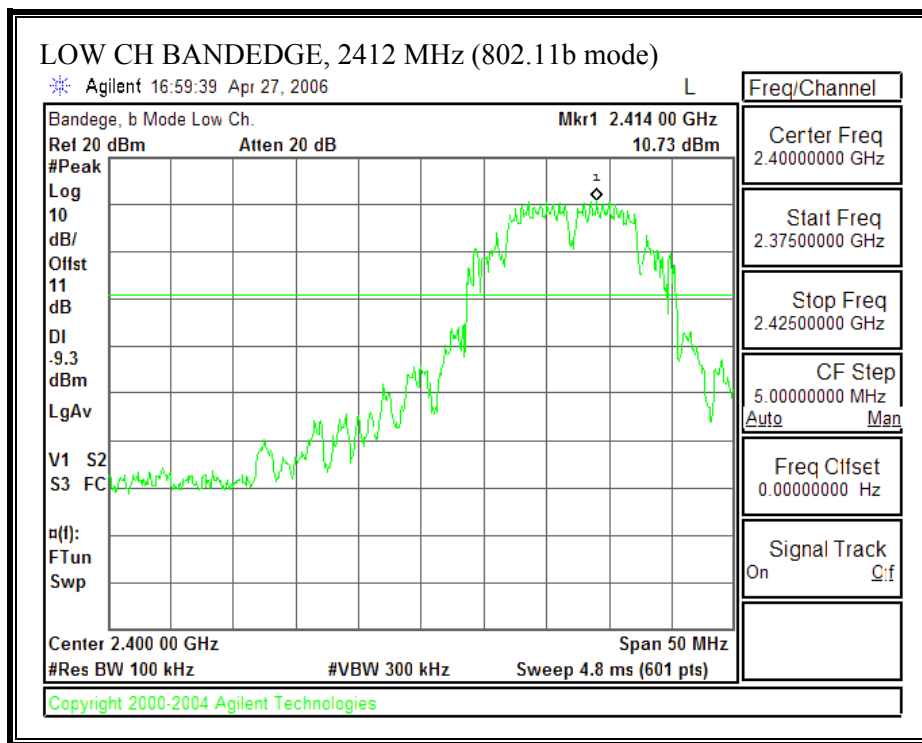
The spectrum from 30 MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

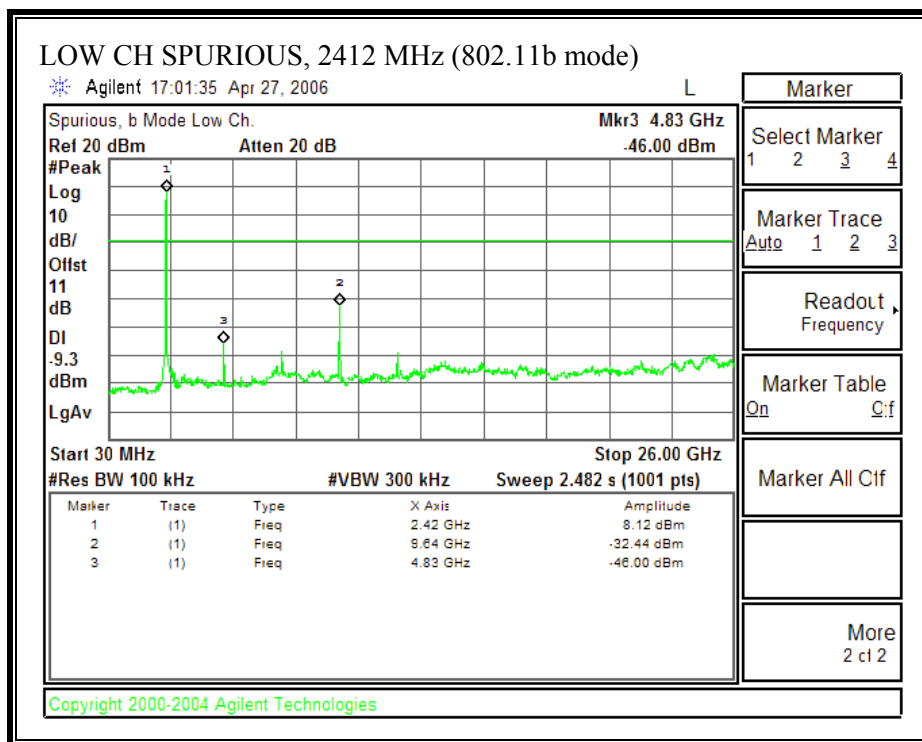
RESULTS

No non-compliance noted:

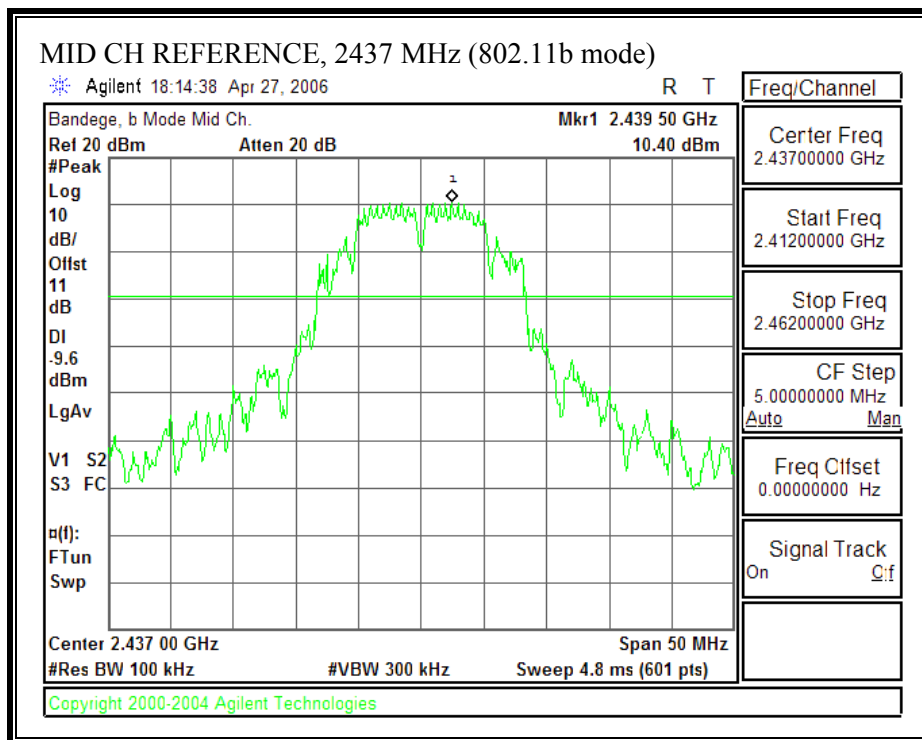
802.11b Legacy Mode

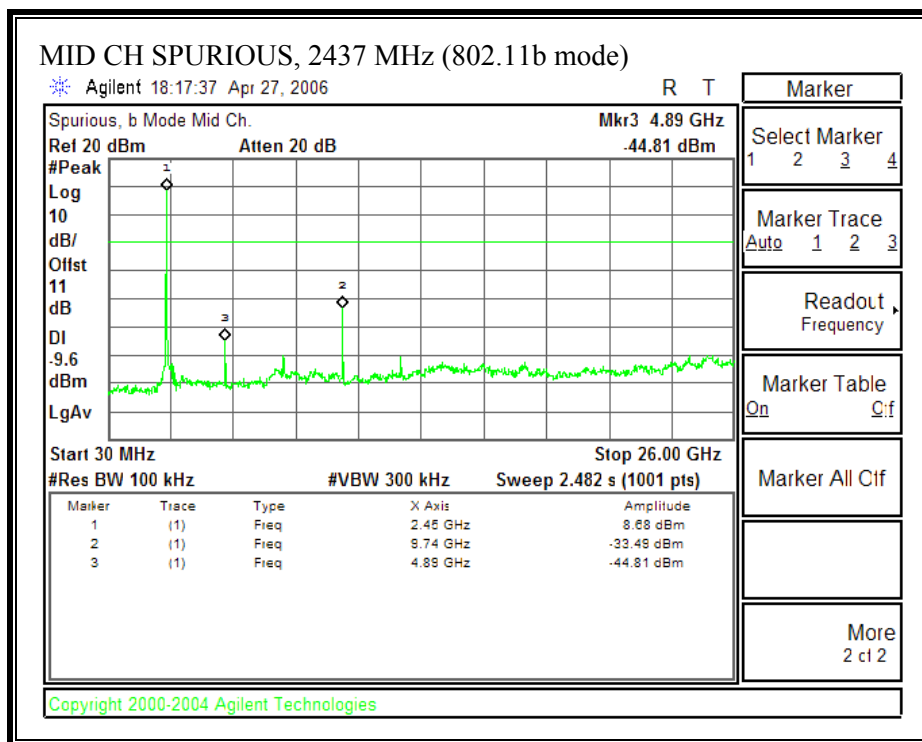
SPURIOUS EMISSIONS, LOW CHANNEL (802.11b MODE)

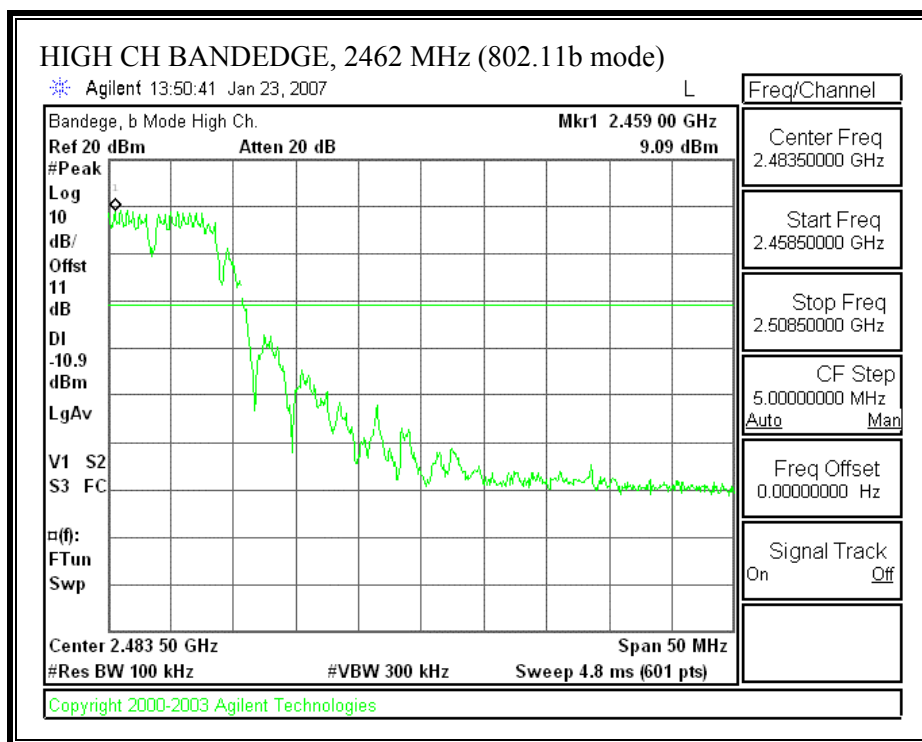


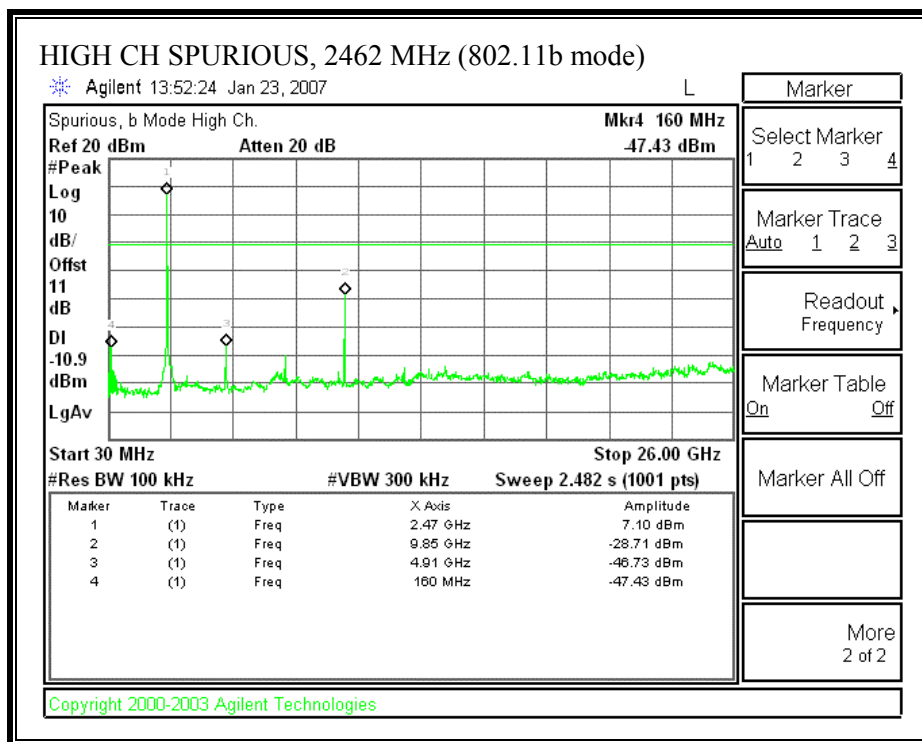


SPURIOUS EMISSIONS, MID CHANNEL (802.11b MODE)



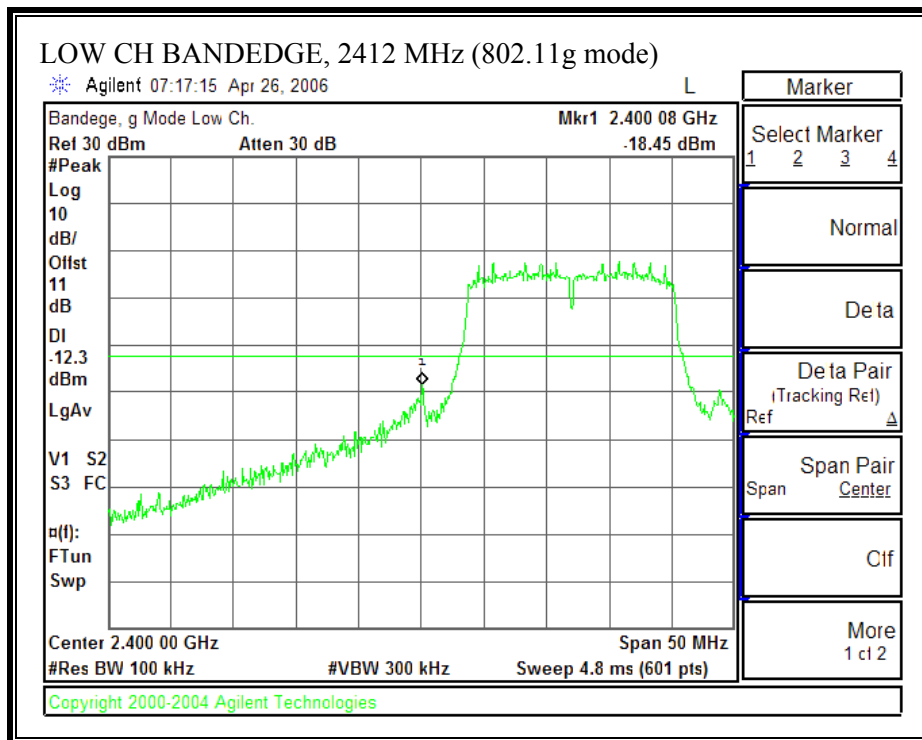


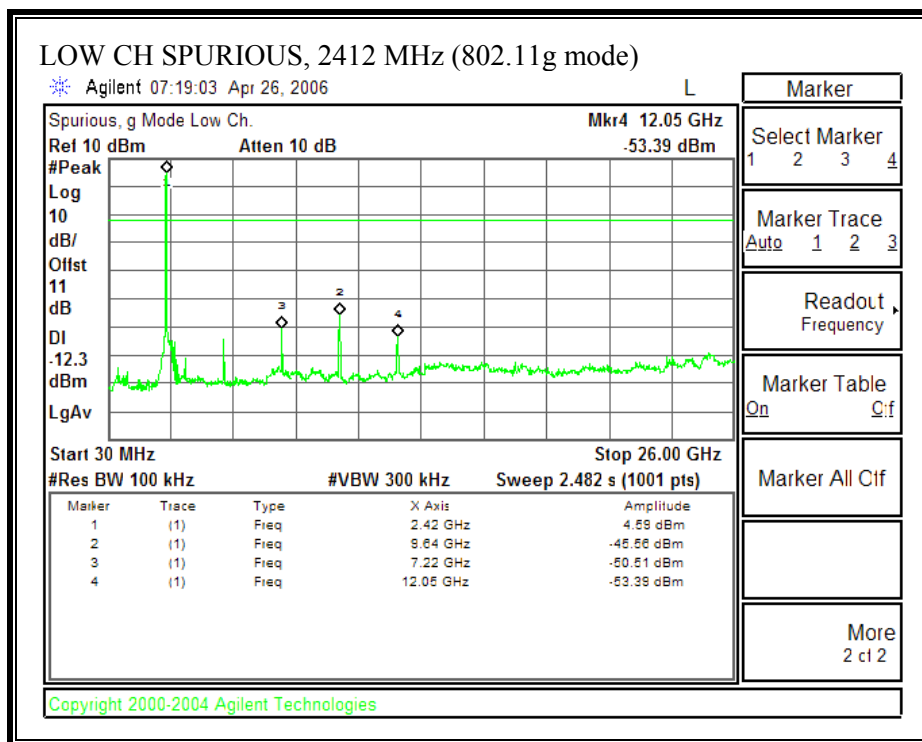




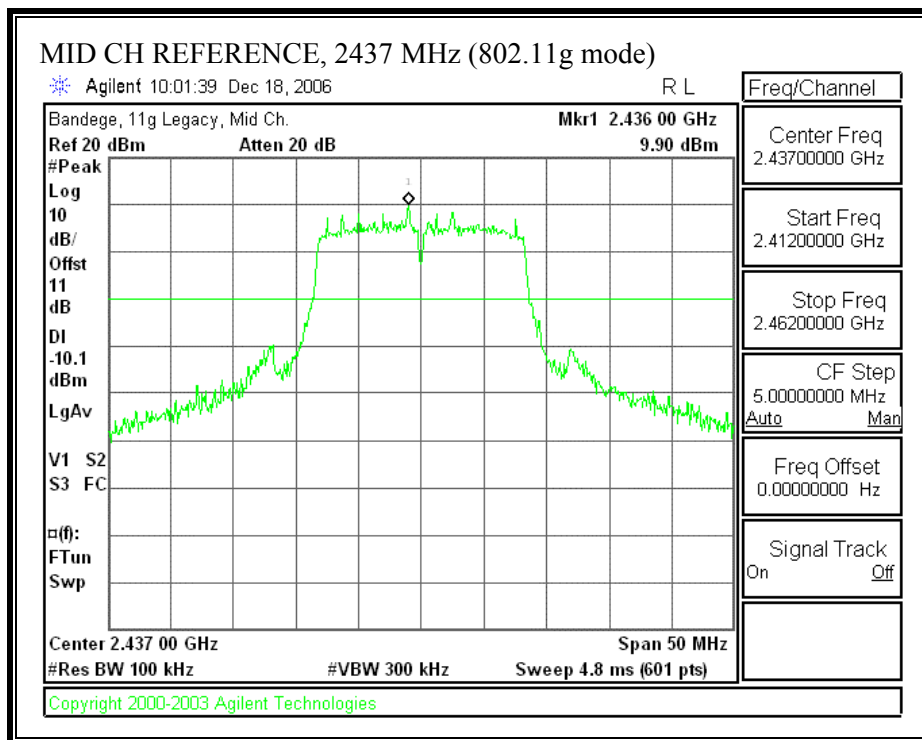
802.11g Legacy Mode

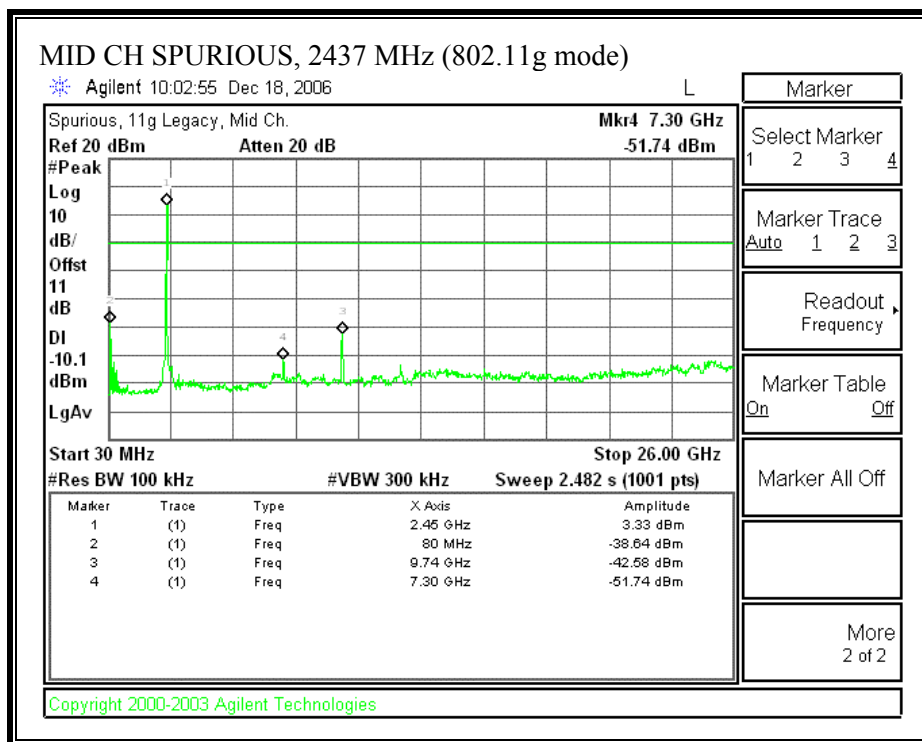
SPURIOUS EMISSIONS, LOW CHANNEL (802.11g MODE)



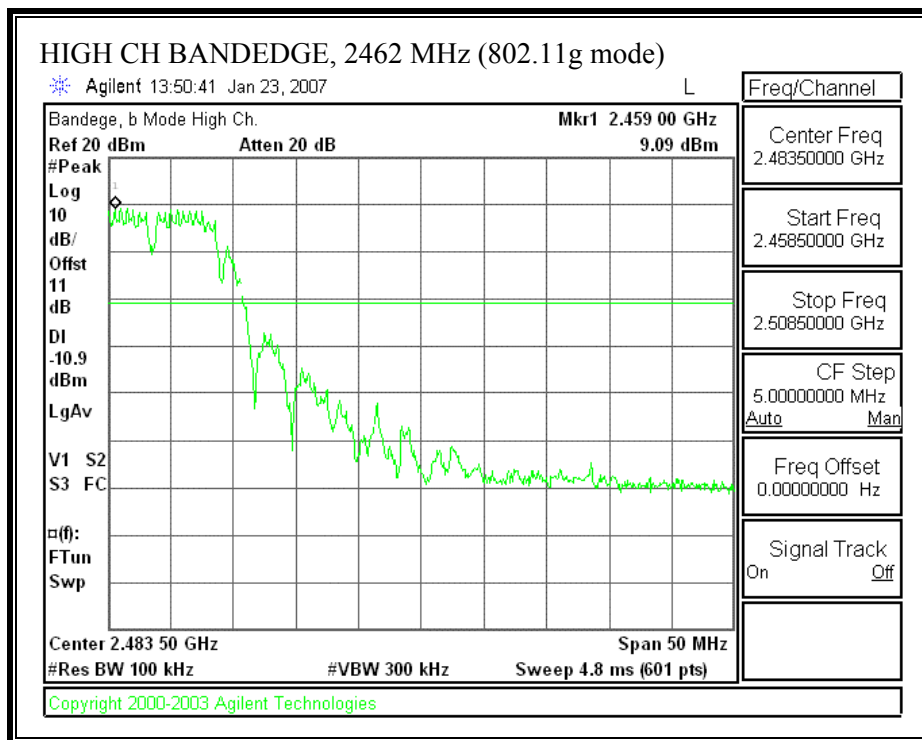


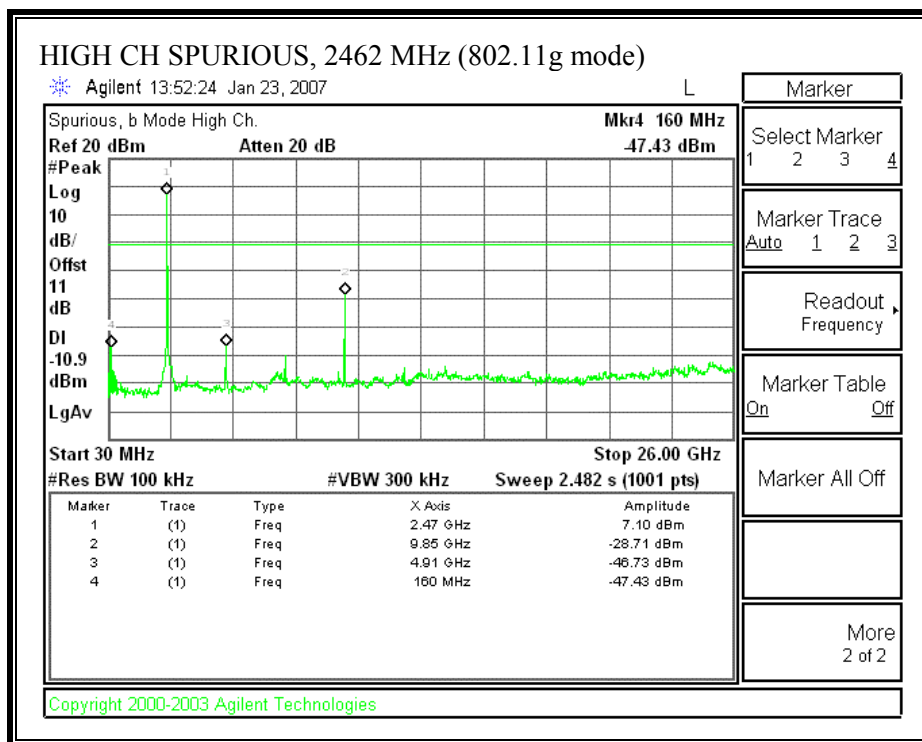
SPURIOUS EMISSIONS, MID CHANNEL (802.11g MODE)





SPURIOUS EMISSIONS, HIGH CHANNEL (802.11g MODE)

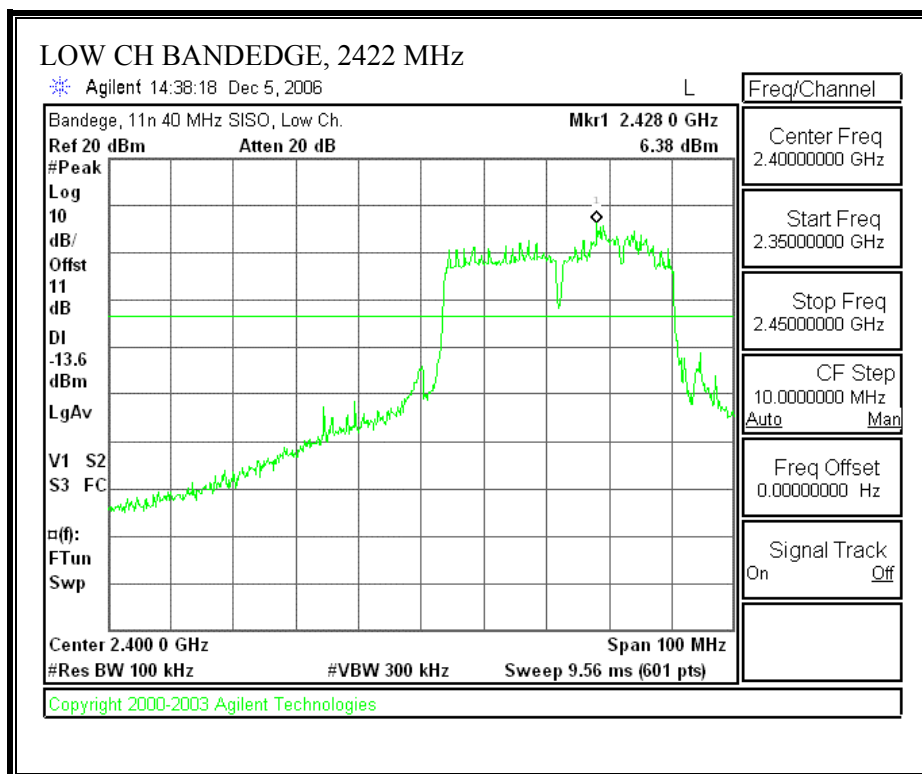


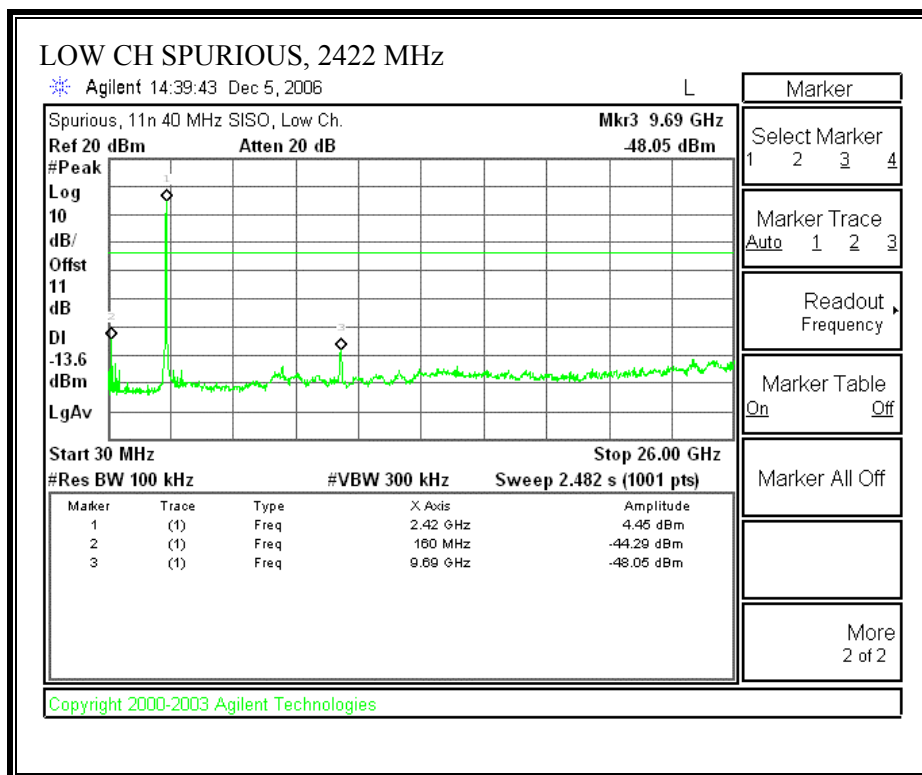


802.11n Mode 20 MHz SISO is covered by the worst case 80211g Mode Legacy testing.

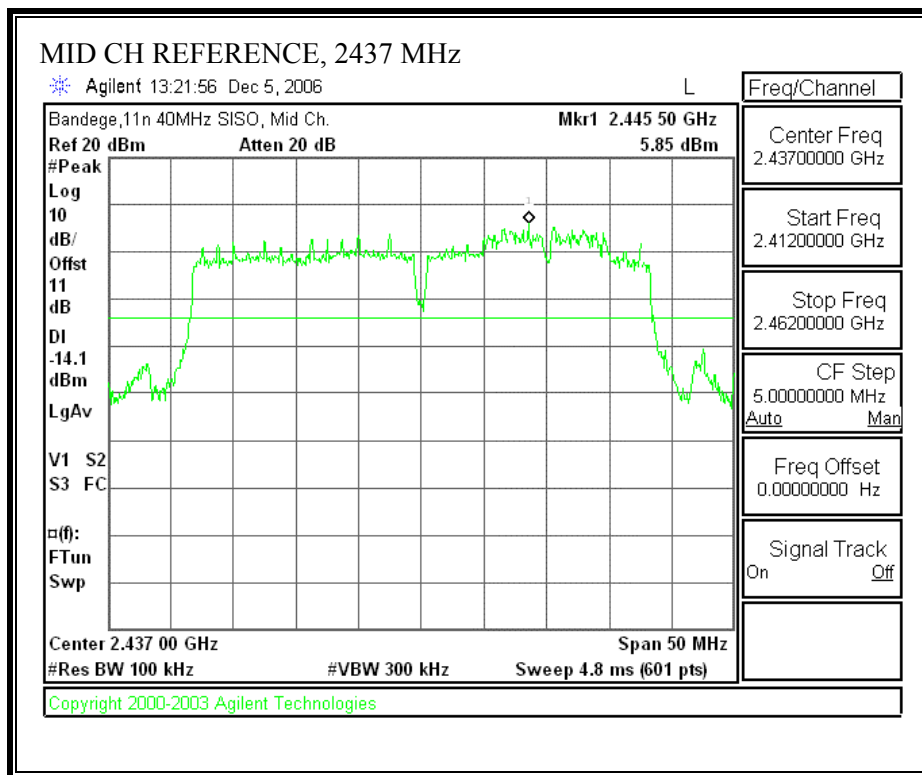
11n Mode 40 MHz SISO

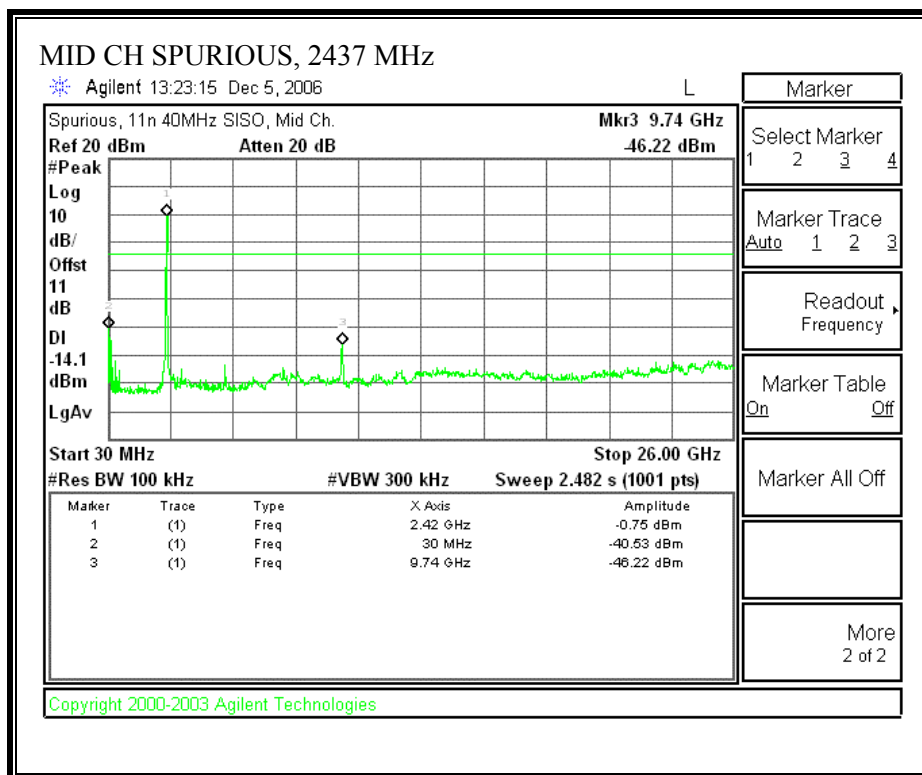
SPURIOUS EMISSIONS, LOW CHANNEL (802.11n 40 MHz SISO MODE)



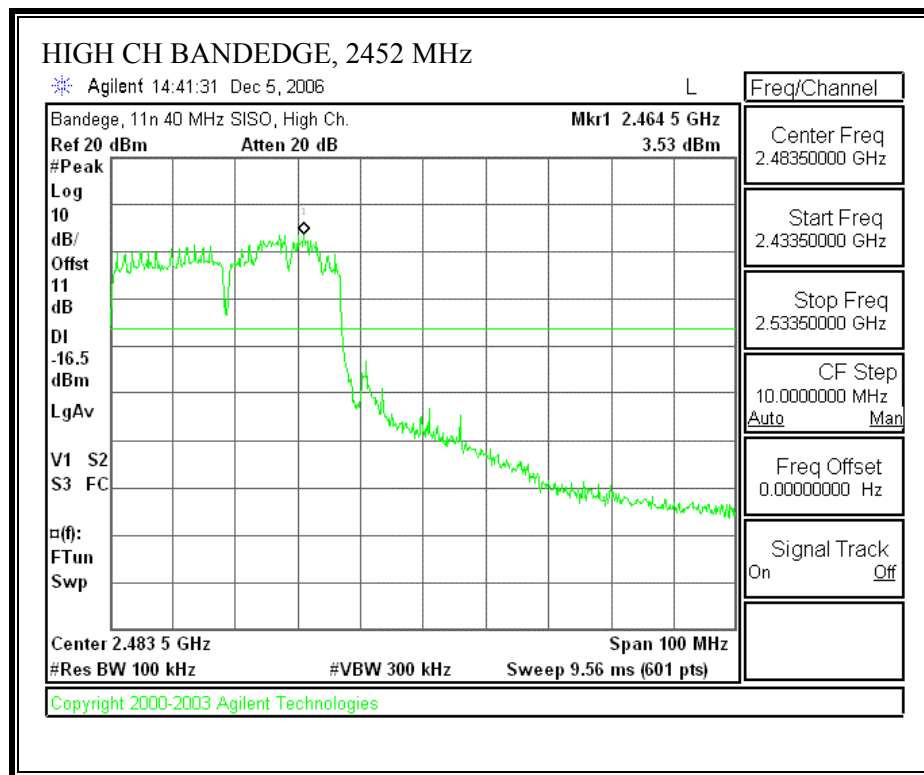


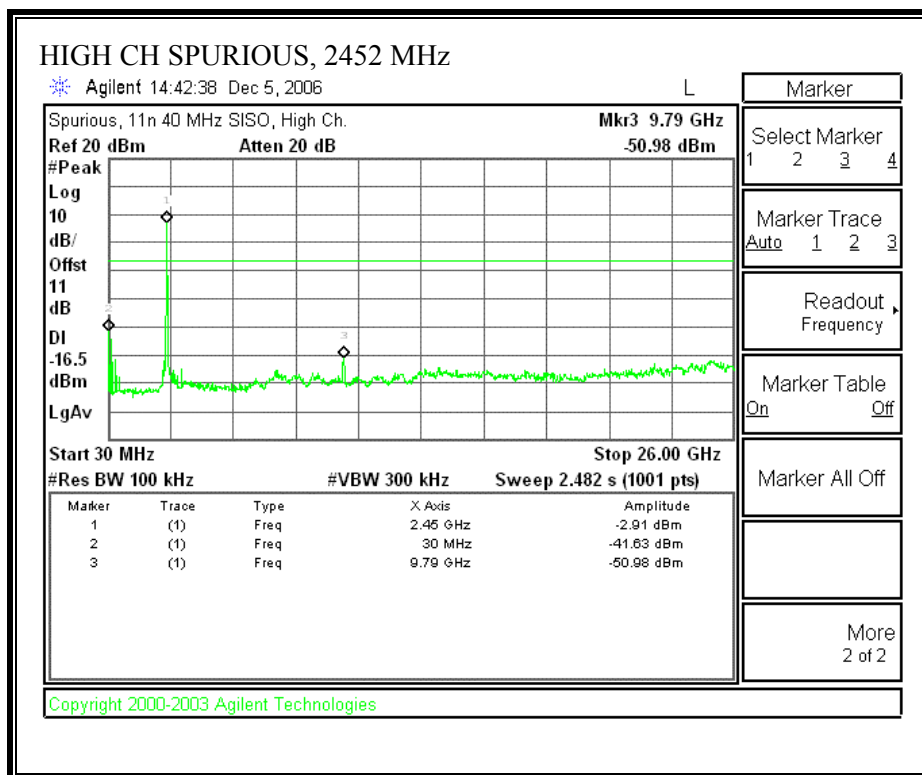
SPURIOUS EMISSIONS, MID CHANNEL (802.11n 40 MHz SISO MODE)





SPURIOUS EMISSIONS, HIGH CHANNEL (802.11n 40 MHz SISO MODE)





7.2. CHANNEL TESTS FOR THE 5725 TO 5850 MHz BAND

7.2.1. 6 dB BANDWIDTH

LIMIT

§15.247 (a) (2) For direct sequence systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 100 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

RESULTS

No non-compliance noted:

802.11a Legacy Mode

Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	5745	15420.00	500	14920
Middle	5785	16000.00	500	15500
High	5825	15500.00	500	15000

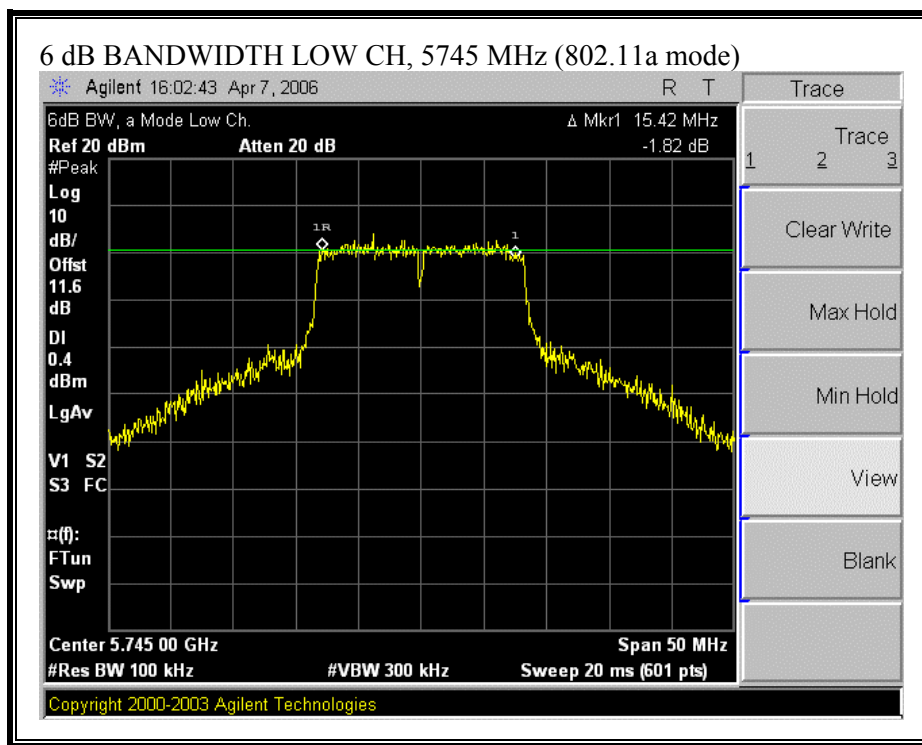
802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

