



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

FOR

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

MODEL NUMBER: BCM94321MC

FCC ID: QDS-BRCM1022HR1

REPORT NUMBER: 07U10893-2B

ISSUE DATE: JUNE 29, 2007

Prepared for
**BROADCOM CORP.
190 MATHILDA PLACE
SUNNYVALE, CA, 94086, USA**

Prepared by
**COMPLIANCE CERTIFICATION SERVICES
47173 BENICIA STREET
FREMONT, CA, 94538, USA
TEL: (510) 771-1000
FAX: (510) 661-0888**



NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
--	6/26/07	Initial Issue	M. Heckrotte
B	06/29/2007	Editorial changes and clarification	M. Heckrotte

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS.....	6
2. TEST METHODOLOGY	7
3. FACILITIES AND ACCREDITATION	7
4. CALIBRATION AND UNCERTAINTY.....	7
4.1. MEASURING INSTRUMENT CALIBRATION.....	7
4.2. MEASUREMENT UNCERTAINTY.....	7
5. EQUIPMENT UNDER TEST.....	8
5.1. DESCRIPTION OF EUT	8
5.2. TEST RESULT CONCLUSIONS.....	8
5.3. MAXIMUM OUTPUT POWER	10
5.4. DESCRIPTION OF AVAILABLE ANTENNAS	12
5.5. SOFTWARE AND FIRMWARE	12
5.6. CONFIGURATION AND MODE	13
5.7. DESCRIPTION OF TEST SETUP	13
6. TEST AND MEASUREMENT EQUIPMENT	15
7. LIMITS AND RESULT	16
5150 TO 5350 MHz BAND.....	16
LEGACY MODE	16
7.1. CHANNEL TESTS FOR THE 5150 TO 5350 MHz BAND	16
7.1.1. EMISSION BANDWIDTH	16
7.1.2. PEAK POWER	24
7.1.3. MAXIMUM PERMISSIBLE EXPOSURE	35
7.1.4. PEAK POWER SPECTRAL DENSITY	38
7.1.5. PEAK EXCURSION	48
7.1.6. CONDUCTED SPURIOUS EMISSIONS.....	59
MIMO MODE.....	73
7.2. CHANNEL TESTS FOR THE 5150 TO 5350 MHz BAND	73
7.2.1. EMISSION BANDWIDTH	73
7.2.2. PEAK POWER	90
7.2.3. MAXIMUM PERMISSIBLE EXPOSURE	116
7.2.4. PEAK POWER SPECTRAL DENSITY	120
7.2.5. PEAK EXCURSION	139

7.2.6.	CONDUCTED SPURIOUS EMISSIONS.....	156
5470 TO 5725 MHz BAND.....		185
LEGACY MODE		185
7.3.	CHANNEL TESTS FOR THE 5470 TO 5725 MHz BAND	185
7.3.1.	EMISSION BANDWIDTH	185
7.3.2.	PEAK POWER	193
7.3.3.	MAXIMUM PERMISSIBLE EXPOSURE	202
7.3.4.	PEAK POWER SPECTRAL DENSITY	205
7.3.5.	PEAK EXCURSION	213
7.3.6.	CONDUCTED SPURIOUS EMISSIONS.....	221
MIMO MODE.....		235
7.4.	CHANNEL TESTS FOR THE 5470 TO 5725 MHz BAND	235
7.4.1.	EMISSION BANDWIDTH	235
7.4.2.	PEAK POWER	250
7.4.3.	MAXIMUM PERMISSIBLE EXPOSURE	277
7.4.4.	PEAK POWER SPECTRAL DENSITY	281
7.4.5.	PEAK EXCURSION	306
7.4.6.	CONDUCTED SPURIOUS EMISSIONS.....	320
7.5.	RADIATED EMISSIONS.....	345
7.5.1.	TRANSMITTER RADIATED SPURIOUS EMISSIONS	345
5150 TO 5350 MHz BAND.....		348
LEGACY MODE		348
7.5.2.	TRANSMITTER ABOVE 1 GHz FOR 5150 TO 5350 MHz BAND	348
MIMO MODE.....		378
7.5.3.	TRANSMITTER ABOVE 1 GHz FOR 5150 TO 5350 MHz BAND	378
5470 TO 5725 MHz BAND.....		401
LEGACY MODE		401
7.5.4.	TRANSMITTER ABOVE 1 GHz FOR 5470 TO 5725 MHz BAND	401
MIMO MODE.....		427
7.5.5.	TRANSMITTER ABOVE 1 GHz FOR 5470 TO 5725 MHz BAND	427
5.2 & 5.5 GHz BANDS.....		453
7.5.6.	WORST-CASE RADIATED EMISSIONS BELOW 1 GHz	453
7.6.	POWERLINE CONDUCTED EMISSIONS	455
8. DYNAMIC FREQUENCY SELECTION		459

8.1.	<i>OVERVIEW</i>	459
8.1.1.	LIMITS	459
8.1.2.	TEST AND MEASUREMENT SYSTEM	462
8.1.3.	DESCRIPTION OF EUT WITH RESPECT TO FCC 06-96 REQUIREMENTS	467
8.2.	<i>RESULTS FOR 20 MHz BANDWIDTH CONFIGURATION</i>	469
8.2.1.	TEST CHANNEL AND METHOD	469
8.2.2.	PLOTS OF RADAR WAVEFORM, AND WLAN TRAFFIC	469
8.2.3.	CHANNEL MOVE TIME AND CHANNEL CLOSING TRANSMISSION TIME	471
8.3.	<i>RESULTS FOR 40 MHz BANDWIDTH CONFIGURATION</i>	475
8.3.1.	TEST CHANNEL AND METHOD	475
8.3.2.	PLOTS OF RADAR WAVEFORM, AND WLAN TRAFFIC	475
8.3.3.	MOVE TIME AND CHANNEL CLOSING TRANSMISSION TIME	477
9.	SETUP PHOTOS	481

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 TO APRIL 15, 2007


APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
FCC PART 15 SUBPART E	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:



MICHAEL HECKROTTE
ENGINEERING MANAGER
COMPLIANCE CERTIFICATION SERVICES

VIEN TRAN
EMC ENGINEER
COMPLIANCE CERTIFICATION SERVICES

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4-2003, FCC CFR 47 Part 2, FCC CFR 47 Part 15 and FCC 06-96 APPENDIX "COMPLIANCE MEASUREMENT PROCEDURES FOR UNLICENSED-NATIONAL INFORMATION INFRASTRUCTURE DEVCIES OPERATING IN THE 5250-5350 MHz AND 5470-5725 MHz BANDS INCORPORATING DYNAMIC FREQUENCY SELECTION".

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 561F Monterey Road, Morgan Hill, California, 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.

The radio module is manufactured by Broadcom Corp.

5.2. TEST RESULT CONCLUSIONS

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

5.2 GHz and 5.5 GHz UNII BANDS

1/ LEGACY MODE:

- _ 802.11a Legacy Mode
- _ 802.11n 20 MHz SISO is covered by the worst case 802.11a Legacy Mode testing)
- _ 802.11n 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 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 conducted output power as follows:

5150 to 5350 MHz Authorized Band

Frequency Range (MHz)	Mode	Peak Power Chain 0 (dBm)	Peak Power Chain 1 (dBm)	Total Peak Power (dBm)	Output Power (mW)
5180 - 5240	802.11a Legacy	N/A	N/A	14.22	26.42
5260 - 5320	802.11a Legacy	N/A	N/A	17.63	57.94
5180 - 5320	802.11n 20MHz SISO	covered by the worst case 802.11a Legacy testing			
5190 - 5230	802.11n 40MHz SISO	N/A	N/A	16.54	45.08
5270 - 5310	802.11n 40MHz SISO	N/A	N/A	17.08	51.05
5180 - 5320	802.11a CDD Mode	covered by the worst case 802.11n 20 MHz CDD			
5190	802.11n 40MHz SDM	12.56	12.59	15.59	36.19

Power with Antenna Array Gain up to 6 dBi					
5180 - 5240	802.11n 20MHz CDD	10.09	10.2	13.16	20.68
5260 - 5320	802.11n 20MHz CDD	17.22	17.34	20.29	106.92
5190 - 5230	802.11n 40MHz CDD	12.37	12.36	15.38	34.48
5270 - 5310	802.11n 40MHz CDD	15.53	15.83	18.69	74.01

Power with Antenna Array Gain up to 7.077 dBi in 5150 - 5250 Band					
5180 - 5240	802.11n 20MHz CDD	9.11	9.34	12.24	16.74
5190 - 5230	802.11n 40MHz CDD	11.59	12.19	14.91	30.98

Power with Antenna Array Gain up to 8.677 dBi in 5250 - 5350 Band					
5260 - 5320	802.11n 20MHz CDD	14.51	14.65	17.59	57.42
5270 - 5310	802.11n 40MHz CDD	15.53	15.83	18.69	74.01

5470 - 5725 MHz Authorized Band

Frequency Range (MHz)	Mode	Peak Power Chain 0 (dBm)	Peak Power Chain 1 (dBm)	Total Peak Power (dBm)	Output Power (mW)
5500 - 5700	802.11a Legacy	N/A	N/A	17.75	59.57
5500 - 5700	802.11n 20MHz SISO	covered by the worst case 802.11a Legacy testing			
5510 - 5670	802.11n 40MHz SISO	N/A	N/A	18.23	66.53
5500 - 5700	802.11a CDD Mode	covered by the worst case 802.11n 20 MHz CDD			

Power with Antenna Array Gain up to 6 dBi					
5500 - 5700	802.11n 20MHz CDD	17.21	17.24	20.24	105.57
5510 - 5670	802.11n 40MHz CDD	19.38	19.39	22.40	173.59

Power with Antenna Array Gain up to 8.75 dBi					
5500 - 5700	802.11n 20MHz CDD	14.63	14.65	17.65	58.21
5510 - 5670	802.11n 40MHz CDD	16.67	16.81	19.75	94.42

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

On selected UNII channels and/or sub-bands, a higher output power is specified for antenna pairs of the same type with an array gain of 6 dBi or less. For these channels and/or sub-bands the maximum power was limited by Output Power and PPSD, rather than Spurious emissions performance. All Spurious testing was performed at the worst-case combination of the highest output power and the highest antenna array gain. This worst-case combination will not be marketed on those channels that would not comply with the Power or PPSD limits.

The conducted Output Power and PPSD measurements at the highest power level are applied to the maximum 6 dBi array gain for the Output Power and PPSD calculations. Additional conducted Output Power and PPSD measurements were made at the reduced power level, and these measurements are applied to the 7.077 / 8.677 / 8.750 dBi array gain for the respective Output Power and PPSD calculations.

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

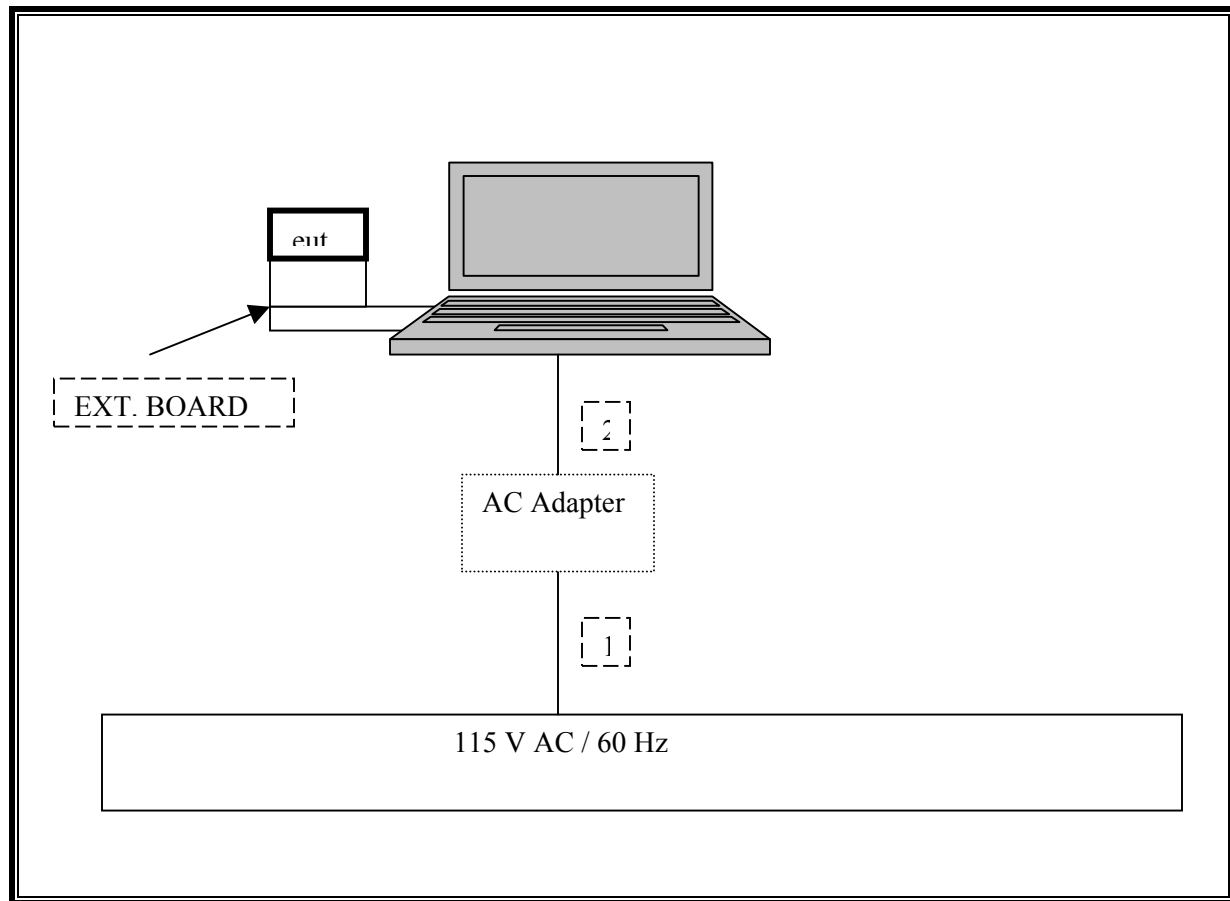
I/O CABLES

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

5150 TO 5350 MHz BAND

LEGACY MODE

7.1. CHANNEL TESTS FOR THE 5150 TO 5350 MHz BAND

7.1.1. EMISSION BANDWIDTH

LIMIT

§15.403 (i) Emission bandwidth. For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolutions bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 1% to 3% of the 26 dB bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled.

RESULTS

No non-compliance noted:

802.11a LEGACY MODE

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5180	19.62	12.93
Middle	5260	33.69	15.28
High	5320	19.81	12.97

802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

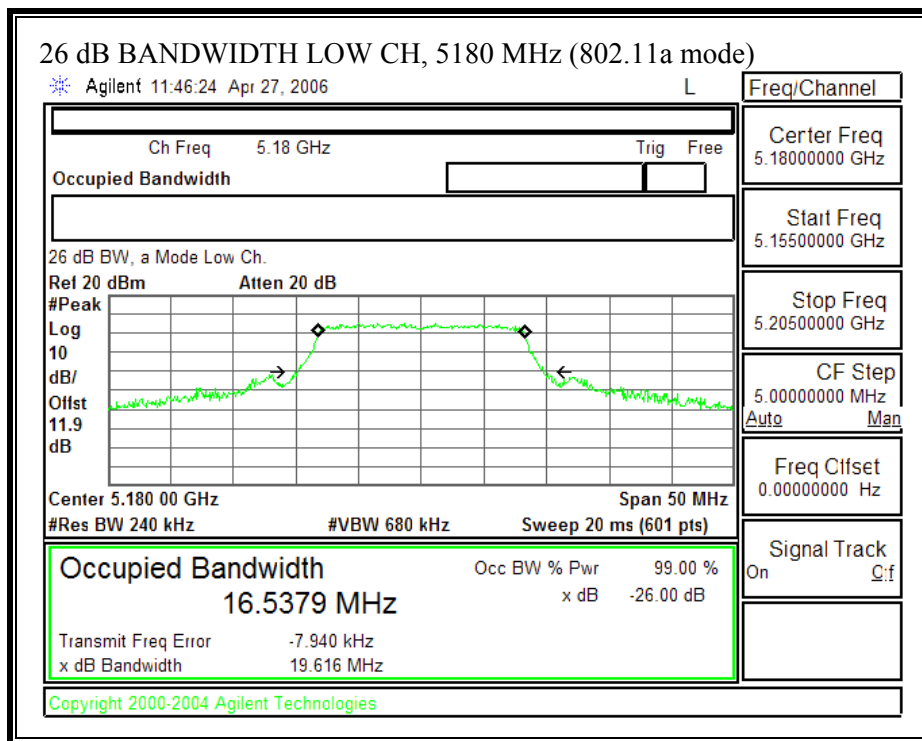
802.11n 40 MHz SISO MODE

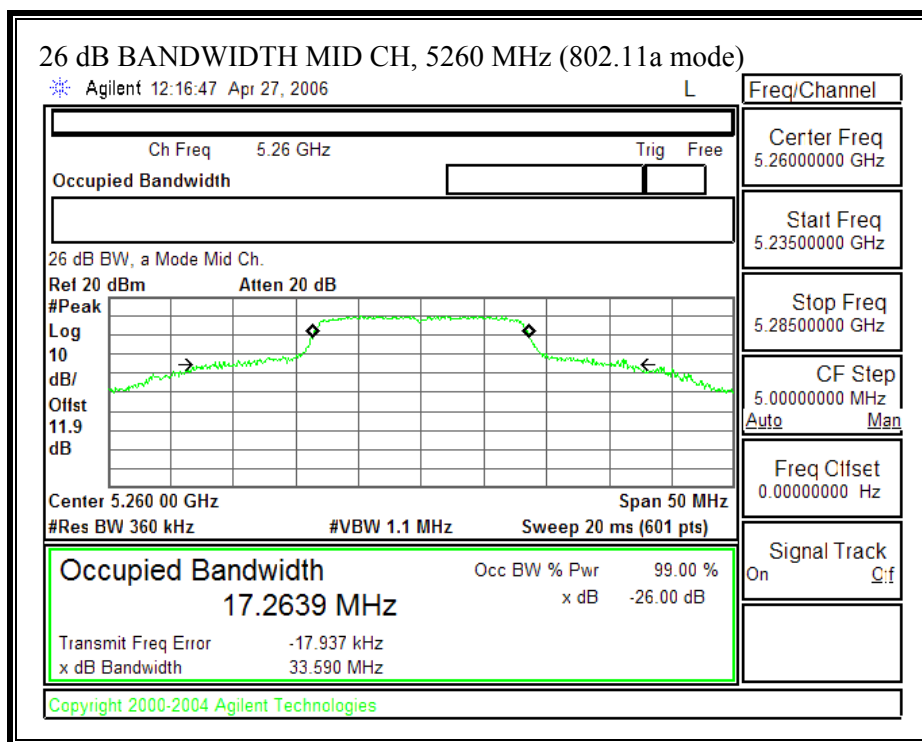
802.11a Mode

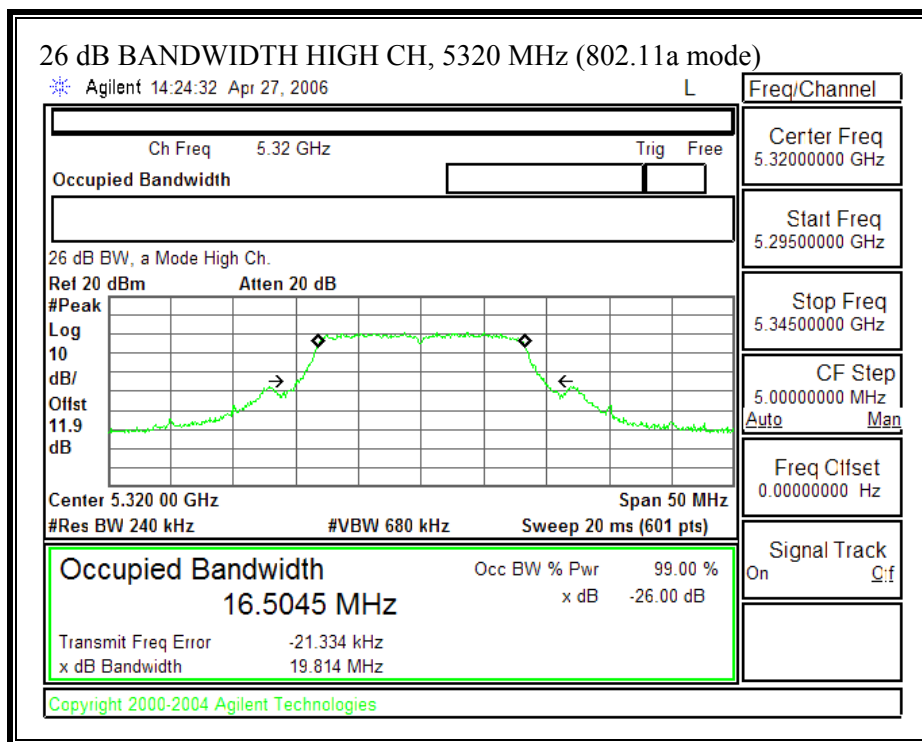
Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	39.17	15.93
Middle	5270	73.74	18.68
High	5310	39.87	16.01

802.11a MODE

26 dB EMISSION BANDWIDTH (802.11a MODE)

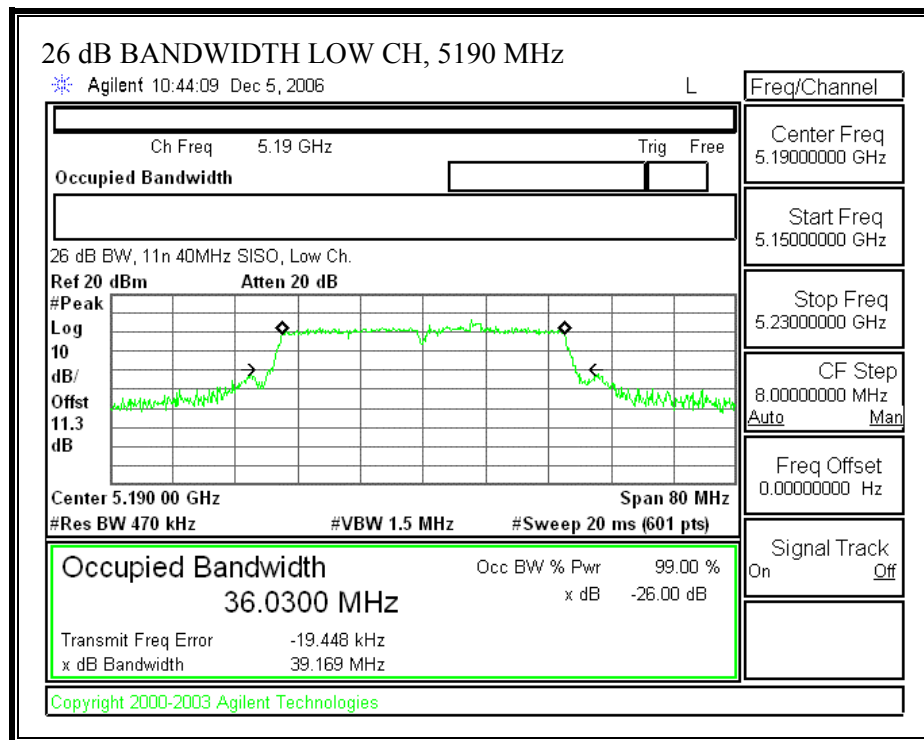


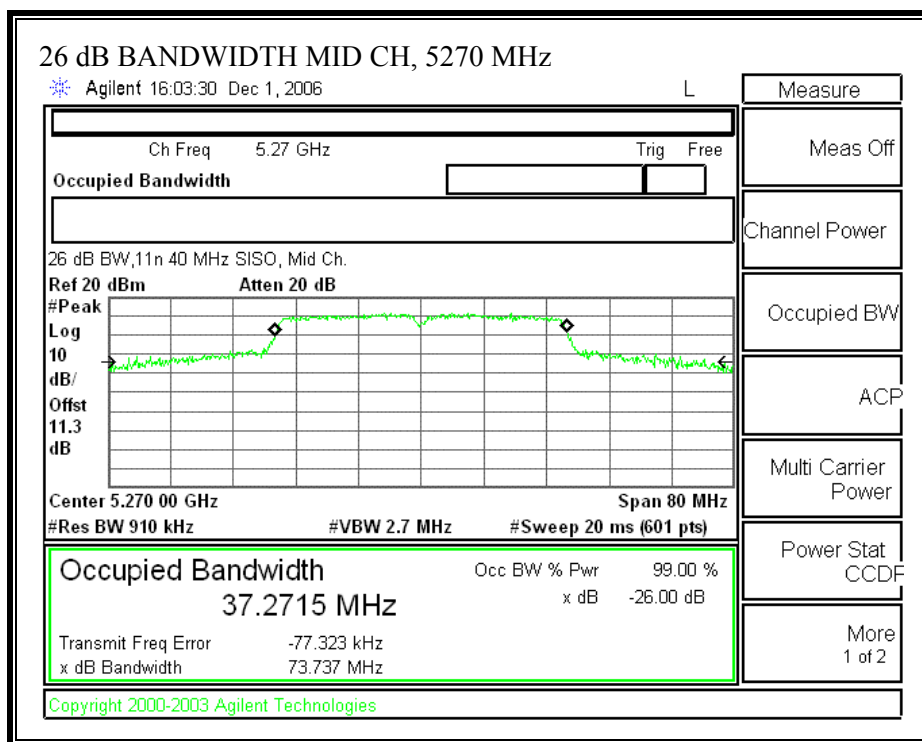


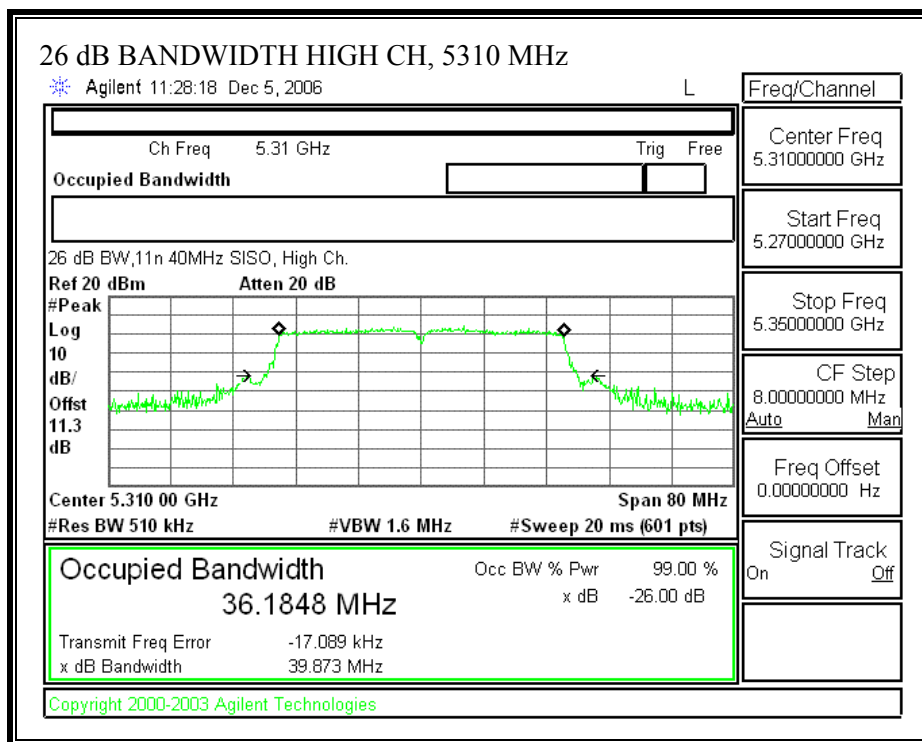


11n 40 MHz SISO MODE

26 dB EMISSION BANDWIDTH (802.11n 40MHz SISO MODE)







7.1.2. PEAK POWER

LIMIT

§15.407 (a) (1) For the band 5.15-5.25 GHz, the peak transmit power over the frequency band of operation shall not exceed the lesser of 50 mW or $4 \text{ dBm} + 10 \log B$, where B is the 26-dB emission bandwidth in MHz. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

§15.407 (a) (1) For the band 5.25-5.35 GHz, the peak transmit power over the frequency band of operation shall not exceed the lesser of 250 mW or $11 \text{ dBm} + 10 \log B$, where B is the 26-dB emission bandwidth in MHz. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002.

The transmitter output operates continuously therefore Method # 1 is used.

THE ANTENNA GAIN:

5.15 – 5.25 GHz: 4.37dBi
5.25 – 5.35 GHz: 6.23dBi

802.11a MODE

LIMITS AND RESULTS FOR TRANSMIT POWER

Limit in 5150 to 5250 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	4 + 10 Log Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5180	17	19.616	16.926	4.370	16.93

Limit in 5250 to 5350 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	11 + 10 Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Mid	5260	24	33.59	26.262	6.230	23.77
High	5300	24	33.22	26.214	6.230	23.77
High	5320	24	19.81	23.970	6.230	23.74

Results

Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Low	5180	14.22	16.93	-2.71
Mid	5260	17.63	23.77	-6.14
High	5300	17.59	23.77	-6.18
High	5320	14.64	23.74	-9.10

802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

802.11n 40 MHz SISO MODE

No non-compliance noted:

Limit in 5150 to 5250 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	4 + 10 Log Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5190	17	39.170	19.930	6.230	16.77
Low	5230	17	61.693	21.902	6.230	16.77

Limit in 5250 to 5350 MHz Band

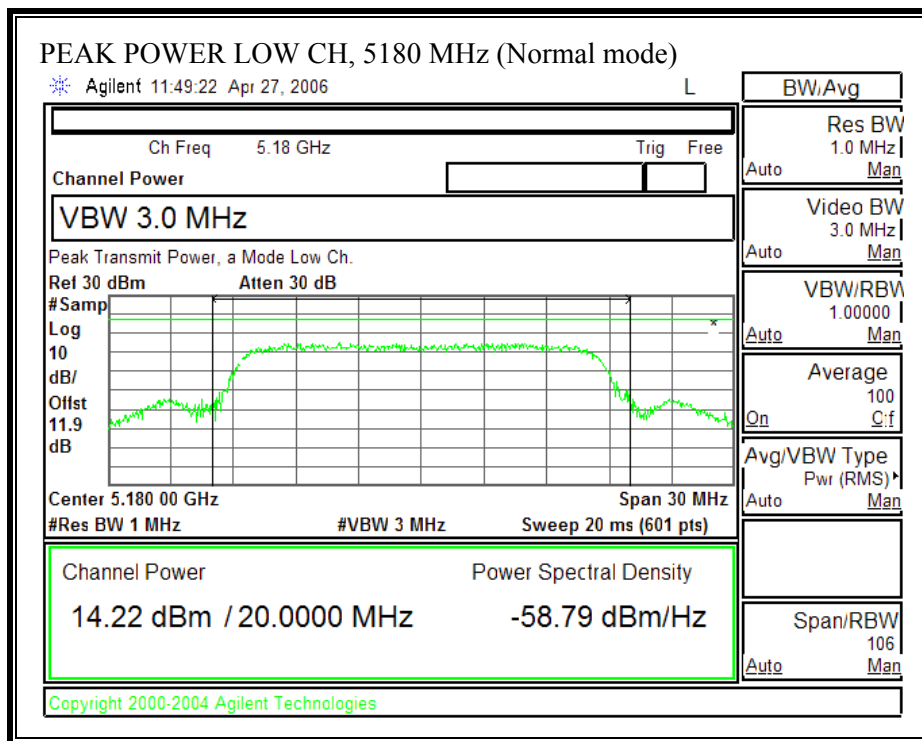
Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	11 + 10 Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Mid	5270	24	73.74	29.677	6.230	23.77
High	5310	24	39.87	27.006	6.230	23.77

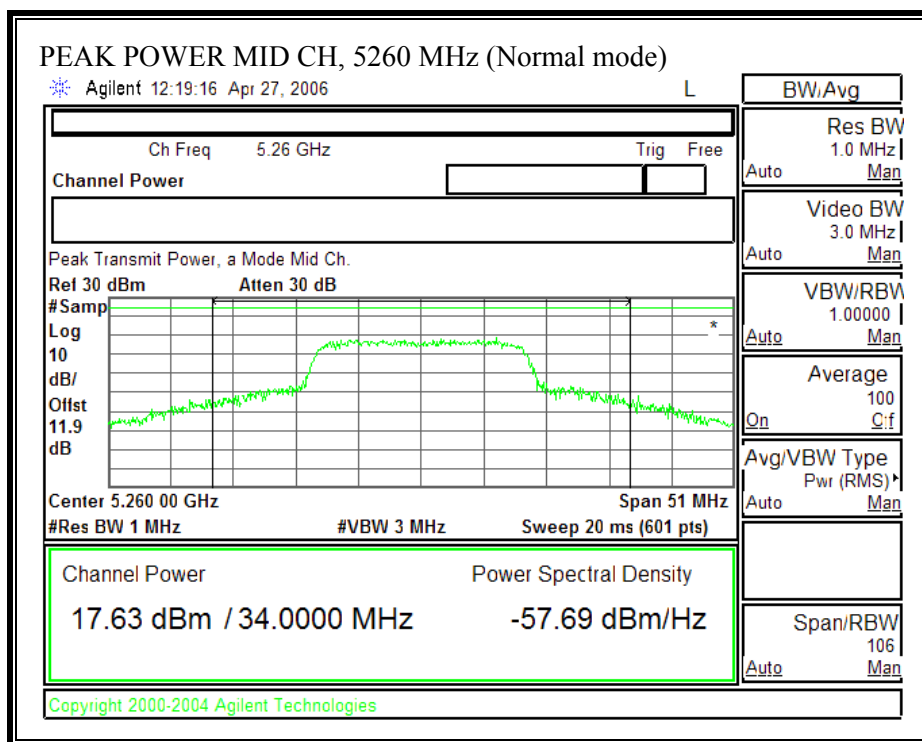
Results

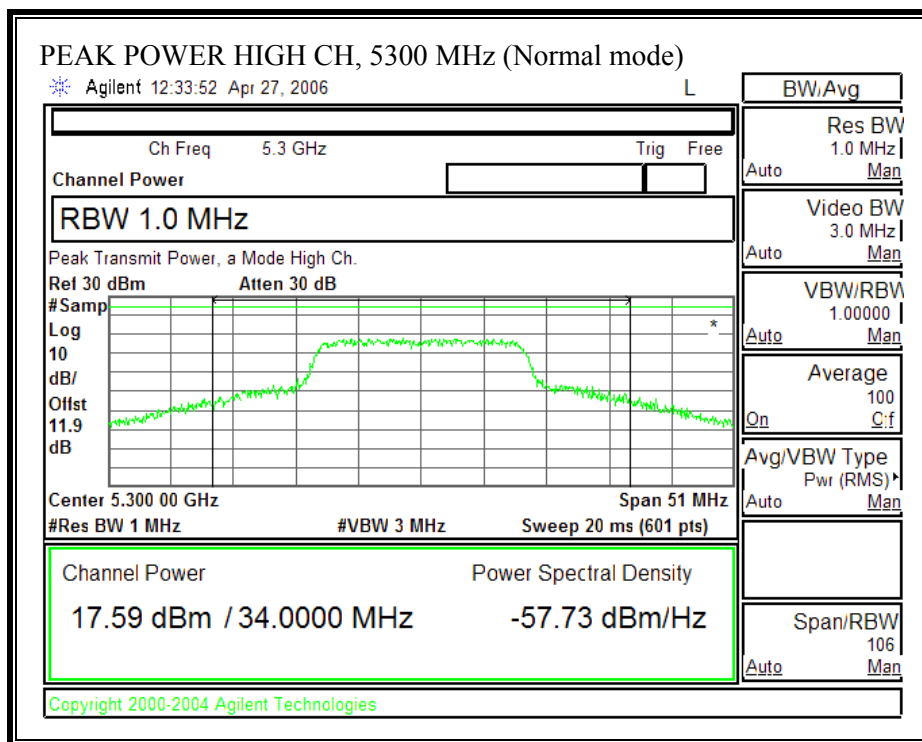
Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Low	5190	13.33	16.77	-3.44
Low	5230	16.54	16.77	-0.23
Mid	5270	17.08	23.77	-6.69
High	5310	12.95	23.77	-10.82

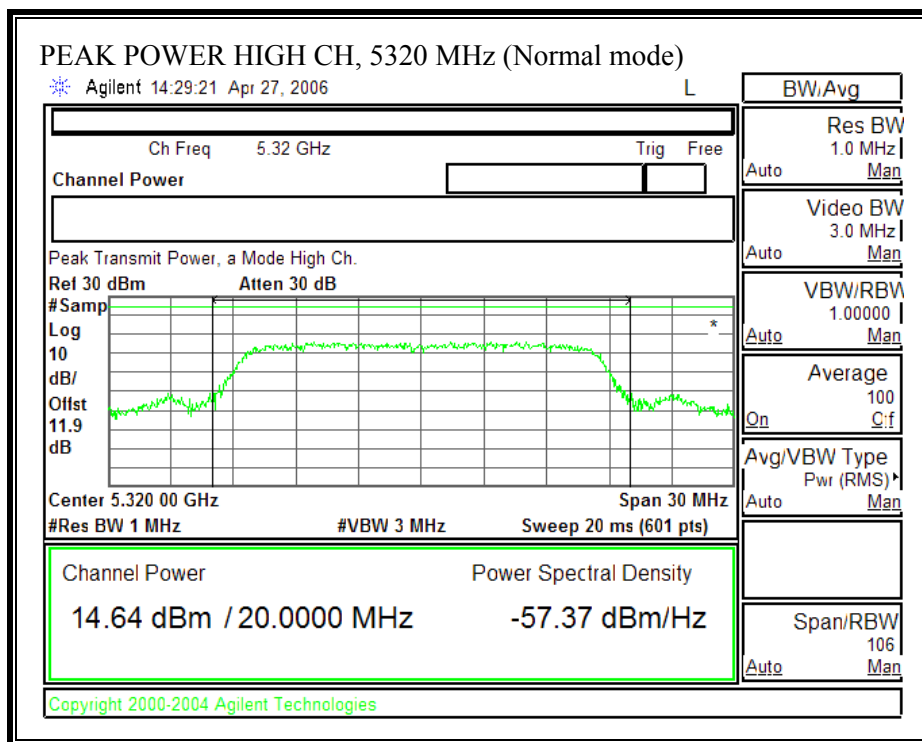
802.11a MODE

PEAK POWER (NORMAL MODE)



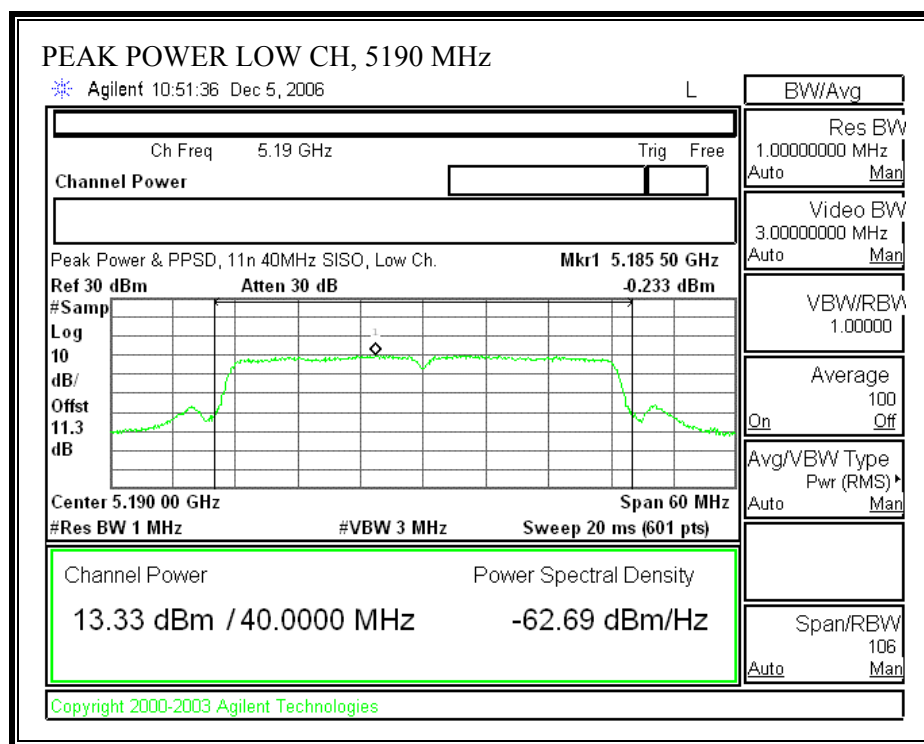


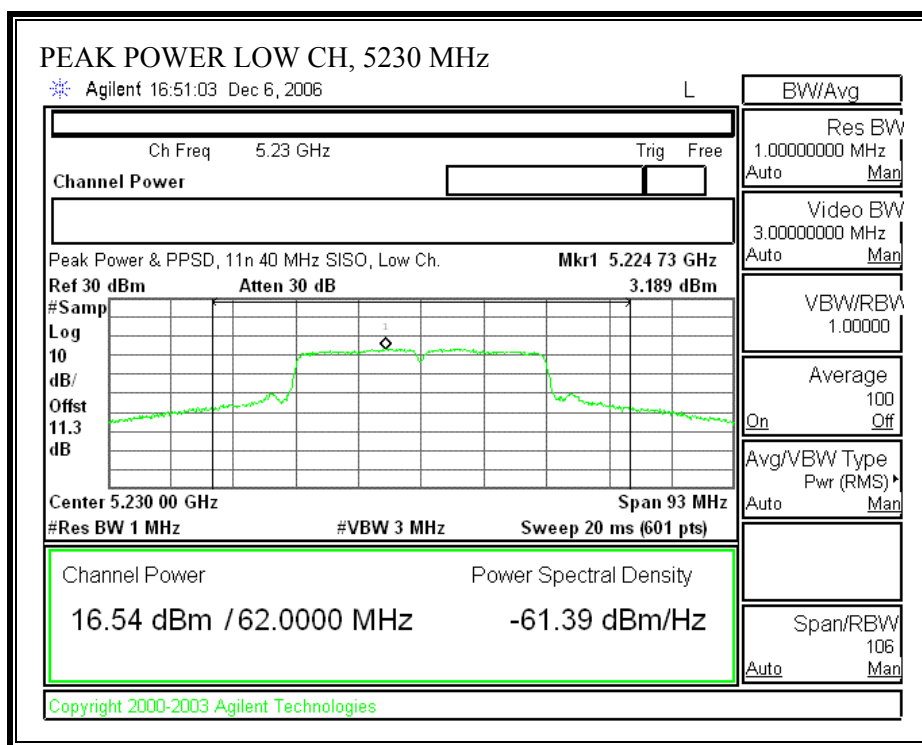


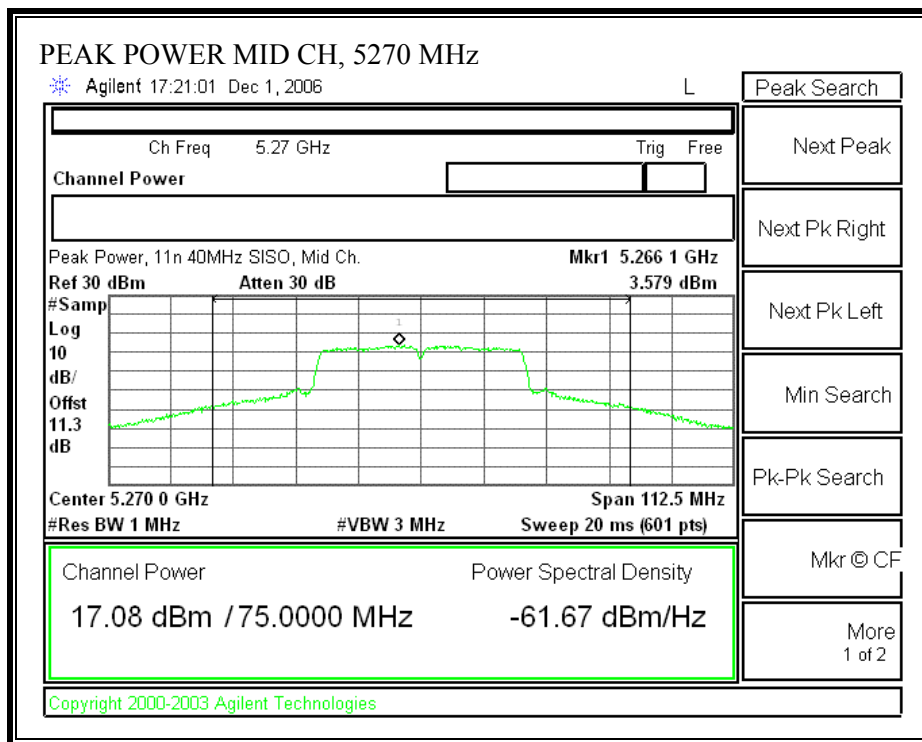


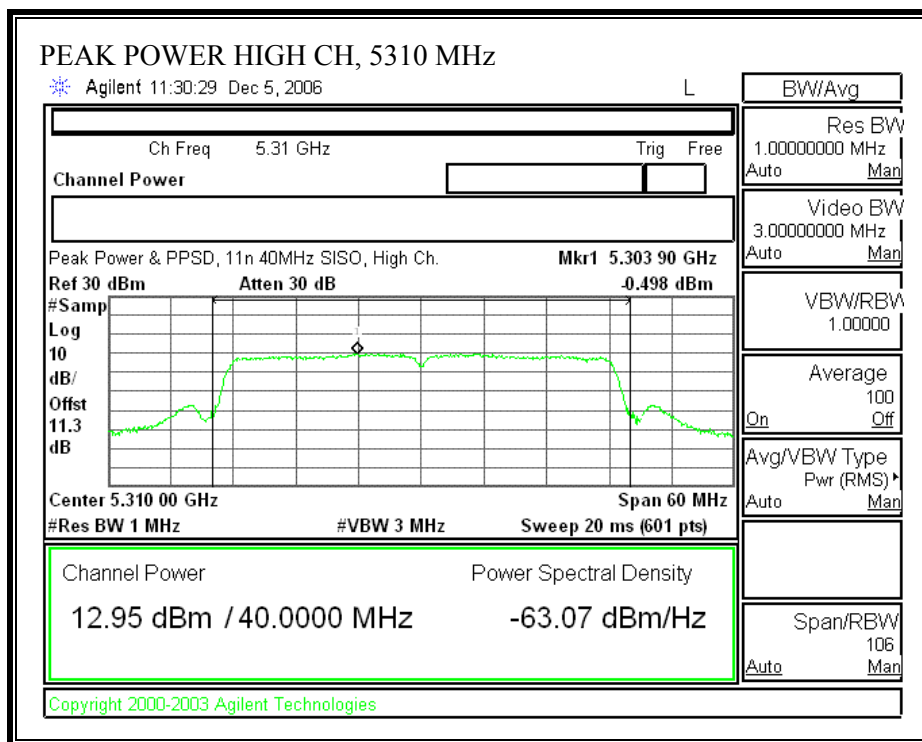
802.11n 40 MHz SISO MODE

PEAK POWER (11n 40MHz SISO MODE)









7.1.3. 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 5.2 / 5.3 GHz band.

RESULTS

No non-compliance noted

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11a	20.0	17.59	6.23	0.05

802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 40 MHz SISO	20.0	17.08	6.23	0.04

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.

7.1.4. PEAK POWER SPECTRAL DENSITY

LIMIT

§15.407 (a) (1) For the band 5.15-5.25 GHz, the peak power spectral density shall not exceed 4 dBm in any 1-MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

§15.407 (a) (1) For the band 5.25-5.35 GHz, the peak power spectral density shall not exceed 11 dBm in any 1-MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002. PPSD method #2 was used.

