FCC CFR47 PART 15 SUBPART E
CERTIFICATION
TEST REPORT

FOR

802.11ag/Draft 802.11n WIRELESS LAN AND BLUETOOTH 2.1 PCI-E MODULE

MODEL NUMBER: BCM94321COEX2

FCC ID: QDS-BRCM1027

REPORT NUMBER: 07U11041-2B

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Prepared for
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Issue Date	Revisions	Revised By
--	6/28/2007	Initial Issue	M. Heckrotte
B	06/29/2007	Editorial changes and clarification	M. Heckrotte

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME:	BROADCOM CORPORATION 190 MATHILDA PLACE SUNNYVALE, CA 94086, USA
EUT DESCRIPTION:	802.11ag/Draft 802.11n WIRELESS LAN AND BLUETOOTH 2.1 PCI-E MODULE
MODEL:	BCM94321COEX2
SERIAL NUMBER:	1129122
DATE TESTED:	MAY 08 TO JUNE 28, 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:

MICHAEL HECKROTTE
ENGINEERING MANAGER
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Tested By:

VIEN TRAN
EMC ENGINEER
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2. TEST METHODOLOGY

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

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 561F Monterey Road, Morgan Hill, California, 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 BCM94321COEX2, containing both Wireless LAN and Bluetooth 2.1.

The radio module is manufactured by Broadcom Corp.

5.2. TEST RESULT CONCLUSIONS

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

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 testing performed at 20MHz (including Band-edge, Emissions testing, PSD).
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:

5.150 - 5.350 GHz UNII BAND

1/ SISO MODE:
_802.11a LEGACY
_802.11n 20 MHz SISO MCS 0 (covered by the worst case Legacy testing)
_802.11n 40 MHz SISO MCS 0

2/ MIMO MODE:
_802.11a CDD (covered by the worst case 11n 20 MHz CDD MCS 0 testing)
_802.11n 20 MHz CDD MCS 0
_802.11n 40 MHz CDD MCS 32
_802.11n 40 MHz SDM MCS 15

5.470 - 5.725 GHz UNII BAND

1/ SISO MODE:
_802.11a LEGACY
_802.11n 20 MHz SISO MCS 0 (covered by the worst case Legacy testing)
_802.11n 40 MHz SISO MCS 0

2/ MIMO MODE:
_802.11a CDD (covered by the worst case 11n 20 MHz CDD MCS 0 testing)
_802.11n 20 MHz CDD MCS 0
_802.11n 40 MHz CDD MCS 32

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. The 2.4 GHz band results presented in this report for the above parameter is Chain 0 and Chain 1. The 2.4 GHz band results presented in this report for the above parameter are with a combiner. The 5 GHz band results presented in this report for the above parameter are 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	14.13	25.88
5260 - 5320	802.11a Legacy	N/A	N/A	17.82	60.53
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	13.04	20.14
5270 - 5310	802.11n 40MHz SISO	N/A	N/A	17.34	54.20
5180 - 5320	802.11a CDD Mode	covered by the worst case 802.11n 20 MHz CDD			
5190	802.11n 40MHz SDM	12.78	12.65	15.73	37.37

Power with Antenna Array Gain up to 6 dBi					
5180 - 5240	802.11n 20MHz CDD	10.24	10.35	13.31	21.41
5260 - 5320	802.11n 20MHz CDD	15.78	15.14	18.48	70.50
5190 - 5230	802.11n 40MHz CDD	13.74	13.53	16.65	46.20
5270 - 5310	802.11n 40MHz CDD	15.91	15.86	18.90	77.54

Power with Antenna Array Gain up to 7.077 dBi in 5150 - 5250 Band					
5180 - 5240	802.11n 20MHz CDD	9.17	9.23	12.21	16.64
5190 - 5230	802.11n 40MHz CDD	10.33	10.91	13.64	23.12
Power with Antenna Array Gain up to 8.677 dBi in 5250 - 5350 Band					
5260 - 5320	802.11n 20MHz CDD	13.49	13.60	16.56	45.24
5270 - 5310	802.11n 40MHz CDD	15.91	15.86	18.90	77.54

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	18.25	66.83
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	18.18	65.77
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	16.93	16.46	19.71	93.58
5510 - 5670	802.11n 40MHz CDD	19.3	19.67	22.50	177.80

Power with Antenna Array Gain up to 8.75 dBi					
5500 - 5700	802.11n 20MHz CDD	14.35	14.26	17.32	53.90
5510 - 5670	802.11n 40MHz CDD	18.26	17.71	21.00	126.01

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^(Ant Main /10)	10^(Ant Aux/10)	10^(ant main/10)+10^(ant aux/10)	10*log[10^(ant main/10)+10^(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_ttcp.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

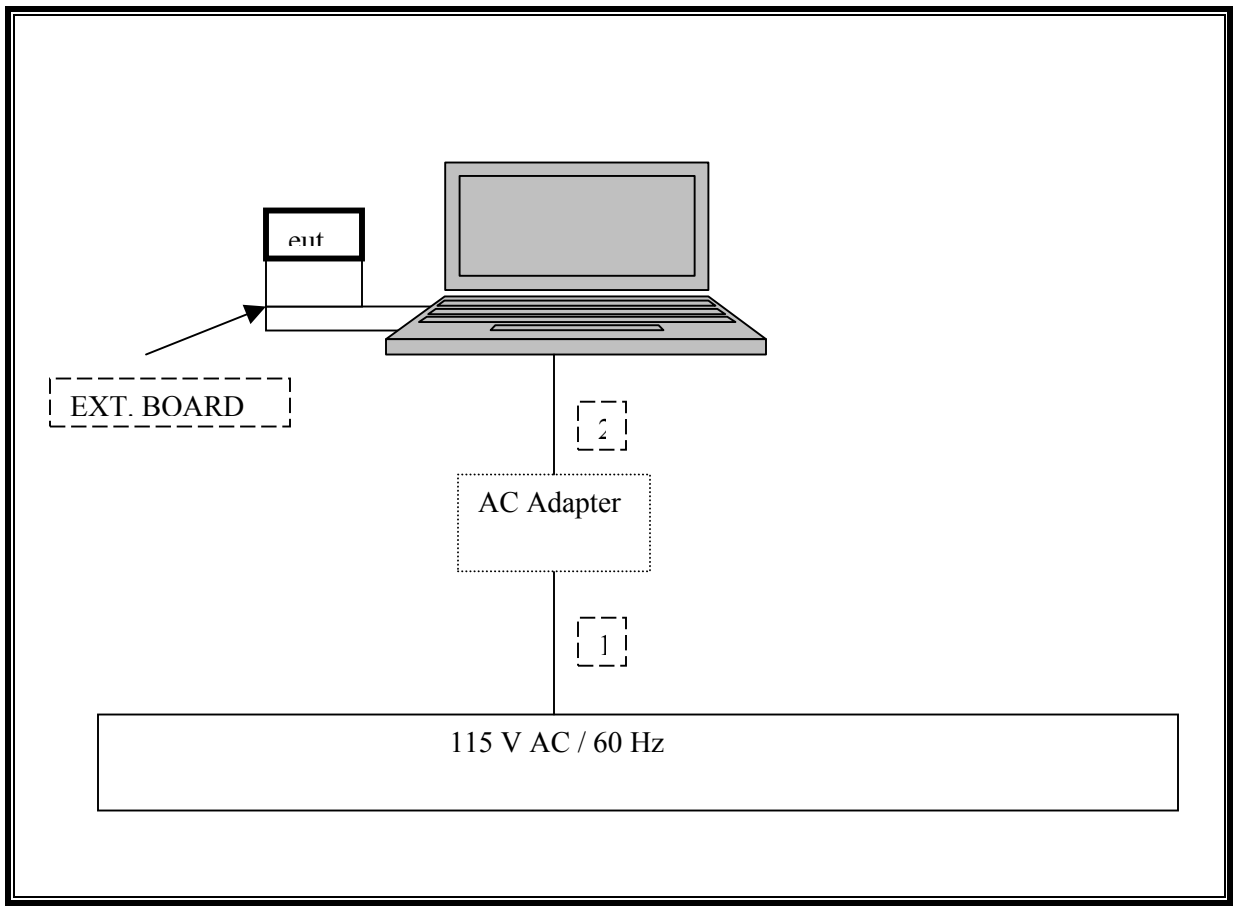
I/O CABLES

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	4/22/2008
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	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	2/4/2008
RF Filter Section	Agilent / HP	85420E	3705A00256	2/4/2008
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 26 ~ 40 GHz	ARA	MWH-2640/B	1029	4/13/2008
4.0 GHz High Pass Filter	Micro Tronics	HPM13351	3	N/A
2.4 - 2.5 Reject Filter	Micro Tronics	BRM50702	3	N/A
7.6 GHz High Pass Filter	Micro Tronics	HPM13350	1	N/A
5.75 - 5.8 Reject Filter	Micro Tronics	BRC13192	2	N/A

7. LIMITS AND RESULT

LEGACY MODE

7.1. CHANNEL TESTS FOR THE 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	19.263	12.85
Middle	5260	21.909	13.41
High	5320	23.354	13.68

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

802.11n 40 MHz SISO MODE

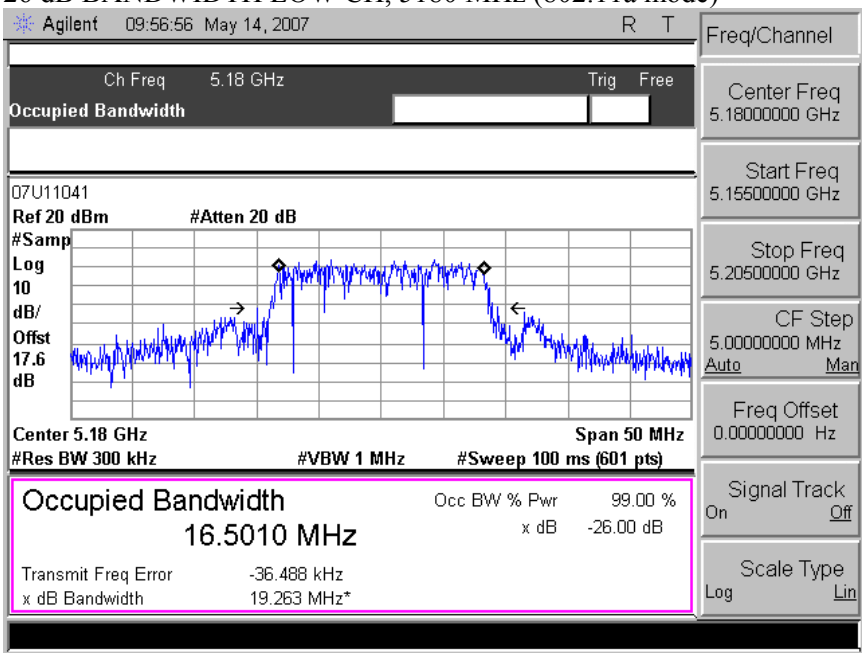
802.11a Mode

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	42.049	16.24
Middle	5270	39.425	15.96
High	5310	42.039	16.24

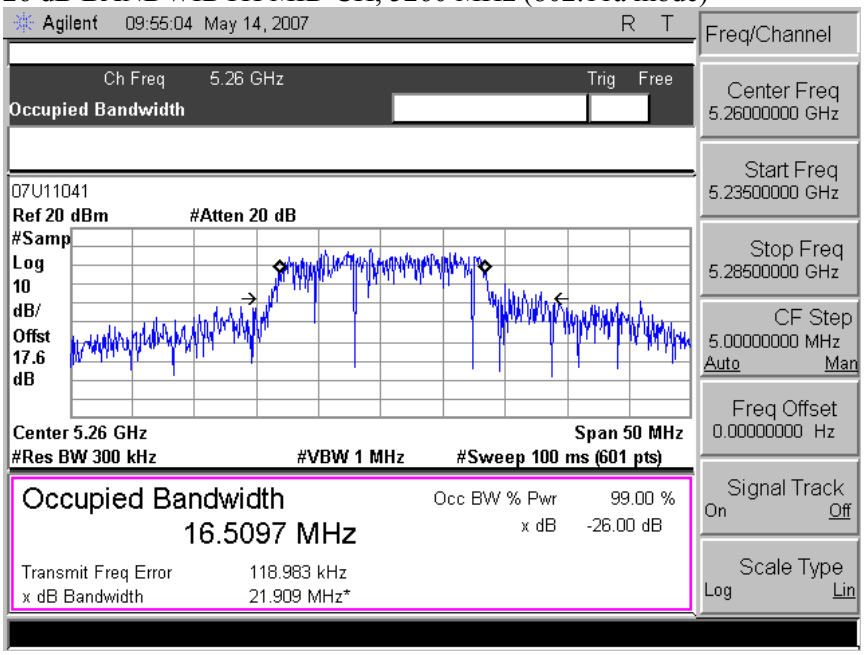
802.11a MODE

26 dB EMISSION BANDWIDTH (802.11a MODE)

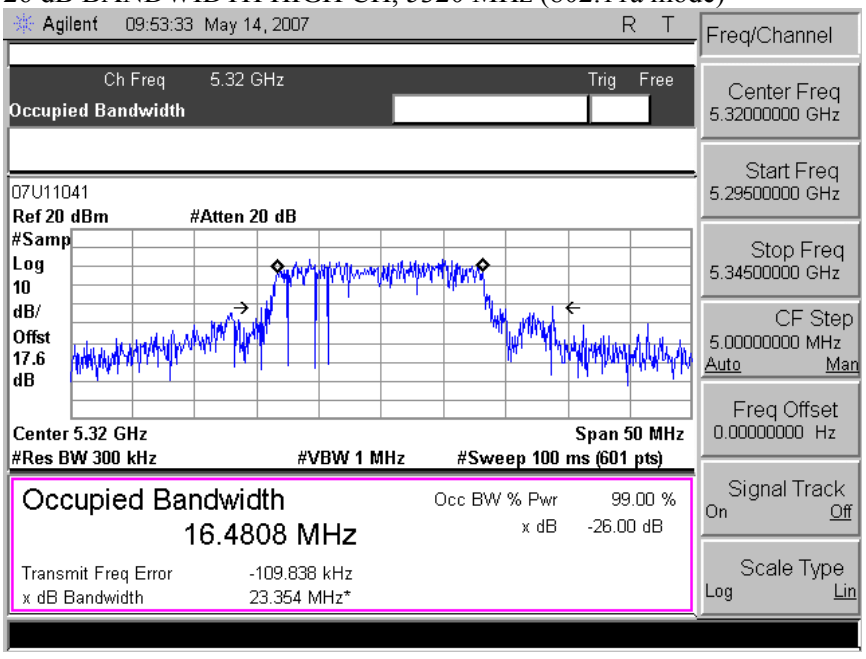
26 dB BANDWIDTH LOW CH, 5180 MHz (802.11a mode)



26 dB BANDWIDTH MID CH, 5260 MHz (802.11a mode)

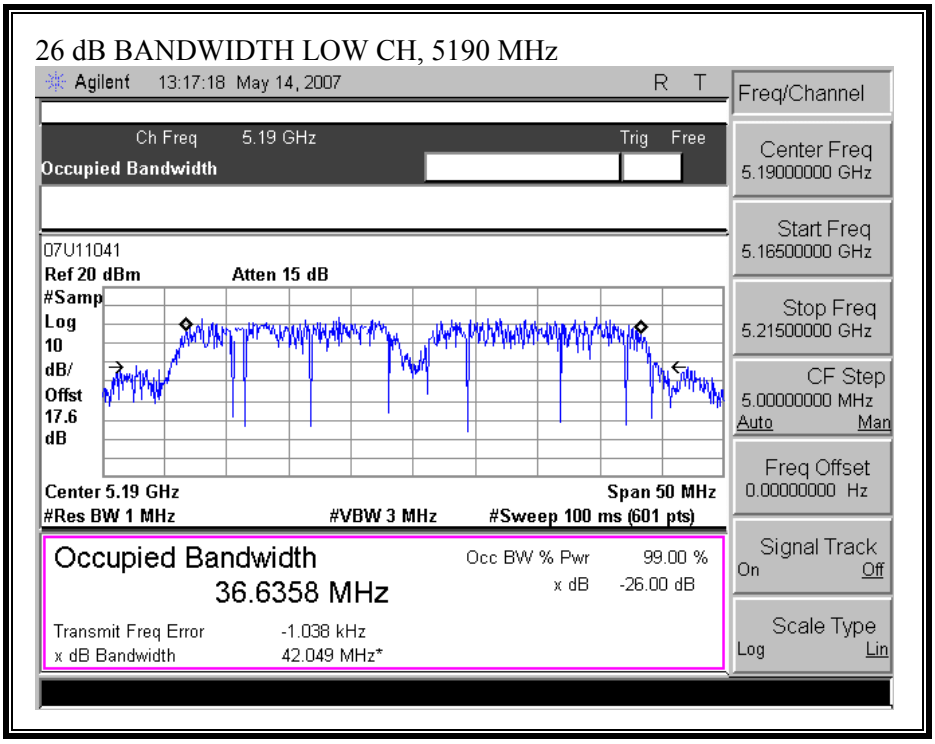


26 dB BANDWIDTH HIGH CH, 5320 MHz (802.11a mode)