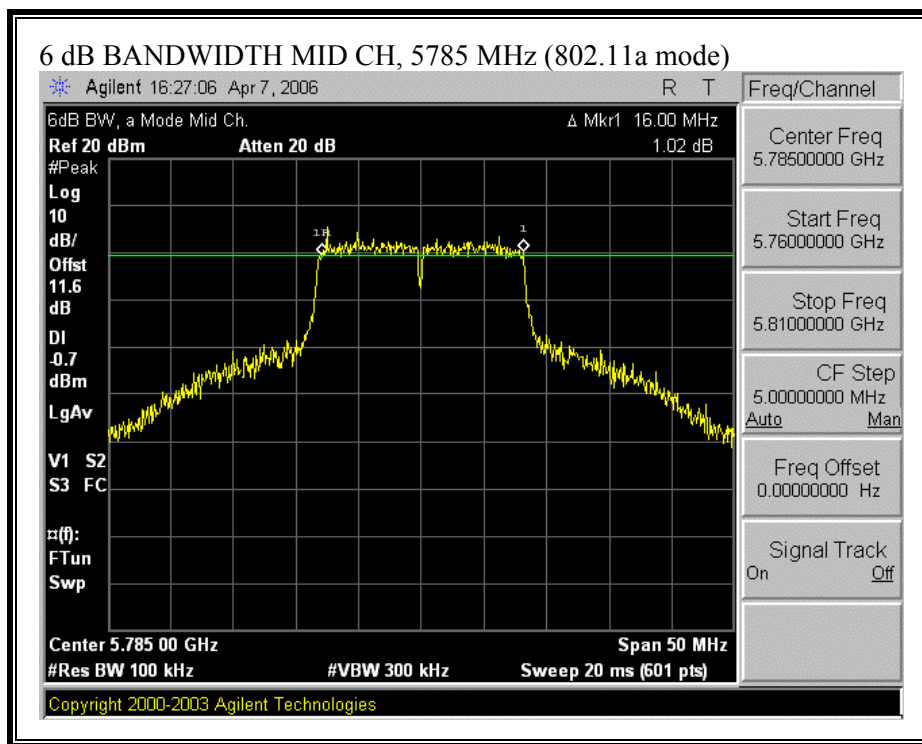
802.11n a Mode 40MHz SISO

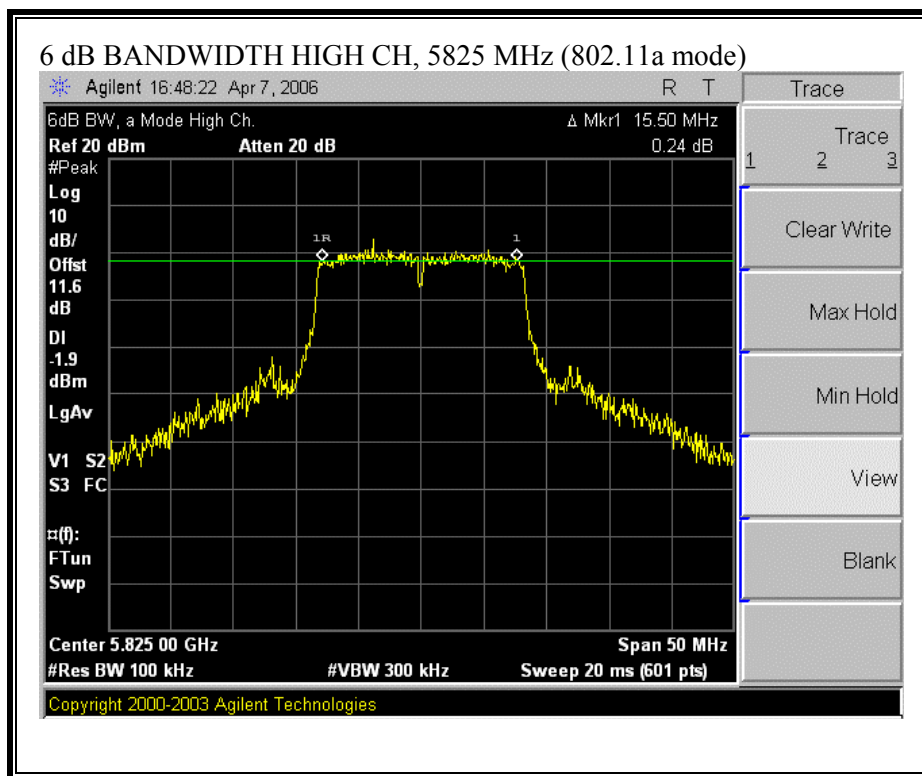
Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	5755	35470.00	500	34970
High	5795	35200.00	500	34700

802.11a Legacy Mode

6 dB BANDWIDTH (802.11a MODE)

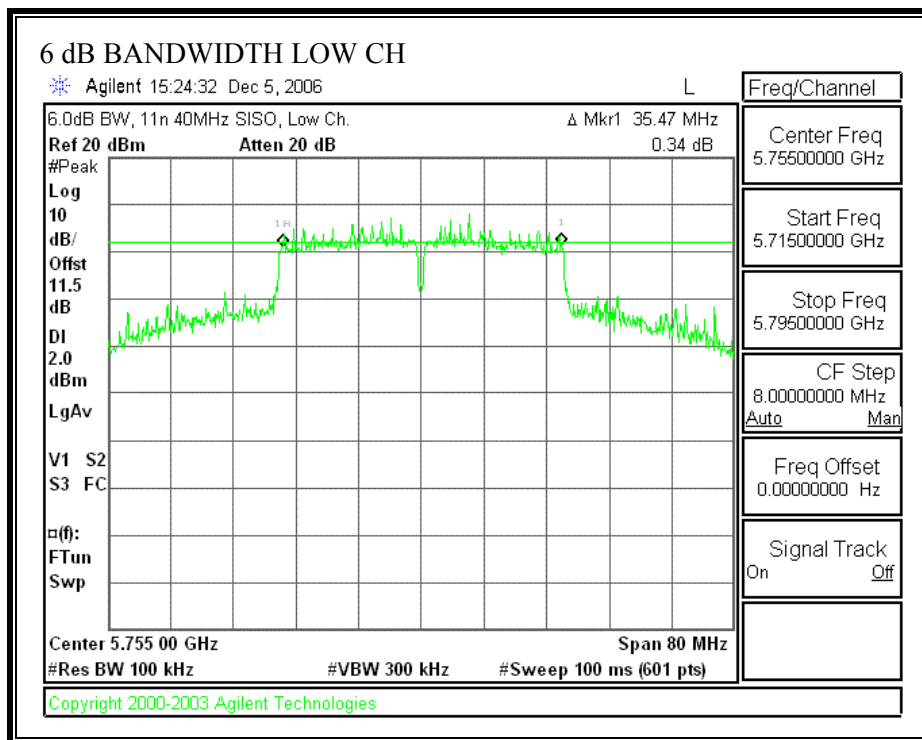


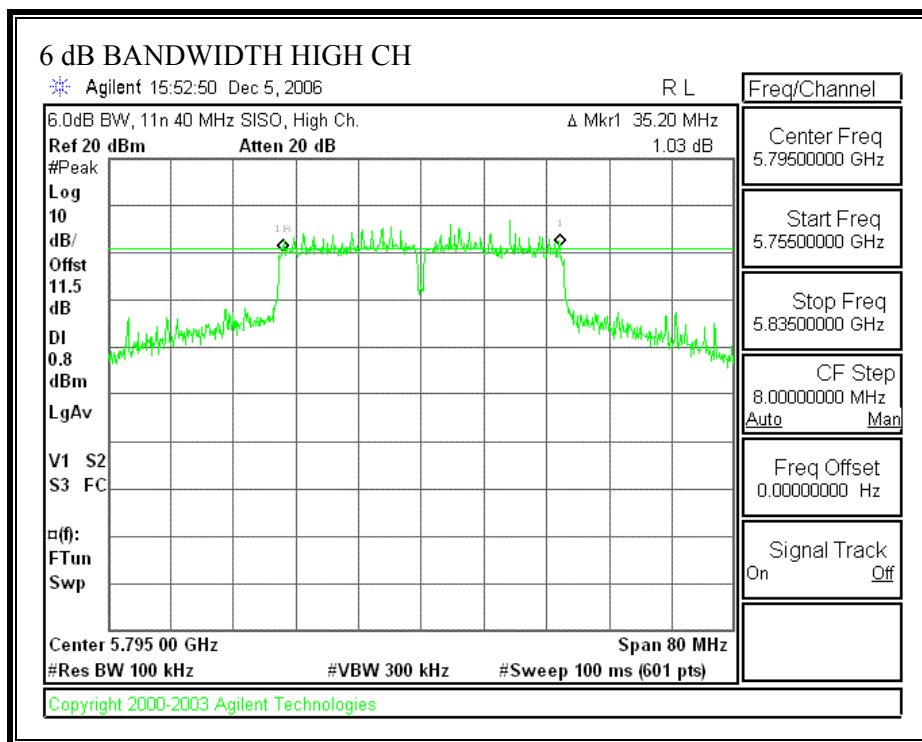




802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

6 dB BANDWIDTH (802.11n a Mode 40 MHz SISO)





7.2.2. 99% BANDWIDTH

LIMIT

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

RESULTS

No non-compliance noted:

802.11a Legacy Mode

Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	5745	16.7397
Middle	5785	16.7855
High	5825	16.5132

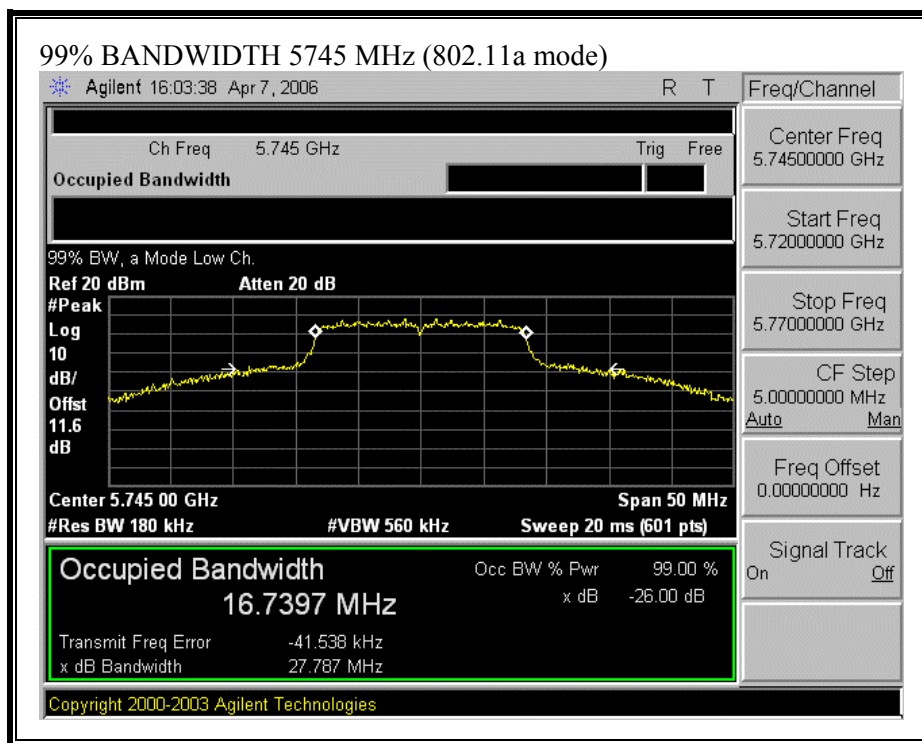
802.11n Mode 20 MHz SISO is covered by the worst case 11a Mode Legacy testing.

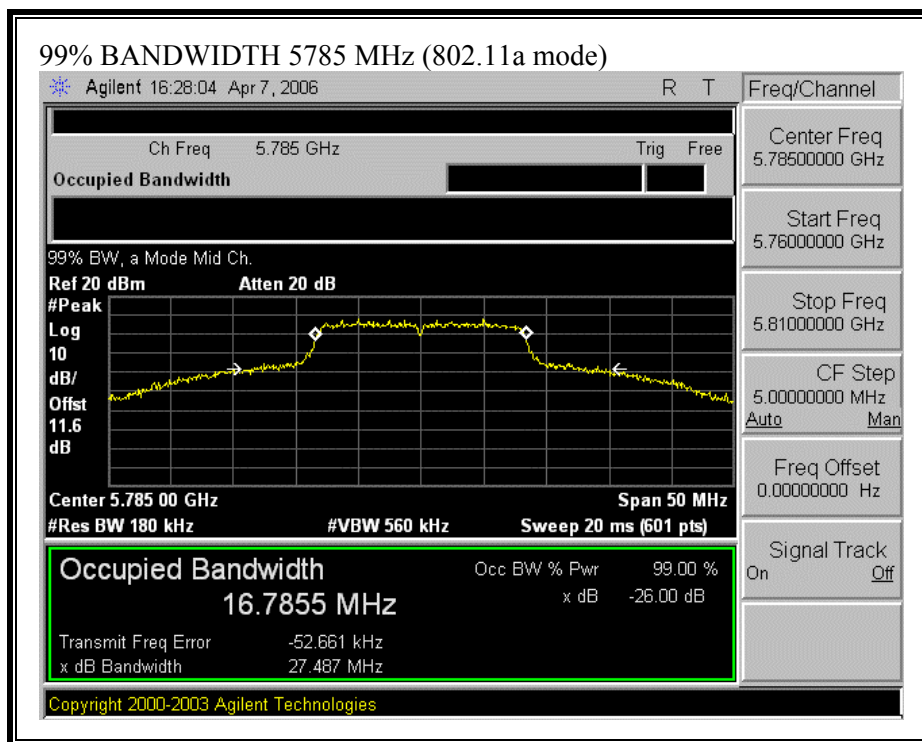
802.11n a Mode 40 MHz SISO

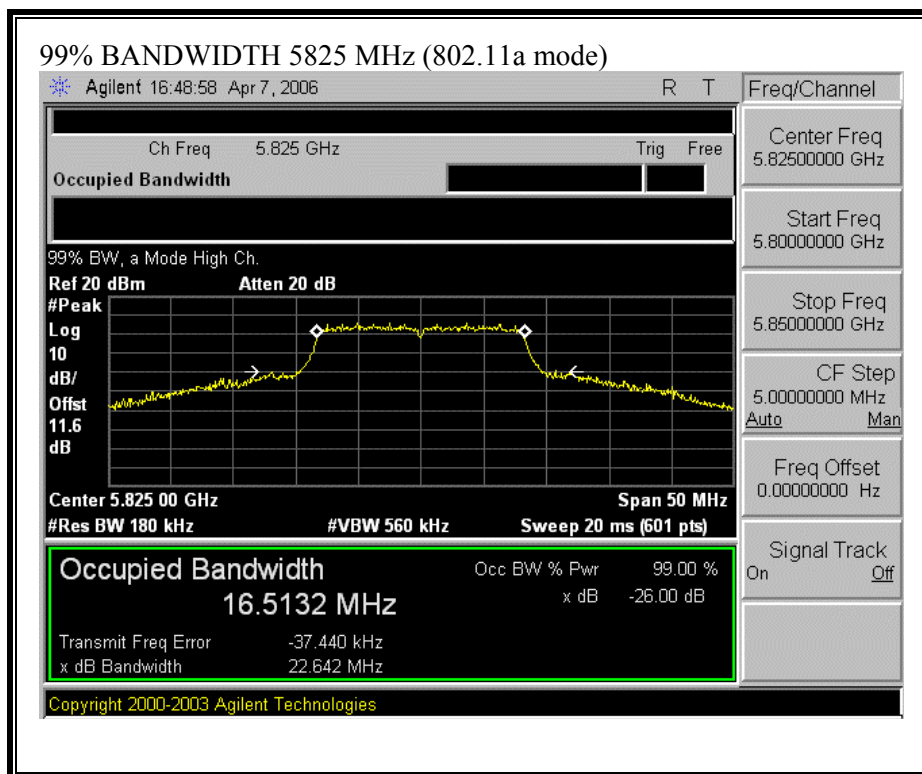
Channel	Frequency (MHz)	99% Bandwidth (MHz)
Low	5755	50.5950
High	5795	44.9565

802.11a Legacy Mode

99% BANDWIDTH (802.11a MODE)



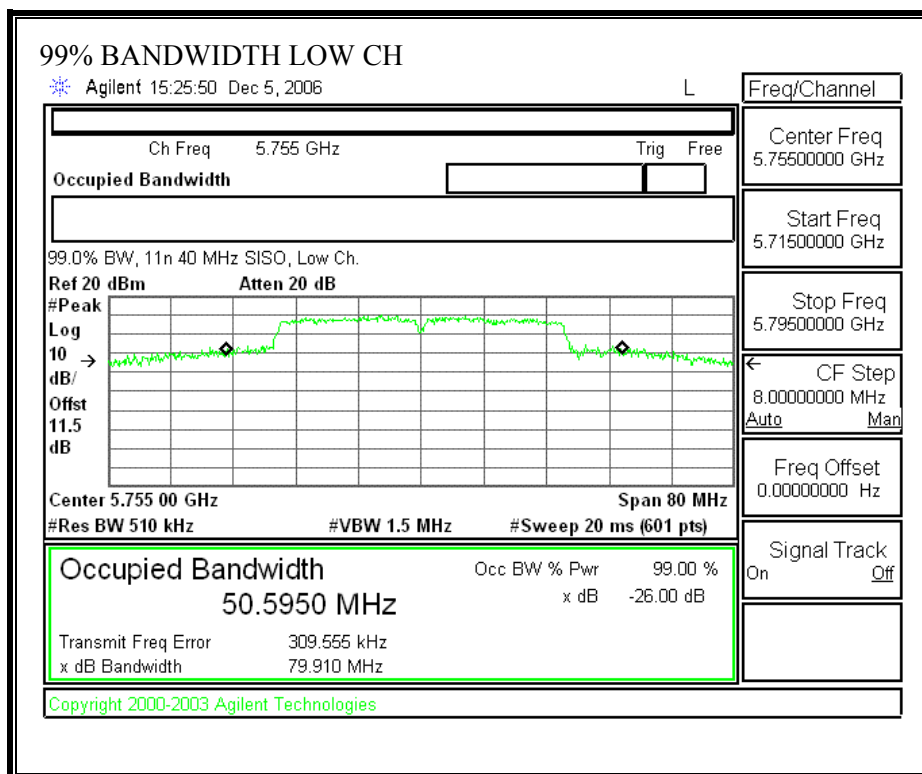


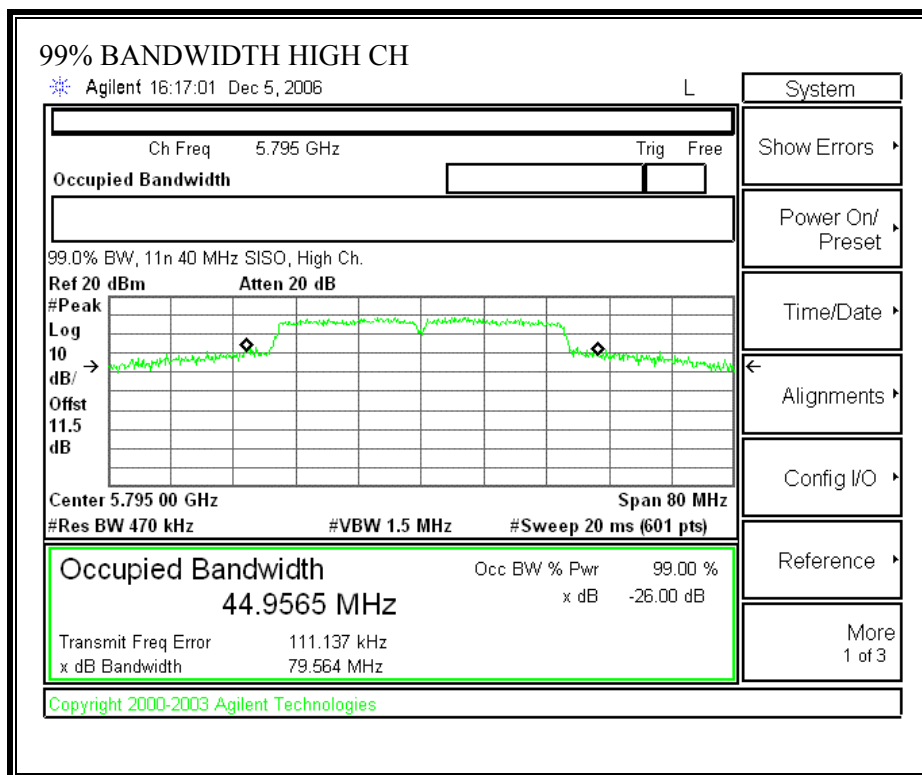


802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

802.11n Mode 40 MHz SISO

99% BANDWIDTH (802.11n a Mode 40 MHz SISO)





7.2.3. PEAK OUTPUT POWER

PEAK POWER LIMIT

§15.247 (b) The maximum peak output power of the intentional radiator shall not exceed the following:

§15.247 (b) (3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz , and 5725-5850 MHz bands: 1 watt.

§15.247 (b) (4) Except as shown in paragraphs (b)(3) (i), (ii) and (iii) of this section, if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1) or (b)(2) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

§15.247 (b) (4) (ii) Systems operating in the 5725–5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer and the analyzer's internal channel power integration function is used to integrate the power over a bandwidth greater than or equal to the 99% bandwidth.

ANTENNA GAIN:

2.4GHz band: 3.36 dBi
5.8GHz band: 6.02 dBi

RESULTS

The maximum antenna gain is 6.02dBi @ 5.8 GHz for other than fixed, point-to-point operations, therefore the limit is 29.98dBm for 5.8 GHz band.

No non-compliance noted:

802.11a Legacy Mode

Channel	Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
Low	5745	24.23	29.98	-5.75
Middle	5785	24.13	29.98	-5.85
High	5825	23.82	29.98	-6.16

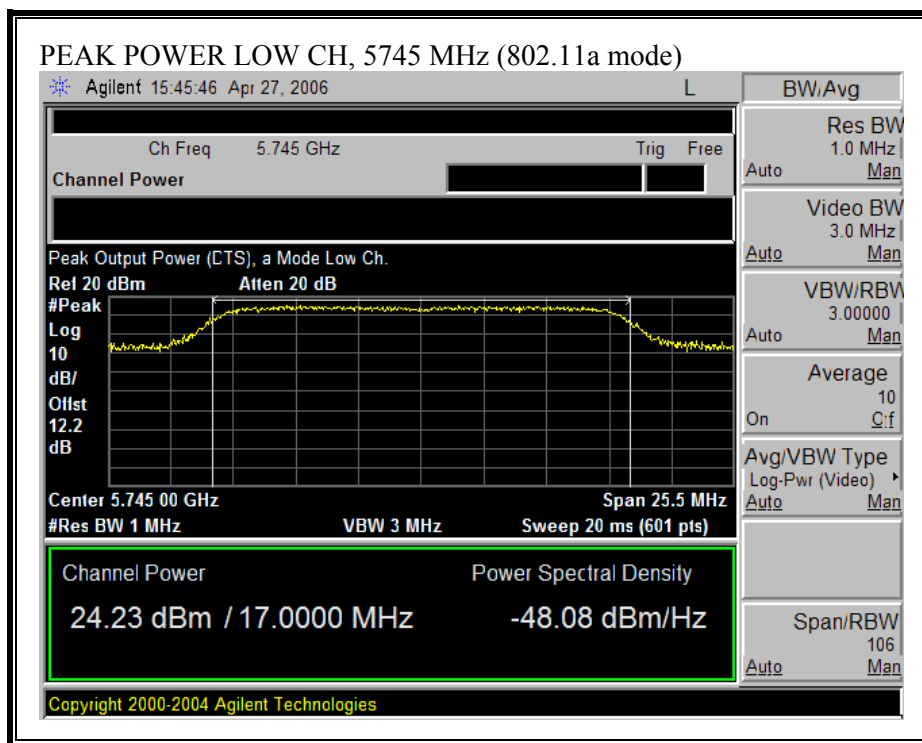
802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

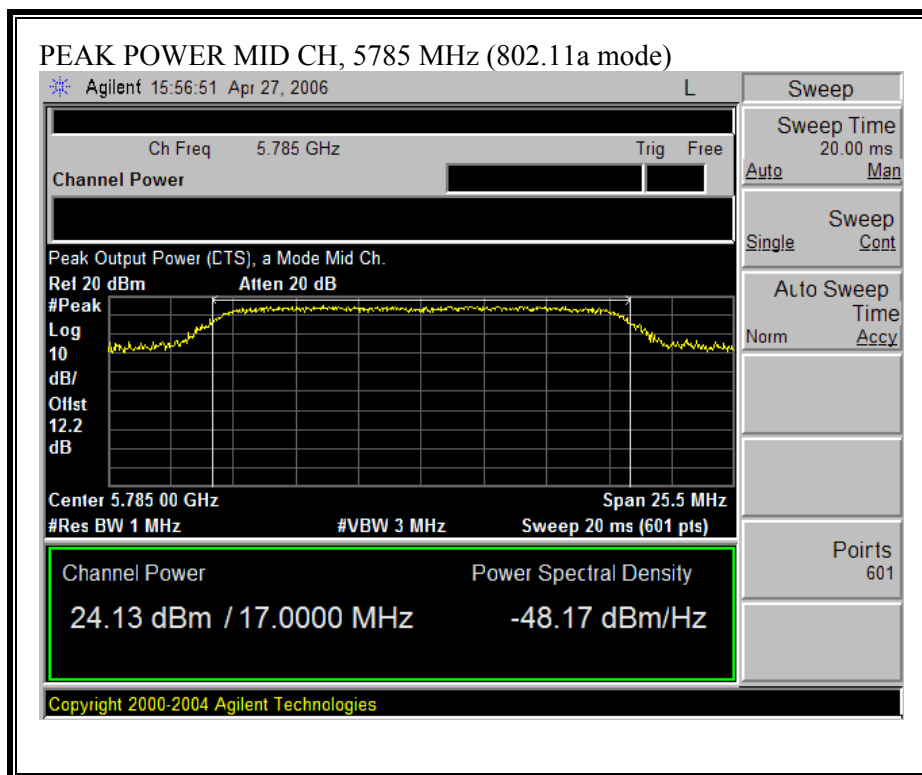
802.11n a Mode 40 MHz SISO

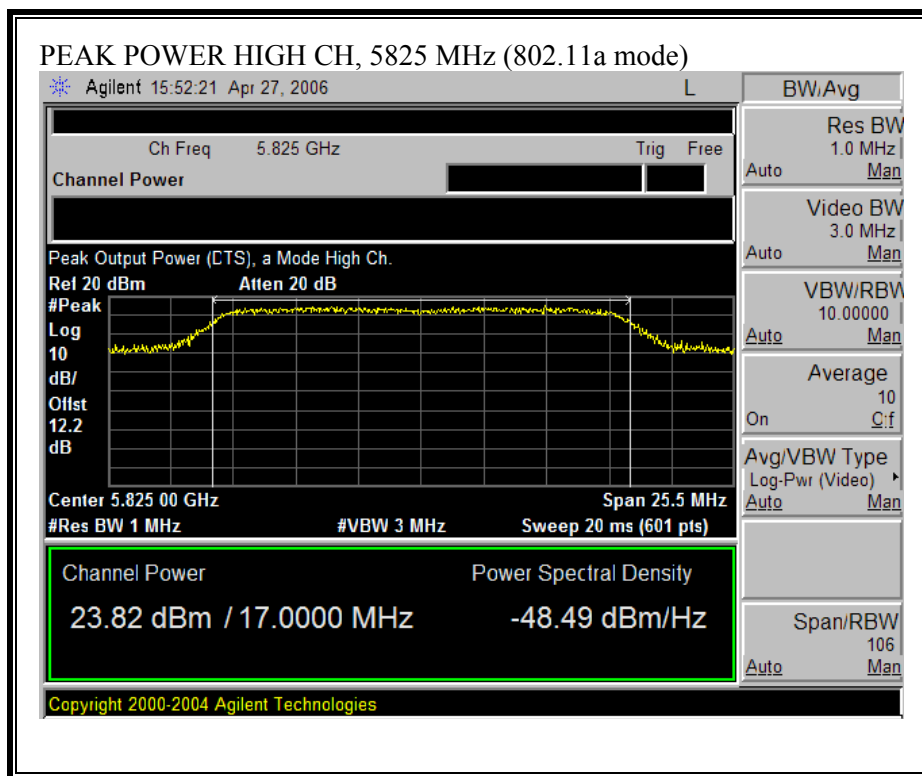
Channel	Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Margin (dB)
Low	5755	25.28	29.98	-4.70
High	5795	25.11	29.98	-4.87

802.11a Legacy Mode

OUTPUT POWER (802.11a MODE)



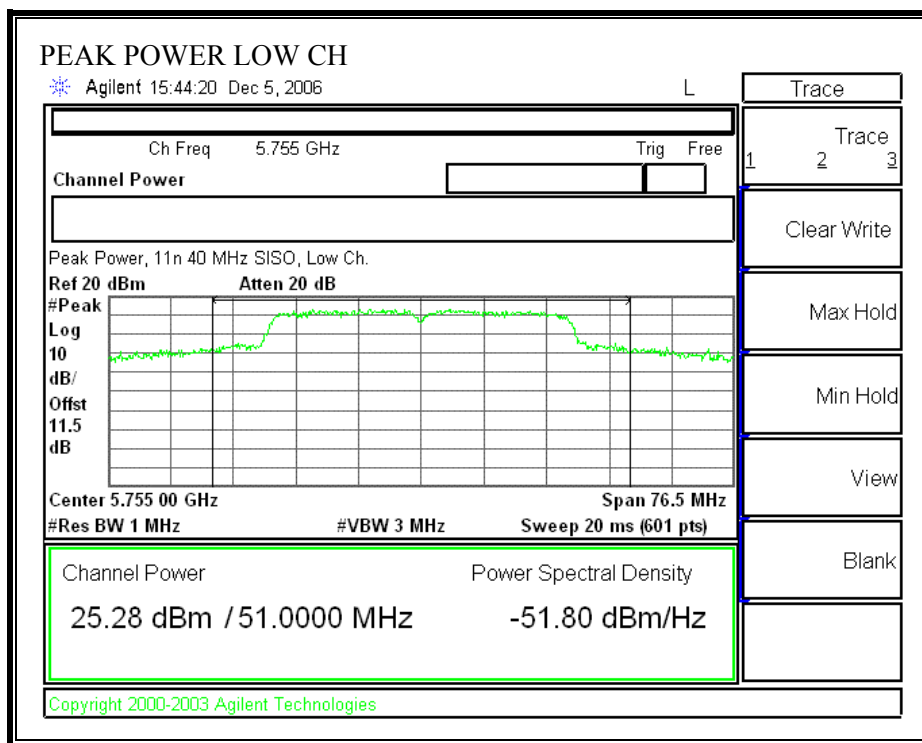


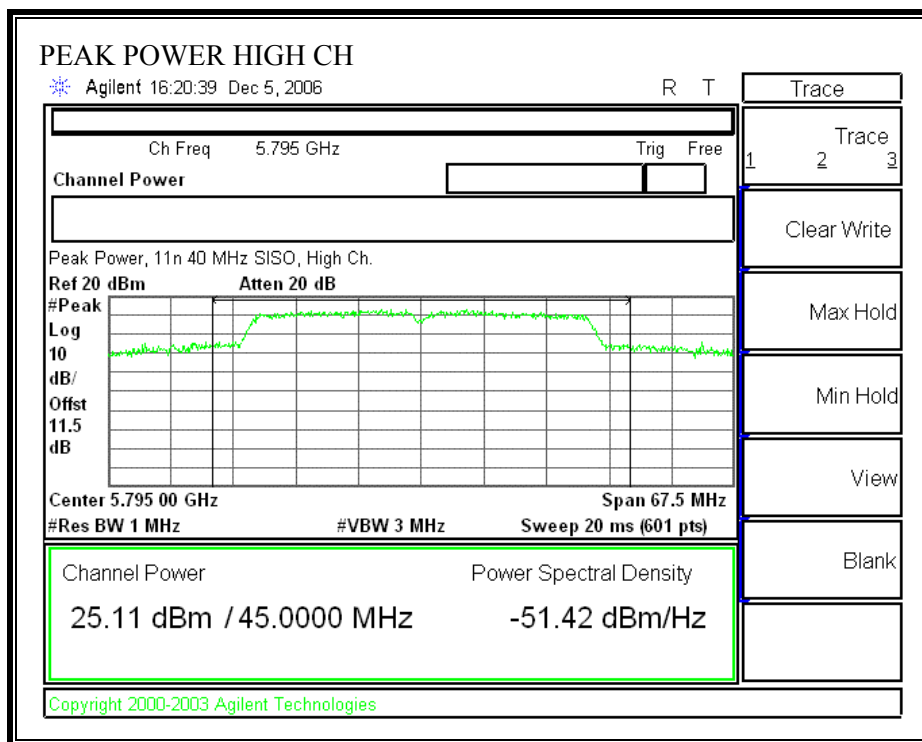


802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

802.11n Mode 40 MHz SISO

OUTPUT POWER (802.11n a Mode 40 MHz SISO)





7.2.4. MAXIMUM PERMISSIBLE EXPOSURE

LIMITS

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f ²)	6
30–300	61.4	0.163	1.0	6
300–1500 .....	.....	.....	f/300	6
1500–100,000 .....	.....	.....	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f ²)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500 .....	.....	.....	f/1500	30
1500–100,000 .....	.....	.....	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

CALCULATIONS

Given

$$E = \sqrt{(30 * P * G) / d}$$

and

$$S = E^2 / 3770$$

where

E = Field Strength in Volts/meter

P = Power in Watts

G = Numeric antenna gain

d = Distance in meters

S = Power Density in milliwatts/square centimeter

Combining equations and rearranging the terms to express the distance as a function of the remaining variables yields:

$$d = \sqrt{((30 * P * G) / (3770 * S))}$$

Changing to units of Power to mW and Distance to cm, using:

$$P \text{ (mW)} = P \text{ (W)} / 1000 \text{ and}$$

$$d \text{ (cm)} = 100 * d \text{ (m)}$$

yields

$$d = 100 * \sqrt{((30 * (P / 1000) * G) / (3770 * S))}$$

$$d = 0.282 * \sqrt{(P * G / S)}$$

where

d = distance in cm

P = Power in mW

G = Numeric antenna gain

S = Power Density in mW/cm²

Substituting the logarithmic form of power and gain using:

$$P \text{ (mW)} = 10^{(P \text{ (dBm)} / 10)} \text{ and}$$

$$G \text{ (numeric)} = 10^{(G \text{ (dBi)} / 10)}$$

yields

$$d = 0.282 * 10^{((P + G) / 20)} / \sqrt{S} \quad \text{Equation (1)}$$

where

d = MPE distance in cm

P = Power in dBm

G = Antenna Gain in dBi

S = Power Density Limit in mW/cm²

Equation (1) and the measured peak power is used to calculate the MPE distance.

LIMITS

From §1.1310 Table 1 (B), $S = 1.0 \text{ mW/cm}^2$ in the 5.8 GHz band.

RESULTS

No non-compliance noted:

802.11a Legacy Mode

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm²)
802.11a	20.0	24.23	6.02	0.21

802.11n Mode 20 MHz SISO is covered by the worst case 11a Mode Legacy testing

802.11n Mode 40 MHz SISO

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm²)
802.11n Mode 40 MHz SISO	20.0	25.28	6.02	0.27

NOTE: For mobile or fixed location transmitters, the minimum separation distance is 20 cm, even if calculations indicate that the MPE distance would be less.

7.2.5. PEAK POWER SPECTRAL DENSITY

LIMIT

§15.247 (d) For direct sequence systems, the peak 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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer, the maximum level in a 3 kHz bandwidth is measured with the spectrum analyzer using RBW = 3 kHz and VBW > 3 kHz, sweep time = span / 3 kHz, and video averaging is turned off. The PPSD is the highest level found across the emission in any 3 kHz band.