THE ANTENNA GAIN:

5.15 – 5.25 GHz: 4.37dBi, limit = 4 dBm

5.25 – 5.35 GHz: 6.23dBi, limit = 10.77 dBm

RESULTS

No non-compliance noted:

802.11a MODE

802.11a Mode

Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5180	3.13	4.000	-0.87
Middle	5260	8.26	10.770	-2.51
High	5300	7.63	10.770	-3.14
High	5320	6.07	10.770	-4.70

802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

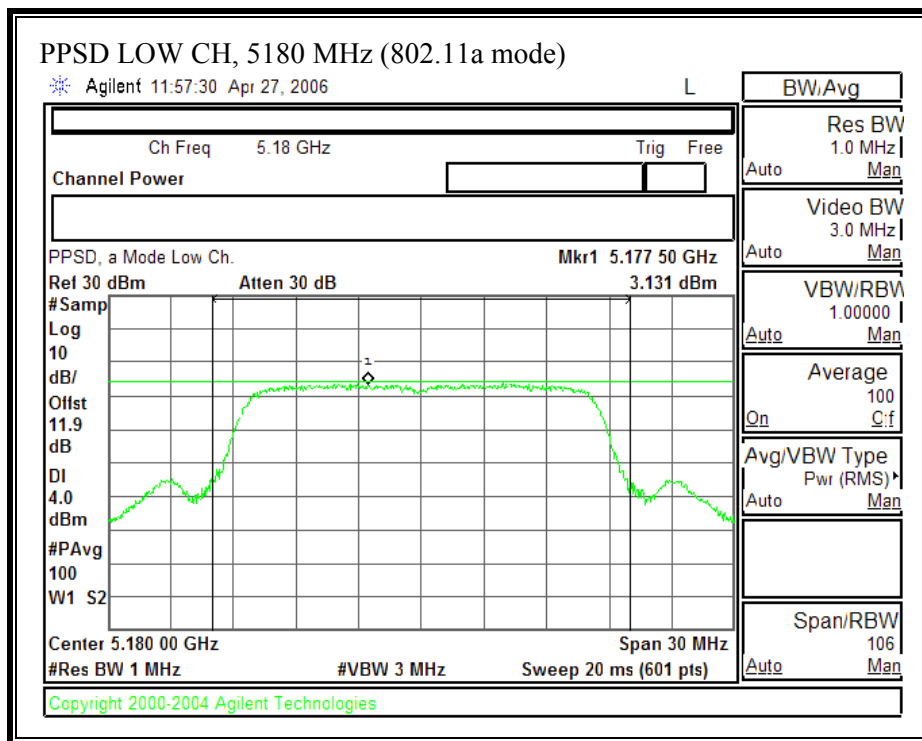
802.11n 40 MHz SISO MODE

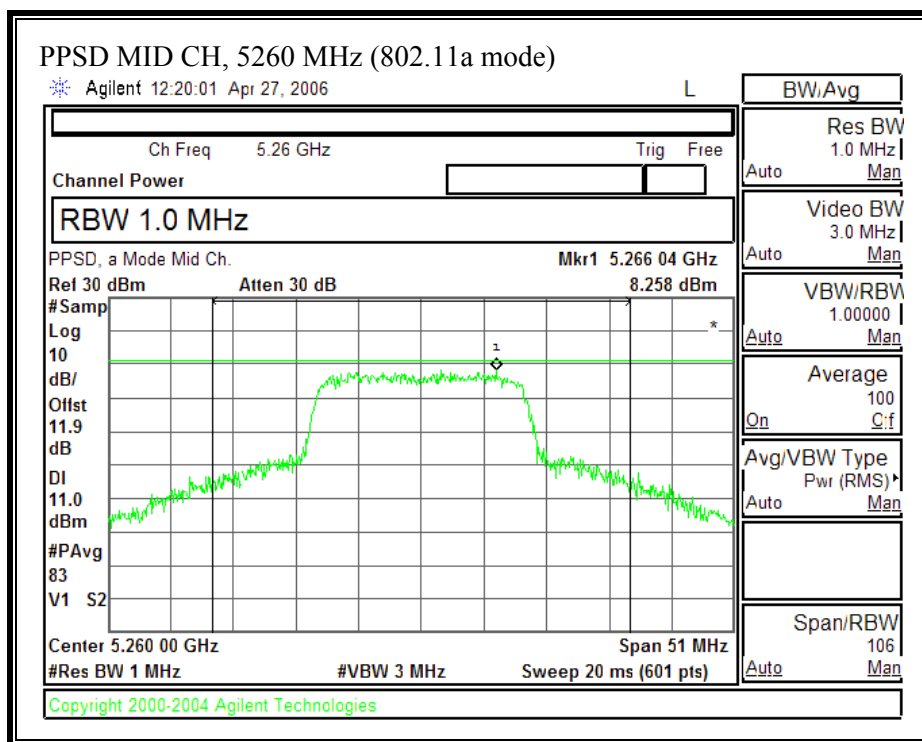
802.11a Mode

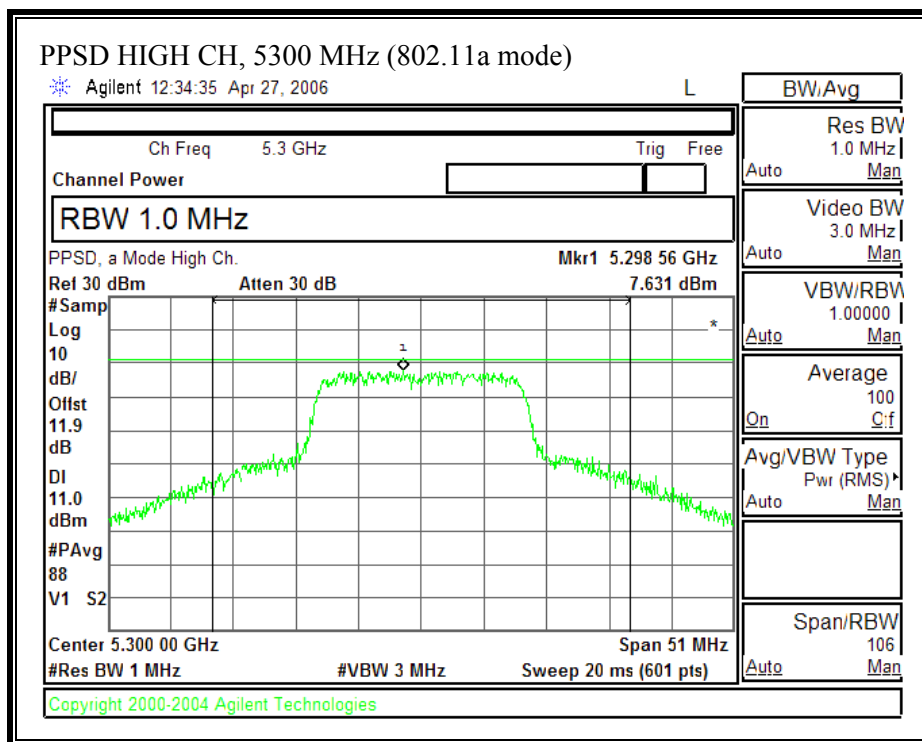
Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5190	-0.23	4.000	-4.23
Middle	5230	3.19	10.770	-7.58
High	5270	3.58	10.770	-7.19
High	5310	-0.50	10.770	-11.27

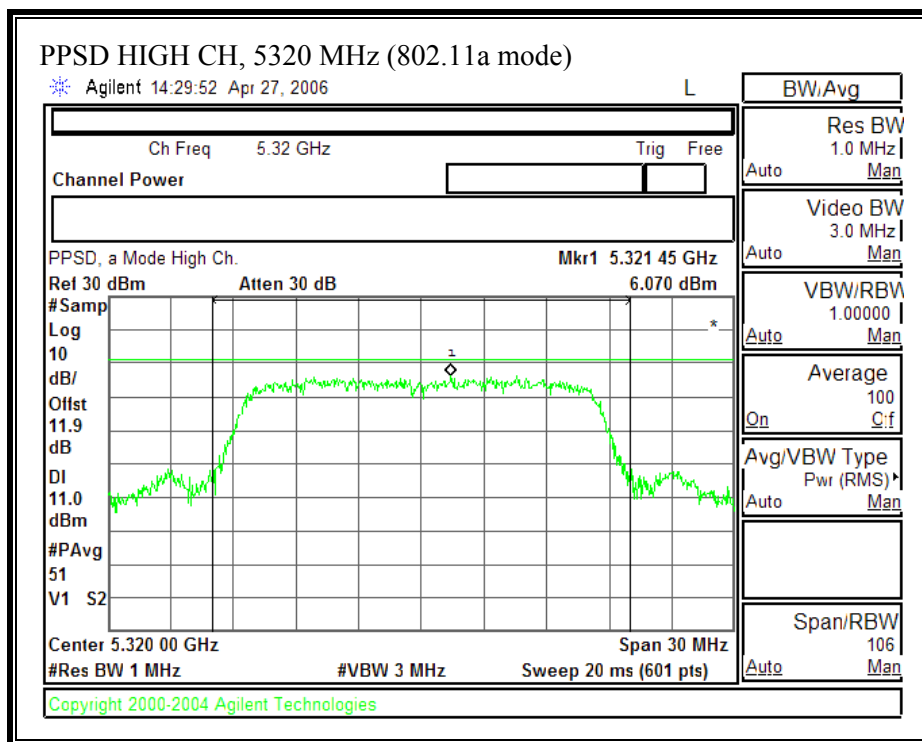
802.11a MODE

PEAK POWER SPECTRAL DENSITY (802.11a MODE)



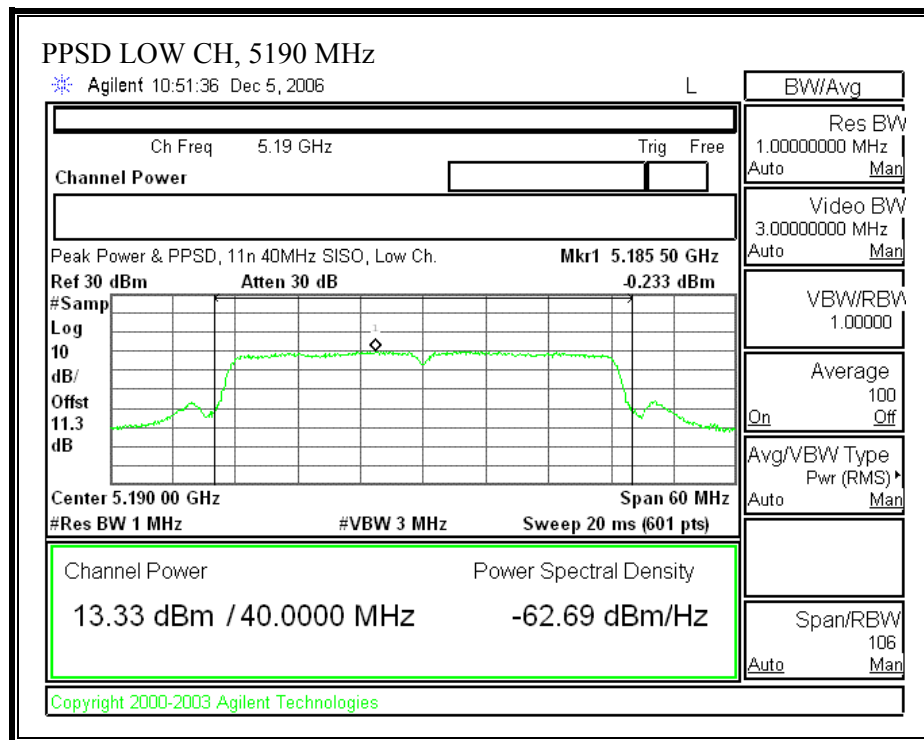


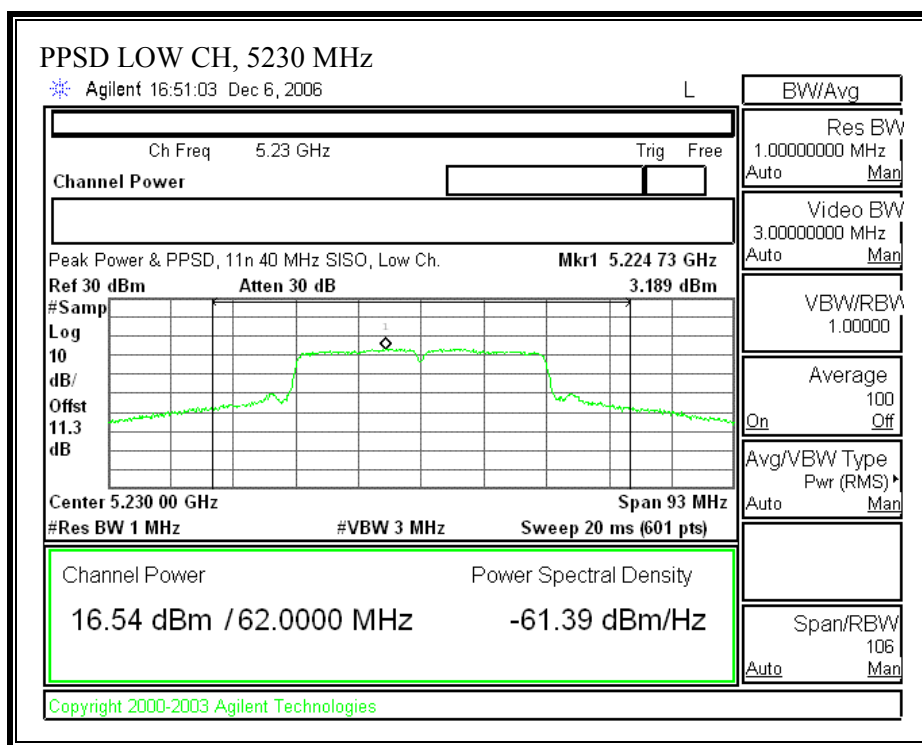


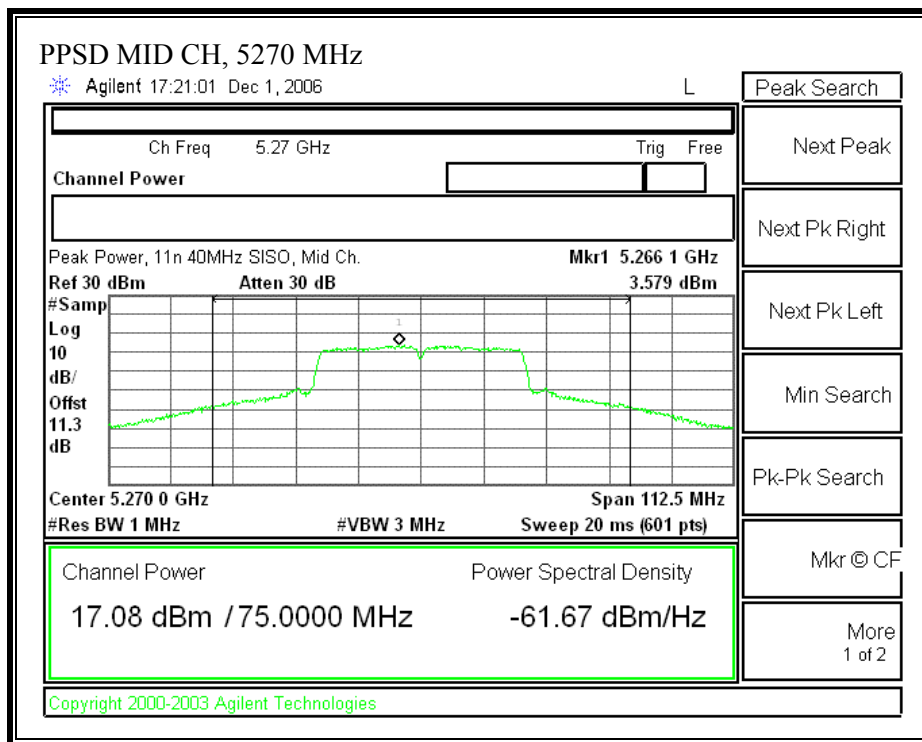


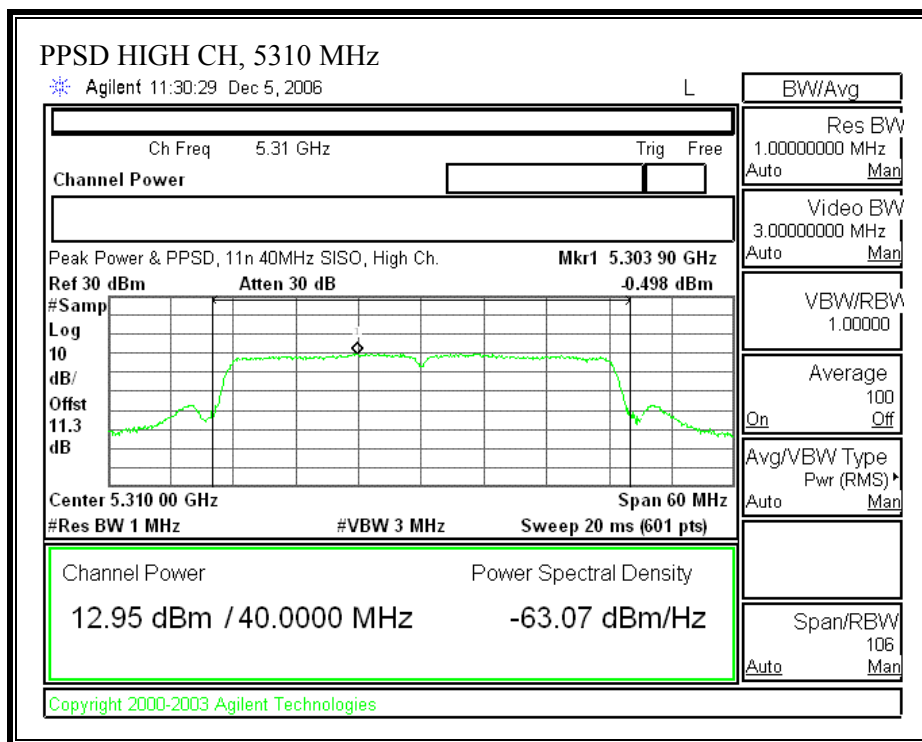
802.11n 40 MHz SISO MODE

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









7.1.5. PEAK EXCURSION

LIMIT

§15.407 (a) (6) The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the peak transmit power (measured as specified above) shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002.

Since Method # 1 was used for peak power measurements, Method # 1 settings are used for the second PPSD trace.

RESULTS

No non-compliance noted:

802.11a MODE

Channel	Frequency (MHz)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
Low	5180	7.76	13	-5.24
Middle	5260	9.21	13	-3.79
High	5300	11.25	13	-1.75
High	5320	8.05	13	-4.95

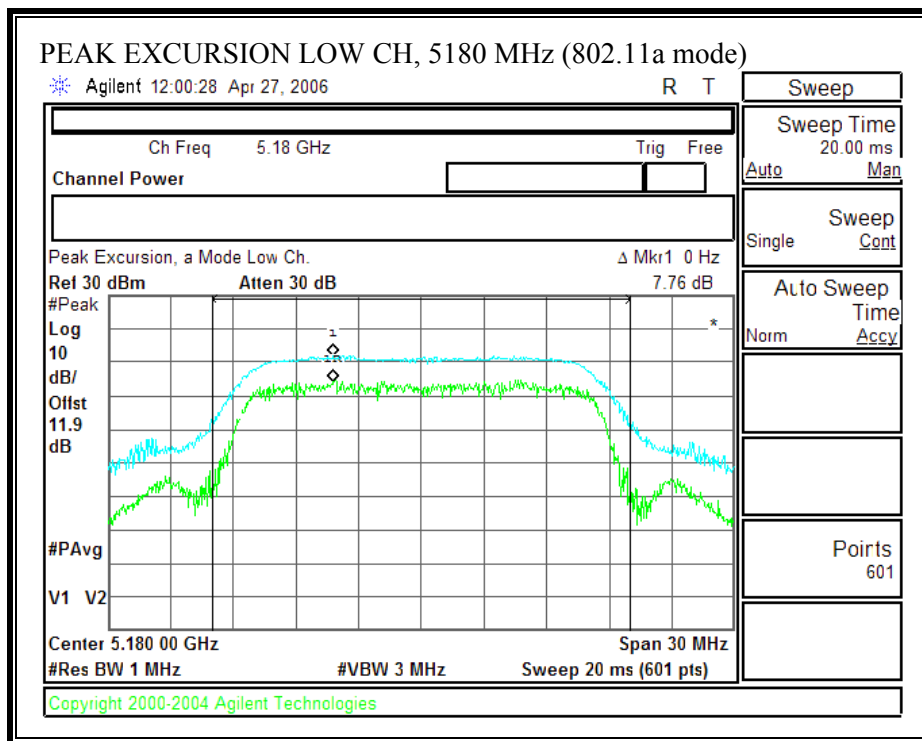
802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

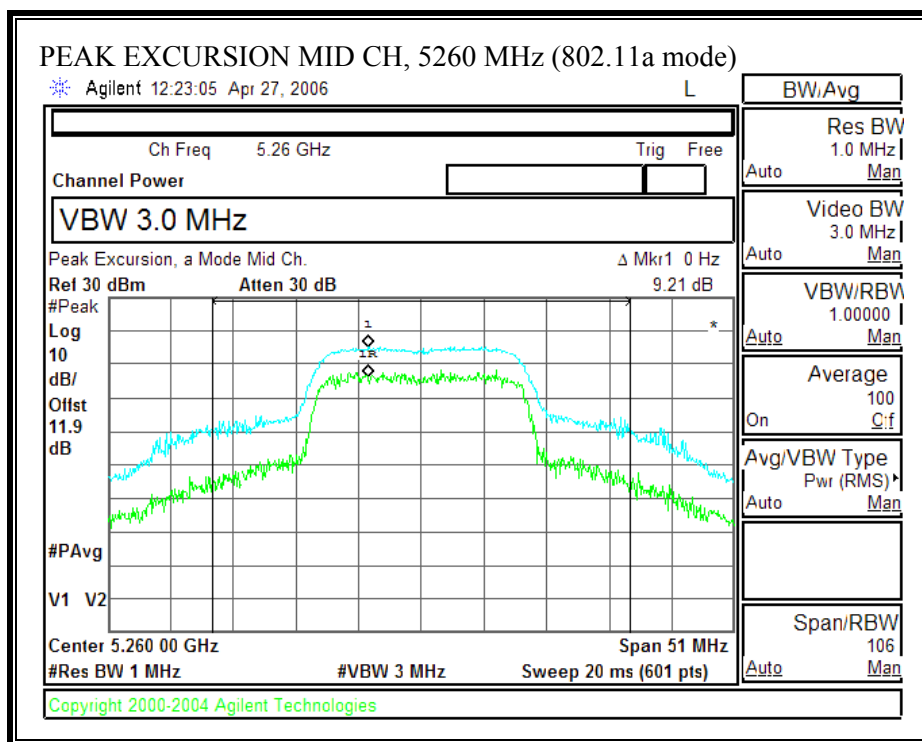
802.11n 40 MHz MODE

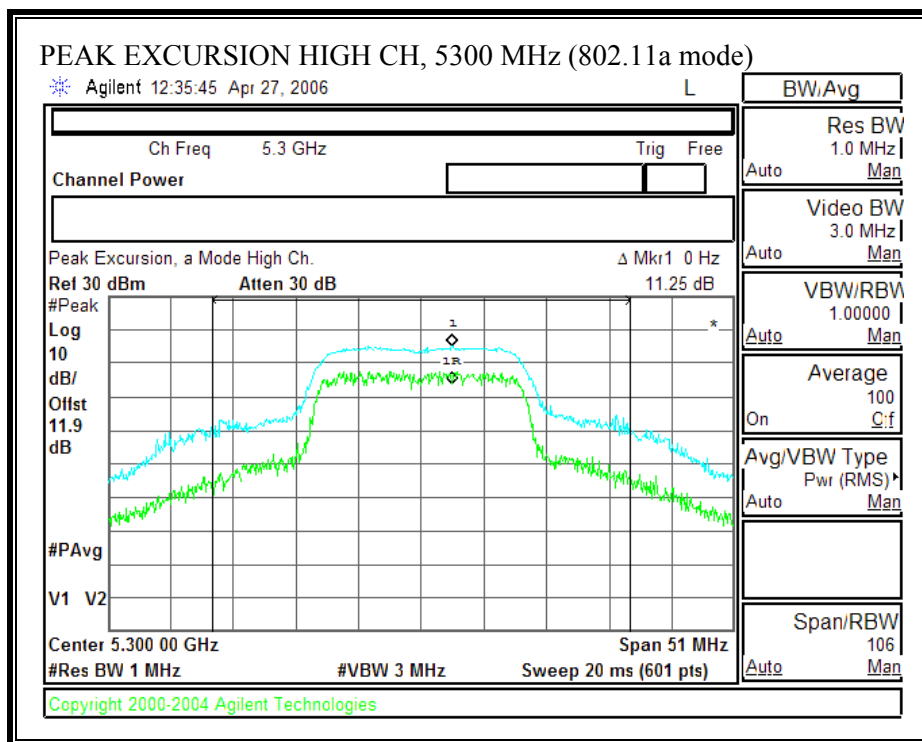
Channel	Frequency (MHz)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
Low	5190	9.24	13	-3.76
Low	5230	10.72	13	-2.28
Middle	5270	11.70	13	-1.30
High	5310	9.82	13	-3.18

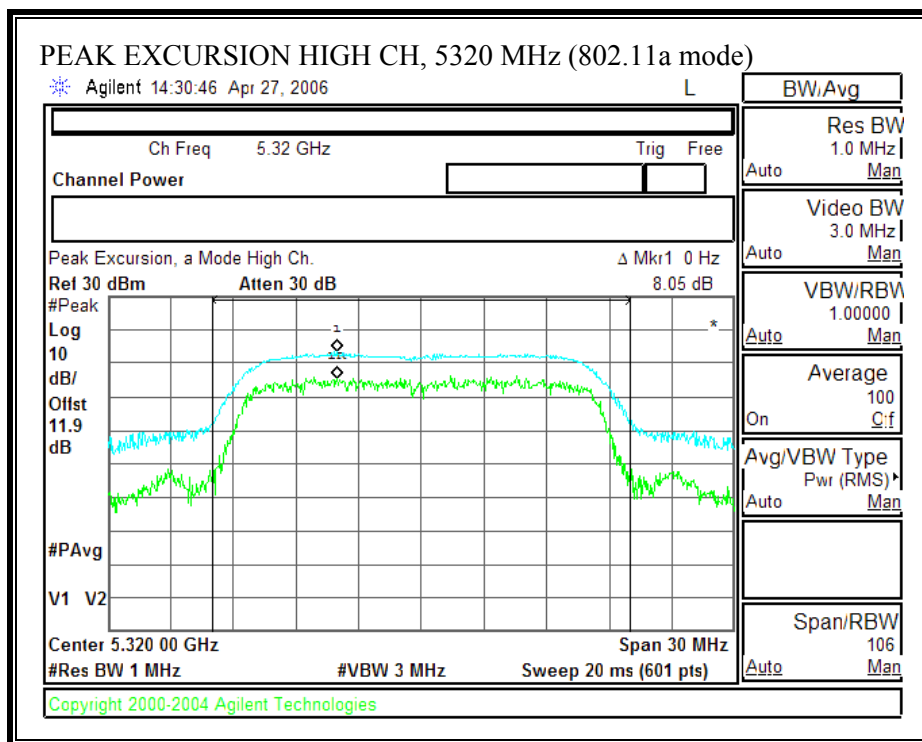
802.11a MODE

PEAK EXCURSION (802.11a MODE)





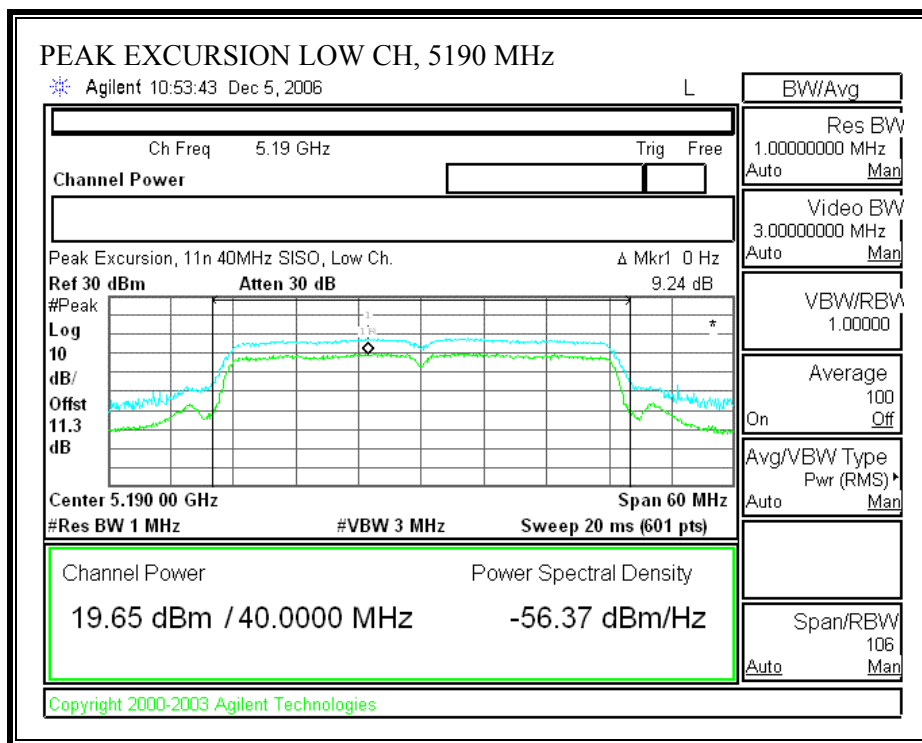


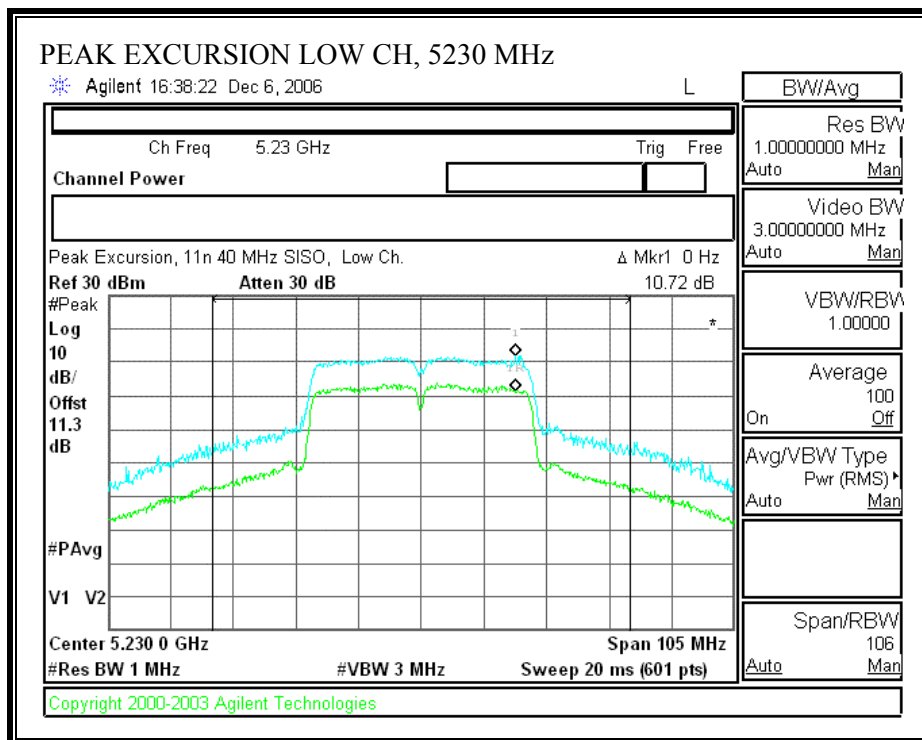


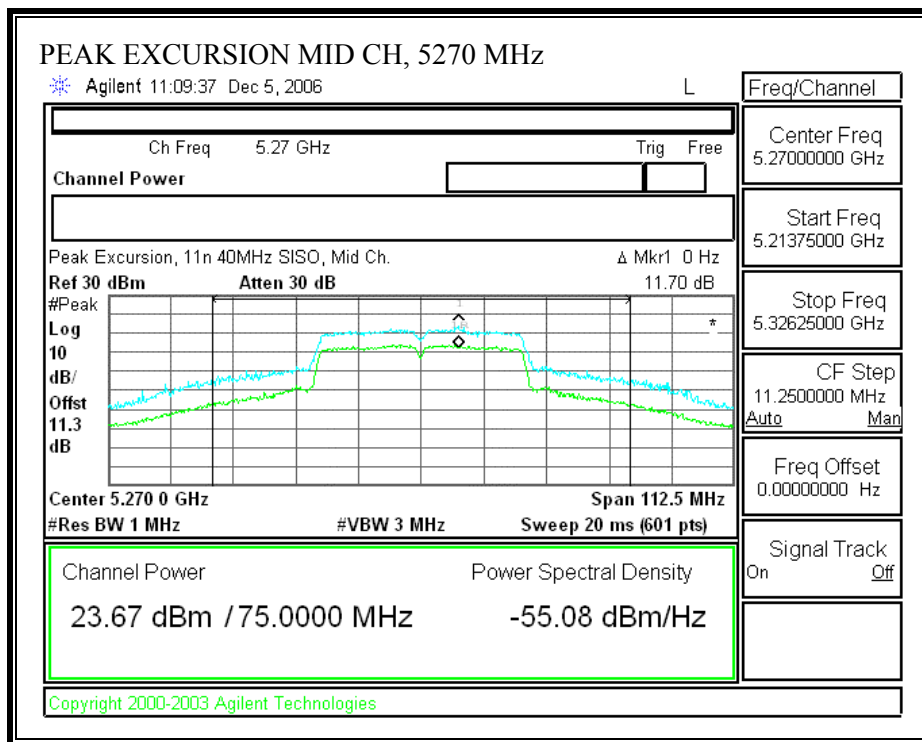
802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

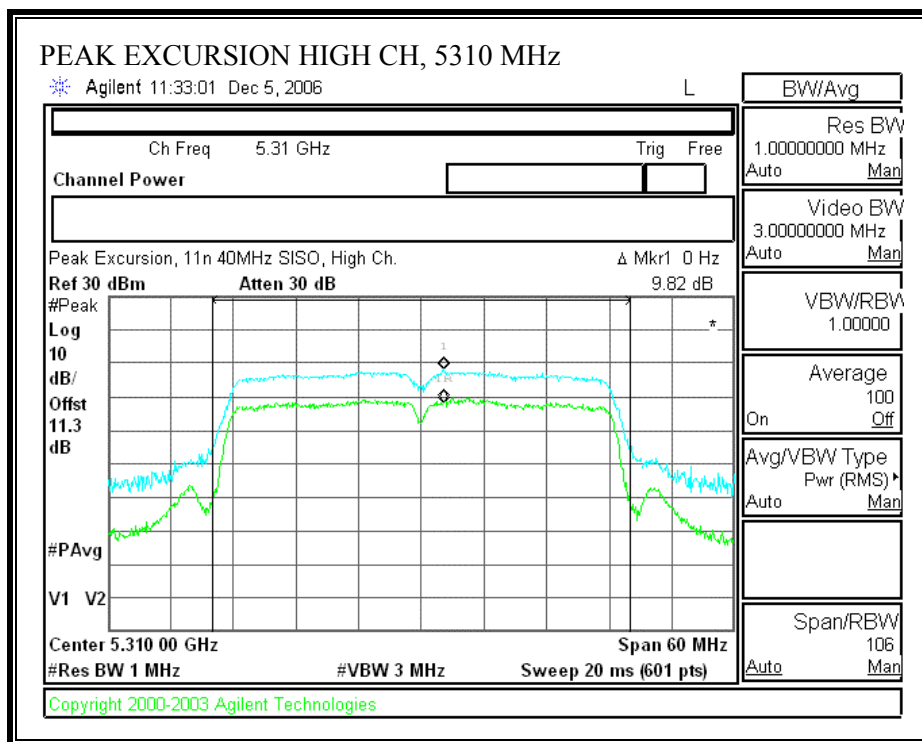
802.11n 40 MHz SISO MODE

PEAK EXCURSION (802.11n 40MHz SISO MODE)









7.1.6. CONDUCTED SPURIOUS EMISSIONS

LIMITS

§15.407 (b) (1 & 2) For transmitters operating in the 5.15-5.35 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27dBm / MHz.

TEST PROCEDURE

Conducted RF measurements of the transmitter output are made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer. The resolution bandwidth is set to 1 MHz. The video bandwidth is set to 1 MHz. Peak detection measurements are compared to the average EIRP limit, adjusted for the maximum antenna gain. If necessary, additional average detection measurements are made.

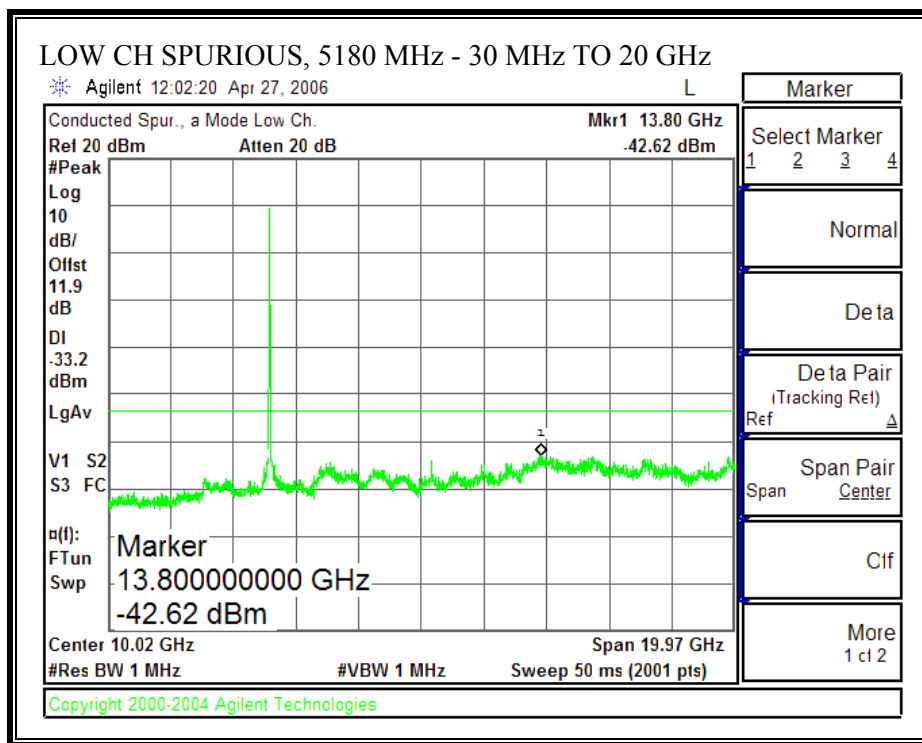
Measurements are made over the 30 MHz to 40 GHz range with the transmitter set to the lowest, middle, and highest channels.

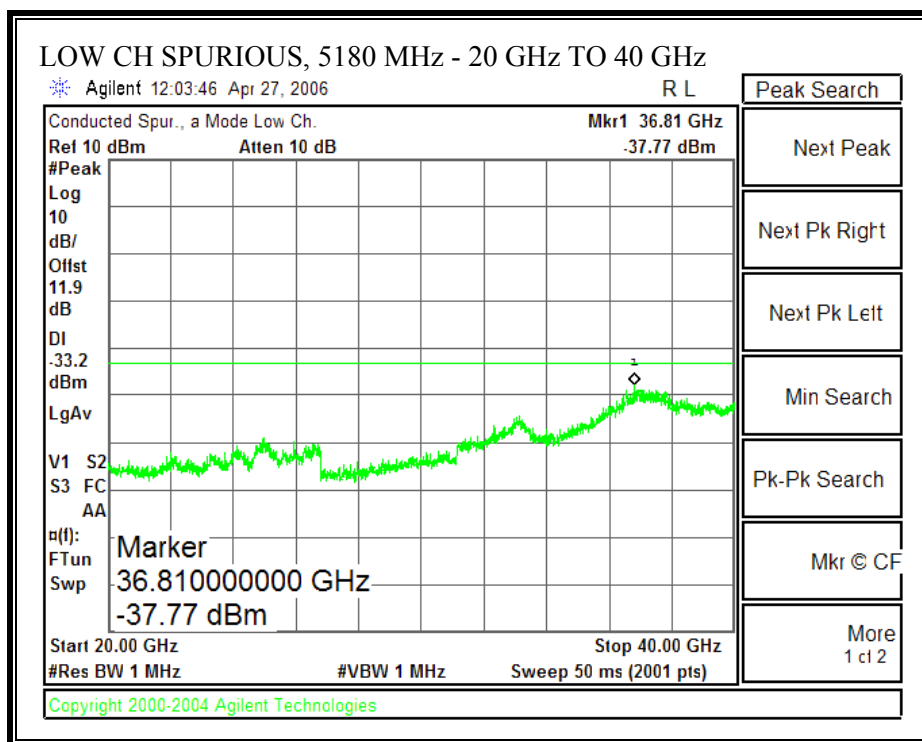
RESULTS

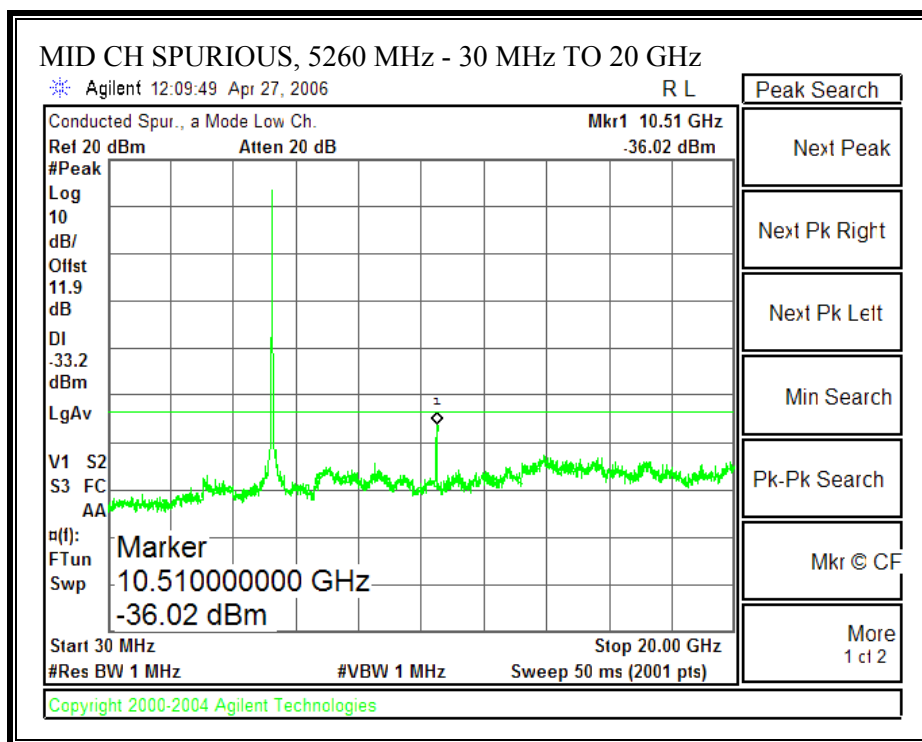
No non-compliance noted:

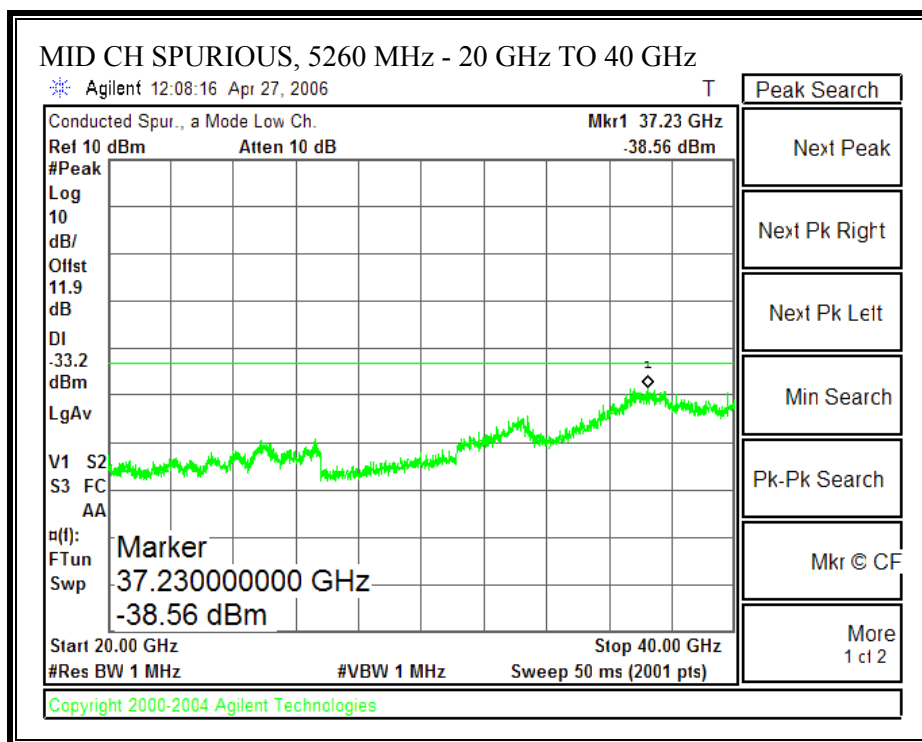
802.11a MODE

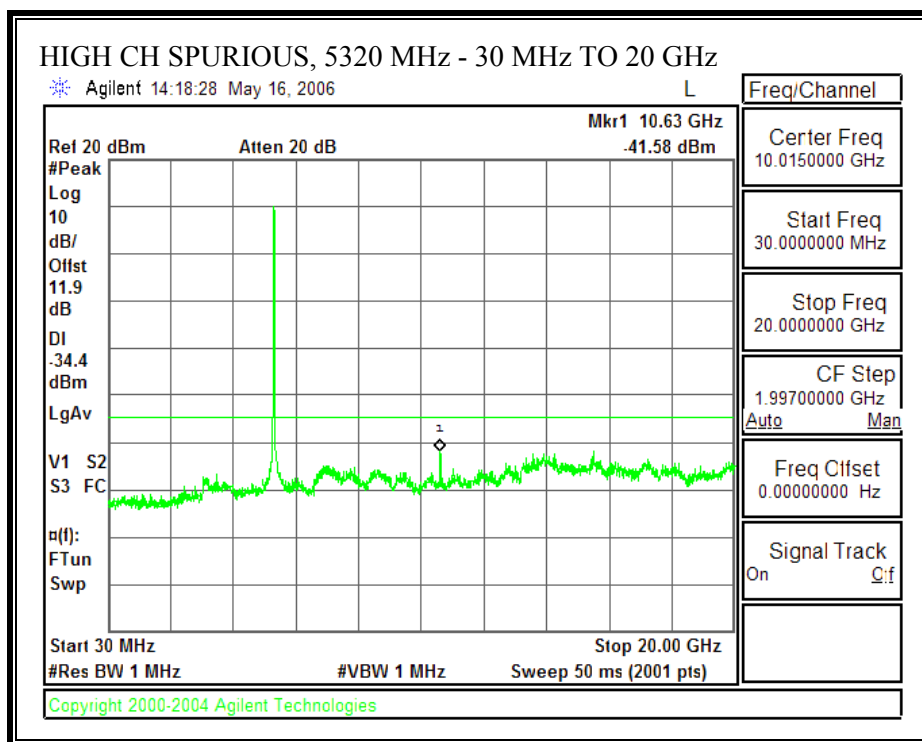
SPURIOUS EMISSIONS (802.11a MODE)

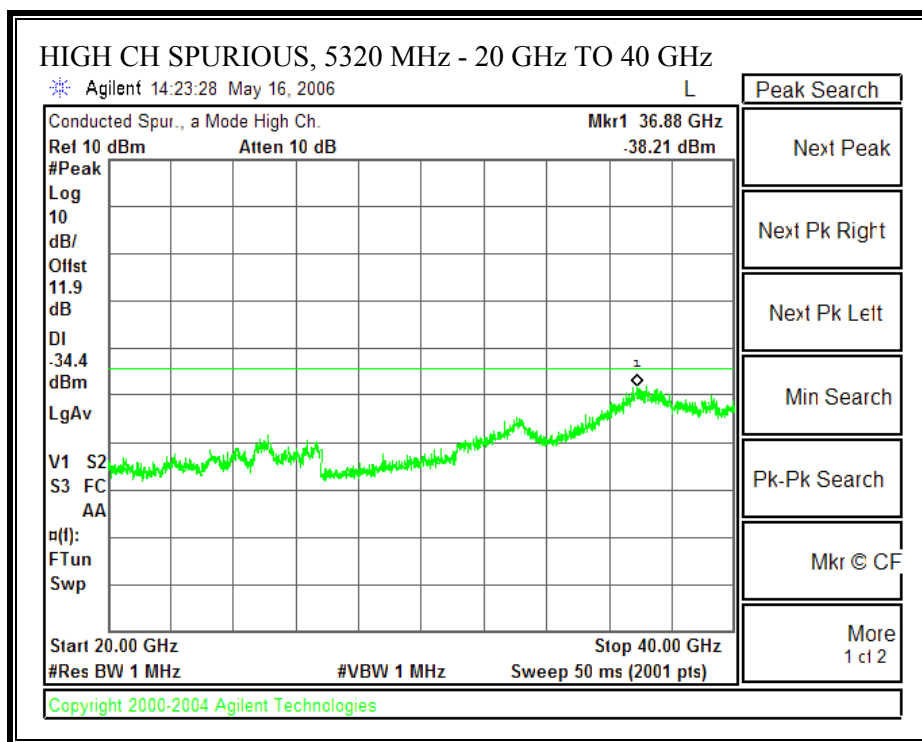








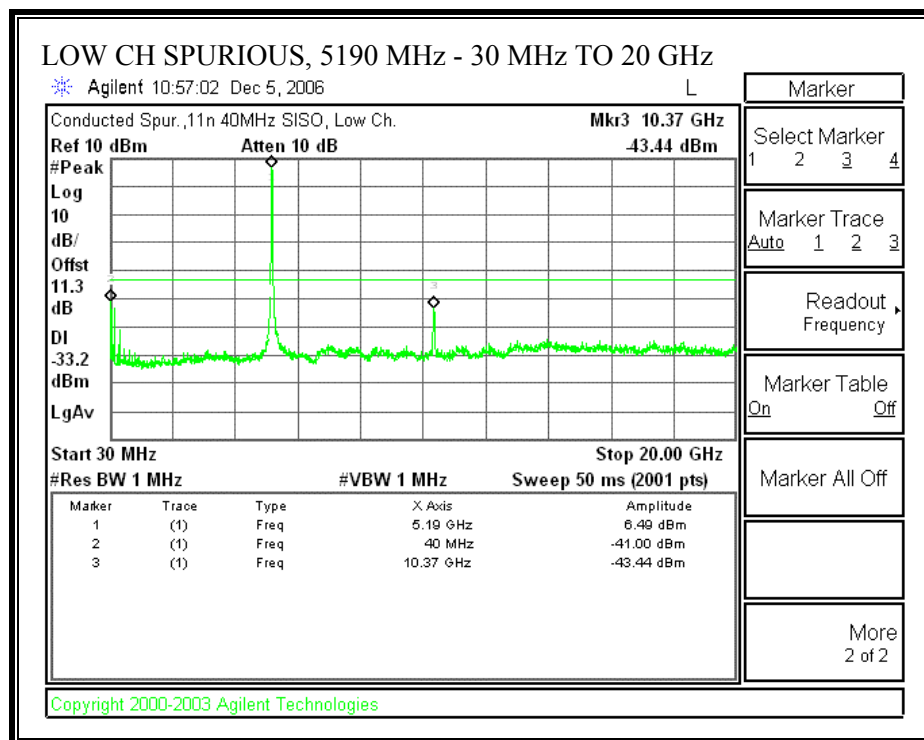


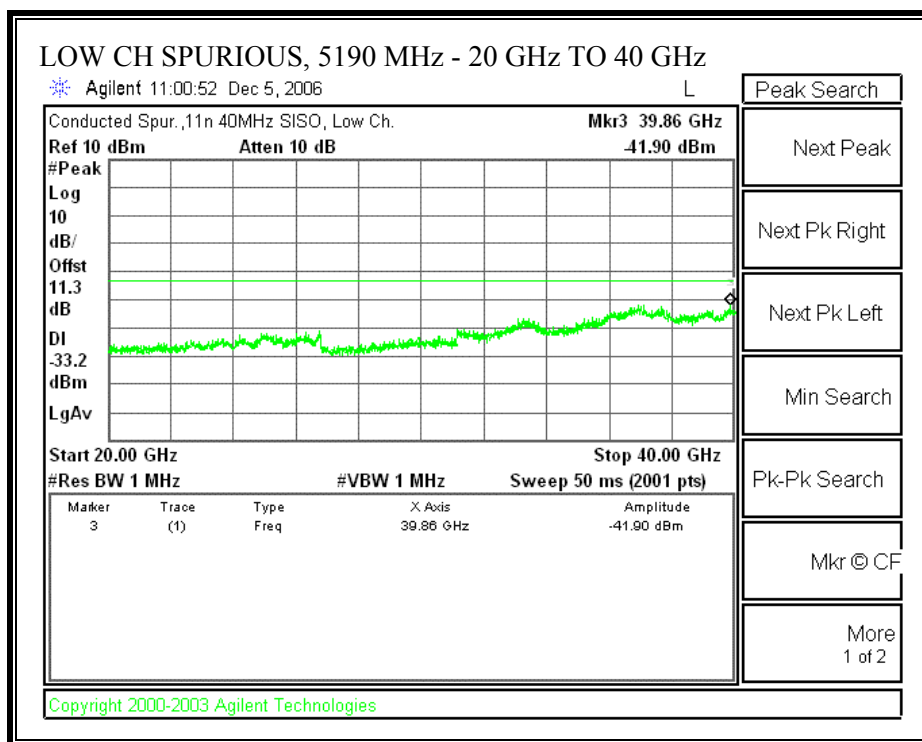


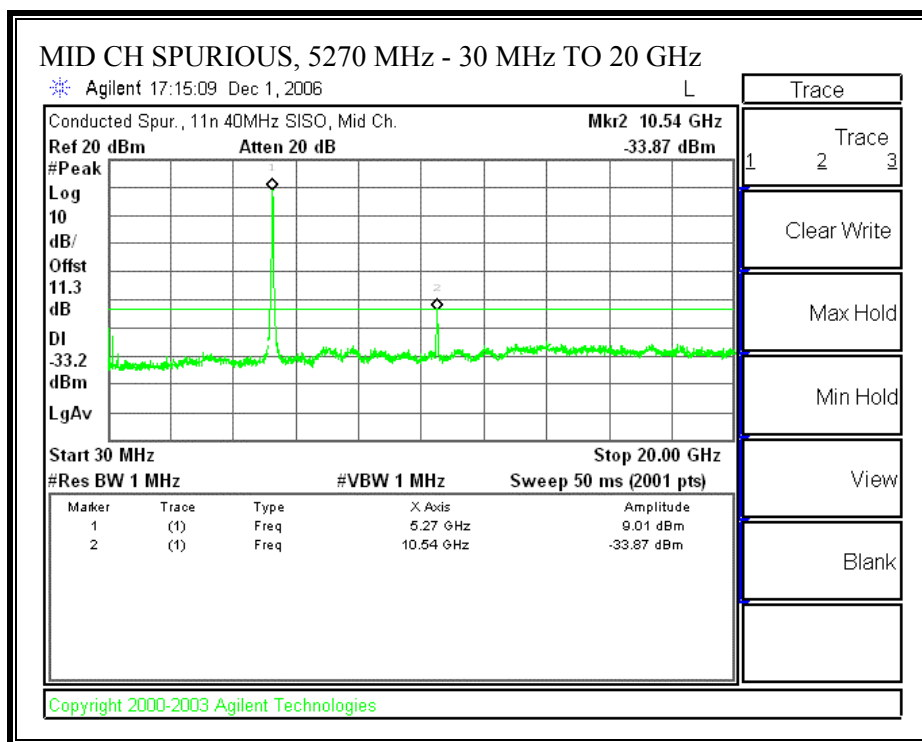
802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