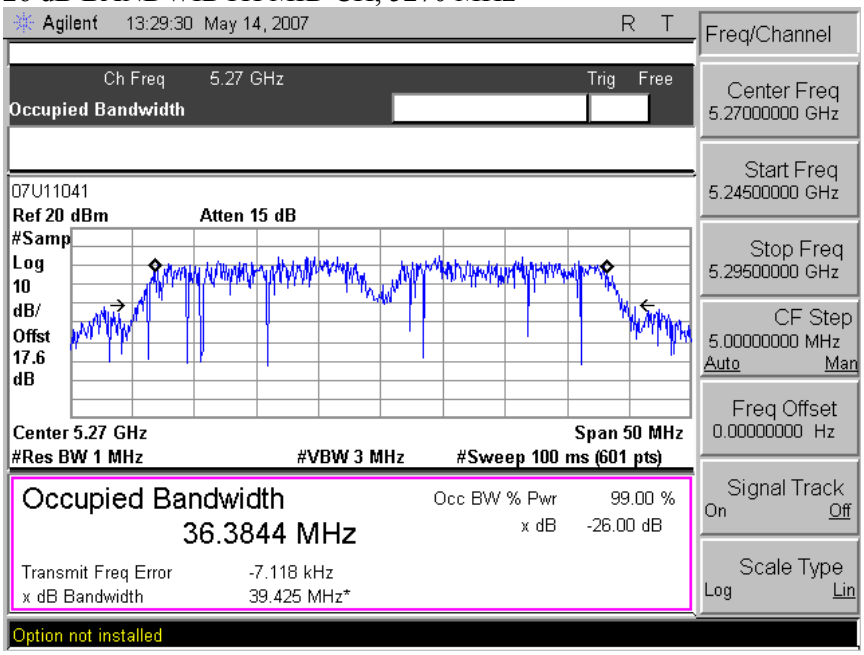


11n 40 MHz SISO MODE

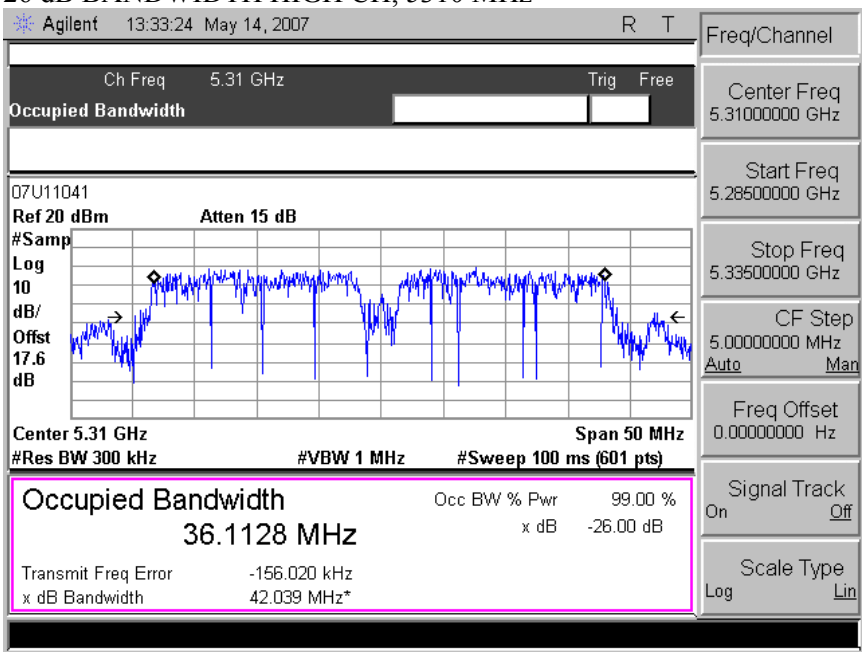
26 dB EMISSION BANDWIDTH (802.11n 40MHz SISO MODE)



26 dB BANDWIDTH MID CH, 5270 MHz



26 dB BANDWIDTH HIGH CH, 5310 MHz



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 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 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

LIMITS AND RESULTS

No non-compliance noted:

802.11a MODE

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	19.263	16.847	4.370	16.85

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	21.909	24.406	6.230	23.77
High	5320	24	23.354	24.684	6.230	23.77

Results

Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Low	5180	14.13	16.85	-2.72
Mid	5260	17.82	23.77	-5.95
High	5320	14.74	23.77	-9.03

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	42.049	20.238	4.370	17.00

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	39.425	26.958	6.230	23.77
High	5310	24	42.039	27.237	6.230	23.77

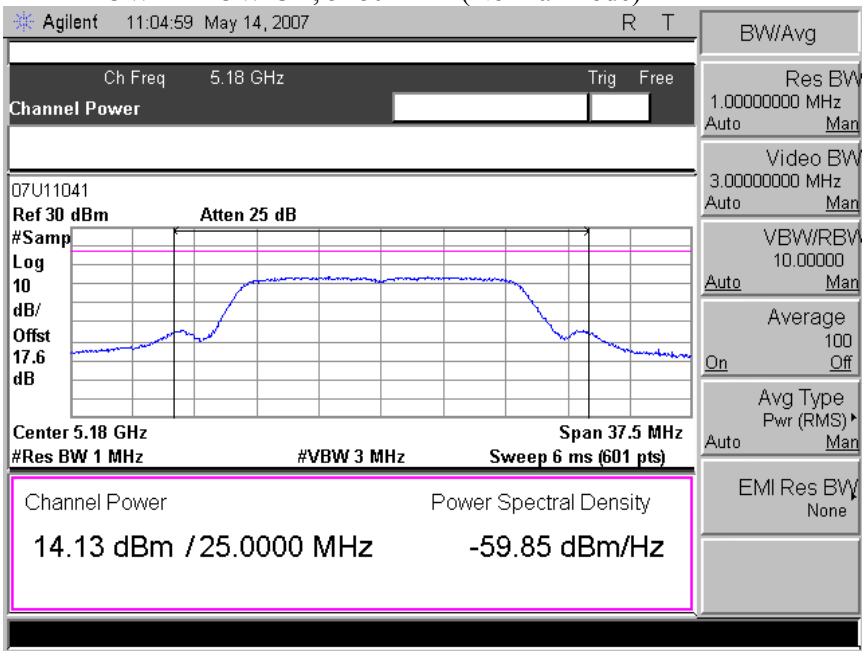
Results

Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Low	5190	13.04	17.00	-3.96
Mid	5270	17.34	23.77	-6.43
High	5310	13.19	23.77	-10.58

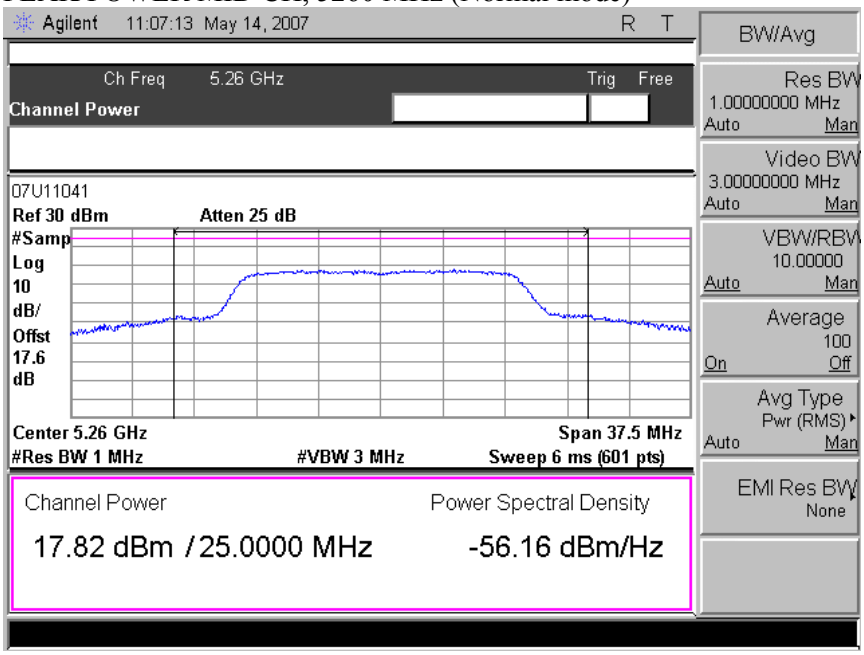
802.11a MODE

PEAK POWER (NORMAL MODE)

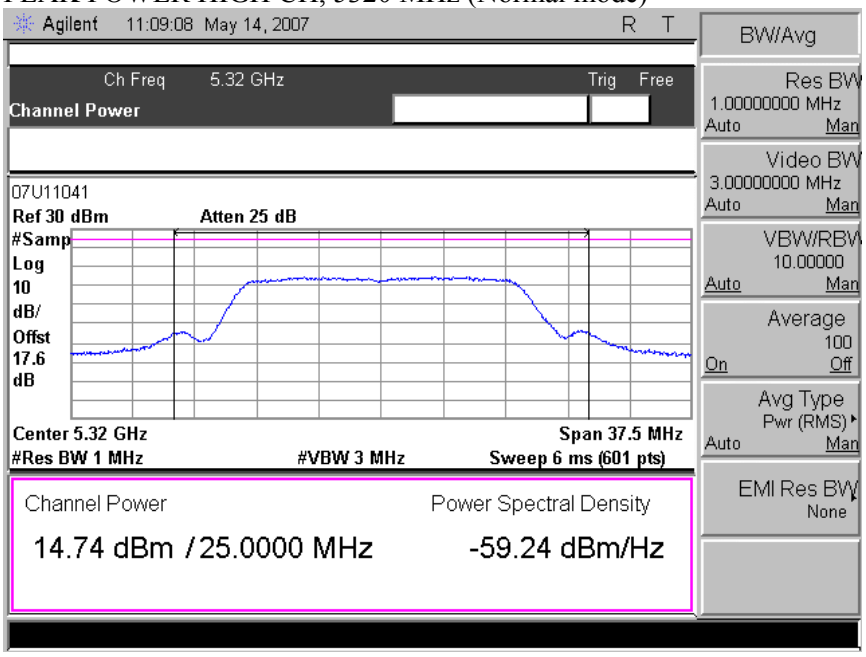
PEAK POWER LOW CH, 5180 MHz (Normal mode)



PEAK POWER MID CH, 5260 MHz (Normal mode)



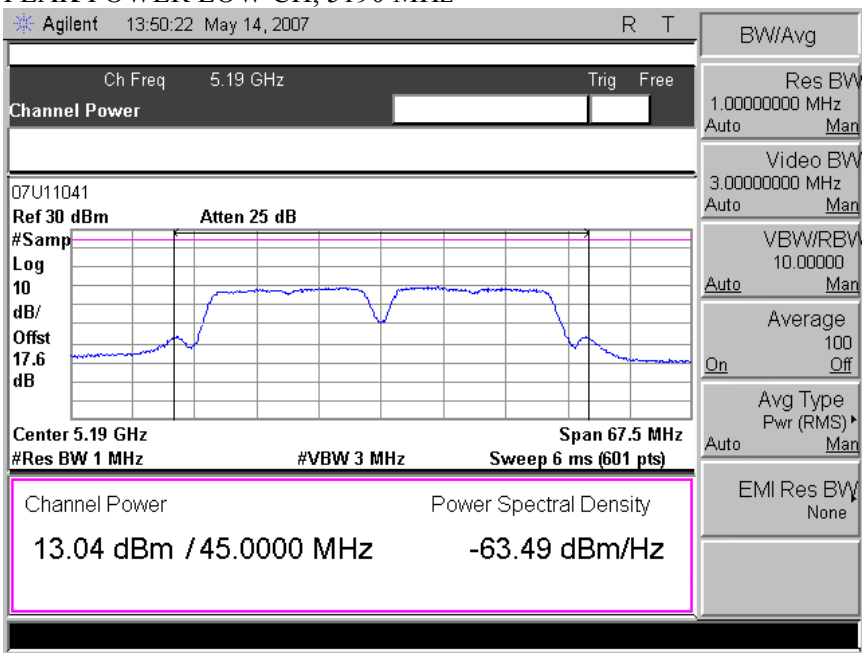
PEAK POWER HIGH CH, 5320 MHz (Normal mode)



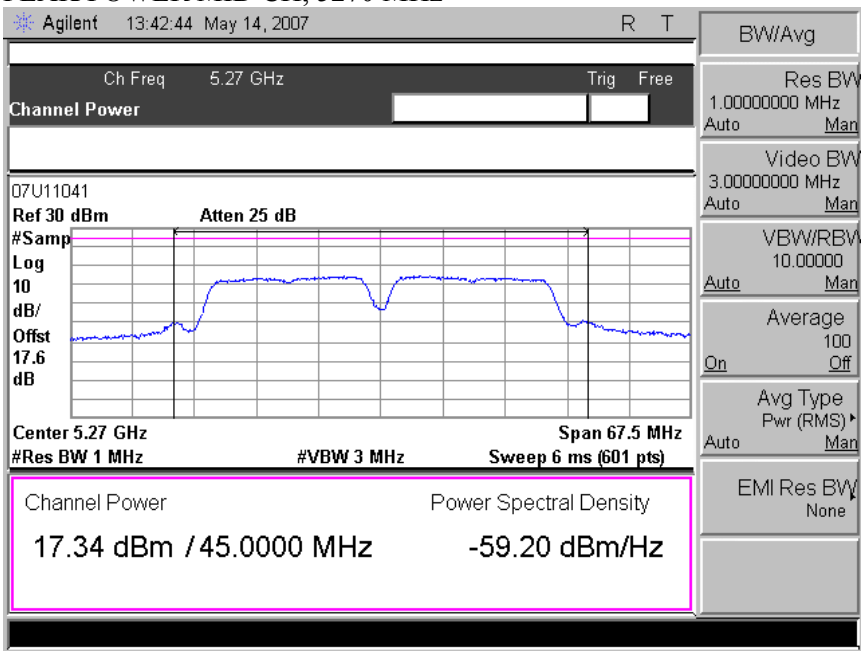
802.11n 40 MHz SISO MODE

PEAK POWER (11n 40MHz SISO MODE)

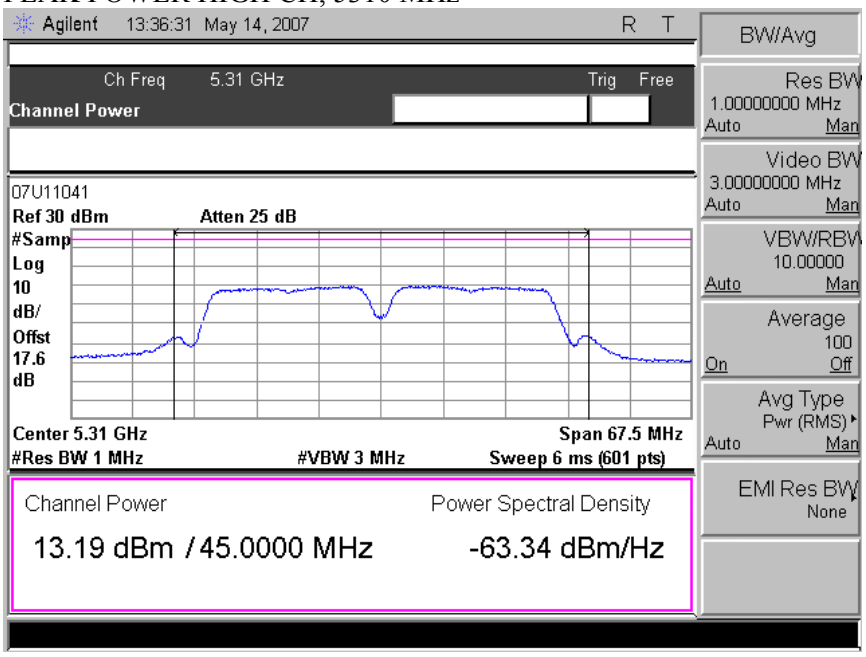
PEAK POWER LOW CH, 5190 MHz



PEAK POWER MID CH, 5270 MHz



PEAK POWER HIGH CH, 5310 MHz



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 (mW) = P (W) / 1000 and
d (cm) =100 * d (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/cm^2

Substituting the logarithmic form of power and gain using:

P (mW) = 10 ^ (P (dBm) / 10) and
G (numeric) = 10 ^ (G (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/cm^2

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), the maximum value of S = 1.0 mW/cm^2 in the 5.2 / 5.3 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	17.82	6.23	0.05

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

802.11n 40 MHz SISO MODE

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 40 MHz SISO	20.0	17.34	6.23	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.

7.1.4. 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	3.261	4.000	-0.74
Middle	5260	7.566	10.770	-3.20
High	5320	4.479	10.770	-6.29

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

802.11n 40 MHz SISO MODE

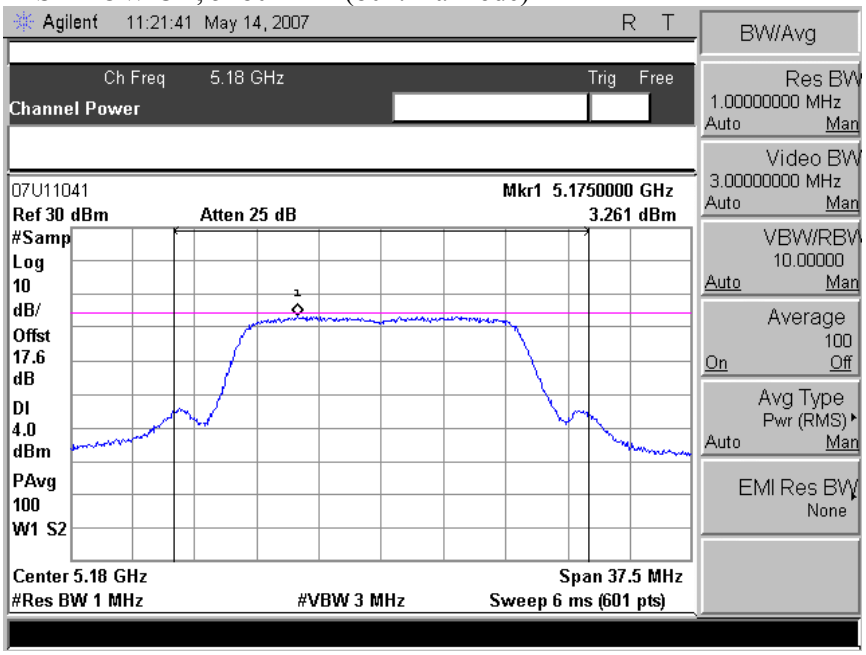
802.11a Mode

Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5190	-0.433	4.000	-4.43
Middle	5230	3.175	10.770	-7.60
High	5310	0.636	10.770	-10.13

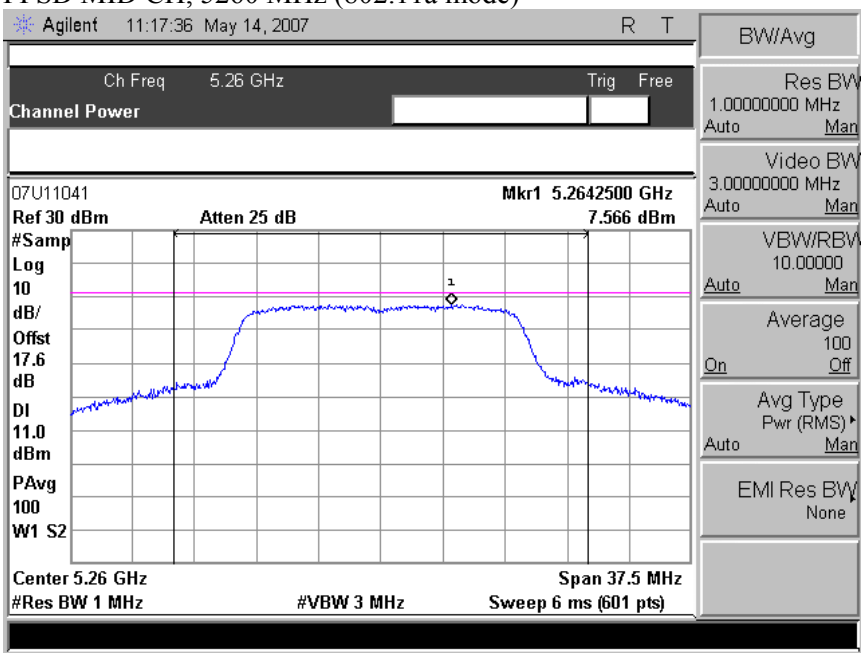
802.11a MODE

PEAK POWER SPECTRAL DENSITY (802.11a MODE)