RESULTS

No non-compliance noted:

802.11a Legacy Mode

Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5745	-8.20	8	-16.20
Middle	5785	-8.21	8	-16.21
High	5825	-9.69	8	-17.69

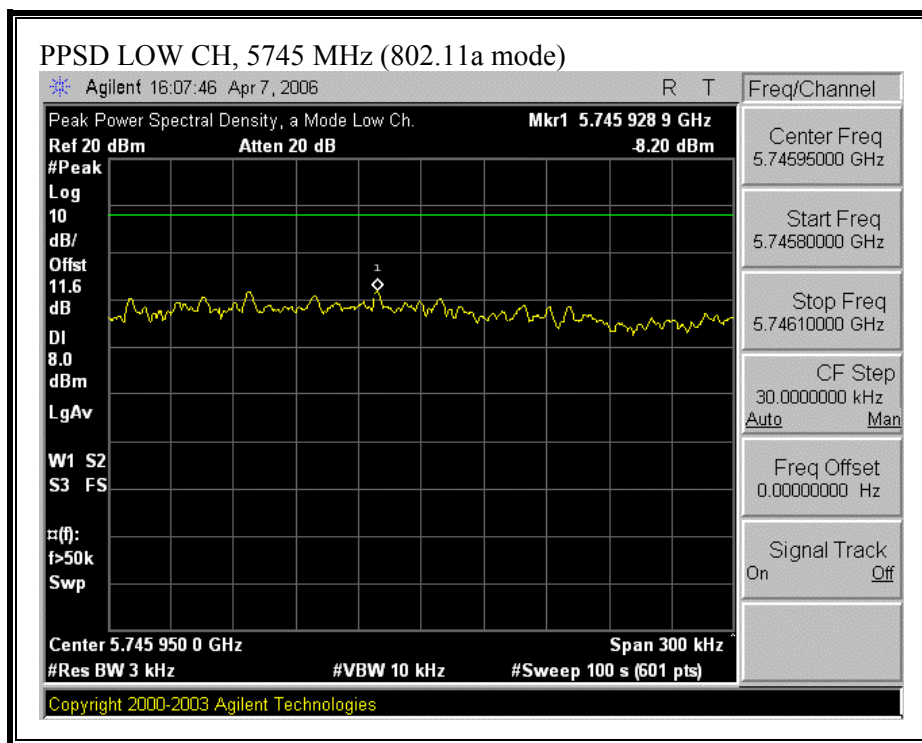
802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

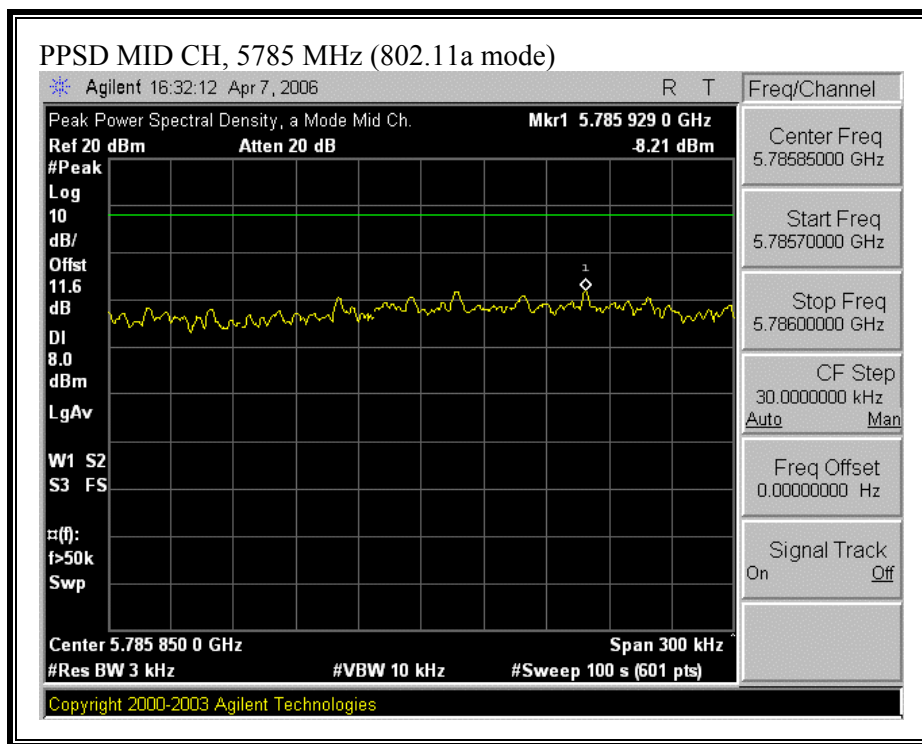
802.11n Mode 40 MHz SISO

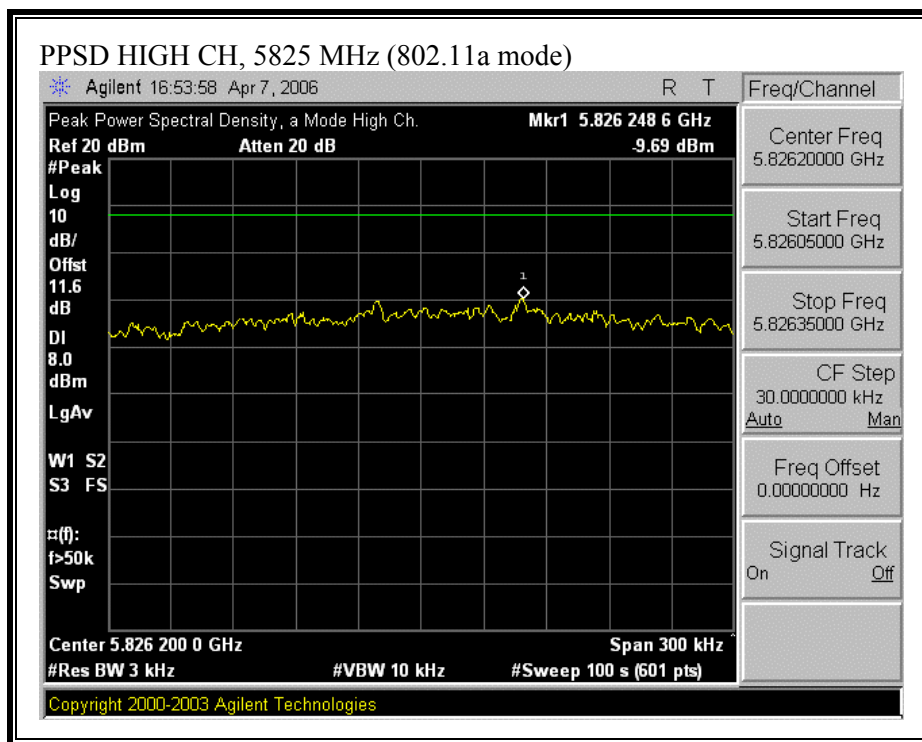
Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5755	-9.39	8	-17.39
High	5795	-9.57	8	-17.57

802.11a Legacy Mode

PEAK POWER SPECTRAL DENSITY (802.11a MODE)



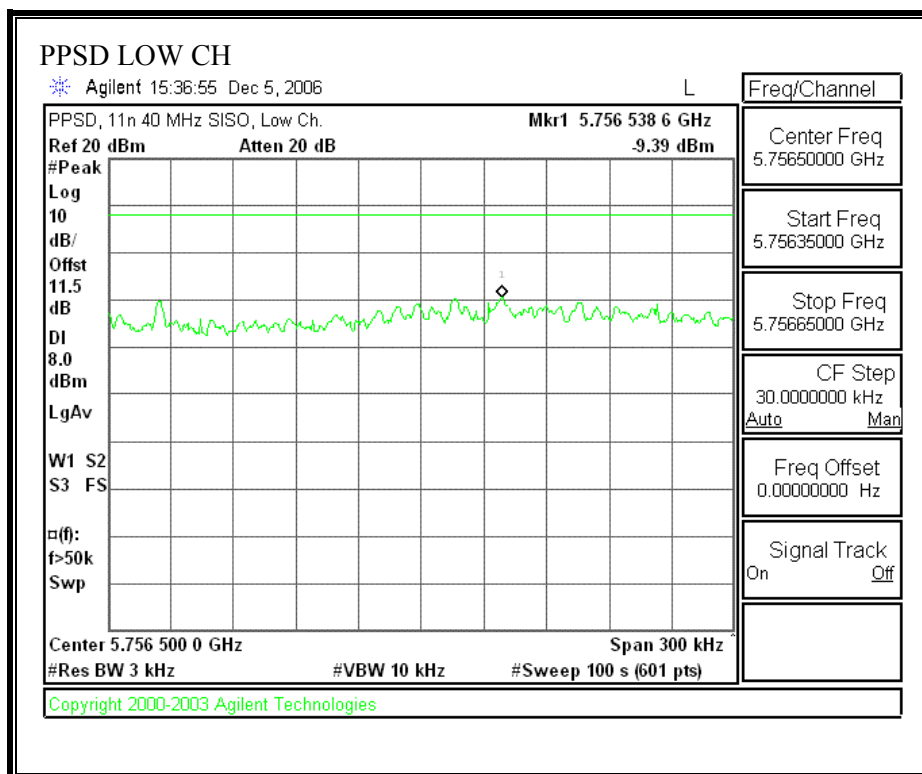


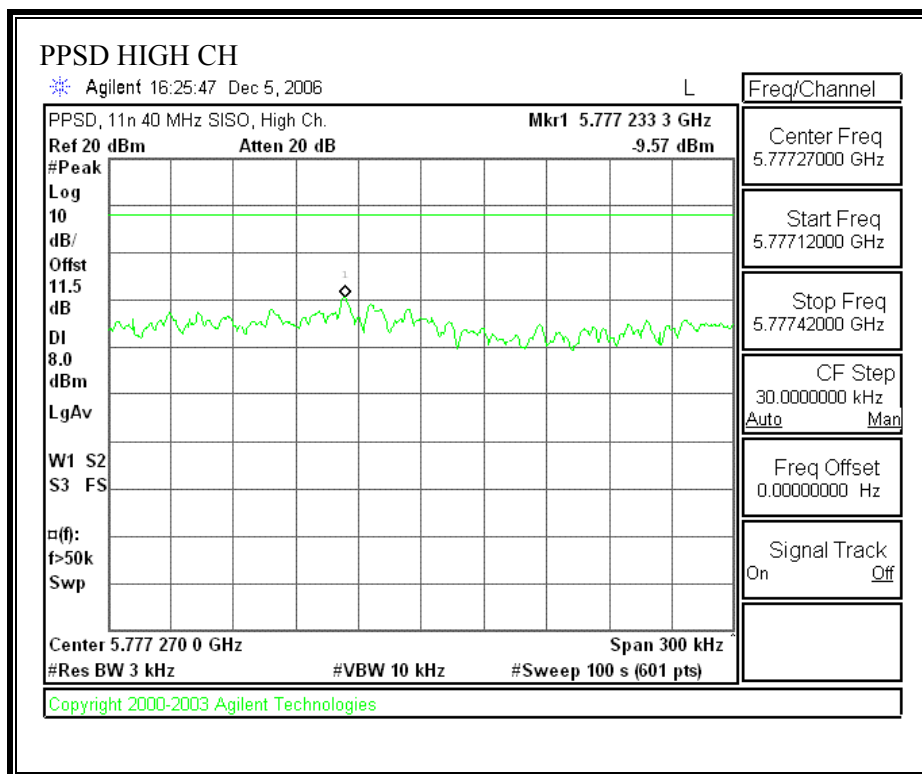


802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

802.11n Mode 40 MHz SISO

PEAK POWER SPECTRAL DENSITY (802.11n 40 MHz SISO MODE)





7.2.6. CONDUCTED SPURIOUS EMISSIONS

LIMITS

§15.247 (c) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in §15.209(a) is not required. 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) (see §15.205(c)).

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.

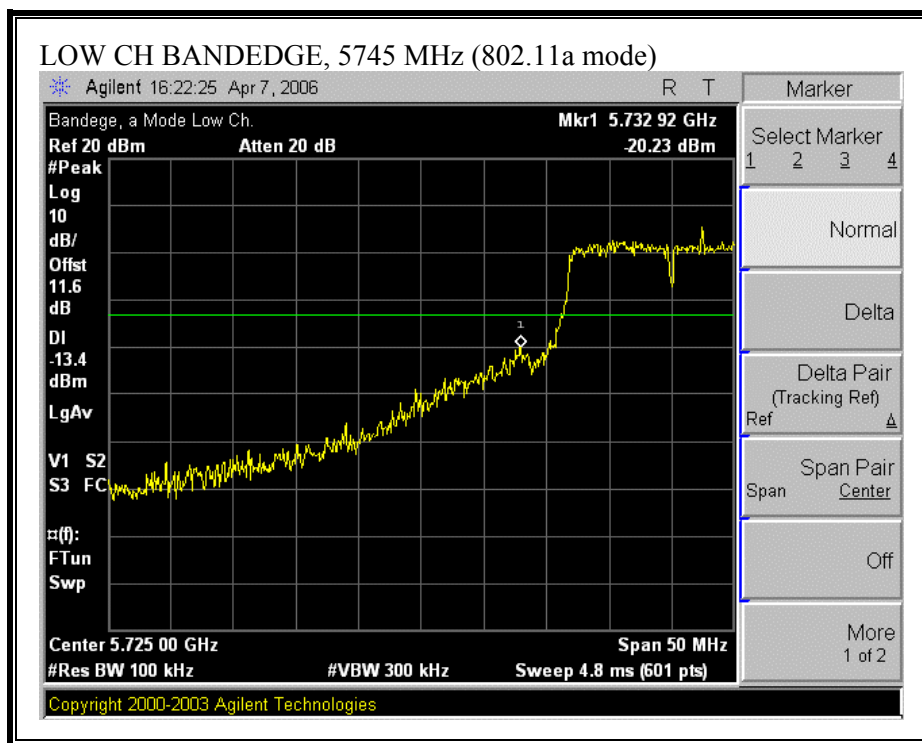
The spectrum from 30 MHz to 40 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

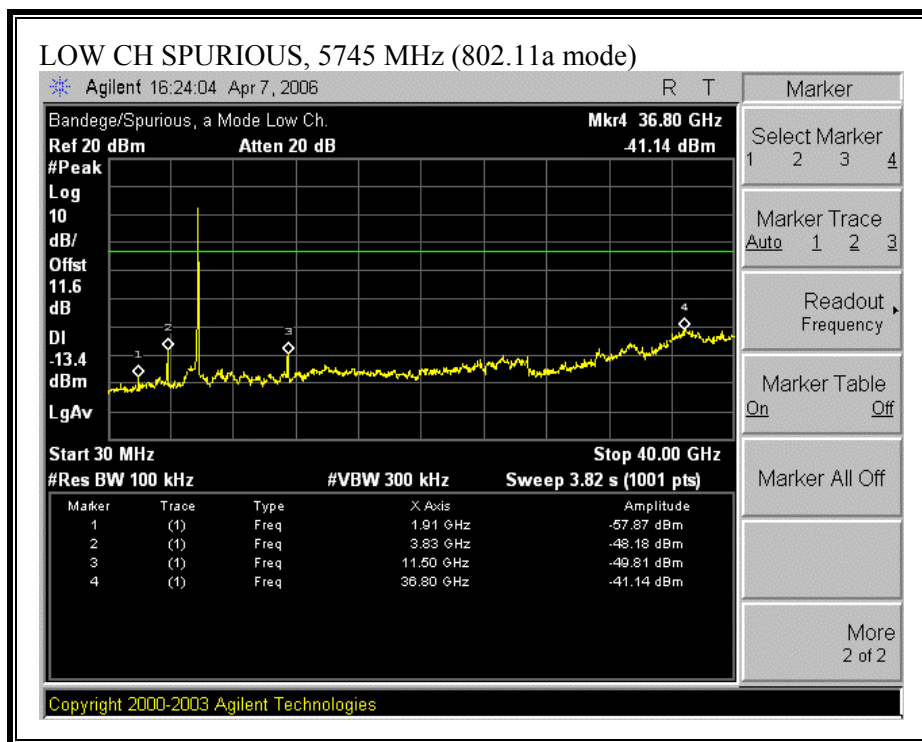
RESULTS

No non-compliance noted:

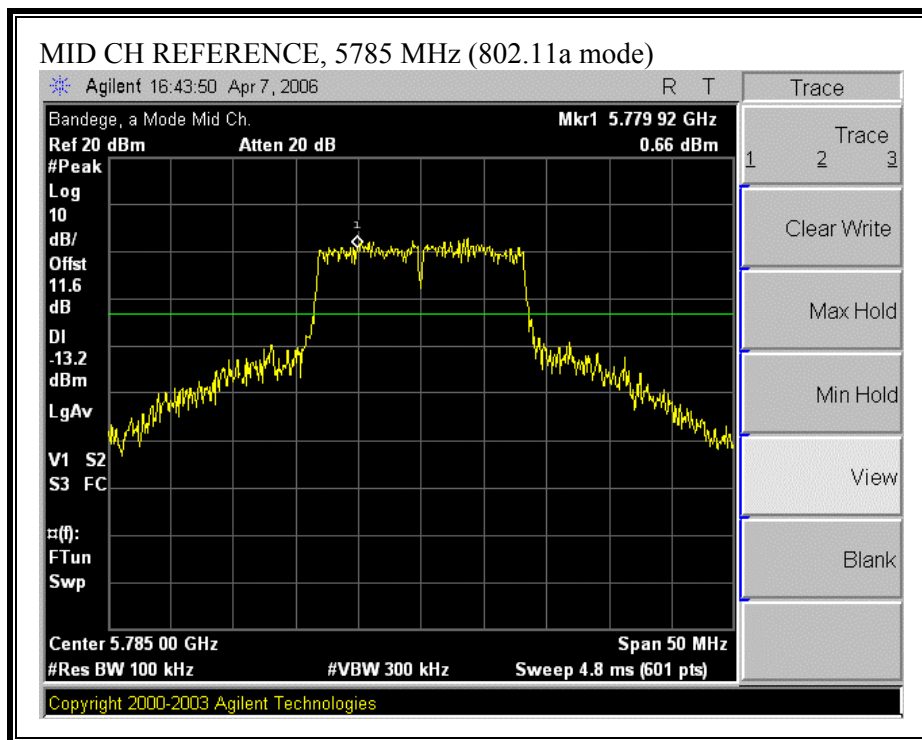
802.11a Legacy Mode

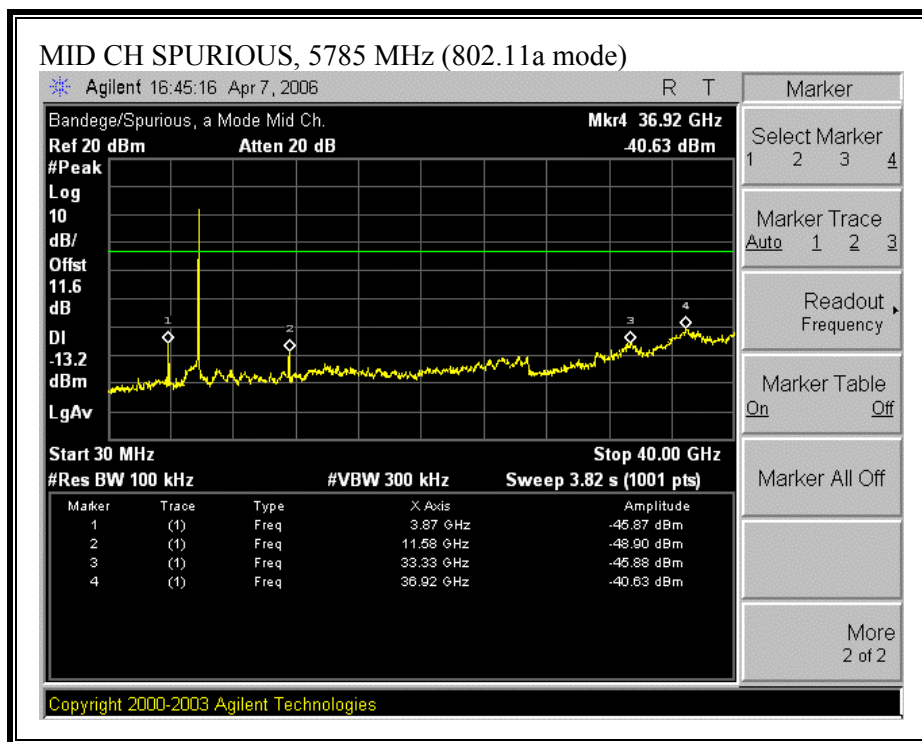
SPURIOUS EMISSIONS, LOW CHANNEL (802.11a MODE)



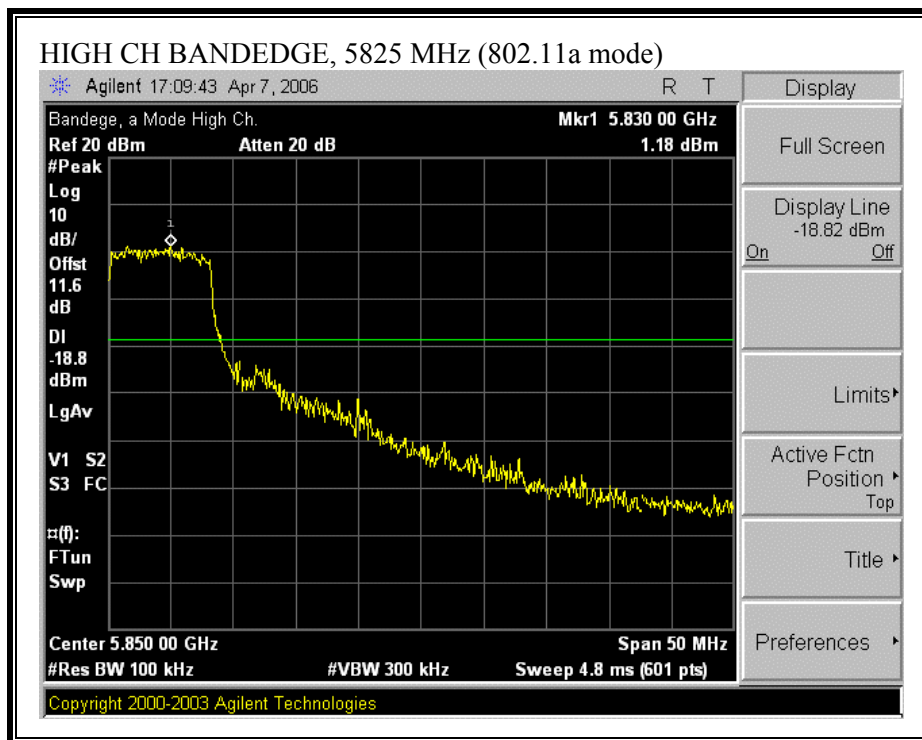


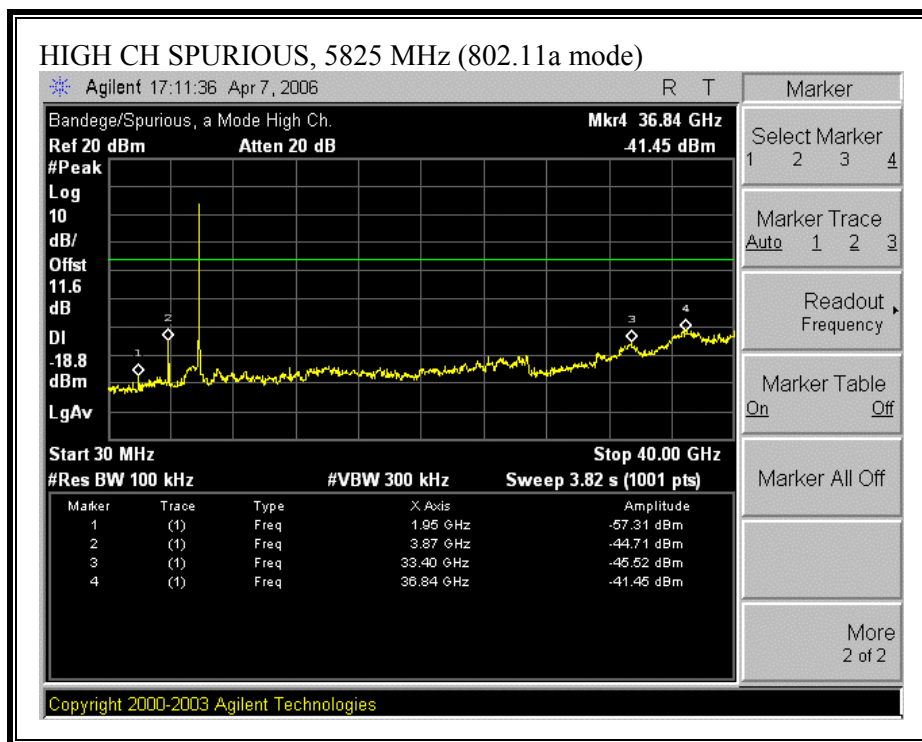
SPURIOUS EMISSIONS, MID CHANNEL (802.11a MODE)





SPURIOUS EMISSIONS, HIGH CHANNEL (802.11a MODE)

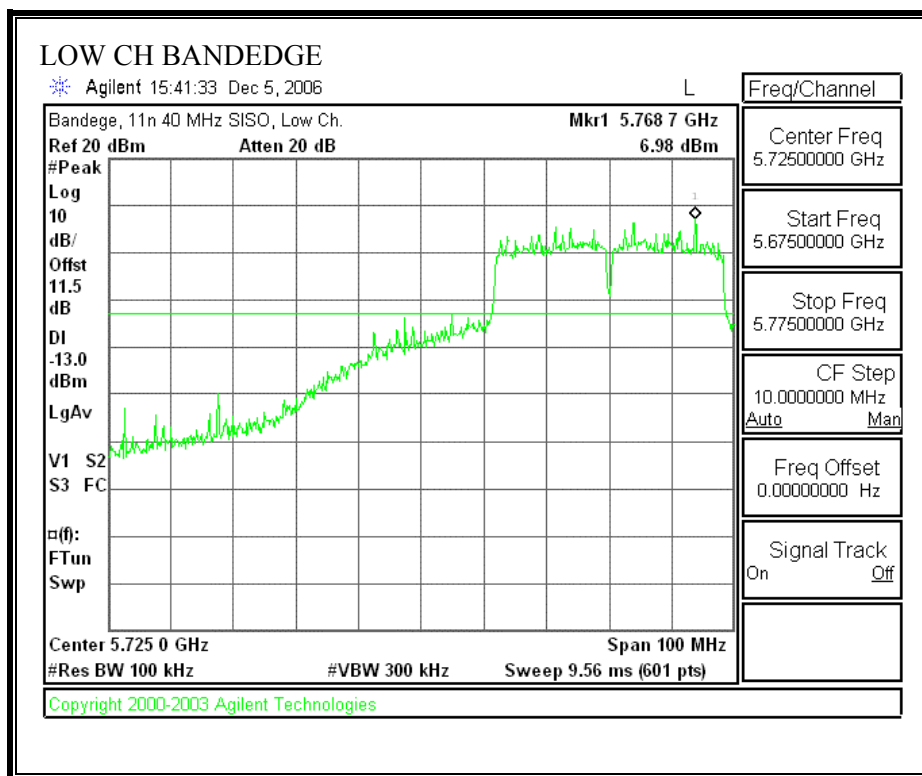


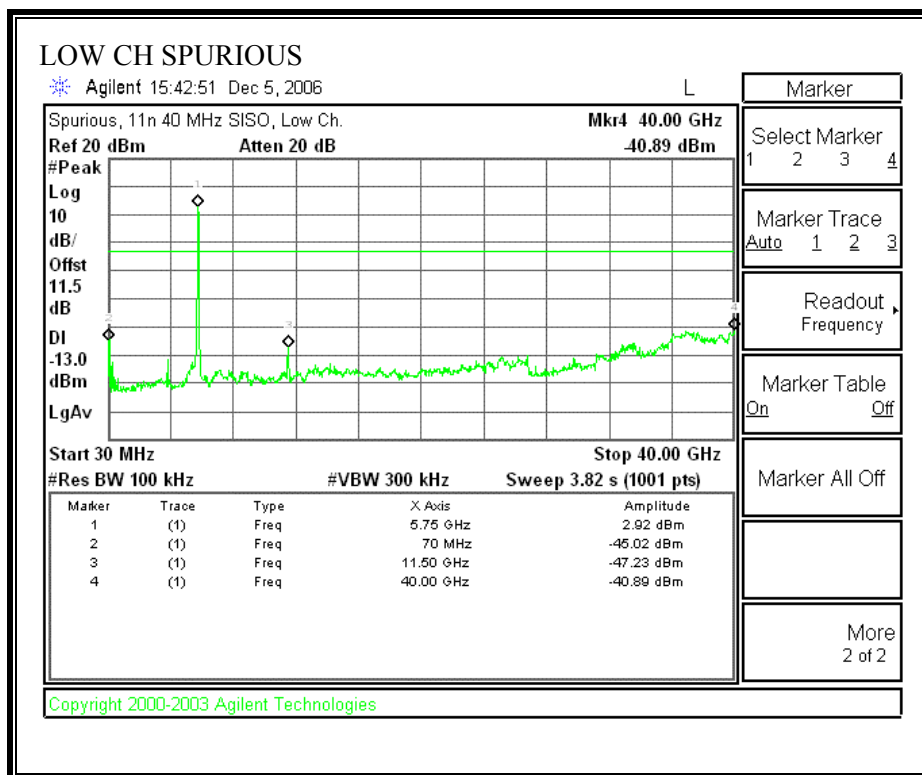


802.11n Mode 20 MHz SISO is covered by the worst case 802.11a Mode Legacy testing.

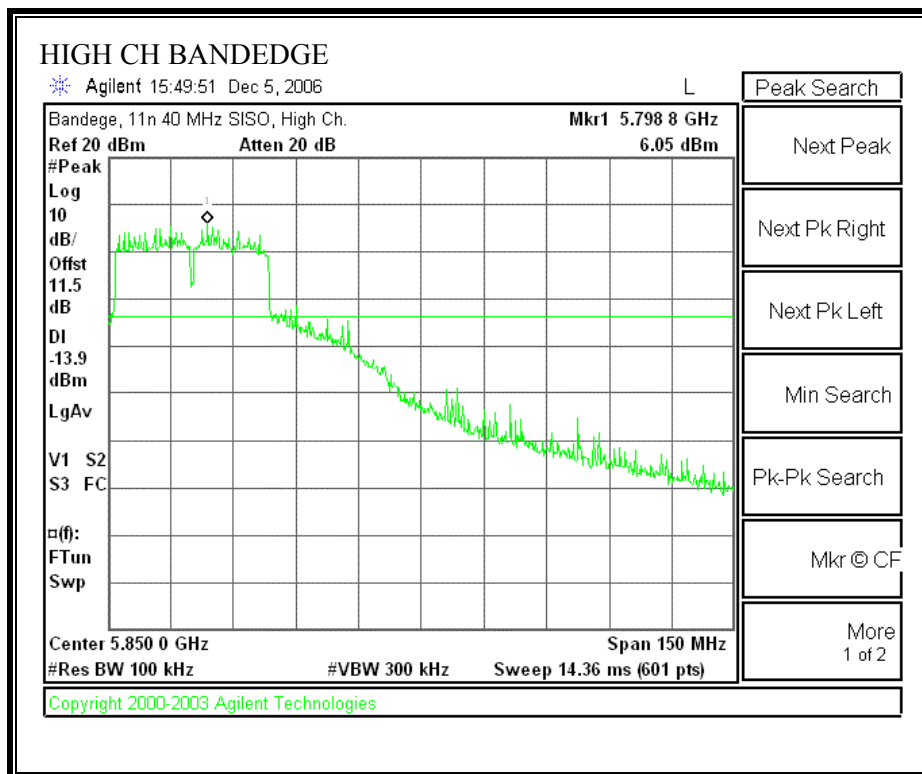
802.11n Mode 40 MHz SISO

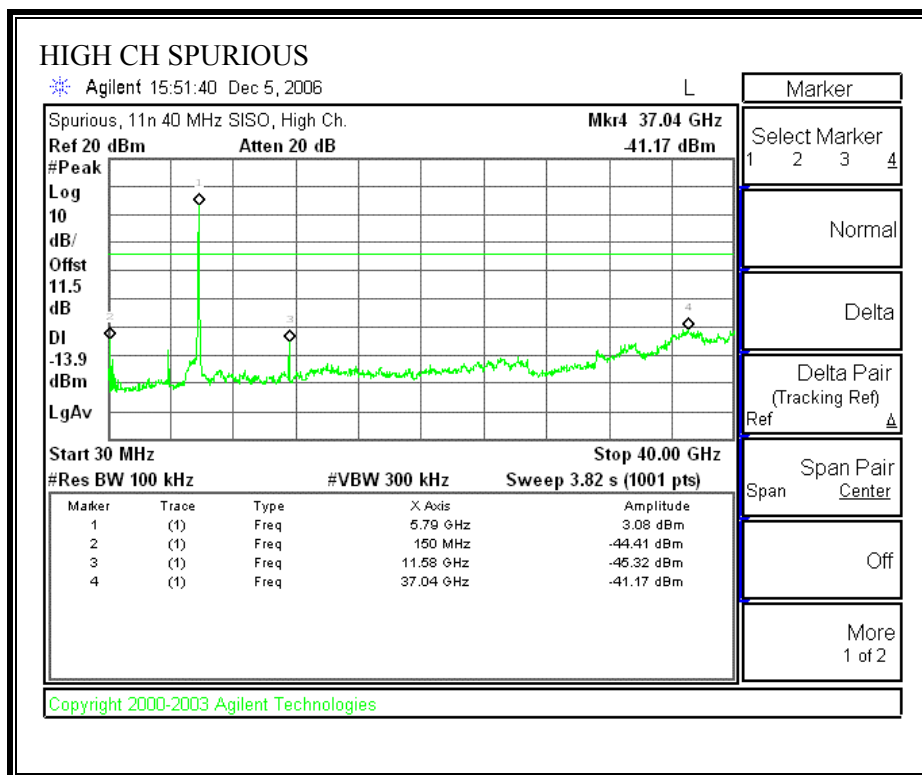
SPURIOUS EMISSIONS, LOW CHANNEL (802.11n 40 MHz SISO MODE)





SPURIOUS EMISSIONS, HIGH CHANNEL (802.11n 40 MHz SISO MODE)





MIMO MODE

7.3. CHANNEL TESTS FOR THE 2400 TO 2483.5 MHz BAND

7.3.1. 6 dB BANDWIDTH

LIMIT

§15.247 (a) (2) For direct sequence systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 100 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

RESULTS

No non-compliance noted:

6 dB BANDWIDTH

802.11g Mode Legacy CDD is covered by the worst case 802.11n Mode 20 MHz CDD MCS0.

802.11n Mode 20 MHz CDD MCS 0:

20 MHz TX BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2412	17080	500	16580
Middle	2437	16920	500	16420
High	2462	16670	500	16170

20 MHz TX BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2412	16330	500	15830
Middle	2437	16250	500	15750
High	2462	16080	500	15580

802.11n Mode 40 MHz CDD MCS 32

40 MHz TX BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2422	36250	500	35750
Middle	2437	35830	500	35330
High	2452	36330	500	35830

40 MHz TX BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2422	35330	500	34830
Middle	2437	36330	500	35830
High	2452	35920	500	35420

802.11n Mode 40 MHz SDM MCS 15:

40 MHz TX BANDWIDTH - CHAIN 0

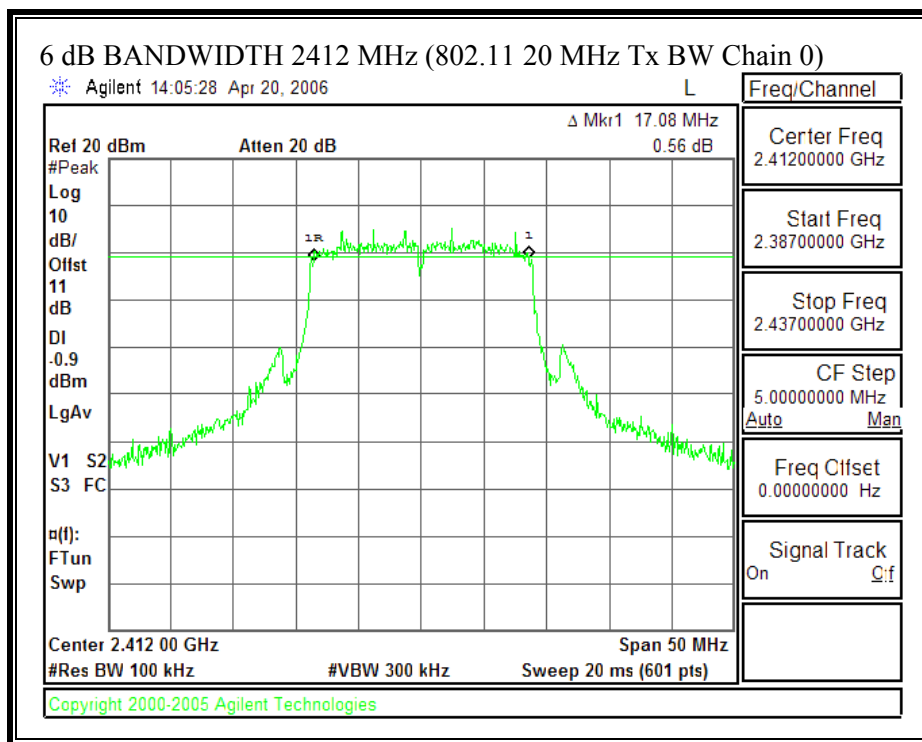
Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2422	36130	500	35630
Middle	2437	36130	500	35630
High	2452	36130	500	35630

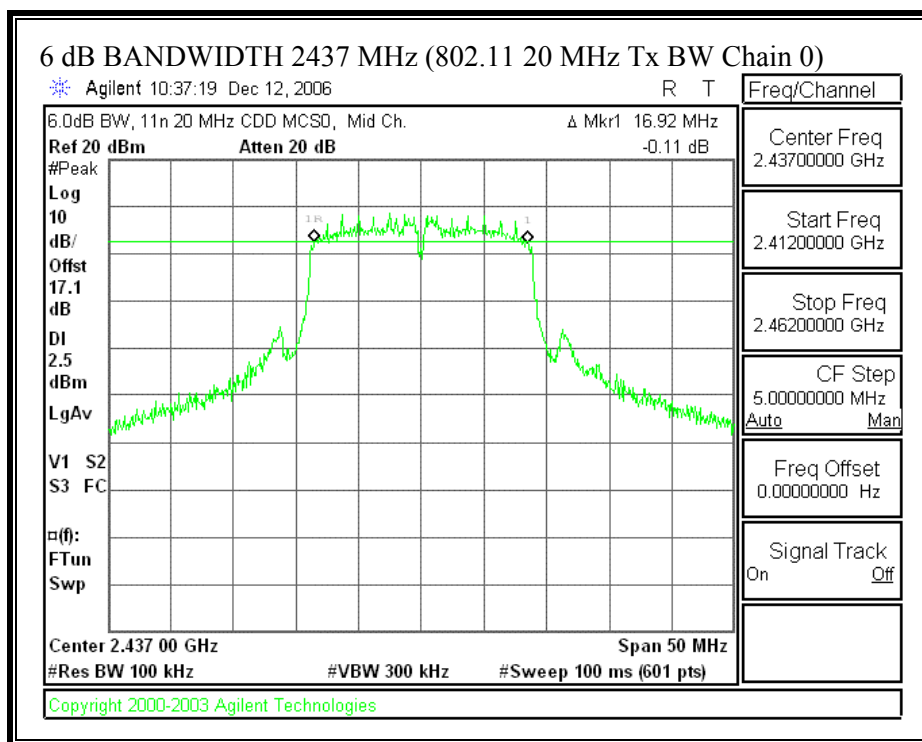
40 MHz TX BANDWIDTH - CHAIN 1

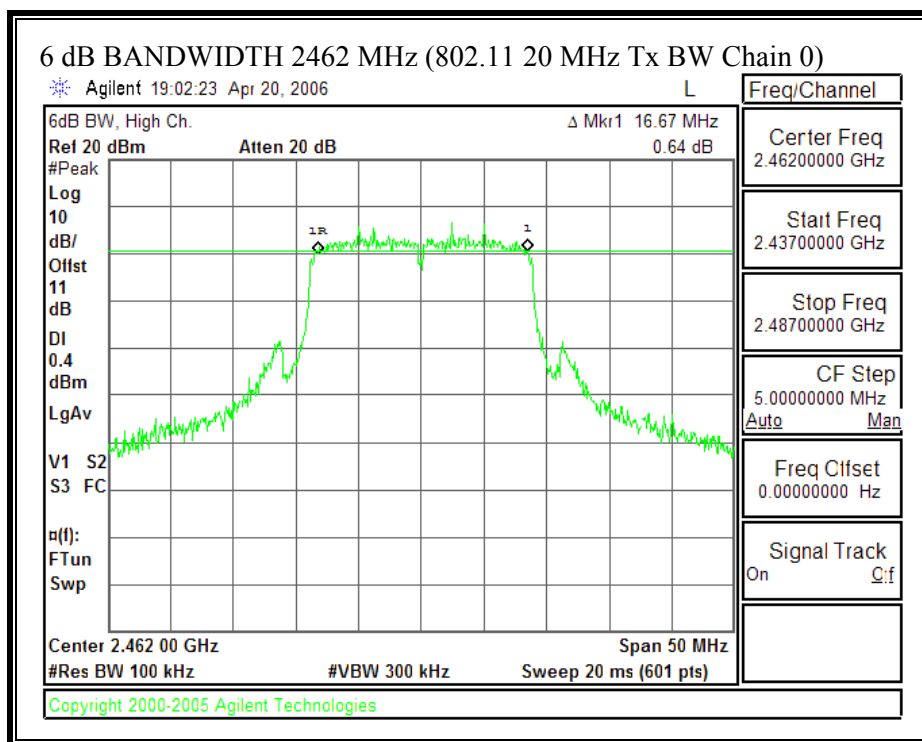
Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Minimum Limit (kHz)	Margin (kHz)
Low	2422	35870	500	35370
Middle	2437	35730	500	35230
High	2452	36000	500	35500

802.11n Mode 20 MHz CDD MCS 0:

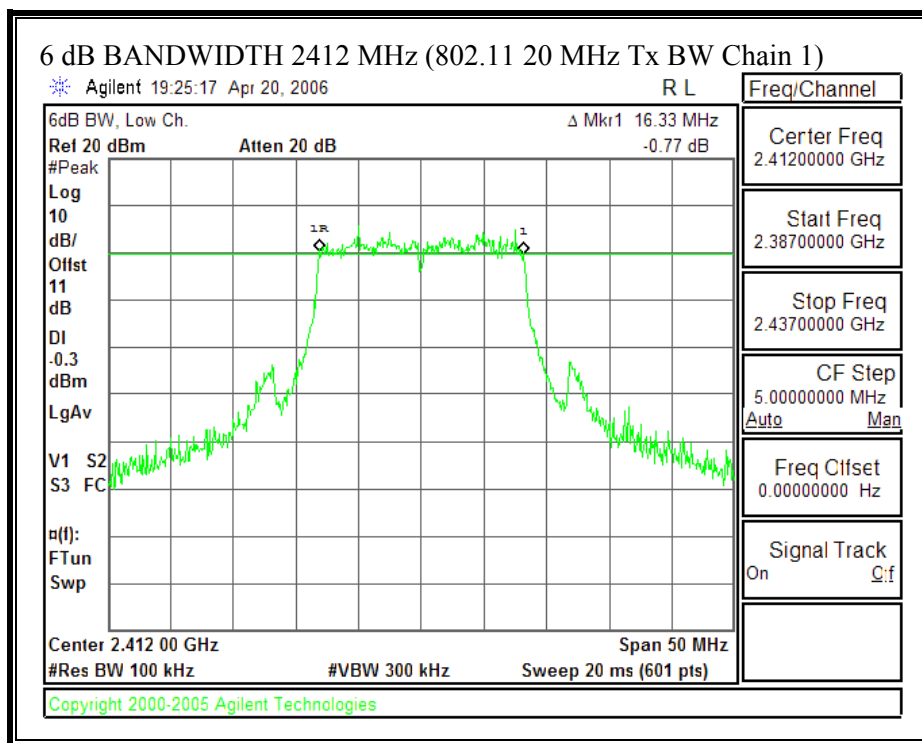
6 dB BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH – CHAIN 0)

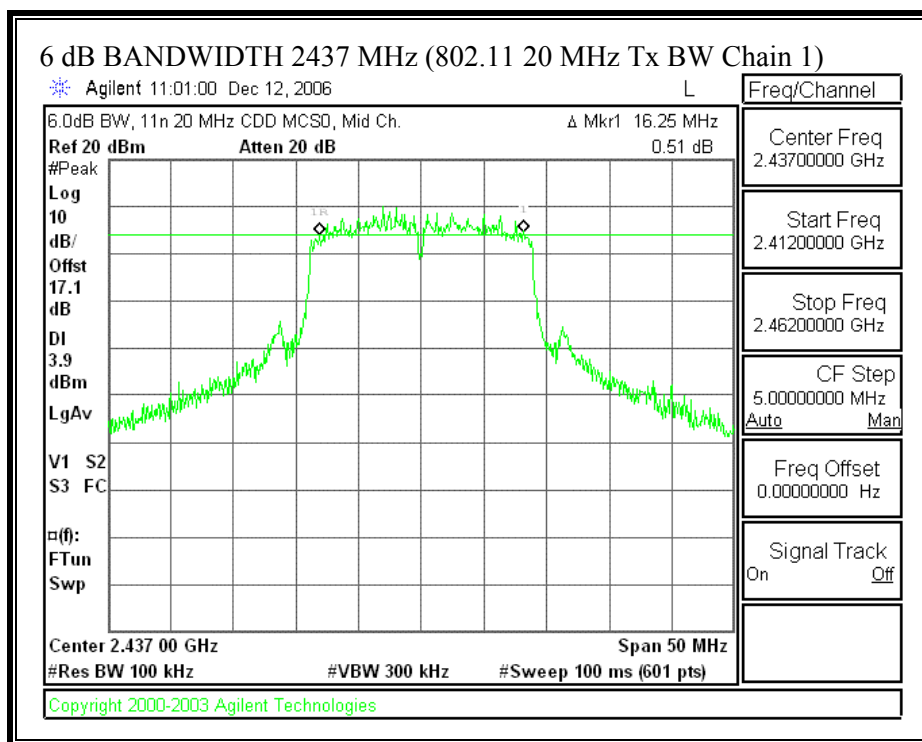


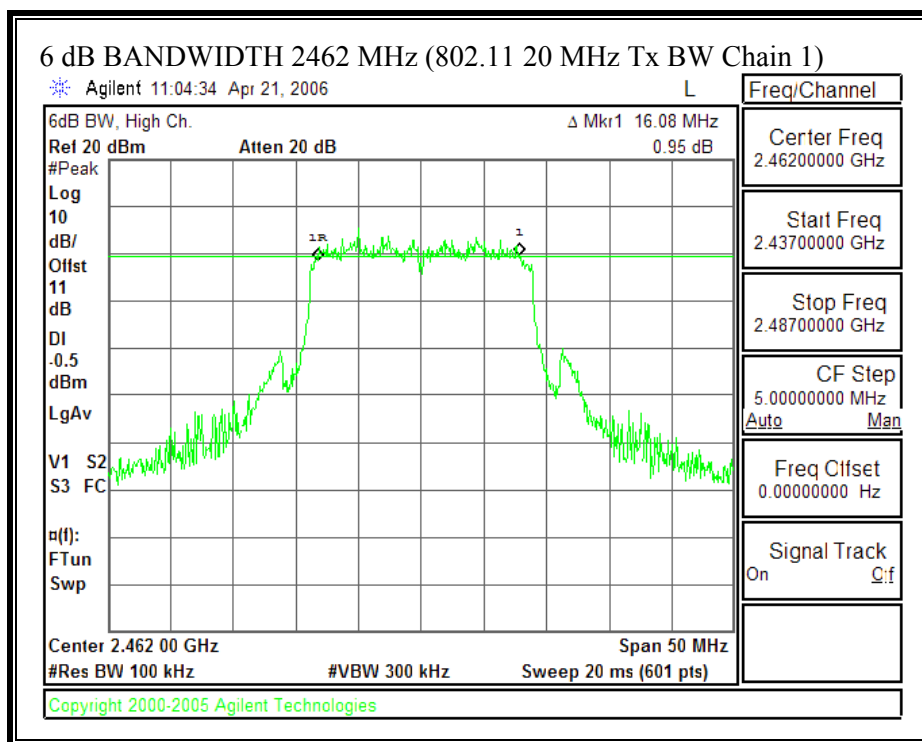




6 dB BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH – CHAIN 1)