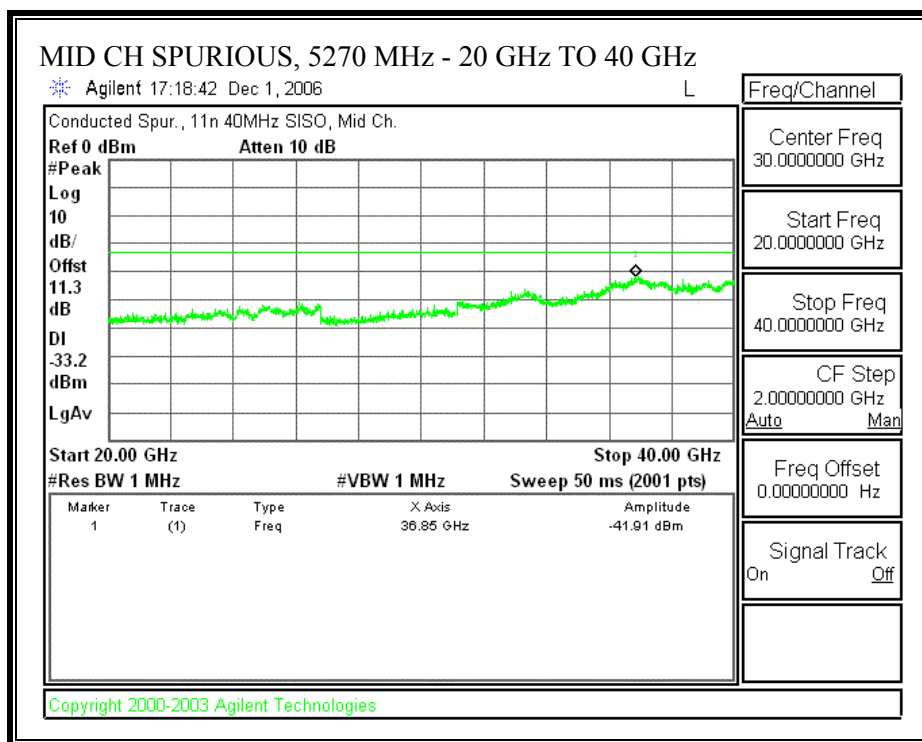
802.11n 40 MHz SISO MODE

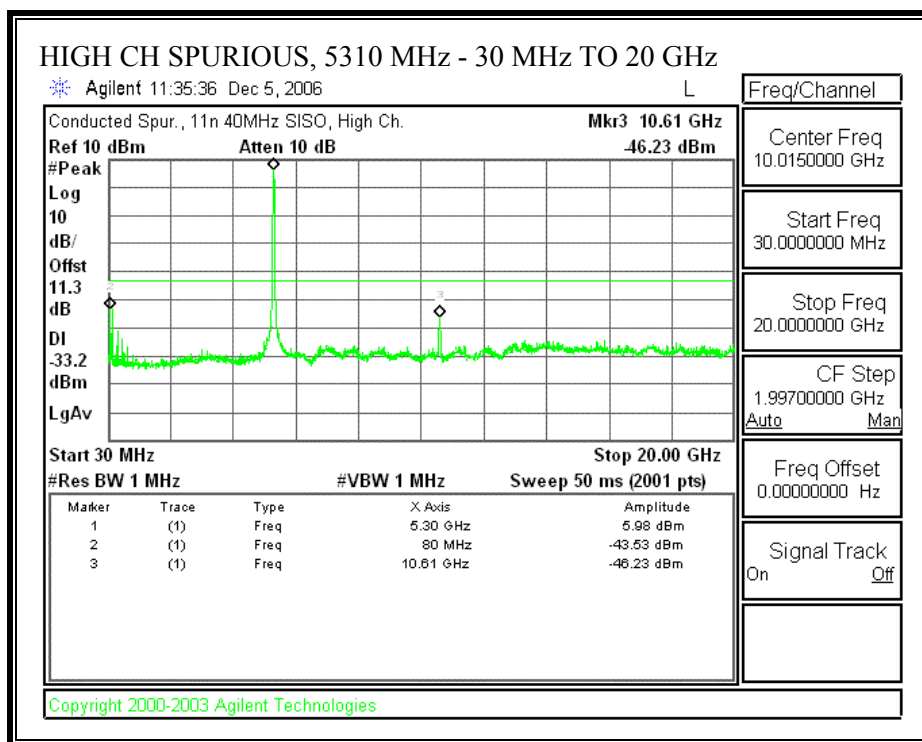
SPURIOUS EMISSIONS (802.11n 40MHz SISO MODE)

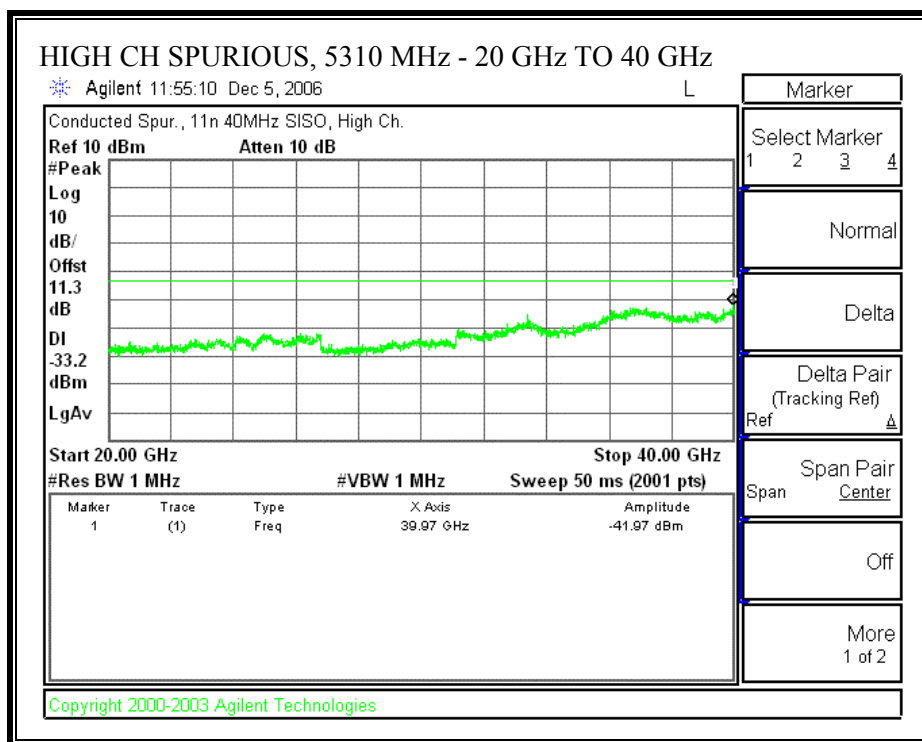












MIMO MODE

7.2. CHANNEL TESTS FOR THE 5150 TO 5350 MHz BAND

7.2.1. EMISSION BANDWIDTH

LIMIT

§15.403 (i) Emission bandwidth. For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolutions bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 1% to 3% of the 26 dB bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled.

RESULTS

No non-compliance noted:

802.11a CDD MODE is covered by worst case 802.11n 20 MHz CDD MCS 0

802.11n 20 MHz CDD MCS 0

802.11 - 20 MHz Tx BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5180	19.255	12.845
Middle	5260	23.272	13.668
High	5320	37.726	15.766

802.11 - 20 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5180	22.998	13.617
Middle	5260	23.834	13.772
High	5320	34.464	15.374

802.11n 40 MHz CDD MCS 32

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	44.836	16.516
Middle	5270	76.184	18.819
High	5310	65.430	18.158

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	39.829	16.002
Middle	5270	74.998	18.750
High	5310	61.061	17.858

802.11n 40 MHz SDM MCS 15

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 0

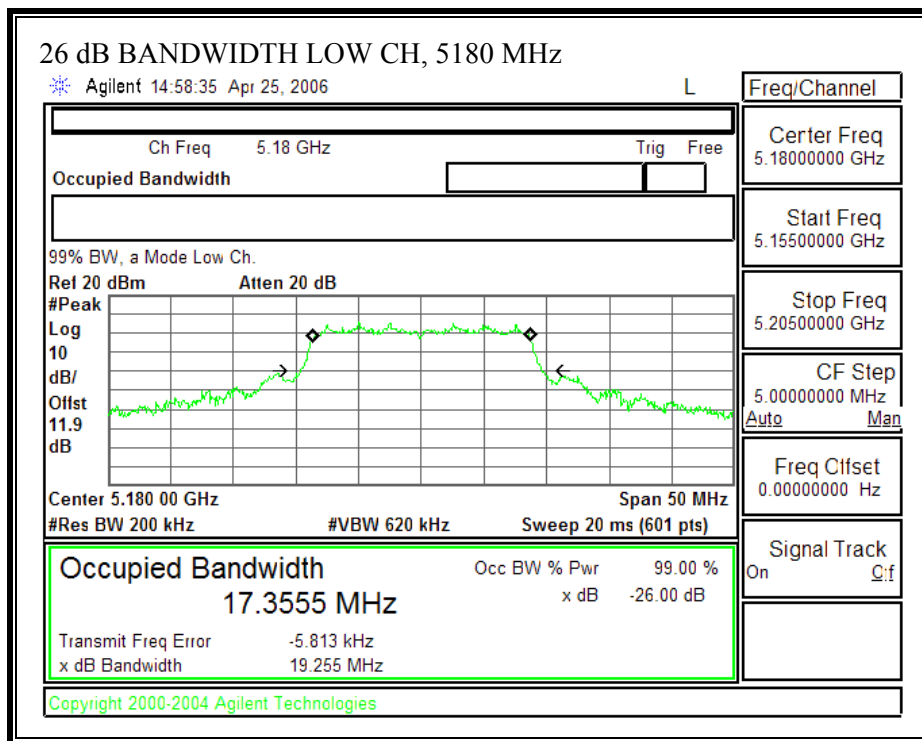
Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	42.020	16.235

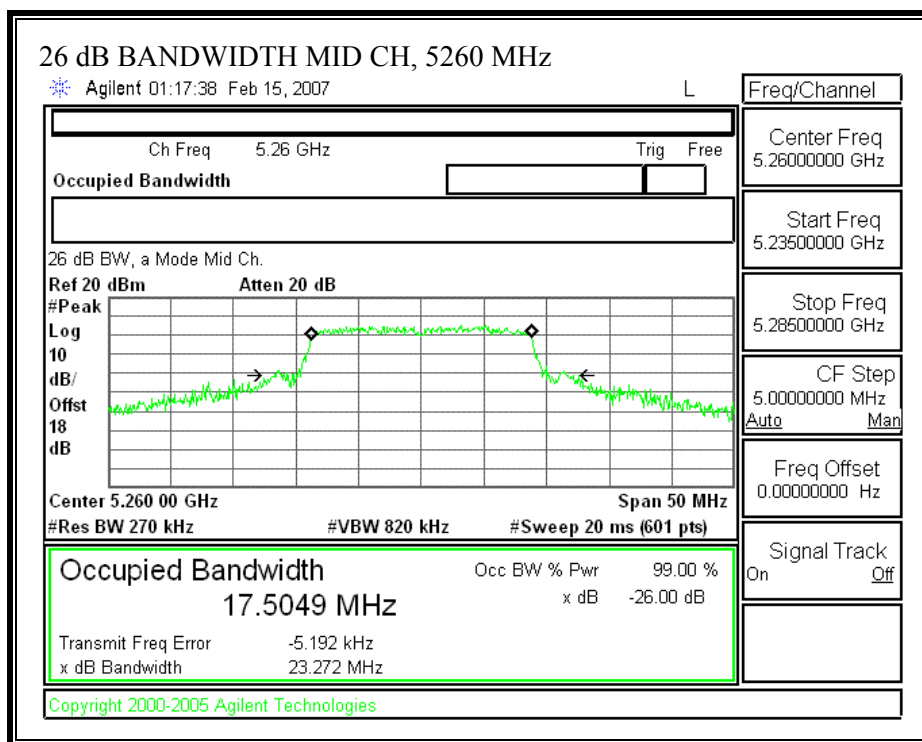
802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

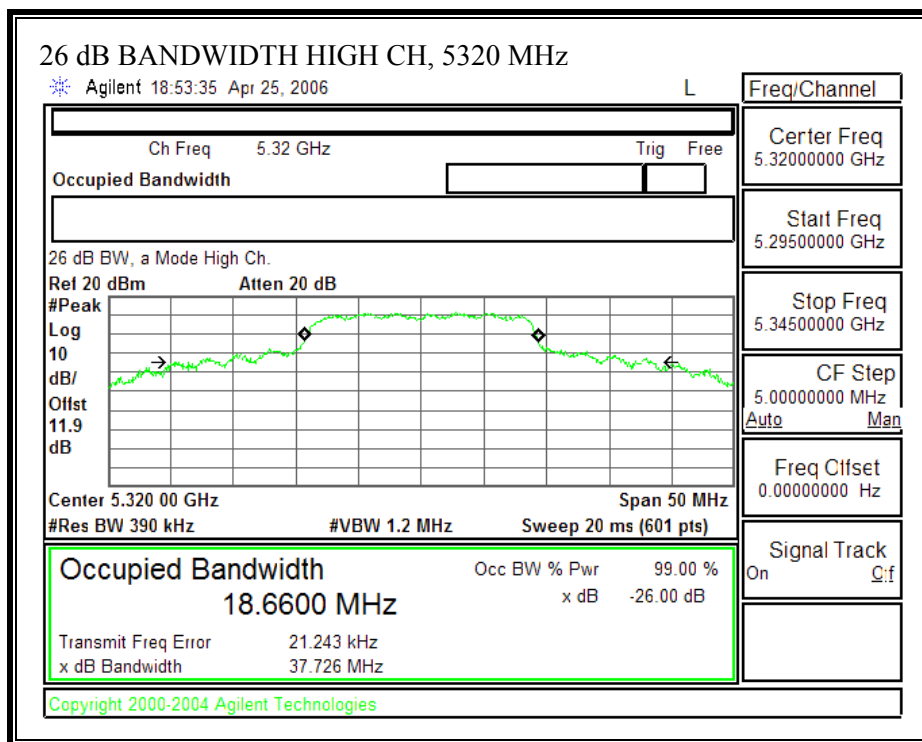
Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	39.804	15.999

802.11n 20 MHz CDD MCS 0

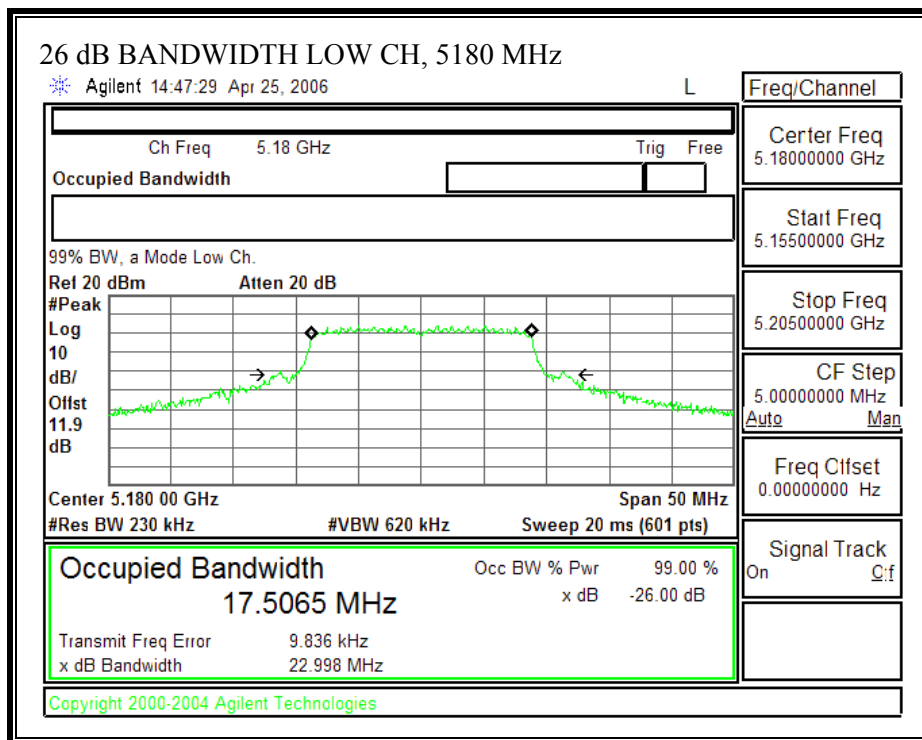
26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 0)

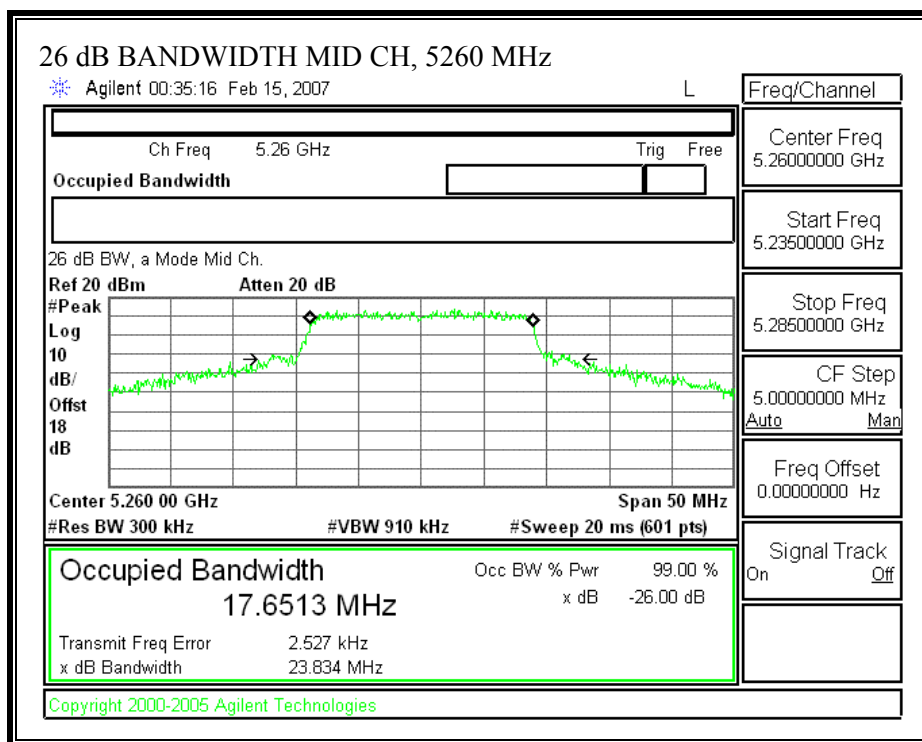


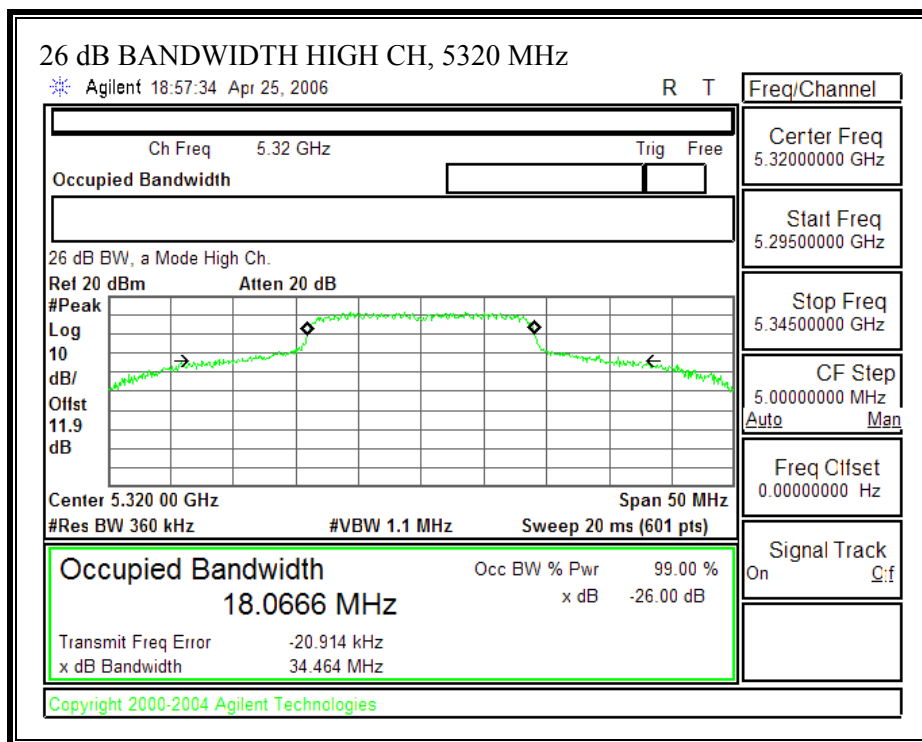


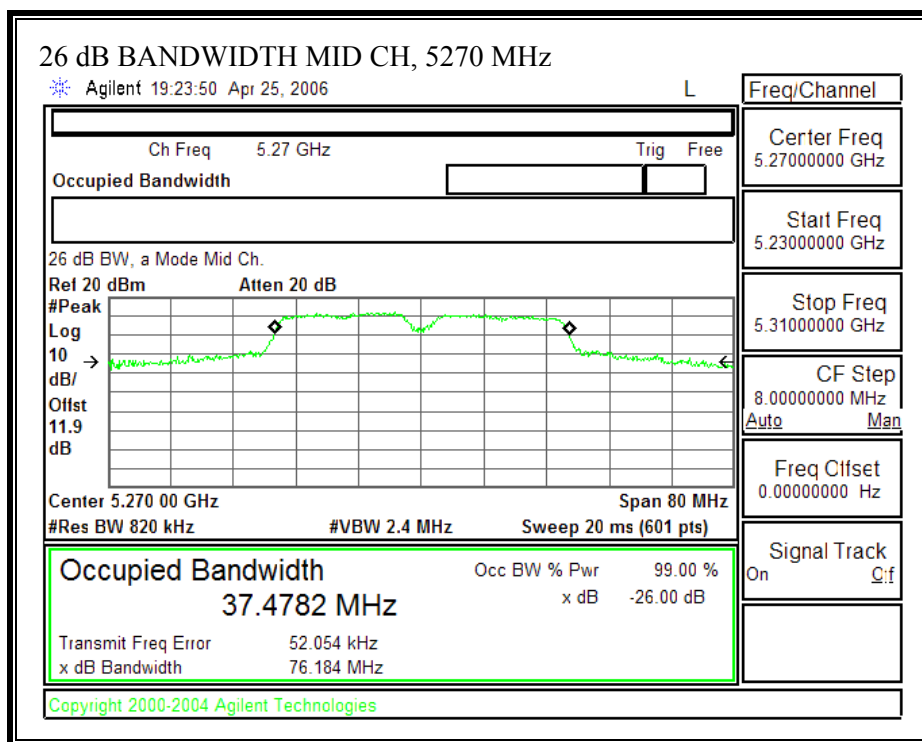


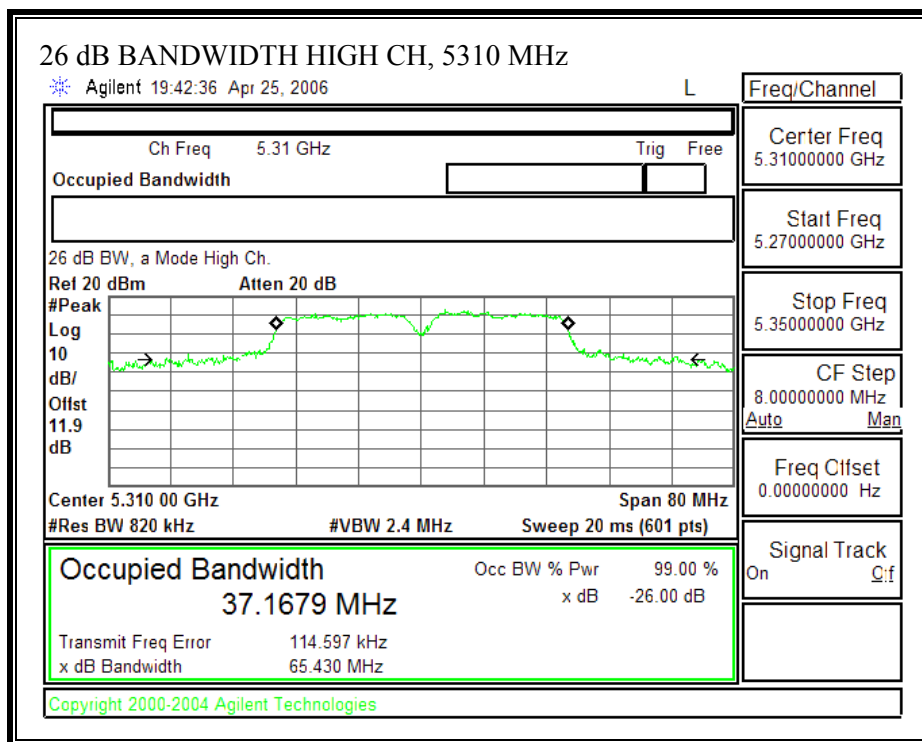
26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 1)



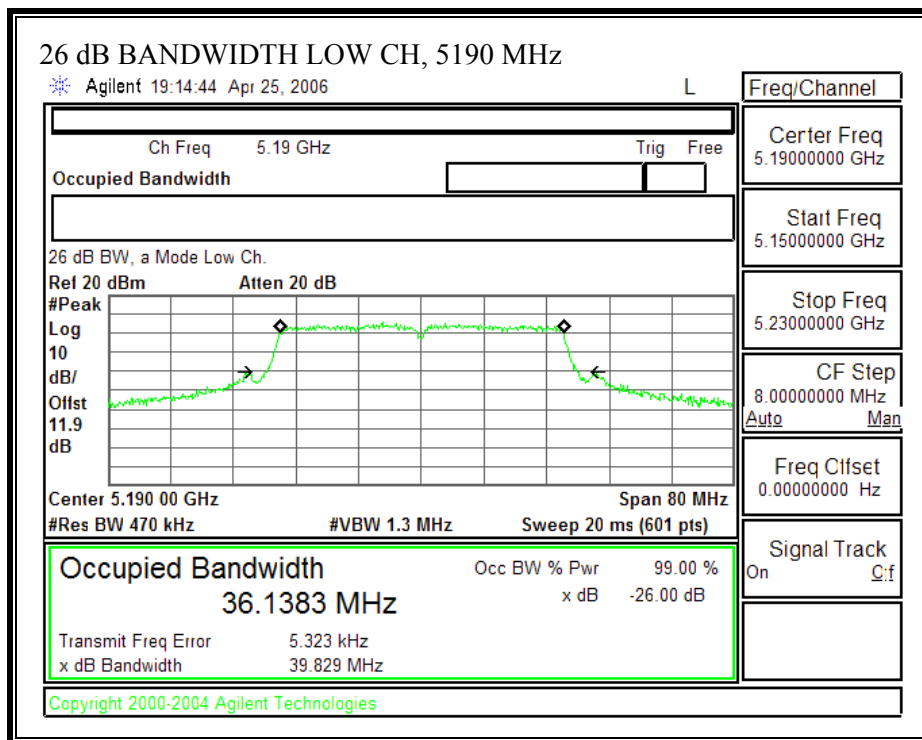


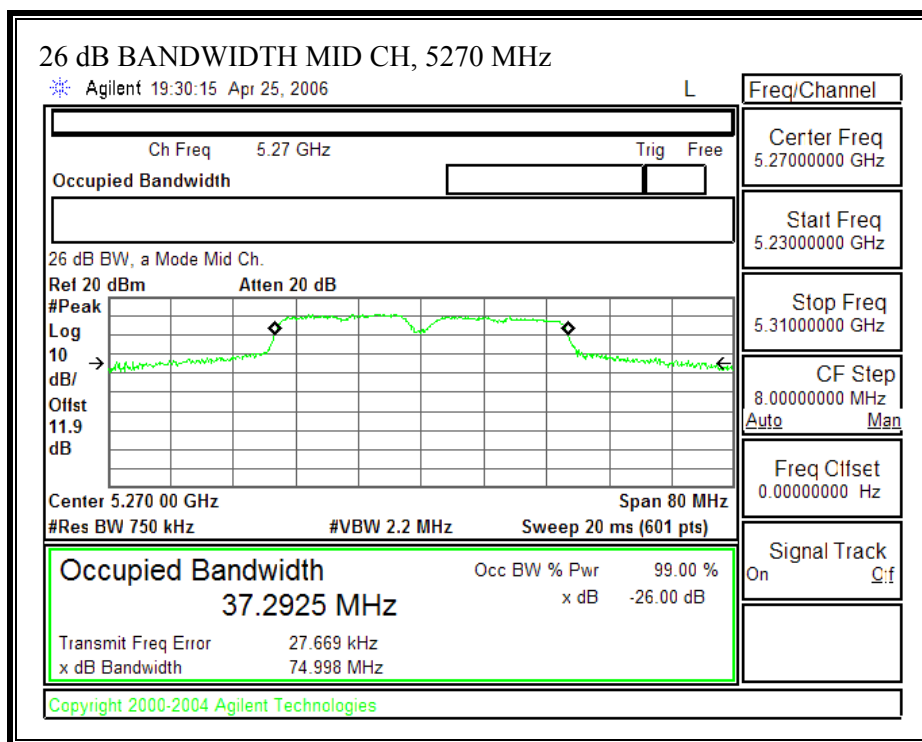


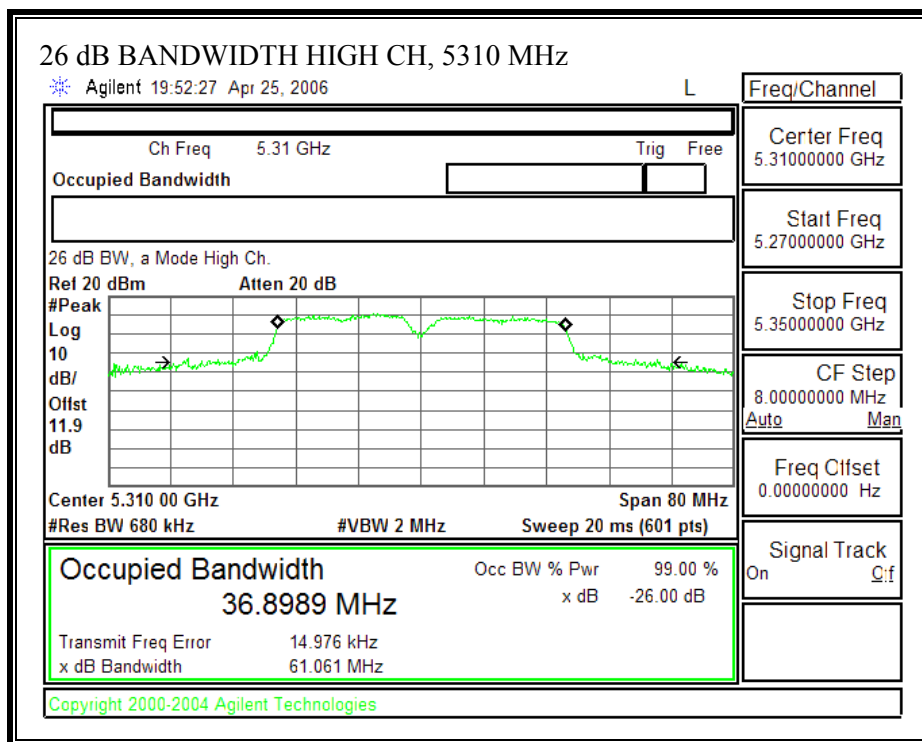




26 dB EMISSION BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH- CHAIN 1)

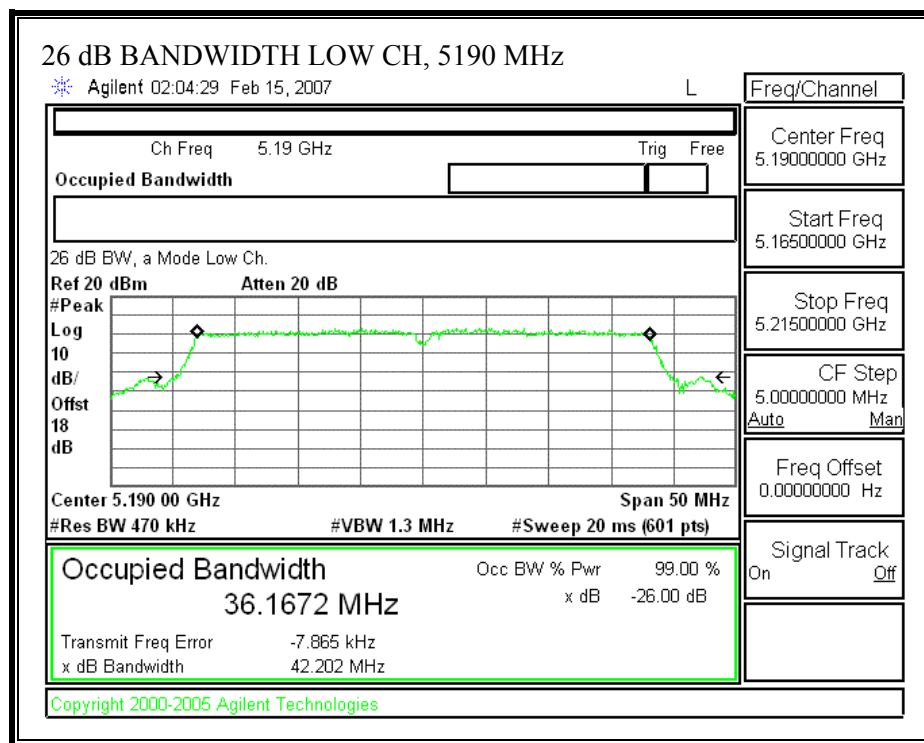




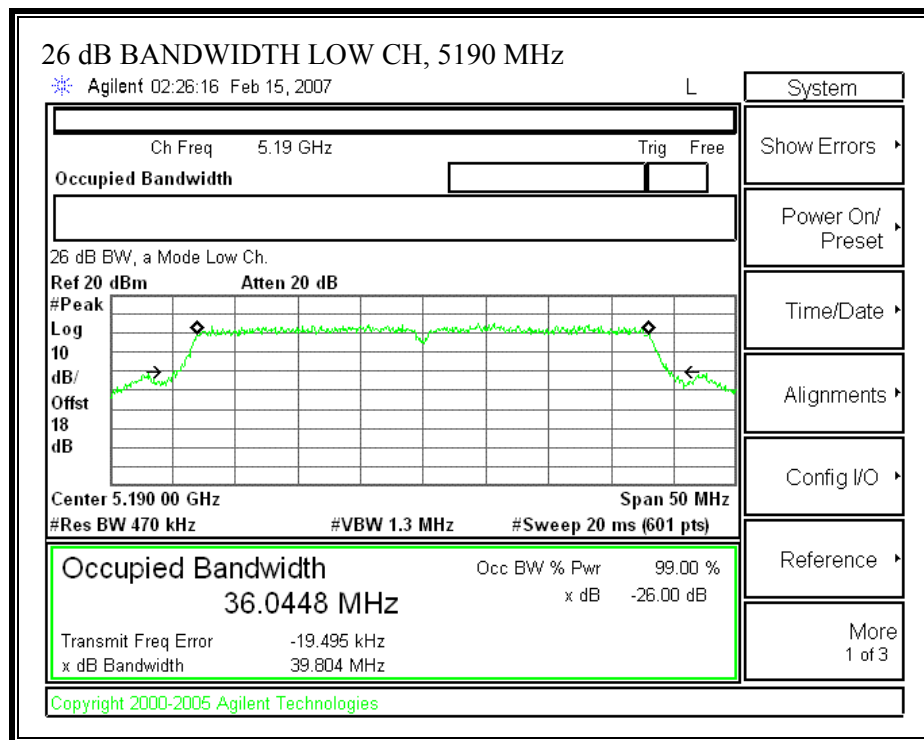


802.11n 40 MHz SDM MCS 15

26 dB EMISSION BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH- CHAIN 0)



26 dB EMISSION BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH- CHAIN 1)



7.2.2. PEAK POWER

LIMIT

§15.407 (a) (1) For the band 5.15-5.25 GHz, the peak transmit power over the frequency band of operation shall not exceed the lesser of 50 mW or $4 \text{ dBm} + 10 \log B$, where B is the 26-dB emission bandwidth in MHz. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

§15.407 (a) (1) For the band 5.25-5.35 GHz, the peak transmit power over the frequency band of operation shall not exceed the lesser of 250 mW or $11 \text{ dBm} + 10 \log B$, where B is the 26-dB emission bandwidth in MHz. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002.

The transmitter output operates continuously therefore Method # 1 is used.

LIMITS AND RESULTS

The cable assembly insertion loss of 11.9 dB (including 10 dB pad and 1.9 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

RESULTS.

Total peak power calculation formula: $10 \log (10^{(P_{\text{chain0}} / 10)} + 10^{(P_{\text{chain1}} / 10)})$

Note: Pchain 0 and Pchain1 are in dBm

For combiner: Following formula to calculate the array gain:

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

5.15 – 5.25GHz band: 7.077dBi

5.25 – 5.35GHz band: 8.677dBi

802.11n 20 MHz CDD MCS 0

7.077dBi for low band & 8.677dBi for high band

Limit in 5150 to 5250 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B Chain 0 (MHz)	B Chain 1 (MHz)	4 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5180	17	19.255	22.998	16.845	7.08	15.77

Limit in 5250 to 5350 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	B (MHz)	11 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Mid	5260	24	23.272	23.834	24.668	8.68	21.32
High	5320	24	37.726	34.464	26.374	8.68	21.32

Results

Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5180	9.11	9.34	12.24	15.77	-3.53
Mid	5260	14.51	14.65	17.59	21.32	-3.73
High	5320	13.07	13.04	16.07	21.32	-5.26

6dBi Antenna

Note: The high channel utilizes the same power level for all antennas, high channel power data in table below is from 8.677 dBi data.

Limit in 5150 to 5250 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B Chain 0 (MHz)	B Chain 1 (MHz)	4 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5180	17	19.255	22.998	16.845	6.00	16.85

Limit in 5250 to 5350 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	B (MHz)	11 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Mid	5260	24	23.272	23.834	24.668	6.00	24.00
High	5320	24	37.726	34.464	26.374	6.00	24.00

Results

Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5180	10.09	10.20	13.16	16.85	-3.69
Mid	5260	17.22	17.34	20.29	24.00	-3.71
High	5320	13.07	13.04	16.07	24.00	-7.93

802.11n 40 MHz CDD MCS 32

7.077dBi for low band & 8.677dBi for high band

Limit in 5150 to 5250 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B Chain 0 (MHz)	B Chain 1 (MHz)	4 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5190	17	44.836	39.829	20.002	7.08	15.92

Limit in 5250 to 5350 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B Chain 0 (MHz)	B Chain 1 (MHz)	11 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Mid	5270	24	76.184	74.998	29.750	8.67	21.33
High	5310	24	65.430	61.061	28.858	8.67	21.33

Results

Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5190	11.59	12.19	14.91	15.92	-1.01
Mid	5270	15.53	15.83	18.69	21.33	-2.64
High	5310	12.17	12.12	15.16	21.33	-6.18

6Bi Antenna

Note: The mid and high channels utilize the same power level for all antennas, mid and high channel power data in table below is from 8.677 dBi data.

Limit in 5150 to 5250 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B Chain 0 (MHz)	B Chain 1 (MHz)	4 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5190	17	44.836	39.829	20.002	6.00	17.00

Limit in 5250 to 5350 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B Chain 0 (MHz)	B Chain 1 (MHz)	11 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Mid	5270	24	76.184	74.998	29.750	6.00	24.00
High	5310	24	65.430	61.061	28.858	6.00	24.00

Results

Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5190	12.37	12.36	15.38	17.00	-1.62
Mid	5270	15.53	15.83	18.69	24.00	-5.31
High	5310	12.17	12.12	15.16	24.00	-8.84

802.11n 40 MHz SDM

LIMITS AND RESULTS FOR EIRP:

Limit in 5150 to 5250 MHz Band

Channel	Frequency (MHz)	Fixed Limit (dBm)	B Chain 0 (MHz)	B Chain 1 (MHz)	4 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5190	17	42.202	39.804	19.999	4.37	17.00

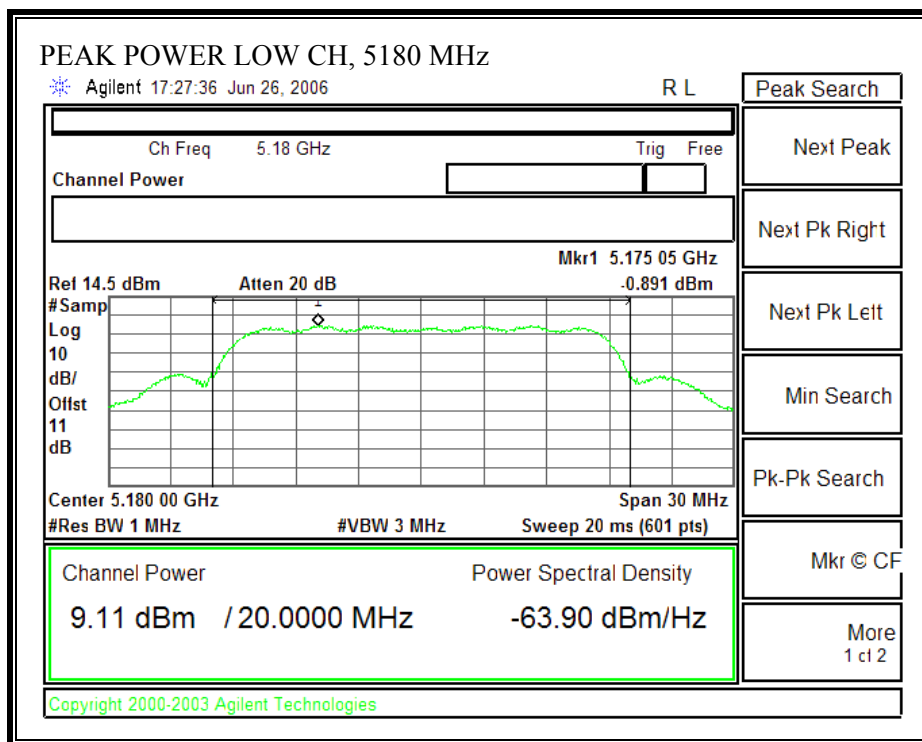
Results

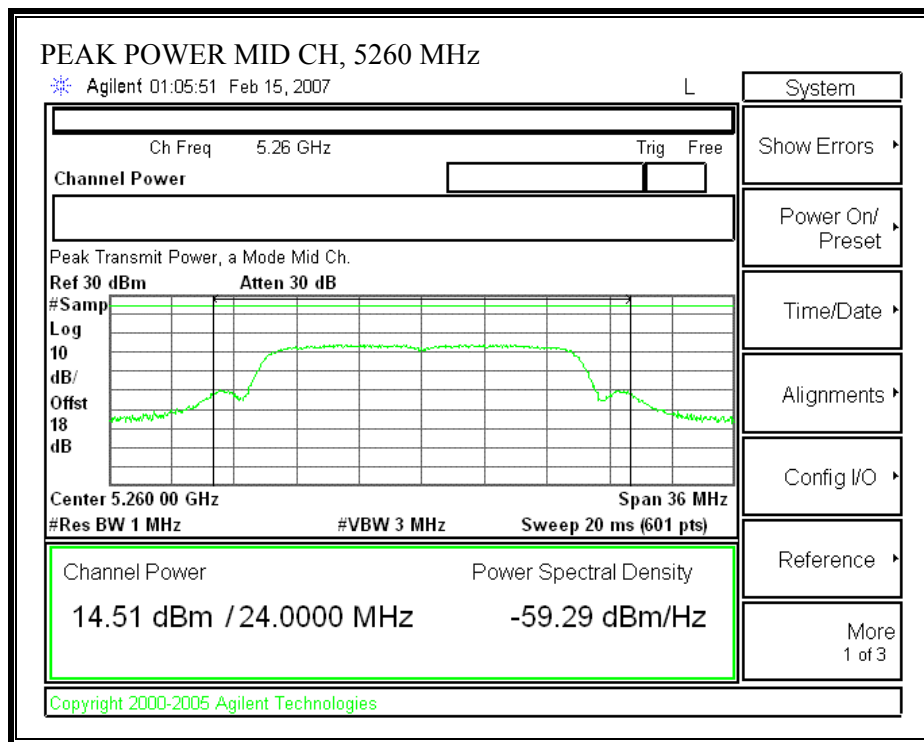
Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5190	12.56	12.59	15.59	17.00	-1.41

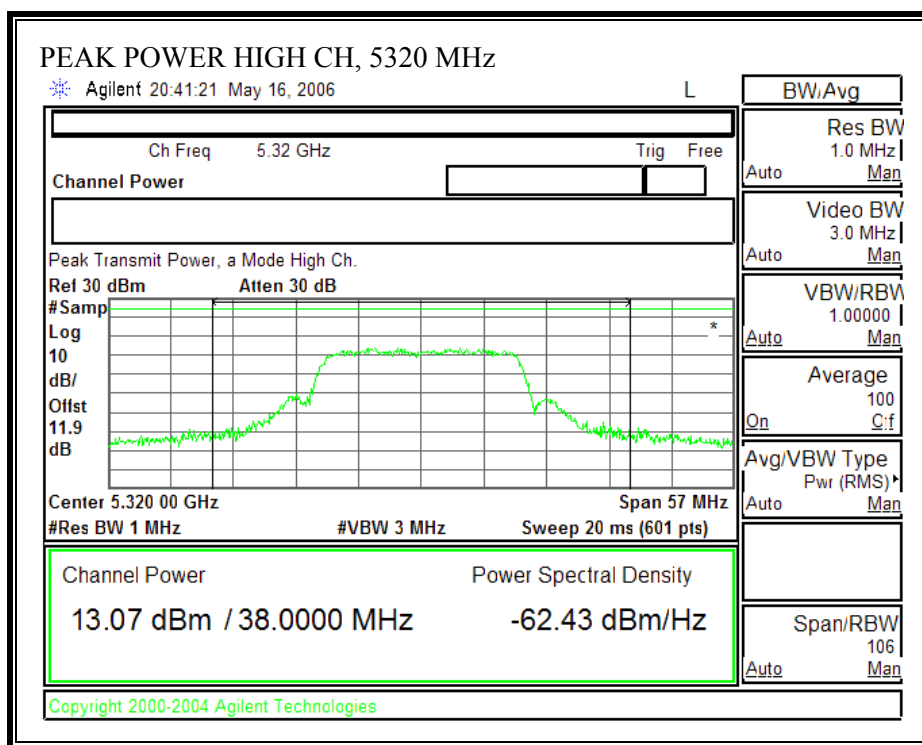
802.11n 20 MHz CDD MCS 0

8.677dBi Antenna

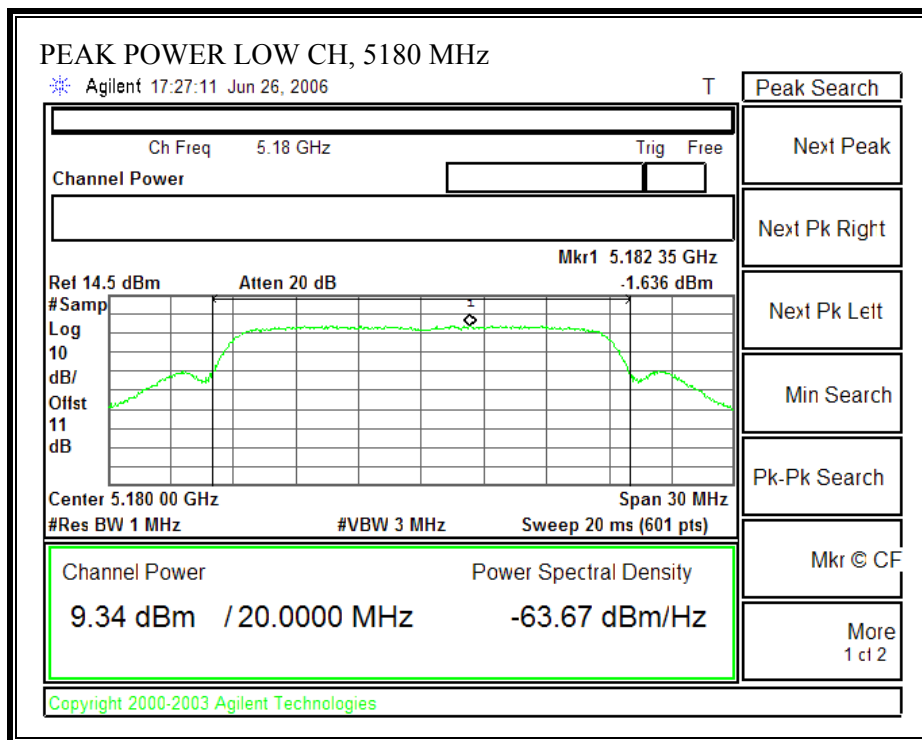
PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 0)