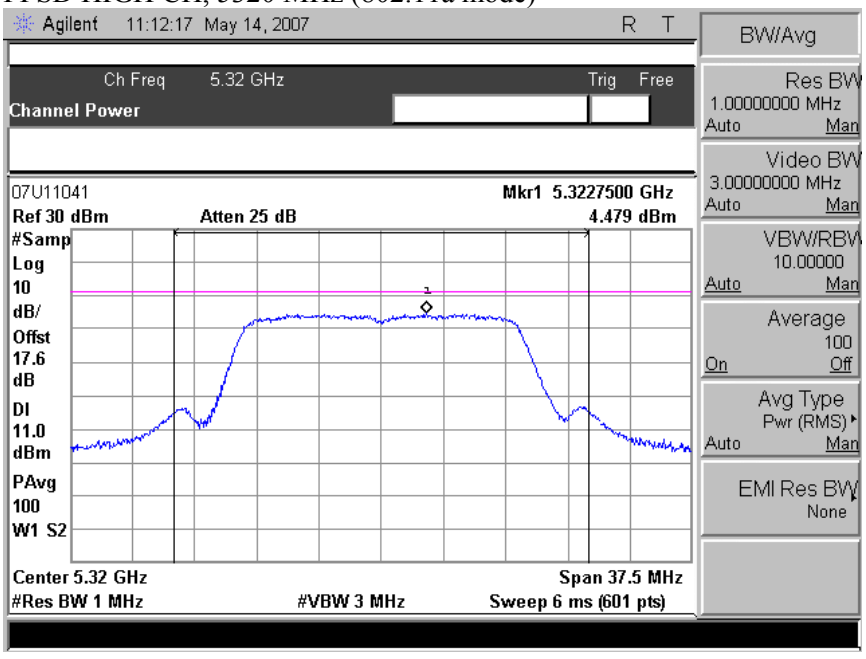
PPSD LOW CH, 5180 MHz (802.11a mode)



PPSD MID CH, 5260 MHz (802.11a mode)



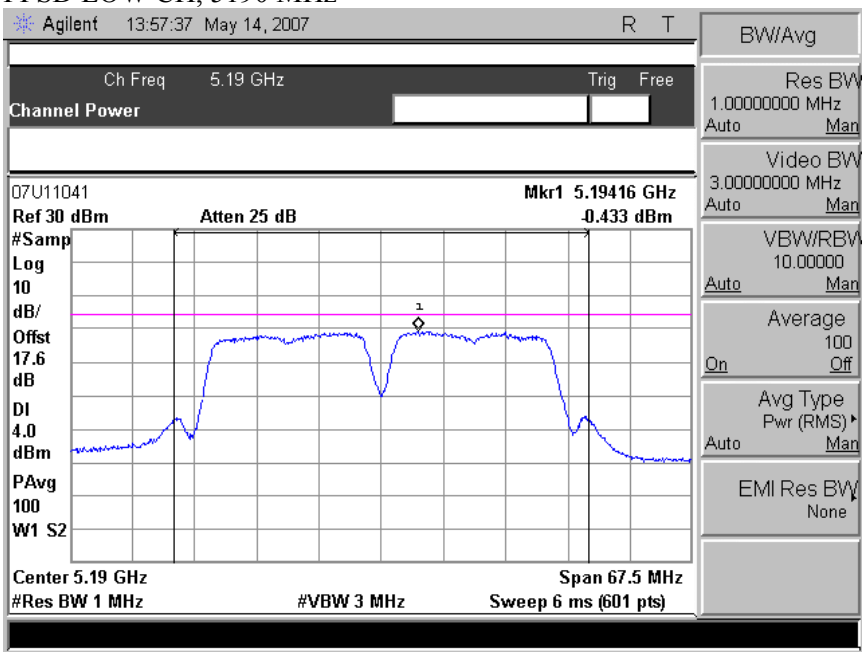
PPSD HIGH CH, 5320 MHz (802.11a mode)



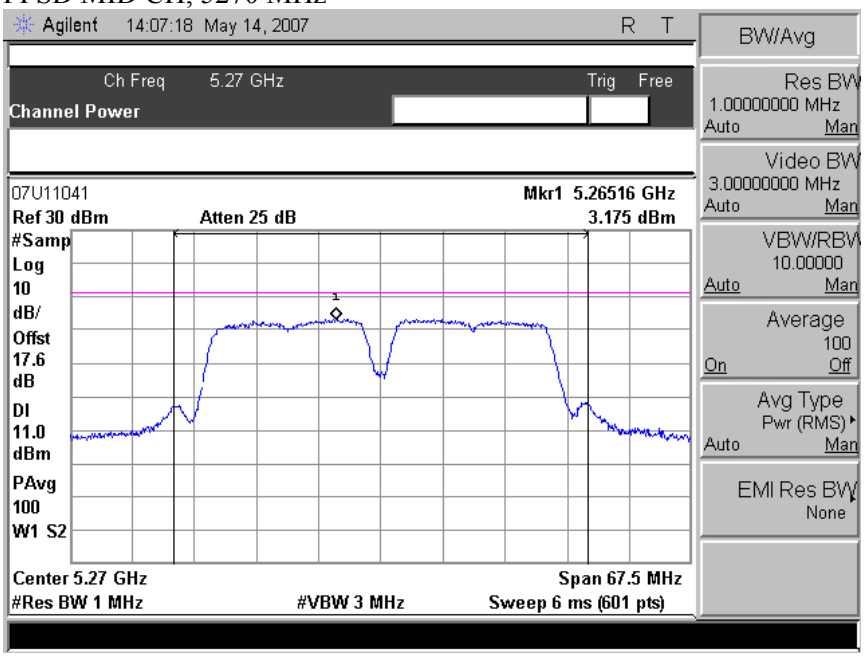
802.11n 40 MHz SISO MODE

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

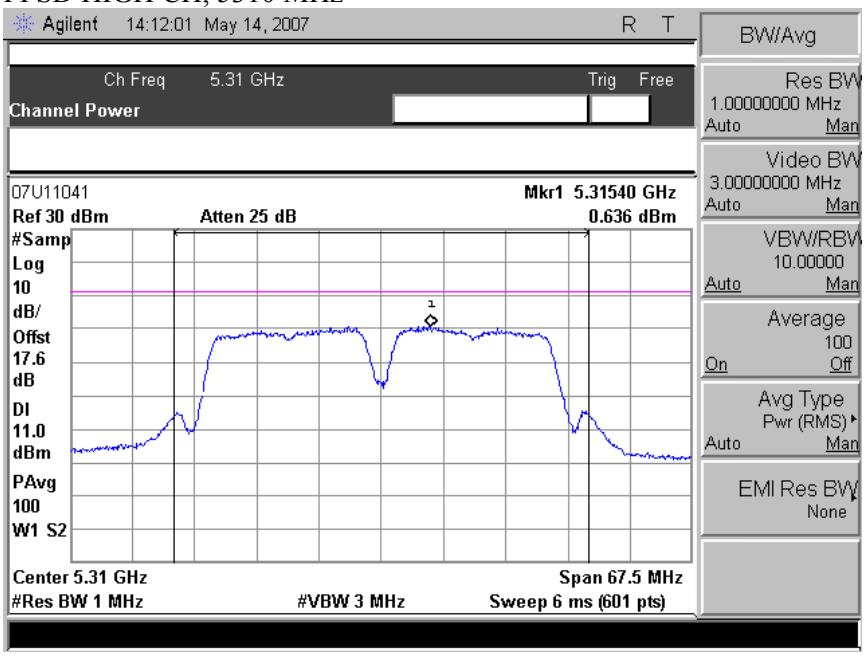
PPSD LOW CH, 5190 MHz



PPSD MID CH, 5270 MHz



PPSD HIGH CH, 5310 MHz



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	9.635	13	-3.37
Middle	5260	11.910	13	-1.09
High	5320	9.692	13	-3.31

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

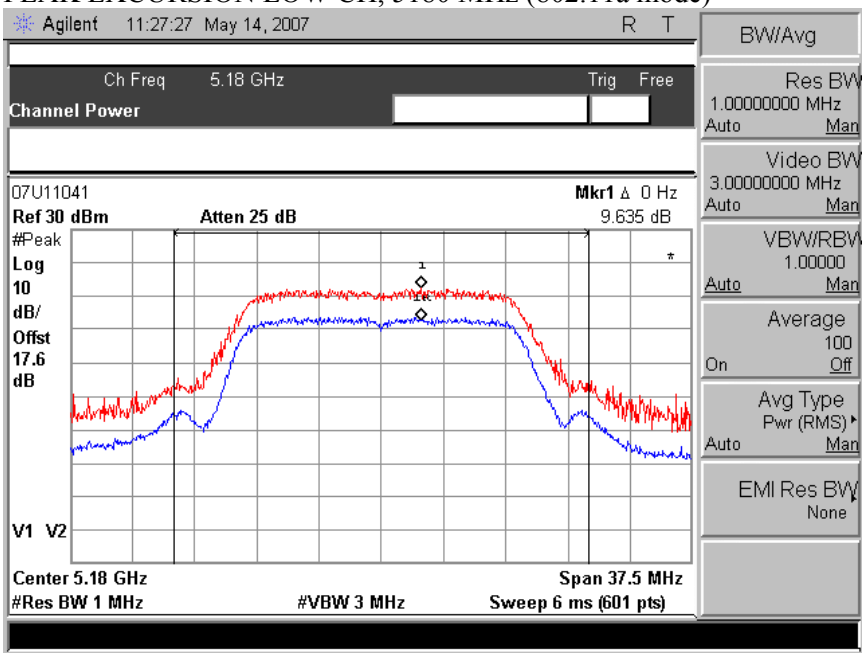
802.11n 40 MHz MODE

Channel	Frequency (MHz)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
Low	5190	9.538	13	-3.46
Middle	5270	10.410	13	-2.59
High	5310	10.490	13	-2.51

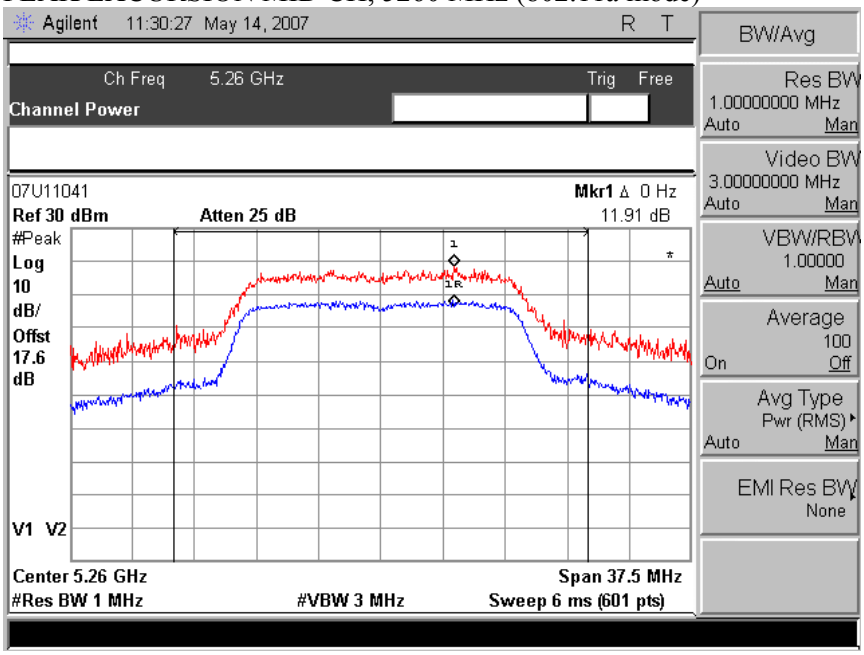
802.11a MODE

PEAK EXCURSION (802.11a MODE)

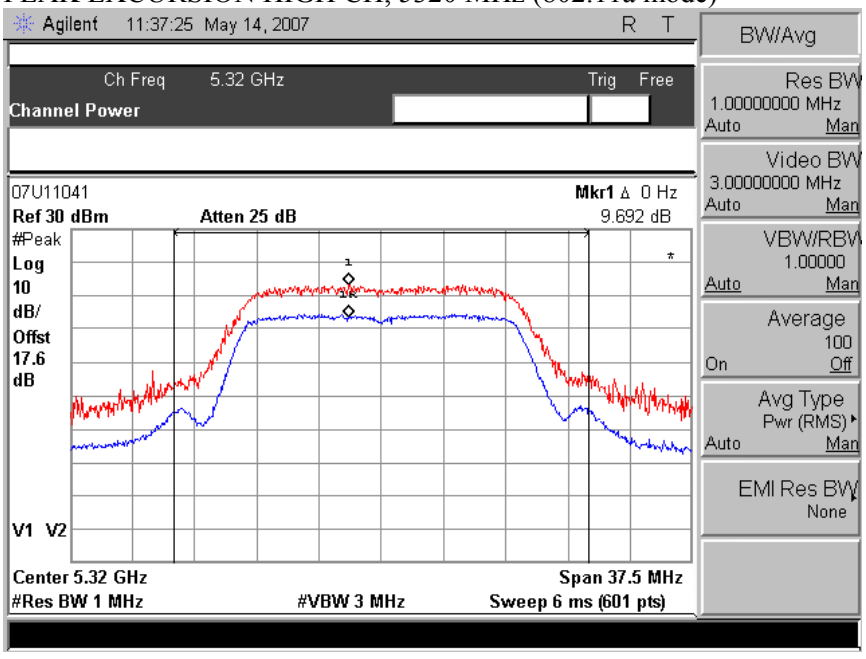
PEAK EXCURSION LOW CH, 5180 MHz (802.11a mode)



PEAK EXCURSION MID CH, 5260 MHz (802.11a mode)



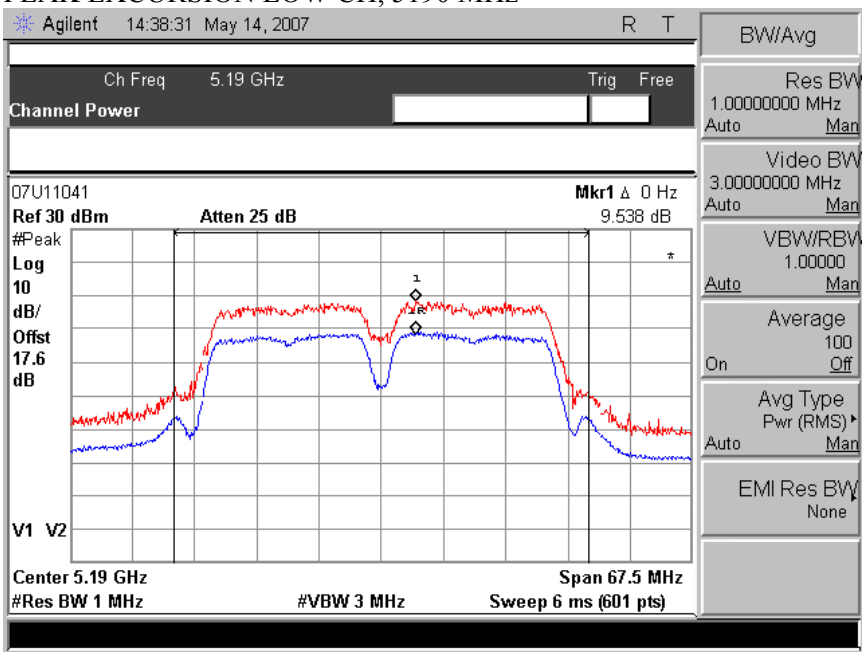
PEAK EXCURSION HIGH CH, 5320 MHz (802.11a mode)



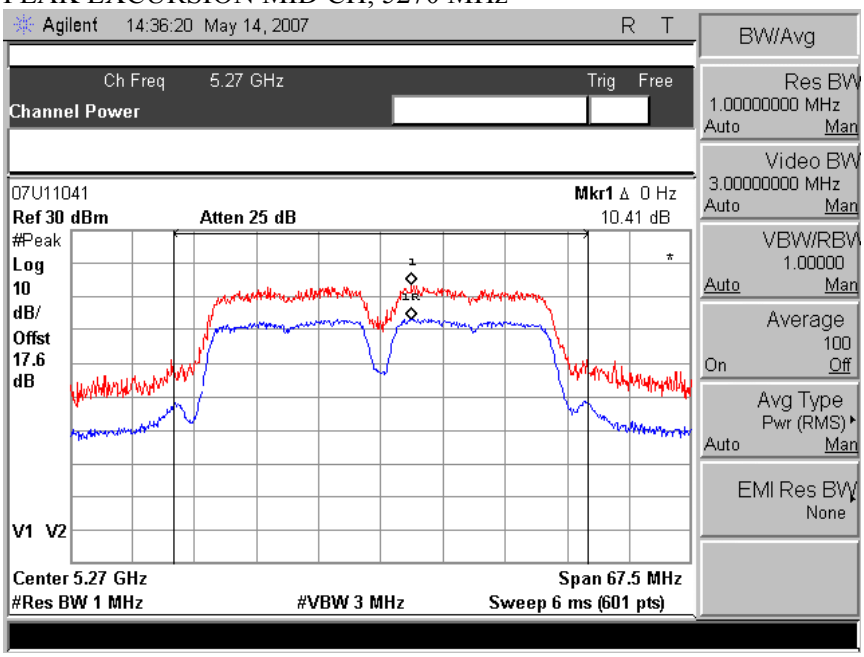
802.11n 40 MHz SISO MODE

PEAK EXCURSION (802.11n 40MHz SISO MODE)

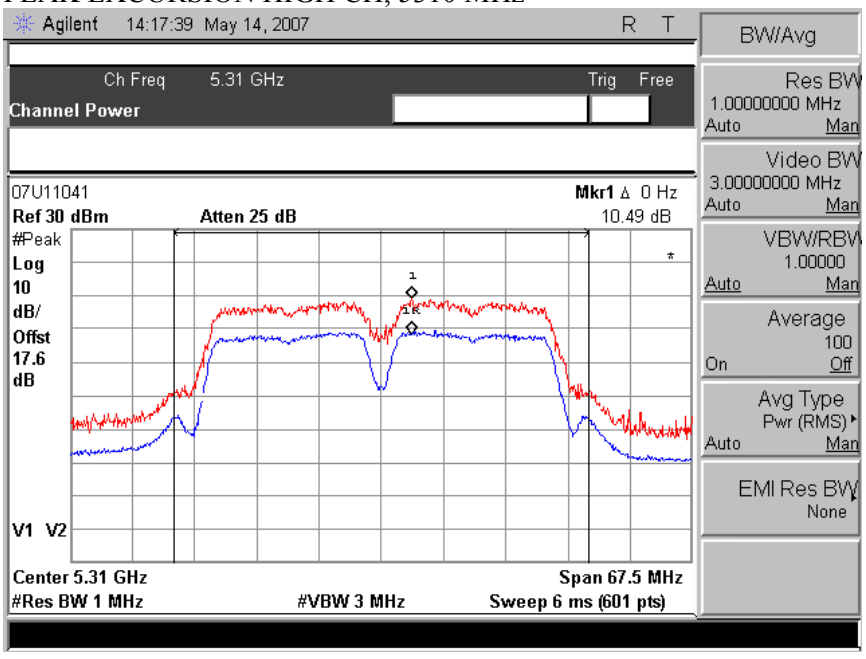
PEAK EXCURSION LOW CH, 5190 MHz



PEAK EXCURSION MID CH, 5270 MHz



PEAK EXCURSION HIGH CH, 5310 MHz



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.