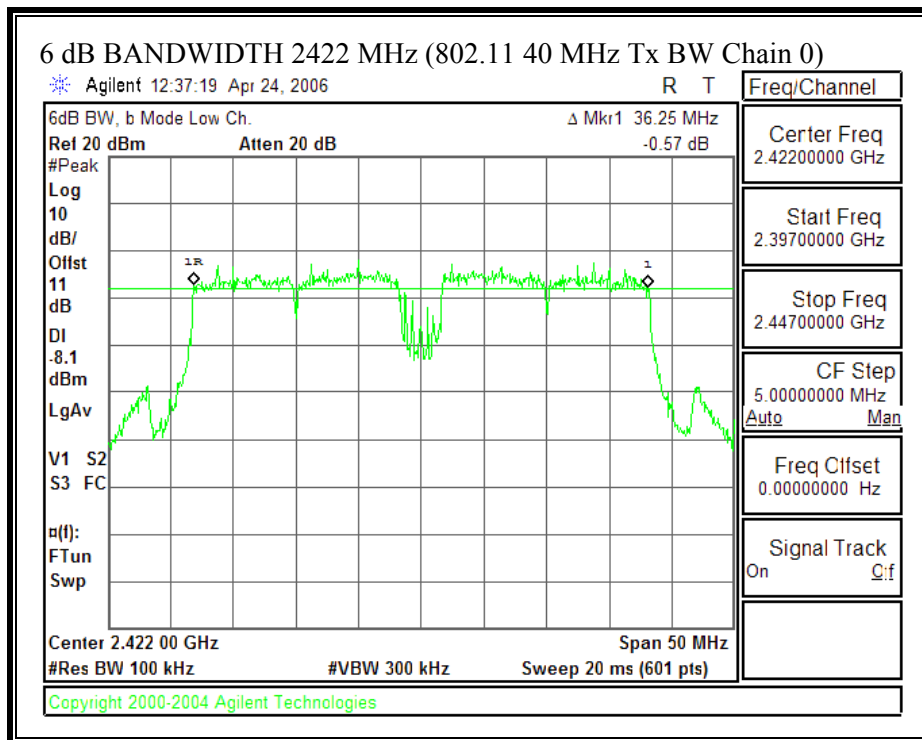


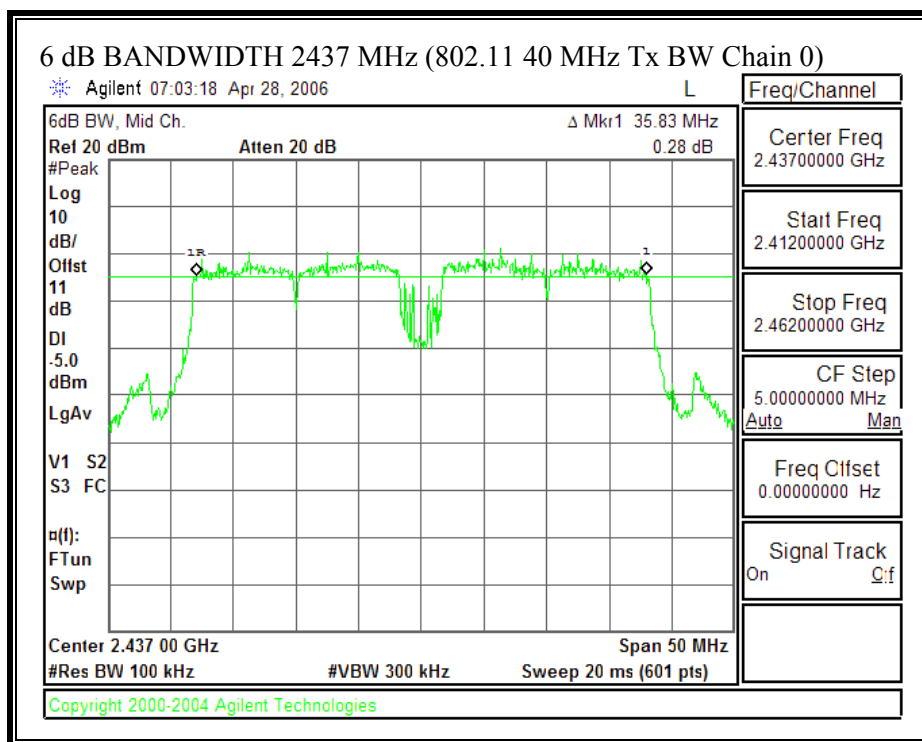


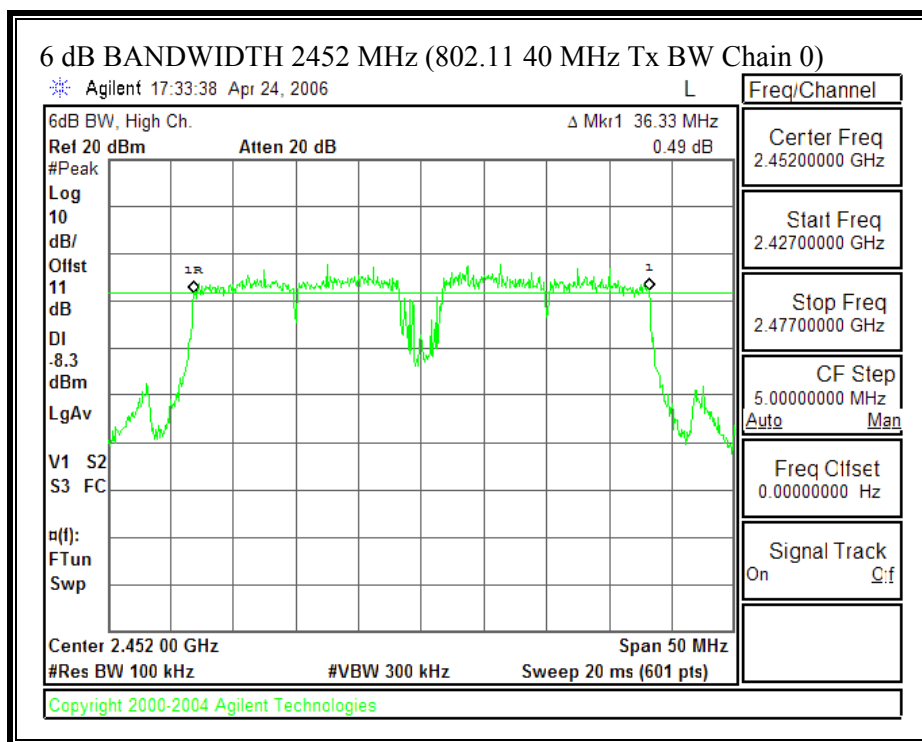


802.11n Mode 40 MHz CDD MCS 32

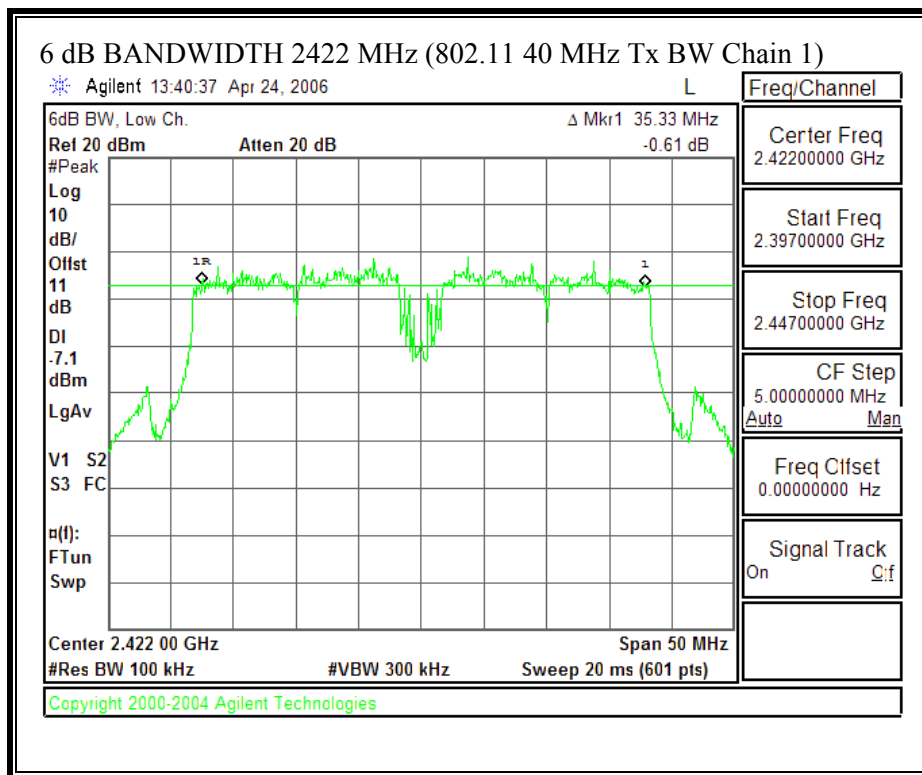
6 dB BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)

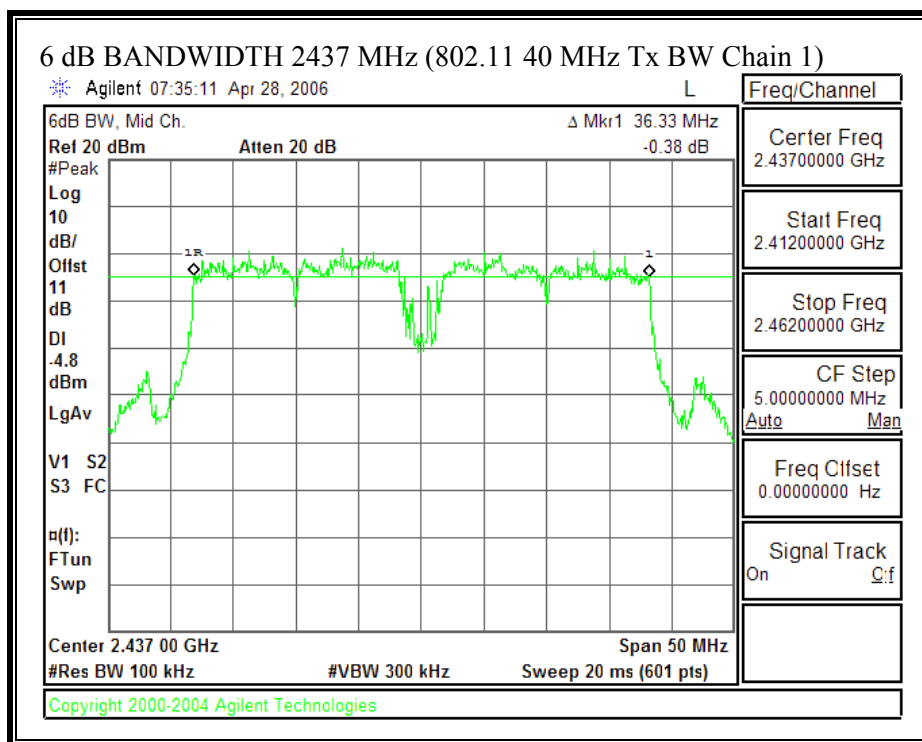


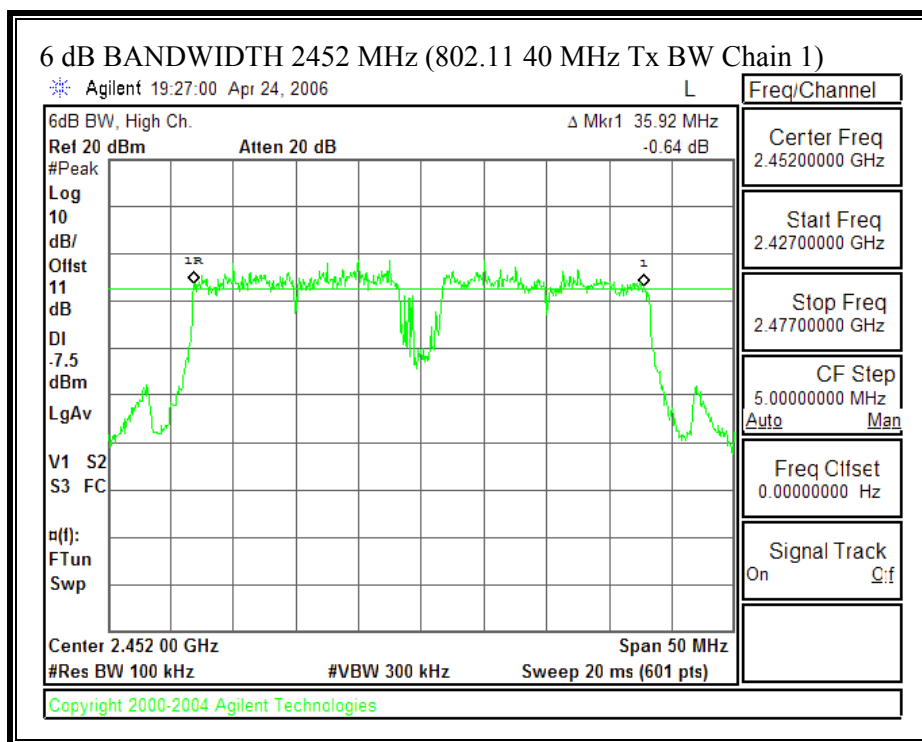




6 dB BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)

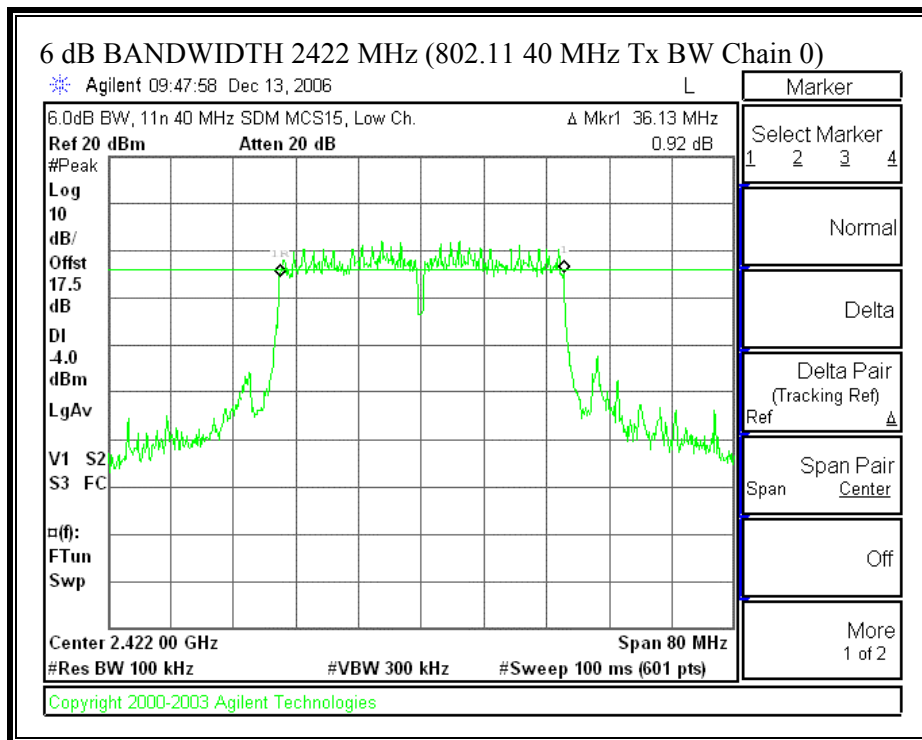


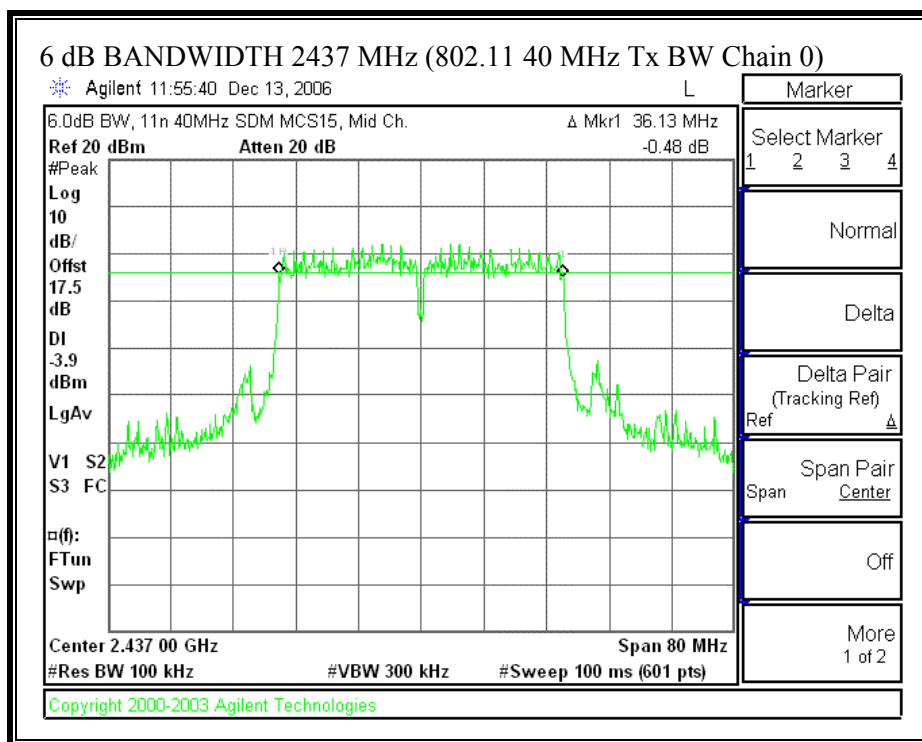


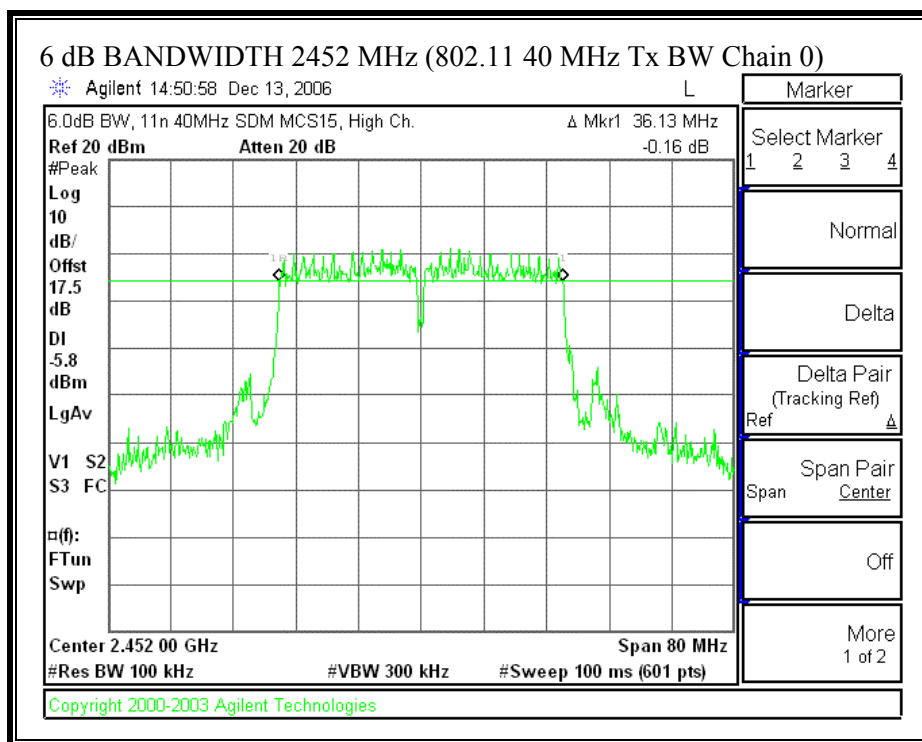


802.11n Mode 40 MHz SDM MCS 15:

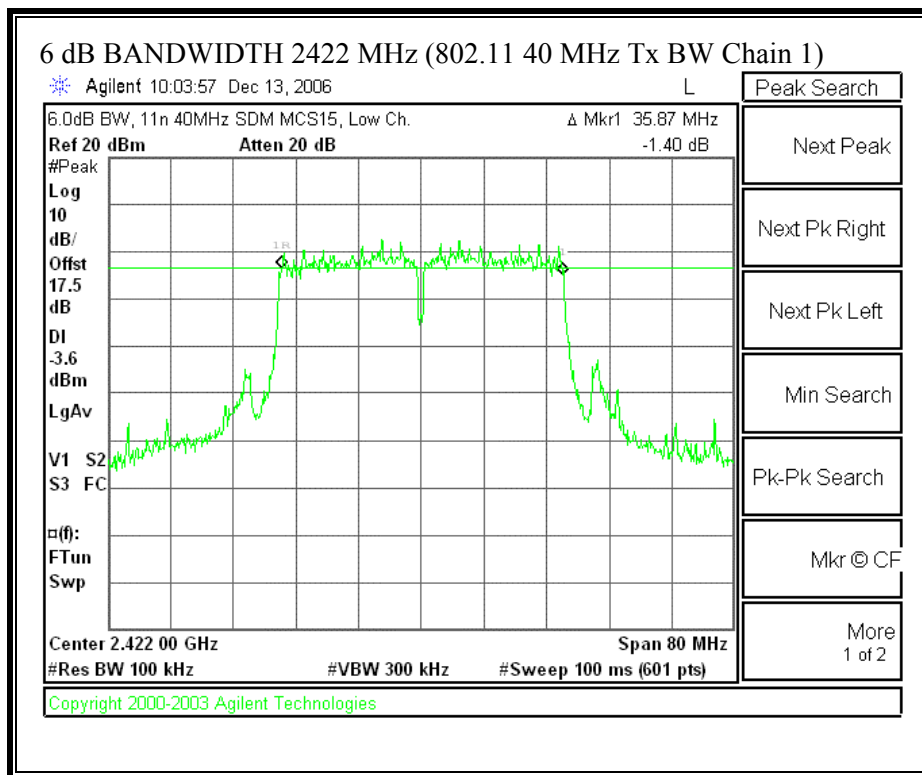
6 dB BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)

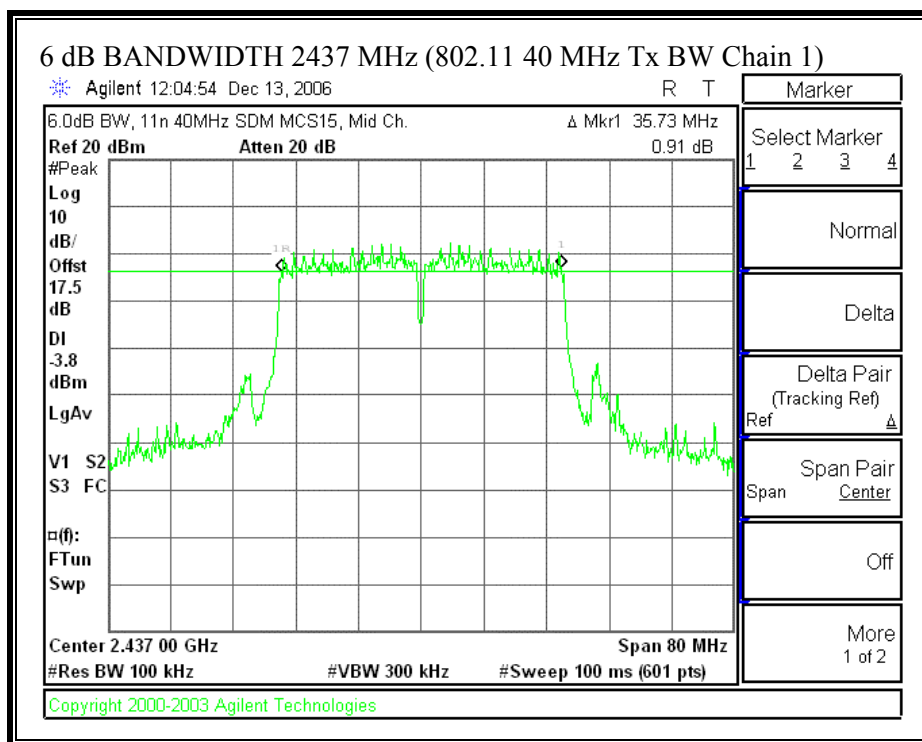


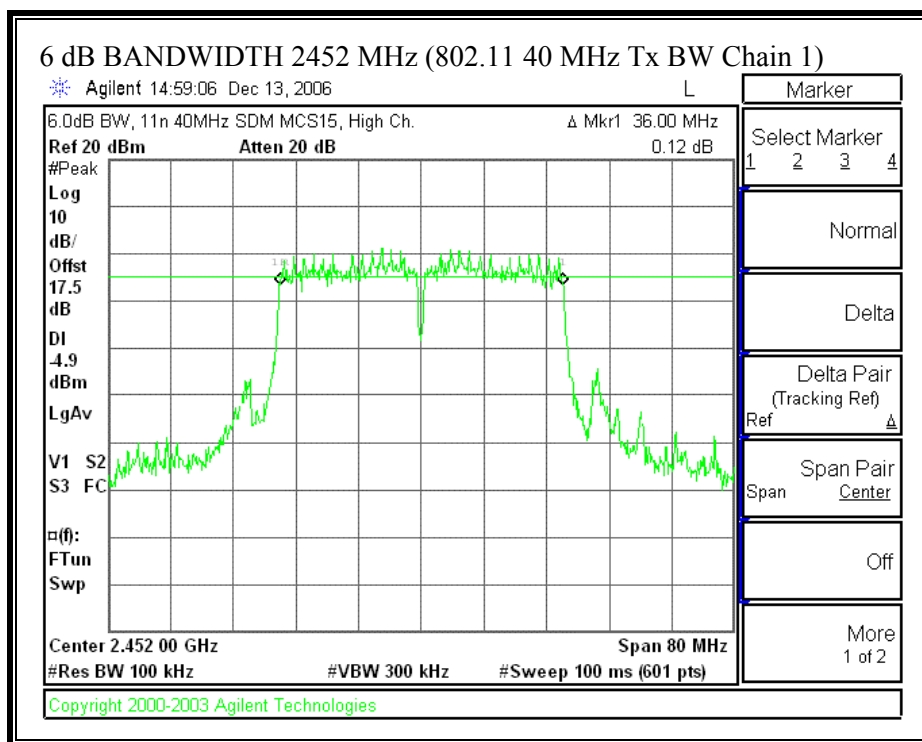




6 dB BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)







7.3.2. 99% BANDWIDTH

LIMIT

None; for reporting purposes only.

TEST PROCEDURE

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

RESULTS

No non-compliance noted:

99% BANDWIDTH

802.11g Mode Legacy CDD is covered by the worst case **802.11n Mode 20 MHz CDD MCS0**.

802.11n Mode 20 MHz CDD MCS 0:

20MHz Tx Bandwidth

Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)
Low	2412	17.5052	17.6162
Middle	2437	17.5459	17.5846
High	2462	17.5016	17.4733

802.11n Mode 40 MHz CDD MCS 32

40MHz Tx Bandwidth

Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)
Low	2422	36.1318	36.1318
Middle	2437	36.1370	36.1061
High	2452	36.1293	36.1186

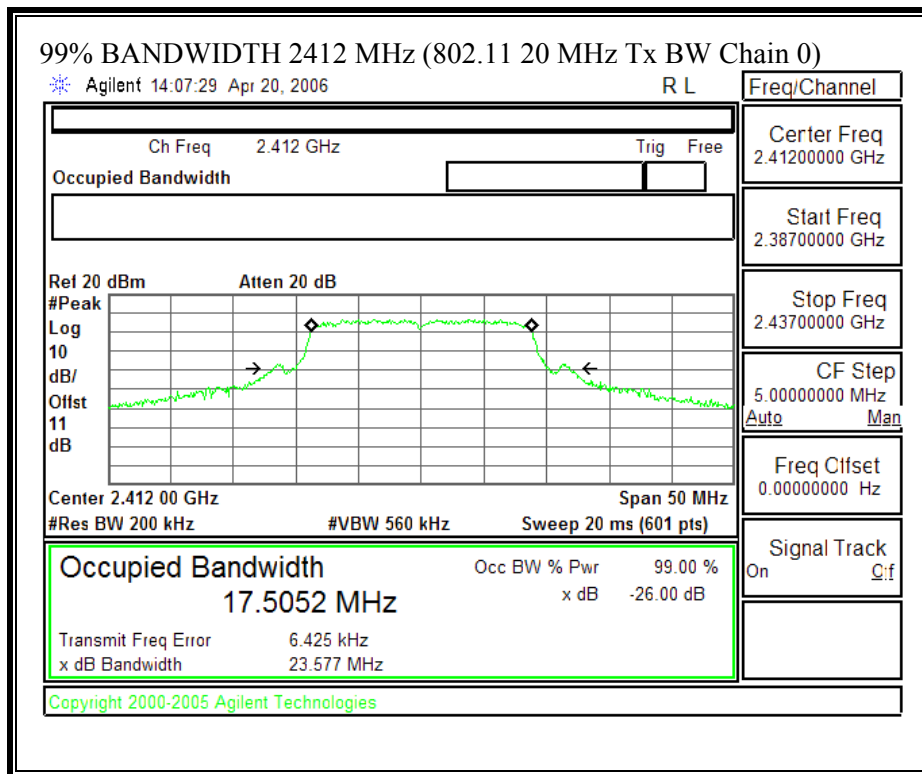
802.11n Mode 40 MHz SDM MCS 15:

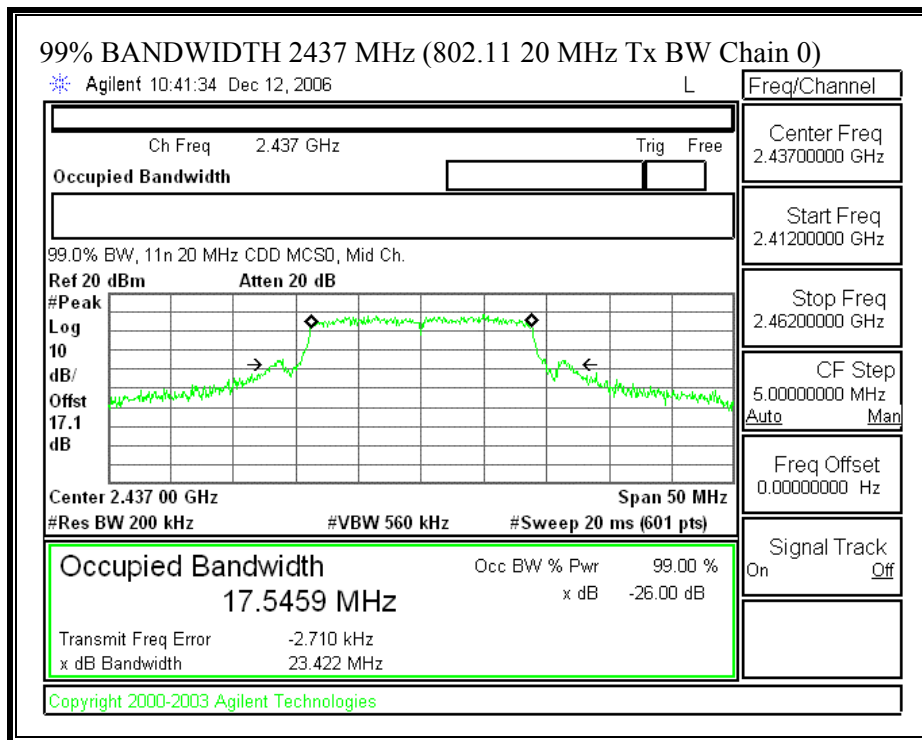
40MHz Tx Bandwidth

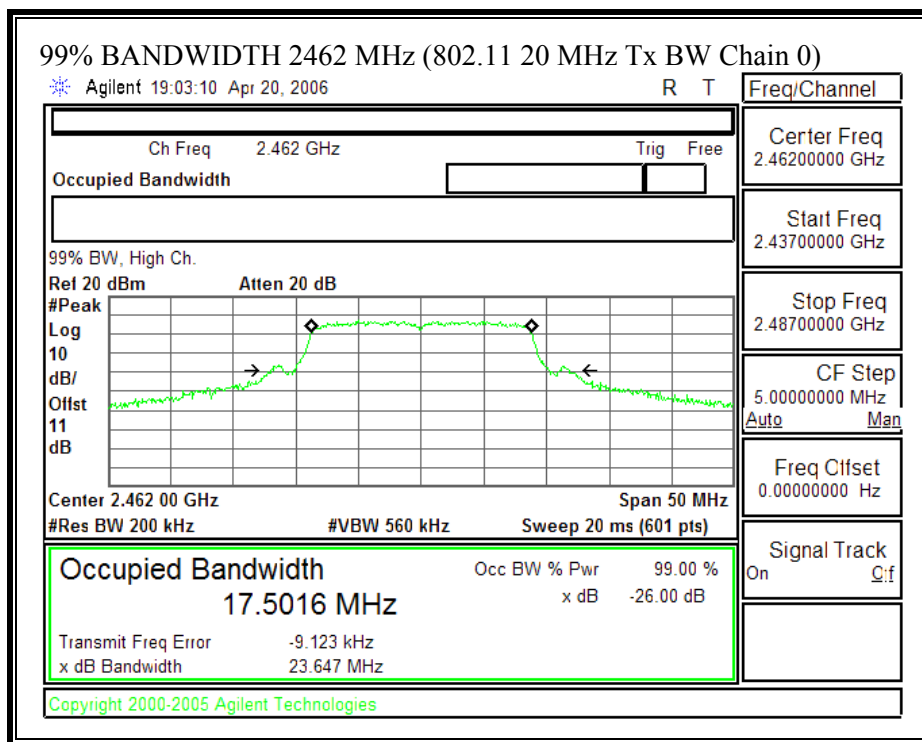
Channel	Frequency (MHz)	99% Bandwidth Chain 0 (MHz)	99% Bandwidth Chain 1 (MHz)
Low	2422	36.0811	36.1326
Middle	2437	36.1526	36.0381
High	2452	36.1145	36.0833

802.11n Mode 20 MHz CDD MCS 0:

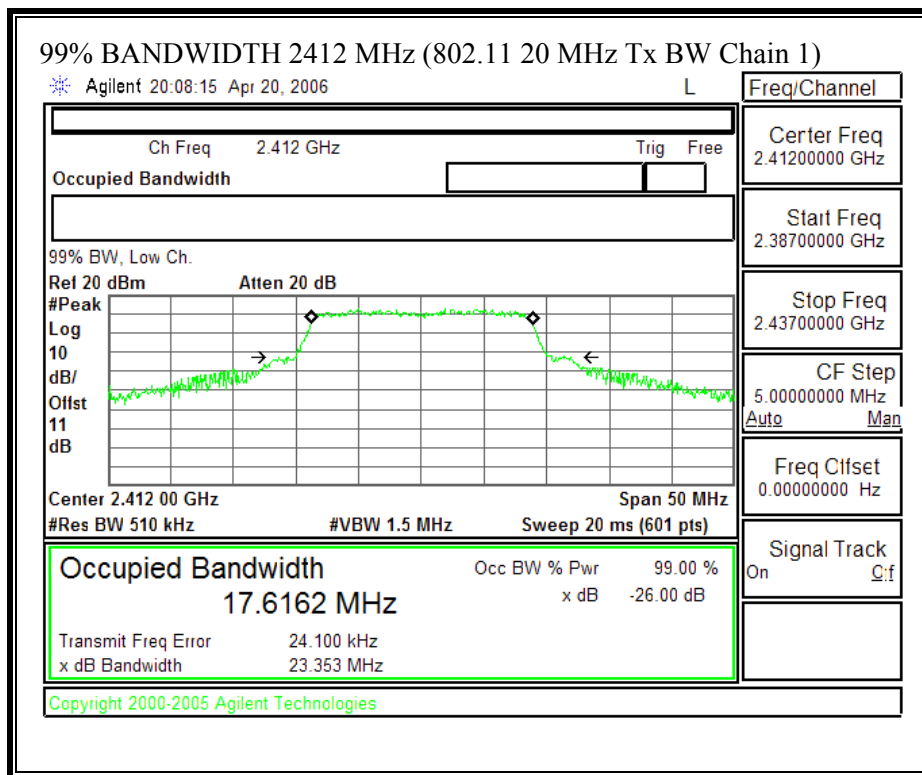
99% BANDWIDTH (802.11 - 20 MHz BANDWIDTH – CHAIN 0)

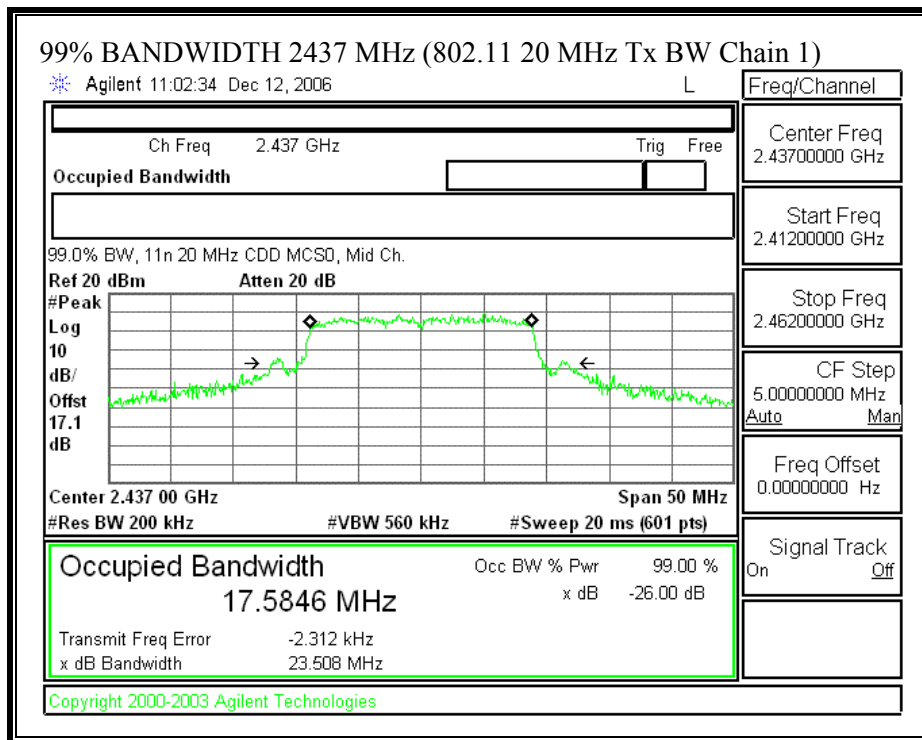


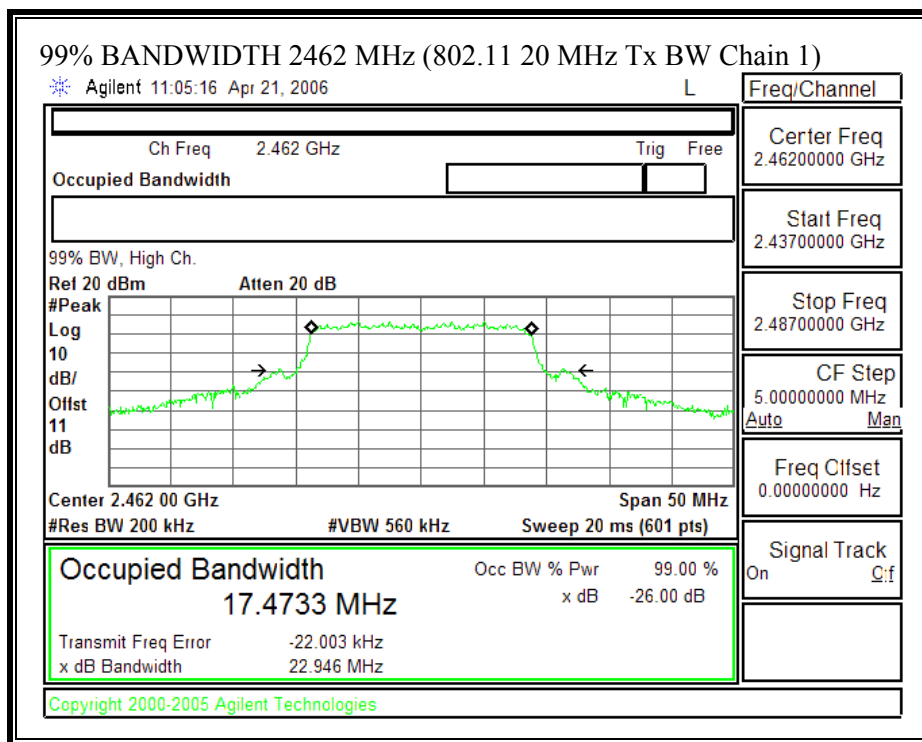




99% BANDWIDTH (802.11 - 20 MHz BANDWIDTH – CHAIN 1)