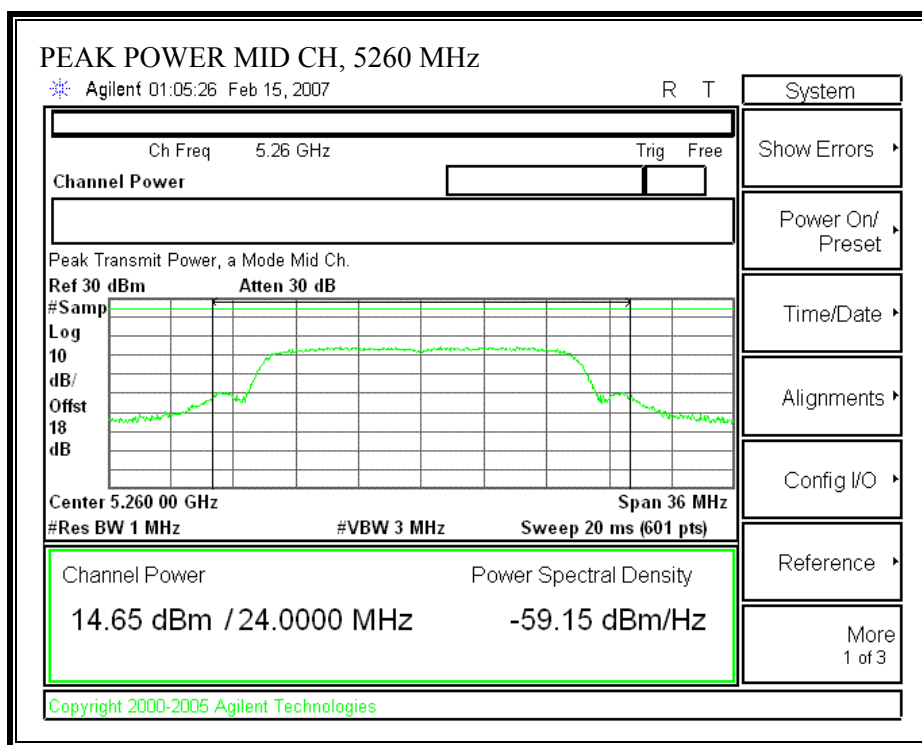


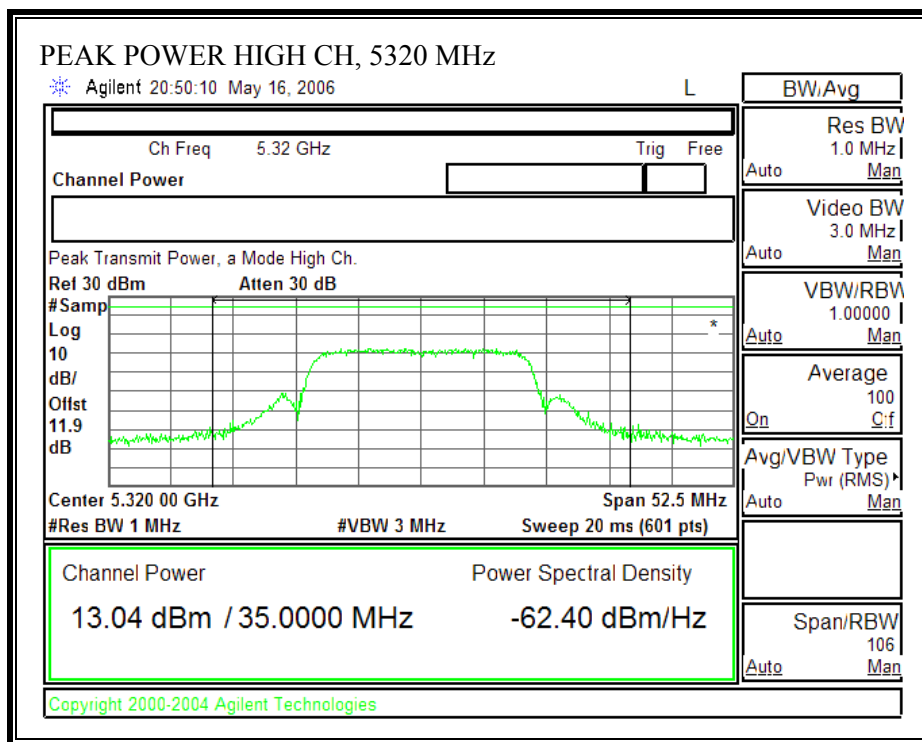




PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 1)

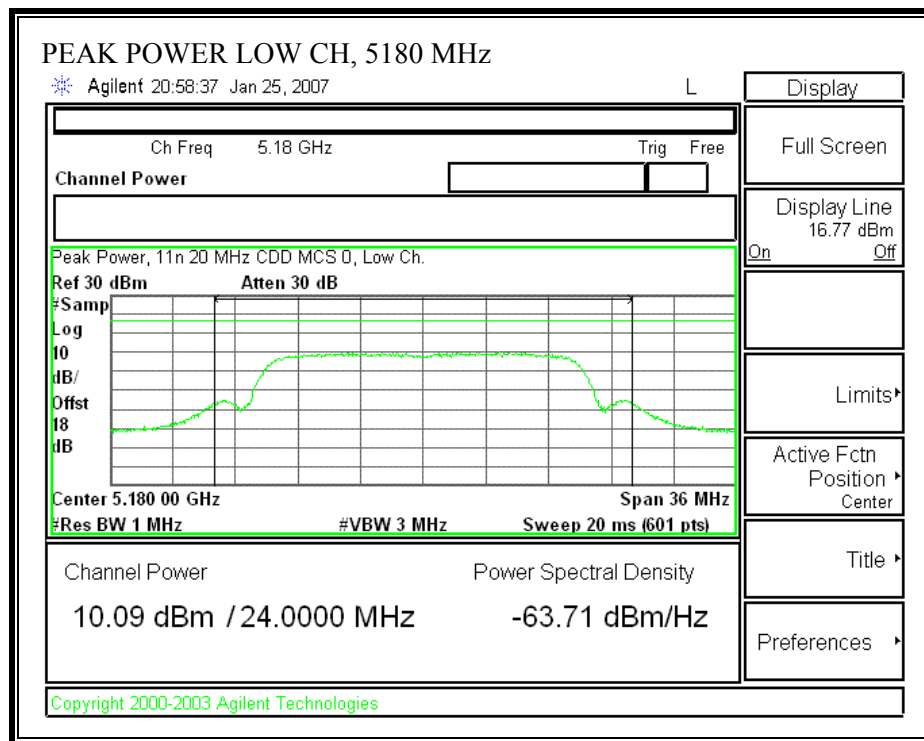


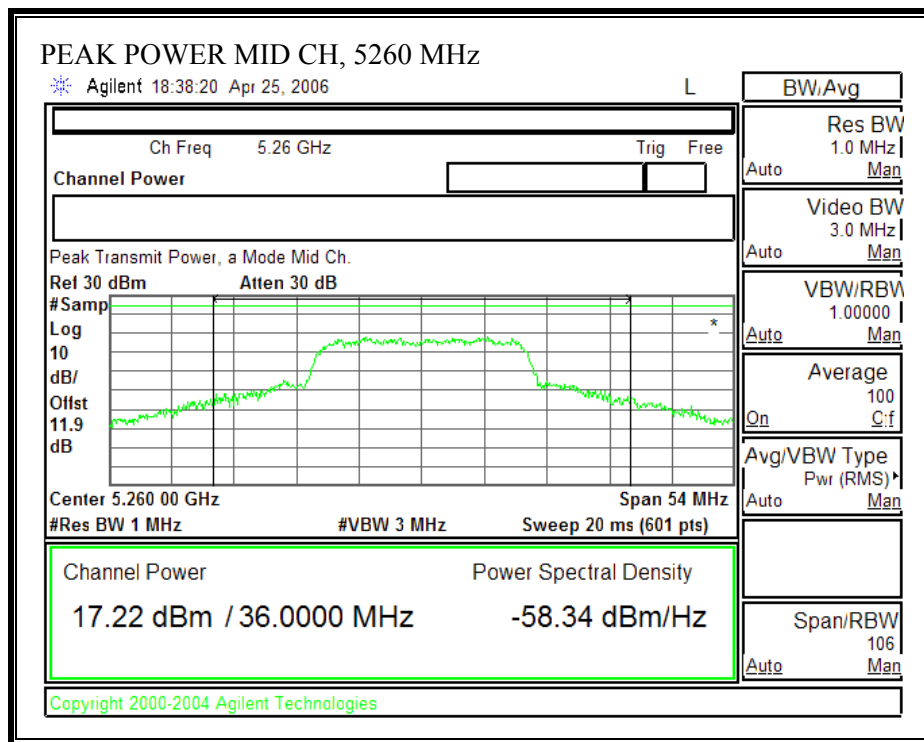




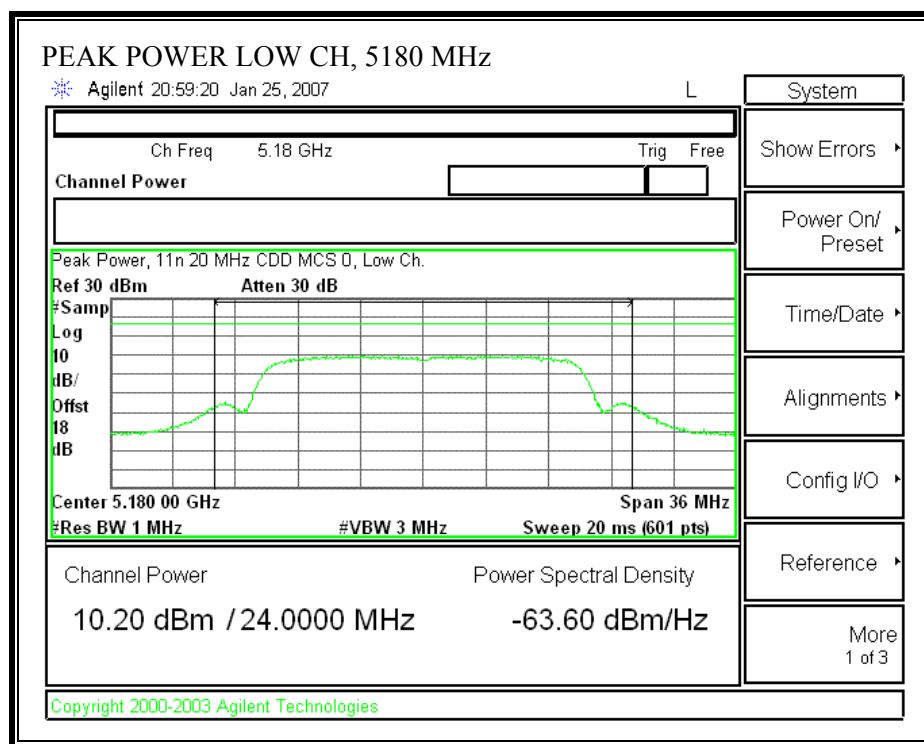
6dBi Antenna

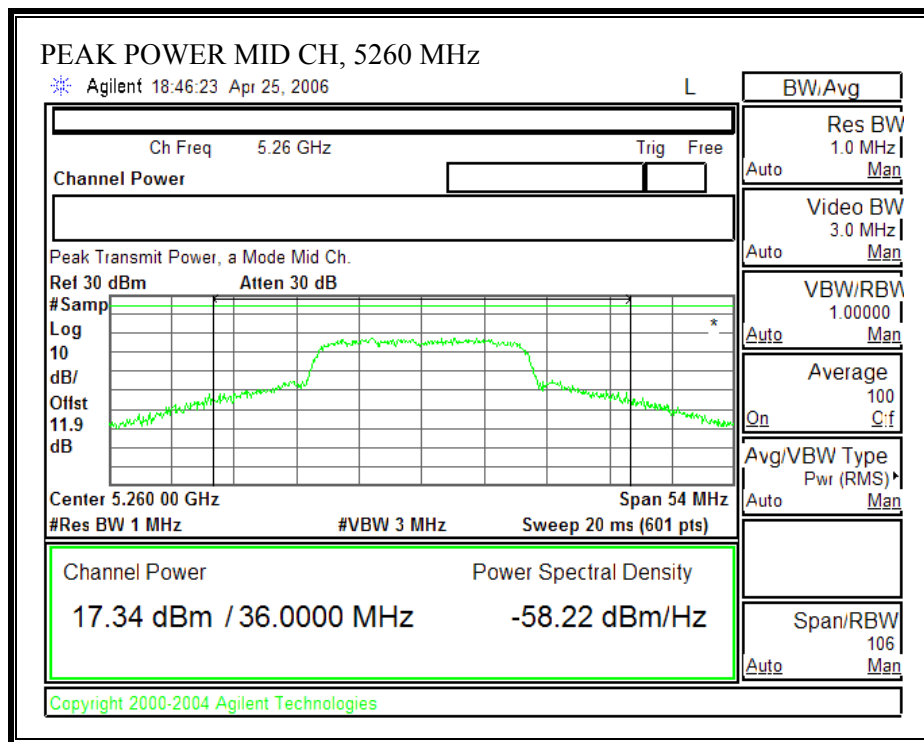
PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 0)





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

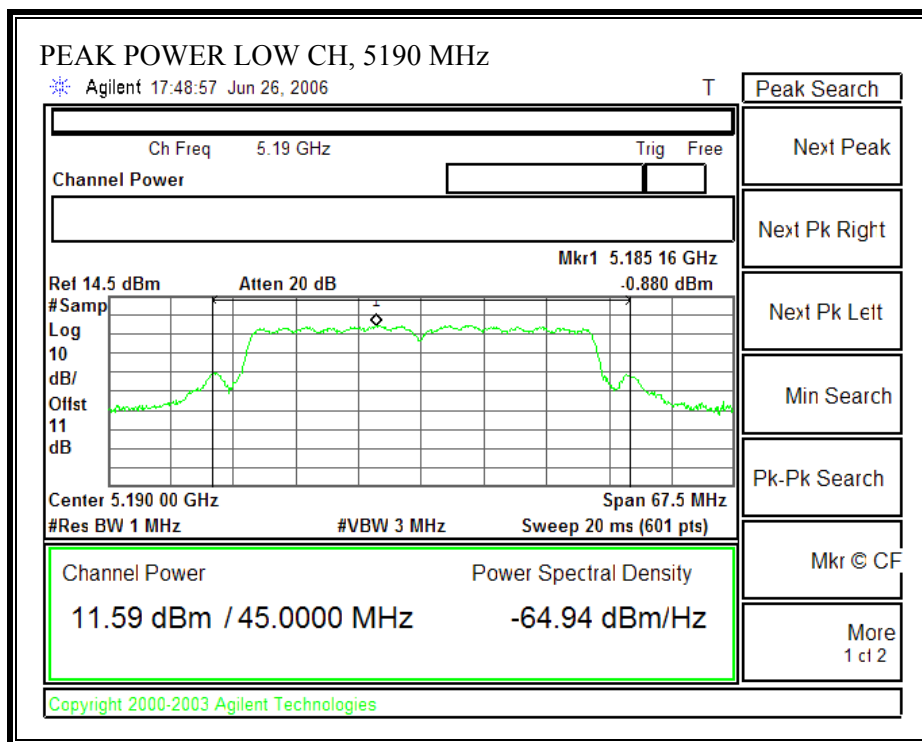


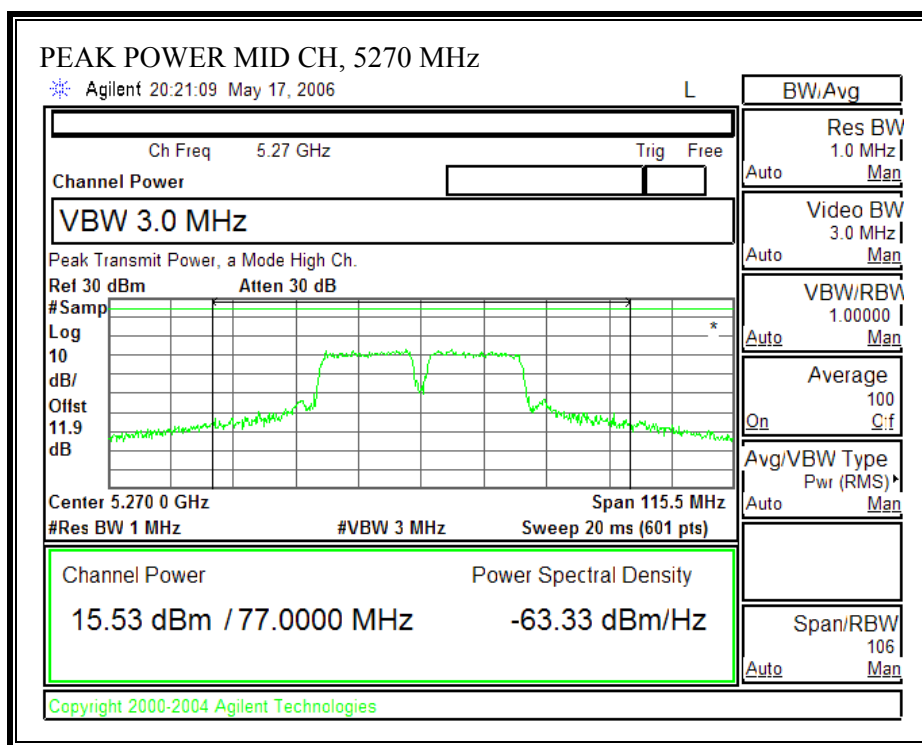


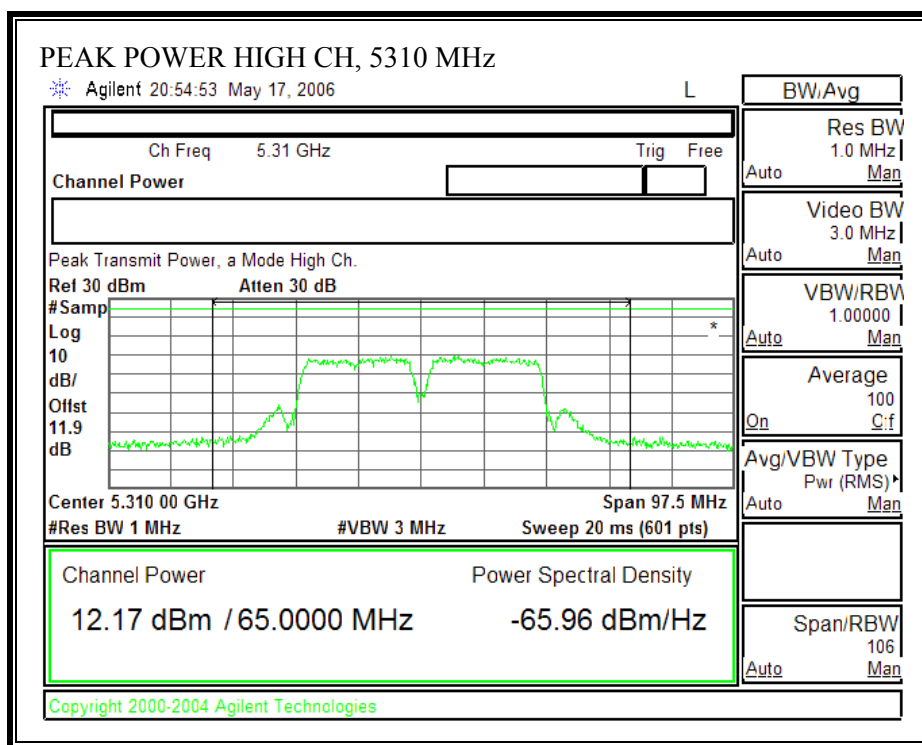
802.11n 40 MHz CDD MCS 32

8.677dBi antenna

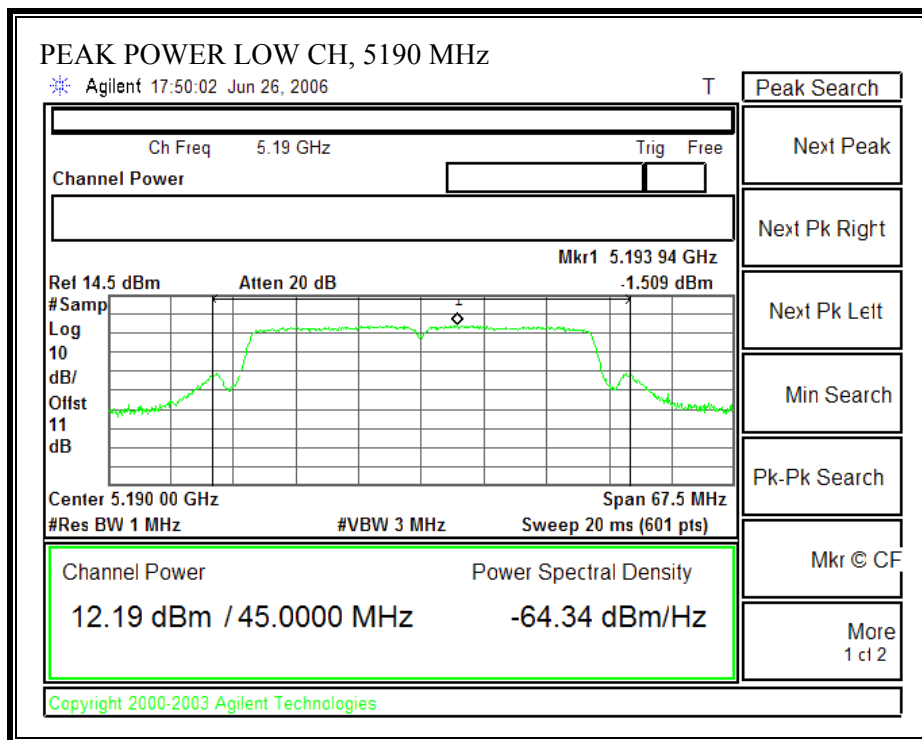
PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 0)

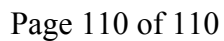


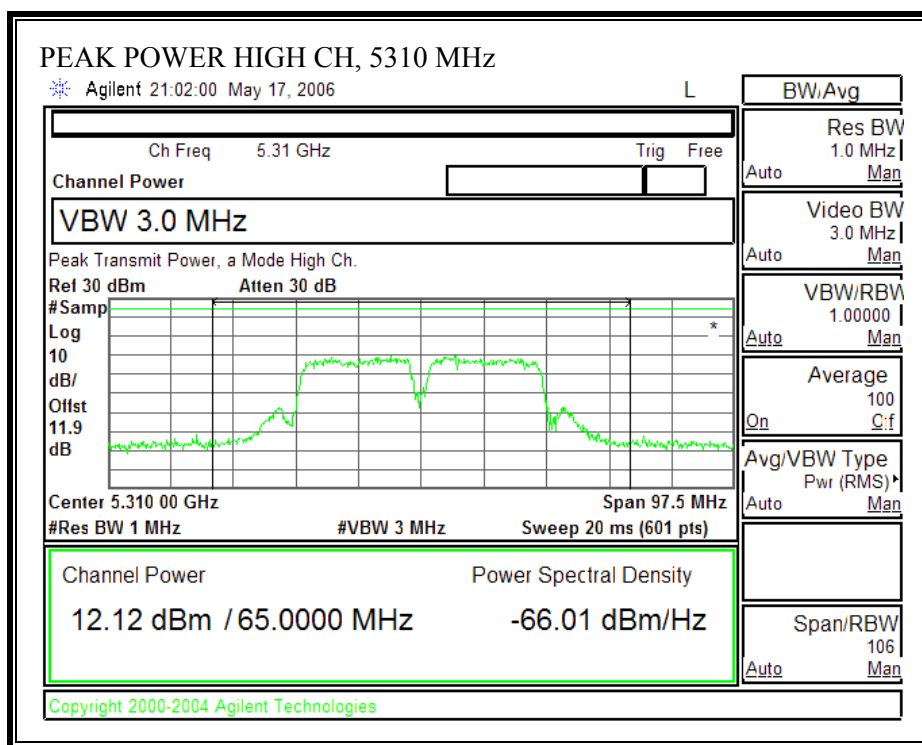




PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 1)

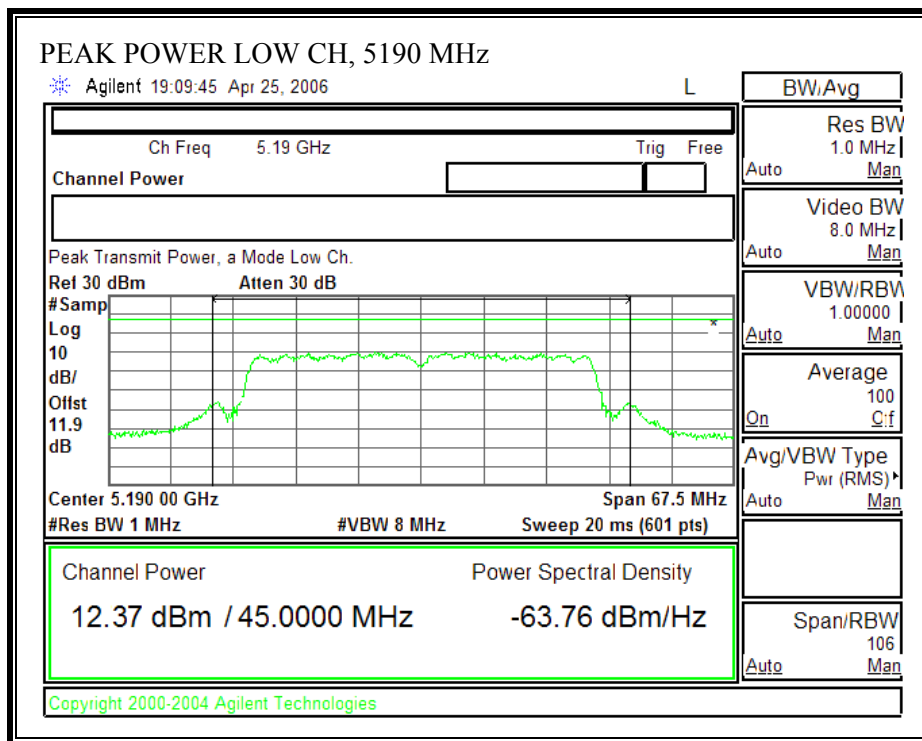




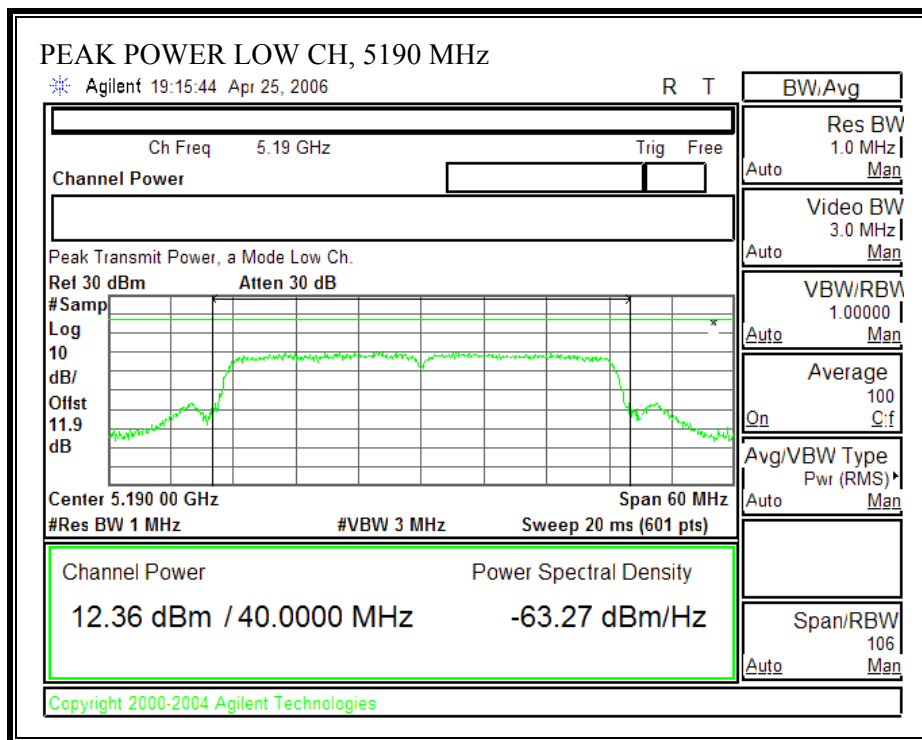


6dBi antenna

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

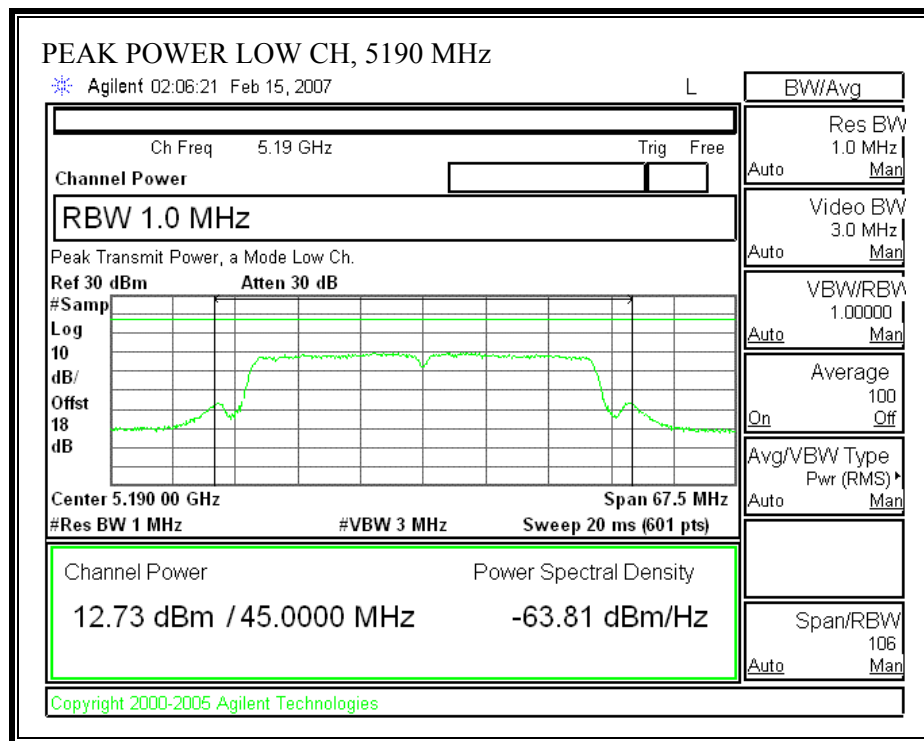


PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 1)

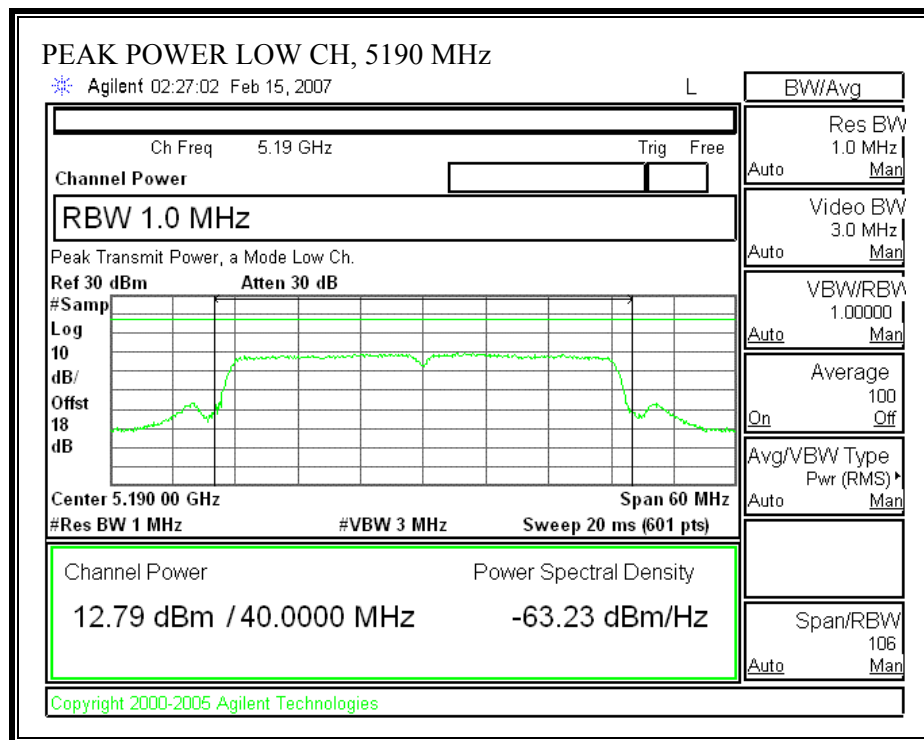


802.11n 40 MHz SDM MCS 15

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



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



7.2.3. 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 5.2 / 5.3 GHz band.

RESULTS

No non-compliance noted.

Note: The MPE calculations below use the highest power and where applicable, the highest array gain, both of which are in the 5250 – 5350 MHz band, as a worst-case representation that also covers the 5150 – 5250 MHz band.

802.11a CDD MODE is covered by worst case **802.11n 20 MHz CDD**.

802.11n 20 MHz CDD

8.677dBi Antenna

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm ²)
802.11n 20 MHz CDD	20.0	17.59	8.68	0.08

6dBi Antenna

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm ²)
802.11n 20 MHz CDD	20.0	20.29	6.00	0.08

802.11n 40MHz CDD

8.677dBi Antenna

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 40 MHz CDD	20.0	18.69	8.68	0.11

6dBi Antenna

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 40 MHz CDD	20.0	18.69	6.00	0.06

802.11n 40 MHz SDM

5.02 dBi Antenna

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 40 MHz SDM	20.0	18.69	5.02	0.05

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.

7.2.4. PEAK POWER SPECTRAL DENSITY

LIMIT

§15.407 (a) (1) For the band 5.15-5.25 GHz, the peak power spectral density shall not exceed 4 dBm in any 1-MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

§15.407 (a) (1) For the band 5.25-5.35 GHz, the peak power spectral density shall not exceed 11 dBm in any 1-MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The maximum antenna gain > 6dBi for CDD modes, therefore there is a reduction due to antenna gain.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002. PPSD method #2 was used.

For combiner: Following formula to calculate the array gain:

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

5.15 – 5.25GHz band: 7.077dBi, limit = 2.92 dBm

5.25 – 5.35GHz band: 8.677dBi, limit = 8.32 dBm

802.11a CDD is covered by worst case 802.11n 20 MHz CDD MCS 0

802.11n 20 MHz CDD MCS 0 (7.077dBi antenna for low band & 8.677dBi antenna for hi band)

Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5180	-0.89	-1.64	1.76	2.92	-1.16
Middle	5260	4.05	4.24	7.16	8.32	-1.17
High	5320	3.66	2.49	6.13	8.32	-2.19

802.11n 20 MHz CDD MCS 0 (6dBi antenna)

Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Middle	5260	7.79	7.34	10.58	11.00	-0.42

Low & high channels meet the limit of high antenna gain

802.11n 40 MHz CDD MCS 0

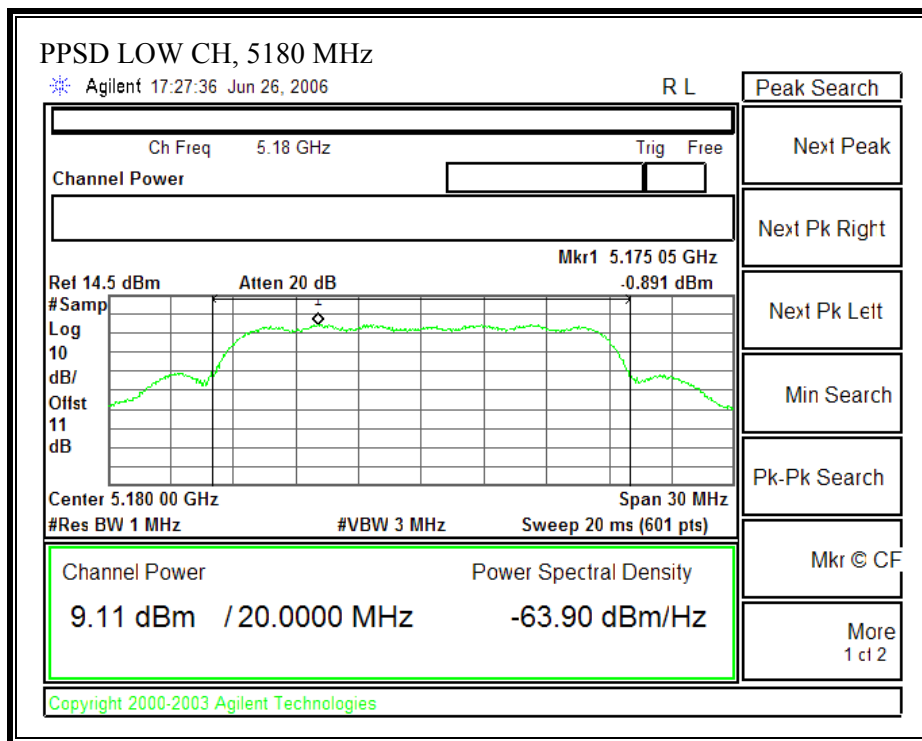
Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5190	-0.88	-1.51	1.83	2.92	-1.10
Middle	5270	3.08	2.73	5.92	8.32	-2.41
High	5310	-0.85	-0.94	2.12	8.32	-6.20

802.11n 40 MHz SDM MCS 15

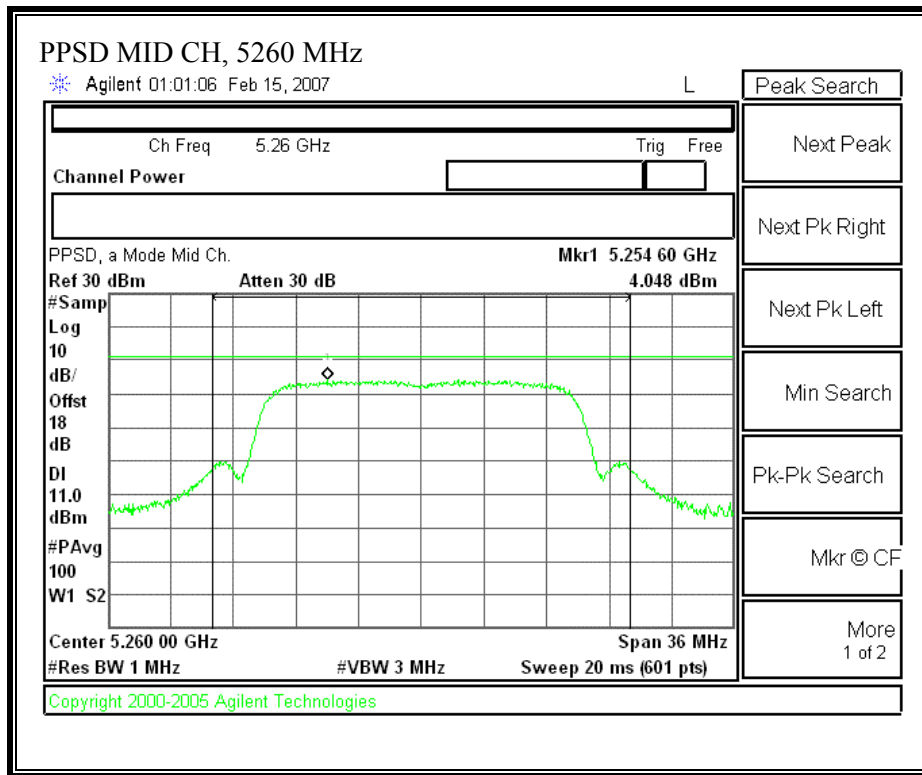
Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5190	-0.69	-0.81	2.26	4.00	-1.74

802.11n 20 MHz CDD MCS 0

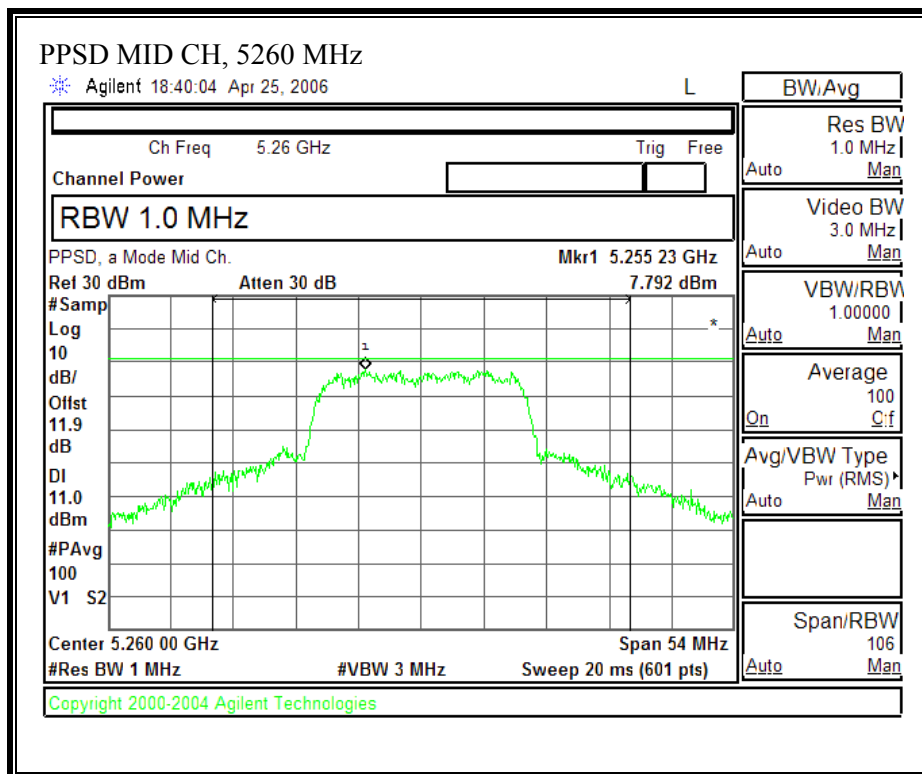
PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH – CHAIN 0)

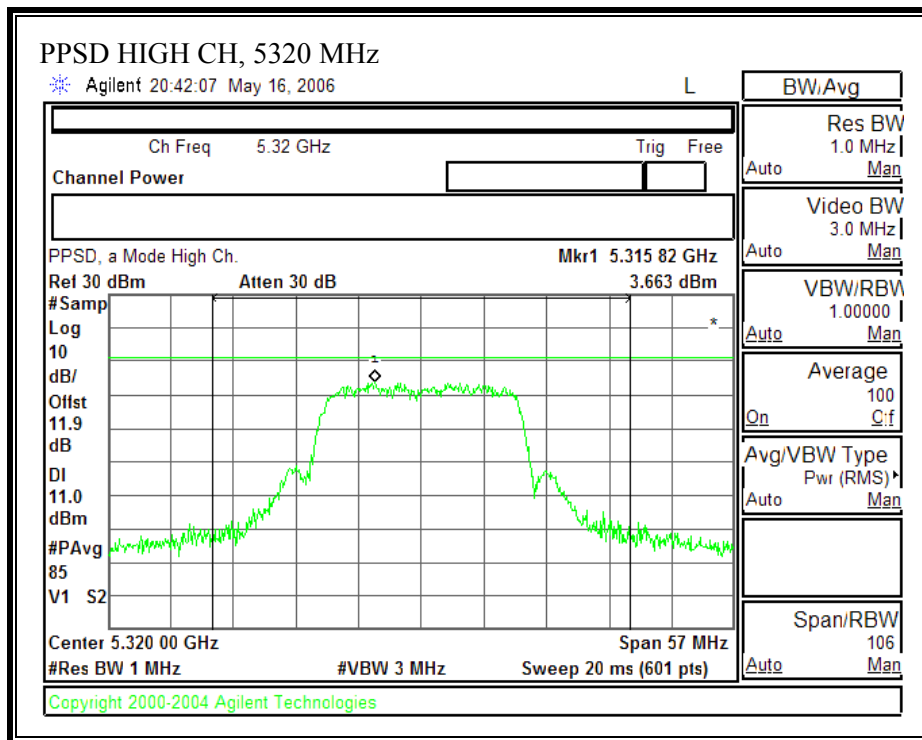


8.677dBi Antenna Gain

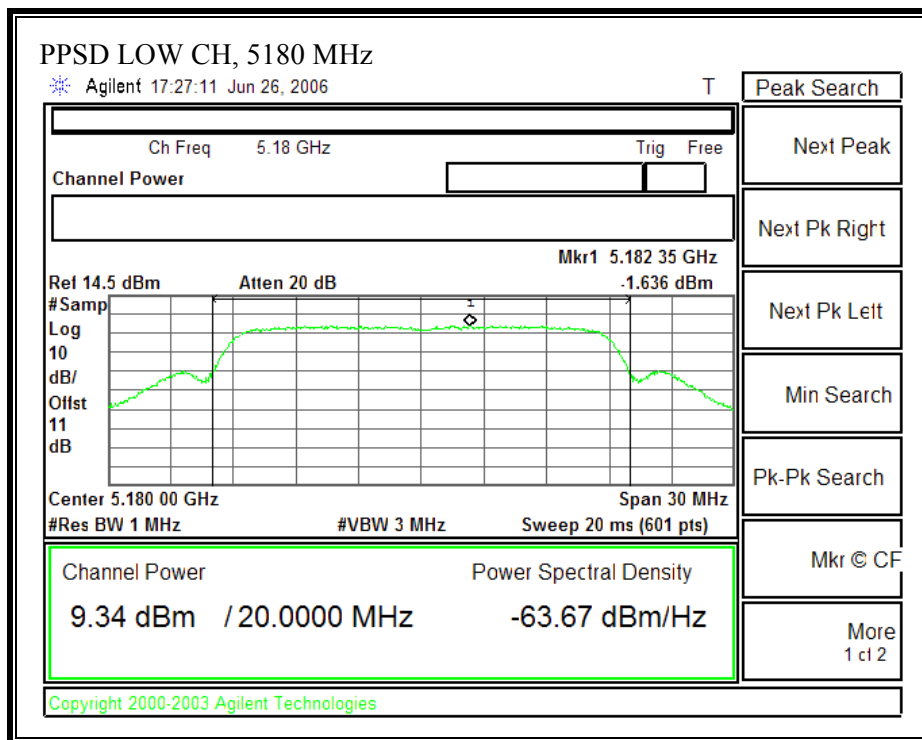


6dBi Antenna

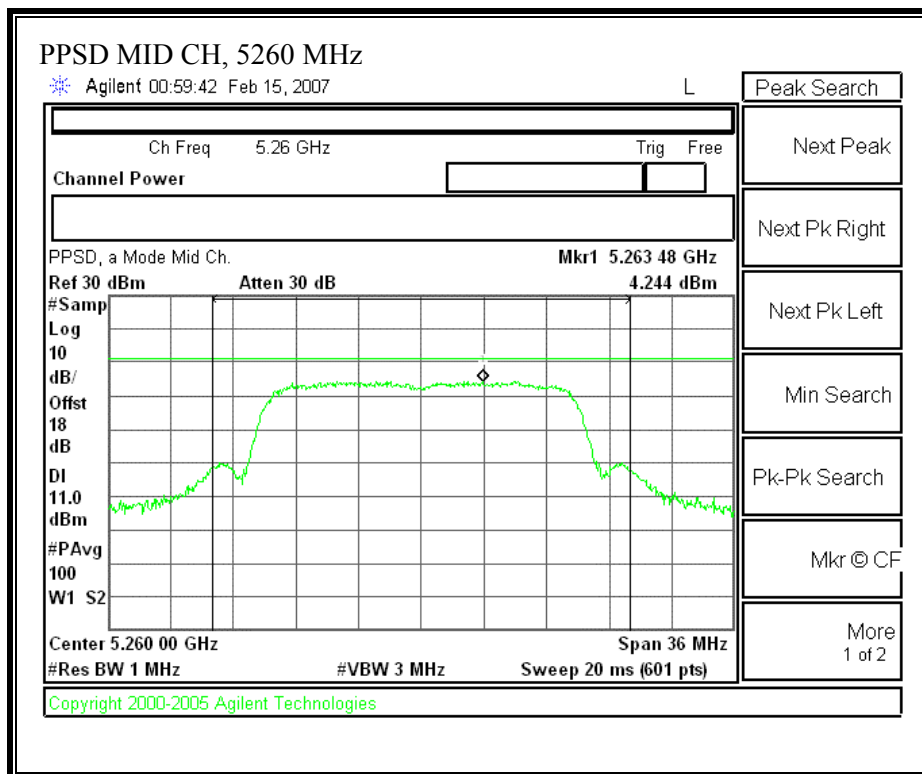




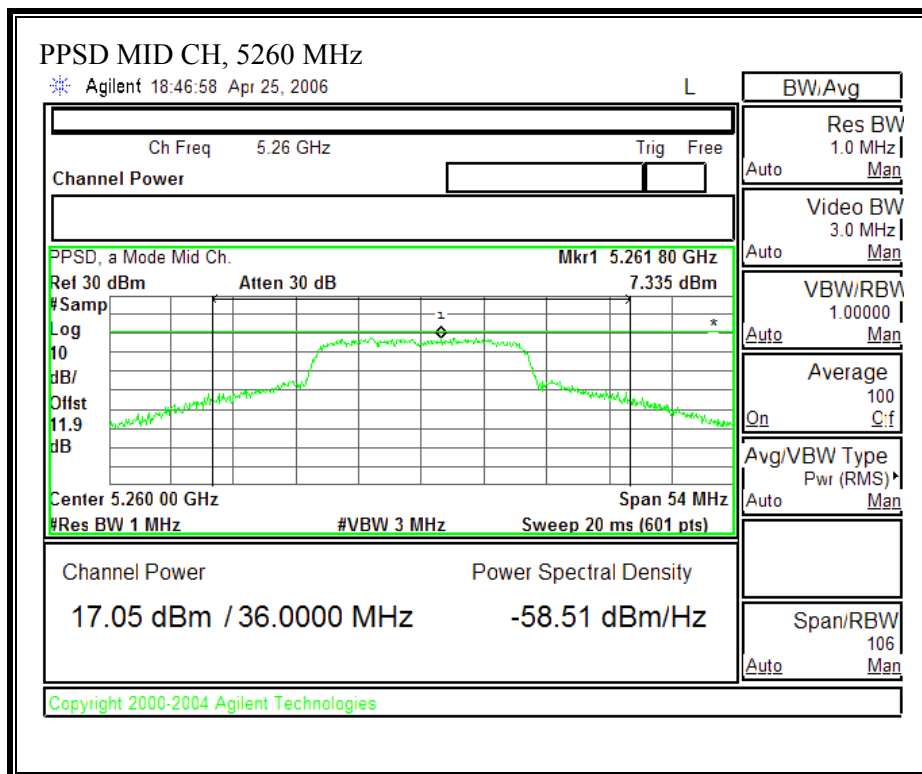
PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH – CHAIN 1)