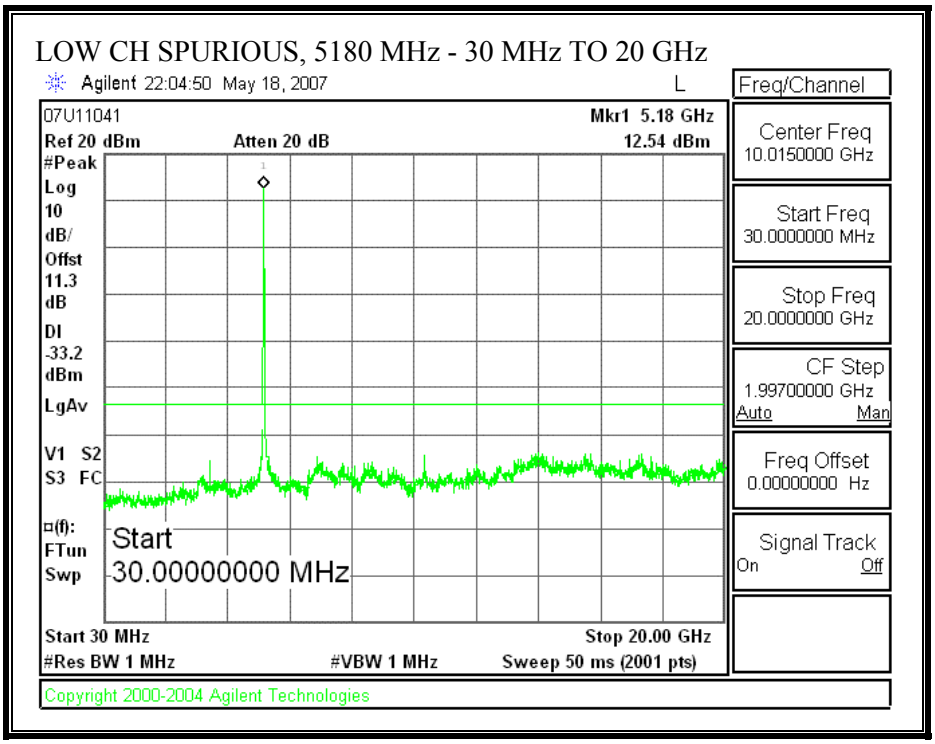
Measurements are made over the 30 MHz to 40 GHz range with the transmitter set to the lowest, middle, and highest channels.

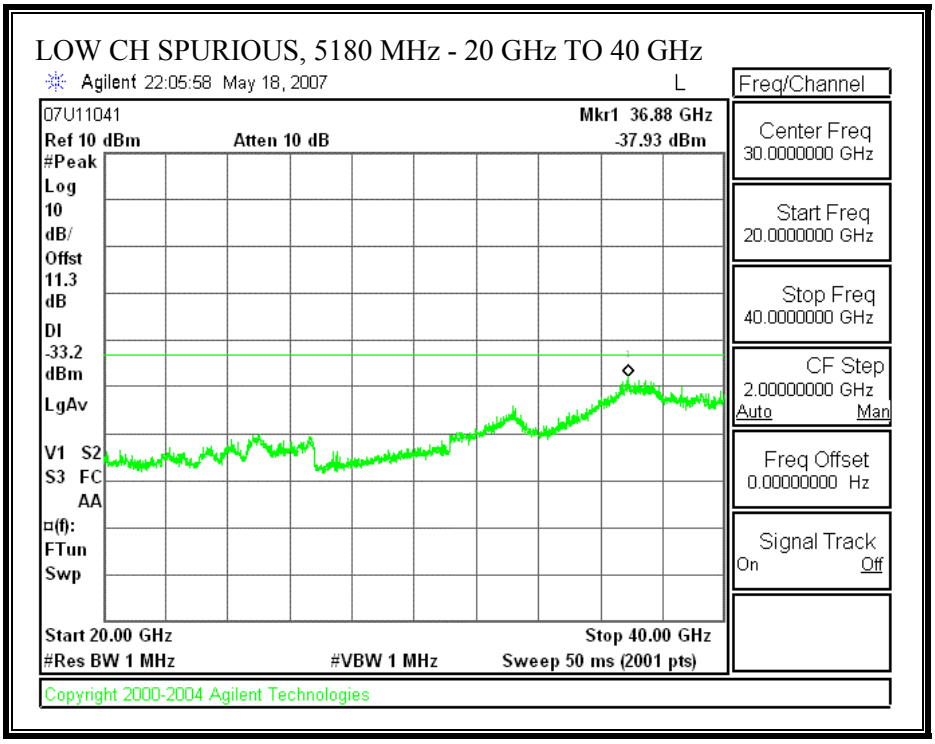
RESULTS

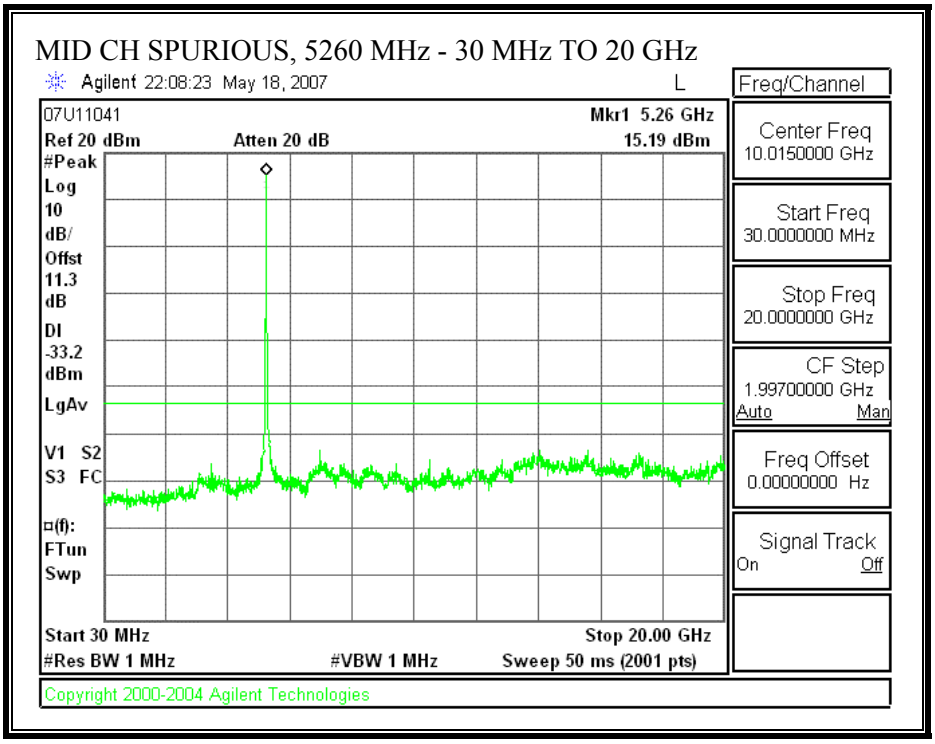
No non-compliance noted:

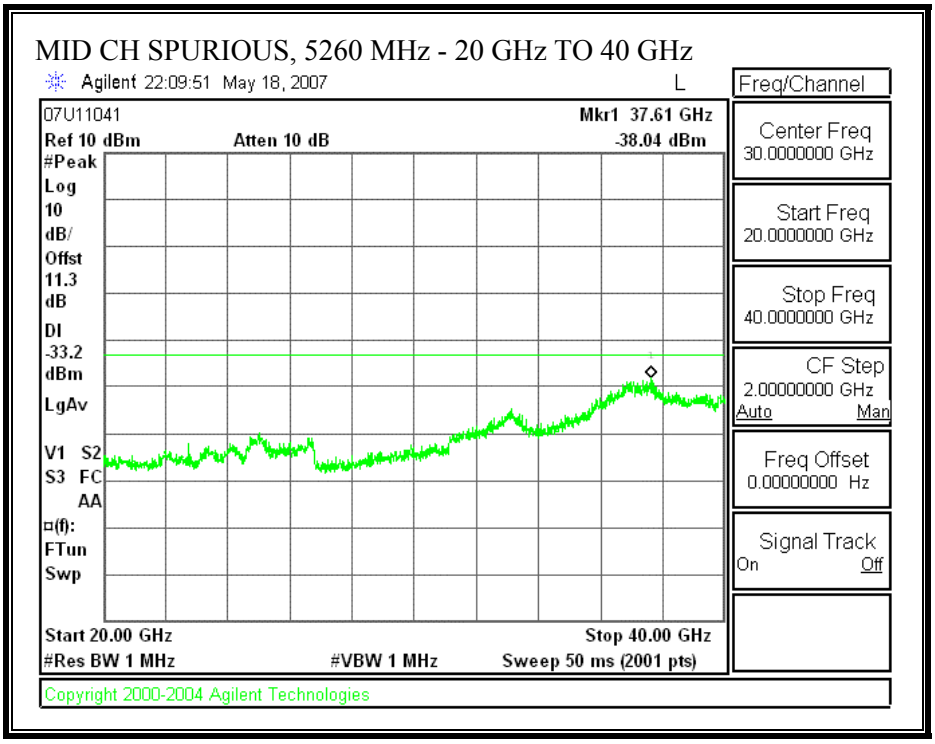
802.11a MODE

SPURIOUS EMISSIONS (802.11a MODE)

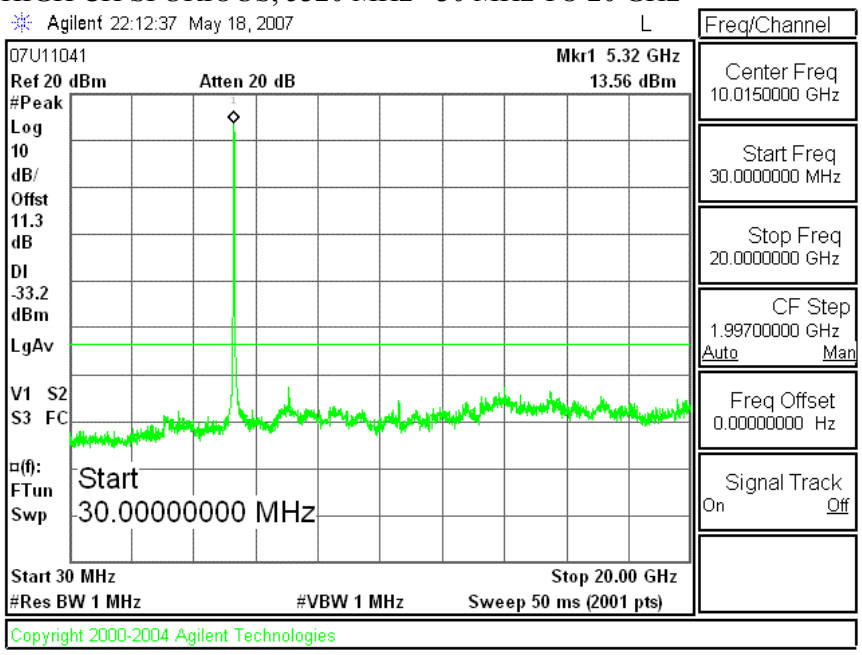




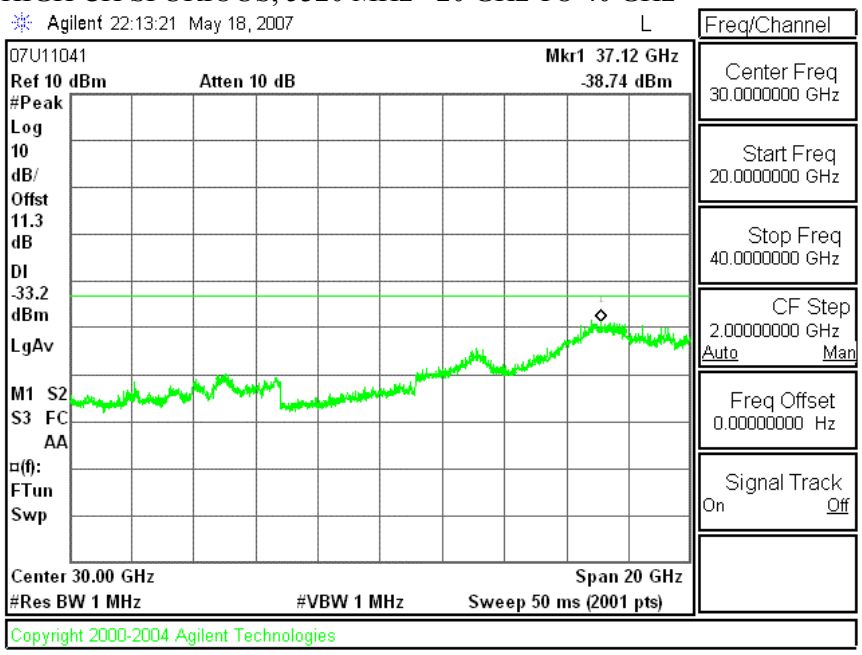




HIGH CH SPURIOUS, 5320 MHz - 30 MHz TO 20 GHz

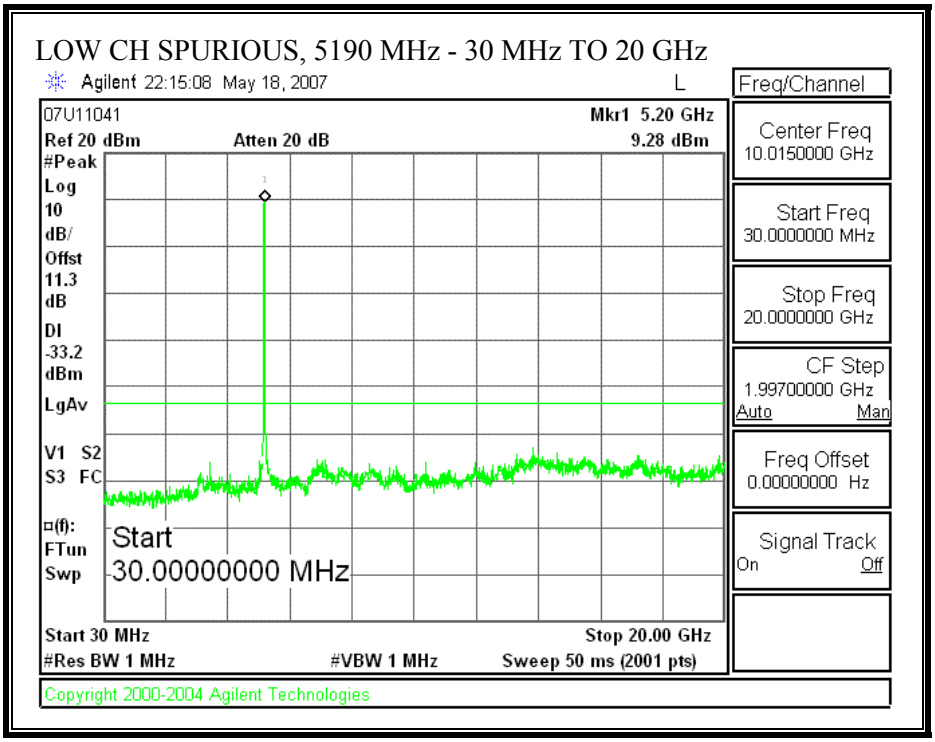


HIGH CH SPURIOUS, 5320 MHz - 20 GHz TO 40 GHz

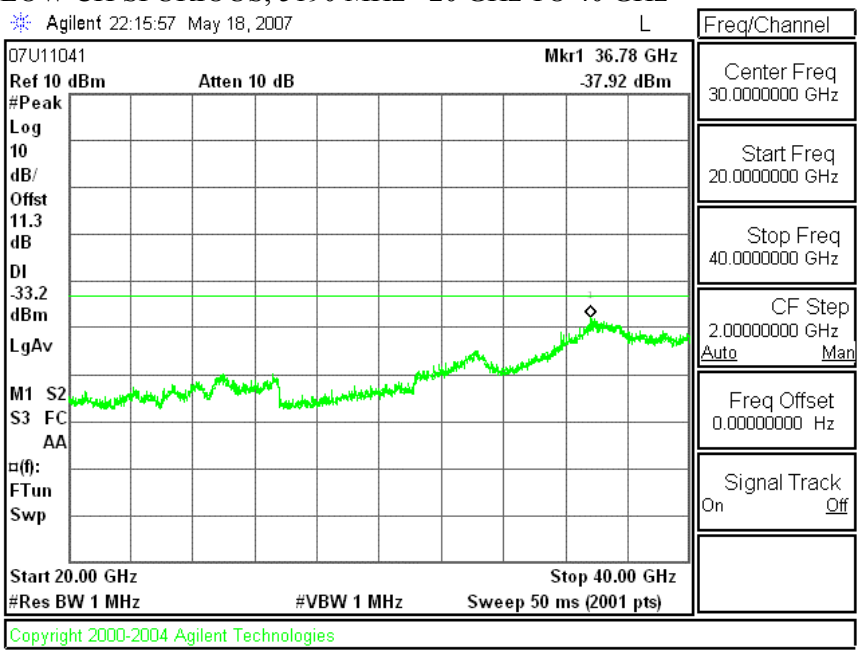


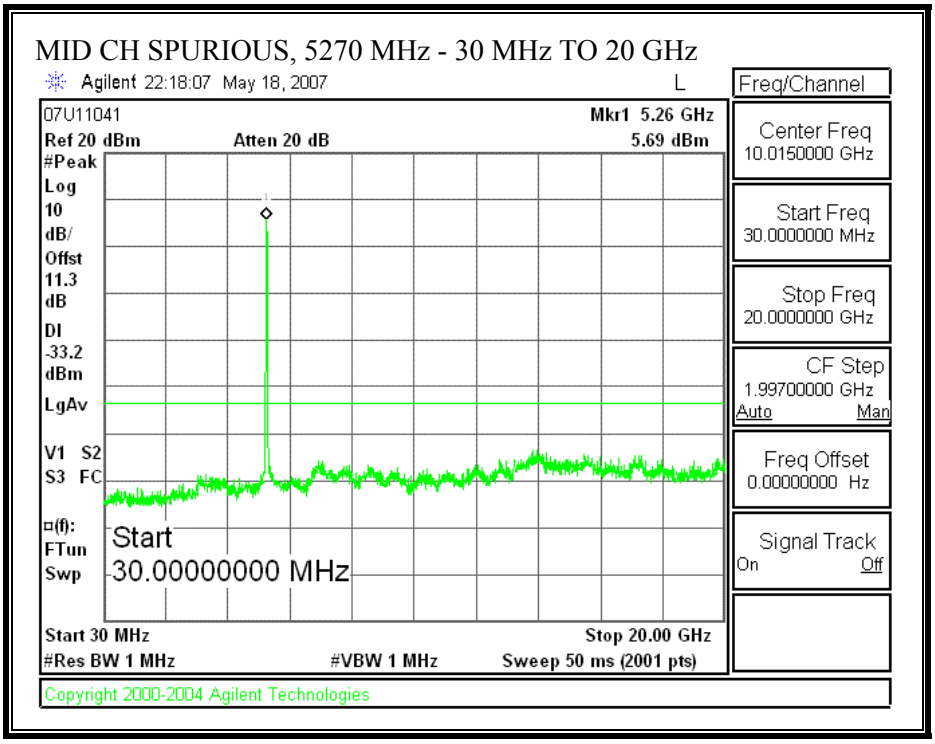
802.11n 40 MHz SISO MODE

SPURIOUS EMISSIONS (802.11n 40MHz SISO MODE)