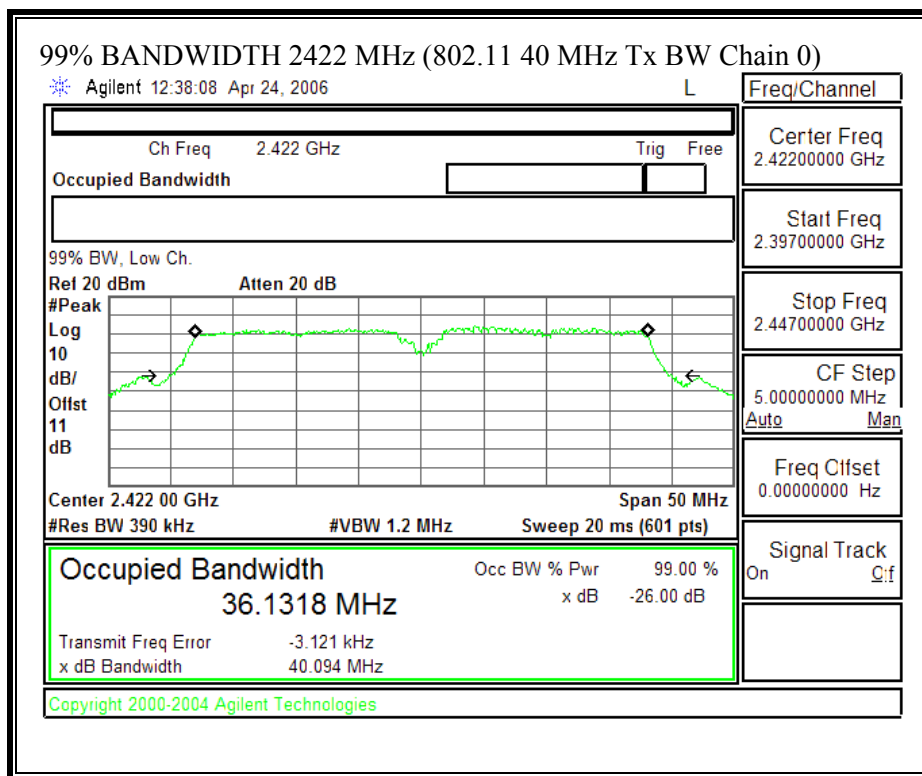


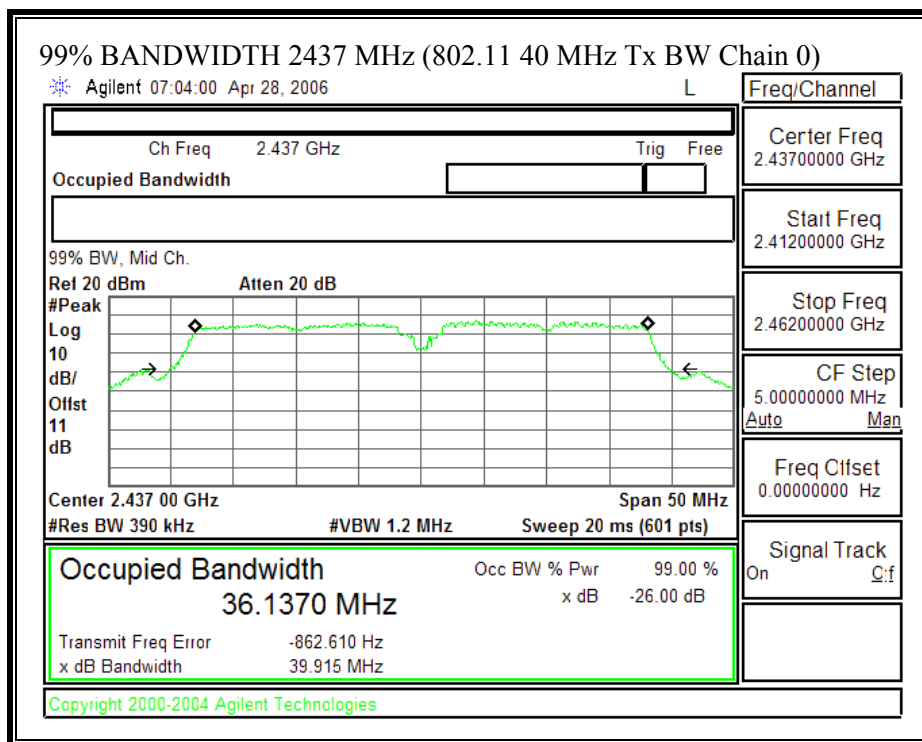


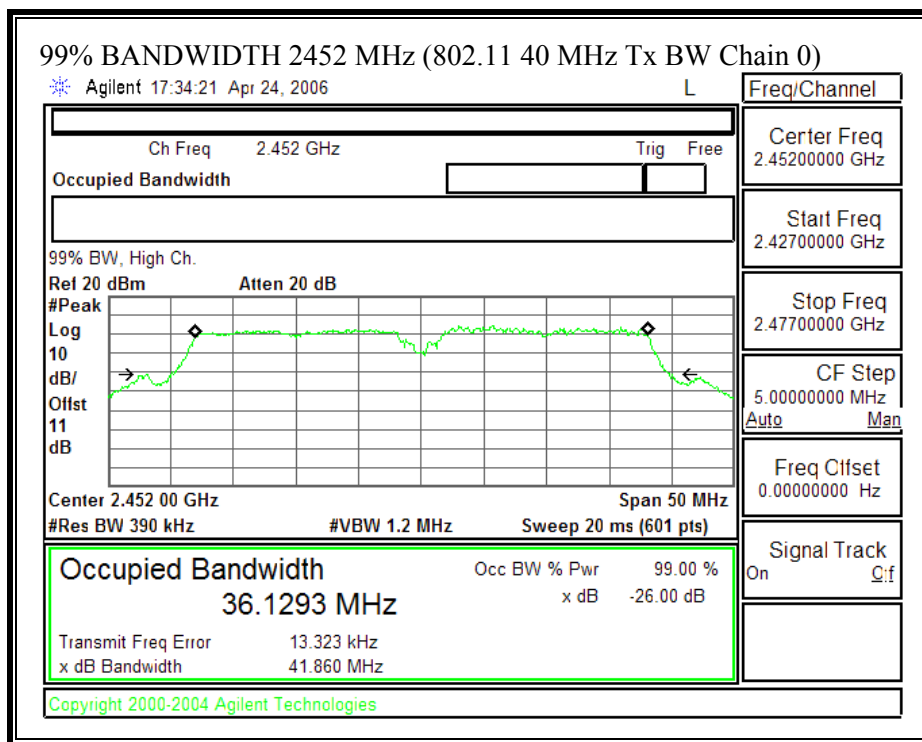


802.11n Mode 40 MHz CDD MCS 32

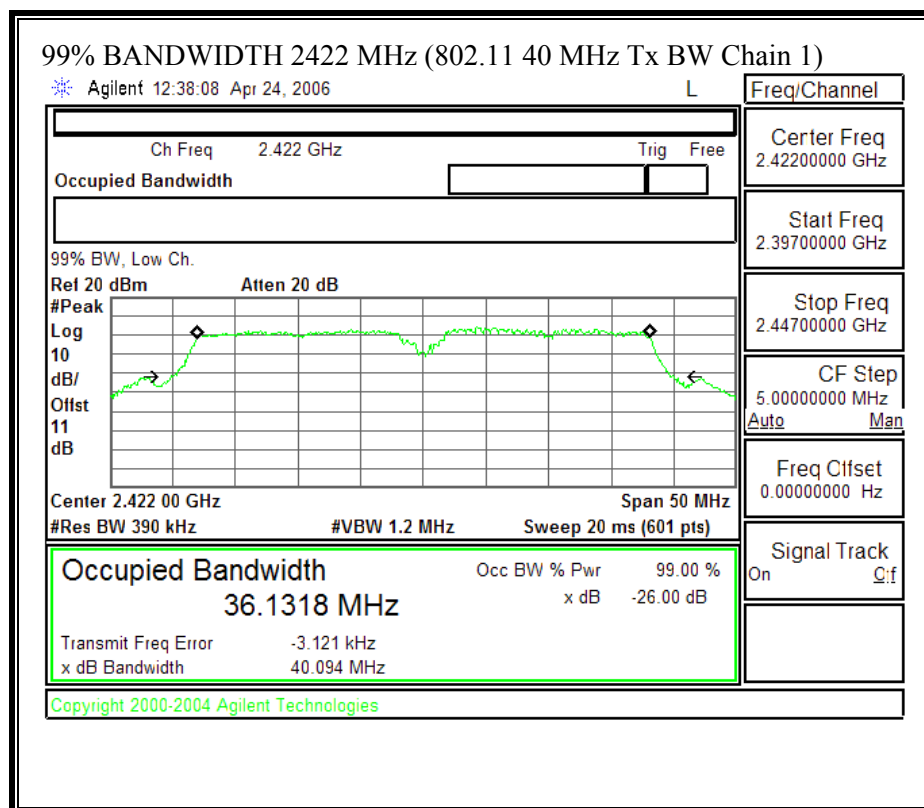
99% BANDWIDTH (802.11 - 40 MHz BANDWIDTH – CHAIN 0)

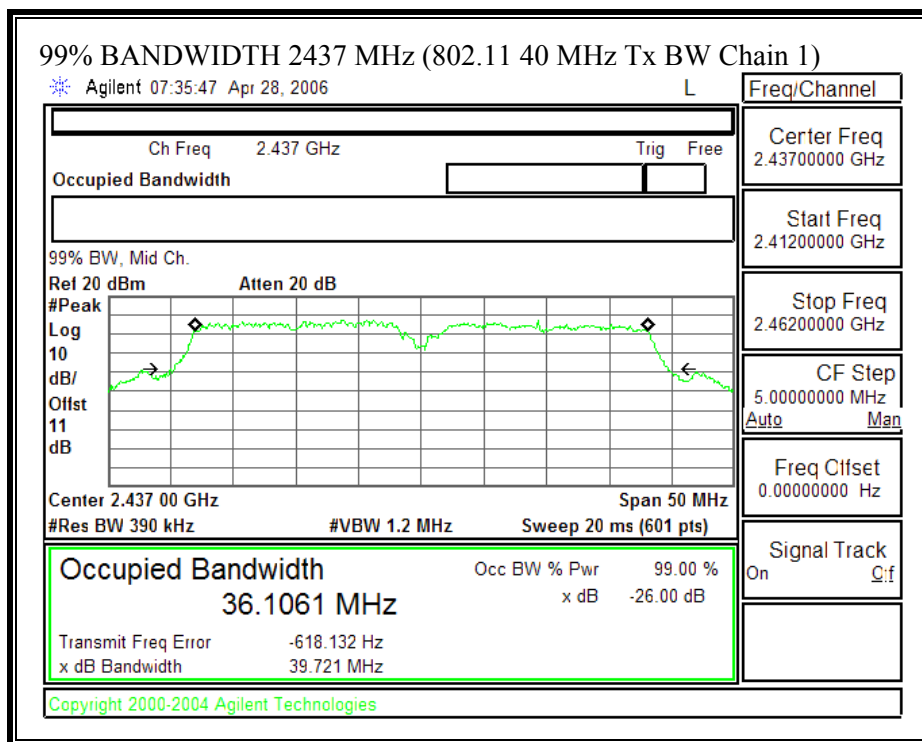


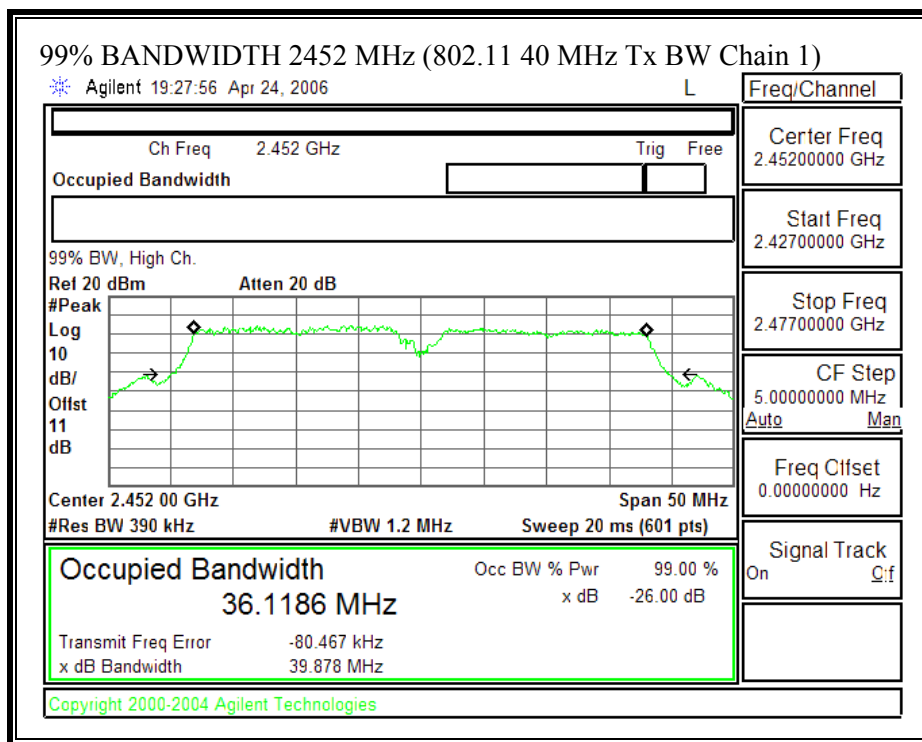




99% BANDWIDTH (802.11 - 40 MHz BANDWIDTH – CHAIN 1)

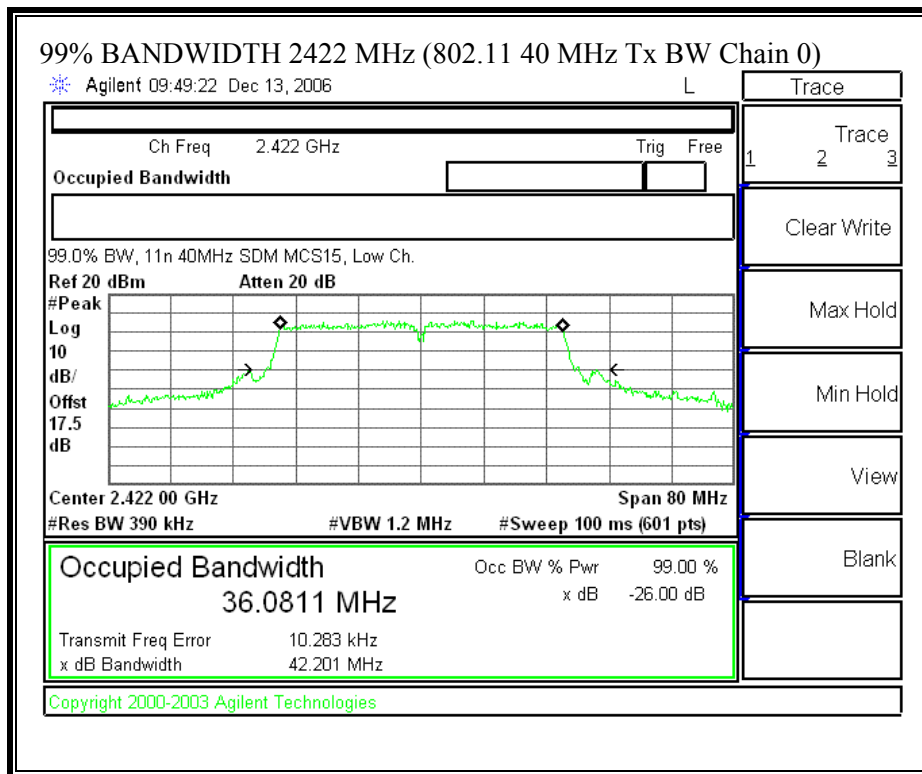


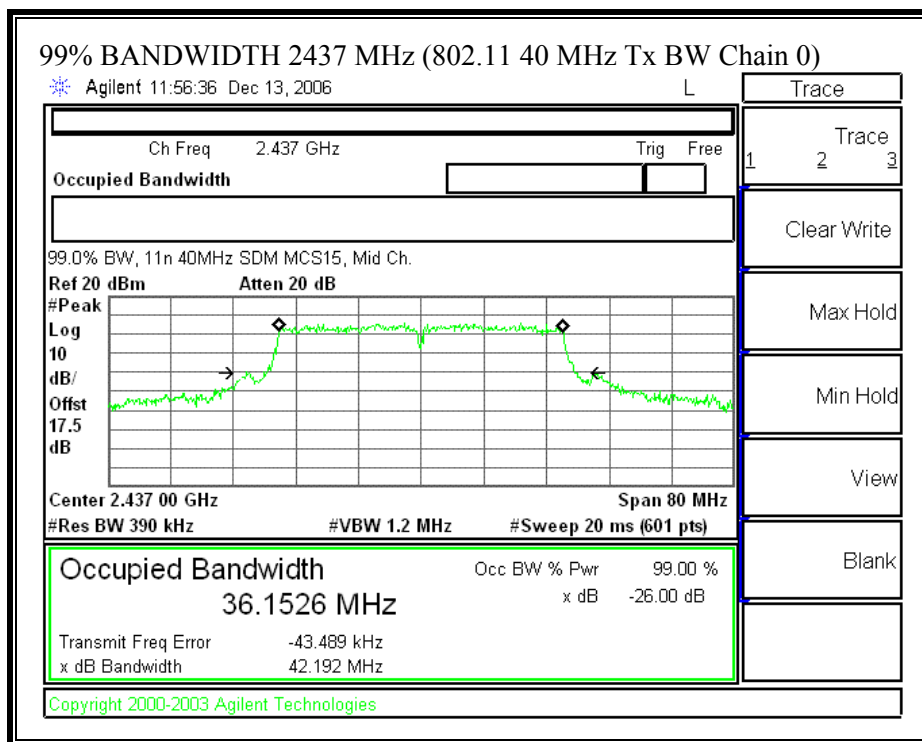


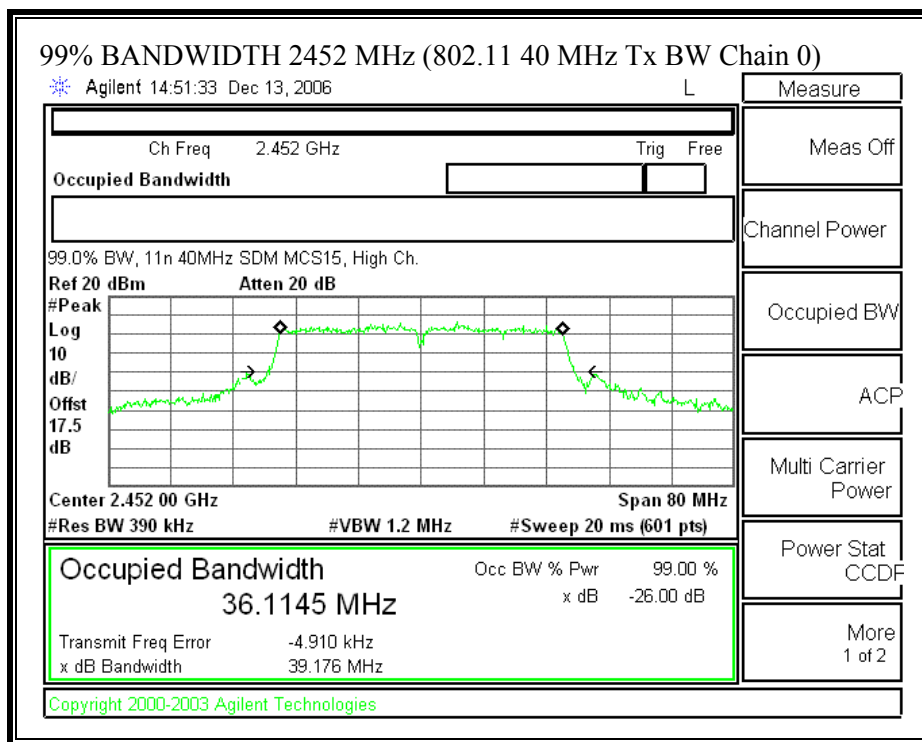


802.11n Mode 40 MHz SDM MCS 15:

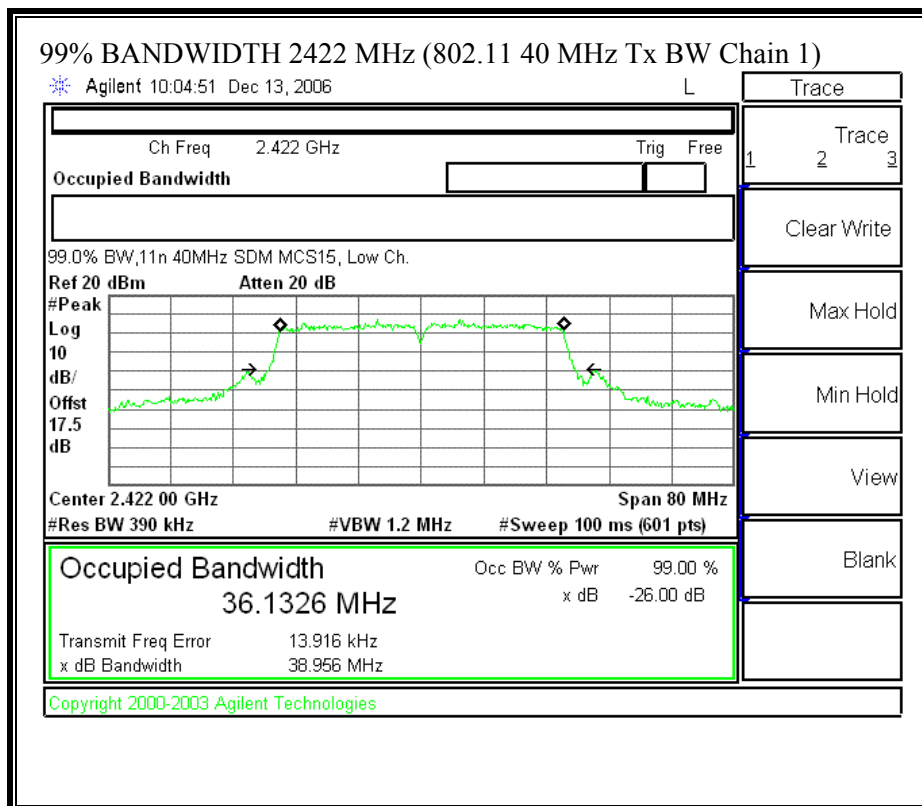
99% BANDWIDTH (802.11 - 40 MHz BANDWIDTH – CHAIN 0)

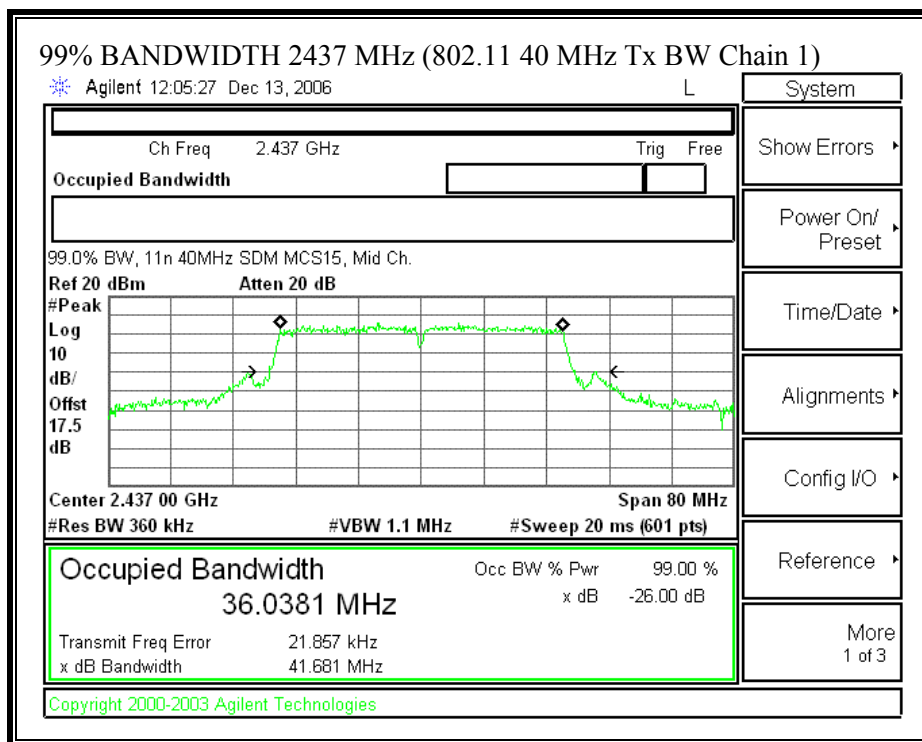


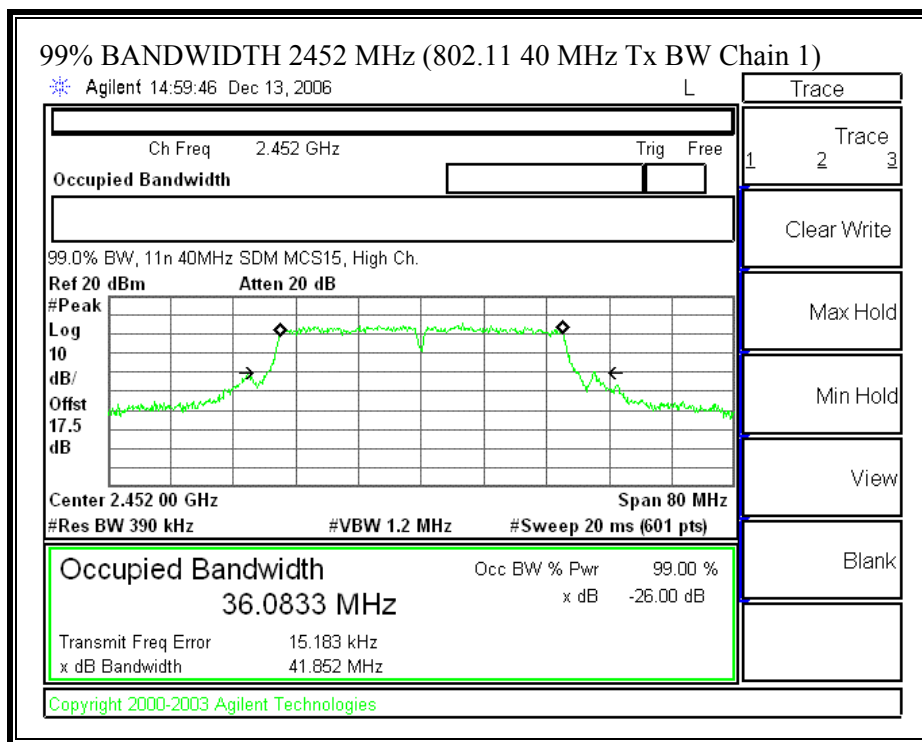




99% BANDWIDTH (802.11 - 40 MHz BANDWIDTH – CHAIN 1)







7.3.3. PEAK OUTPUT POWER

PEAK POWER LIMIT

§15.247 (b) The maximum peak output power of the intentional radiator shall not exceed the following:

§15.247 (b) (3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz , and 5725-5850 MHz bands: 1 watt.

§15.247 (b) (3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz , and 5725-5850 MHz bands: 1 watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

§15.247 (b) (4) (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer and the analyzer's internal channel power integration function is used to integrate the power over a bandwidth greater than or equal to the 99% bandwidth.

The test is performed in accordance with FCC document "Measurement of Digital Transmission Systems Operating under Section 15.247", March 23, 2005. The transmitter operates continuously therefore Power Output Option 2, Method # 1 is used.

Following formula to calculate the array gain:

$$\text{Array gain} = 10 \cdot \log (10^{(\text{main gain}/10)} + 10^{(\text{aux gain}/10)})$$

2.4GHz band: 6.142 dBi

5.8GHz band: 8.555 dBi

RESULTS.

The maximum antenna gain is 6.142dBi @ 2.4 GHz for other than fixed, point-to-point operations, therefore the limit is 29.86dBm.

Total peak power calculation formula: $10 \log (10^{\text{Pchain0} / 10} + 10^{\text{Pchain1} / 10})$

Note: Pchain 0 and Pchain1 are in dBm

No non-compliance noted:

802.11g Mode Legacy CDD is covered by the worst case 802.11n Mode 20 MHz CDD MCS0.

802.11n Mode 20 MHz CDD MCS 0:

CHAIN 0 & CHAIN 1

Channel	Frequency (MHz)	Peak Power Chain 0 (dBm)	Peak Power Chain 1 (dBm)	Peak Power Total (dBm)	Limit (dBm)	Margin (dB)
20 MHz TX BANDWIDTH						
Low	2412	20.89	20.91	23.91	29.86	-5.95
Low	2417	21.68	21.90	24.80	29.86	-5.06
Low	2422	21.62	21.98	24.81	29.86	-5.05
Middle	2437	26.02	26.20	29.12	29.86	-0.74
High	2457	21.32	21.96	24.66	29.86	-5.20
High	2462	20.16	20.74	23.47	29.86	-6.39

802.11n Mode 40 MHz CDD MCS 32

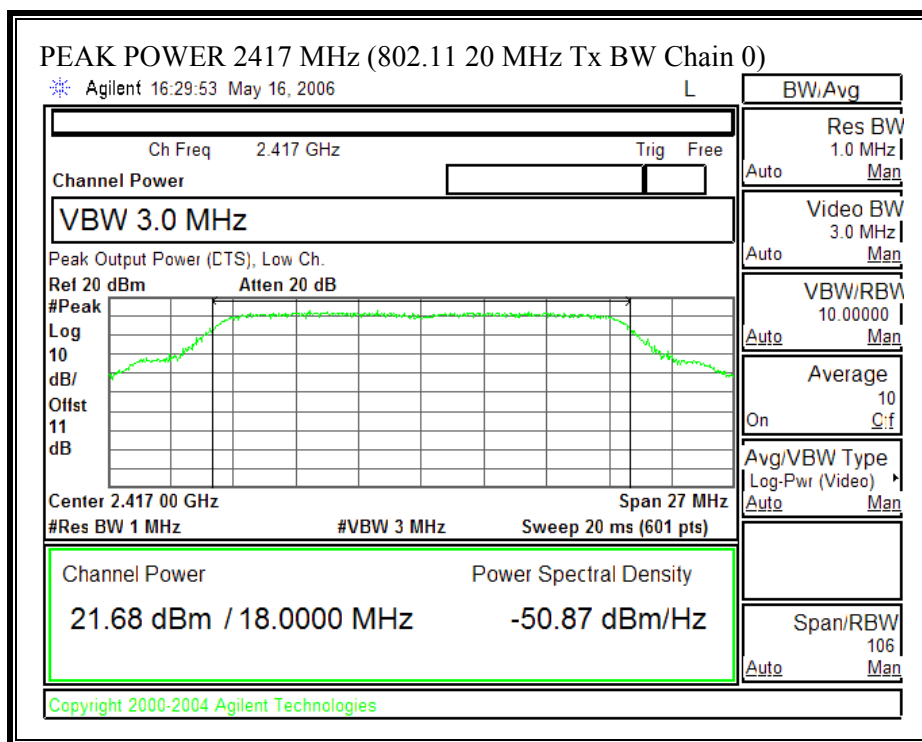
CHAIN 0 & CHAIN 1

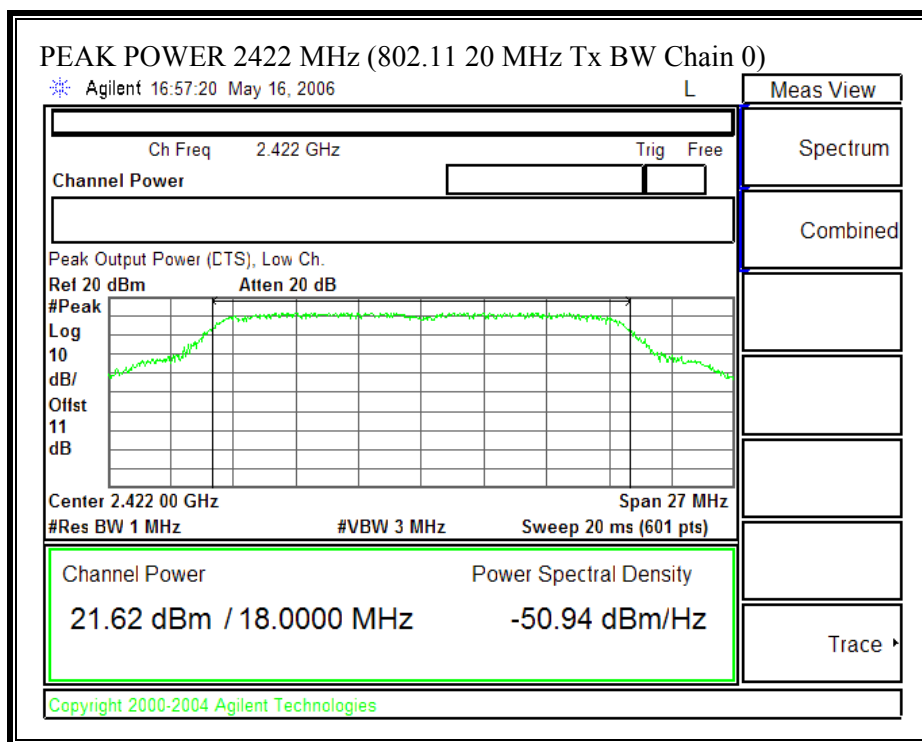
Channel	Frequency (MHz)	Peak Power Chain 0 (dBm)	Peak Power Chain 1 (dBm)	Peak Power Total (dBm)	Limit (dBm)	Margin (dB)
40 MHz TX BANDWIDTH						
Low	2422	19.48	19.56	22.53	29.86	-7.33
Low	2427	21.12	21.36	24.25	29.86	-5.61
Middle	2437	21.77	21.61	24.70	29.86	-5.16
High	2442	21.22	21.23	24.24	29.86	-5.62
High	2447	20.05	20.25	23.16	29.86	-6.70
High	2452	18.84	18.77	21.82	29.86	-8.04

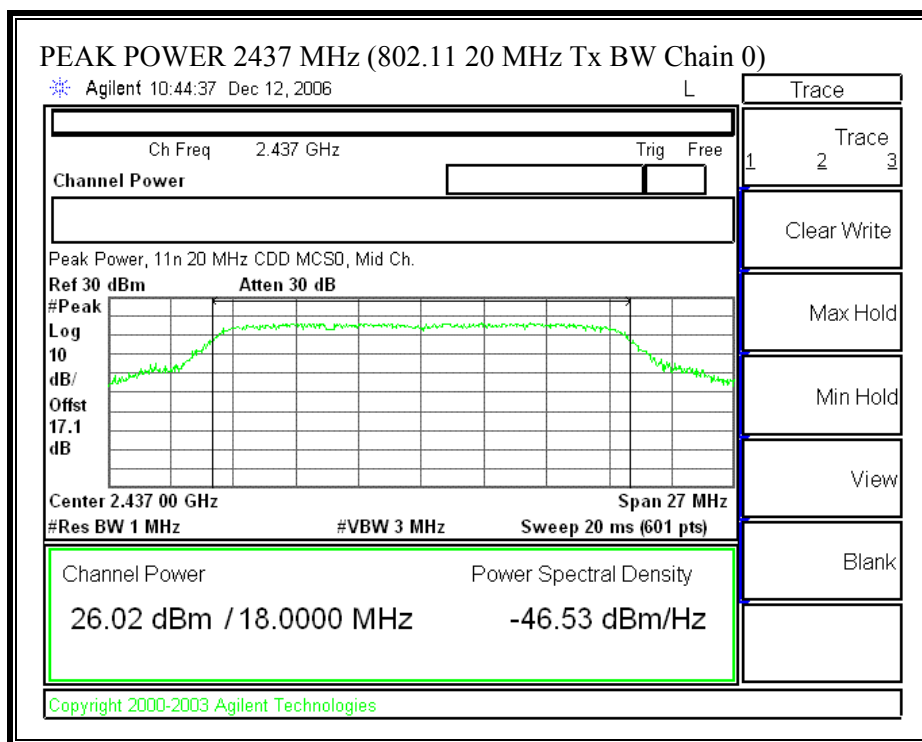
802.11n Mode 40 MHz SDM MCS 15:

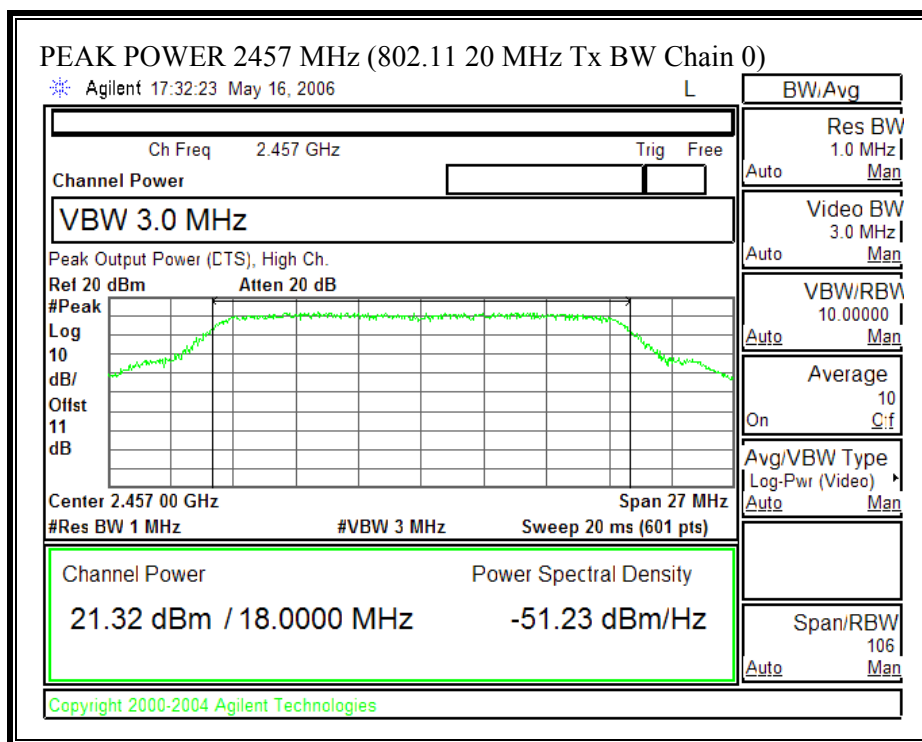
CHAIN 0 & CHAIN 1

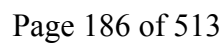
Channel	Frequency (MHz)	Peak Power Chain 0 (dBm)	Peak Power Chain 1 (dBm)	Peak Power Total (dBm)	Limit (dBm)	Margin (dB)
40 MHz TX BANDWIDTH						
Low	2422	21.45	21.88	24.68	29.86	-5.18
Low	2427	22.40	22.50	25.46	29.86	-4.40
Middle	2437	22.88	22.69	25.80	29.86	-4.06
High	2442	22.53	22.54	25.55	29.86	-4.31
High	2447	22.09	22.26	25.19	29.86	-4.67
High	2452	20.94	21.06	24.01	29.86	-5.85