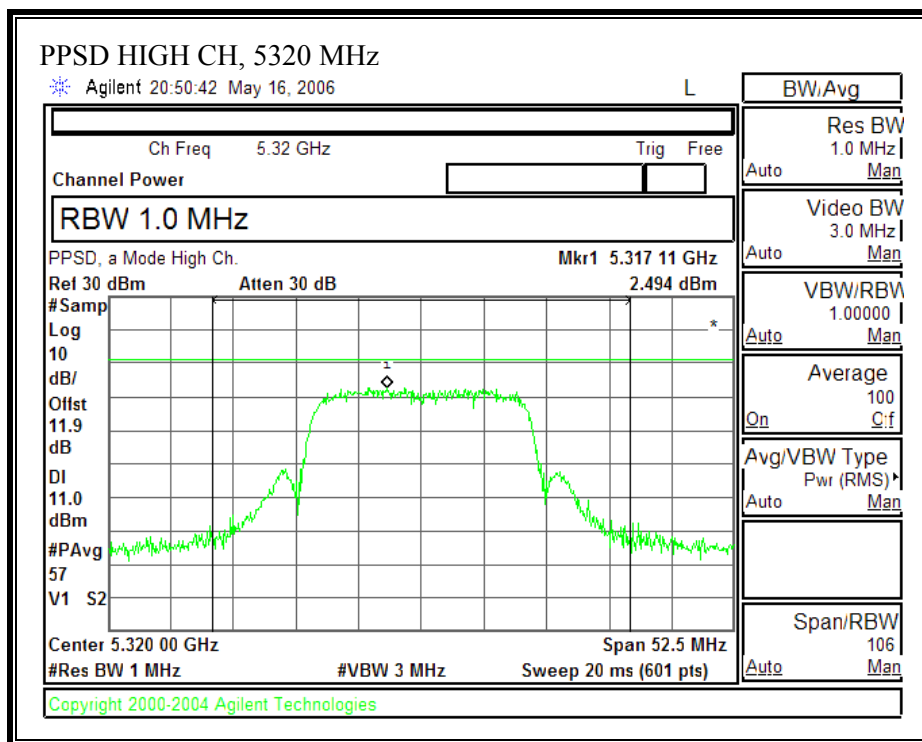


8.677dBi Antenna



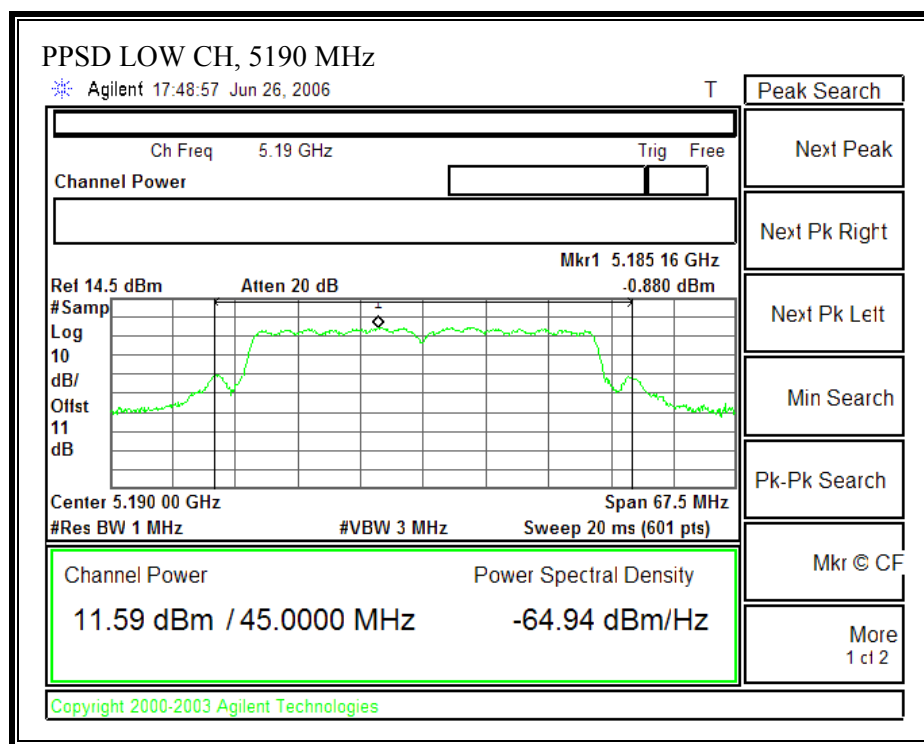
6dBi Antenna

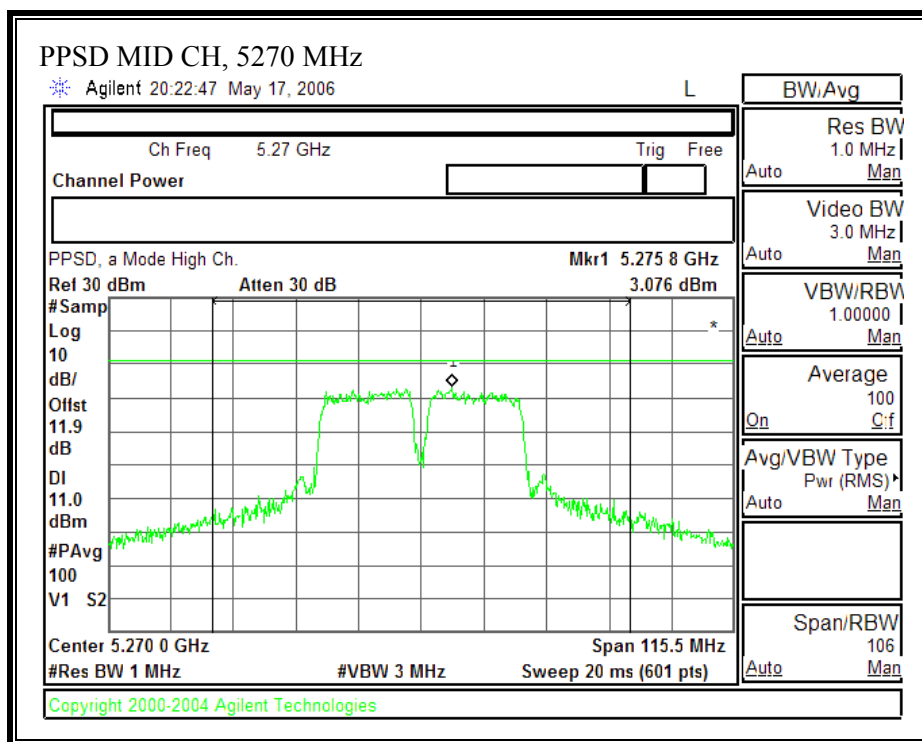


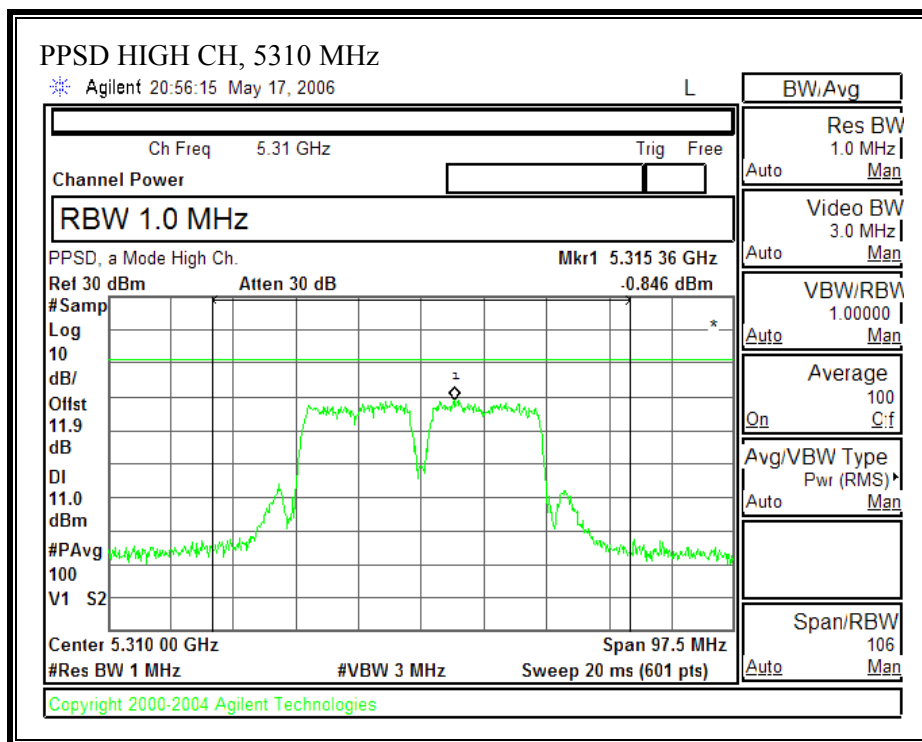


802.11n 40 MHz CDD MCS 32

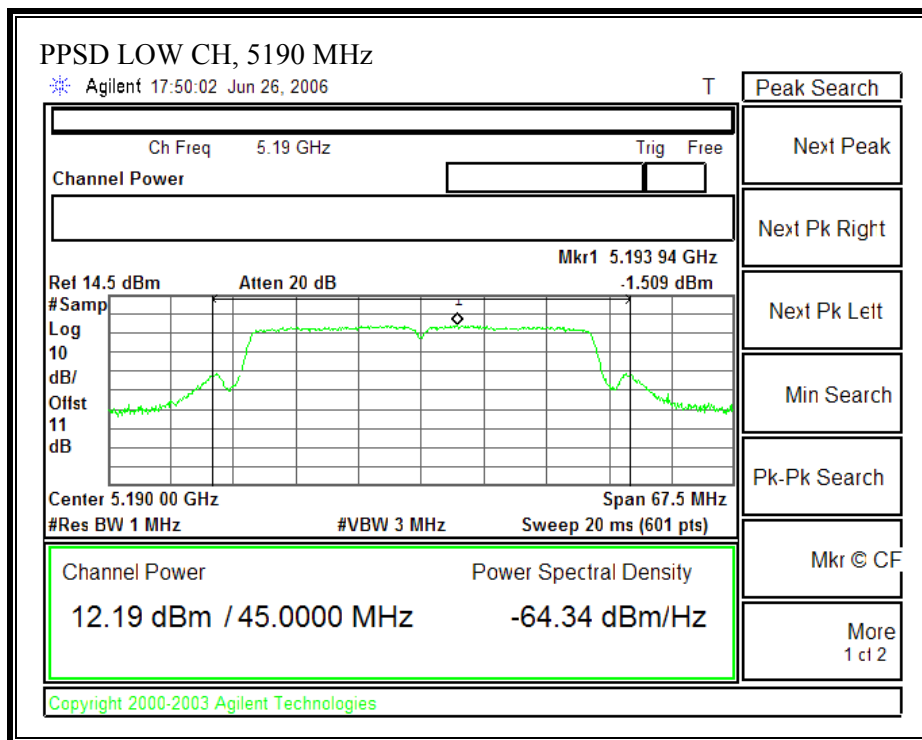
PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)

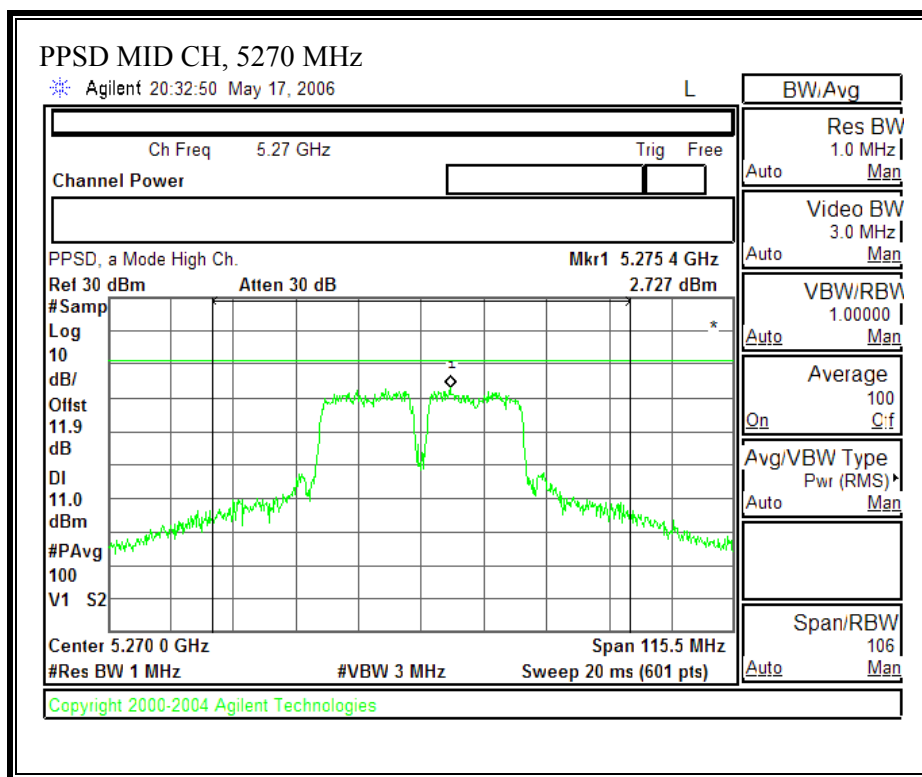


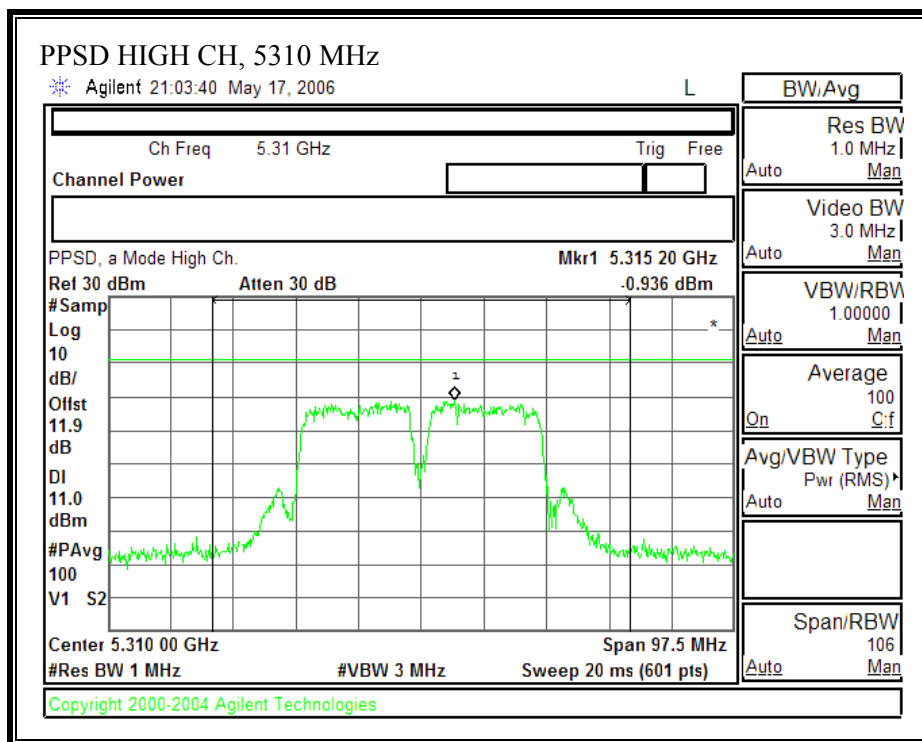




PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)

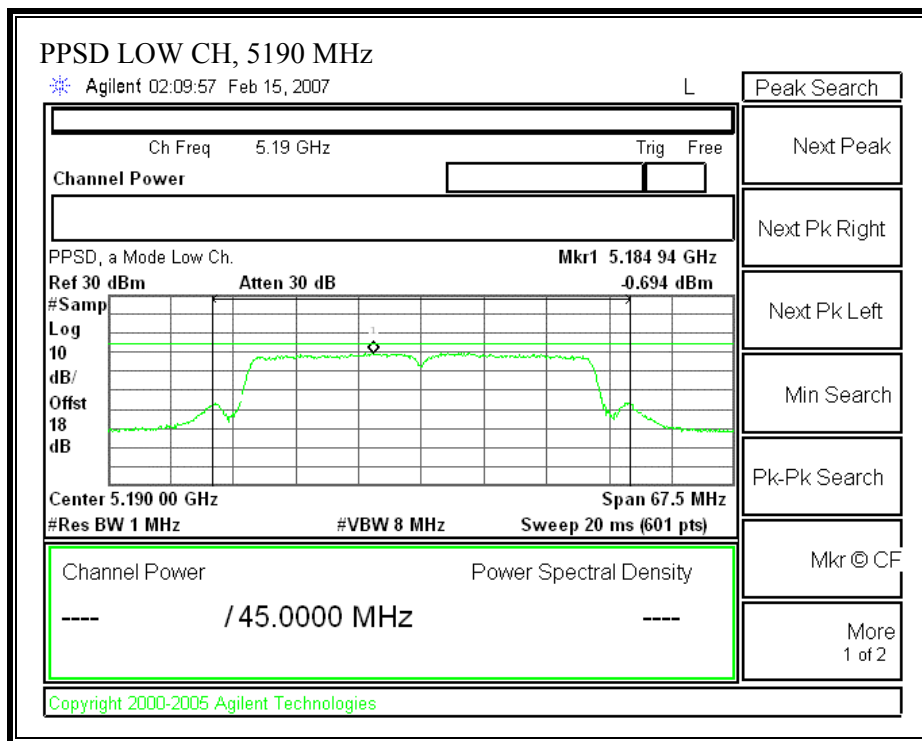




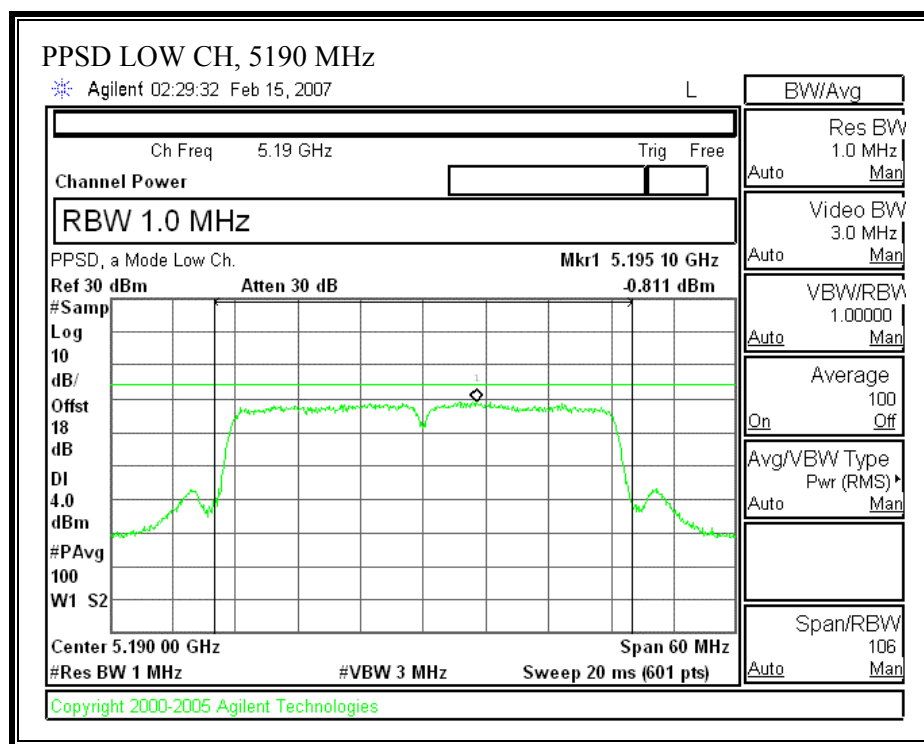


802.11n 40 MHz SDM MCS 15

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



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



7.2.5. PEAK EXCURSION

LIMIT

§15.407 (a) (6) The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the peak transmit power (measured as specified above) shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002.

Since Method # 1 was used for peak power measurements, Method # 1 settings are used for the second PPSD trace.

RESULTS

No non-compliance noted:

802.11a CDD is covered by worst case 802.11n 20 MHz CDD MCS 0 MODE

802.11n 20 MHz CDD MCS 0

20 MHz TX BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	Peak Excursion Chain 0 (dB)	Limit (dB)	Margin (dB)
Low	5180	8.60	13	-4.40
Middle	5260	8.31	13	-4.69
High	5320	9.14	13	-3.86

20 MHz TX BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	Peak Excursion Chain 1 (dB)	Limit (dB)	Margin (dB)
Low	5180	10.72	13	-2.28
Middle	5260	8.01	13	-4.99
High	5320	11.25	13	-1.75

802.11n 40 MHz CDD MCS 32

40 MHz TX BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	Peak Excursion Chain 0 (dB)	Limit (dB)	Margin (dB)
Low	5190	11.18	13	-1.82
Middle	5270	9.57	13	-3.43
High	5310	9.23	13	-3.77

40 MHz TX BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	Peak Excursion Chain 1 (dB)	Limit (dB)	Margin (dB)
Low	5190	10.34	13	-2.66
Middle	5270	11.72	13	-1.28
High	5310	9.60	13	-3.40

802.11n 40 MHz SDM MCS15

40 MHz TX BANDWIDTH - CHAIN 0

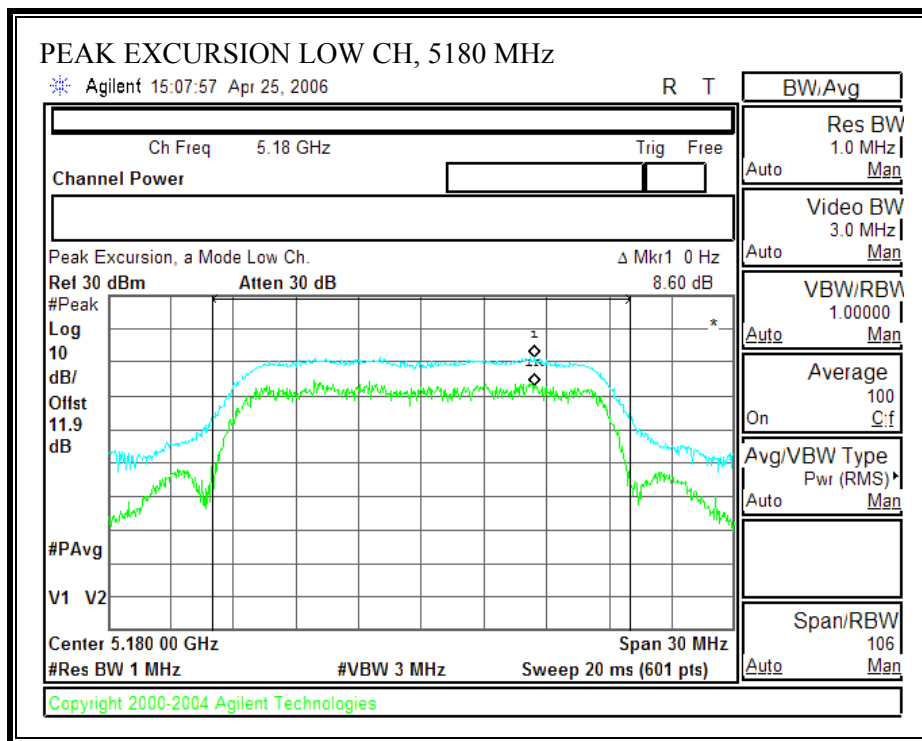
Channel	Frequency (MHz)	Peak Excursion Chain 0 (dB)	Limit (dB)	Margin (dB)
Low	5190	12.03	13	-0.97

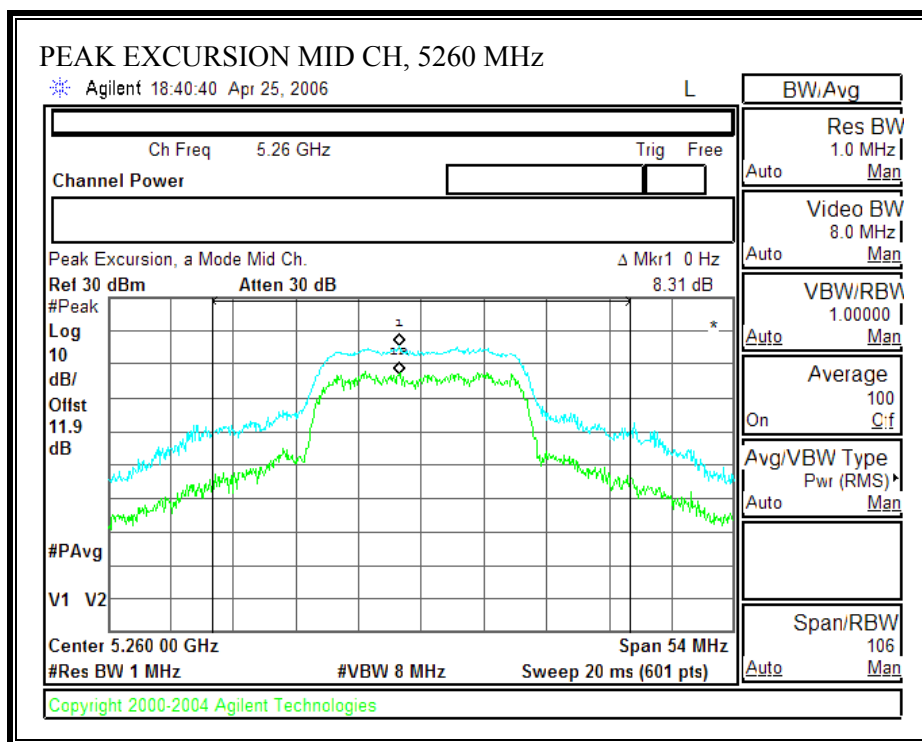
40 MHz TX BANDWIDTH - CHAIN 1

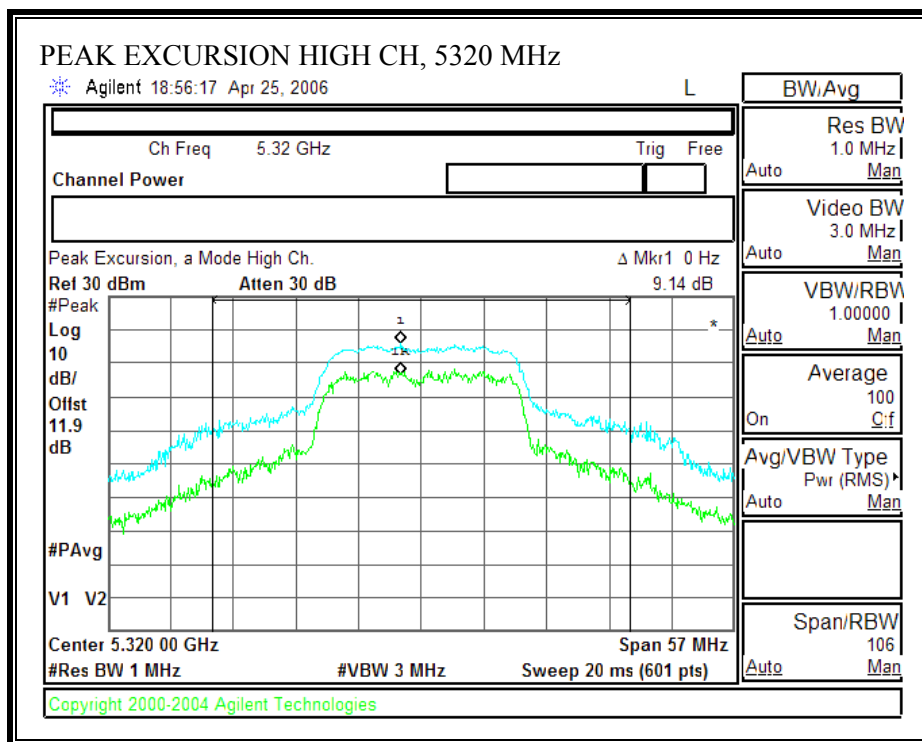
Channel	Frequency (MHz)	Peak Excursion Chain 1 (dB)	Limit (dB)	Margin (dB)
Low	5190	12.18	13	-0.82

802.11n 20 MHz CDD MCS 0

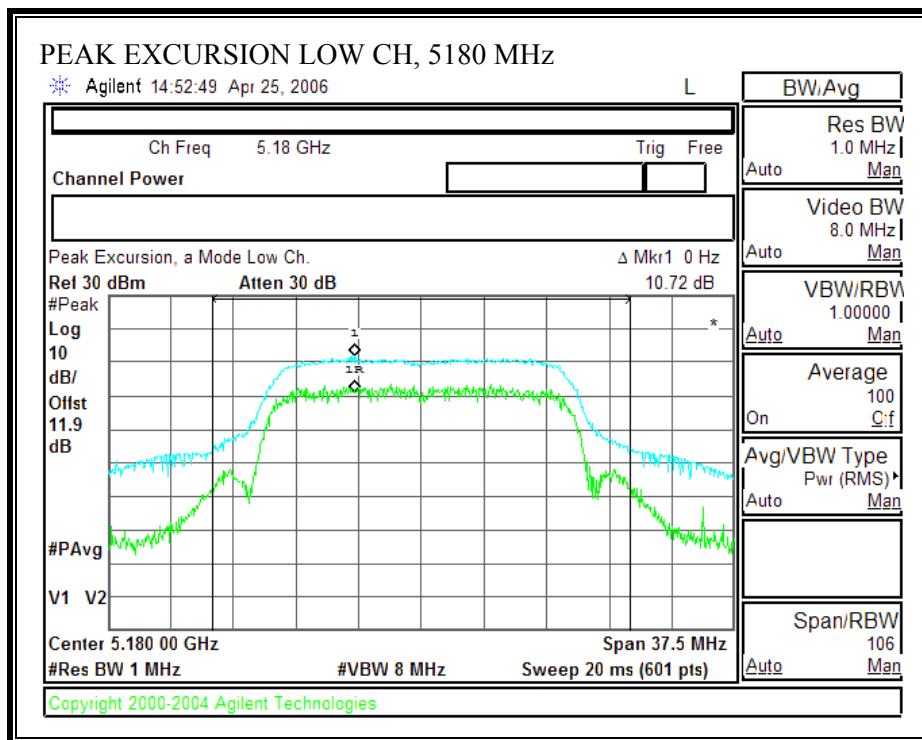
PEAK EXCURSION (802.11 - 20 MHz TX BANDWIDTH – CHAIN 0)

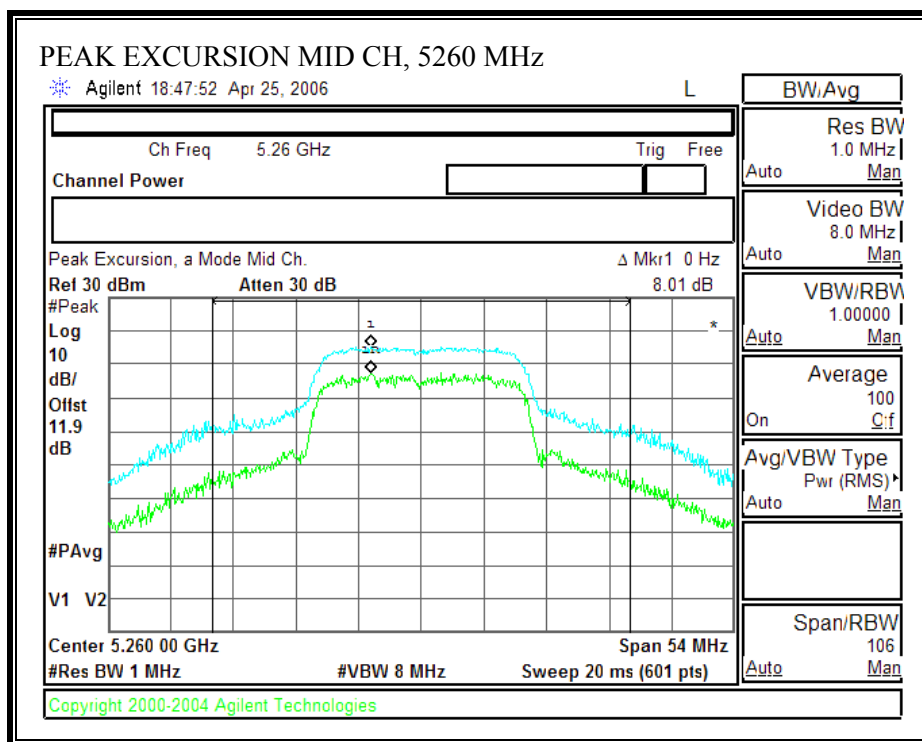


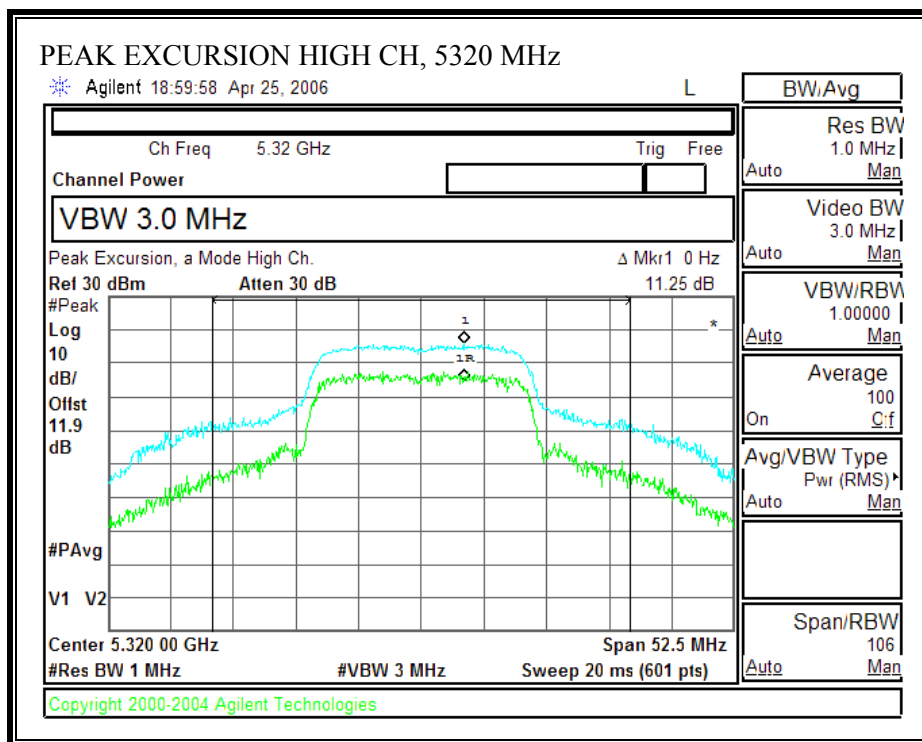




PEAK EXCURSION (802.11 - 20 MHz TX BANDWIDTH – CHAIN 1)

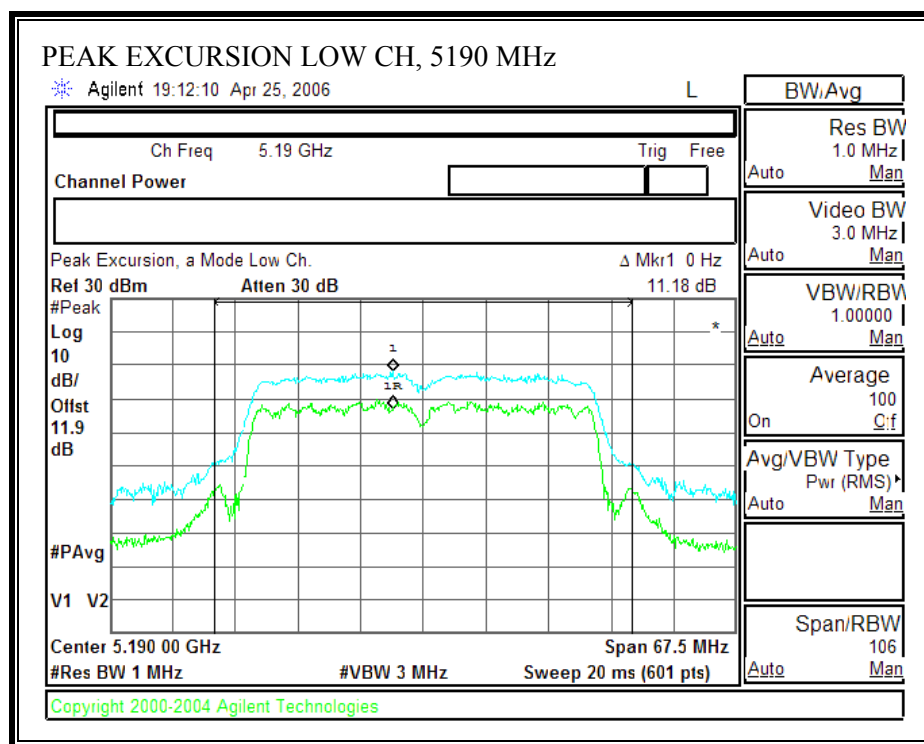


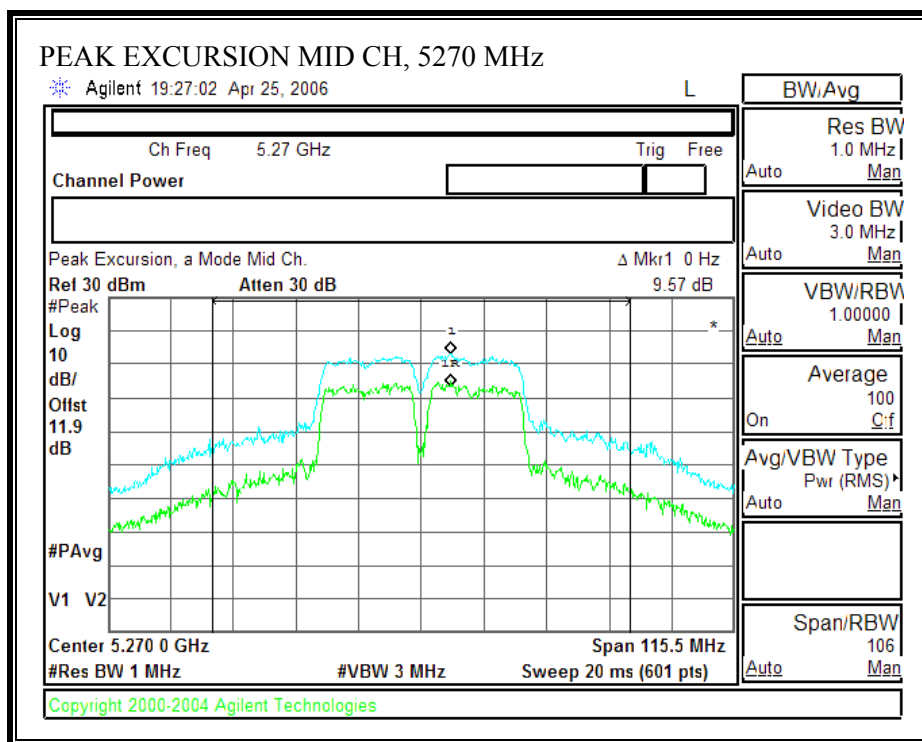


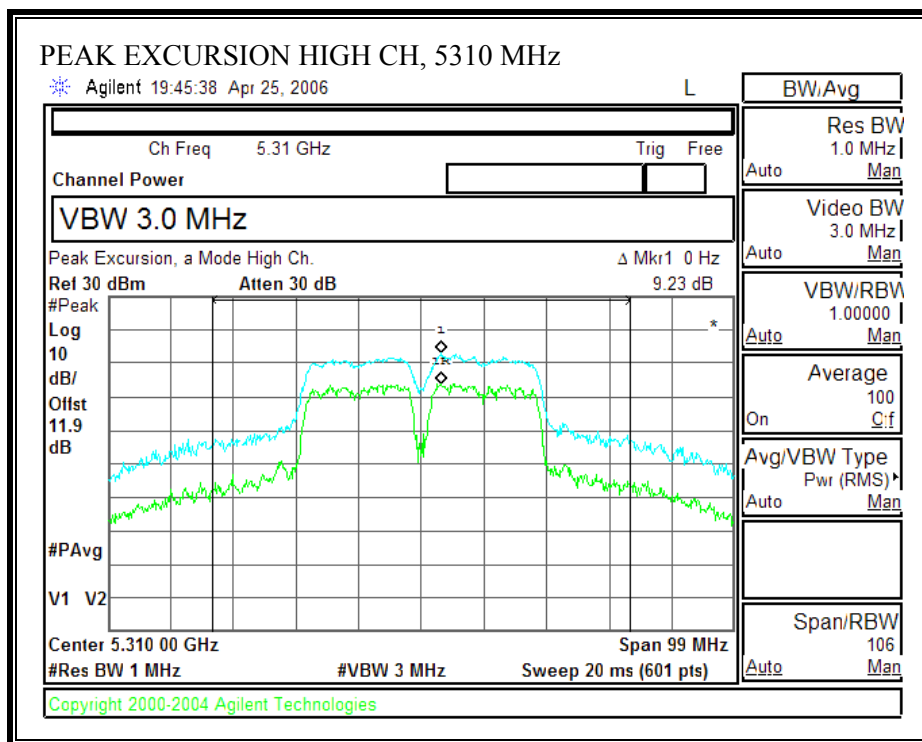


802.11n 40 MHz CDD MCS 32

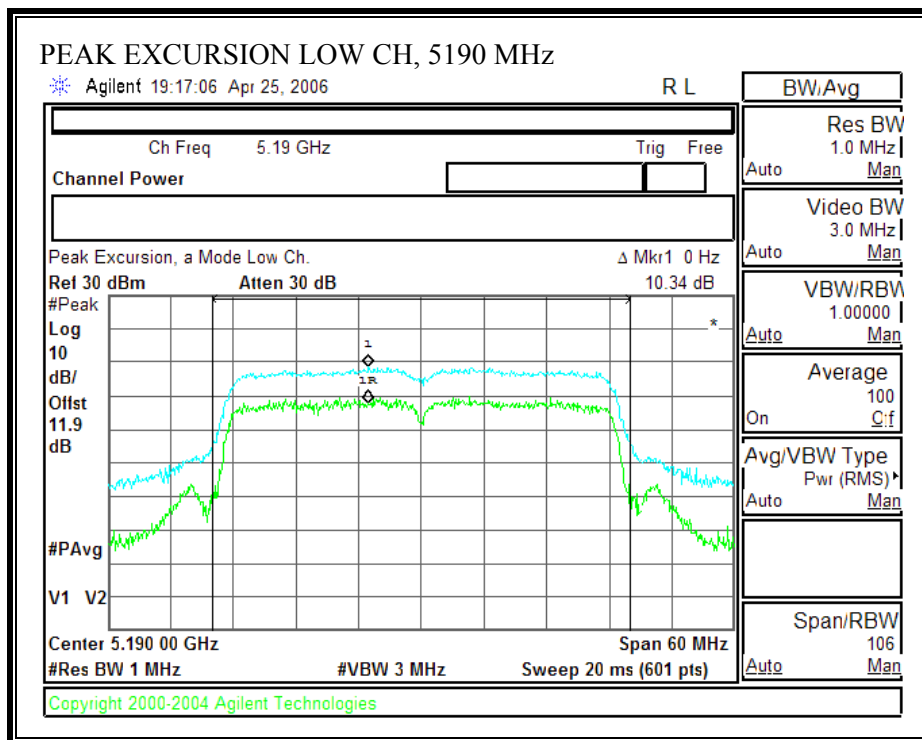
PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)

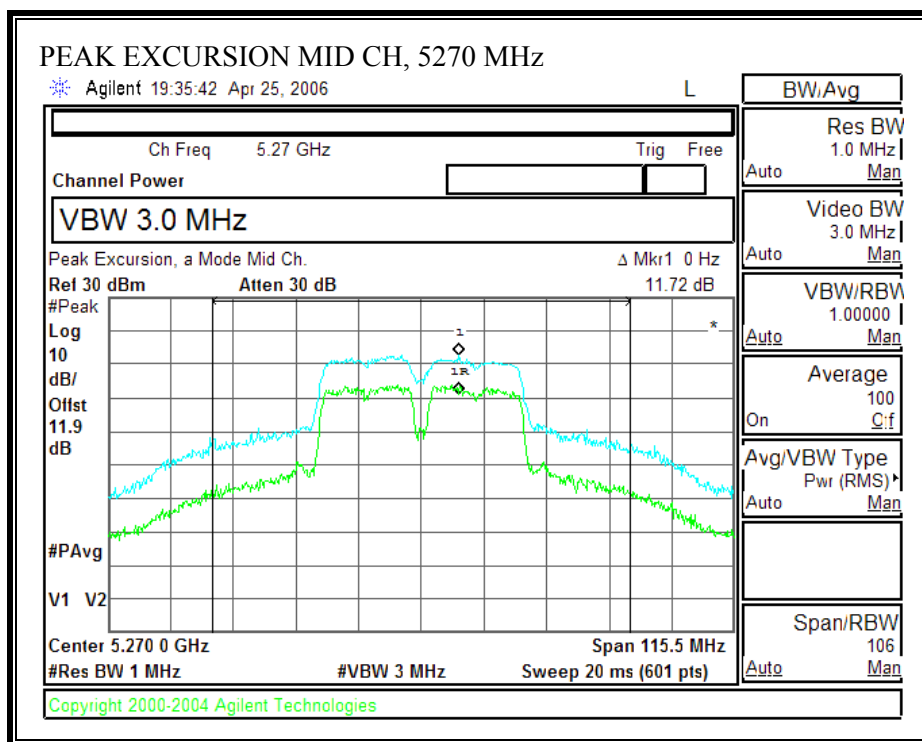


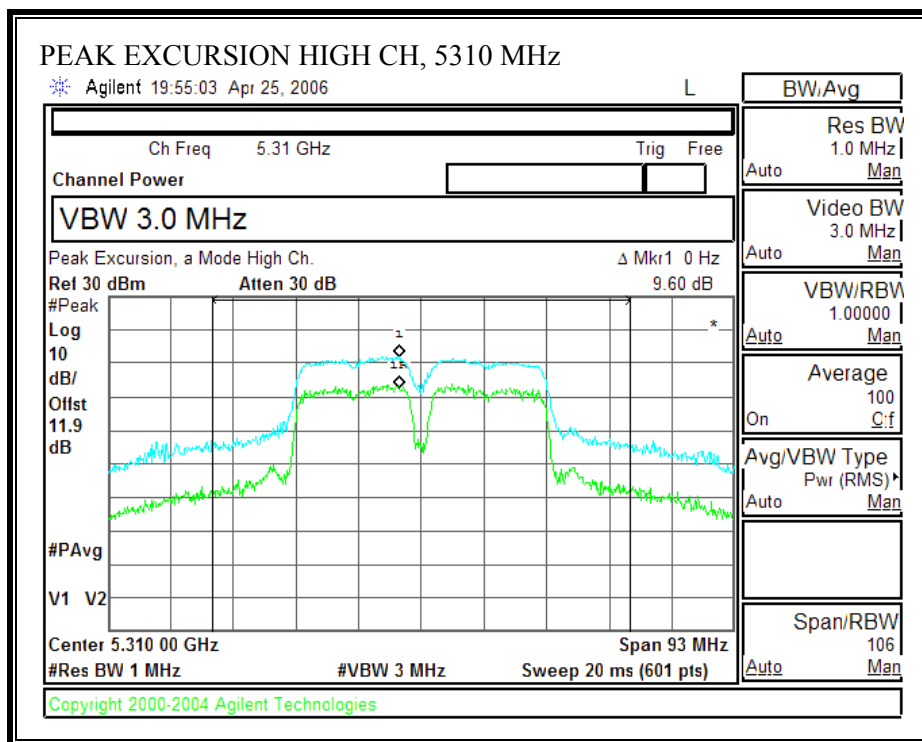




PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)

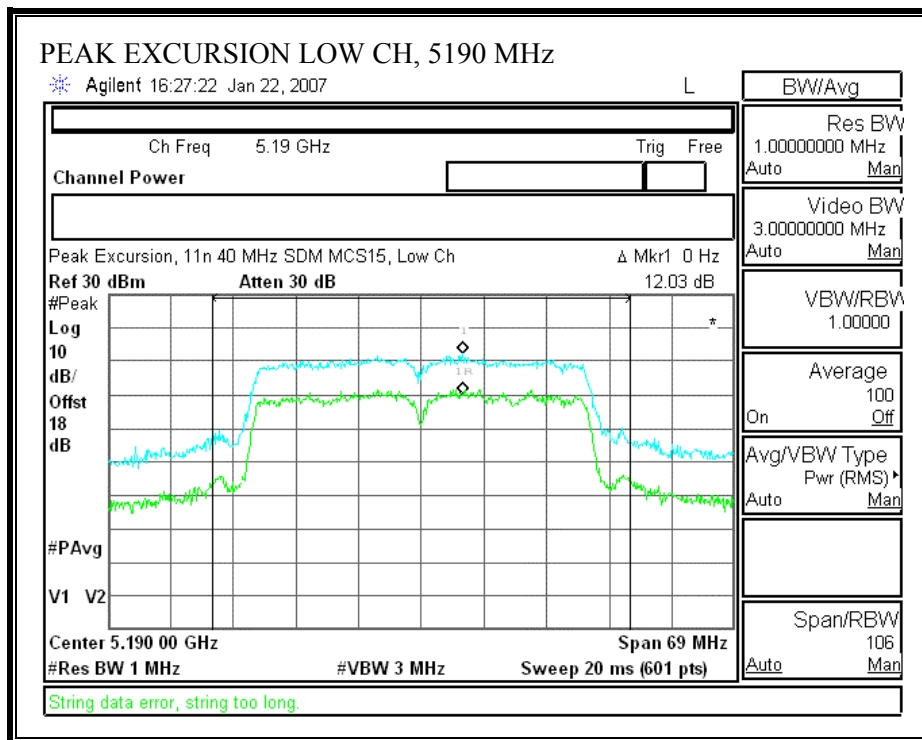




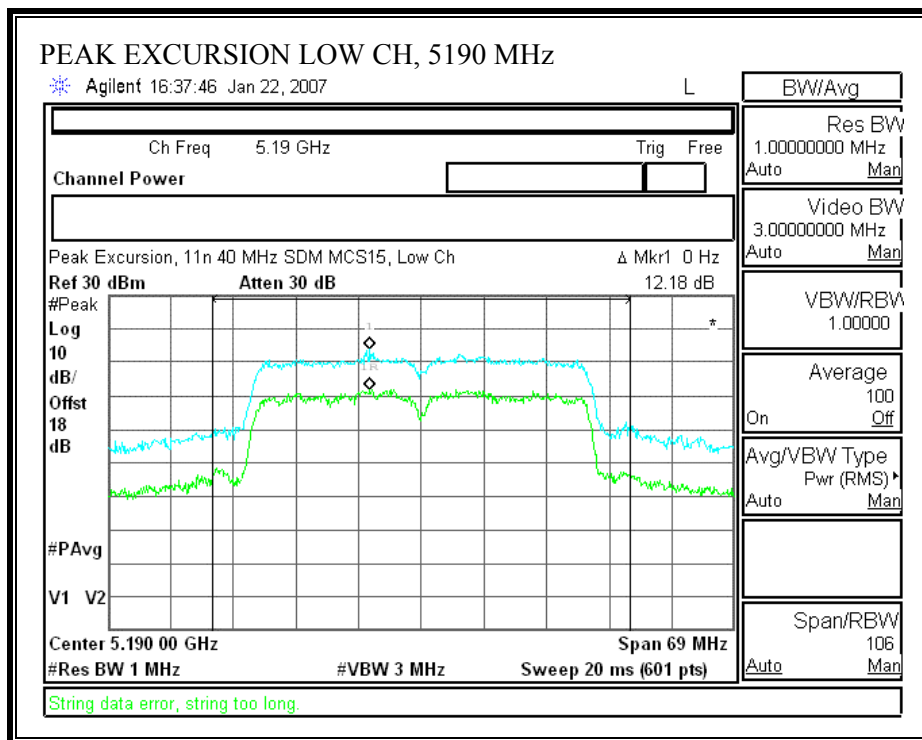


802.11n 40 MHz SDM MCS 15

PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)



PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)



7.2.6. CONDUCTED SPURIOUS EMISSIONS

LIMITS

§15.407 (b) (1 & 2) For transmitters operating in the 5.15-5.35 GHz band: all emissions outside of the 5.15-5.35 GHz band shall not exceed an EIRP of -27dBm / MHz.