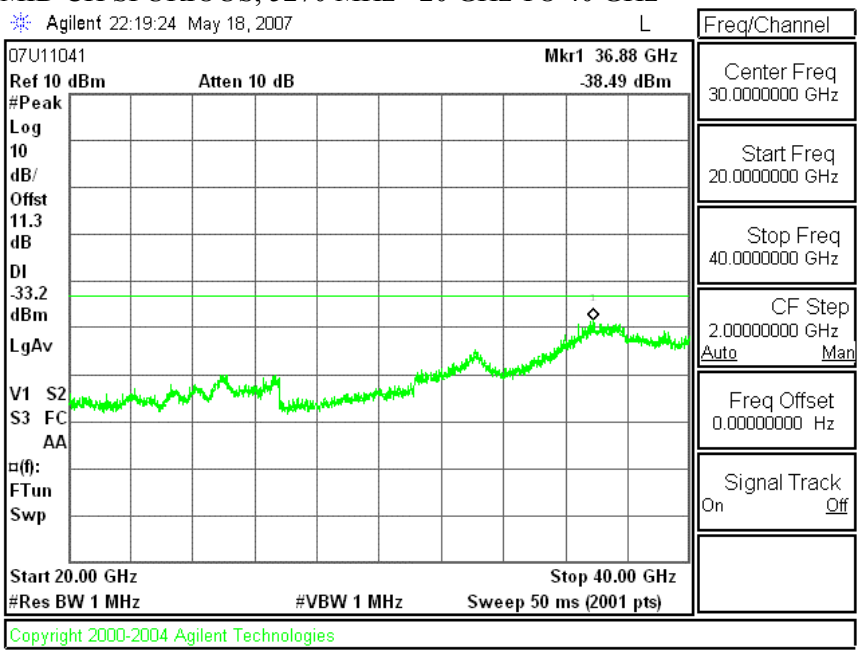


LOW CH SPURIOUS, 5190 MHz - 20 GHz TO 40 GHz

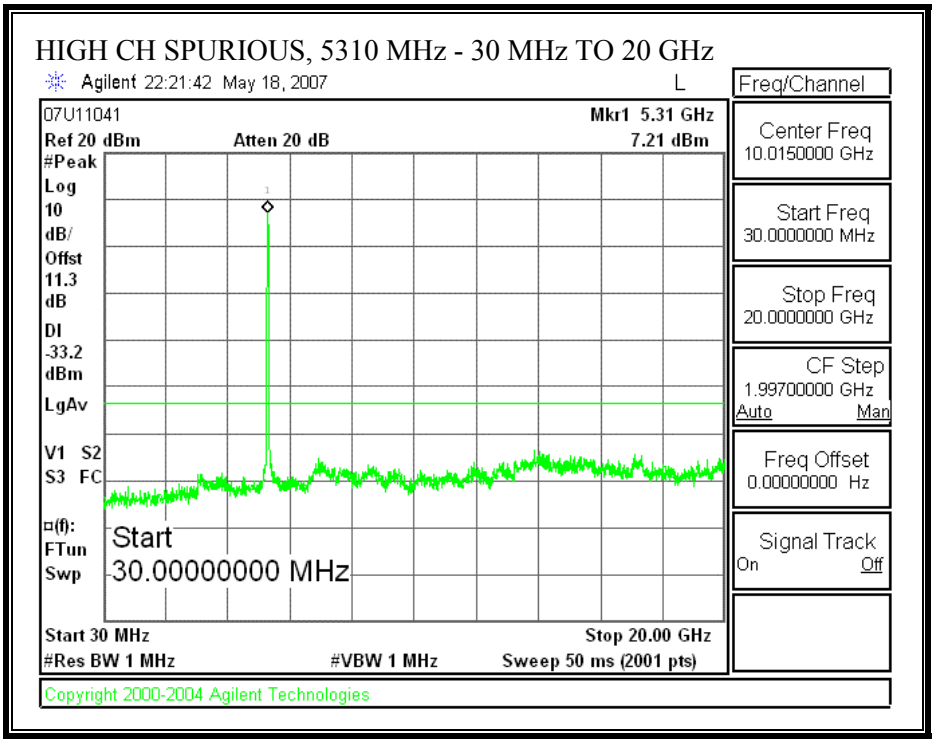


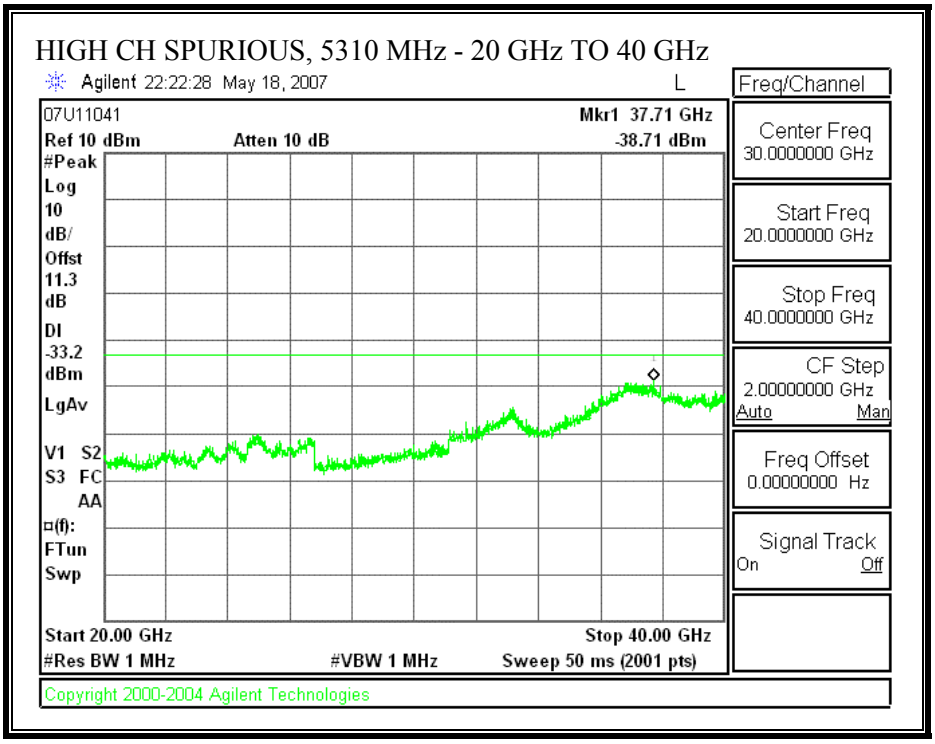


MID CH SPURIOUS, 5270 MHz - 20 GHz TO 40 GHz



HIGH CH SPURIOUS, 5310 MHz - 30 MHz TO 20 GHz





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	21.410	13.306
Middle	5260	25.449	14.057
High	5320	21.855	13.396

802.11 - 20 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5180	23.111	13.638
Middle	5260	22.119	13.448
High	5320	21.706	13.366

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	39.440	15.959
Middle	5270	39.983	16.019
High	5310	41.842	16.216

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	44.726	16.506
Middle	5270	46.227	16.649
High	5310	43.722	16.407

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	43.780	16.413

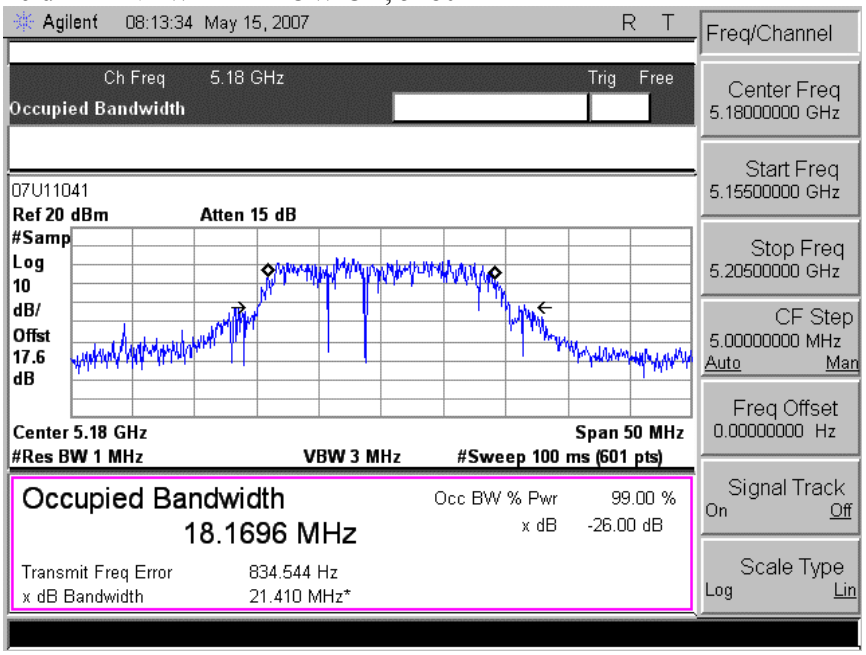
802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5190	39.403	15.955

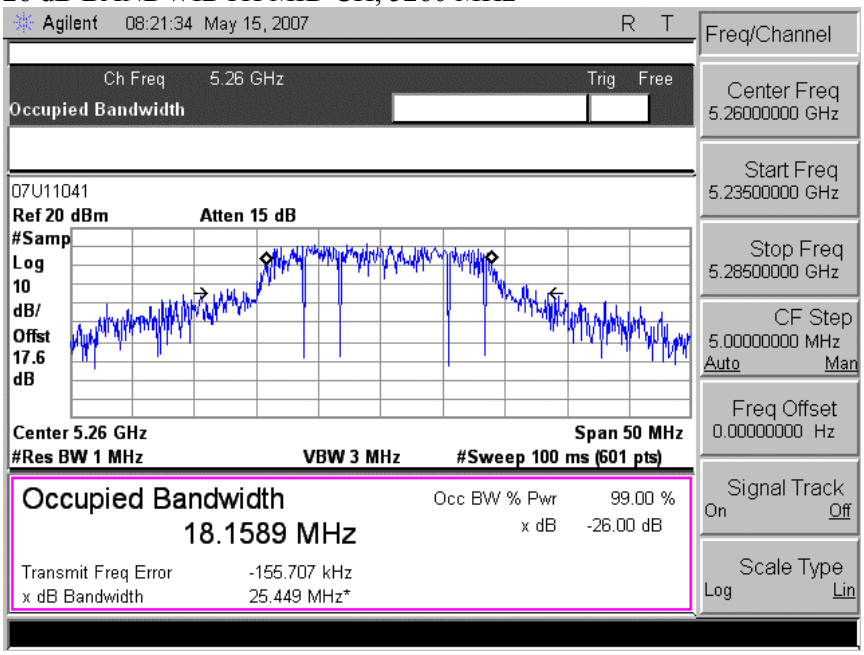
802.11n 20 MHz CDD MCS 0

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

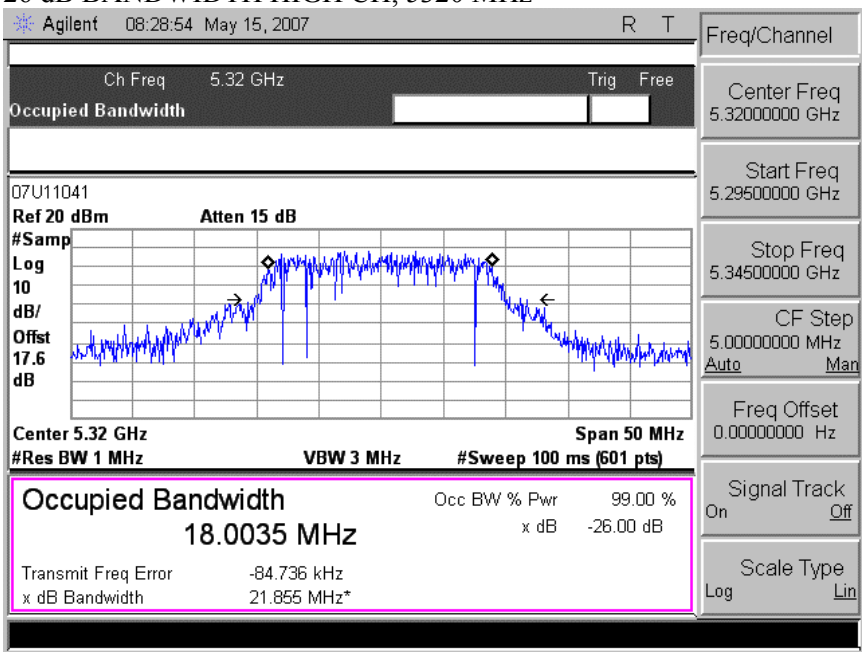
26 dB BANDWIDTH LOW CH, 5180 MHz



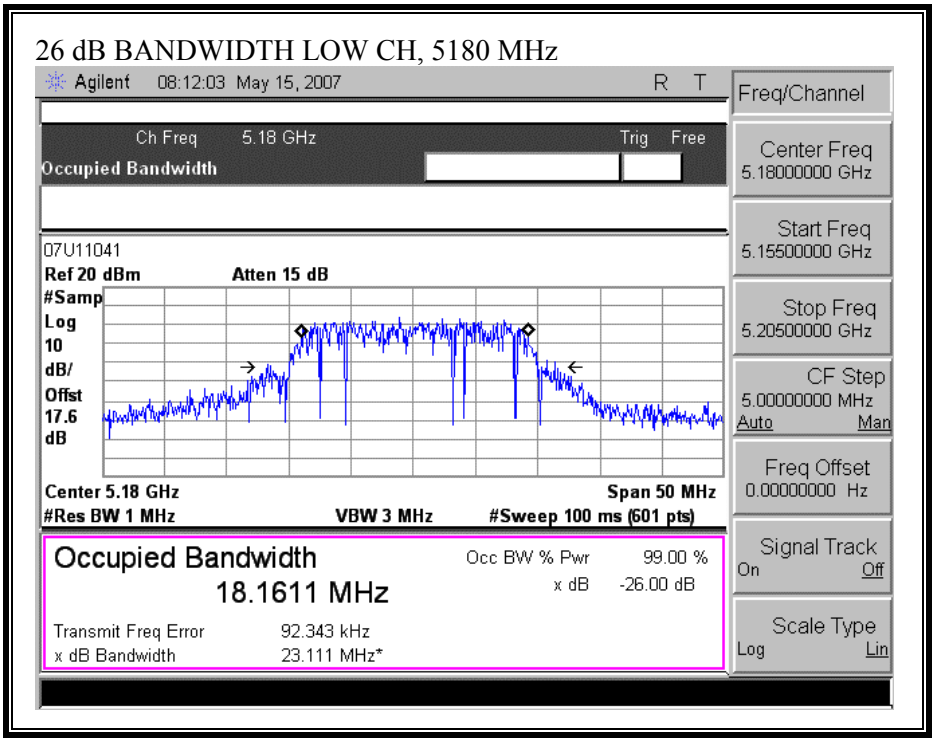
26 dB BANDWIDTH MID CH, 5260 MHz



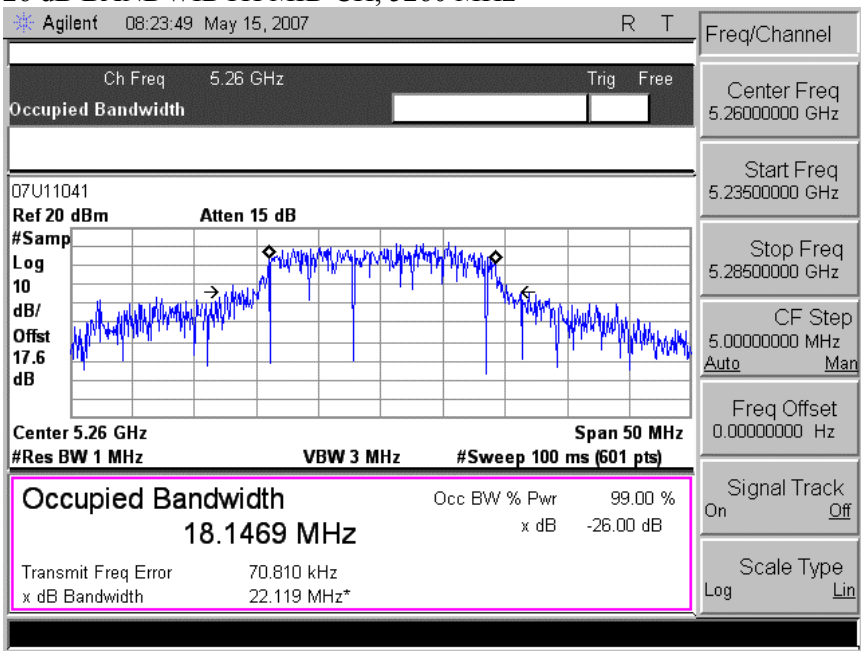
26 dB BANDWIDTH HIGH CH, 5320 MHz



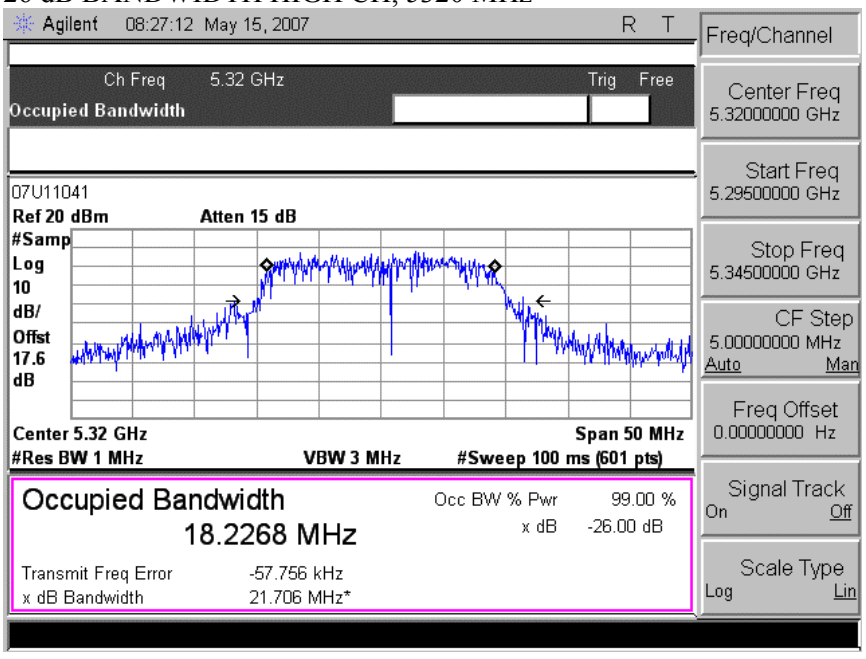
26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 1)