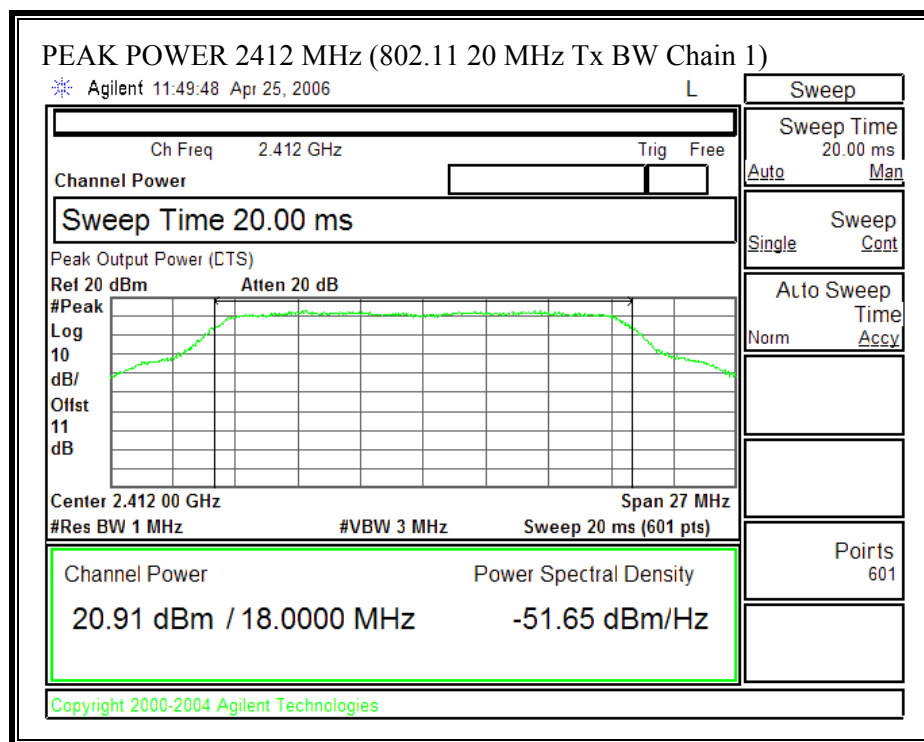


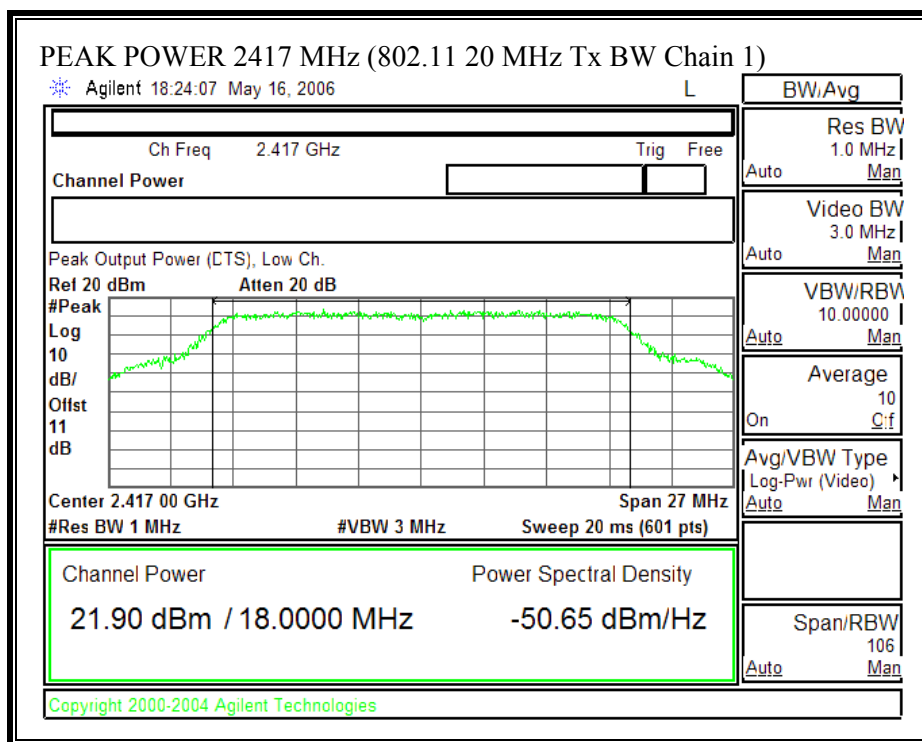


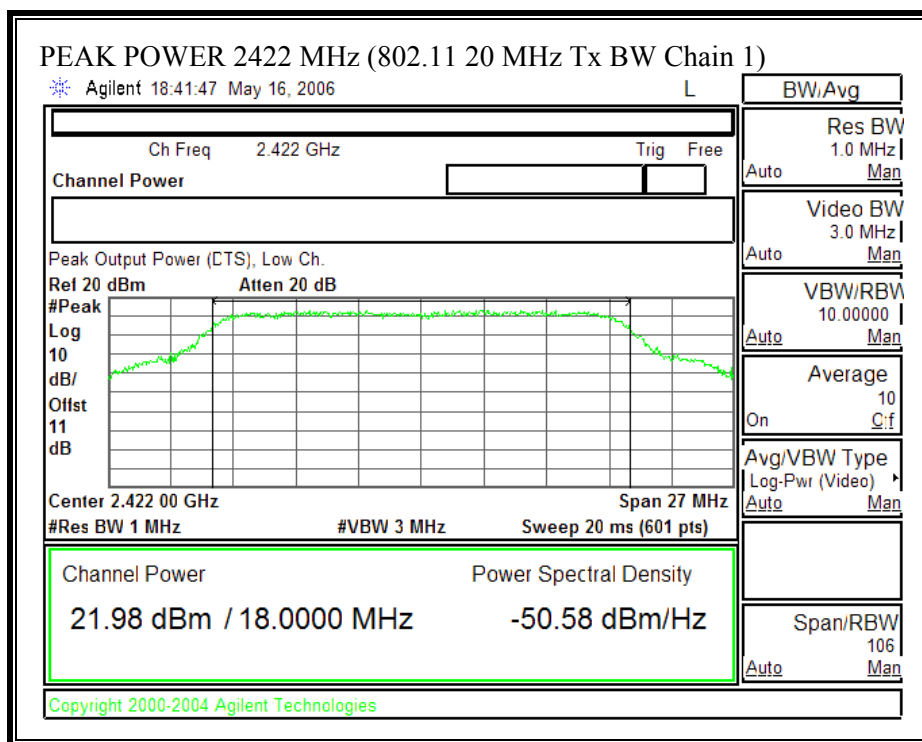


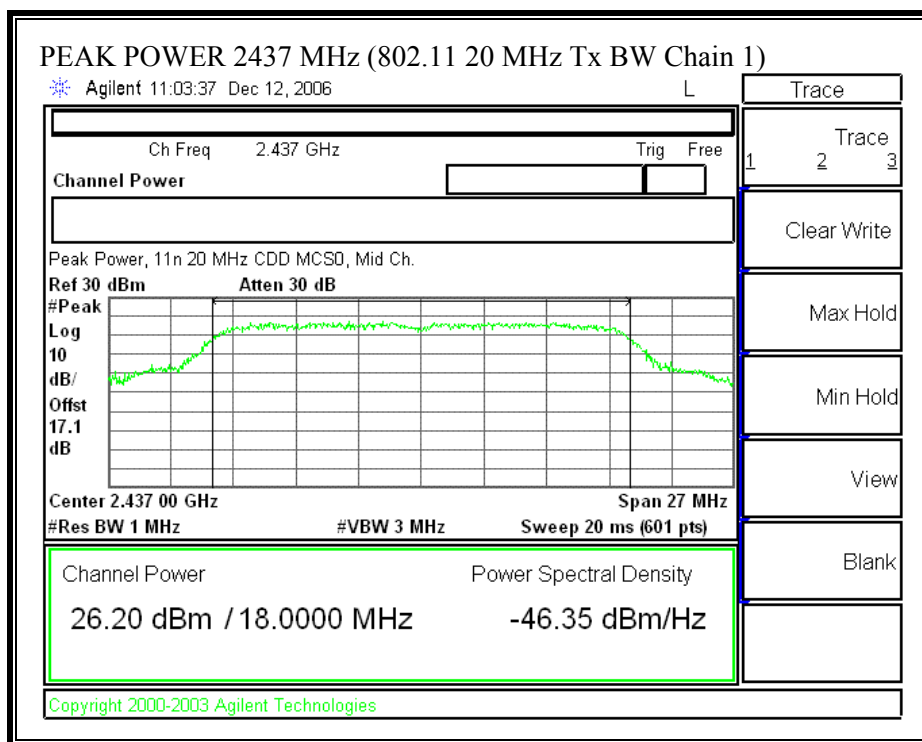


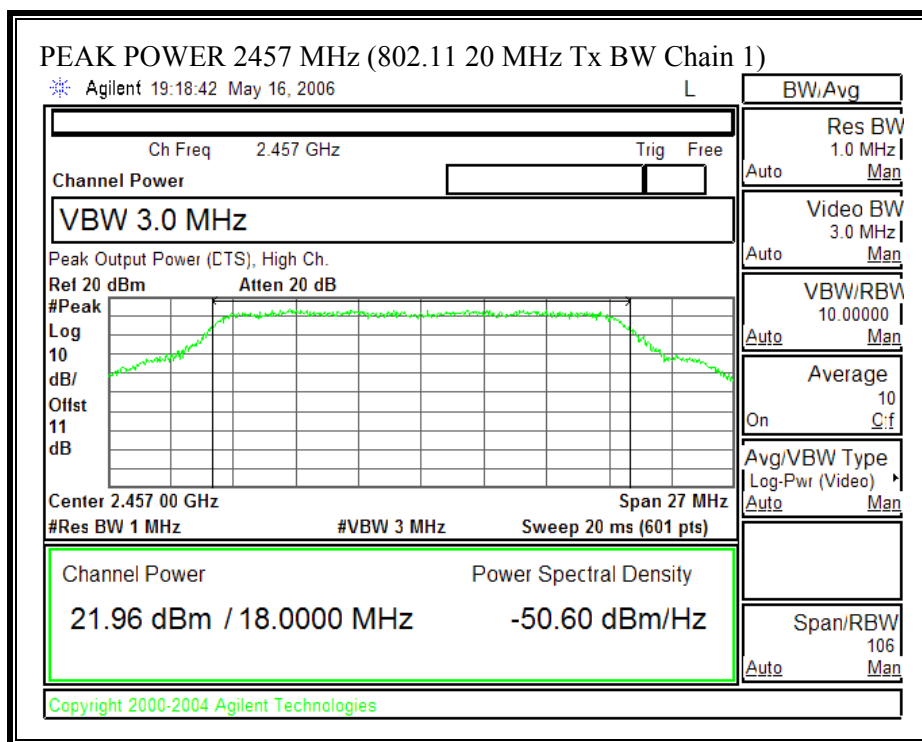
OUTPUT POWER (802.11 20 MHz TX BANDWIDTH – CHAIN 1)

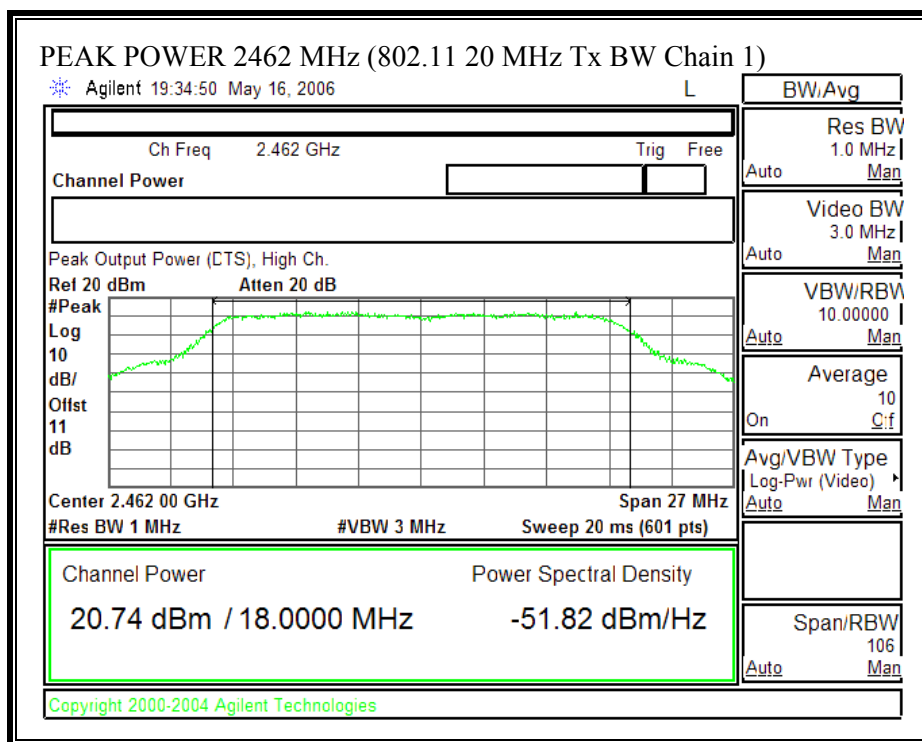






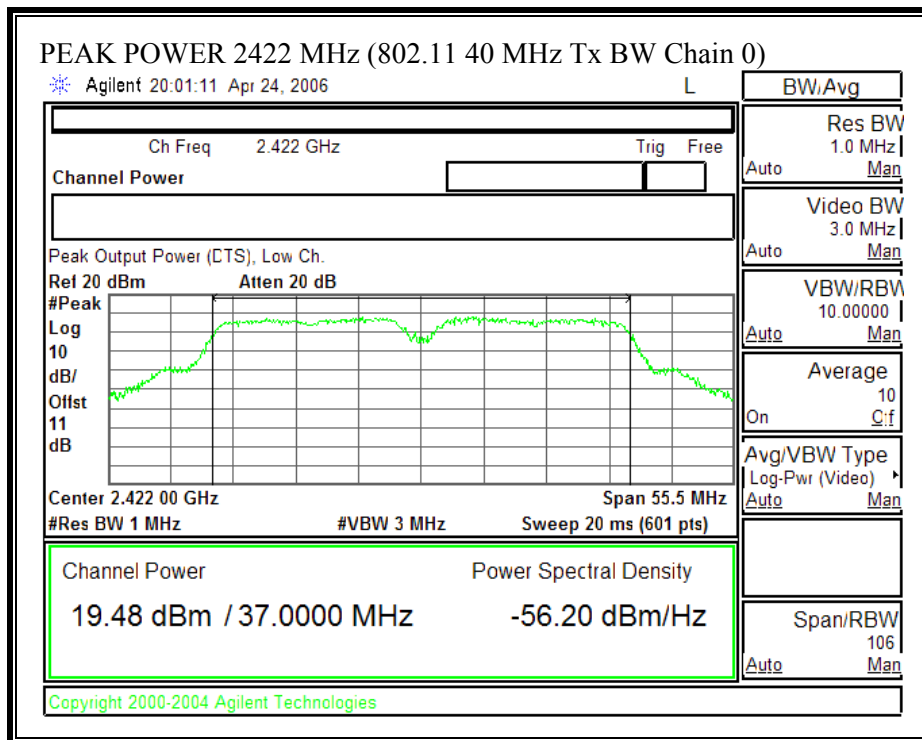


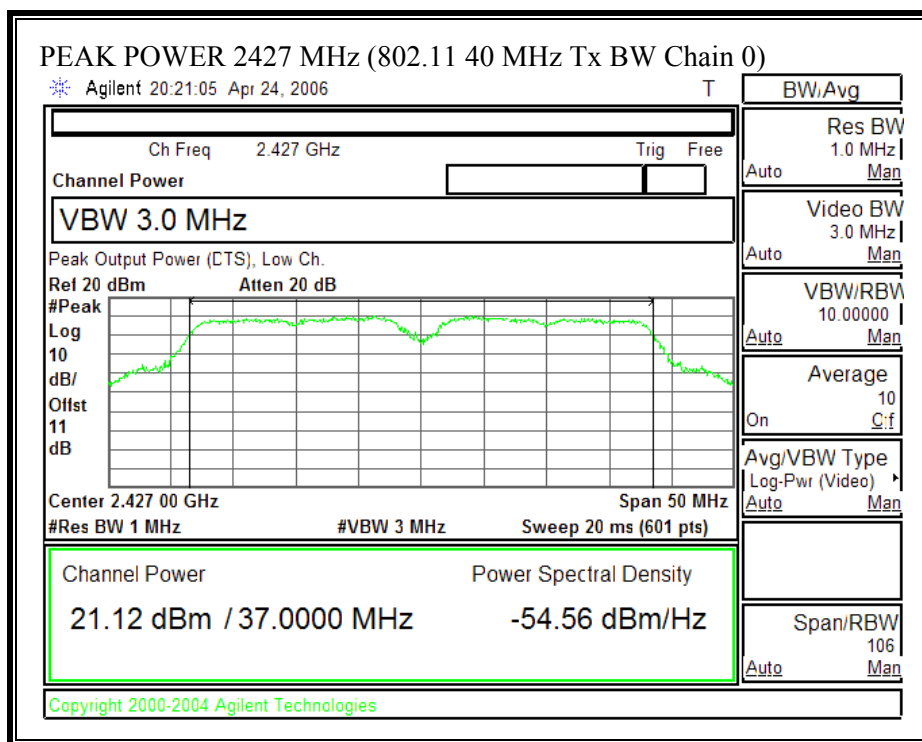


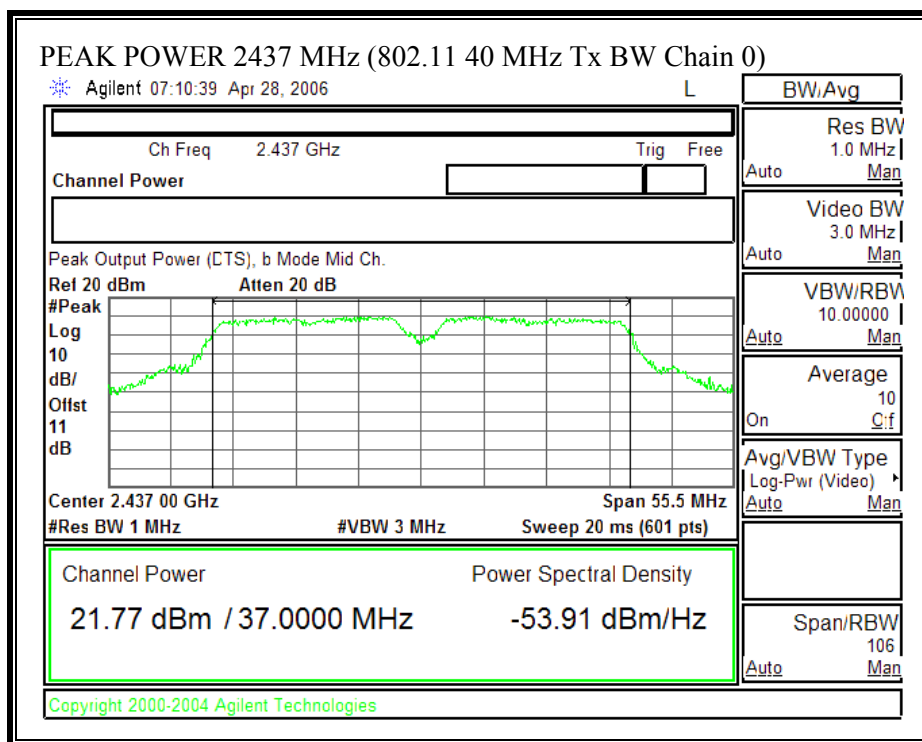


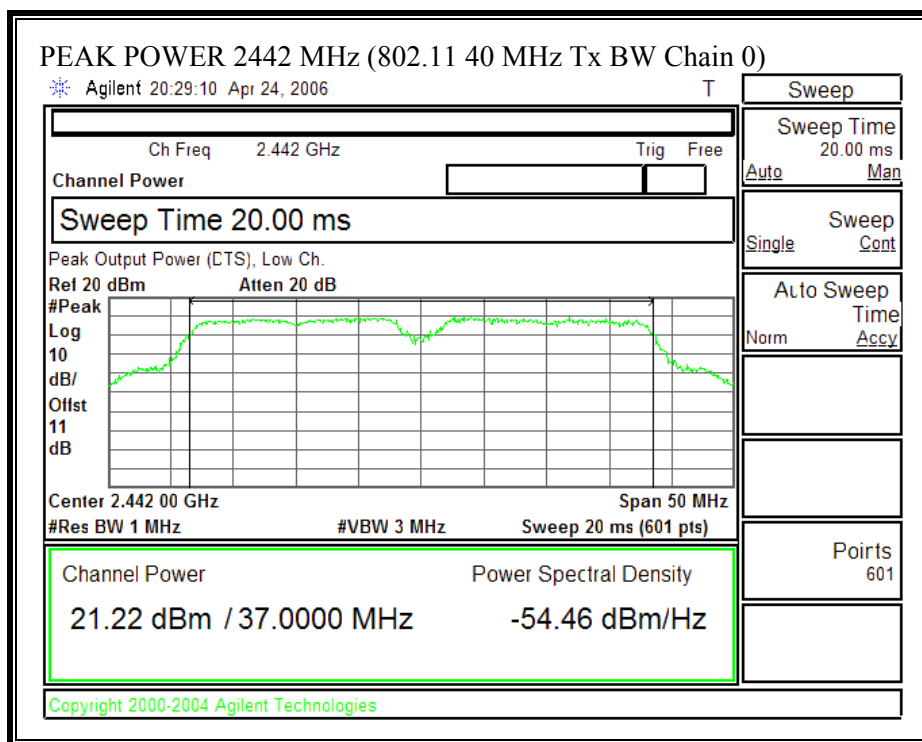
802.11n Mode 40 MHz CDD MCS 32

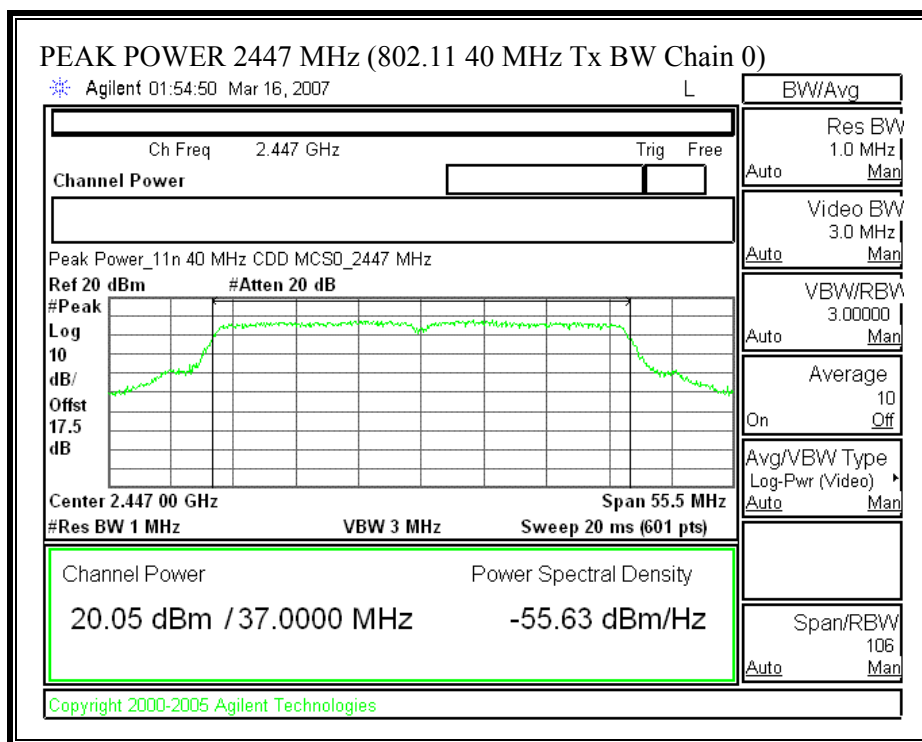
OUTPUT POWER (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)

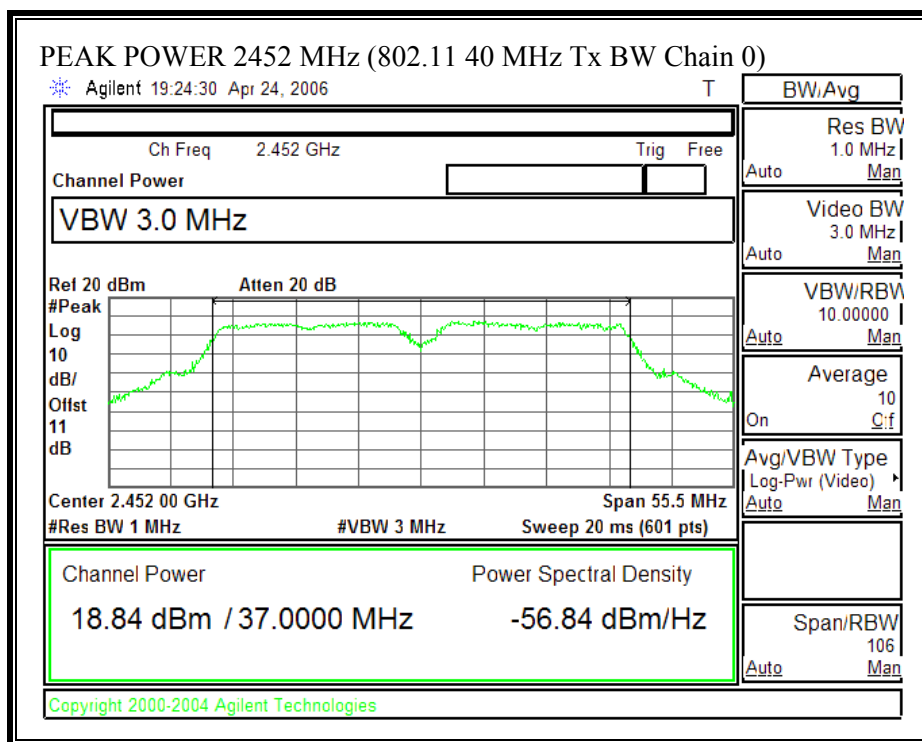




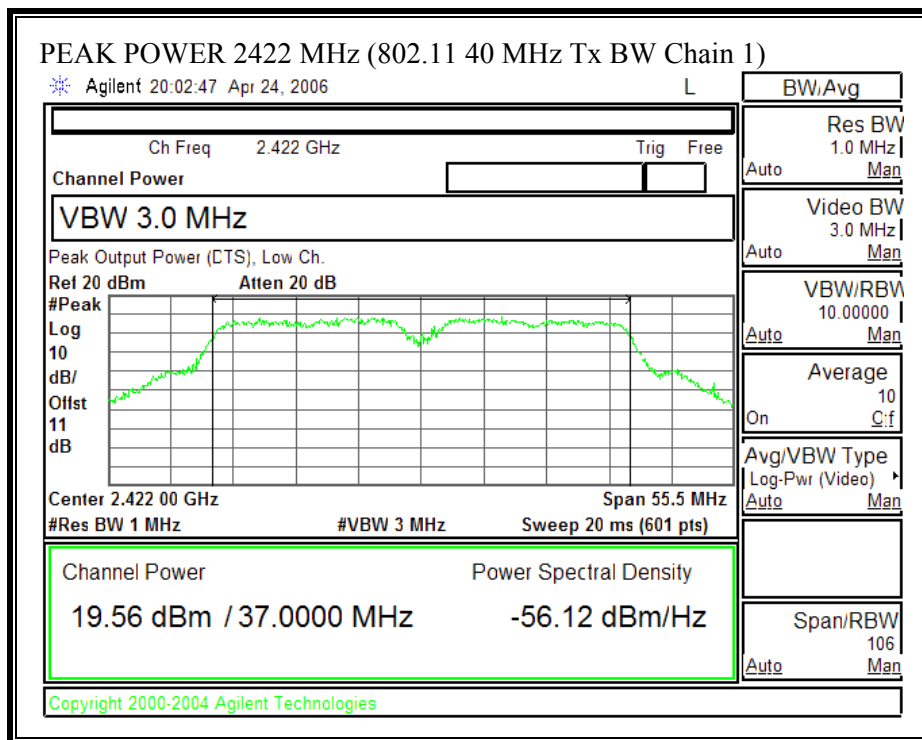


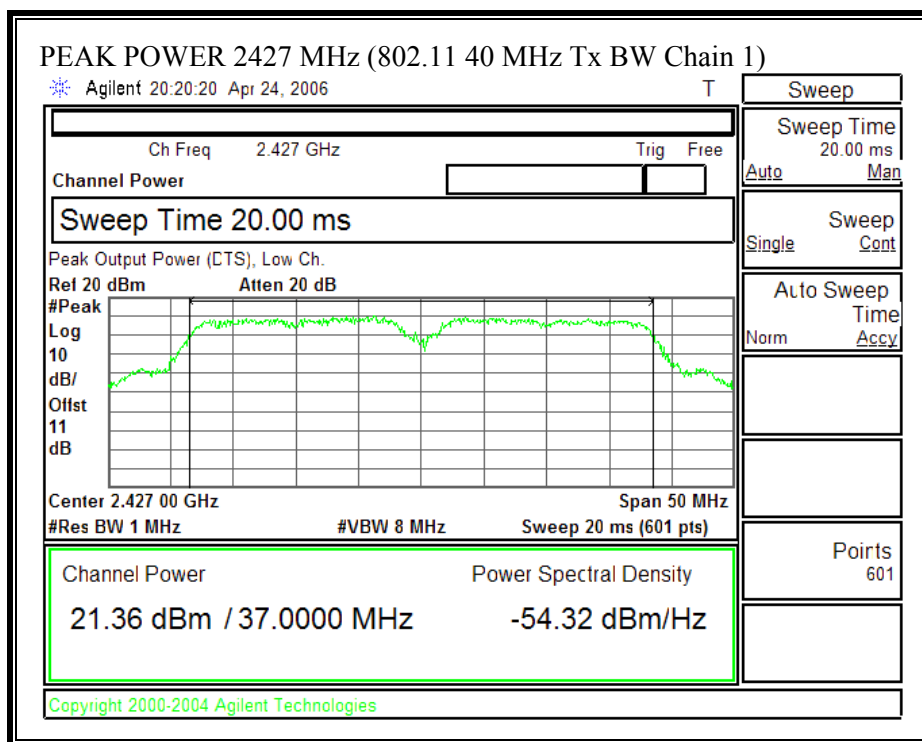


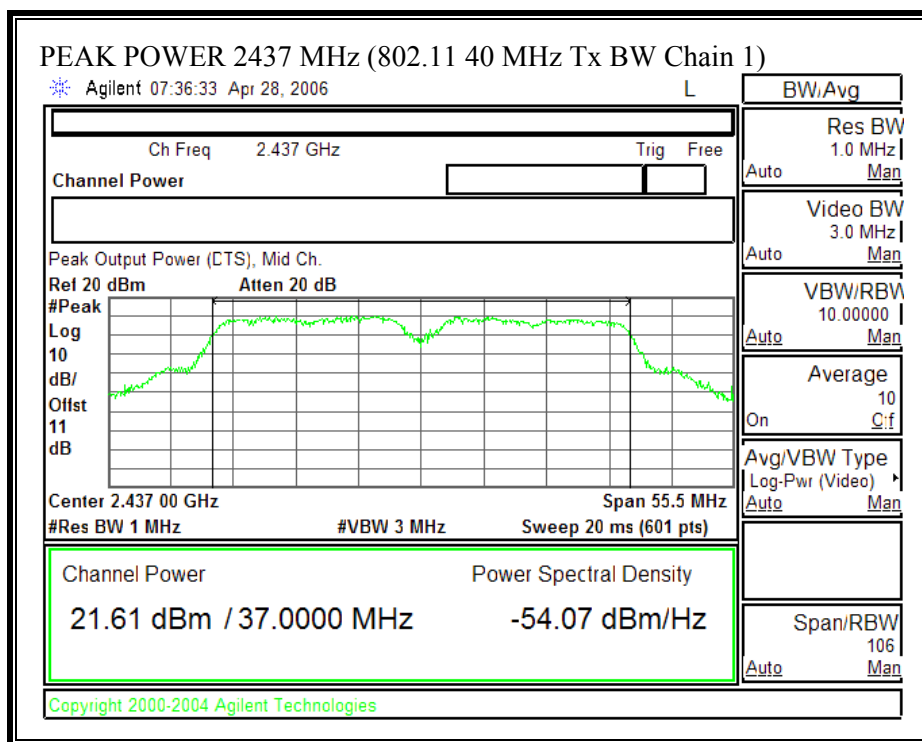


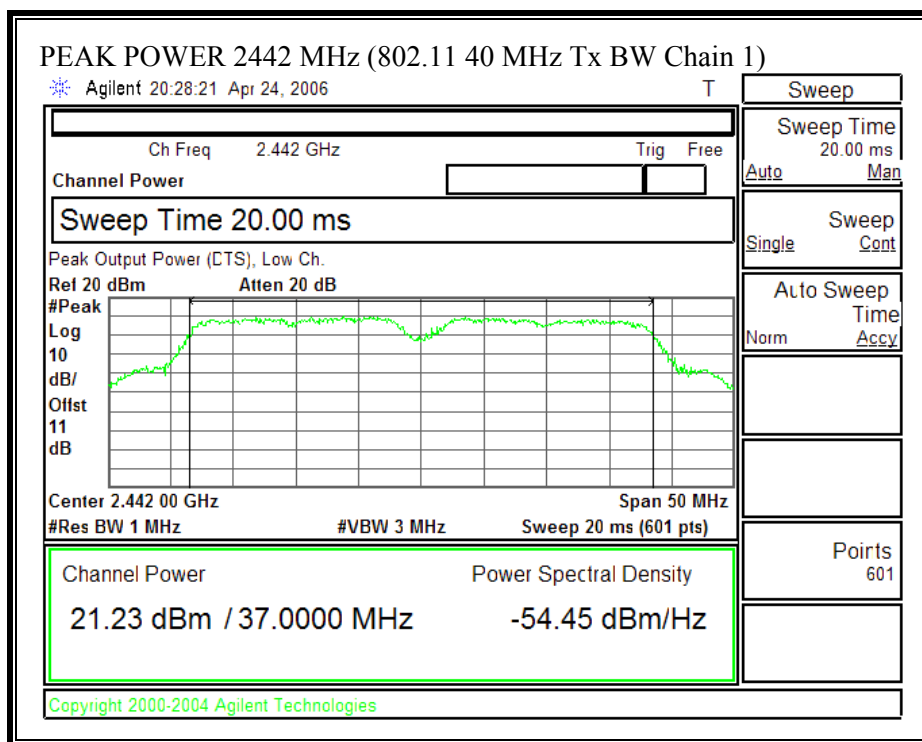


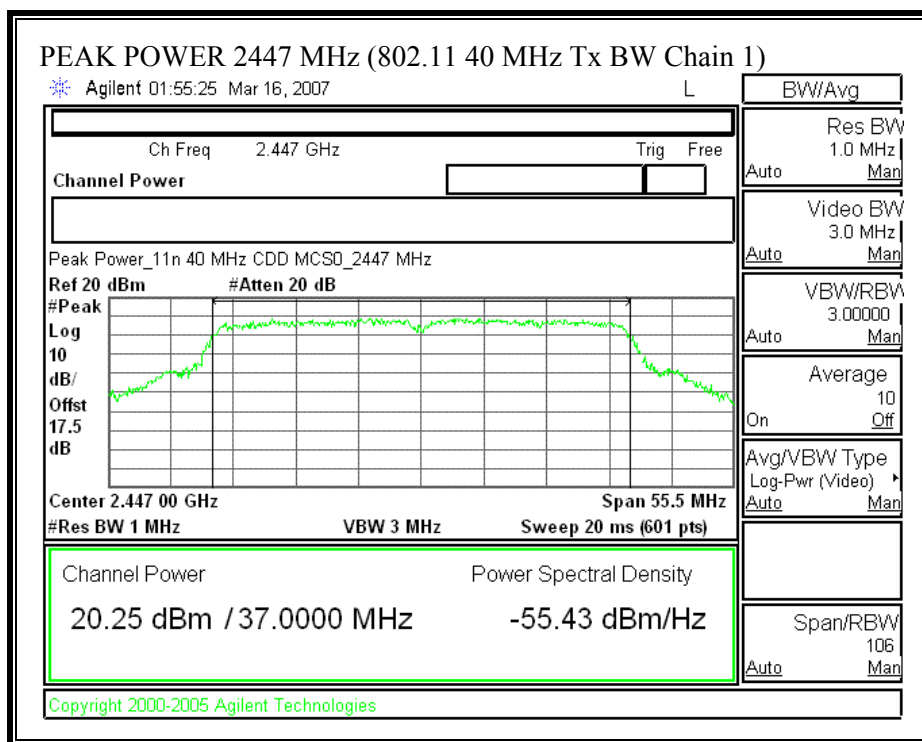
OUTPUT POWER (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)

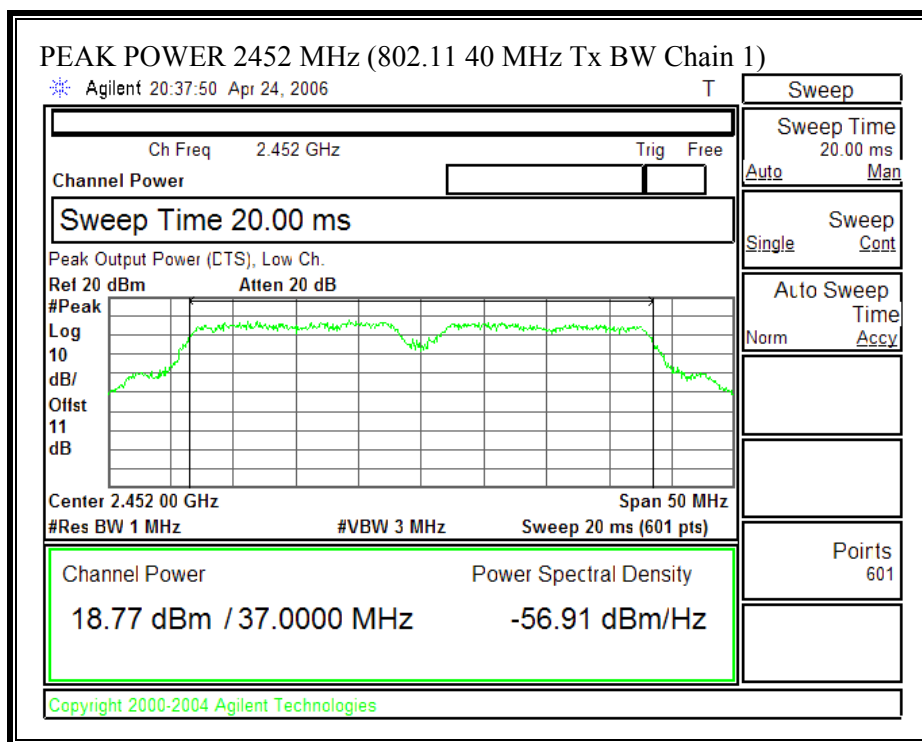






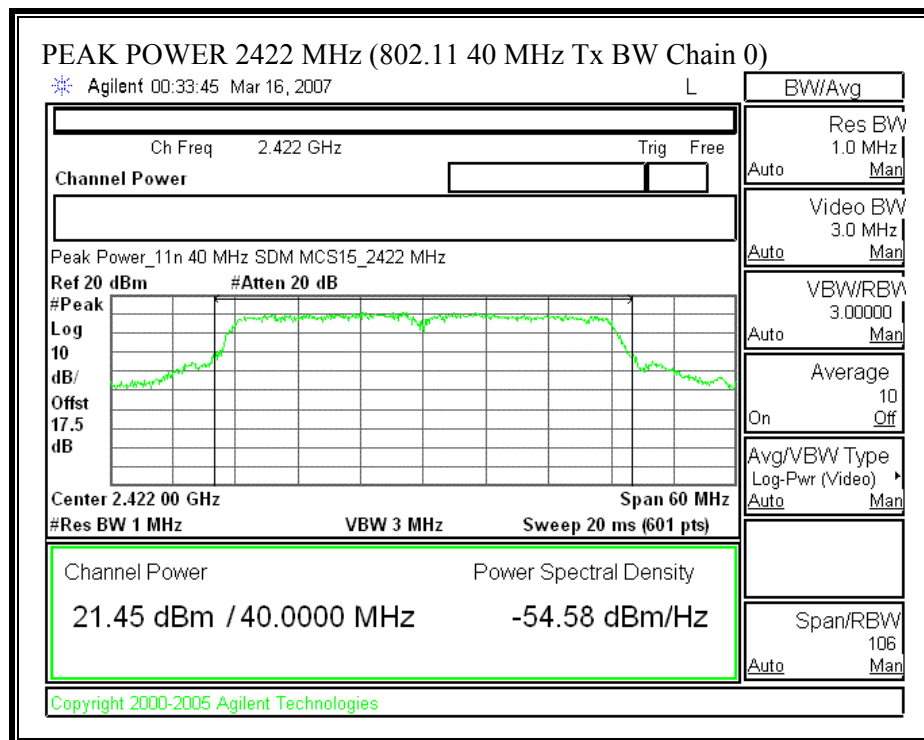


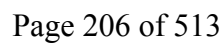


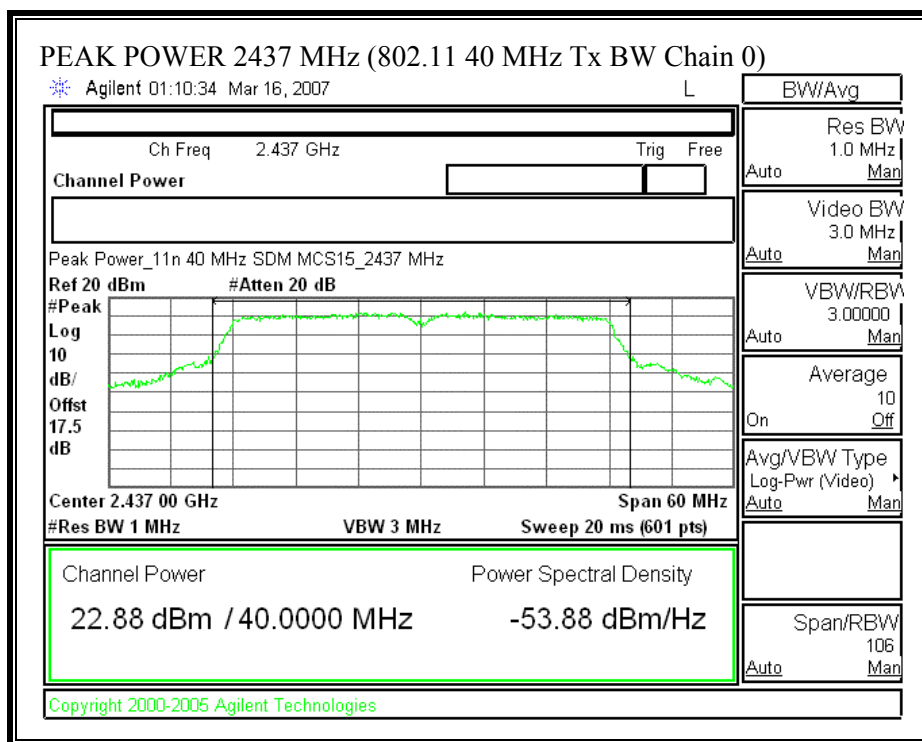


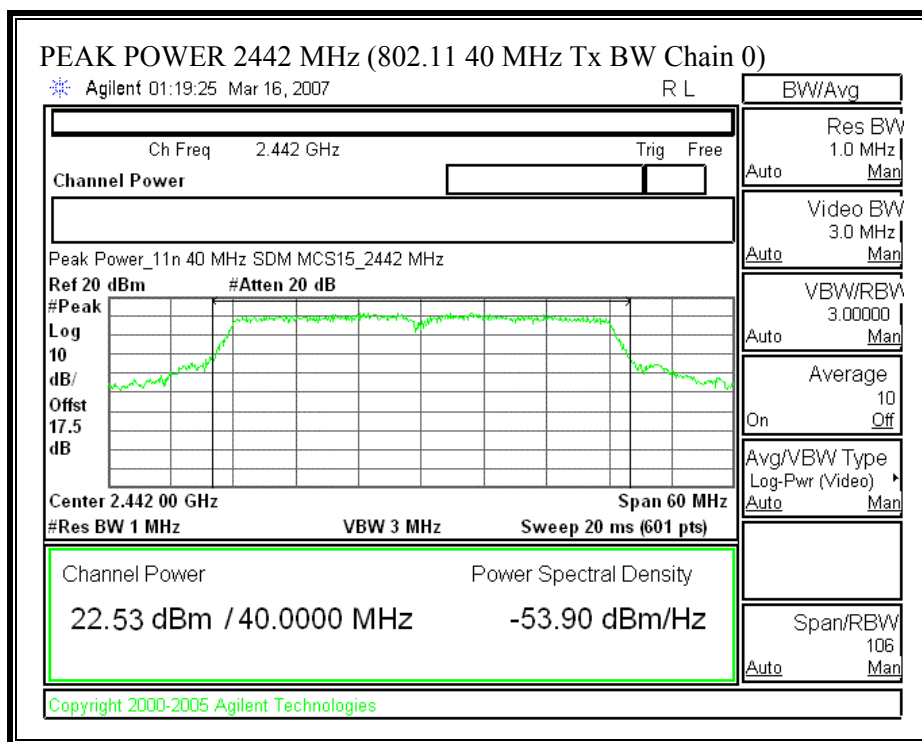
802.11n Mode 40 MHz SDM MCS 15:

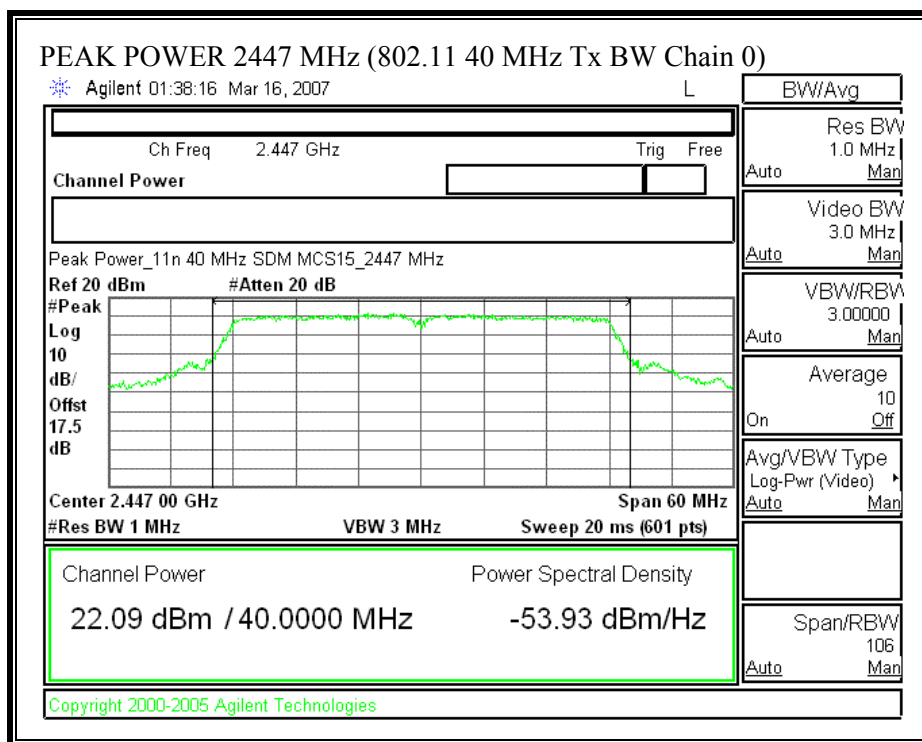
OUTPUT POWER (802.11 40 MHz TX BANDWIDTH – CHAIN 0)

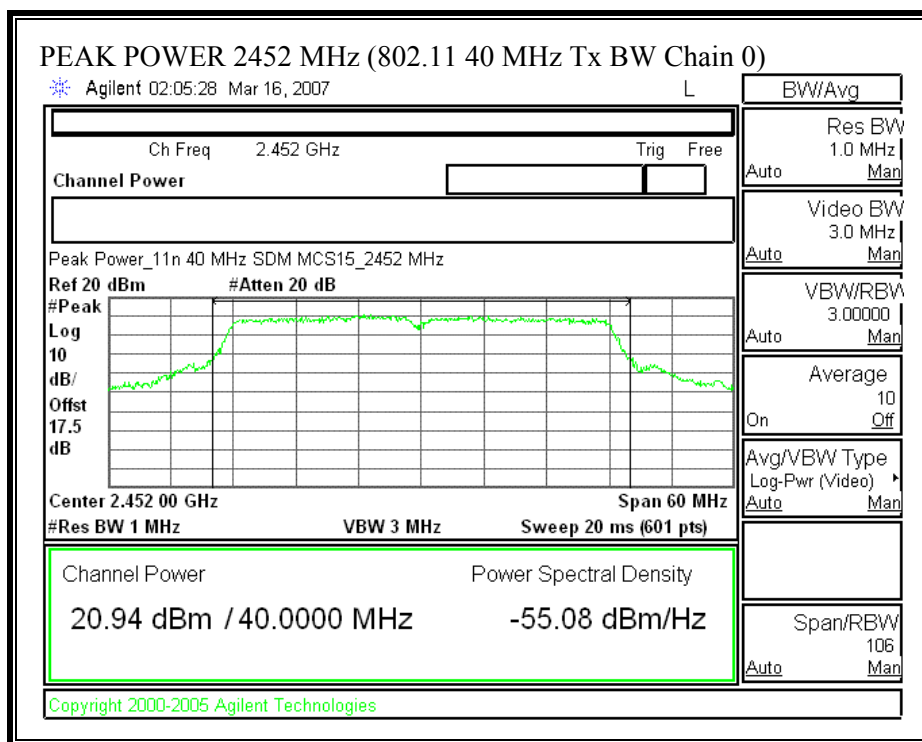




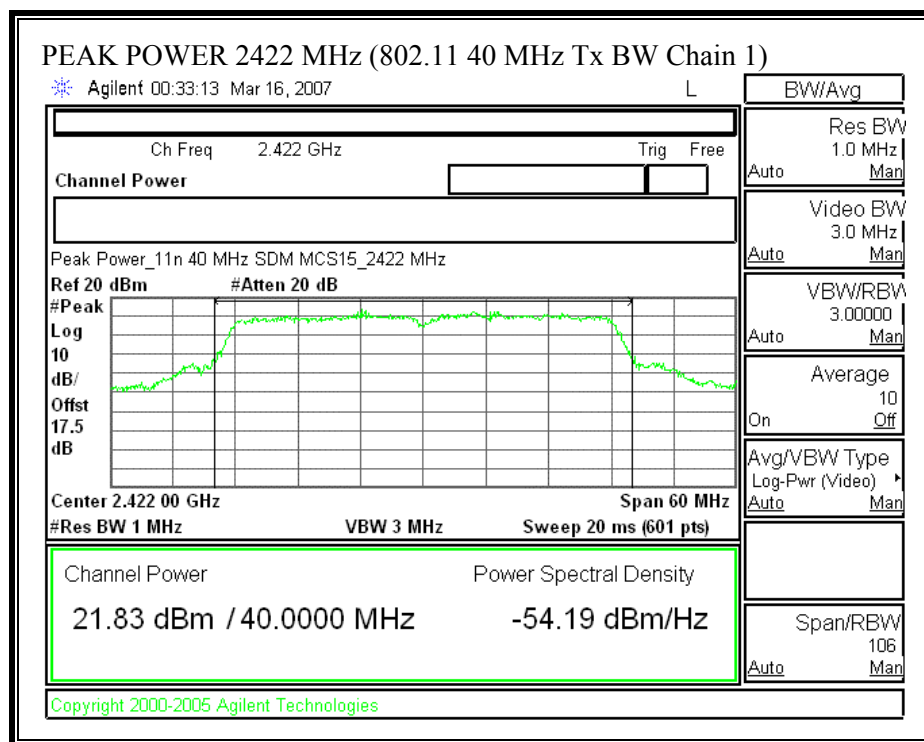


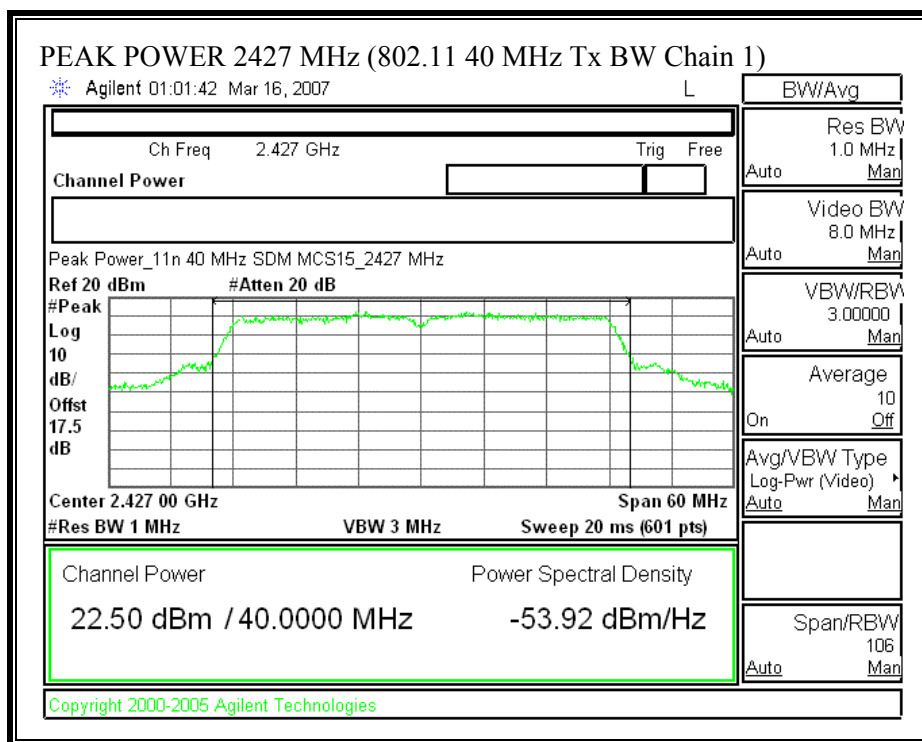


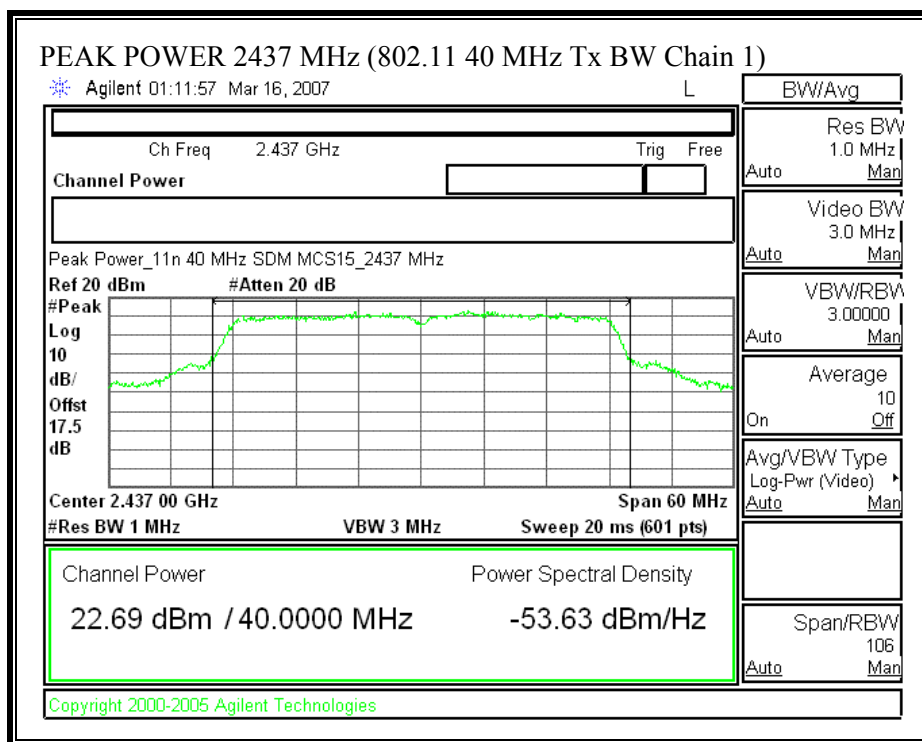


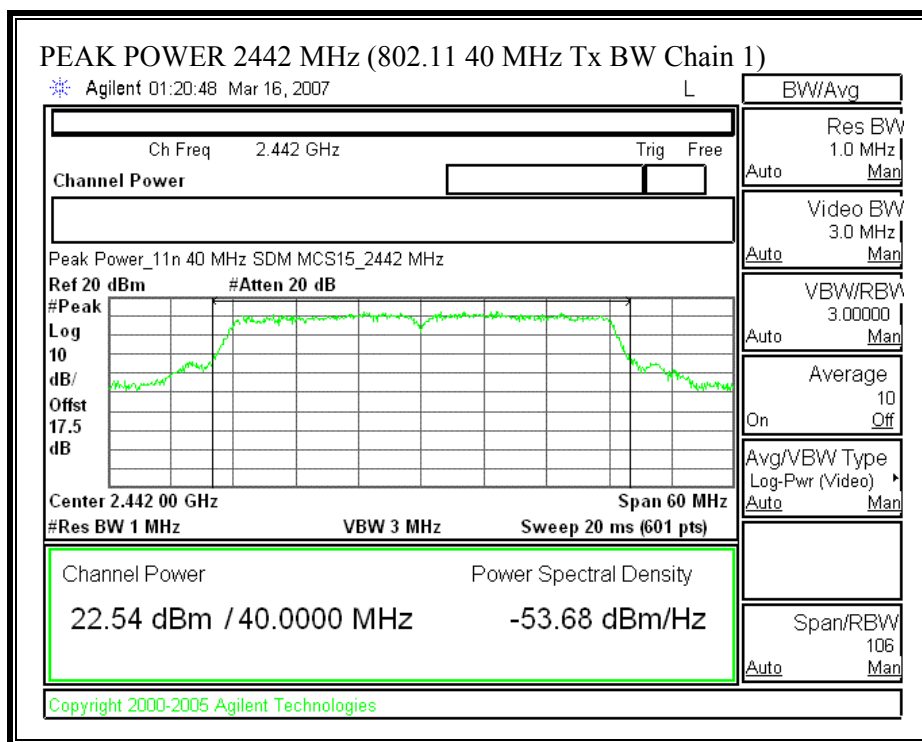


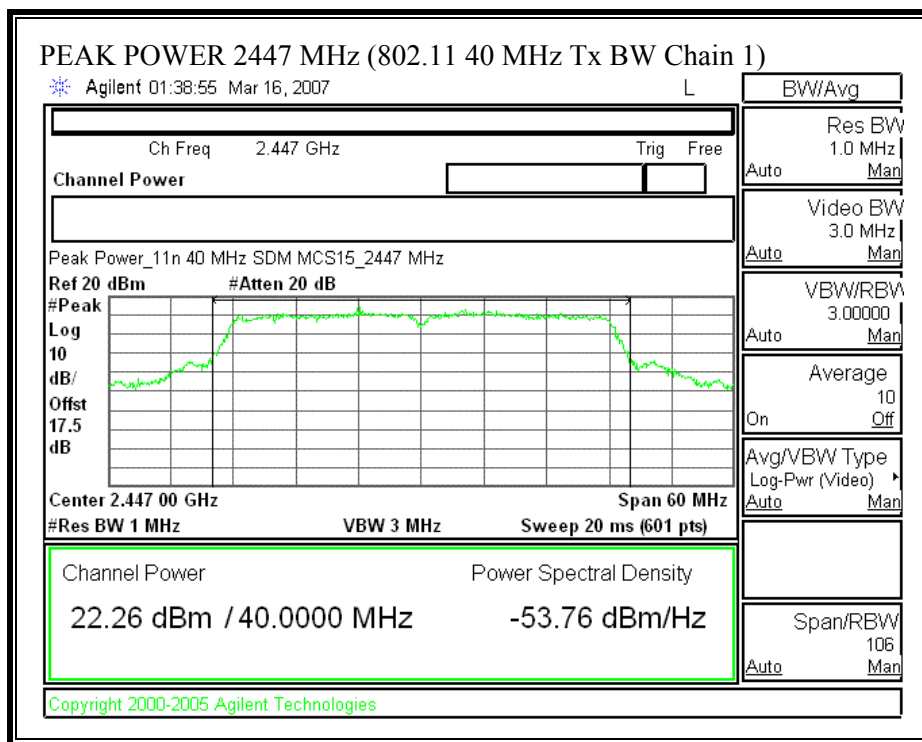
OUTPUT POWER (802.11 40 MHz TX BANDWIDTH – CHAIN 1)

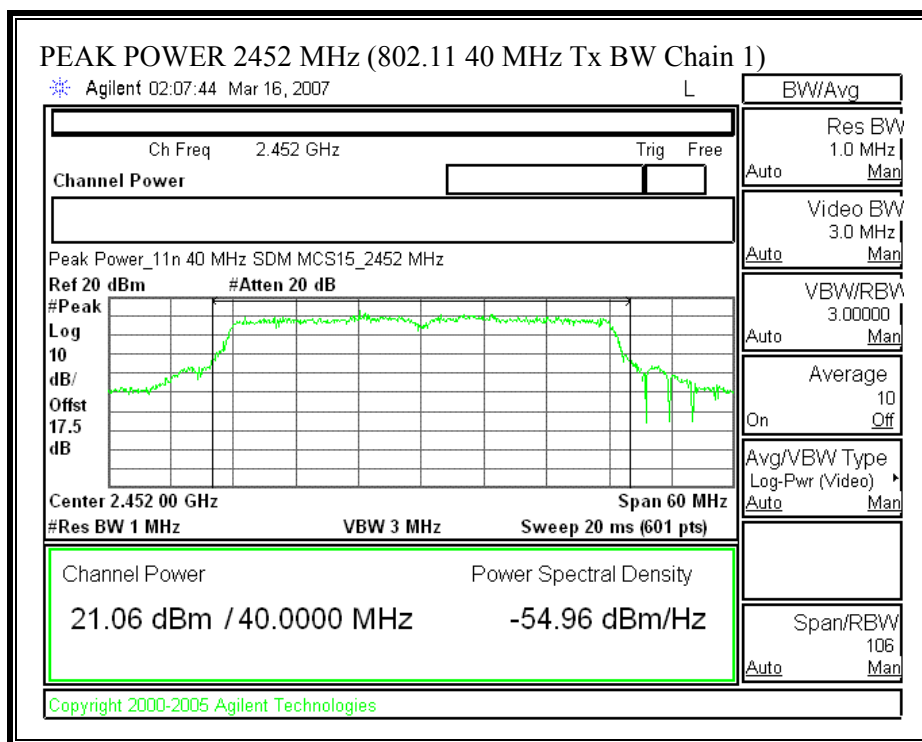












7.3.4. MAXIMUM PERMISSIBLE EXPOSURE

LIMITS

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f ²)	6
30–300	61.4	0.163	1.0	6
300–1500 .....	.....	.....	f/300	6
1500–100,000 .....	.....	.....	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f ²)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500 .....	.....	.....	f/1500	30
1500–100,000 .....	.....	.....	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

CALCULATIONS

Given

$$E = \sqrt{(30 * P * G) / d}$$

and

$$S = E^2 / 3770$$

where

E = Field Strength in Volts/meter

P = Power in Watts

G = Numeric antenna gain

d = Distance in meters

S = Power Density in milliwatts/square centimeter

Combining equations and rearranging the terms to express the distance as a function of the remaining variables yields:

$$d = \sqrt{((30 * P * G) / (3770 * S))}$$

Changing to units of Power to mW and Distance to cm, using:

$$P \text{ (mW)} = P \text{ (W)} / 1000 \text{ and}$$

$$d \text{ (cm)} = 100 * d \text{ (m)}$$

yields

$$d = 100 * \sqrt{((30 * (P / 1000) * G) / (3770 * S))}$$

$$d = 0.282 * \sqrt{(P * G / S)}$$

where

d = distance in cm

P = Power in mW

G = Numeric antenna gain

S = Power Density in mW/cm²

Substituting the logarithmic form of power and gain using:

$$P \text{ (mW)} = 10^{(P \text{ (dBm)} / 10)} \text{ and}$$

$$G \text{ (numeric)} = 10^{(G \text{ (dBi)} / 10)}$$

yields

$$d = 0.282 * 10^{((P + G) / 20)} / \sqrt{S}$$

where

d = MPE distance in cm

P = Power in dBm

G = Antenna Gain in dBi

S = Power Density Limit in mW/cm²

Rearranging terms to calculate the power density at a specific distance yields

$$S = 0.0795 * 10^{((P + G) / 10)} / (d^2)$$

LIMITS

From §1.1310 Table 1 (B), $S = 1.0 \text{ mW/cm}^2$ in the 2.4 GHz band.

No non-compliance noted

802.11g Mode Legacy CDD is covered by the worst case 802.11n Mode 20 MHz CDD.

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm ²)
20MHz CDD	20.0	29.12	6.14	0.67
40MHz CDD	20.0	24.70	6.14	0.24
40MHz SDM	20.0	25.80	3.36	0.16

NOTE: For mobile or fixed location transmitters, the minimum separation distance is 20 cm, even if calculations indicate that the MPE distance would be less.

7.3.5. PEAK POWER SPECTRAL DENSITY

LIMIT

§15.247 (d) For direct sequence systems, the peak 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.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer, the maximum level in a 3 kHz bandwidth is measured with the spectrum analyzer using $RBW = 3 \text{ kHz}$ and $VBW > 3 \text{ kHz}$, sweep time = span / 3 kHz, and video averaging is turned off. The PPSD is the highest level found across the emission in any 3 kHz band.

RESULTS

No non-compliance noted:

802.11g Mode Legacy CDD is covered by the worst-case 802.11n Mode 20 MHz CDD MCS0.

802.11n Mode 20 MHz CDD MCS 0:

CHAIN 0 & CHAIN 1

Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	2412	-7.93	-6.61	-4.21	8	-12.21
Low	2417	-6.13	-6.55	-3.32	8	-11.32
Low	2422	-6.60	-5.22	-2.85	8	-10.85
Middle	2437	-4.86	-5.28	-2.05	8	-10.05
High	2457	-4.19	-4.92	-1.53	8	-9.53
High	2462	-7.47	-8.08	-4.75	8	-12.75

802.11n Mode 40 MHz CDD MCS 32

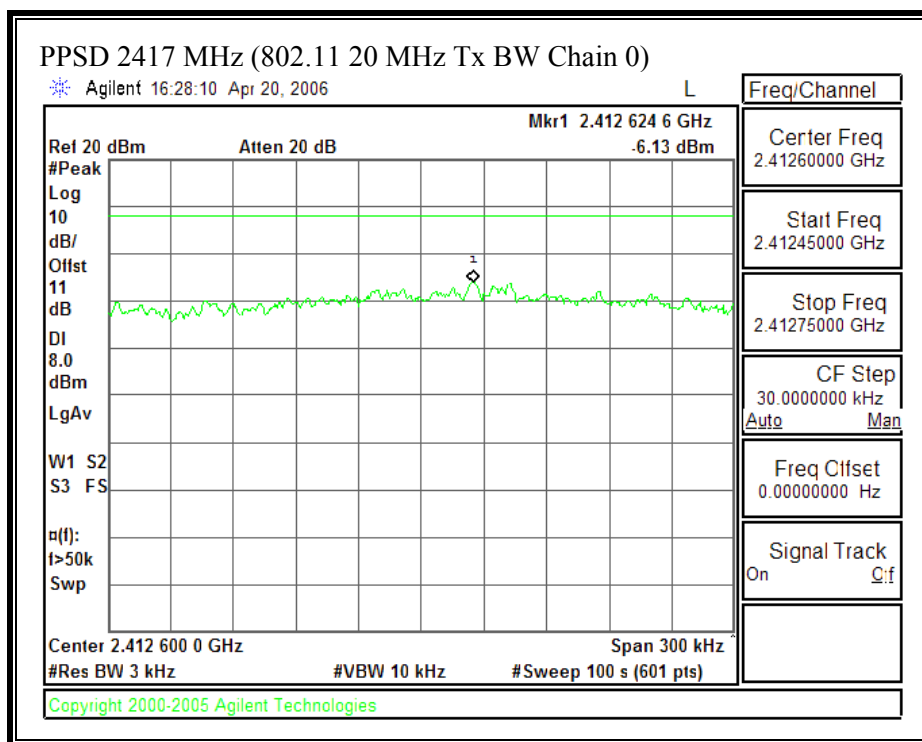
CHAIN 0 & CHAIN 1

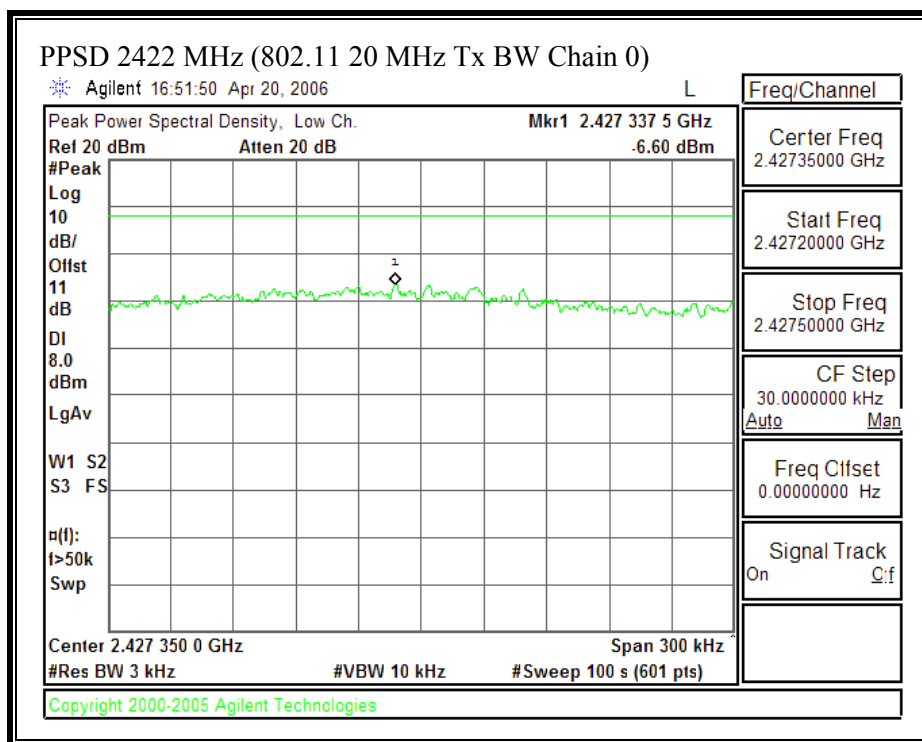
Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	2422	-15.23	-14.92	-12.06	8	-20.06
Low	2427	-13.09	-12.66	-9.86	8	-17.86
Middle	2437	-12.13	-10.38	-8.16	8	-16.16
High	2442	-12.69	-12.39	-9.53	8	-17.53
High	2447	-13.58	-12.87	-10.20	8	-18.20
High	2452	-15.03	-14.11	-11.54	8	-19.54

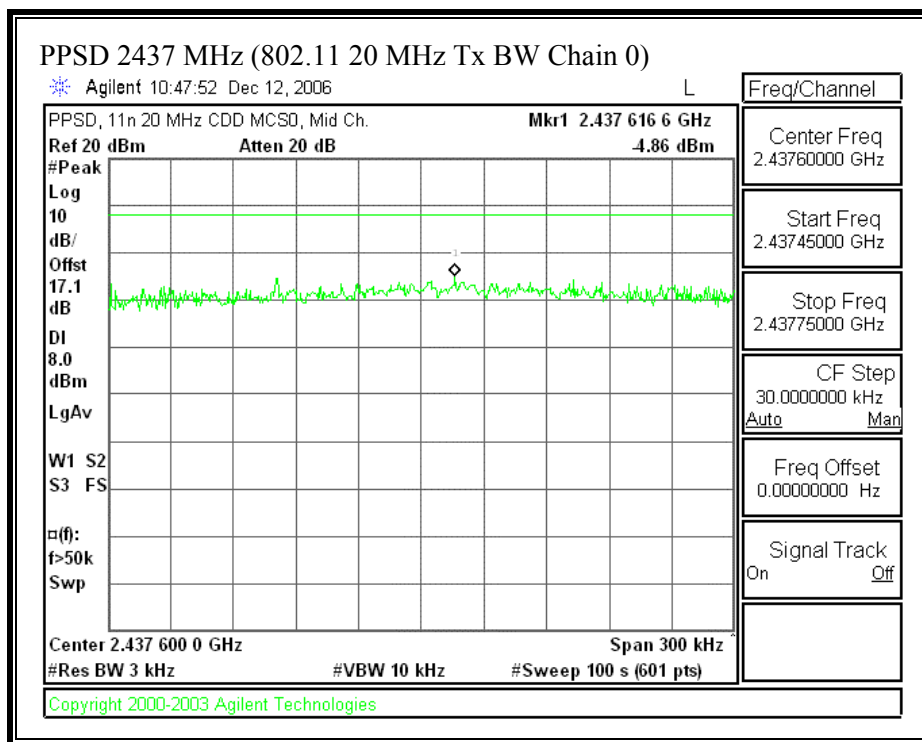
802.11n Mode 40 MHz SDM MCS 15:

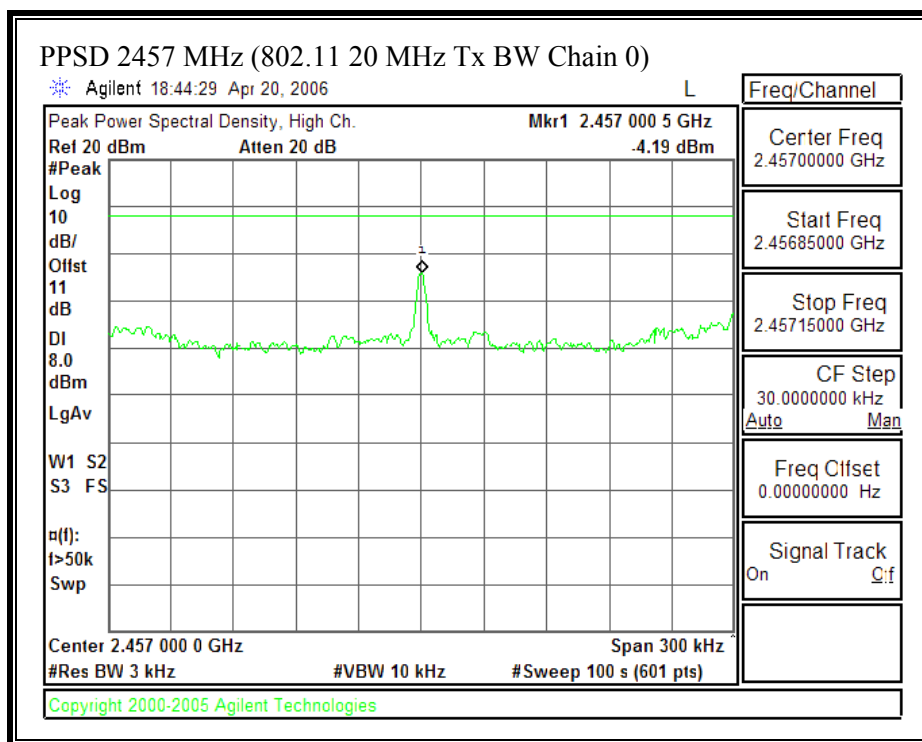
CHAIN 0 & CHAIN 1

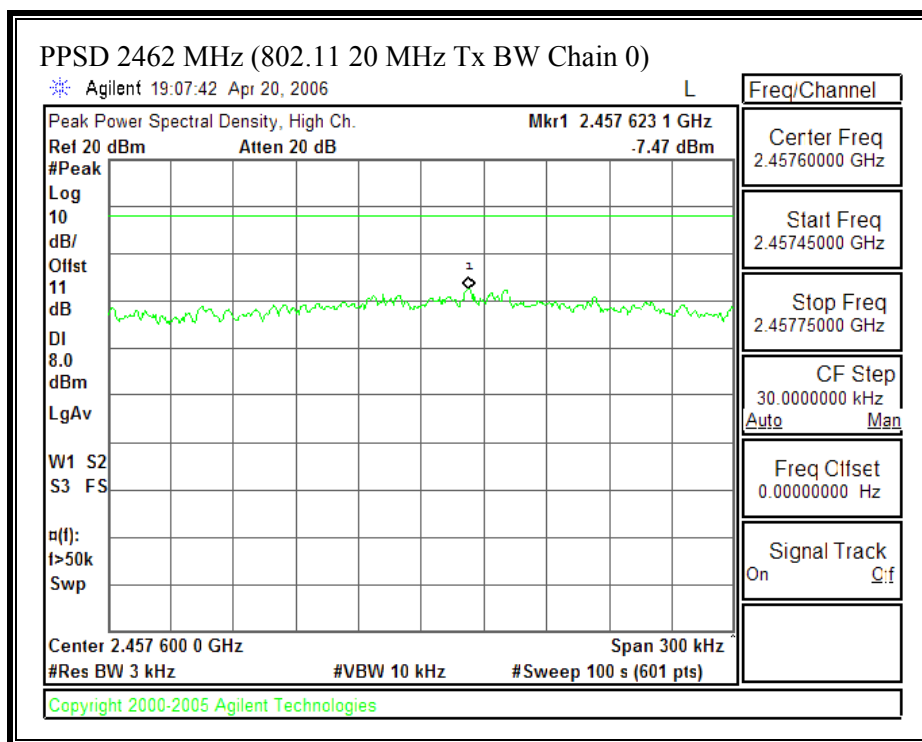
Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	2422	-6.01	-7.40	-3.64	8	-11.64
Low	2427	-6.25	-7.12	-3.65	8	-11.65
Middle	2437	-4.68	-5.73	-2.16	8	-10.16
High	2447	-5.84	-4.67	-2.21	8	-10.21
High	2452	-6.62	-7.61	-4.08	8	-12.08



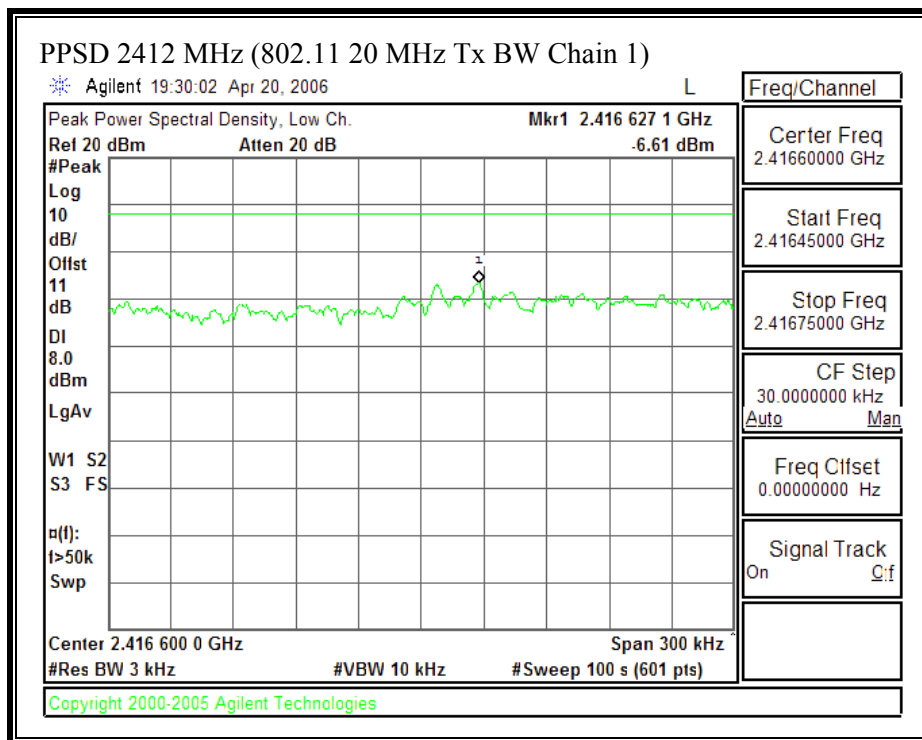


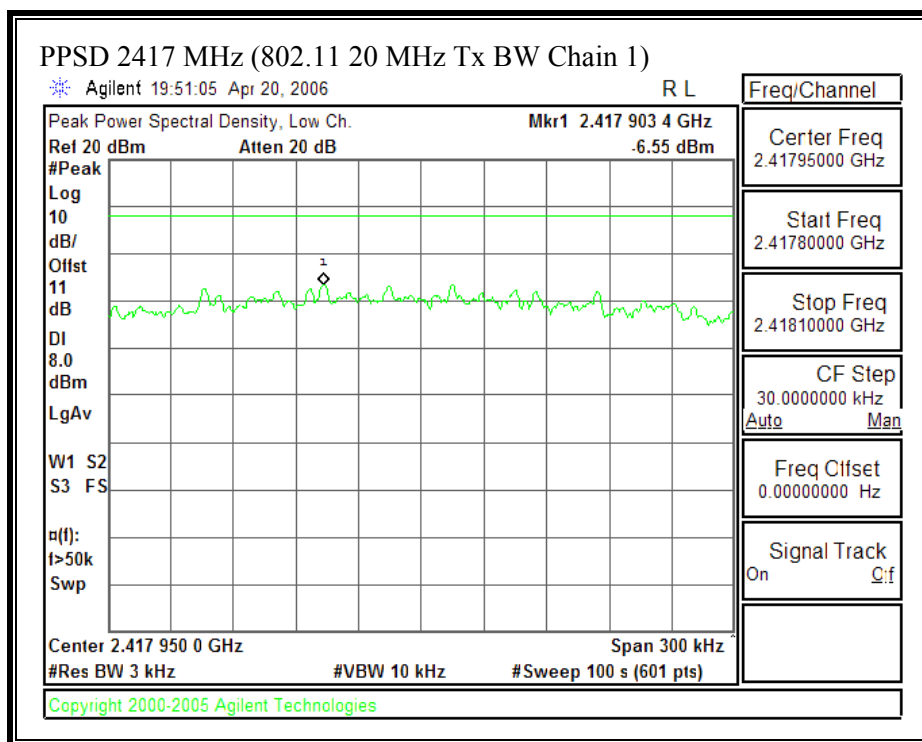


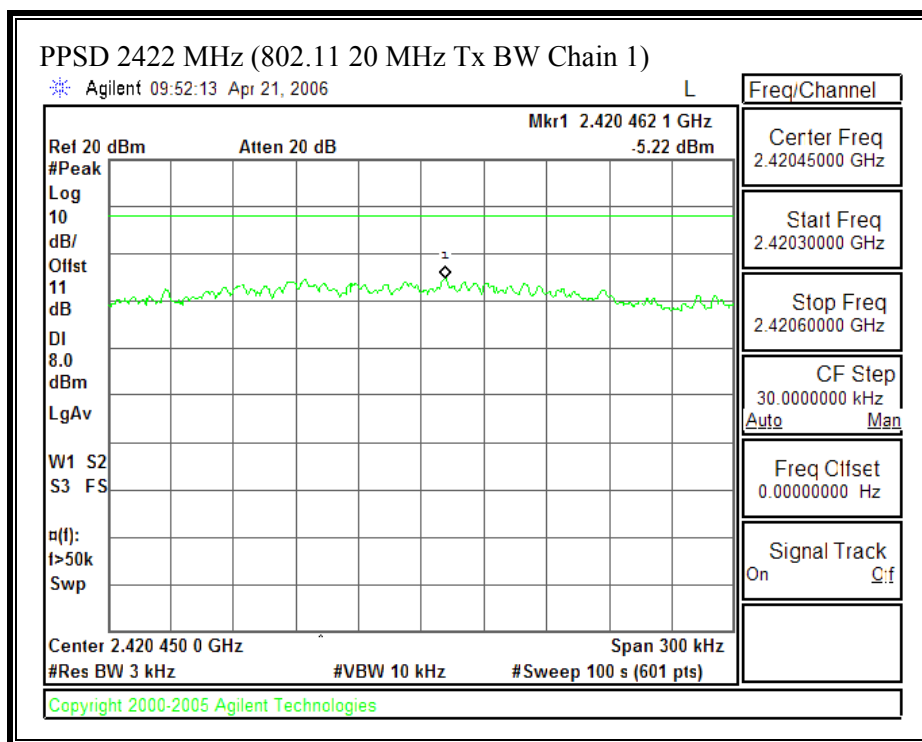


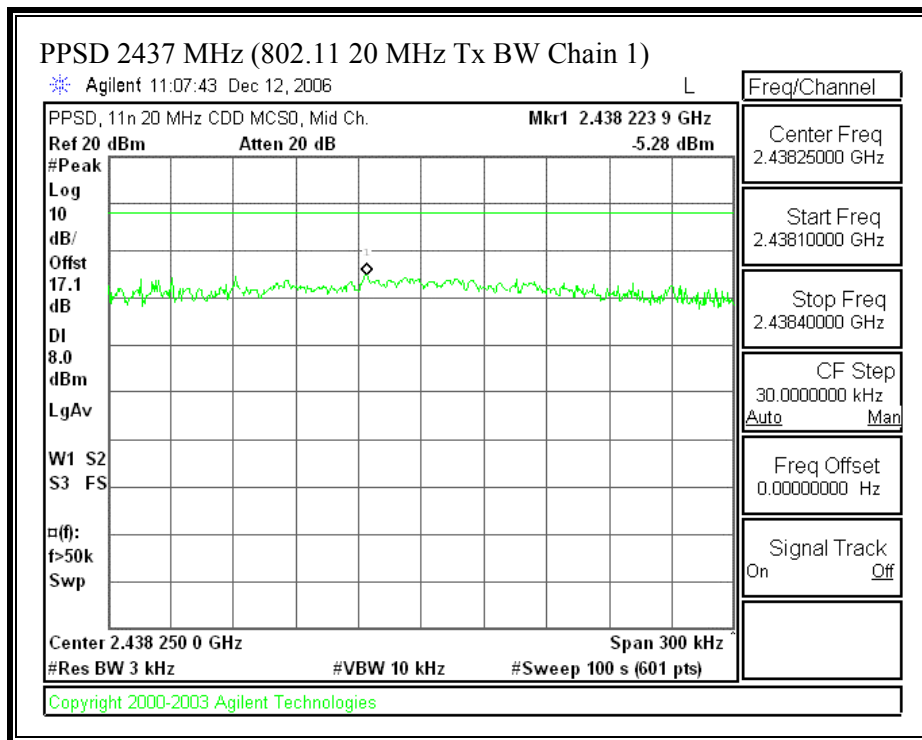


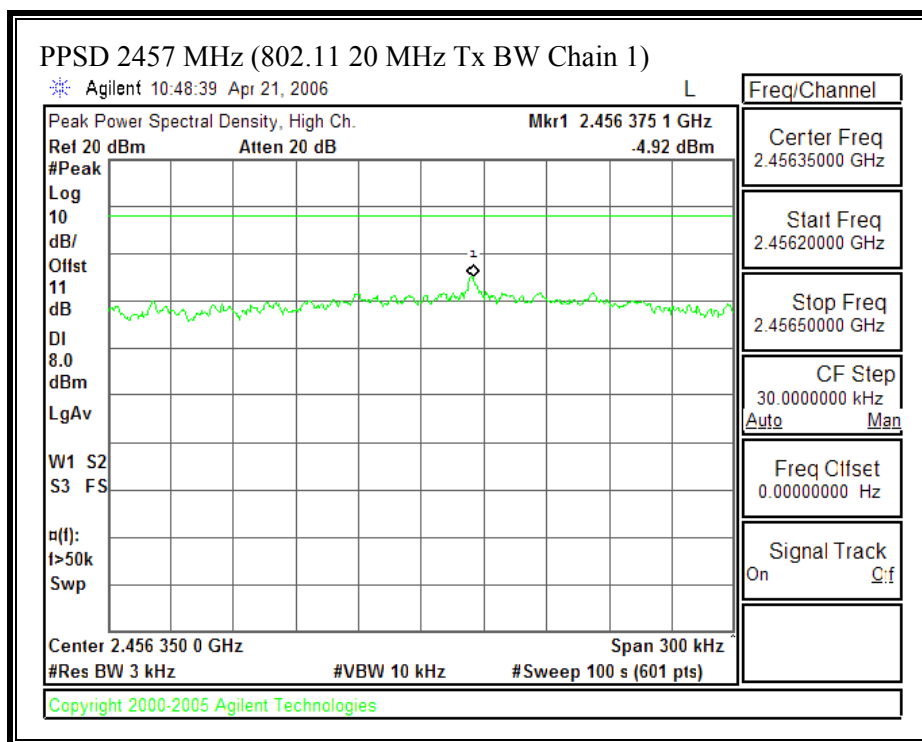
PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH – CHAIN 1)