TEST PROCEDURE

Conducted RF measurements of the transmitter output are made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer. The resolution bandwidth is set to 1 MHz. The video bandwidth is set to 1 MHz. Peak detection measurements are compared to the average EIRP limit, adjusted for the maximum antenna gain. If necessary, additional average detection measurements are made.

Measurements are made over the 30 MHz to 40 GHz range with the transmitter set to the lowest, middle, and highest channels.

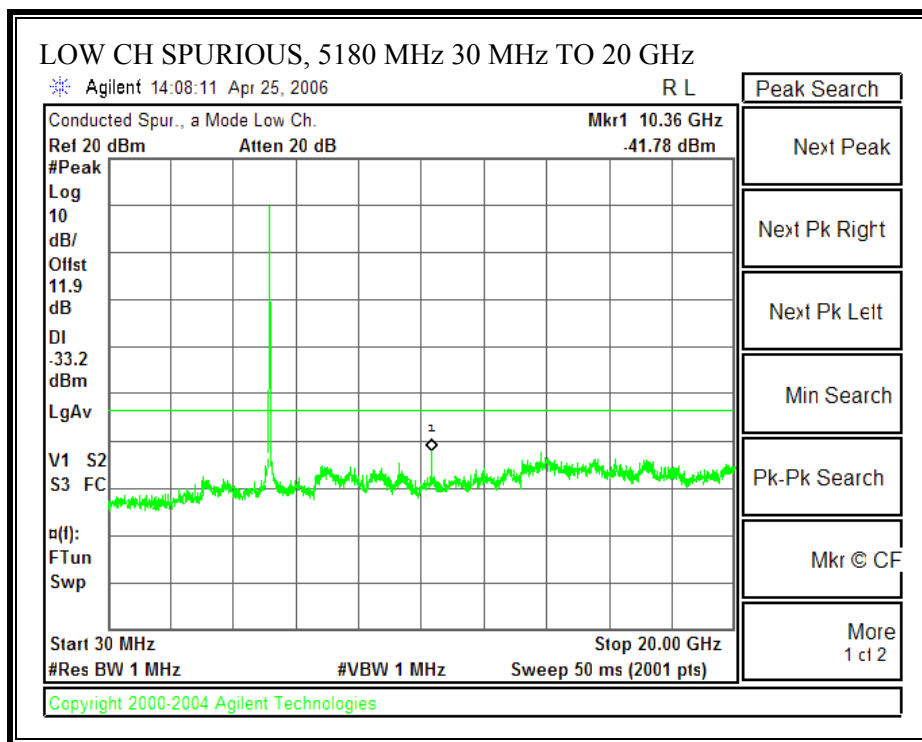
RESULTS

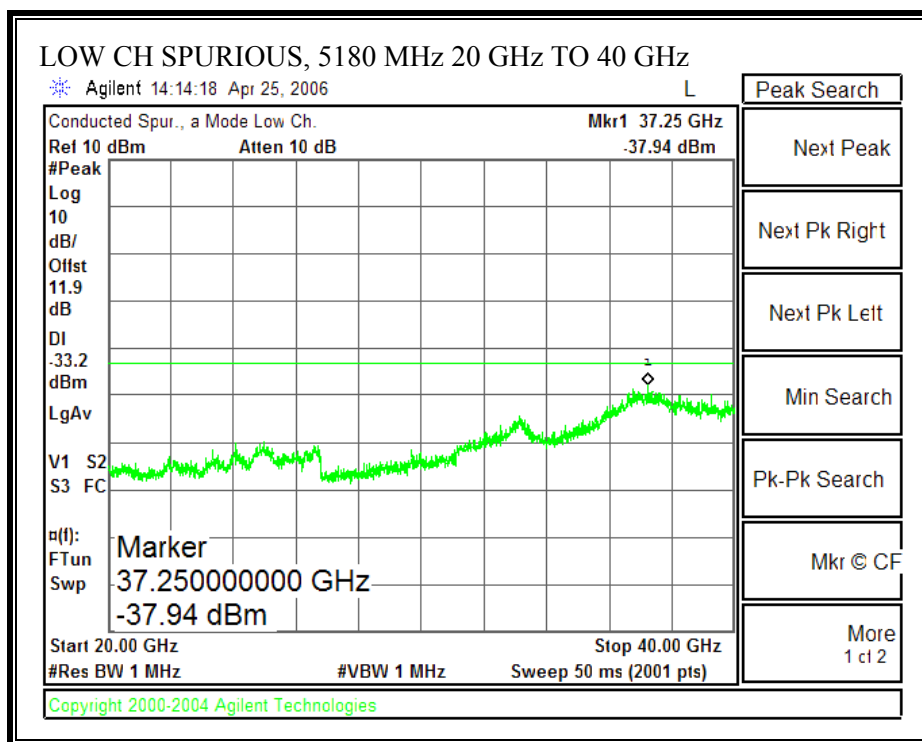
No non-compliance noted:

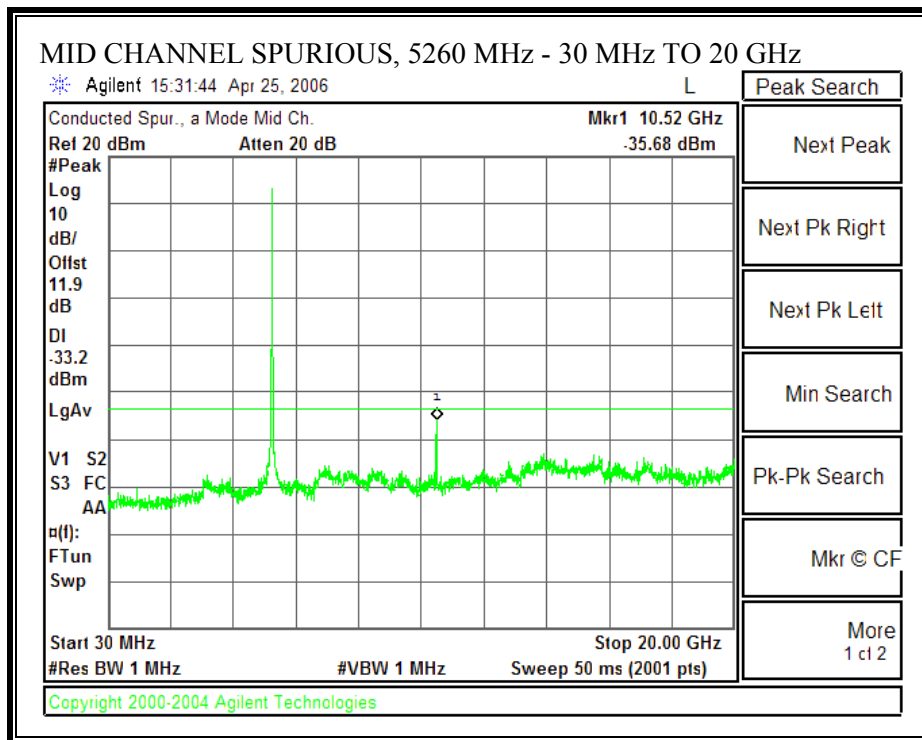
802.11a CDD is covered by worst case 802.11n 20 MHz CDD MCS 0

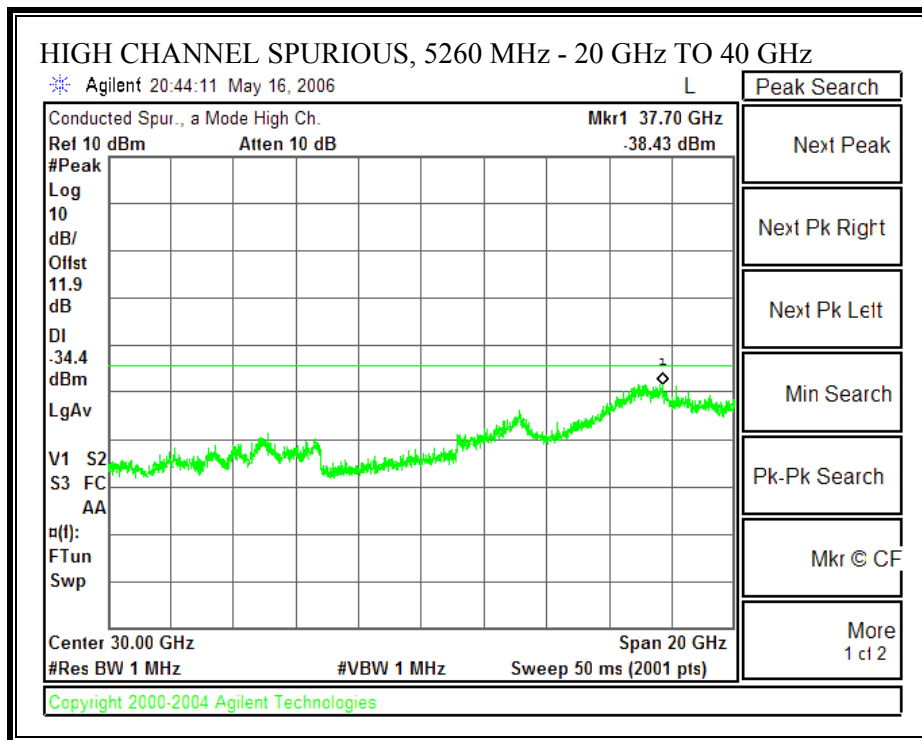
802.11n 20 MHz CDD MCS 0

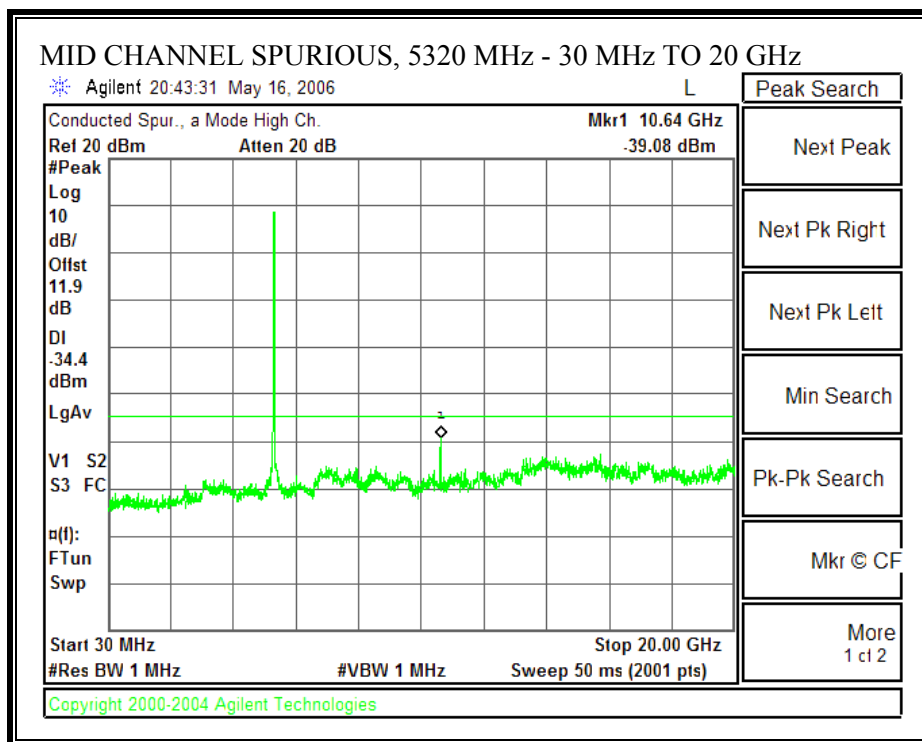
SPURIOUS EMISSIONS - 802.11a -20 MHz TX BANDWIDTH - CHAIN 0

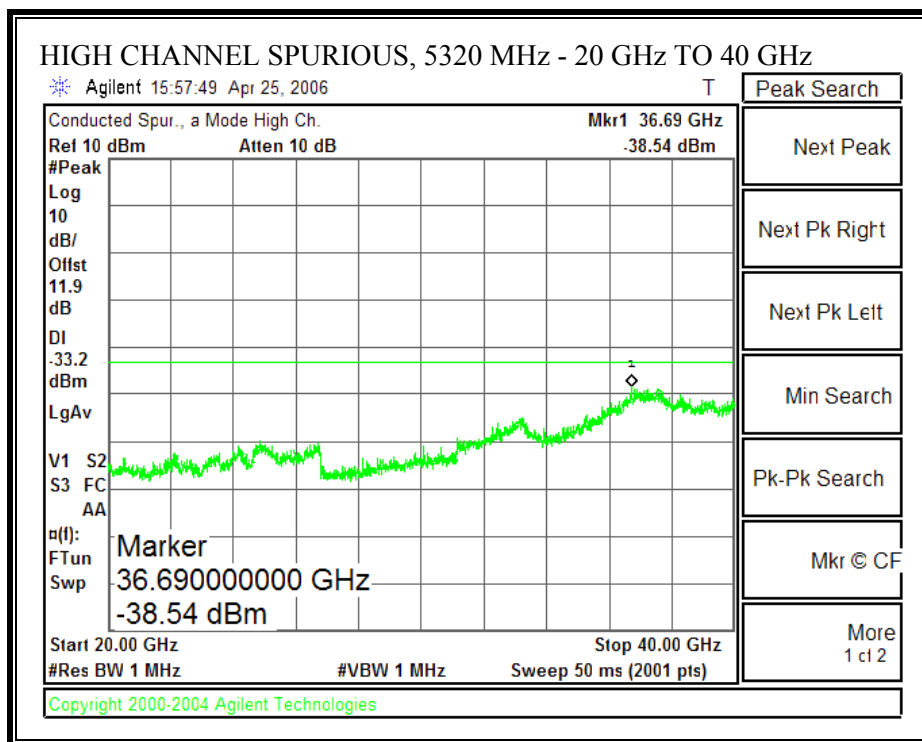




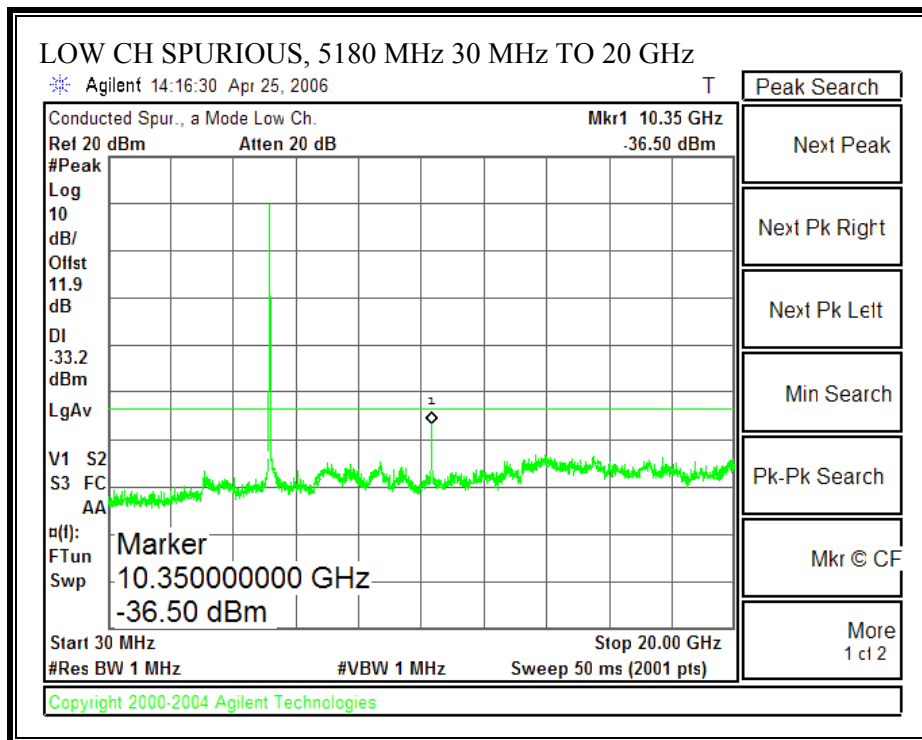


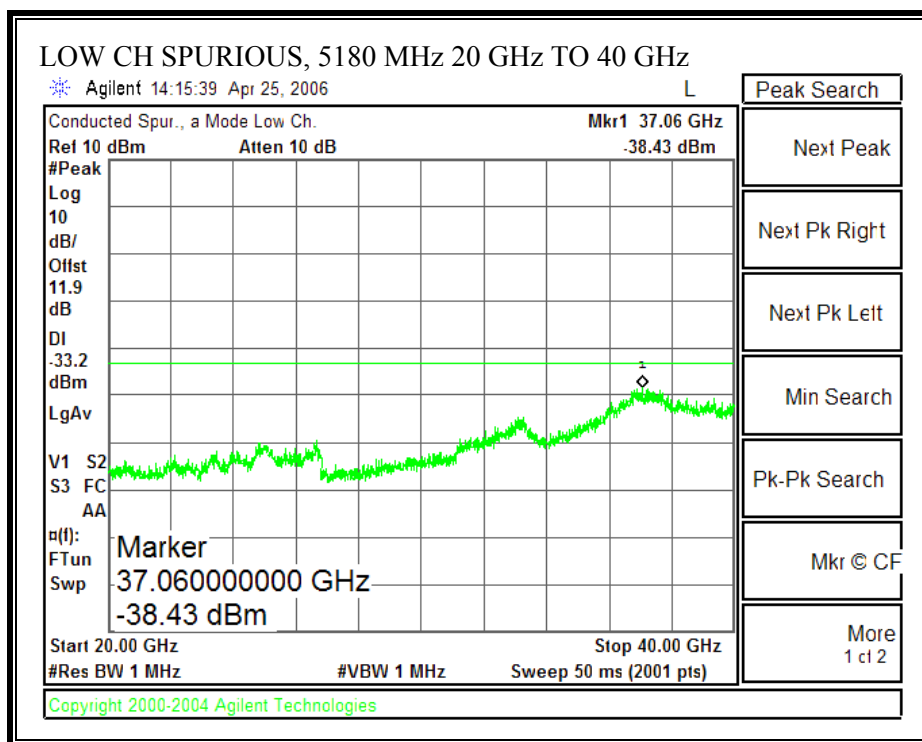


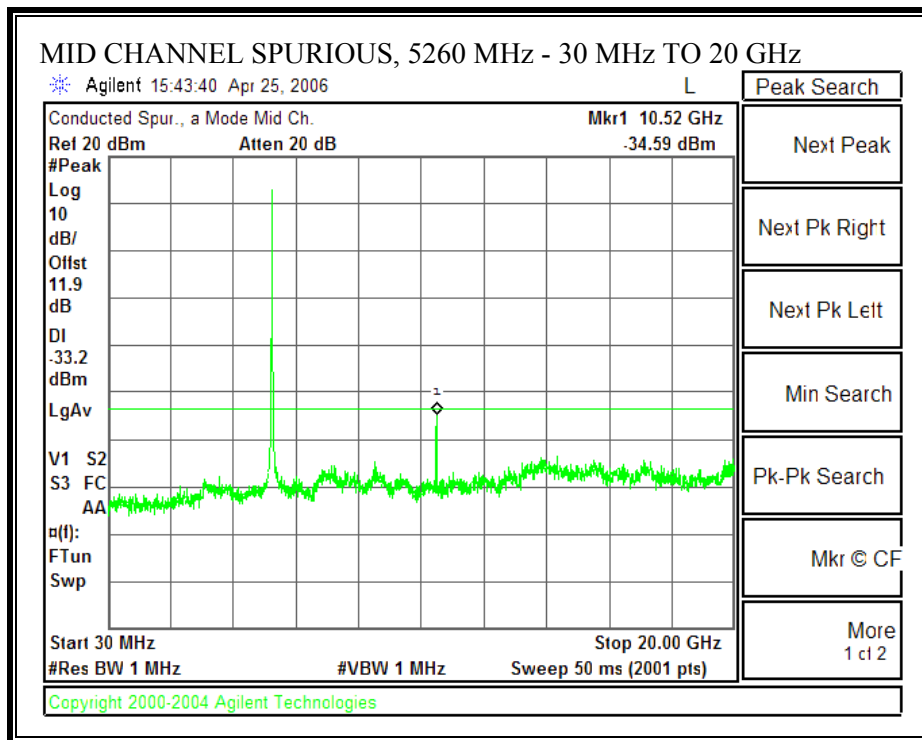


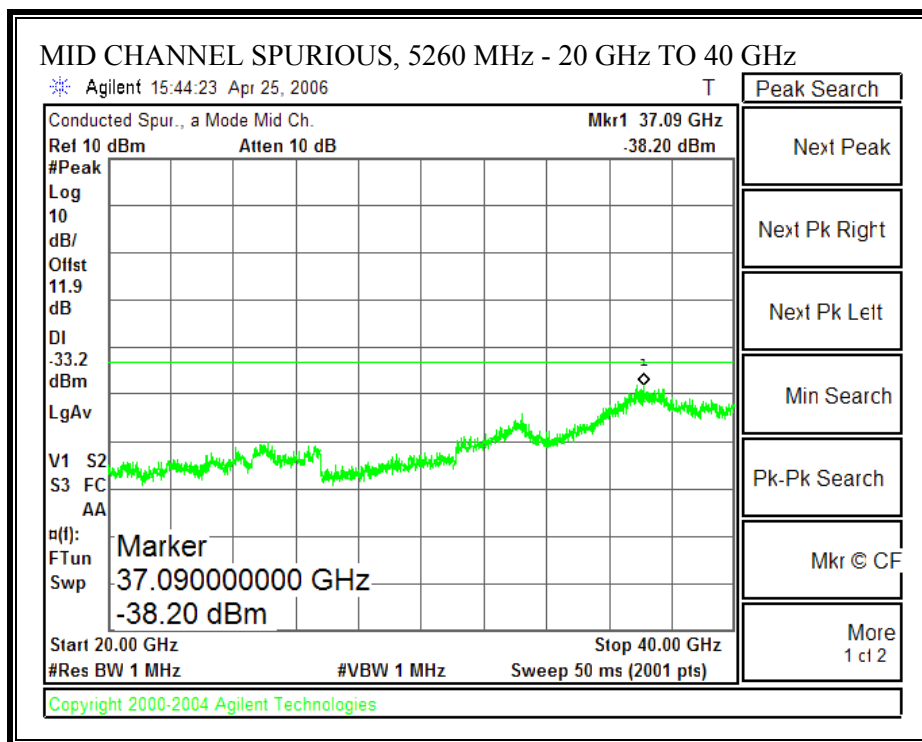


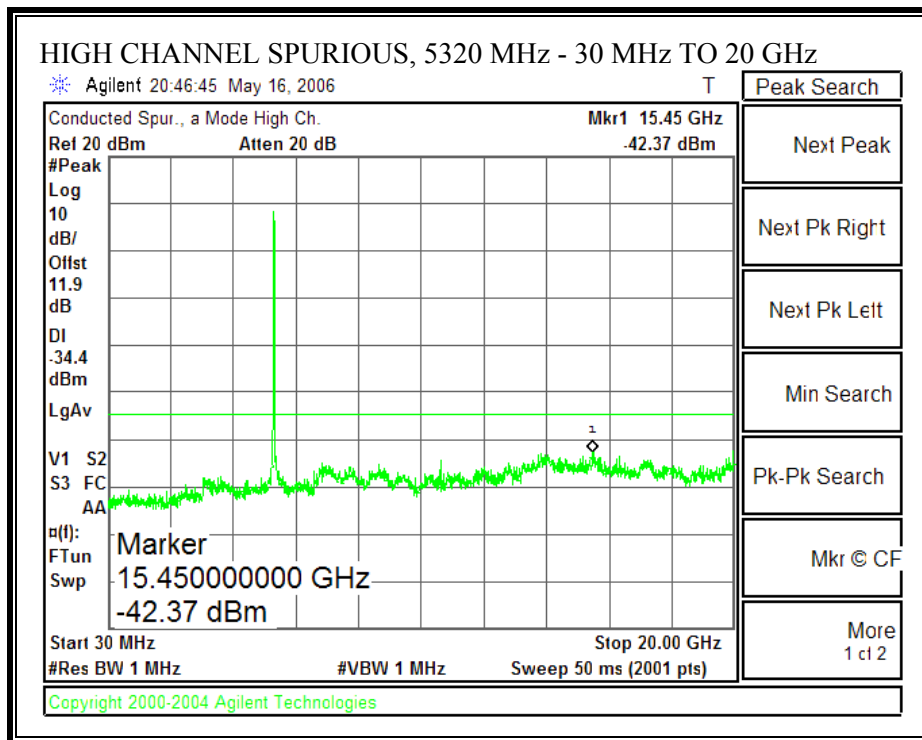
SPURIOUS EMISSIONS - 802.11a -20 MHz TX BANDWIDTH - CHAIN 1

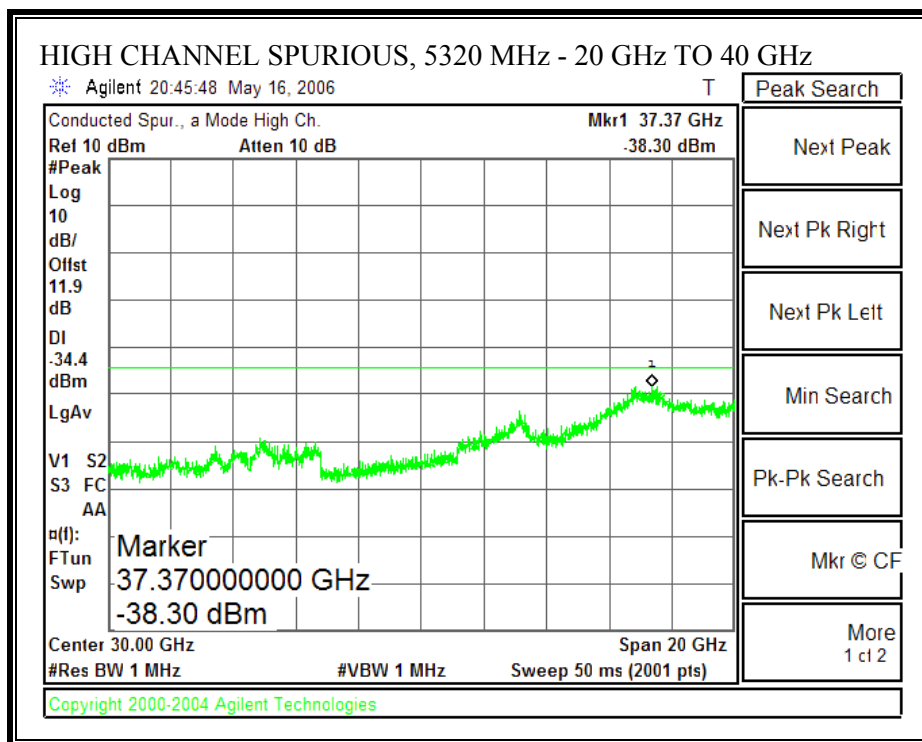






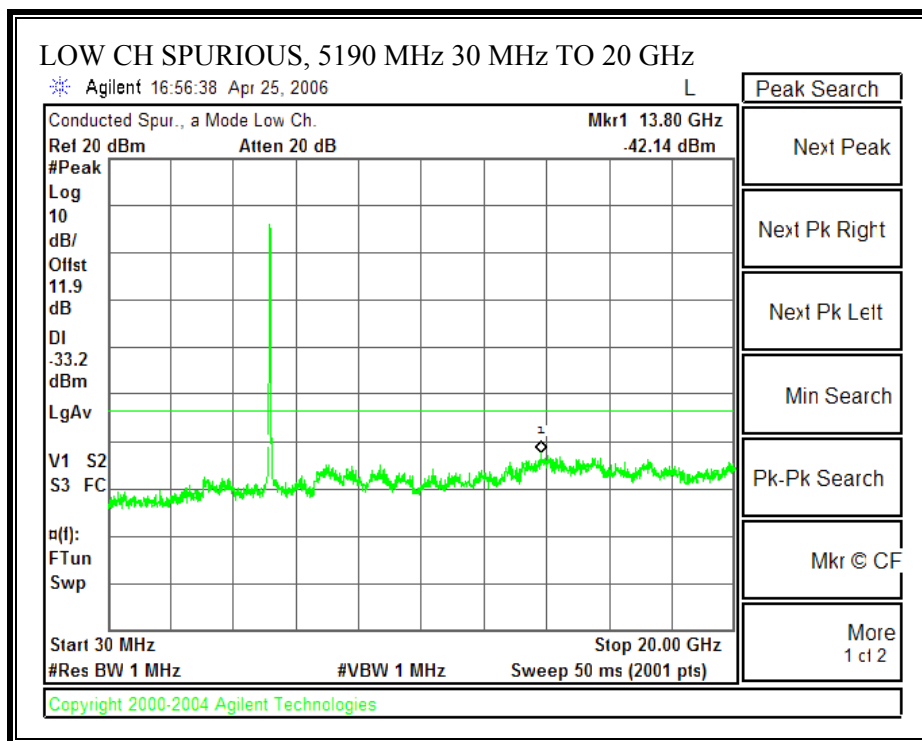


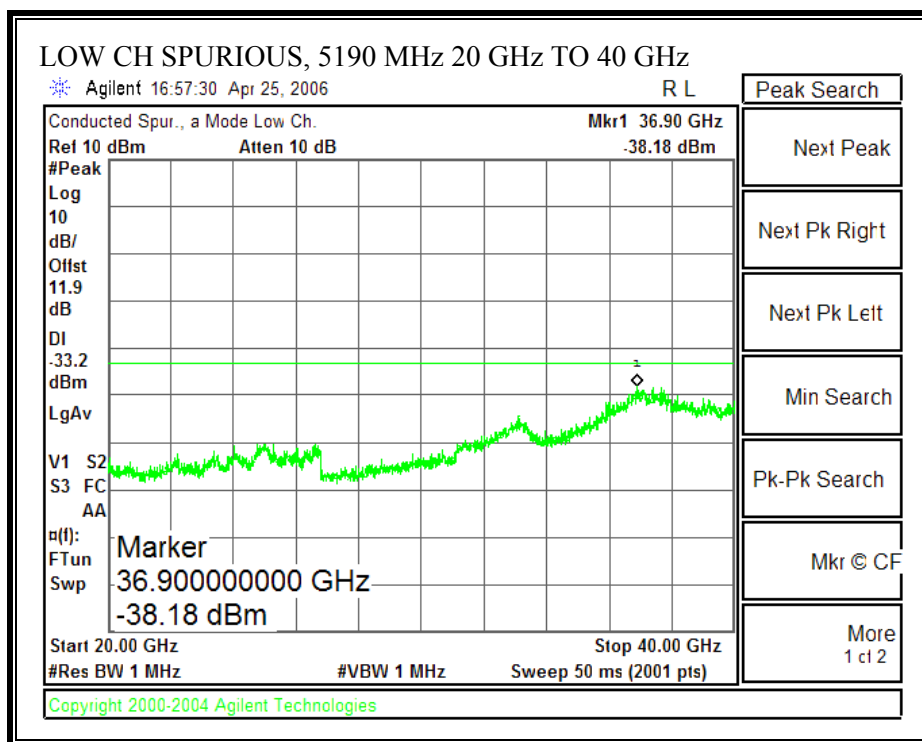


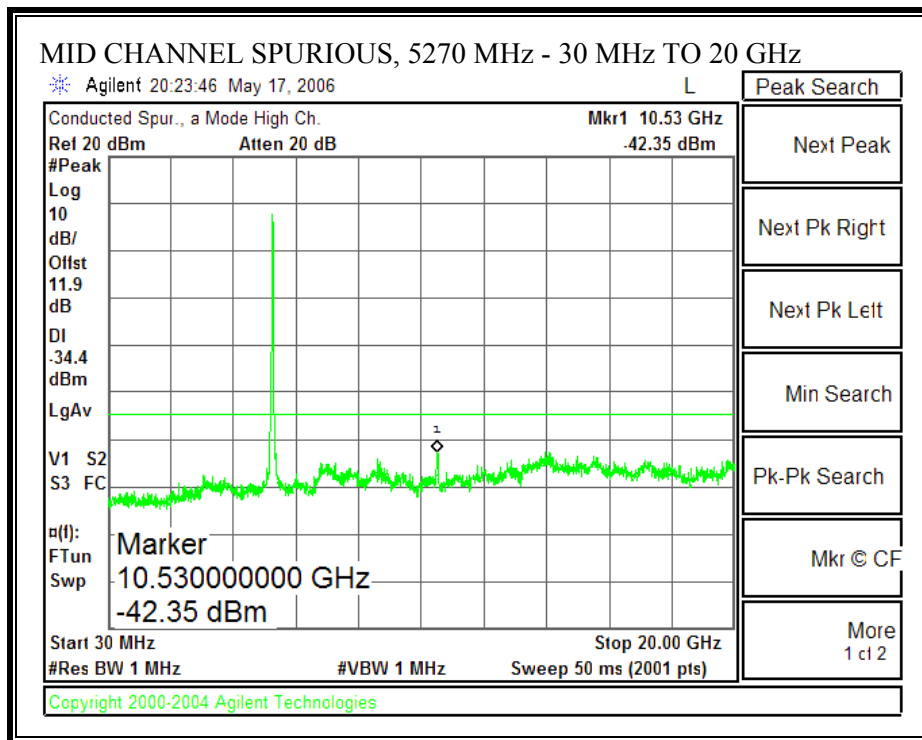


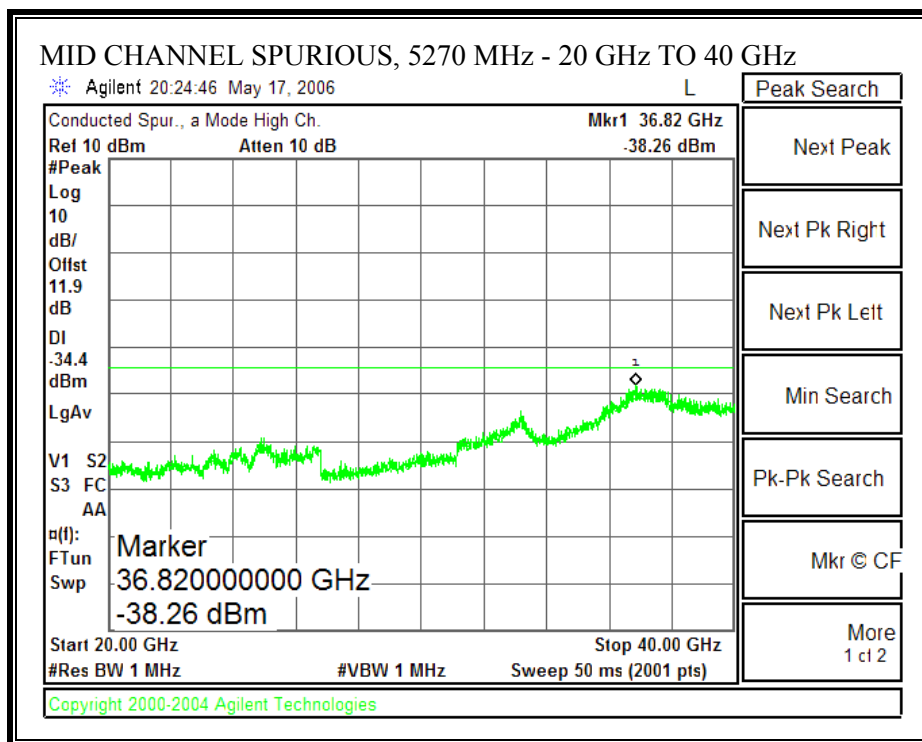
802.11n 40 MHz CDD MCS 32

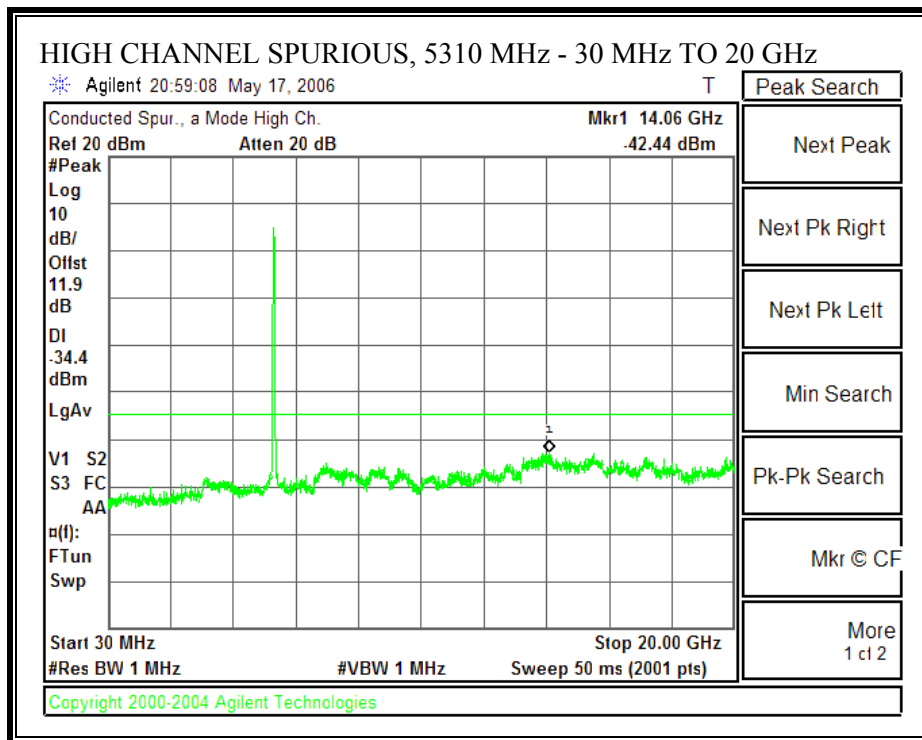
SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 0

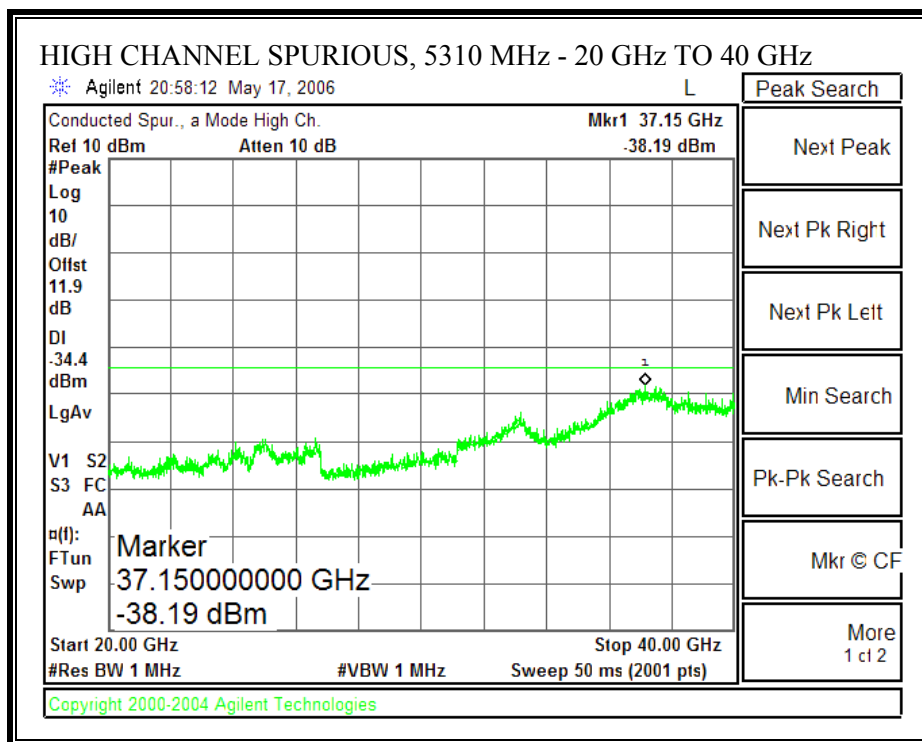




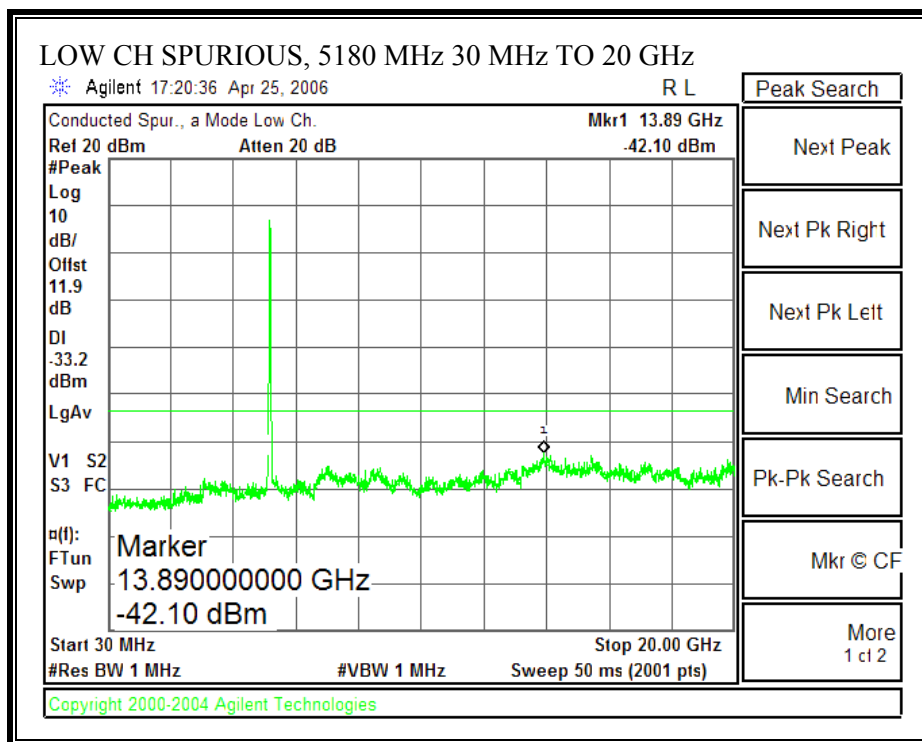


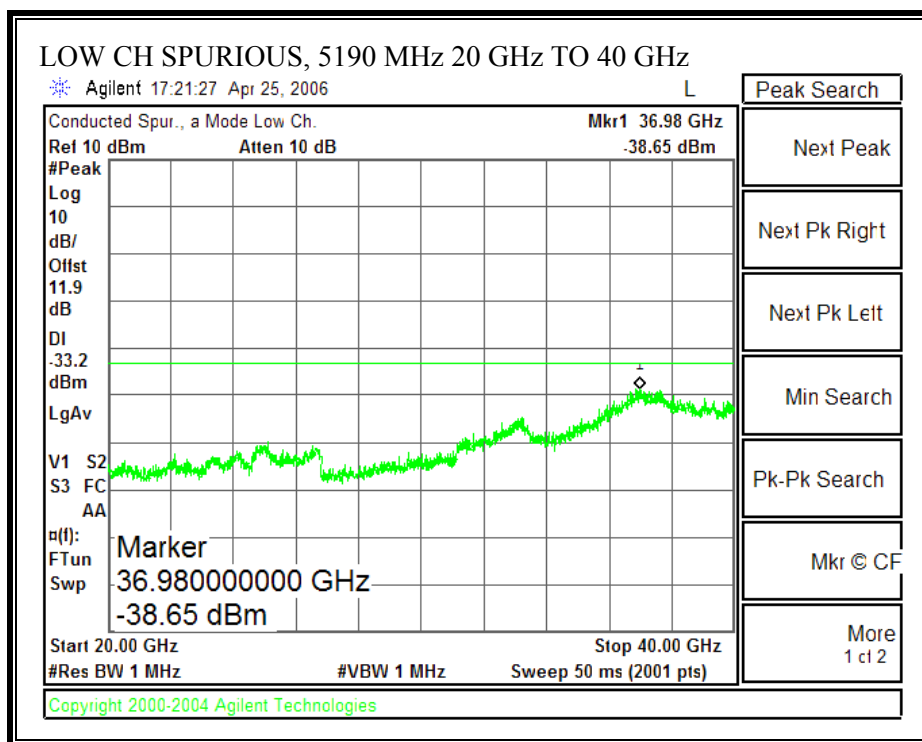


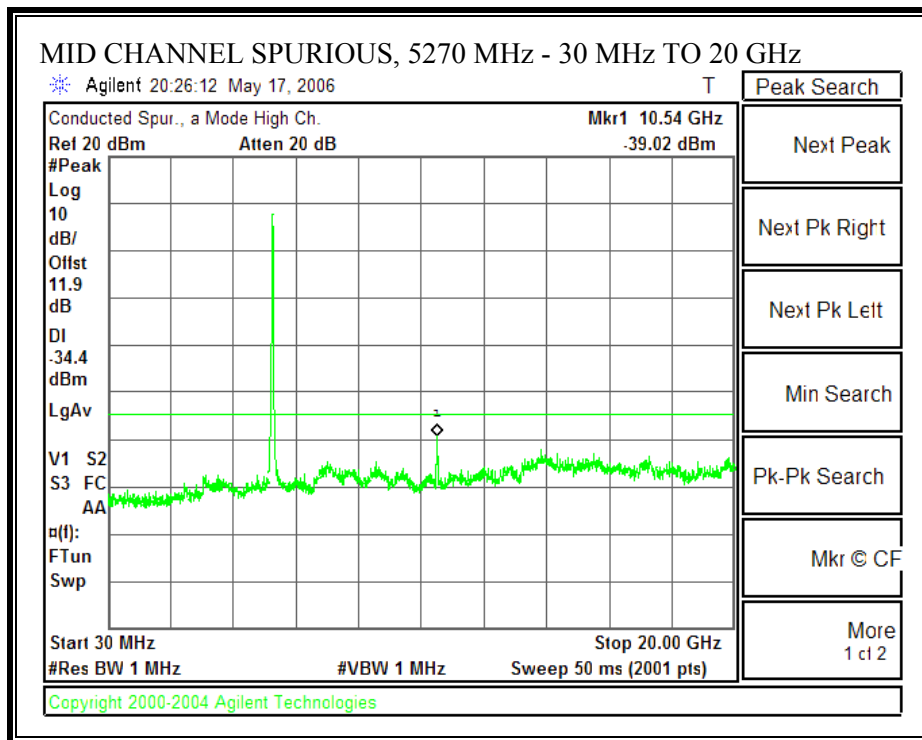


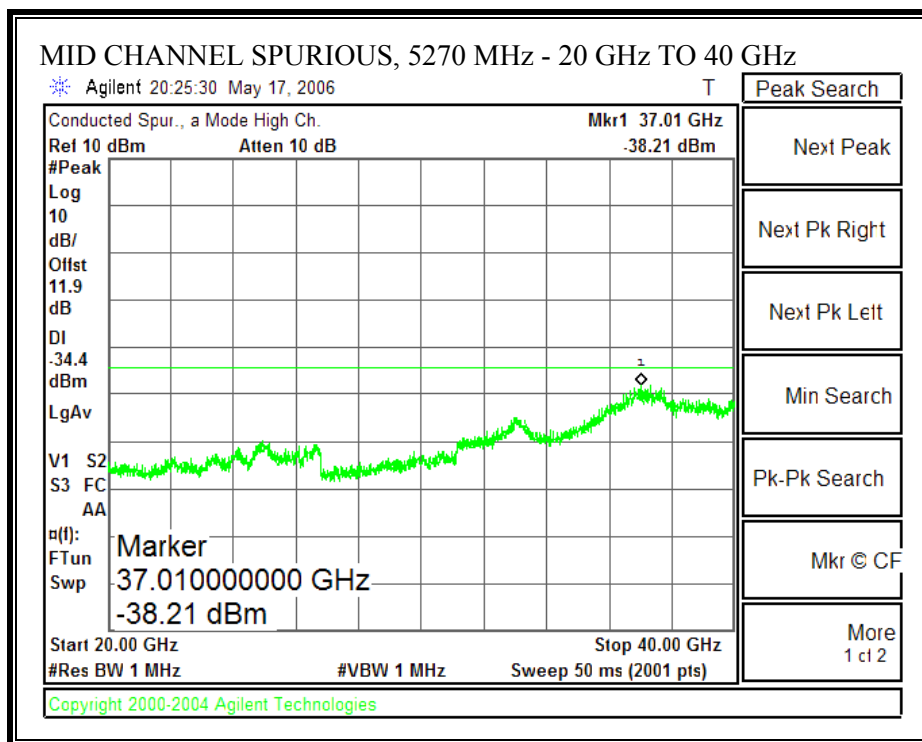


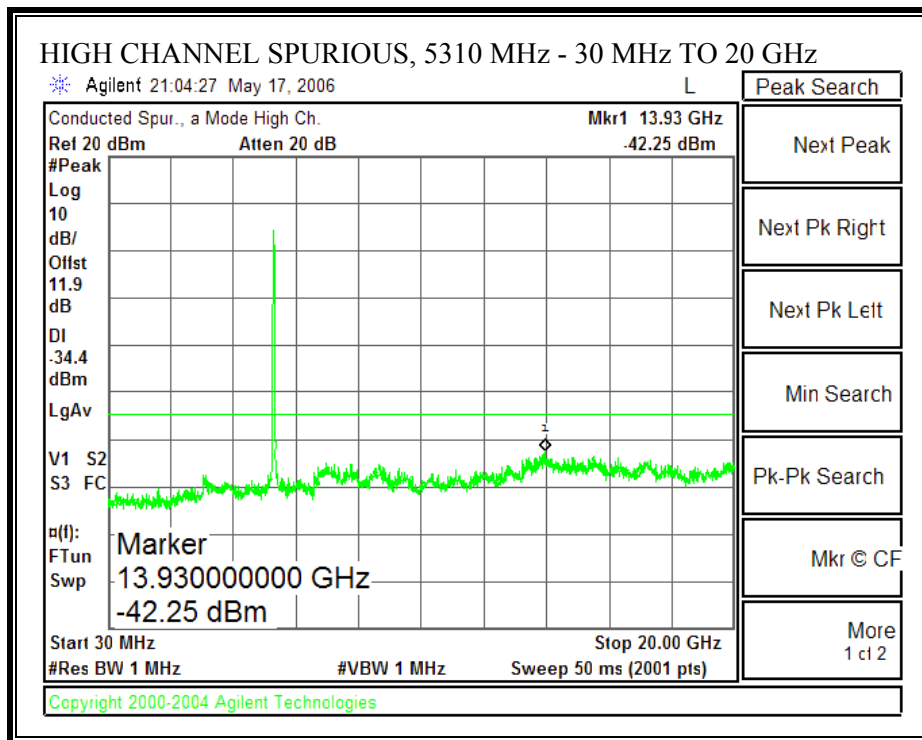
SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 1