26 dB BANDWIDTH MID CH, 5260 MHz



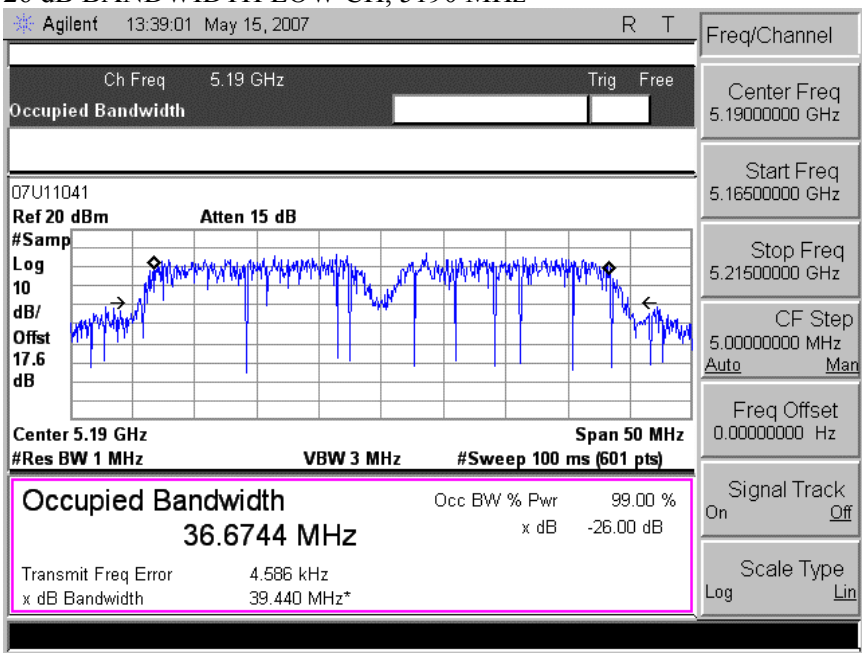
26 dB BANDWIDTH HIGH CH, 5320 MHz



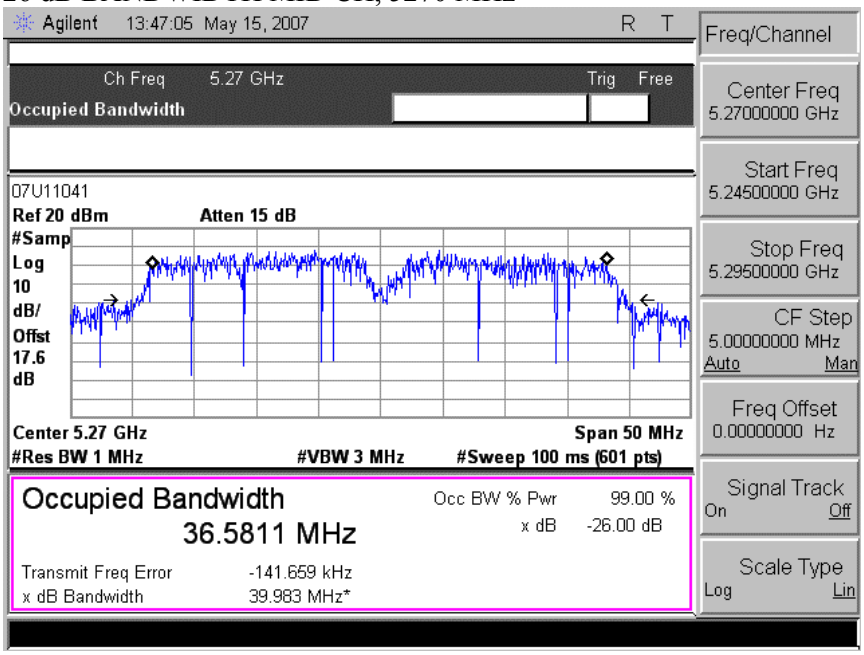
802.11n 40 MHz CDD MCS 32

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

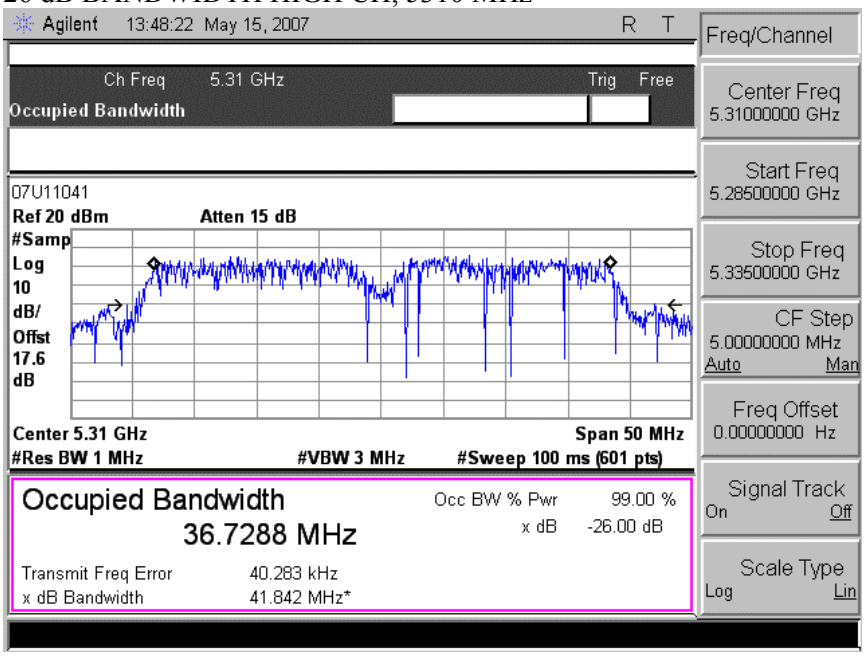
26 dB BANDWIDTH LOW CH, 5190 MHz



26 dB BANDWIDTH MID CH, 5270 MHz

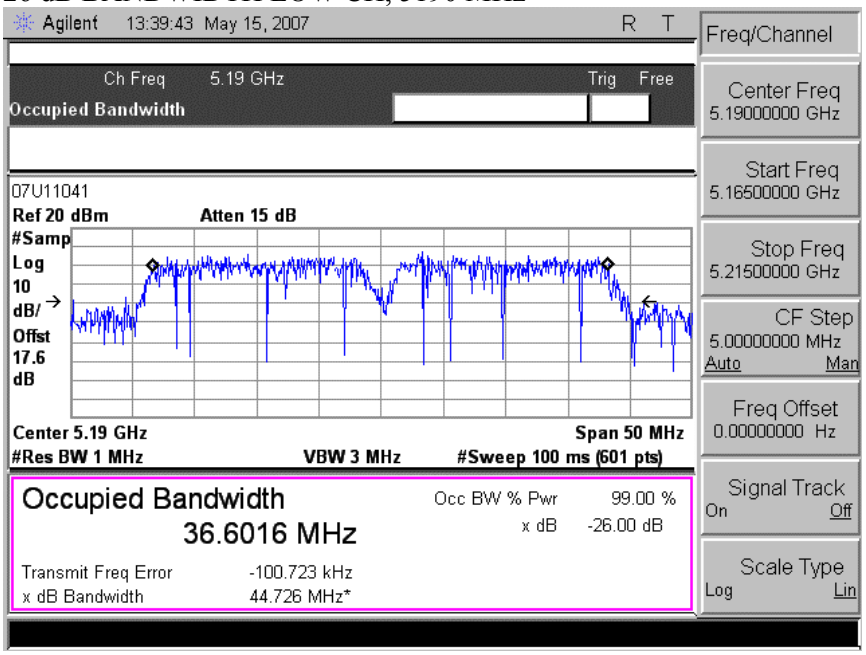


26 dB BANDWIDTH HIGH CH, 5310 MHz

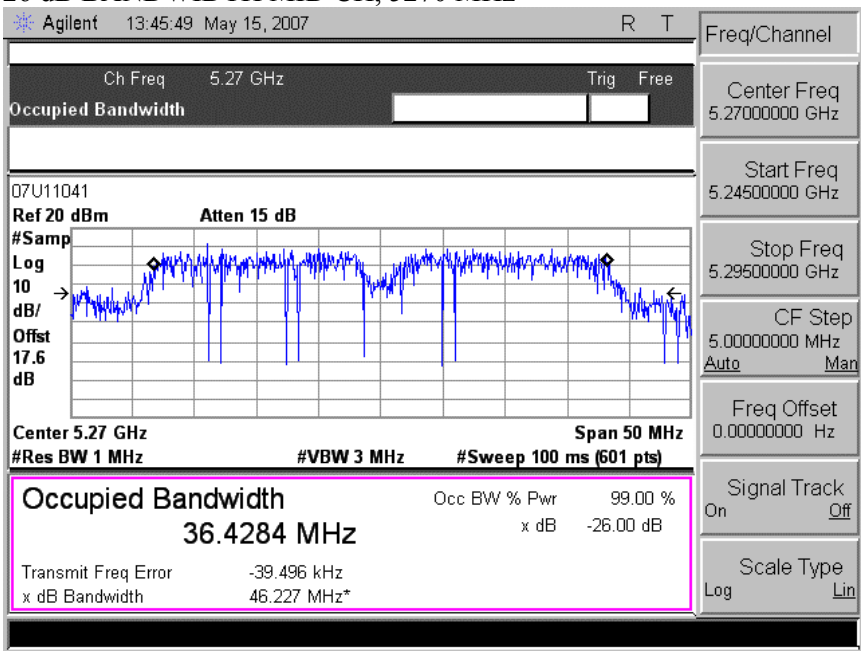


26 dB EMISSION BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH- CHAIN 1)

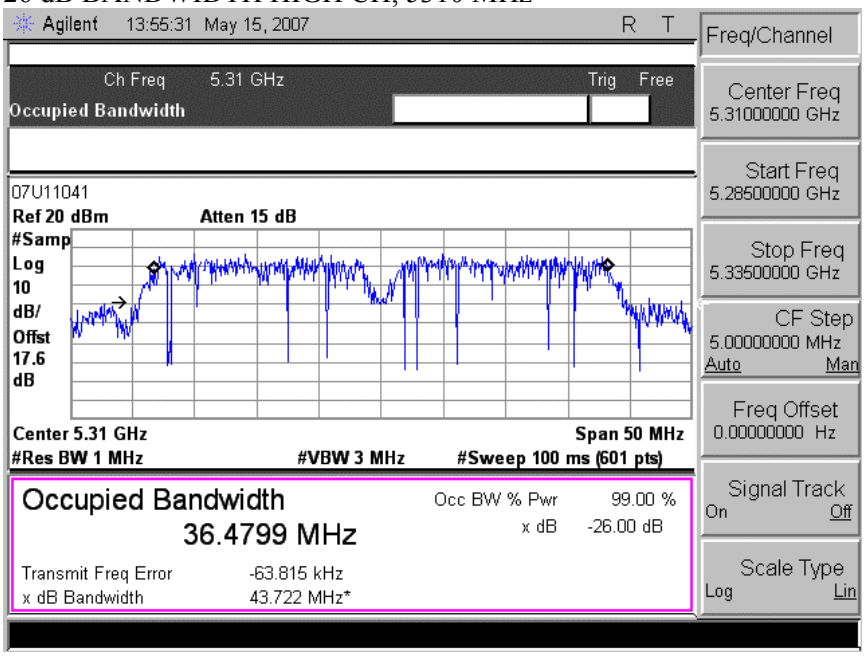
26 dB BANDWIDTH LOW CH, 5190 MHz



26 dB BANDWIDTH MID CH, 5270 MHz



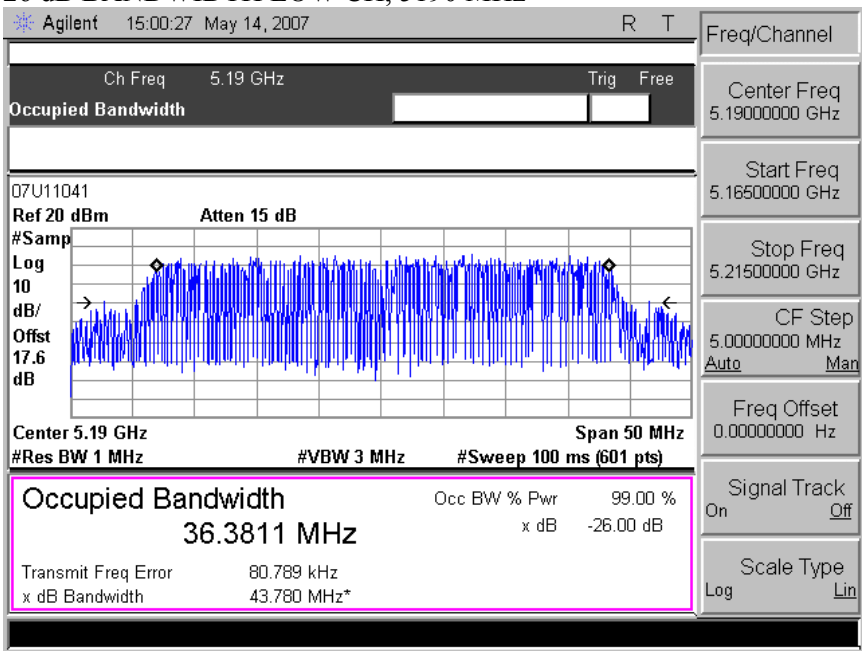
26 dB BANDWIDTH HIGH CH, 5310 MHz



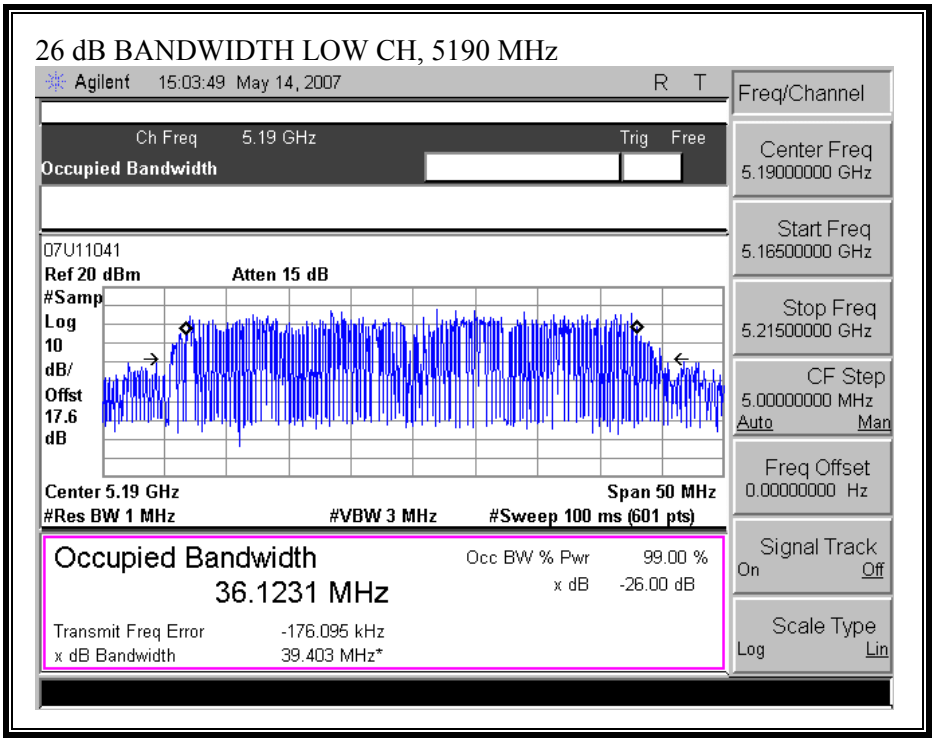
802.11n 40 MHz SDM MCS 15

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

26 dB BANDWIDTH LOW CH, 5190 MHz



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 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 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

No non-compliance noted:

Total peak power calculation formula: 10 log (10^ (Pchain0 / 10) + 10^ (Pchain1 / 10))

Note: Pchain 0 and Pchain1 are in dBm

Array gain = 10*log (10^ (main gain/10) + 10^ (aux gain/10))

5.15 – 5.25GHz band: 7.077dBi
5.25 – 5.35GHz band: 8.677dBi

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

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	21.410	23.111	17.306	7.077	15.923

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	25.449	22.119	24.448	8.677	21.323
High	5320	24	21.855	21.706	24.366	8.677	21.323

Results

Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5180	9.17	9.23	12.21	15.923	-3.713
Mid	5260	13.33	13.37	16.36	21.323	-4.963
High	5320	13.49	13.60	16.56	21.323	-4.767

6dBi Antenna – Mid & high channels still meet the limit of high antenna gain

Note: The high channel utilizes the same power level for all antennas; high channel power data in table below is from 8.677dBi 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	21.410	23.111	17.306	6.00	17.00

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	25.449	22.119	24.448	6.00	24.00
High	5320	24	21.855	21.706	24.366	6.00	24.00

Results

Channel	Frequency (MHz)	Power Chain 0	Power Chain 1	Total Power	Limit (dBm)	Margin (dB)
Low	5180	10.24	10.35	13.31	17.00	-3.69
Mid	5260	15.78	15.14	18.48	24.00	-5.52
High	5320	13.49	13.60	16.56	24.00	-7.44

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	39.440	44.726	19.959	7.077	15.923

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	39.983	46.227	27.019	8.667	21.333
High	5310	24	41.842	43.722	27.216	8.667	21.333

Results

Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5190	10.33	10.91	13.64	15.923	-2.283
Mid	5270	15.91	15.86	18.90	21.333	-2.438
High	5310	12.19	12.38	15.30	21.333	-6.037

6dBi Antenna

Note: The mid and high channels utilize the same power level for all antennas. Data in the table below only shows the differences within the 5150 to 5250 MHz 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	39.440	44.726	19.959	6.00	17.00

Results

Channel	Frequency (MHz)	Power Chain 0	Power Chain 1	Total Power	Limit (dBm)	Margin (dB)
Low	5190	13.74	13.53	16.65	17.00	-0.35

802.11n 40 MHz SDM MCS 15

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	43.780	39.403	19.955	6.23	16.77