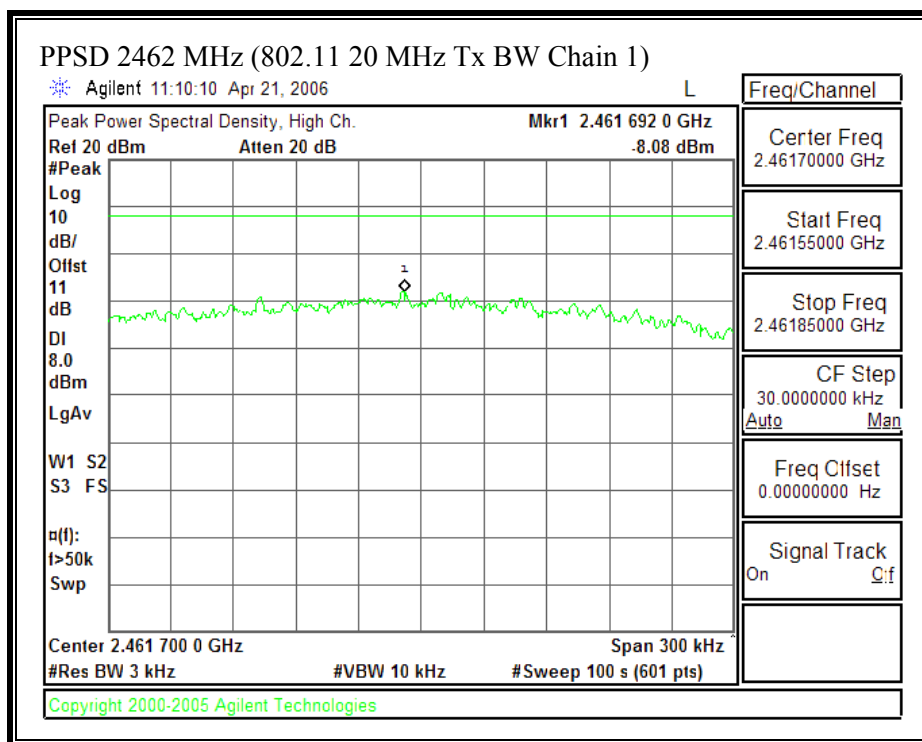






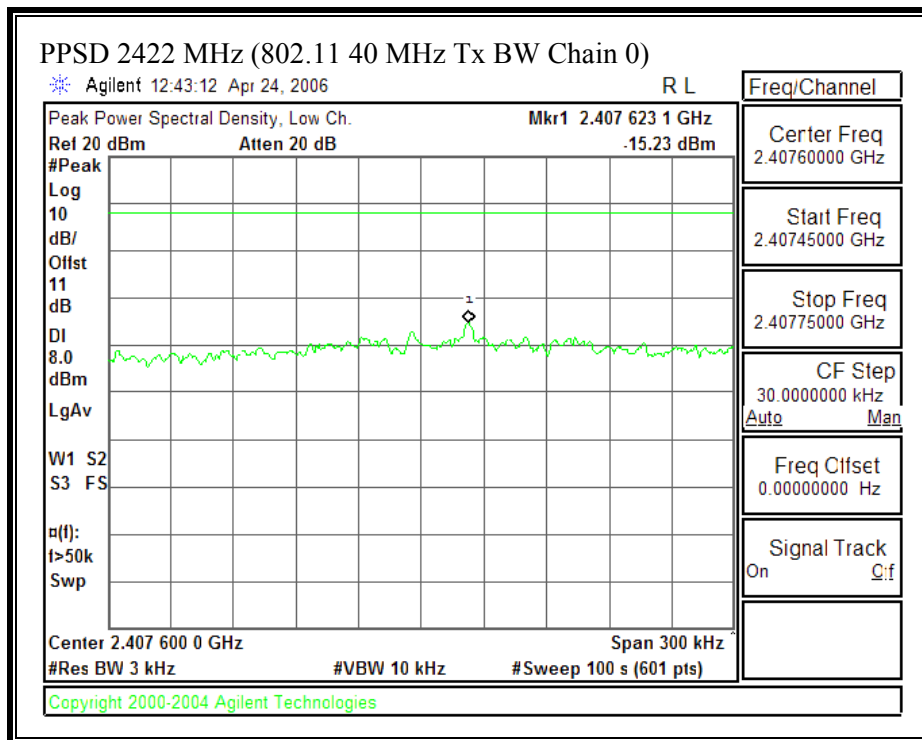


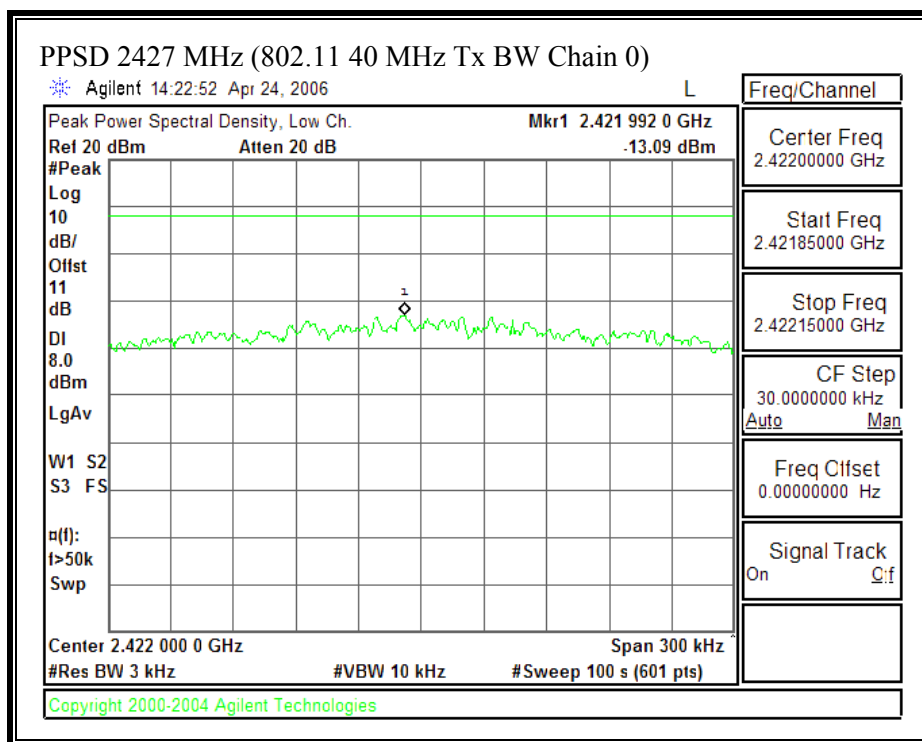


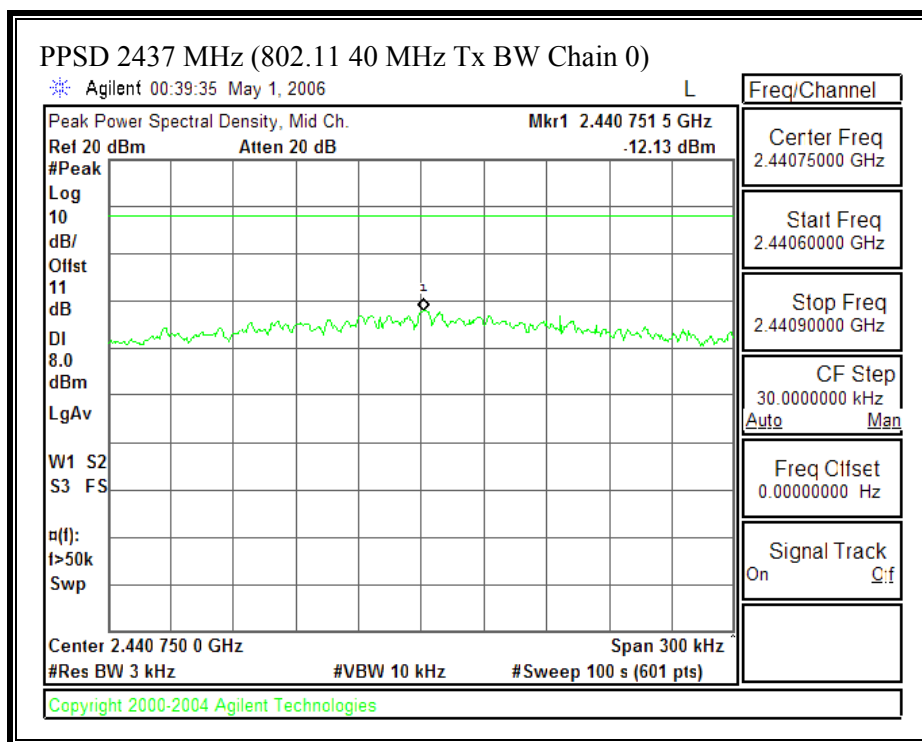


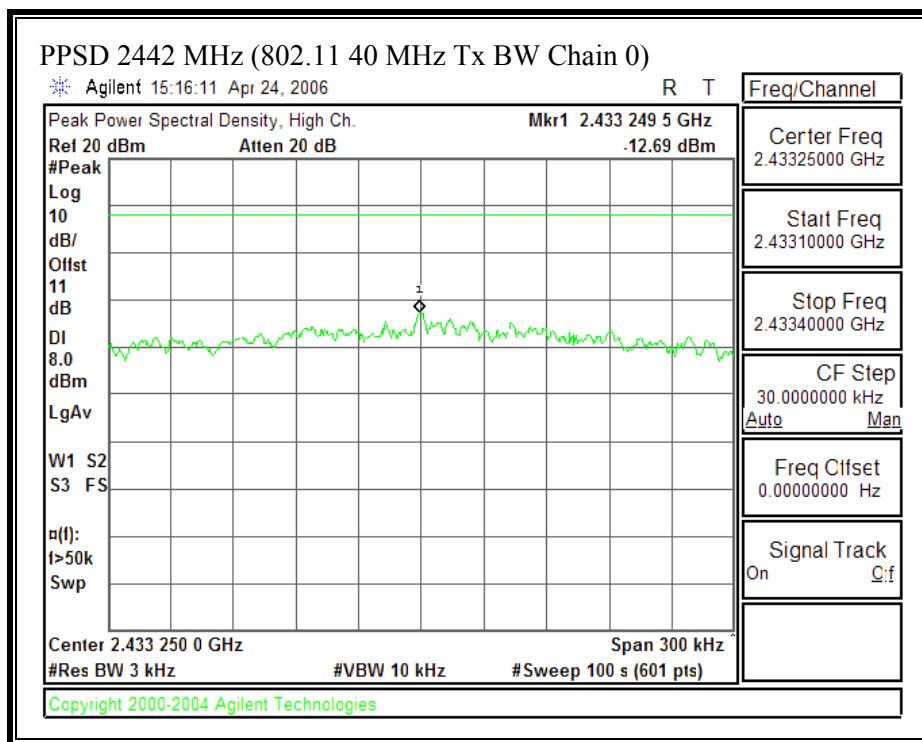
802.11n Mode 40 MHz CDD MCS 32

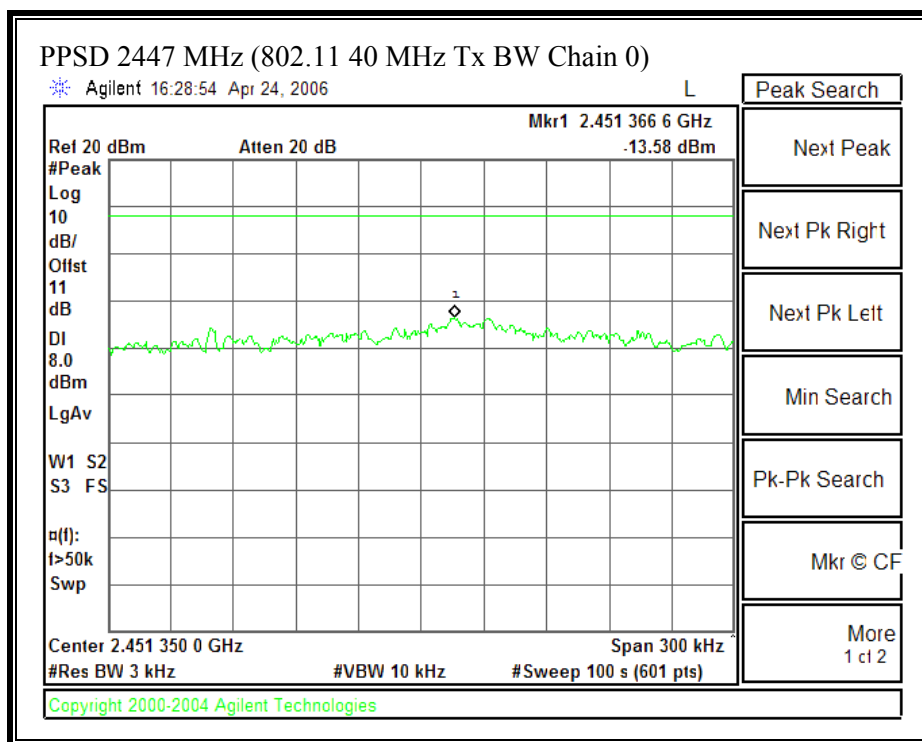
PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)

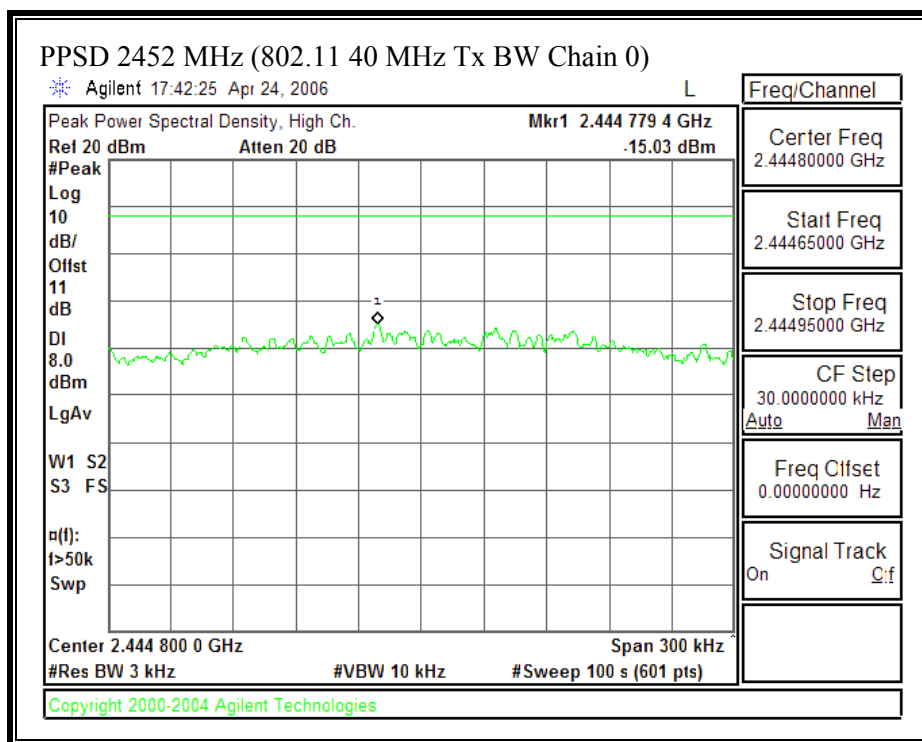




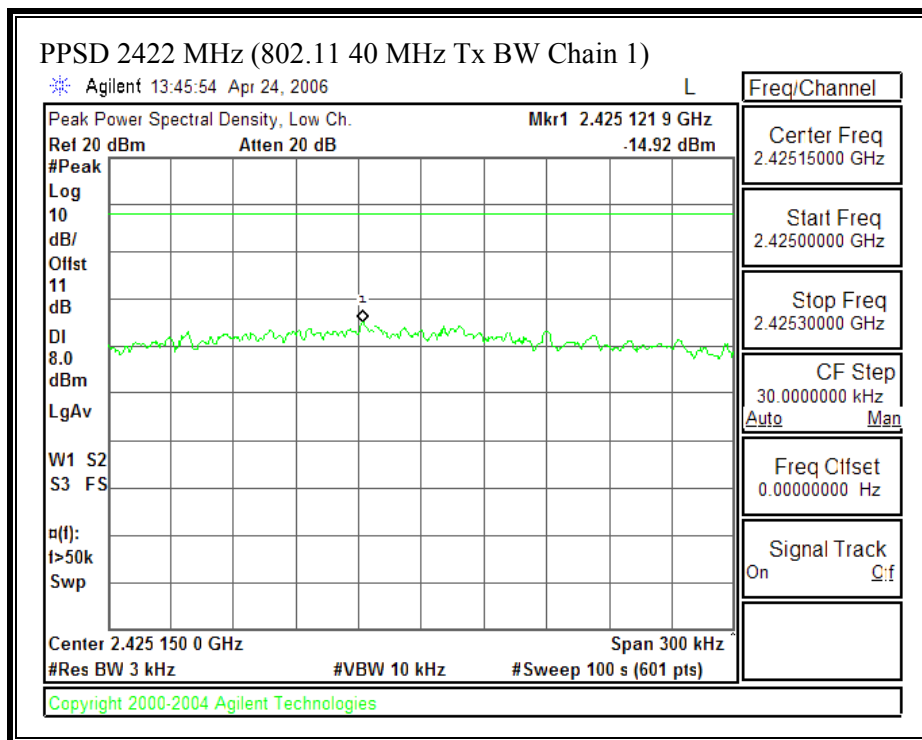


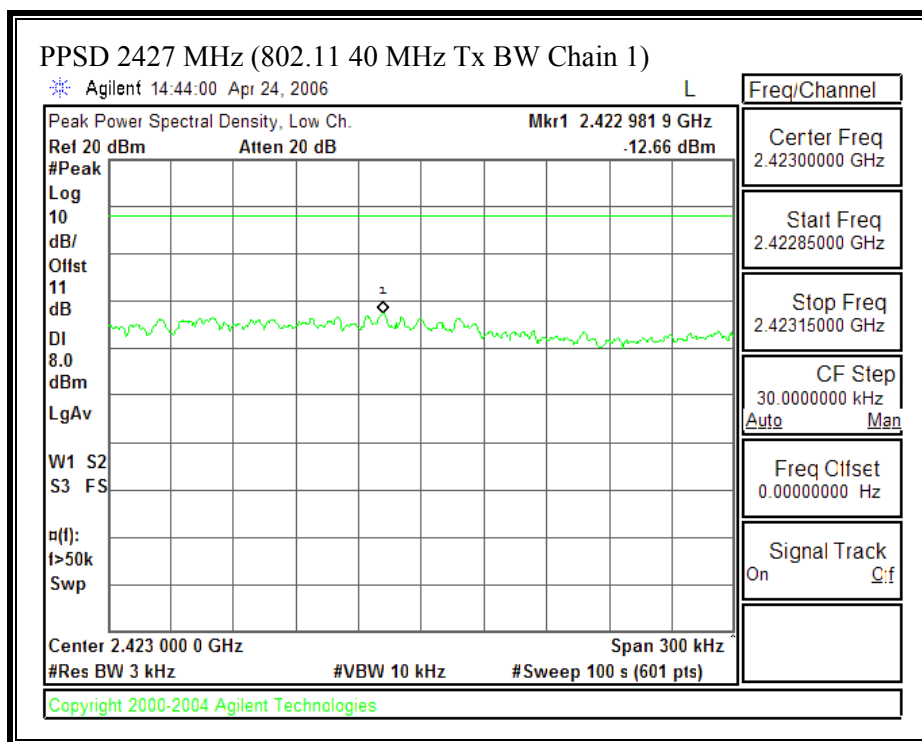


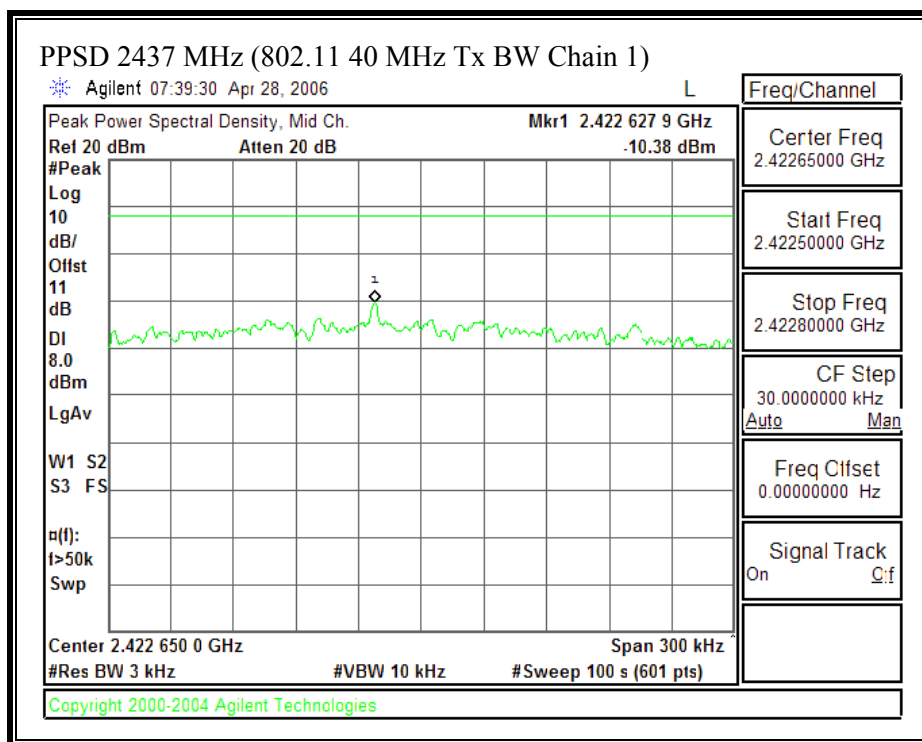


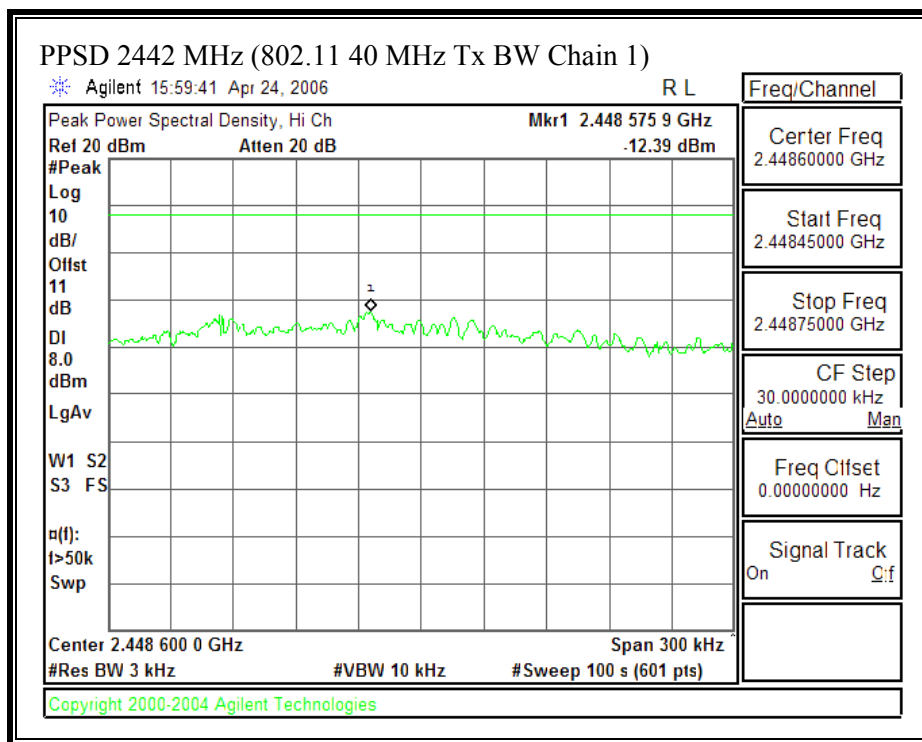


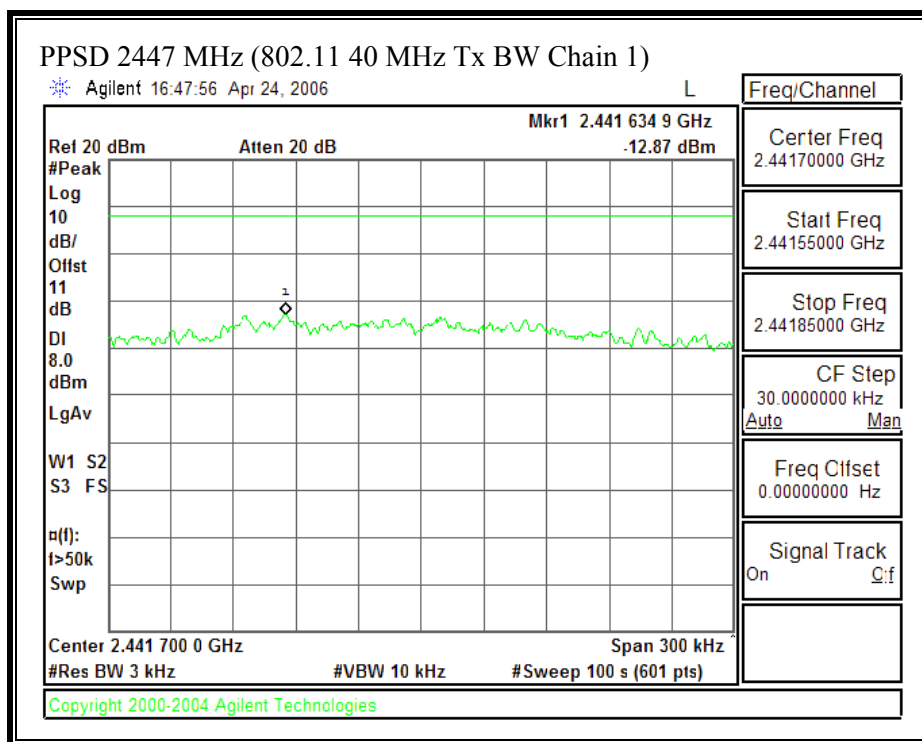
PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)

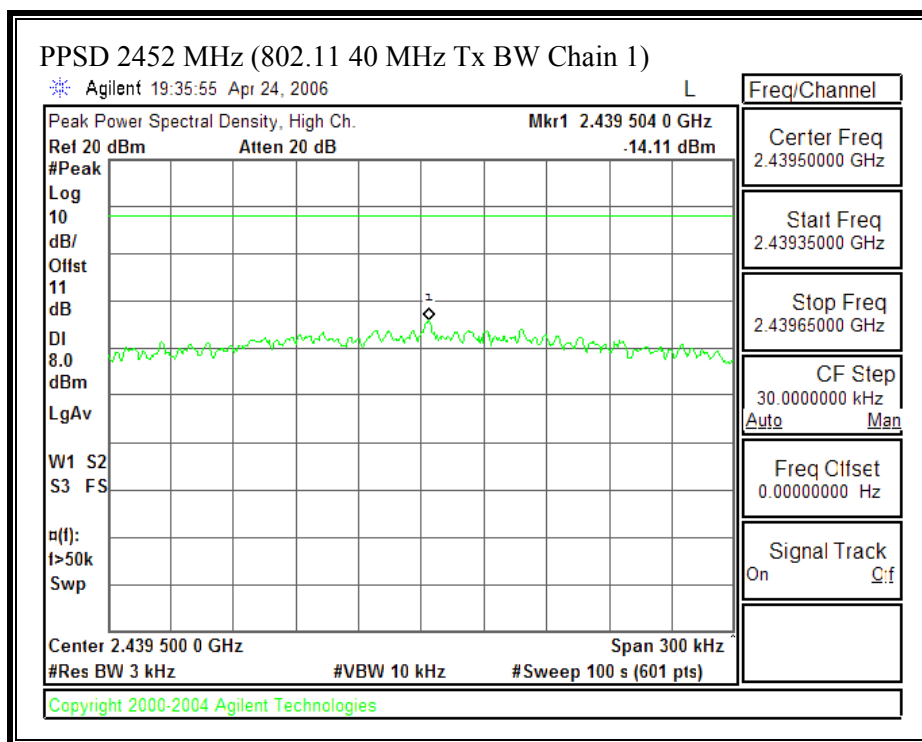






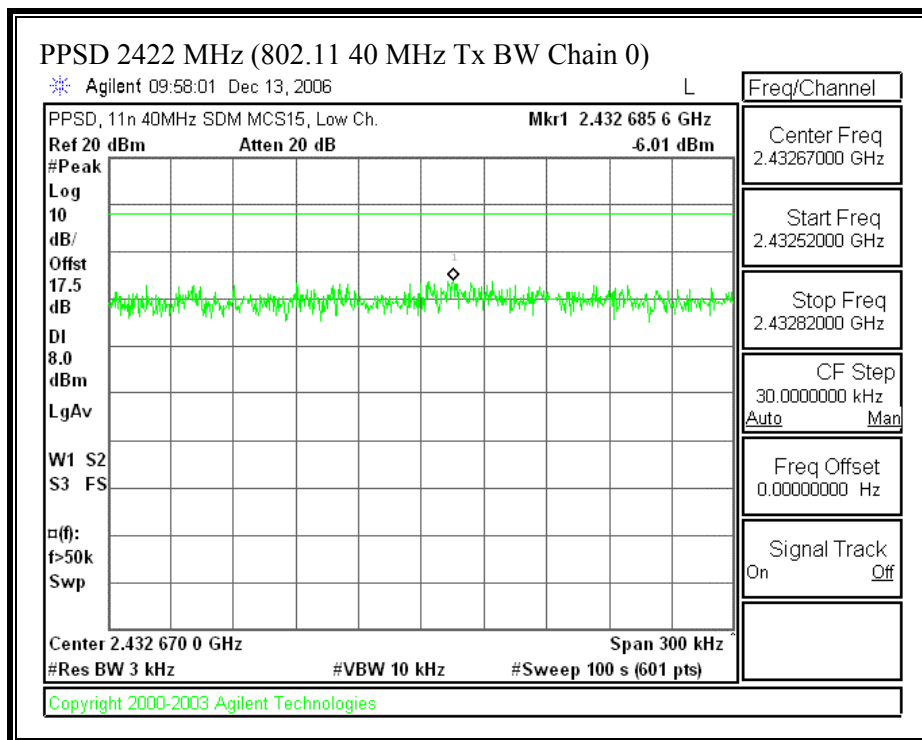


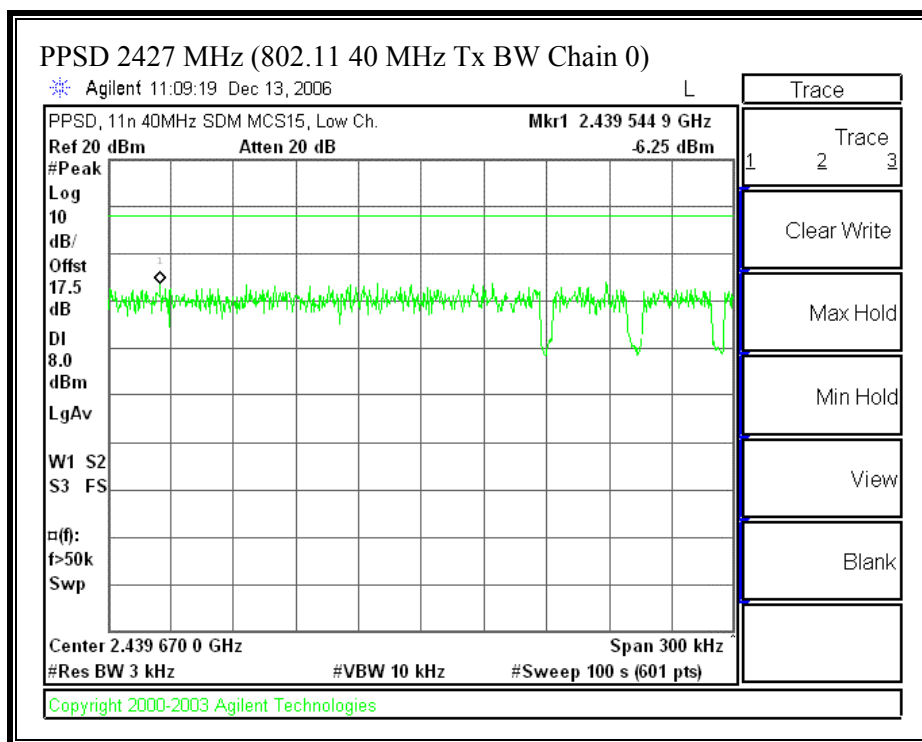


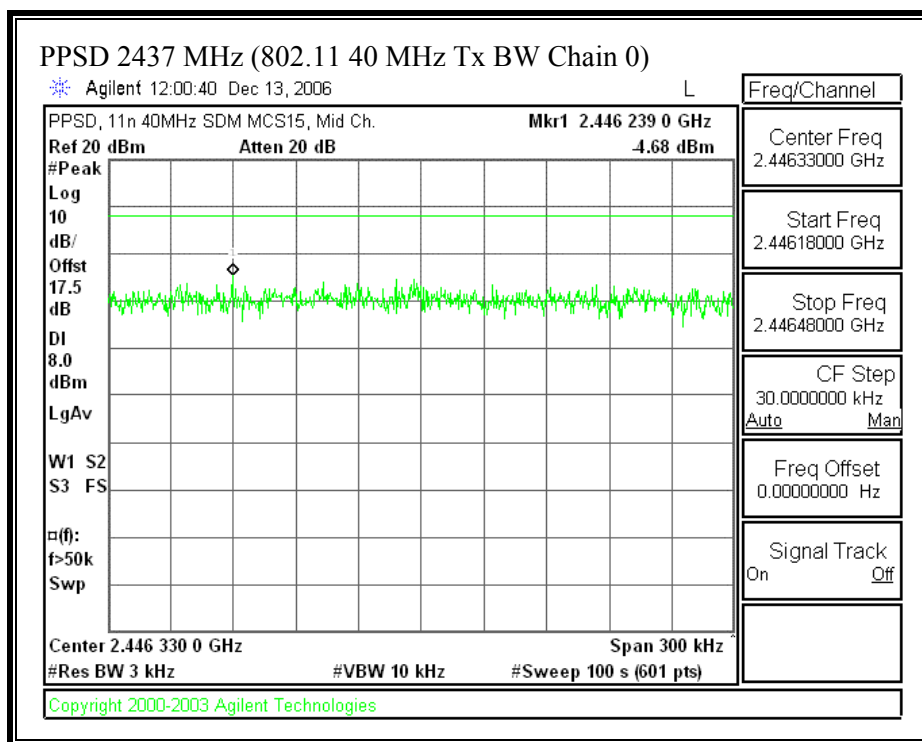


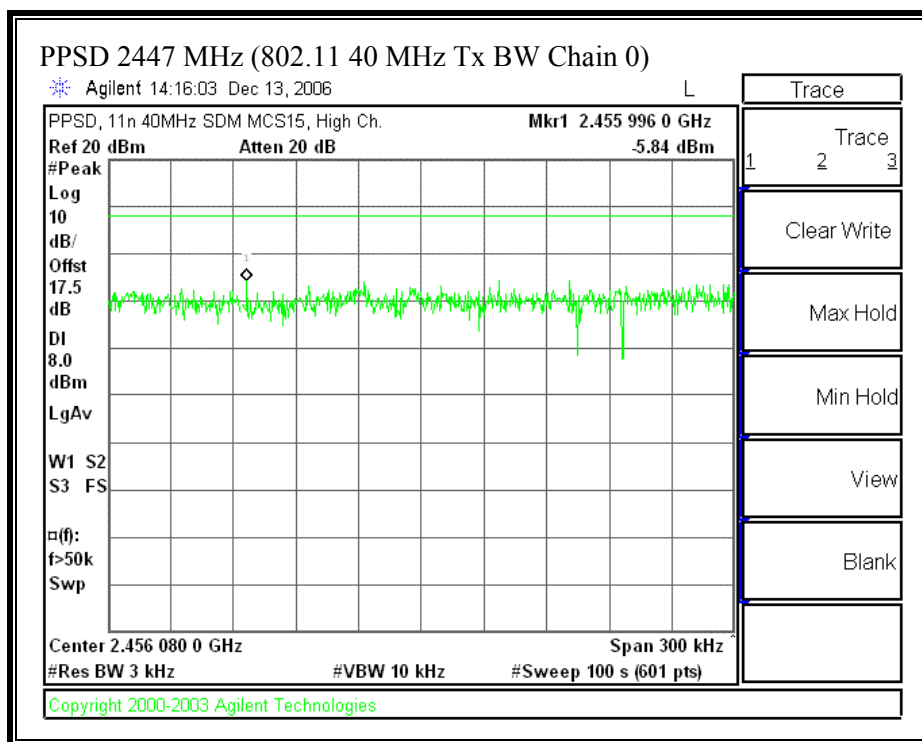
802.11n Mode 40 MHz SDM MCS 15:

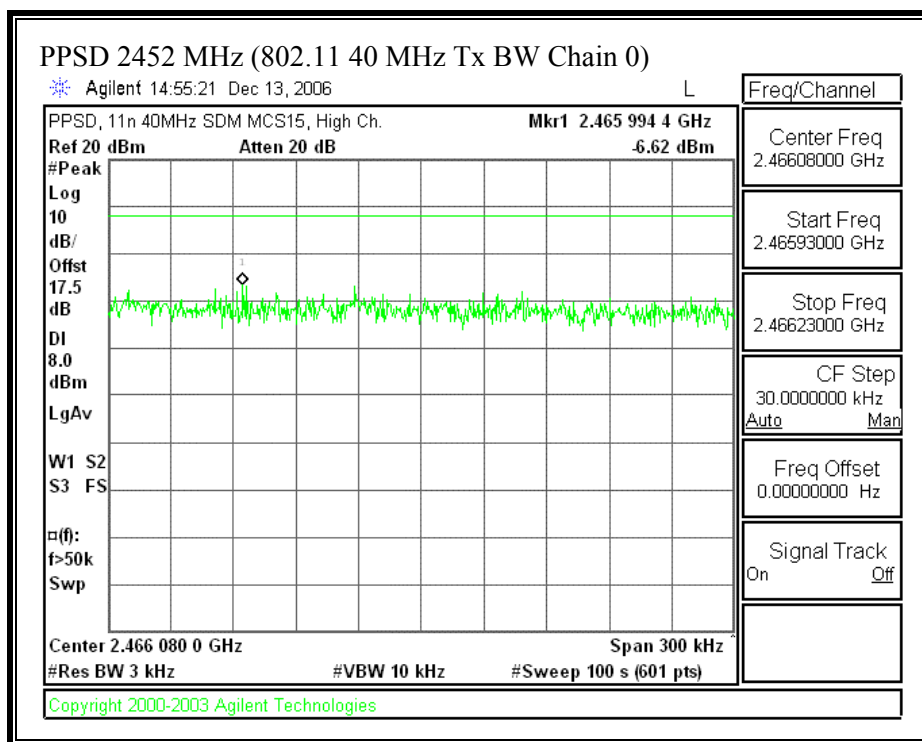
PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)











PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)