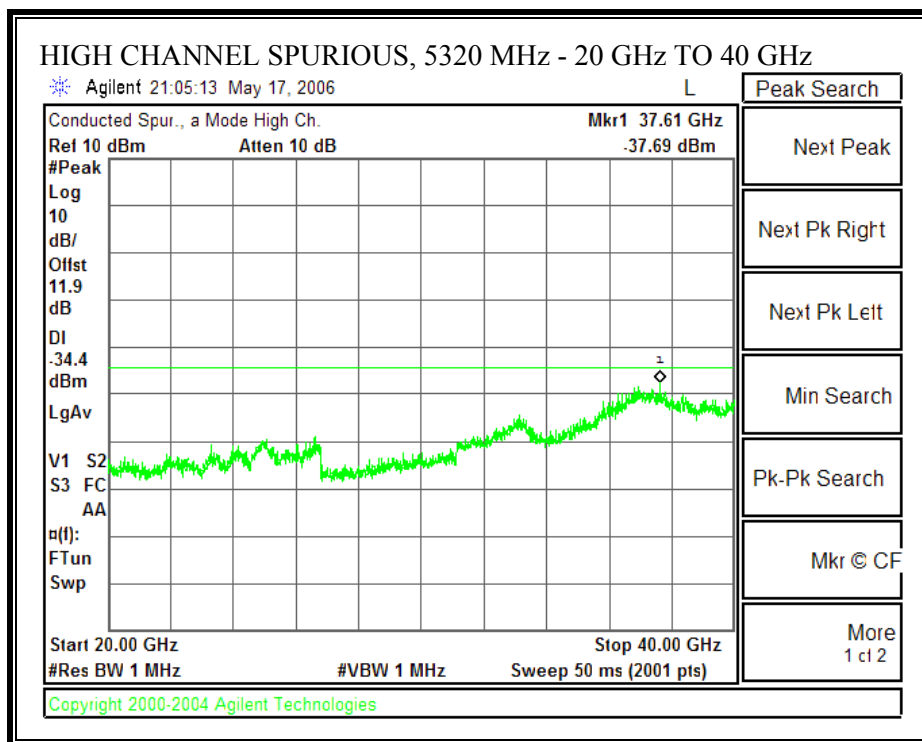






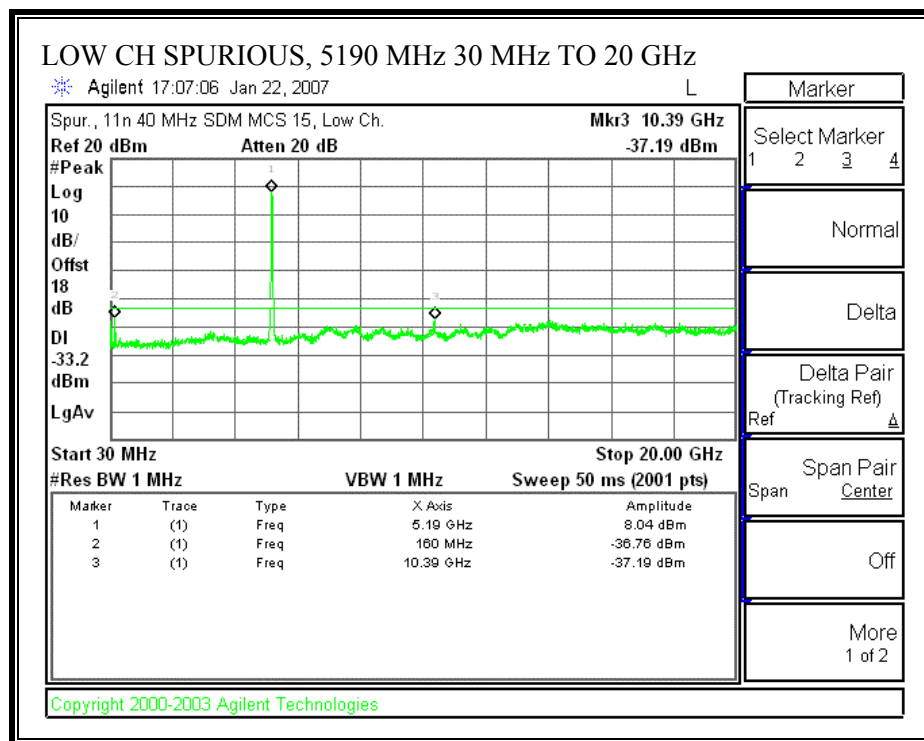


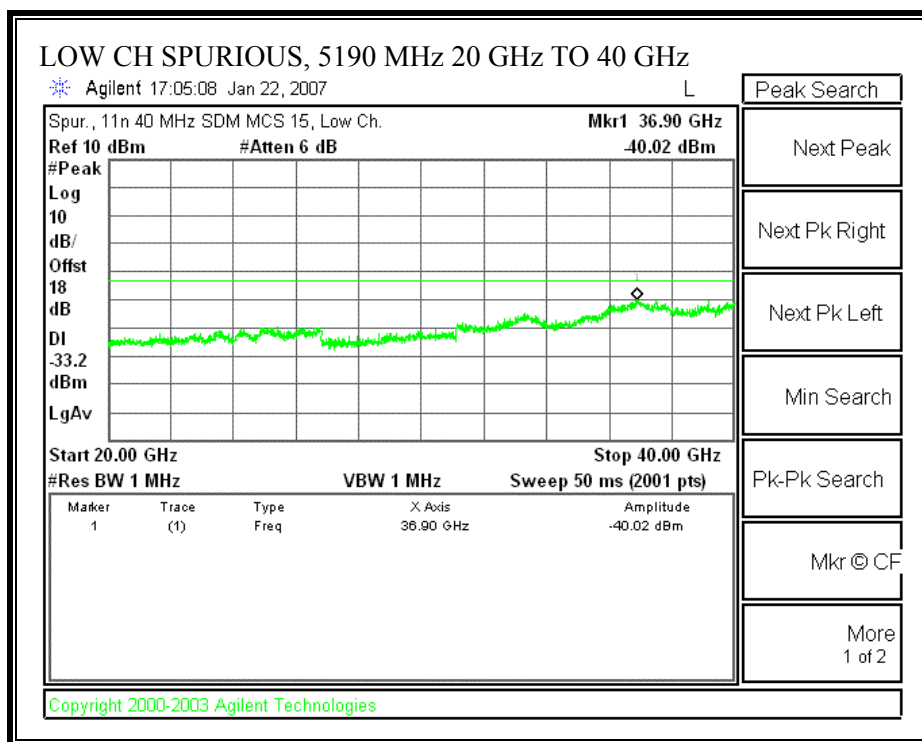




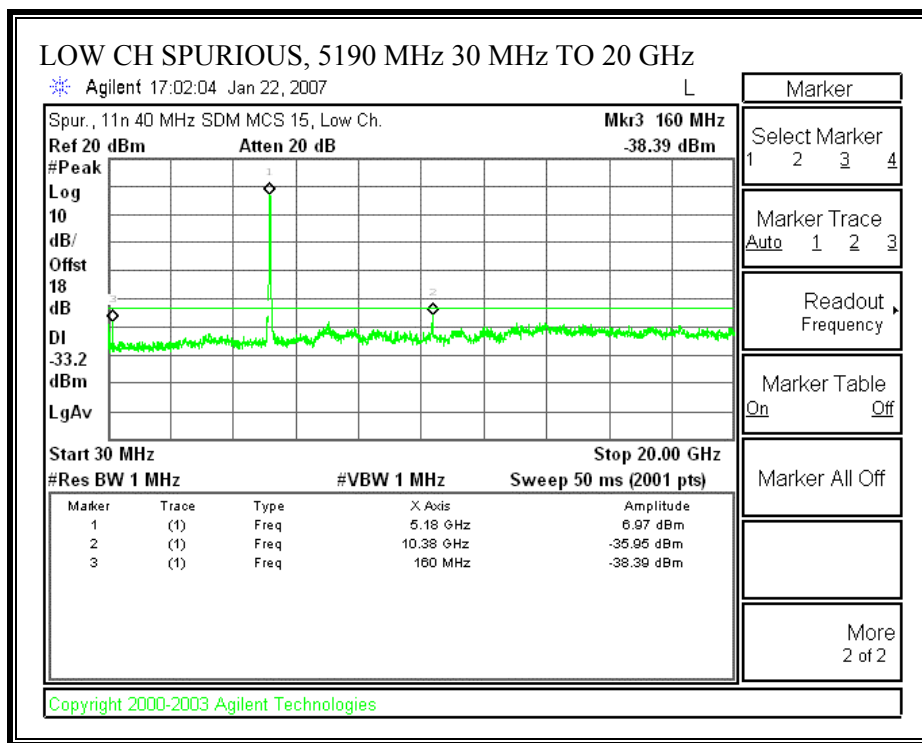
802.11n 40 MHz SDM MCS 15

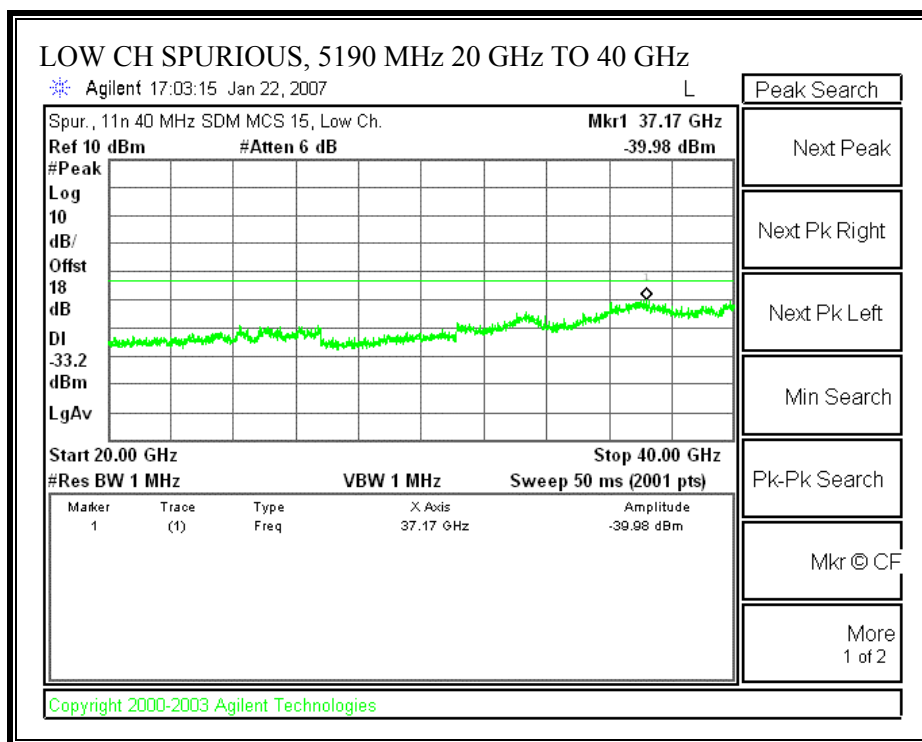
SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 0





SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 1





5470 TO 5725 MHz BAND

LEGACY MODE

7.3. CHANNEL TESTS FOR THE 5470 TO 5725 MHz BAND

7.3.1. EMISSION BANDWIDTH

LIMIT

§15.403 (i) Emission bandwidth. For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolutions bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 1% to 3% of the 26 dB bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled.

RESULTS

No non-compliance noted:

802.11a LEGACY MODE

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5500	29.64	14.72
Middle	5600	31.93	15.04
High	5700	32.49	15.12

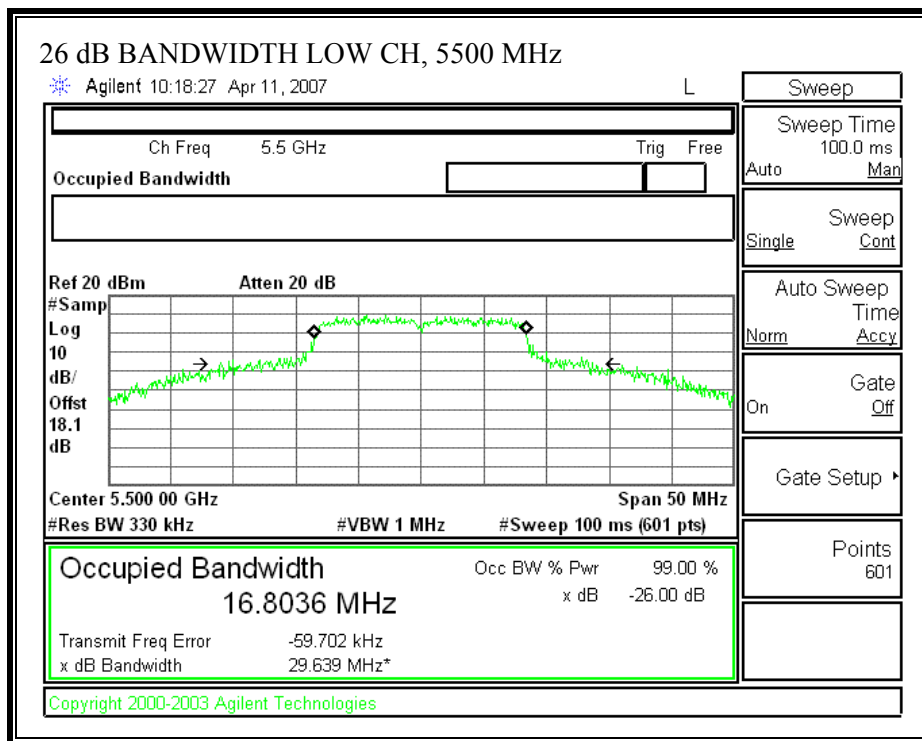
802.11n 20 MHz SISO MCS 0 MODE is covered by the worst case Legacy testing

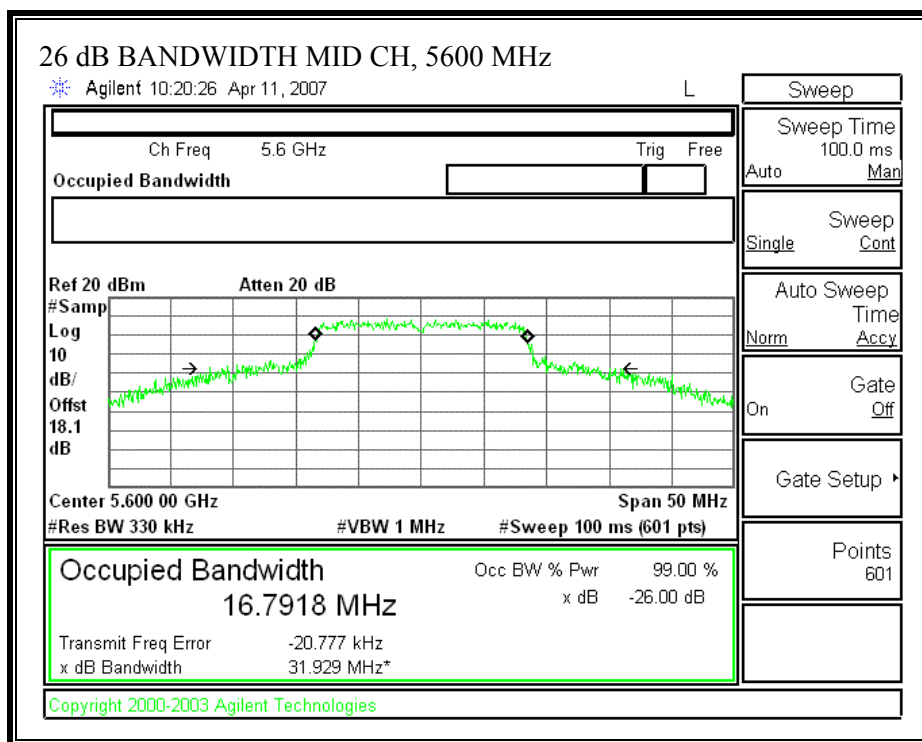
802.11n 40 MHz SISO MCS 32 MODE

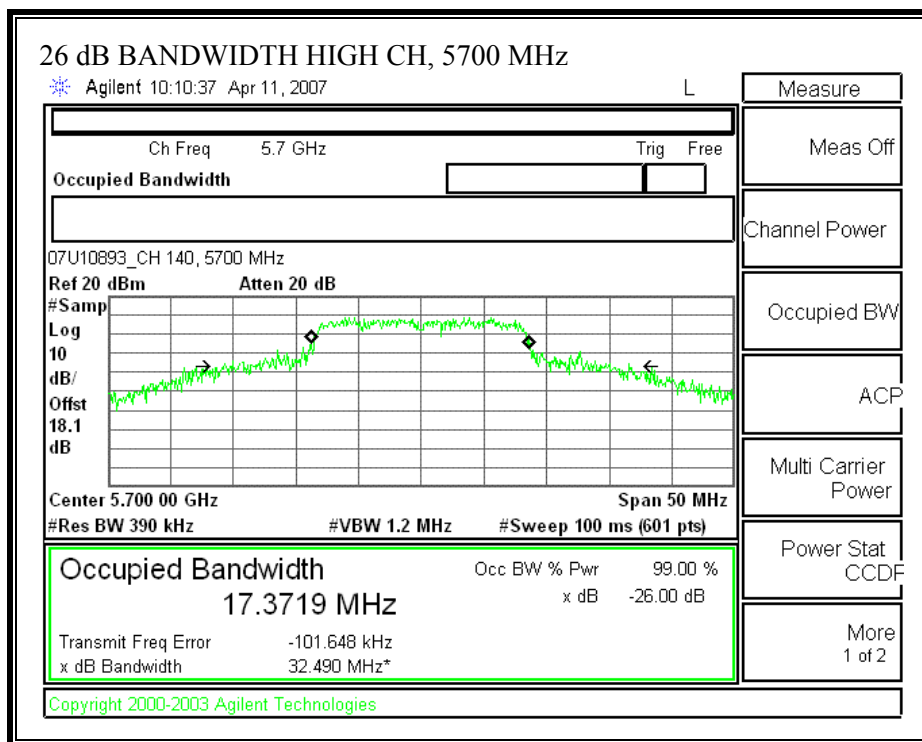
Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5510	48.77	16.88
Middle	5590	49.04	16.91
High	5670	43.37	16.37

802.11a MODE

26 dB EMISSION BANDWIDTH (802.11a MODE)

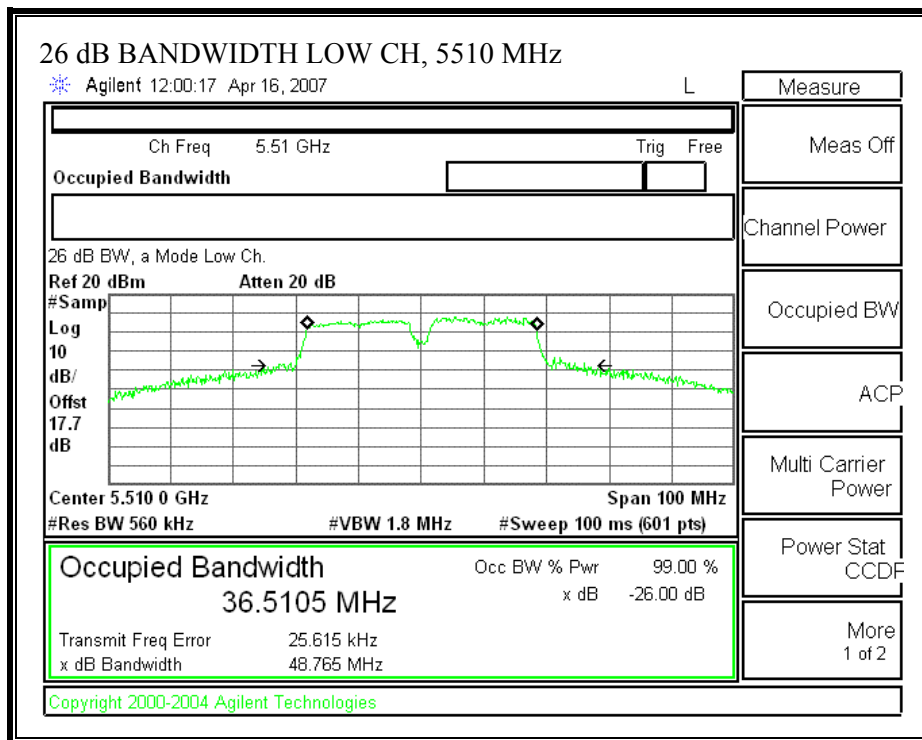


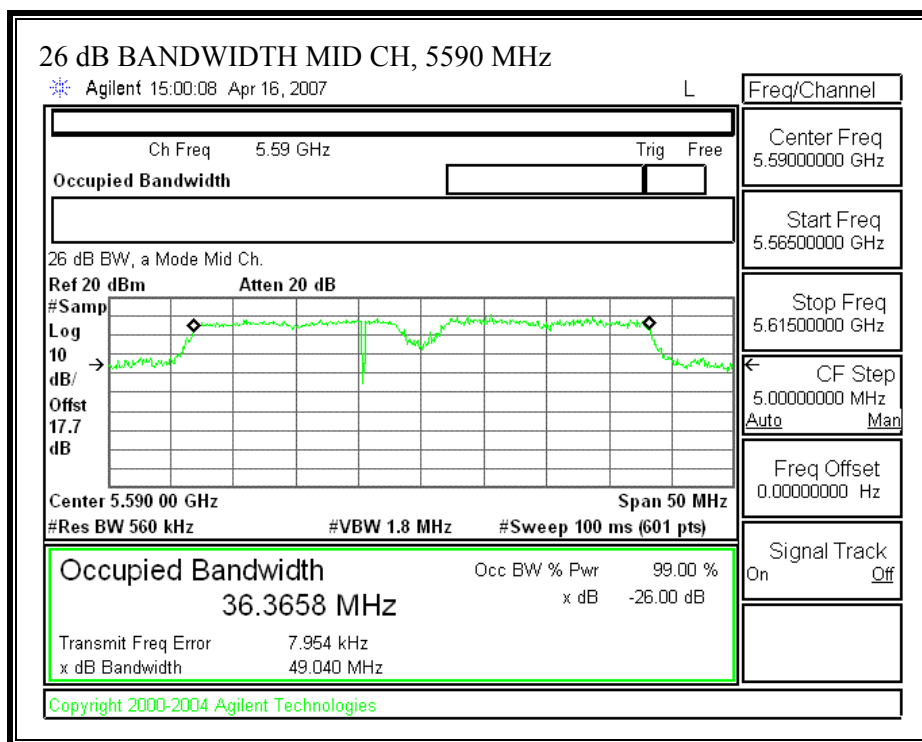


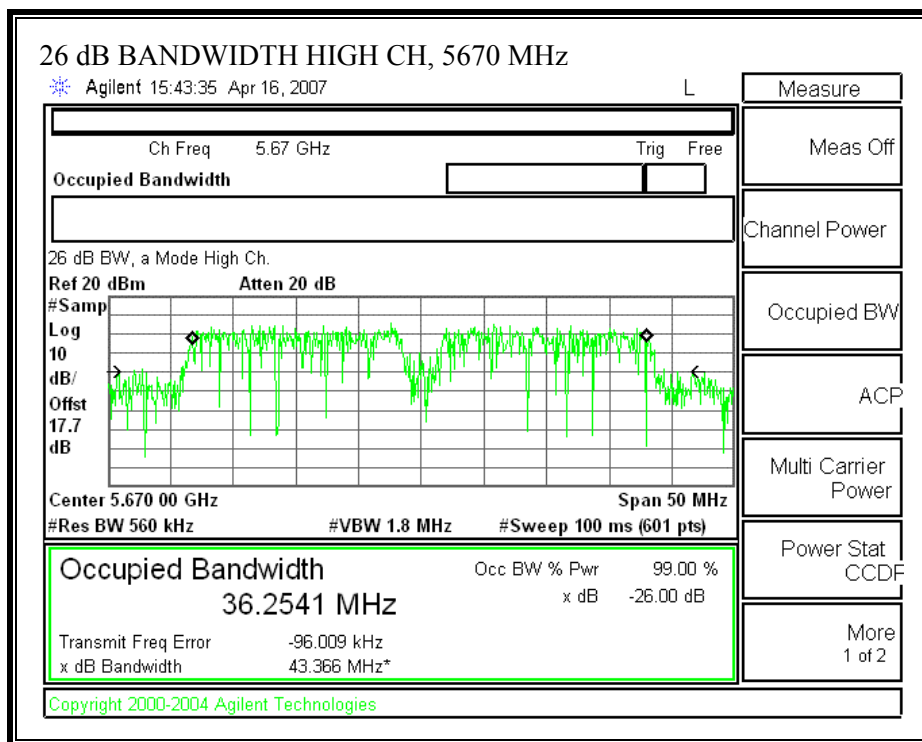


11n 40 MHz SISO MCS 32 MODE

26 dB EMISSION BANDWIDTH







7.3.2. PEAK POWER

LIMIT

§15.407 (a) (2) For the 5.47–5.725 GHz band, the peak transmit power over the frequency band of operation shall not exceed the lesser of 250 mW or $11 \text{ dBm} + 10 \log B$, where B is the 26-dB emission bandwidth in MHz. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002.

The transmitter output operates continuously therefore Method # 1 is used.

LIMITS AND RESULTS

The cable assembly insertion loss of 11.4 dB (including 10 dB pad and 1.4 dB cable) was entered as an offset in the power meter to allow for direct reading of power.

THE ANTENNA GAIN:

5.470 – 5.725 GHz: 6.02dB

LIMITS AND RESULTS

No non-compliance noted:

802.11a MODE

LIMITS AND RESULTS FOR TRANSMIT POWER:

Transmit Power Limit

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	11 + 10 Log B Limit (dBm)	Limit (dBm)
Low	5500	24	16.80	23.25	23.25
Mid	5600	24	16.79	23.25	23.25
High	5700	24	17.37	23.40	23.40

Transmit Power Results

Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Low	5500	17.34	23.25	-5.91
Mid	5600	17.59	23.25	-5.66
High	5700	17.75	23.40	-5.65

LIMITS AND RESULTS FOR EIRP:

EIRP Limit

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	17 + 10 Log B Limit (dBm)	Limit (dBm)
Low	5500	30	16.80	29.25	29.25
Middle	5600	30	16.79	29.25	29.25
High	5700	30	17.37	29.40	29.40

EIRP Results

Channel	Frequency (MHz)	Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)
Low	5500	17.34	6.02	23.36	29.25	-5.89
Middle	5600	17.59	6.02	23.61	29.25	-5.64
High	5700	17.75	6.02	23.77	29.40	-5.63

802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

802.11n 40 MHz SISO MCS 32 MODE

LIMITS AND RESULTS FOR TRANSMIT POWER:

Transmit Power Limit

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	11 + 10 Log B Limit (dBm)	Limit (dBm)
Low	5510	24	36.51	26.62	24.00
Mid	5590	24	36.37	26.61	24.00
High	5670	24	36.25	26.59	24.00

Transmit Power Results

Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Low	5510	15.45	24.00	-8.55
Mid	5590	17.99	24.00	-6.01
High	5670	18.23	24.00	-5.77

LIMITS AND RESULTS FOR EIRP:

EIRP Limit

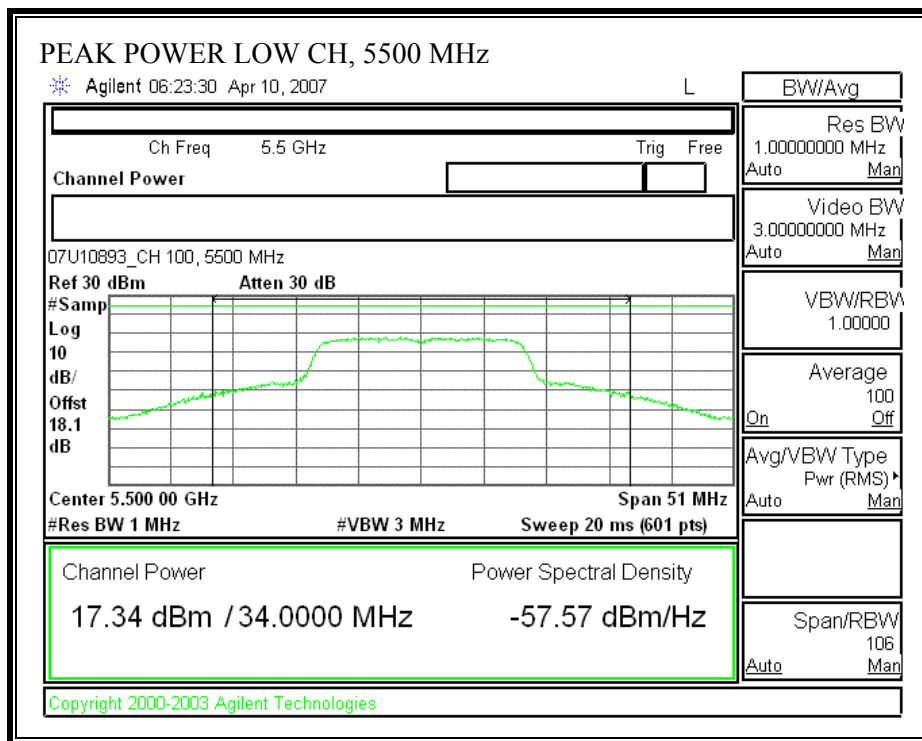
Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	17 + 10 Log B Limit (dBm)	Limit (dBm)
Low	5510	30	16.80	29.25	29.25
Middle	5590	30	16.79	29.25	29.25
High	5670	30	17.37	29.40	29.40

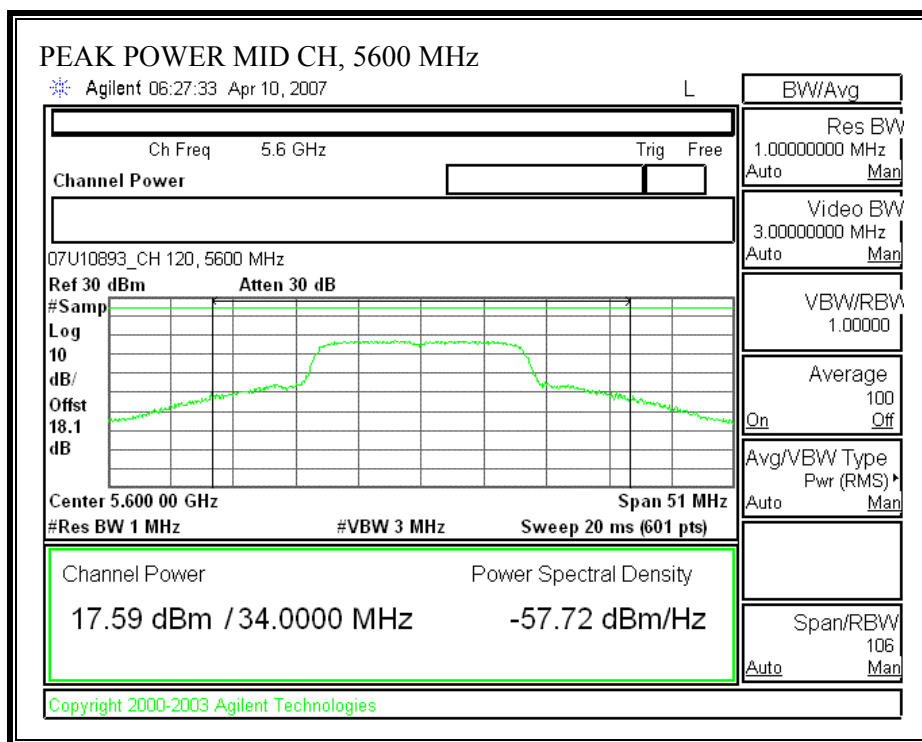
EIRP Results

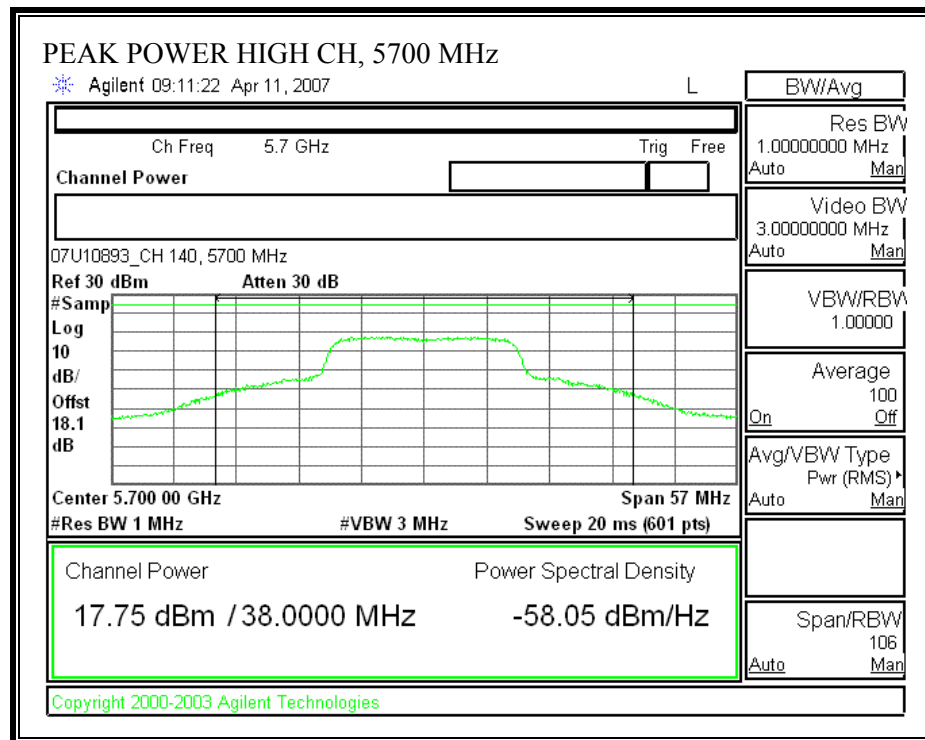
Channel	Frequency (MHz)	Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Limit (dBm)	Margin (dB)
Low	5510	15.45	6.02	21.47	29.25	-7.78
Middle	5590	17.99	6.02	24.01	29.25	-5.24
High	5670	18.23	6.02	24.25	29.40	-5.15

802.11a MODE

PEAK POWER

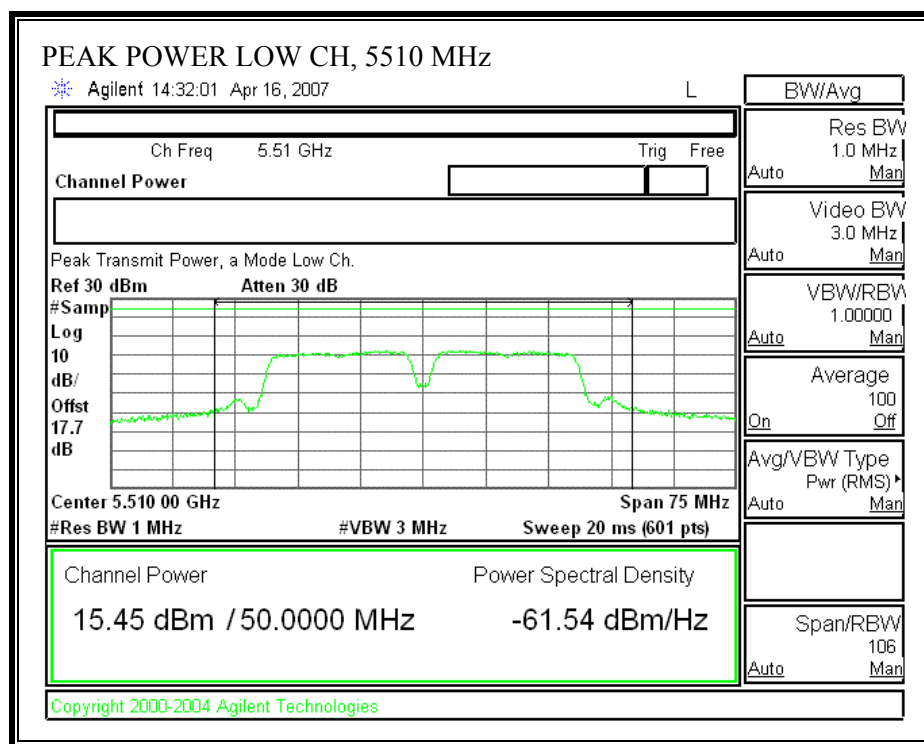


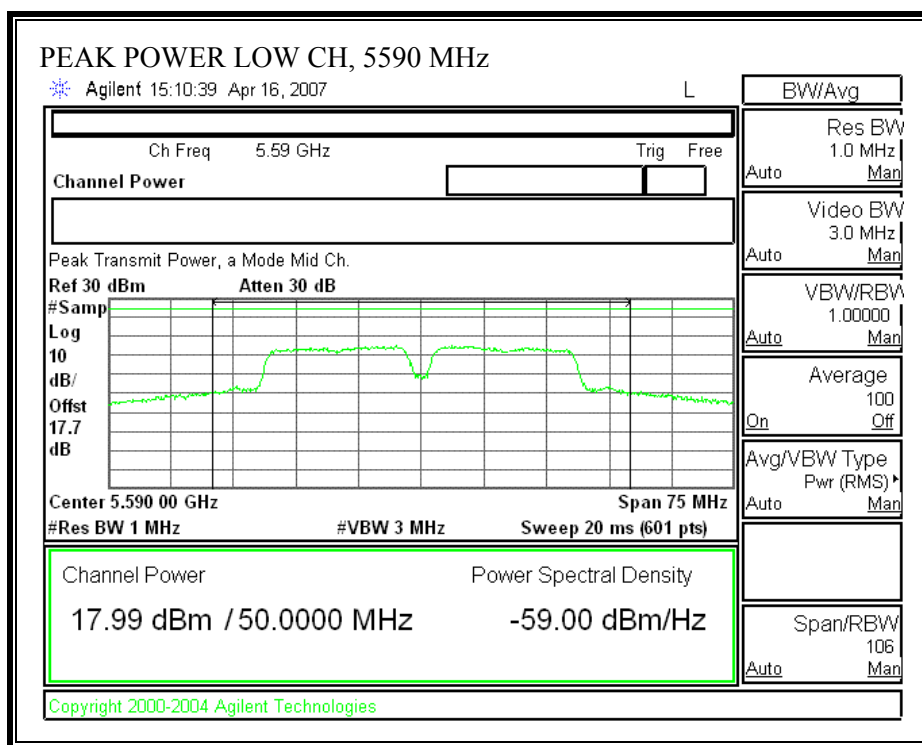


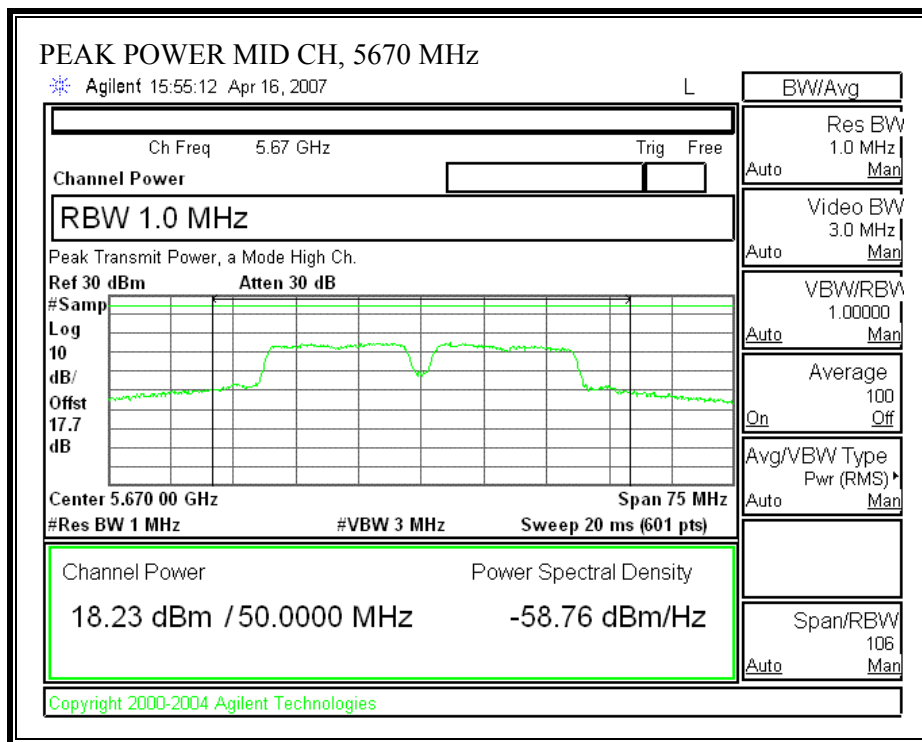


802.11n 40 MHz SISO MCS 32 MODE

PEAK POWER







7.3.3. 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 5.6 GHz band.

RESULTS

No non-compliance noted

802.11a LEGACY MODE

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm ²)
802.11a LEGACY	20.0	17.75	6.02	0.05

802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

802.11n 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	18.23	6.02	0.05

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.

7.3.4. PEAK POWER SPECTRAL DENSITY

LIMIT

§15.407 (a) (2) For the 5.47–5.725 GHz band, the peak power spectral density shall not exceed 11 dBm in any 1-MHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002. PPSD method #2 was used.