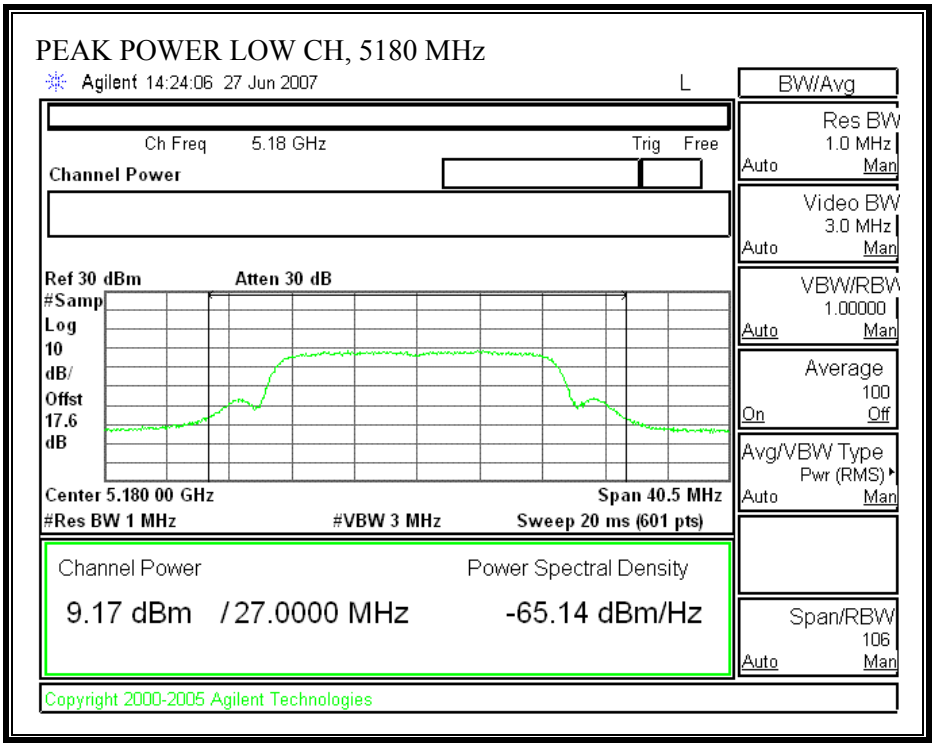
Results

Channel	Frequency (MHz)	Power Chain 0 (dBm)	Power Chain 1 (dBm)	Total Power (dBm)	Limit (dBm)	Margin (dB)
Low	5190	12.78	12.65	15.73	16.77	-1.04

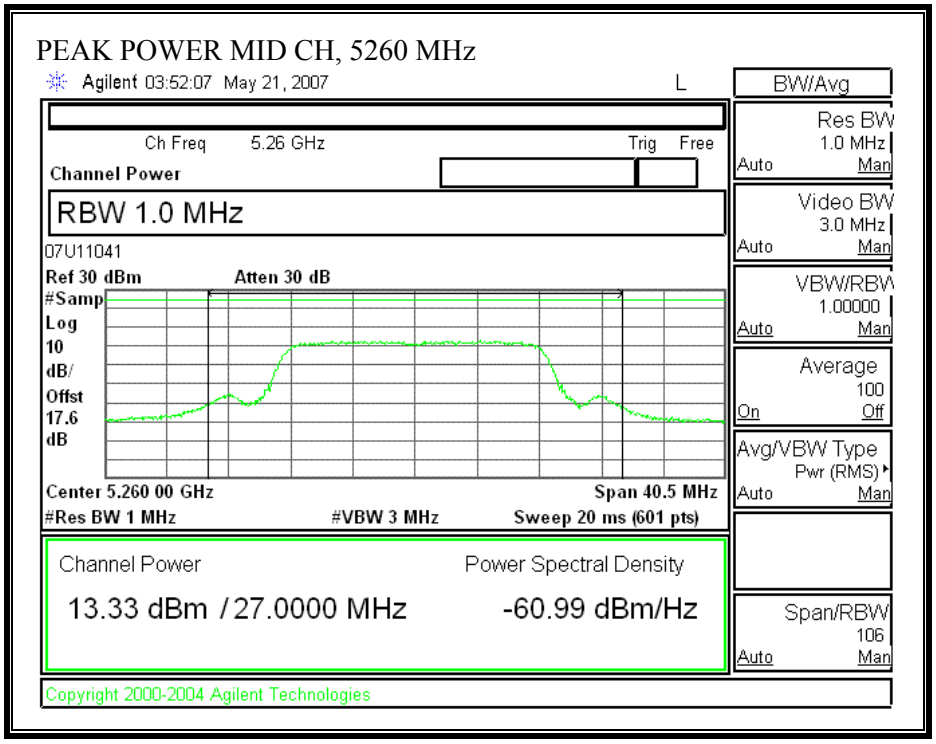
802.11n 20 MHz CDD MCS 0

8.677dBi Antenna

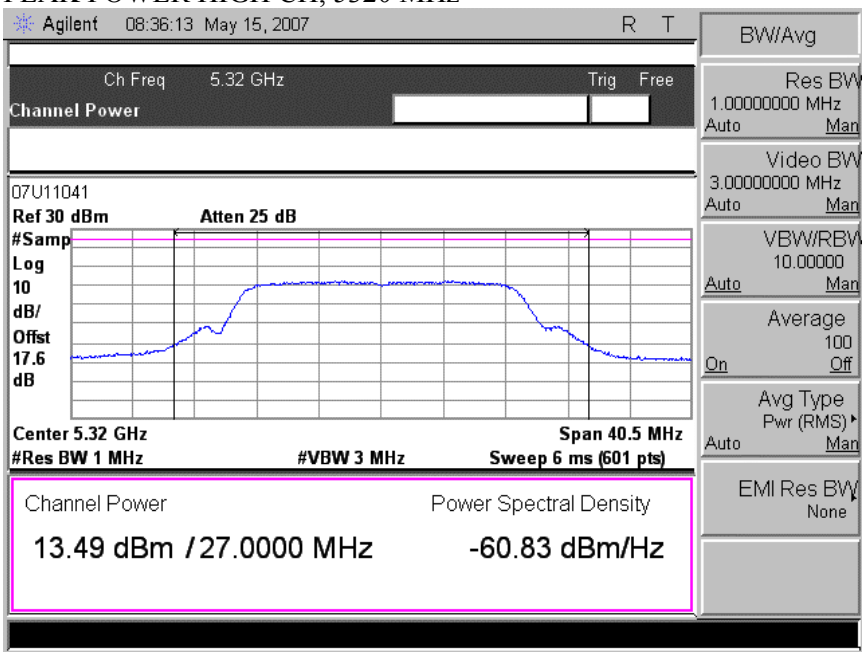
PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 0)



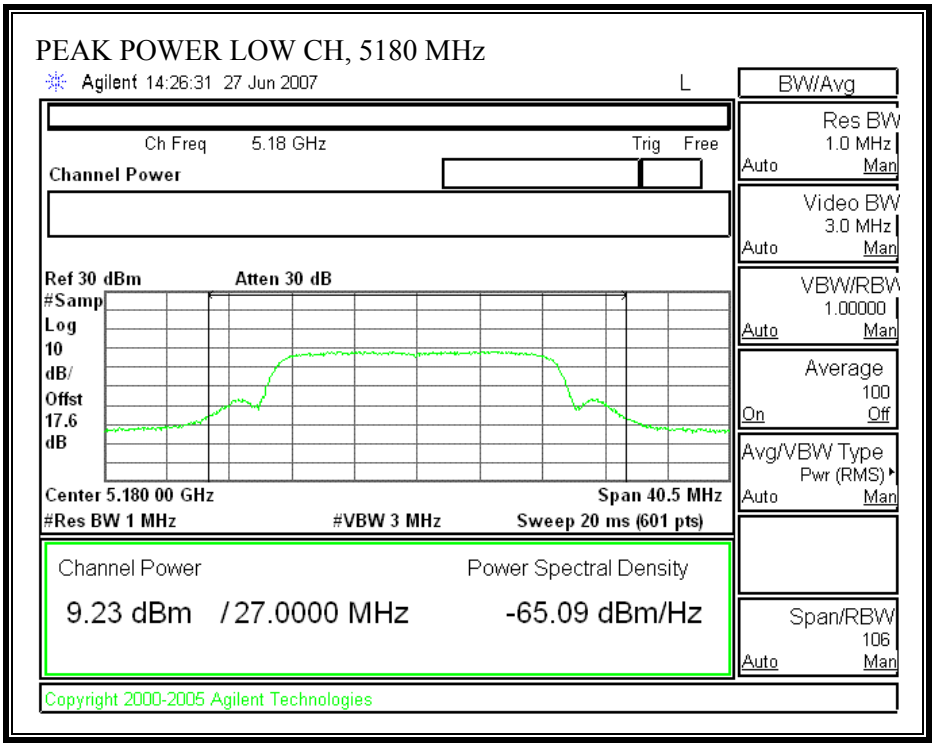
PEAK POWER MID CH, 5260 MHz



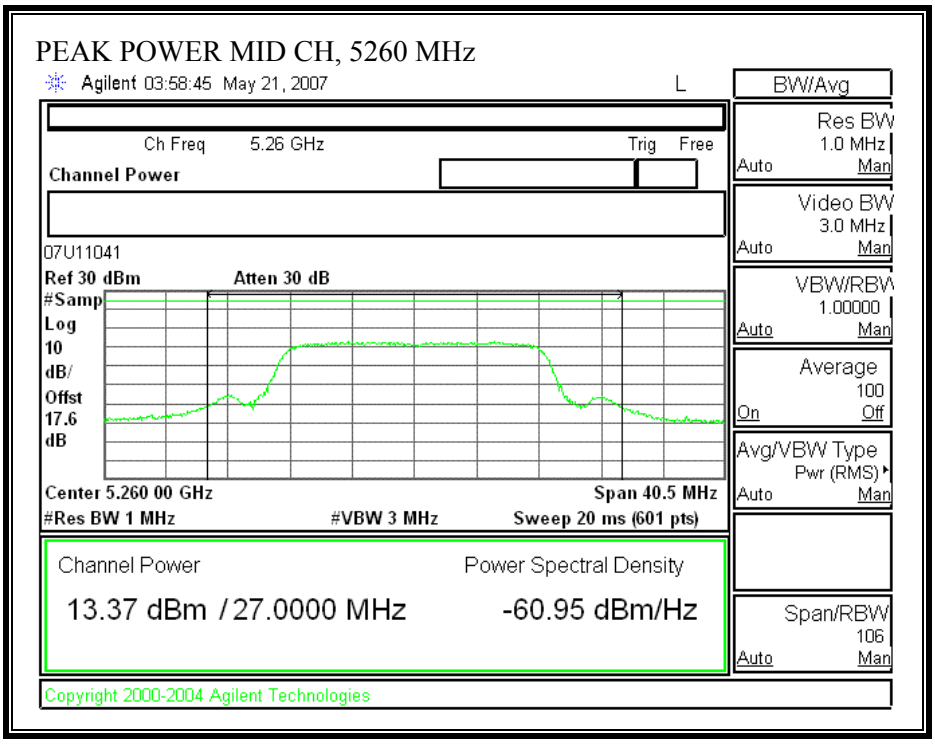
PEAK POWER HIGH CH, 5320 MHz



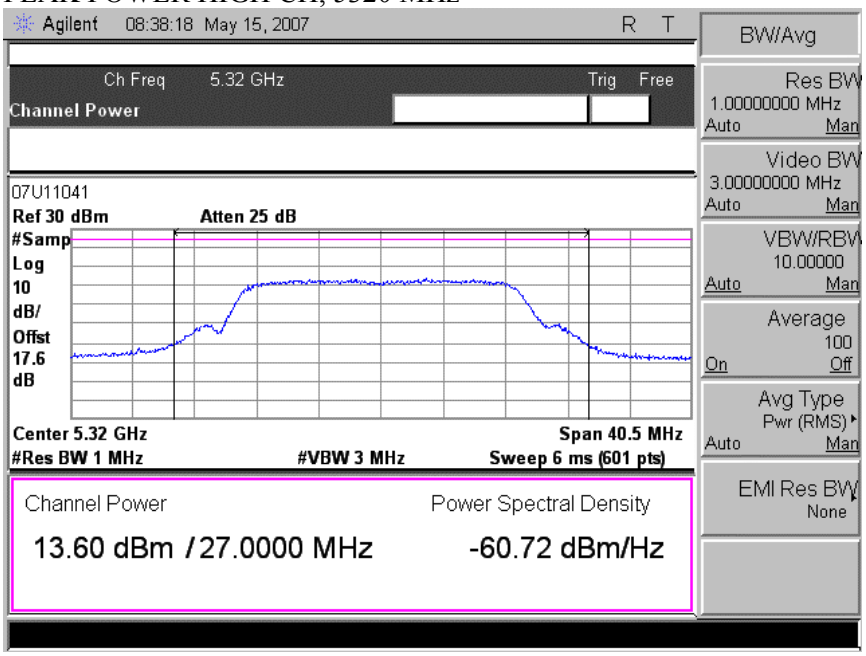
PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 1)



PEAK POWER MID CH, 5260 MHz



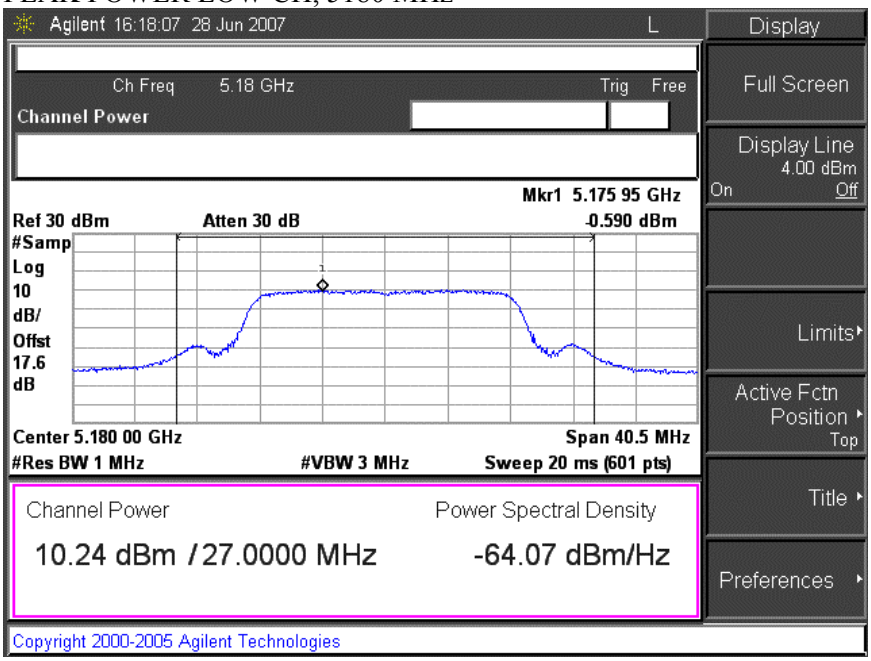
PEAK POWER HIGH CH, 5320 MHz



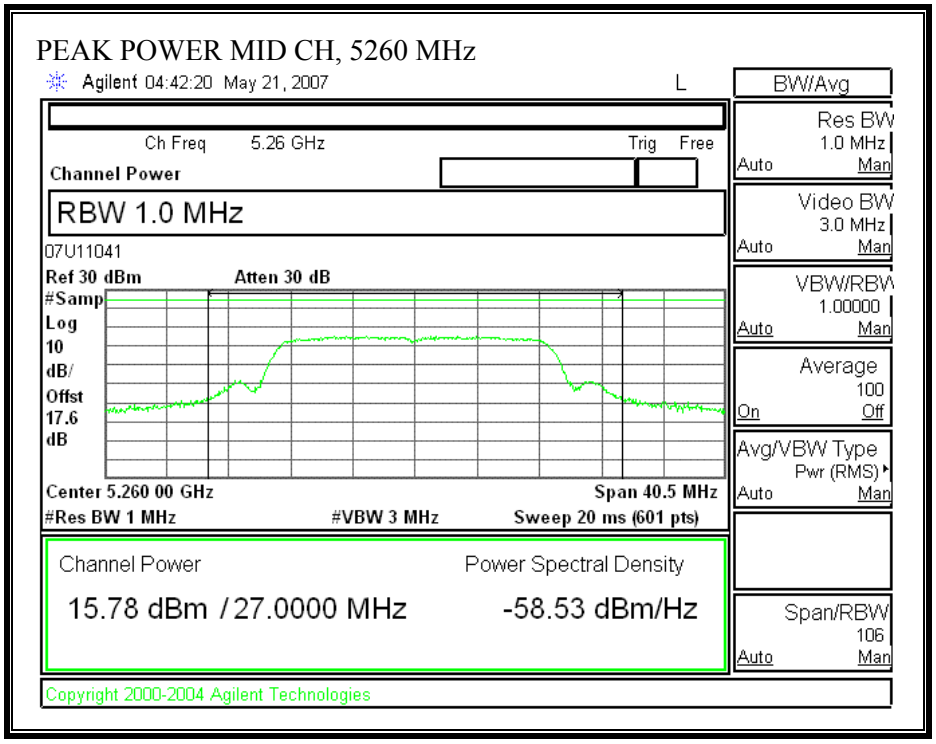
6dBi Antenna

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

PEAK POWER LOW CH, 5180 MHz

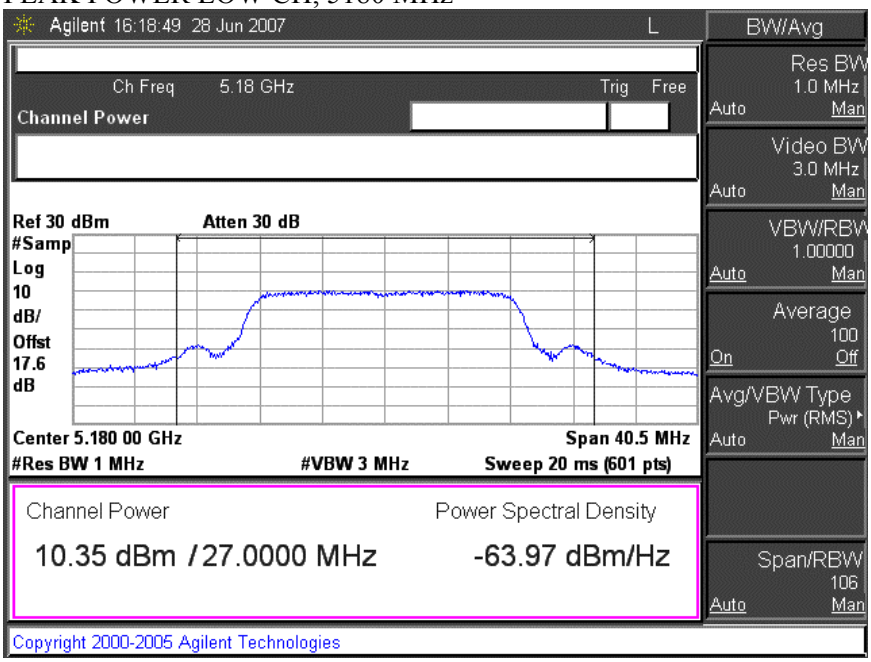


PEAK POWER MID CH, 5260 MHz

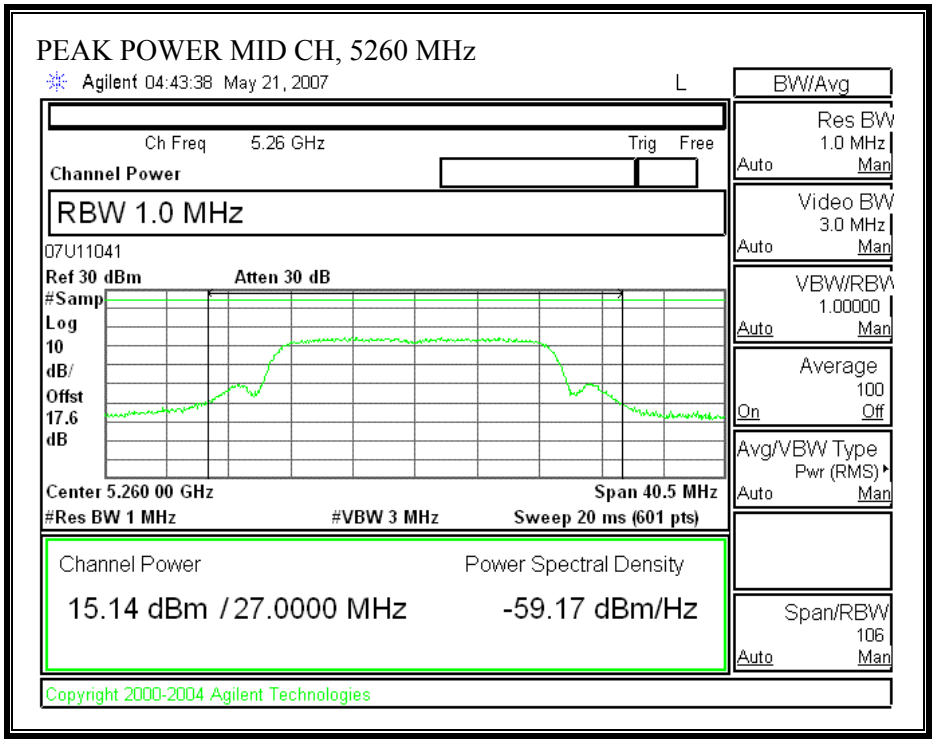


PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 1)