RESULTS

No non-compliance noted:

THE ANTENNA GAIN:

5.470 – 5.725 GHz: 6.02dBi, limit = 10.98 dBm

RESULTS

No non-compliance noted:

802.11a MODE

802.11a Mode

Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5500	7.67	10.980	-3.31
Middle	5560	6.97	10.980	-4.01
High	5570	7.41	10.980	-3.57

802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

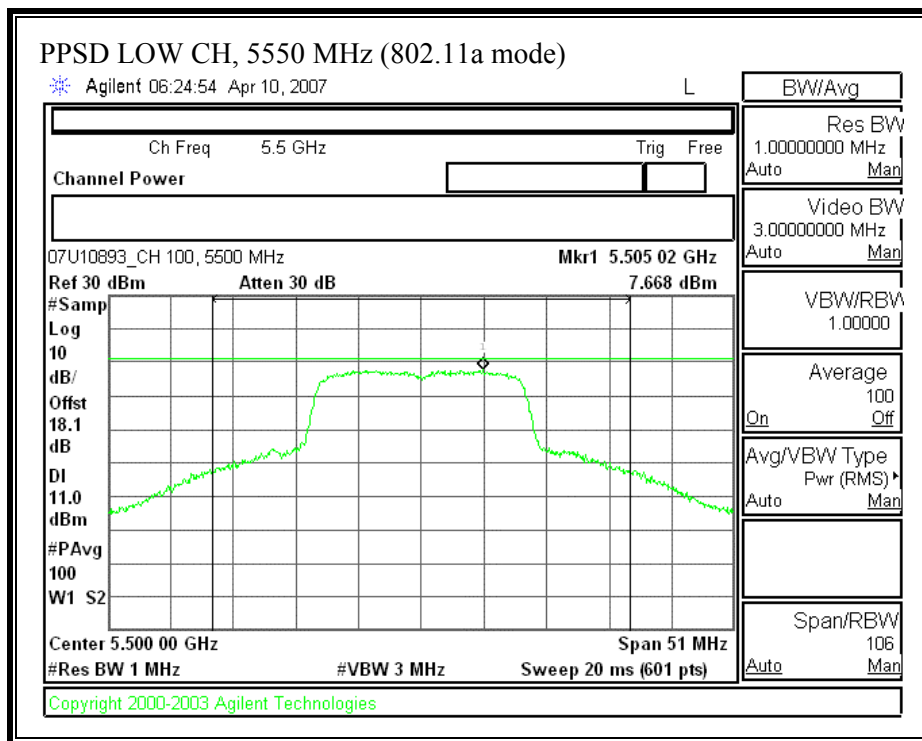
802.11n 40 MHz SISO MCS 32 MODE

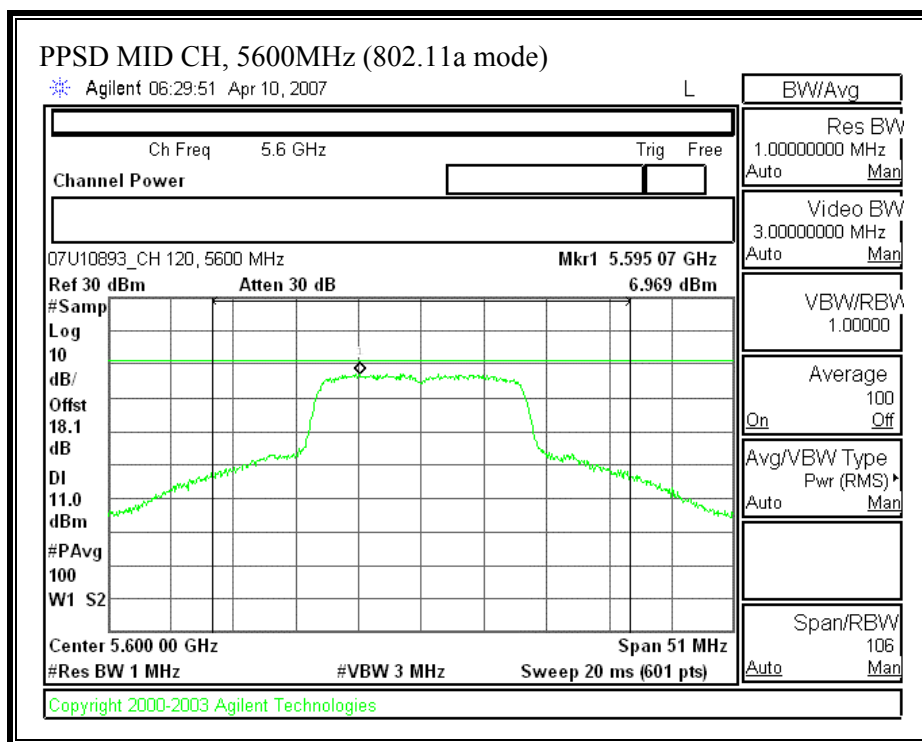
802.11a Mode

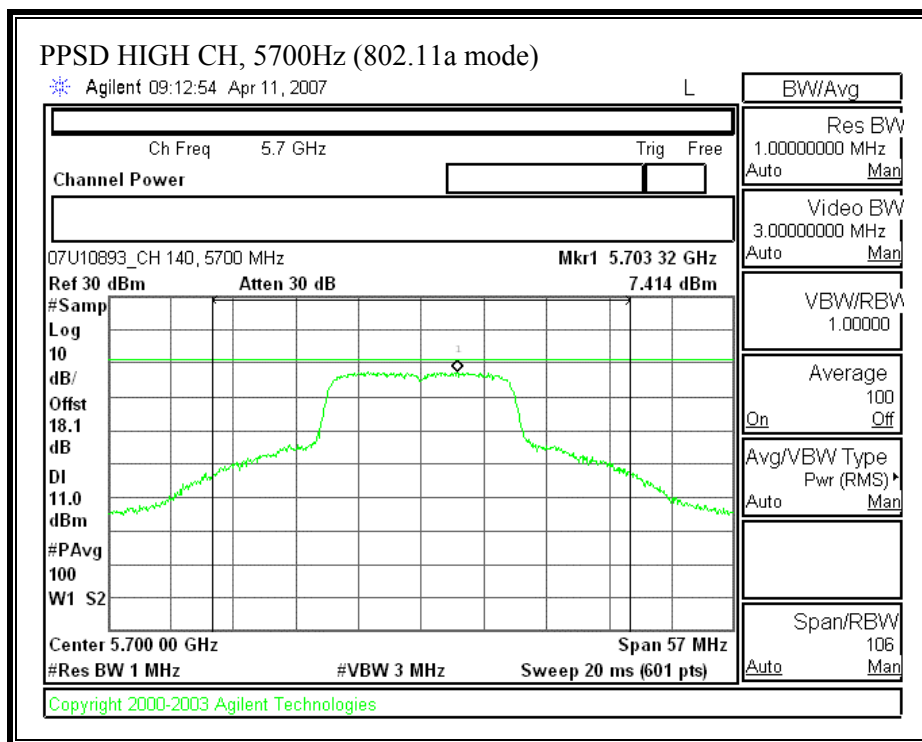
Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5510	2.60	10.980	-8.38
Middle	5590	4.71	10.980	-6.27
High	5570	4.65	10.980	-6.33

802.11a MODE

PEAK POWER SPECTRAL DENSITY (802.11a MODE)

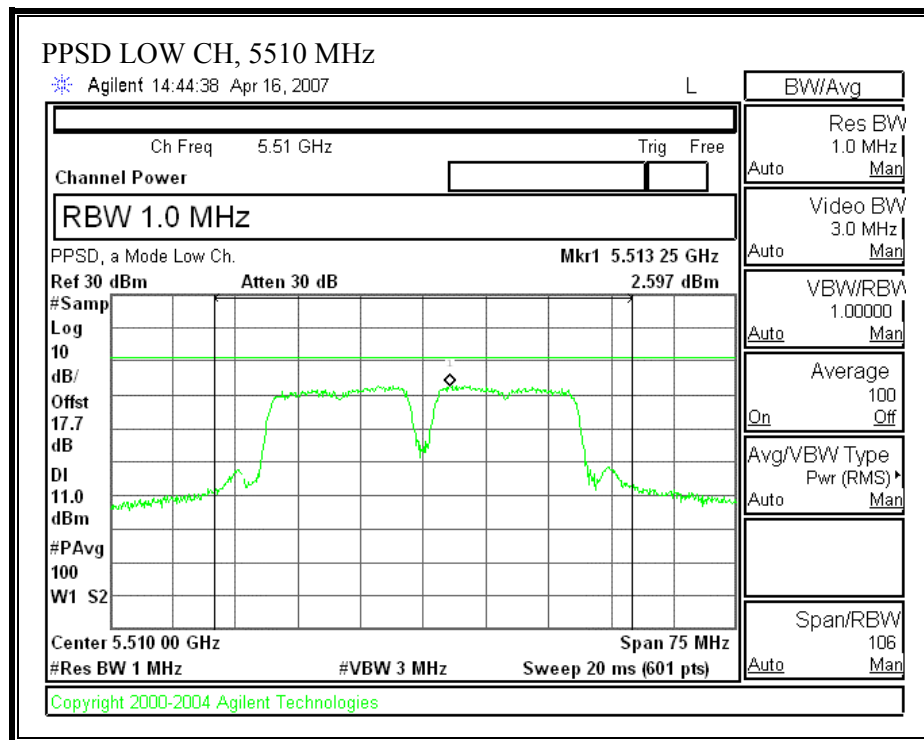


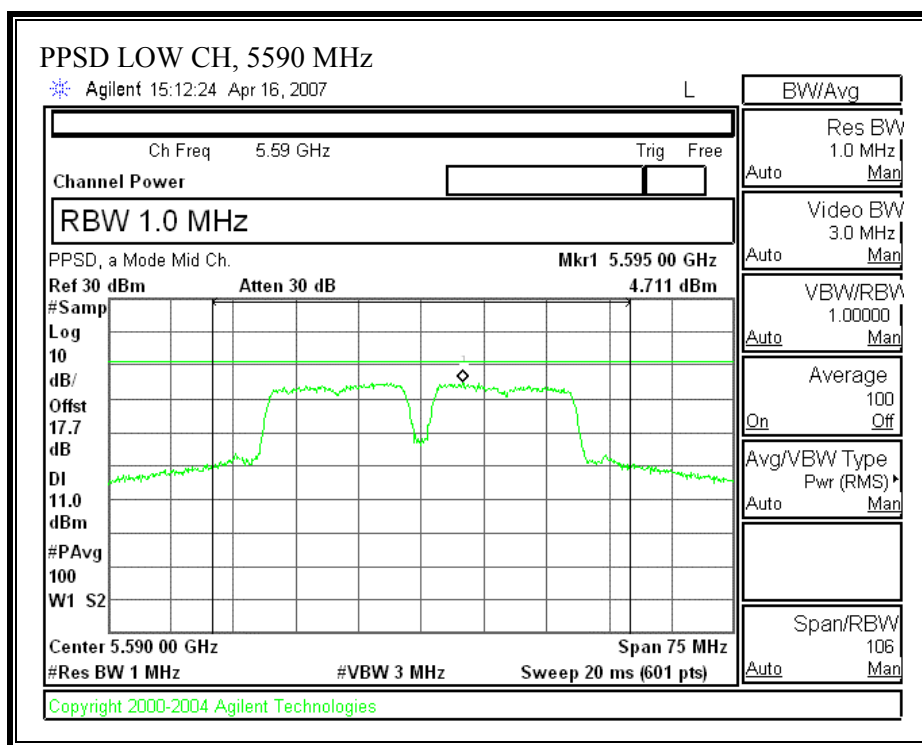


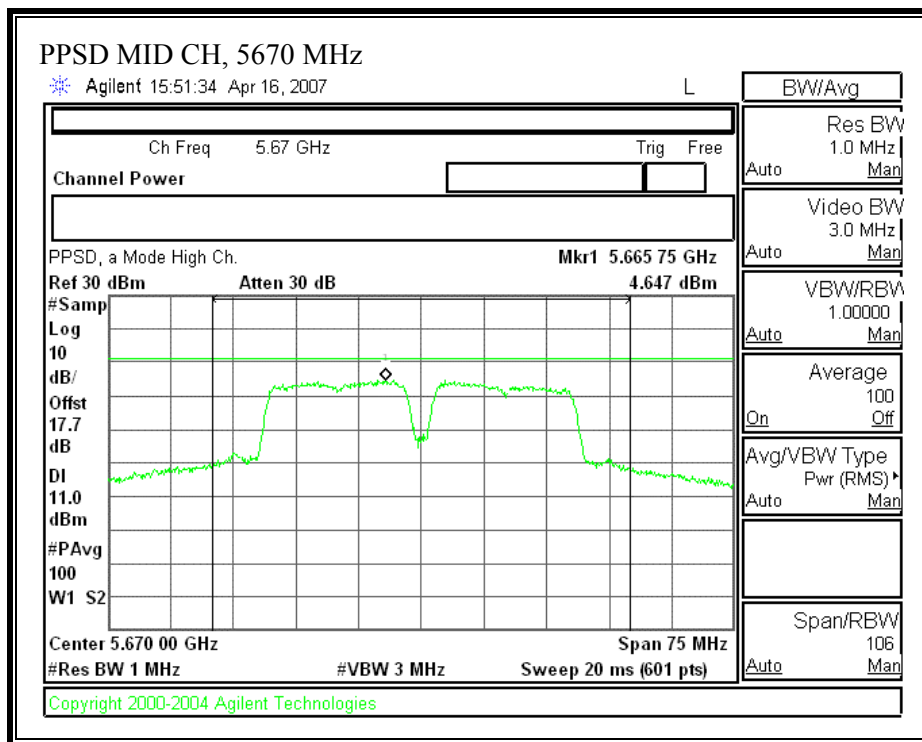


802.11n 40 MHz SISO MCS 32 MODE

PEAK POWER SPECTRAL DENSITY







7.3.5. PEAK EXCURSION

LIMIT

§15.407 (a) (6) The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the peak transmit power (measured as specified above) shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

TEST PROCEDURE

The test is performed in accordance with FCC Public Notice: APPENDIX A Guidelines for Assessing Unlicensed National Information Infrastructure (U-NII) Devices – Part 15, Subpart E, August 2002.

Since Method # 1 was used for peak power measurements, Method # 1 settings are used for the second PPSD trace.

RESULTS

No non-compliance noted:

802.11a MODE

Channel	Frequency (MHz)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
Low	5500	8.30	13	-4.70
Middle	5600	9.92	13	-3.08
High	5700	9.54	13	-3.46

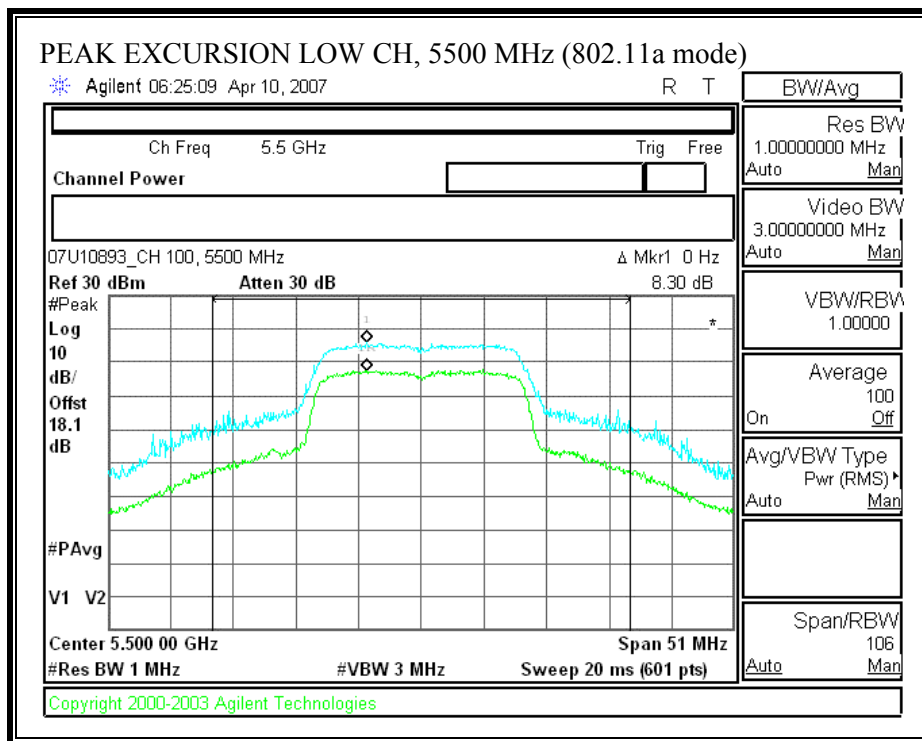
802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

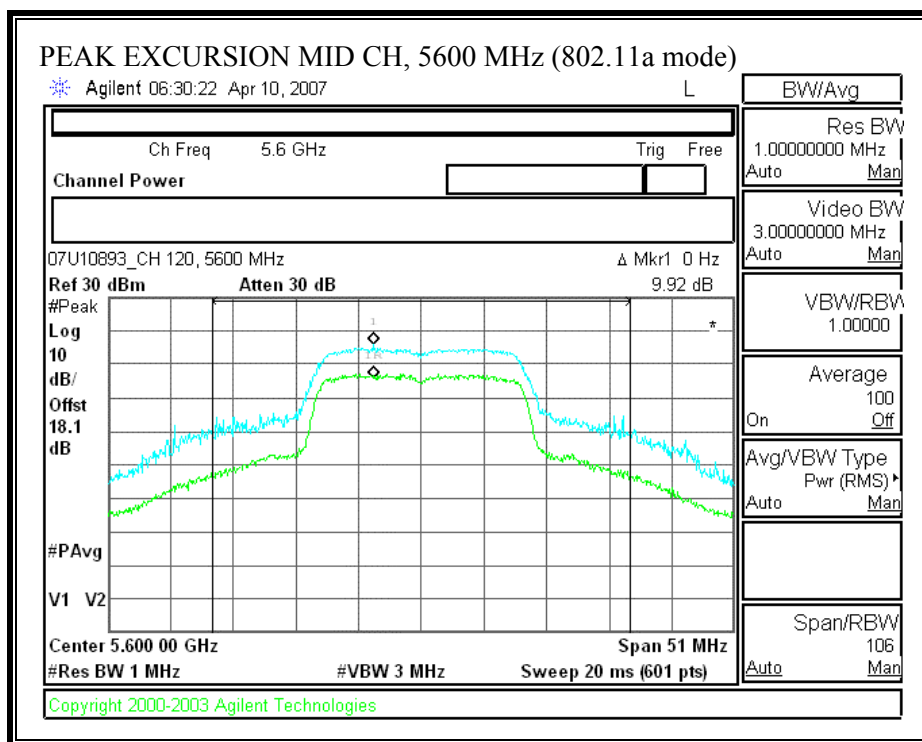
802.11n 40 MHz SISO MCS 32 MODE

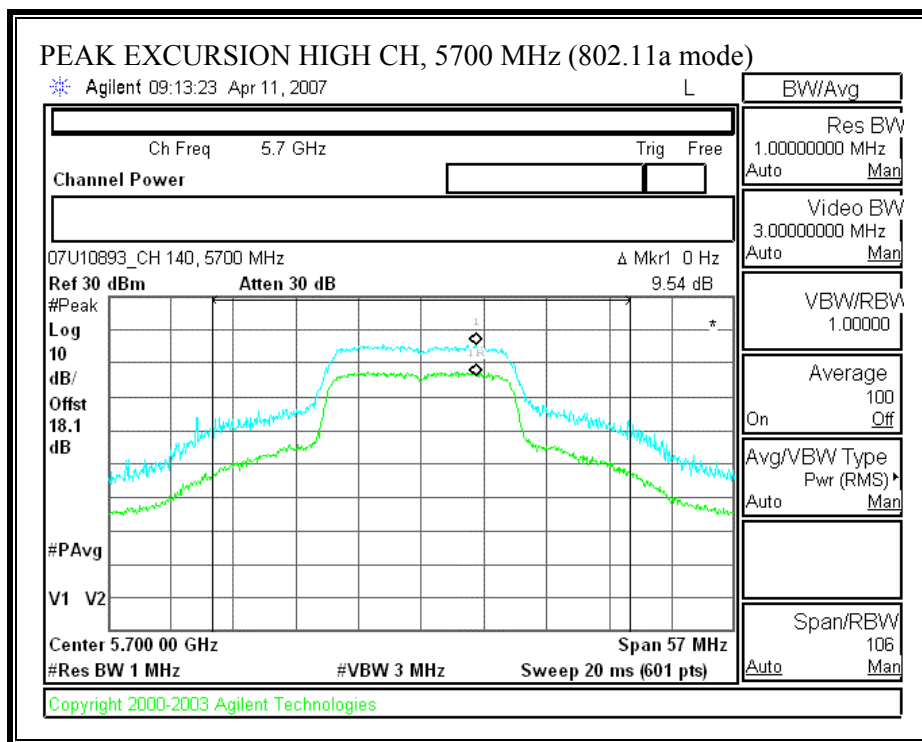
Channel	Frequency (MHz)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
Low	5510	9.36	13	-3.64
Middle	5590	12.34	13	-0.66
High	5670	10.20	13	-2.80

802.11a MODE

PEAK EXCURSION (802.11a MODE)

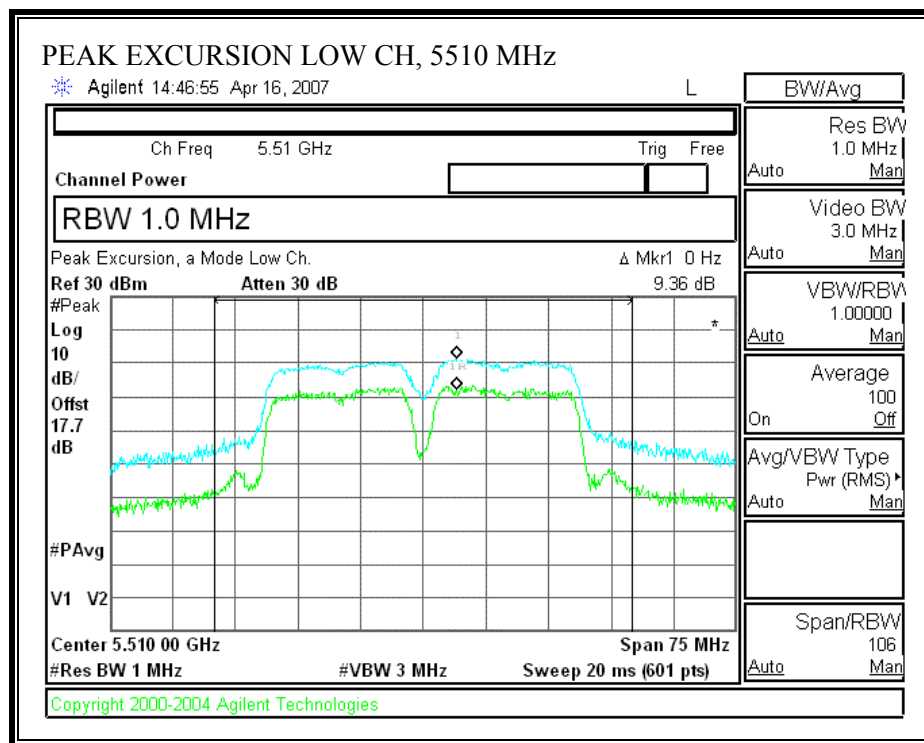


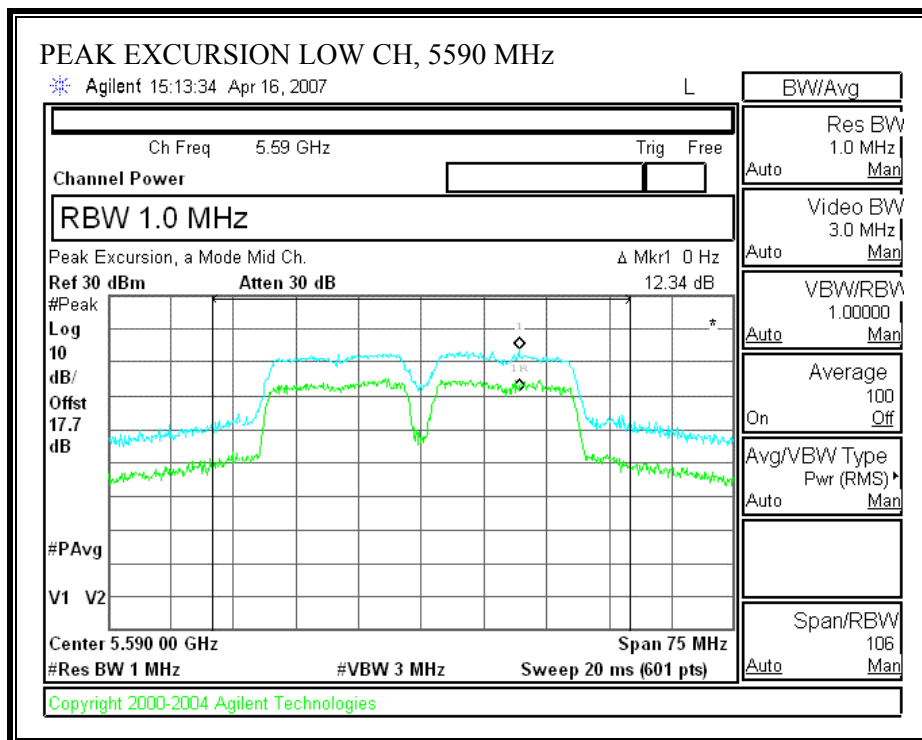


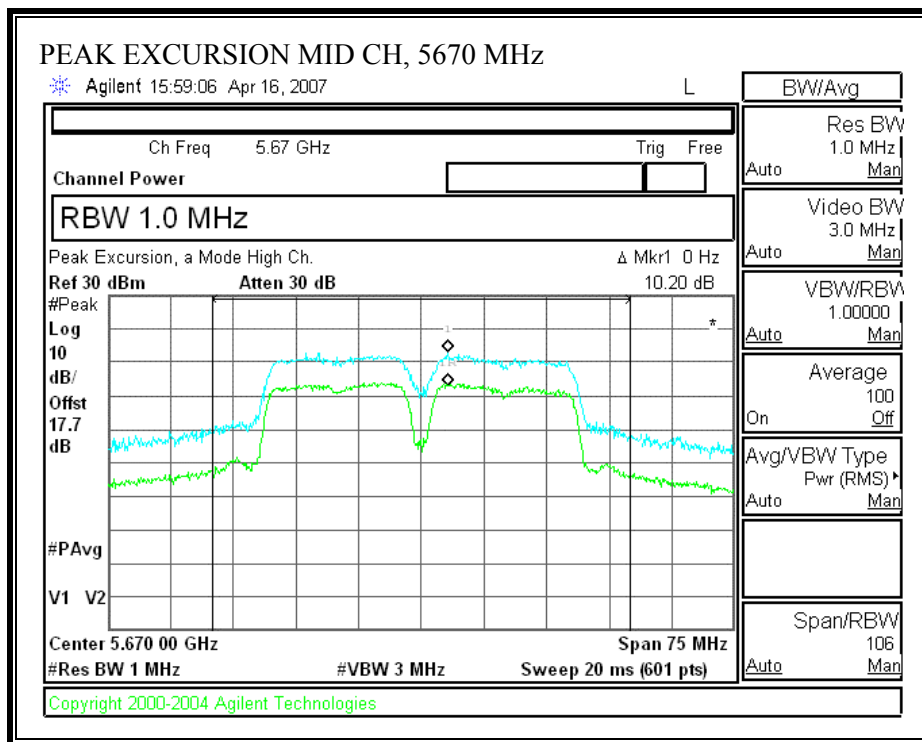


802.11n 40 MHz SISO MCS 32 MODE

PEAK EXCURSION







7.3.6. CONDUCTED SPURIOUS EMISSIONS

LIMITS

§15.407 (b) (3) For transmitters operating in the 5.47–5.725 GHz band: all emissions outside of the 5.47–5.725 GHz band shall not exceed an EIRP of -27 dBm / MHz.

TEST PROCEDURE

Conducted RF measurements of the transmitter output are made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer. The resolution bandwidth is set to 1 MHz. The video bandwidth is set to 1 MHz. Peak detection measurements are compared to the average EIRP limit, adjusted for the maximum antenna gain. If necessary, additional average detection measurements are made.

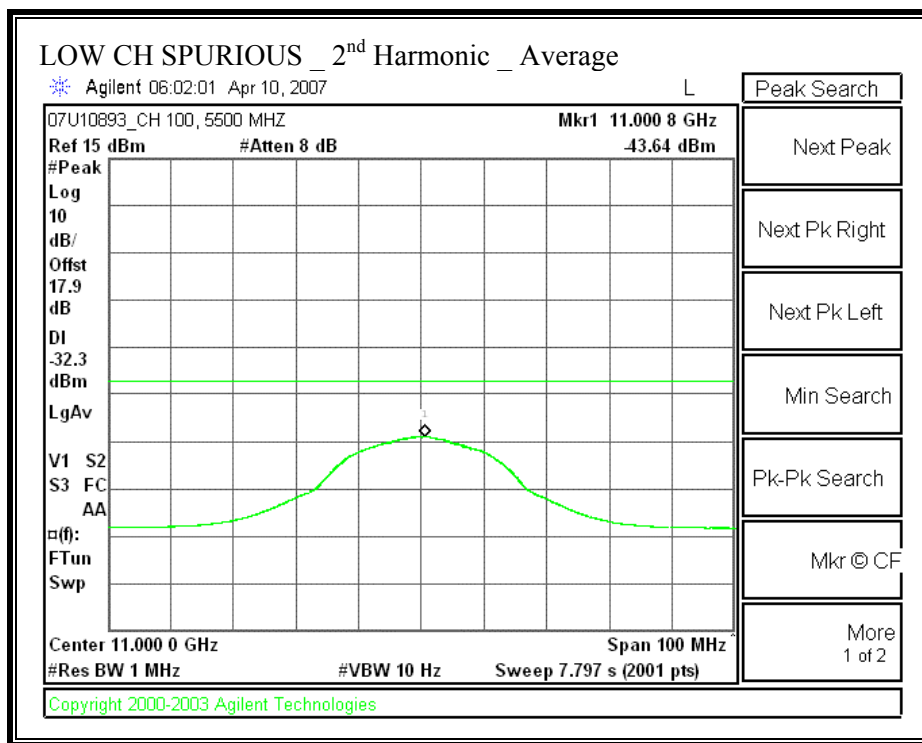
Measurements are made over the 30 MHz to 40 GHz range with the transmitter set to the lowest, middle, and highest channels.

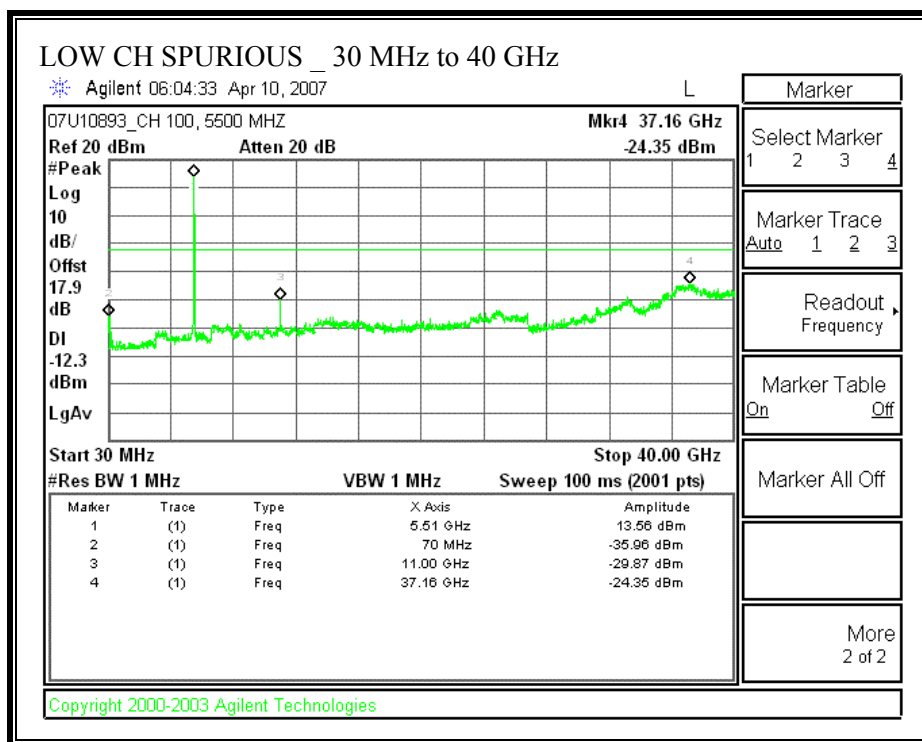
RESULTS

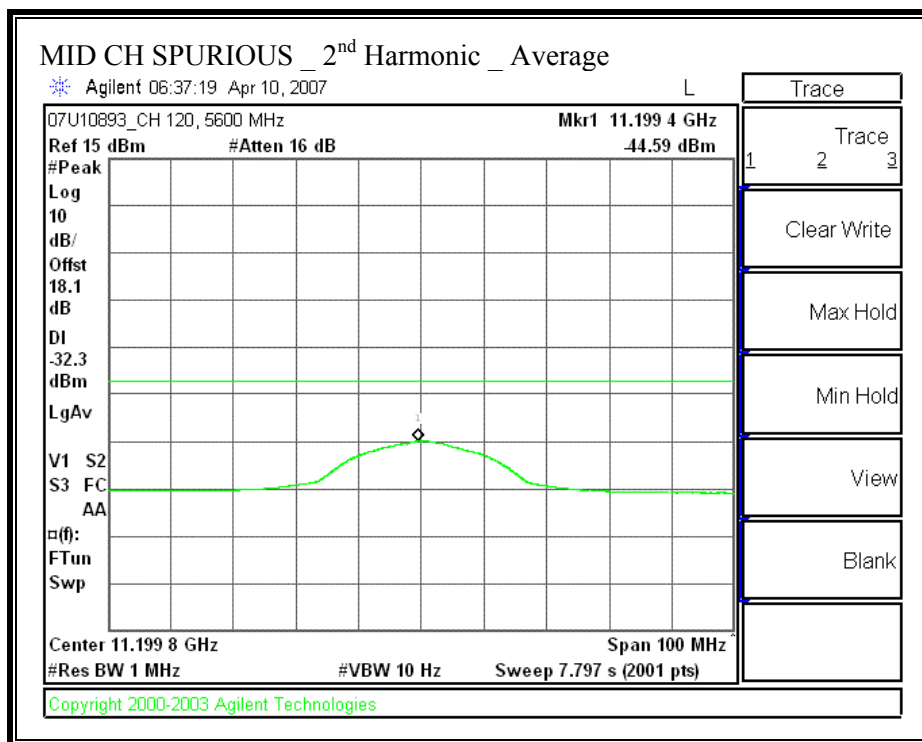
No non-compliance noted:

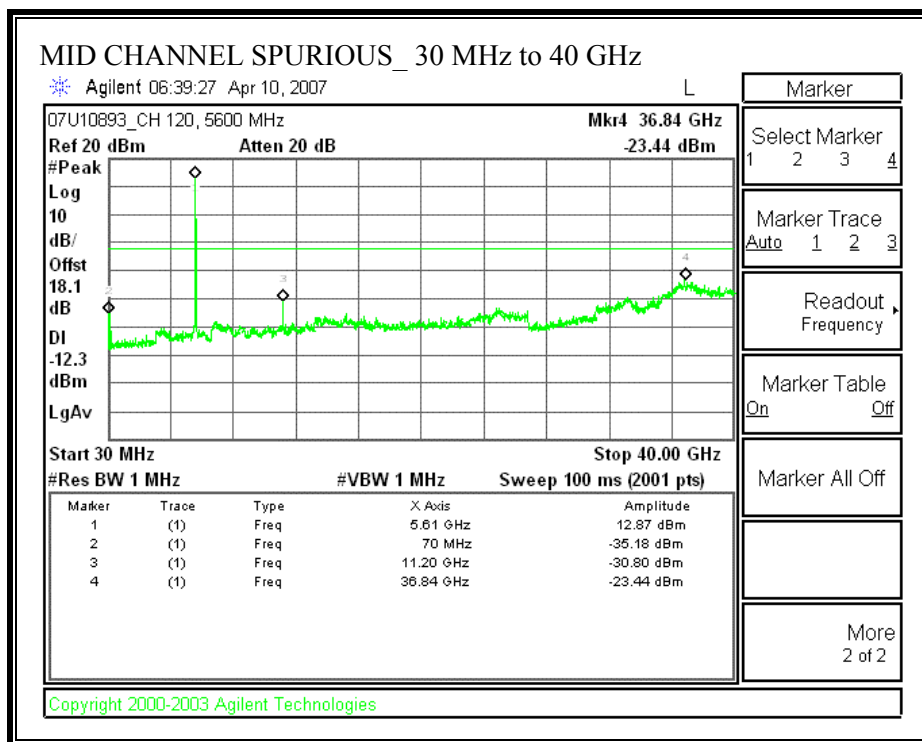
802.11a MODE

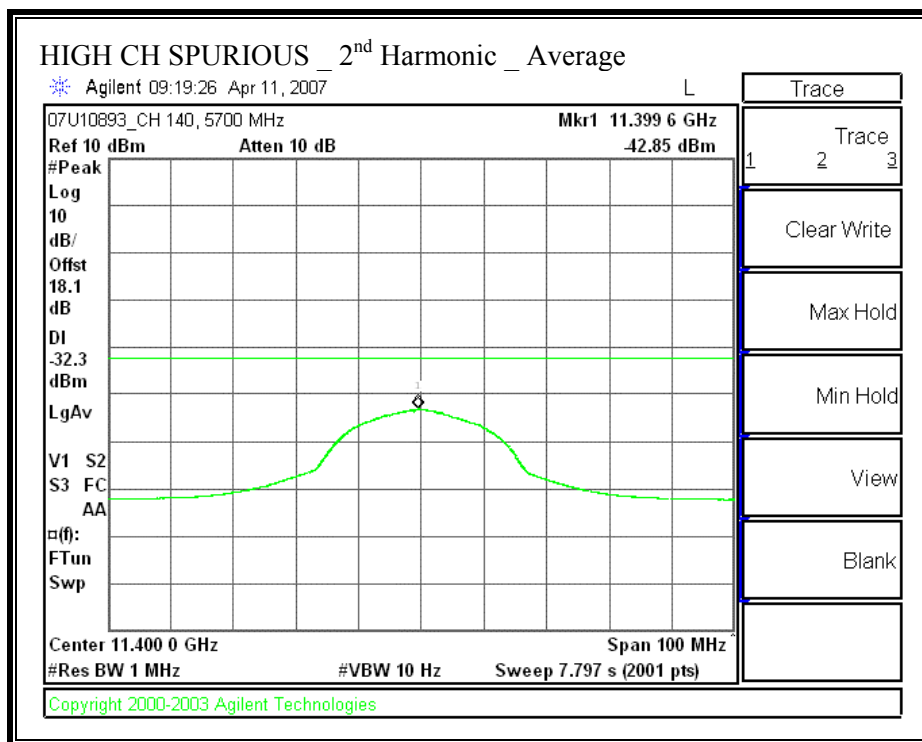
SPURIOUS EMISSIONS (802.11a MODE)

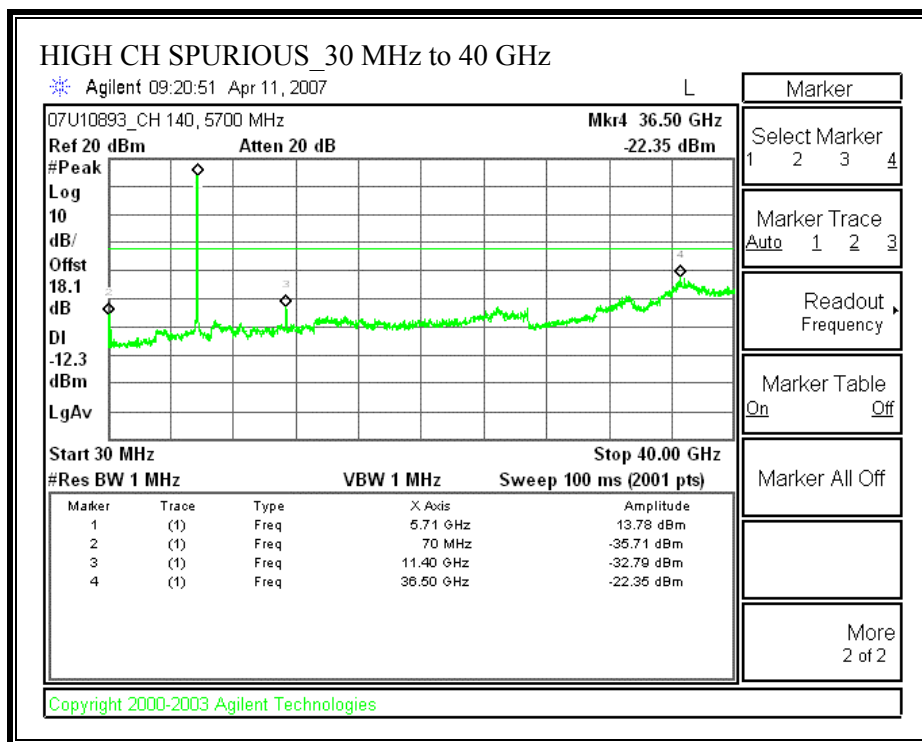








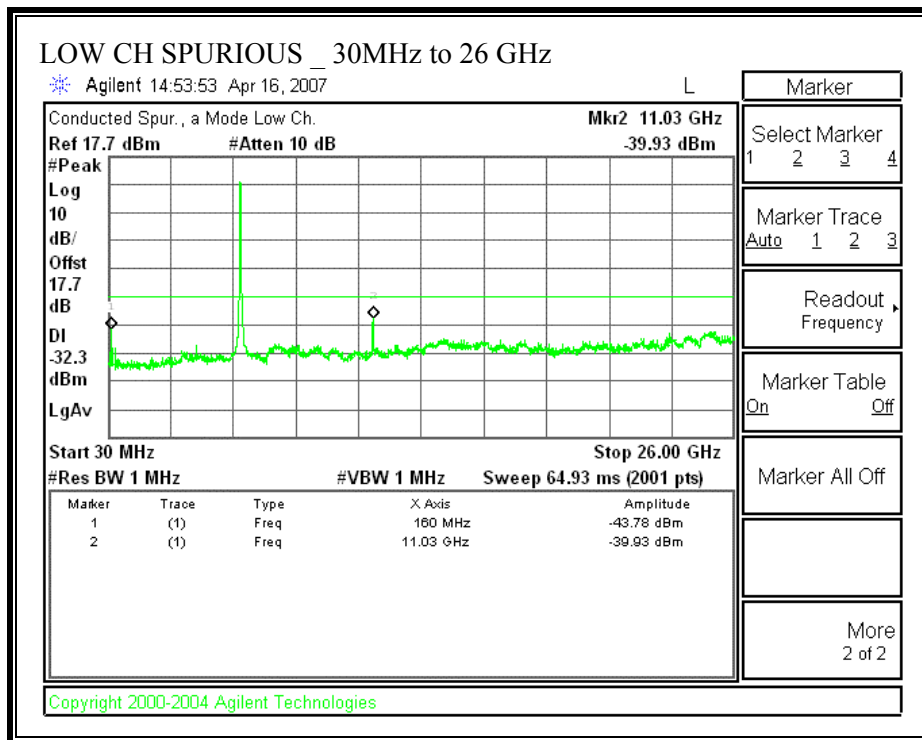


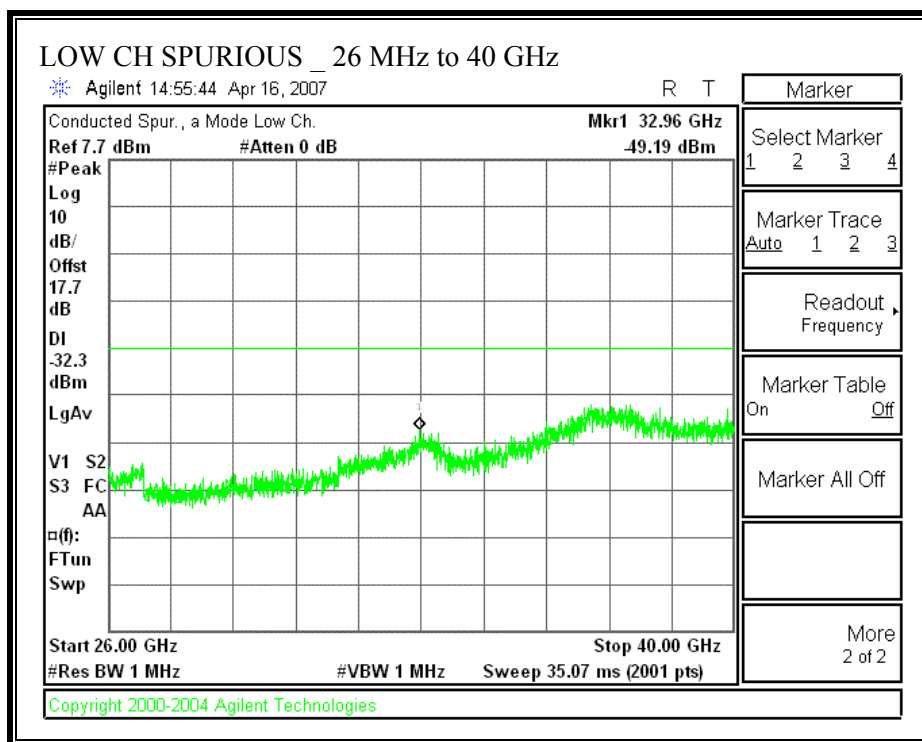


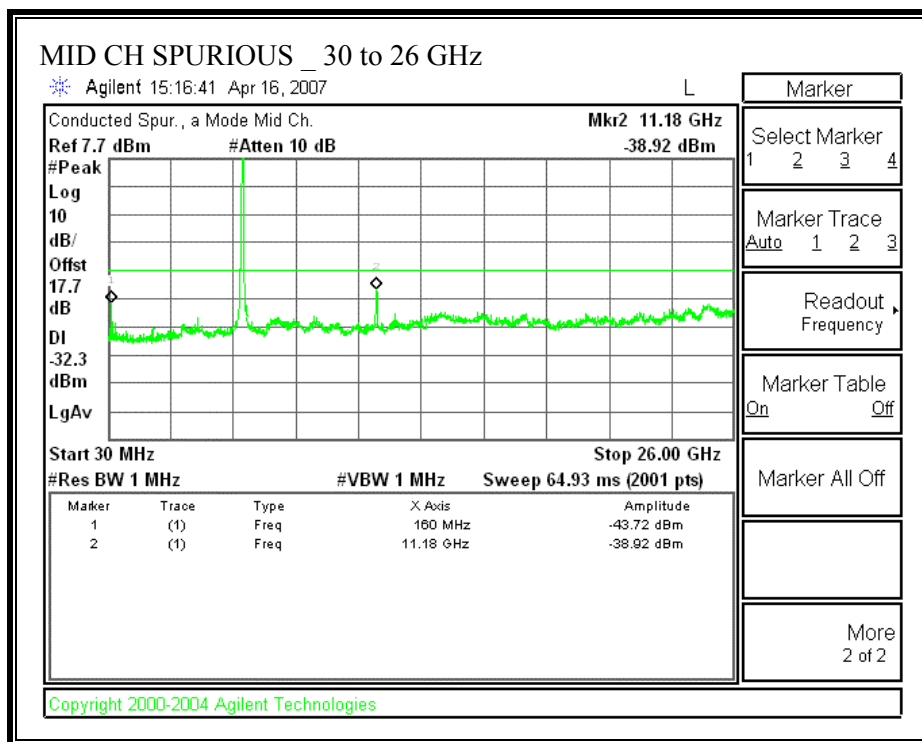
802.11n 20 MHz SISO MODE is covered by the worst case Legacy testing

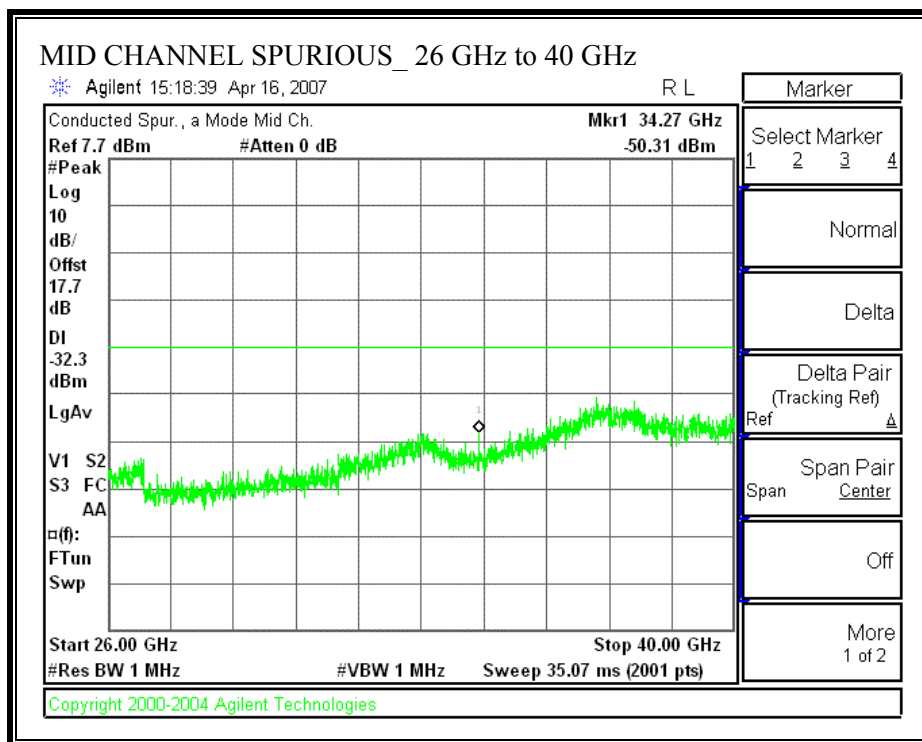
802.11n 40 MHz SISO MCS 32 MODE

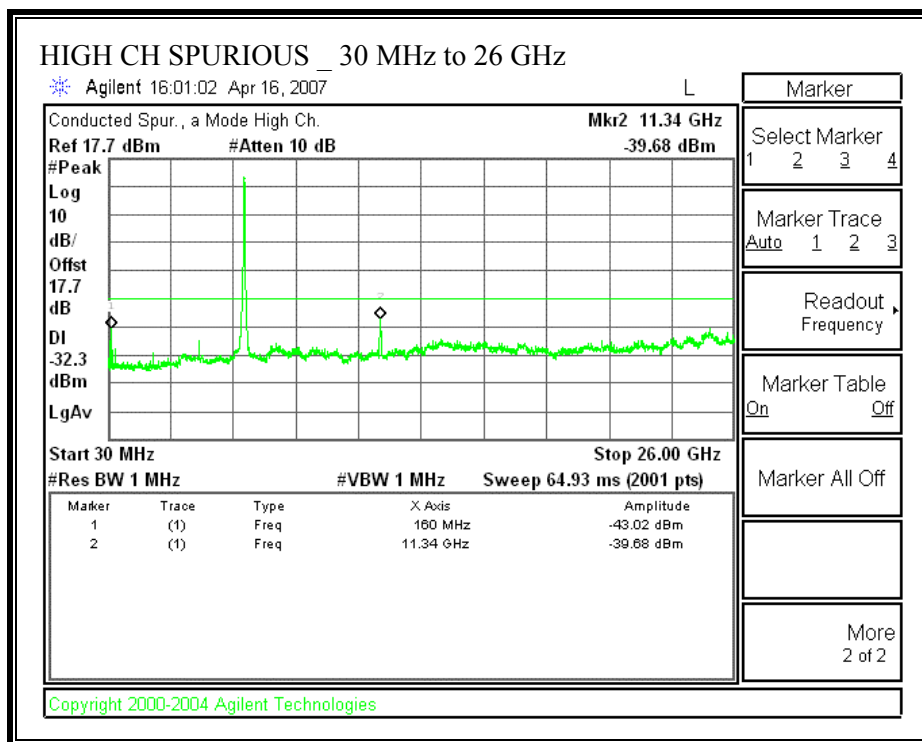
SPURIOUS EMISSIONS

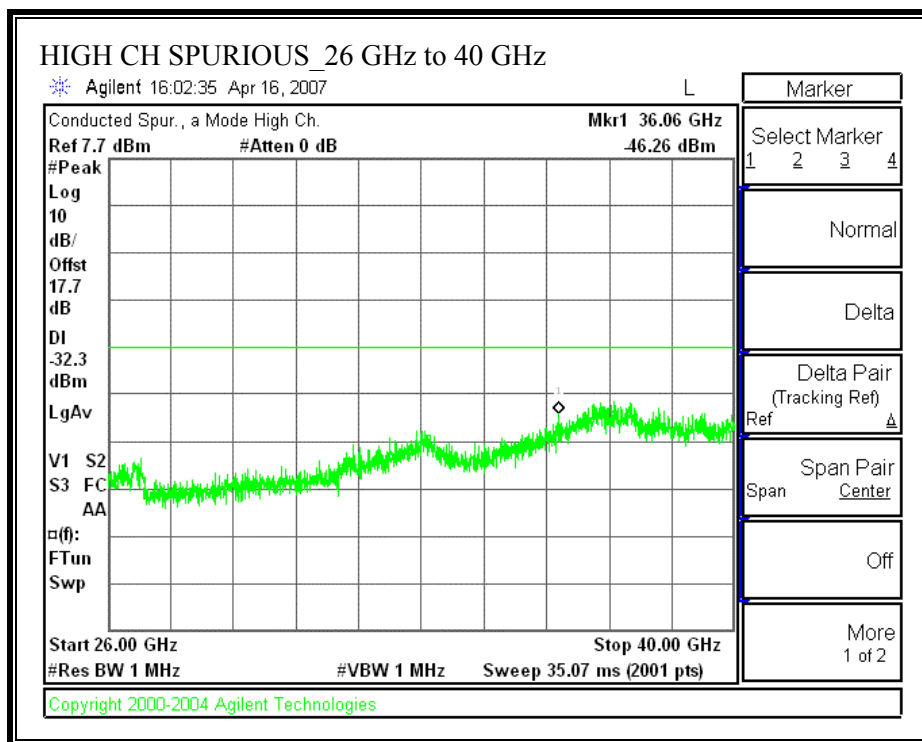












MIMO MODE

7.4. CHANNEL TESTS FOR THE 5470 TO 5725 MHz BAND

7.4.1. EMISSION BANDWIDTH

LIMIT

§15.403 (i) Emission bandwidth. For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolutions bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

TEST PROCEDURE

The transmitter output is connected to a spectrum analyzer. The RBW is set to 1% to 3% of the 26 dB bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled.

RESULTS

No non-compliance noted:

802.11a CDD MODE is covered by worst case **802.11n 20 MHz CDD MCS 0 MODE**

802.11n 20 MHz CDD MCS 0 MODE

802.11 - 20 MHz Tx BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5500	29.169	14.649
Middle	5560	35.640	15.519
High	5700	40.440	16.068

802.11 - 20 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5500	32.658	15.140
Middle	5560	33.139	15.203
High	5700	37.214	15.707

802.11n 40 MHz CDD MCS 32 MODE

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 0

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5510	51.364	17.107
Middle	5590	78.442	18.945
High	5670	67.147	18.270

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5510	49.658	16.960
Middle	5590	77.880	18.914
High	5670	64.891	18.122

802.11n 20 MHz CDD MCS 0

26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 0)