PEAK POWER LOW CH, 5180 MHz



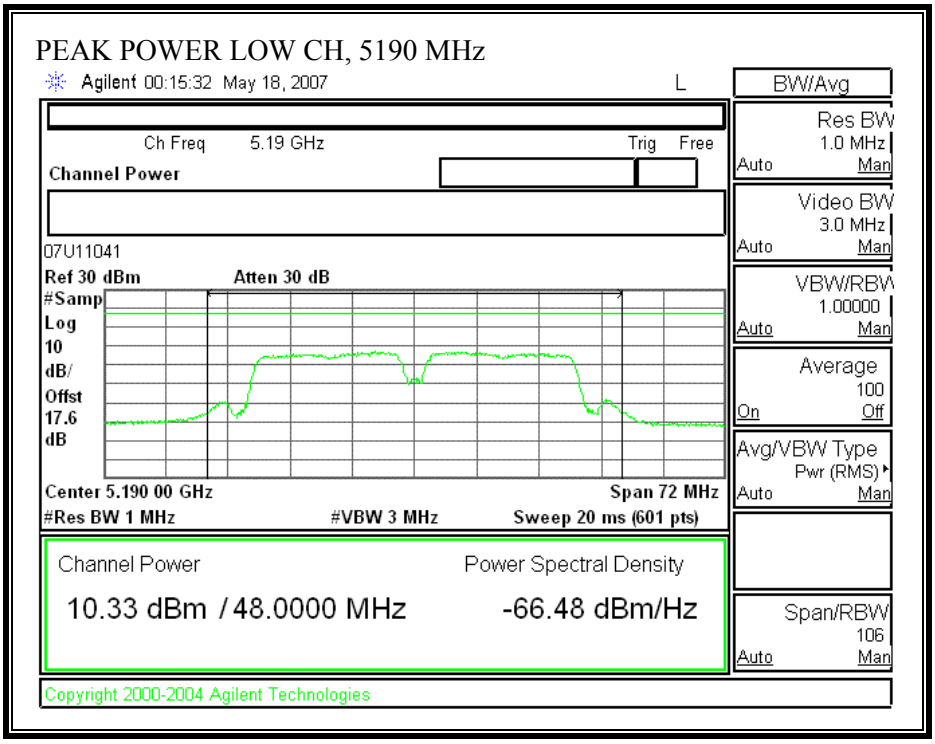
PEAK POWER MID CH, 5260 MHz



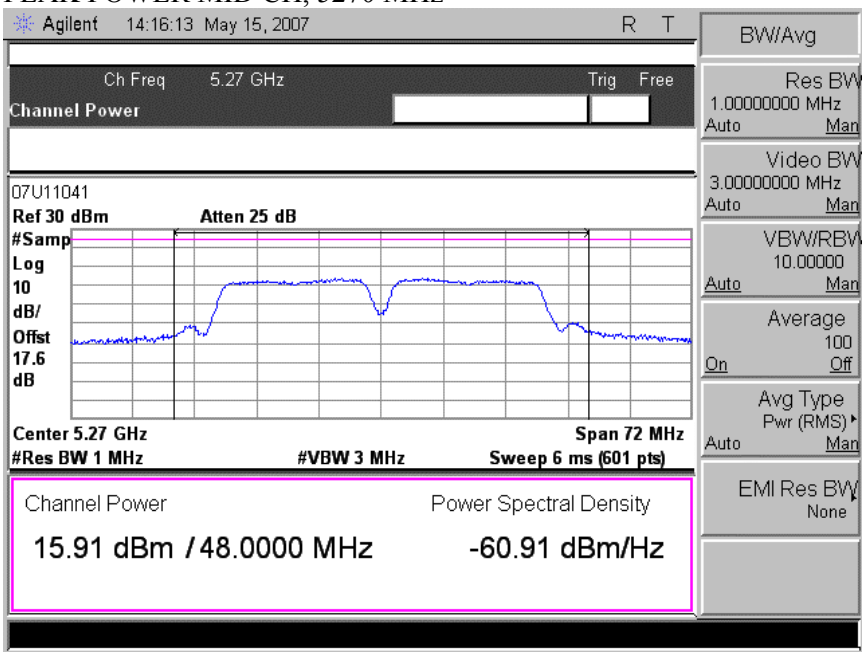
802.11n 40 MHz CDD MCS 32

8.677dBi antenna

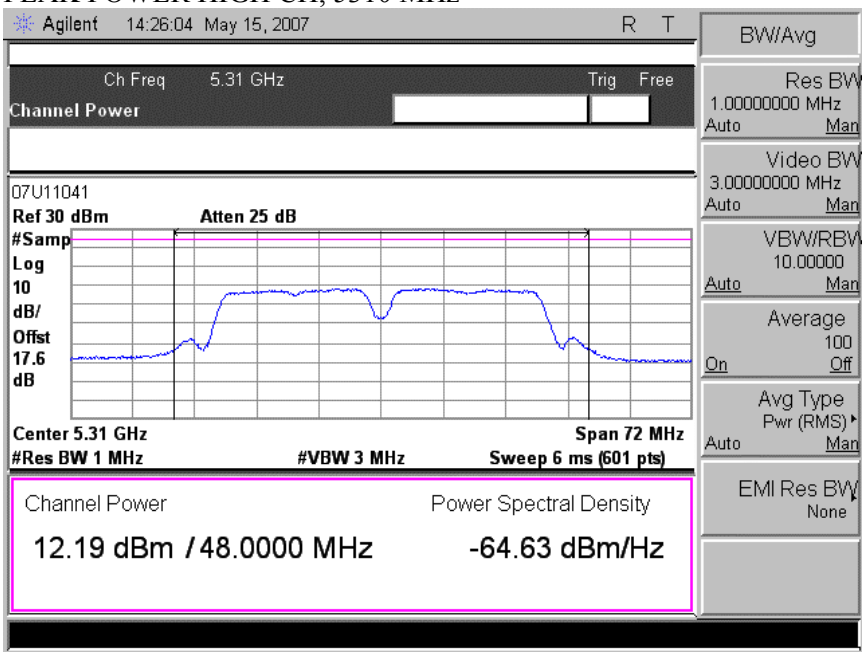
PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 0)



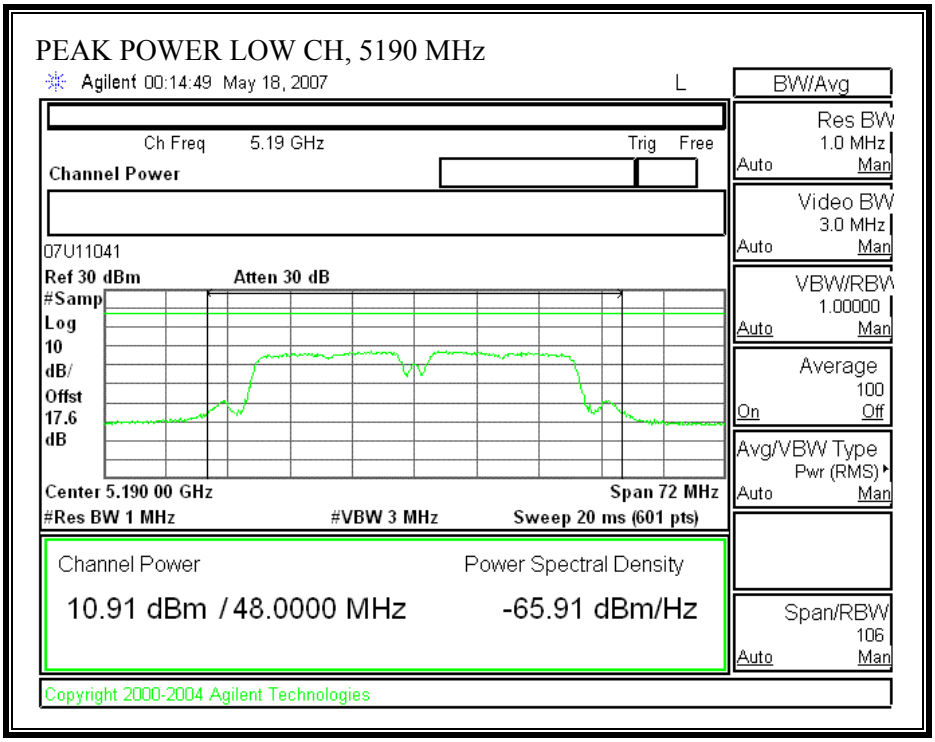
PEAK POWER MID CH, 5270 MHz



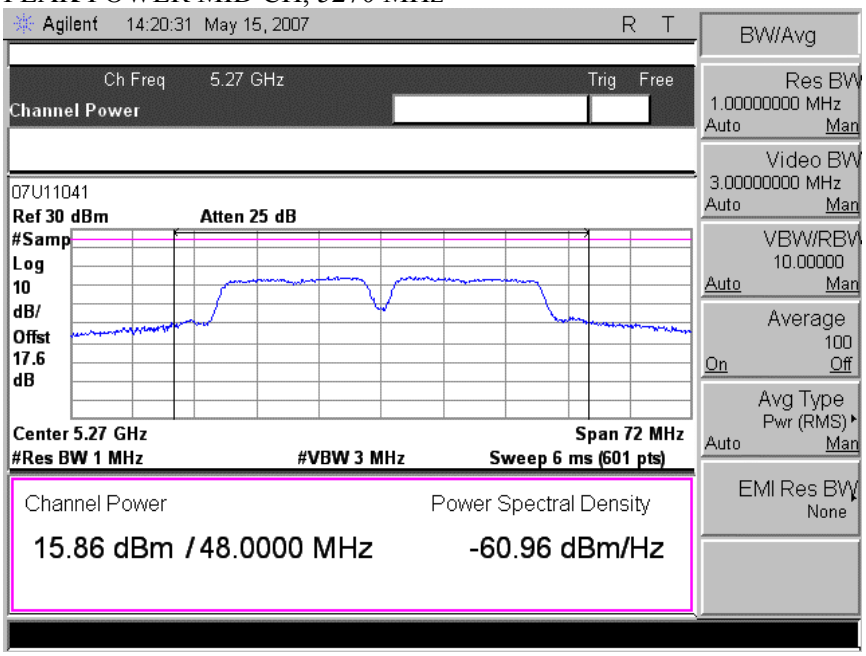
PEAK POWER HIGH CH, 5310 MHz



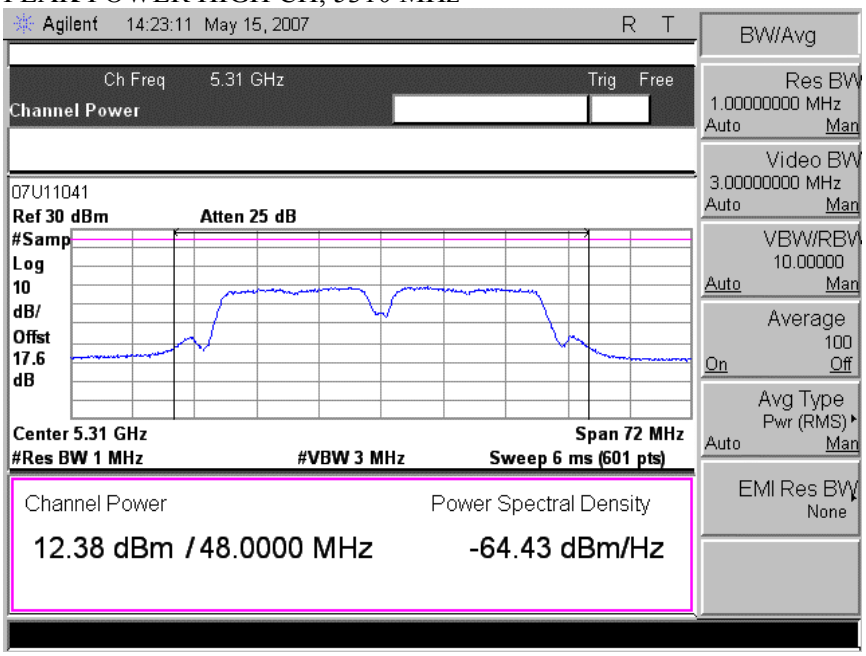
PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 1)



PEAK POWER MID CH, 5270 MHz

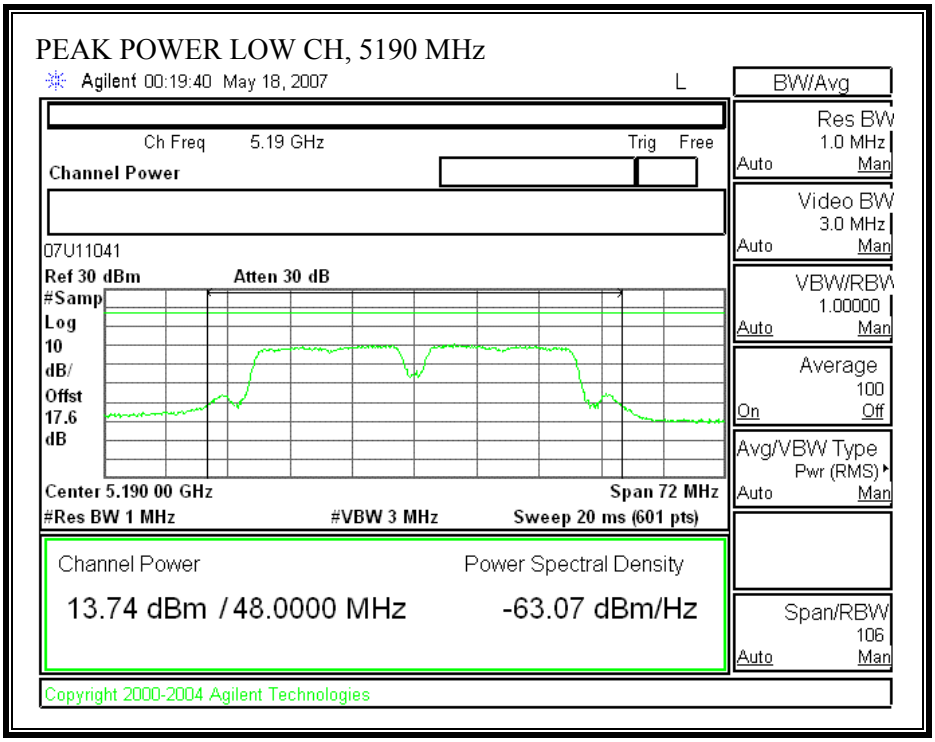


PEAK POWER HIGH CH, 5310 MHz

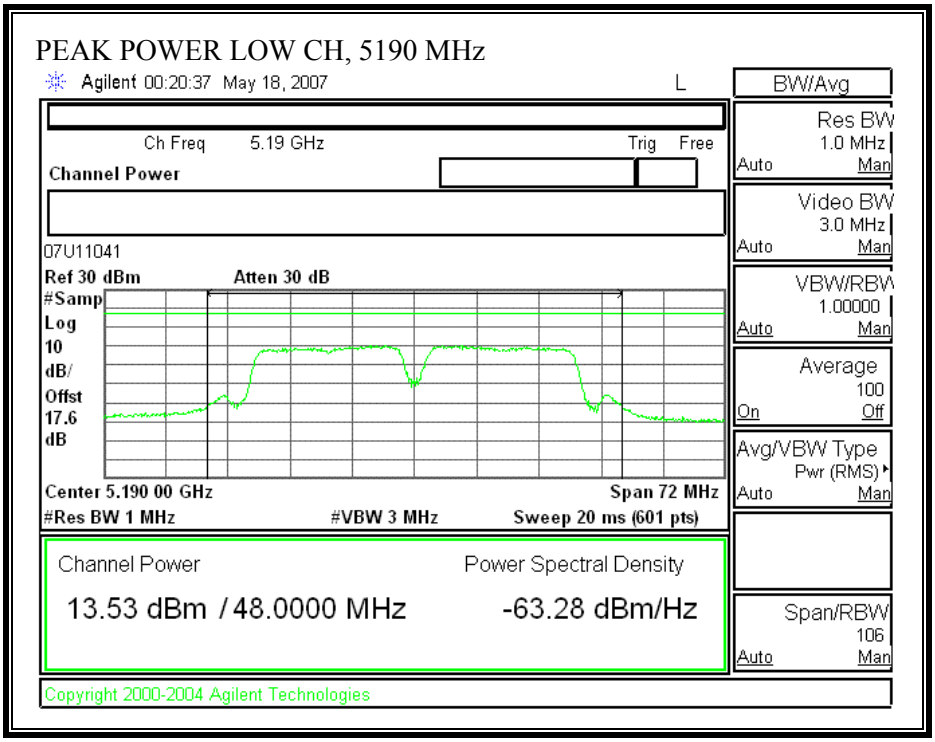


6dBi antenna

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



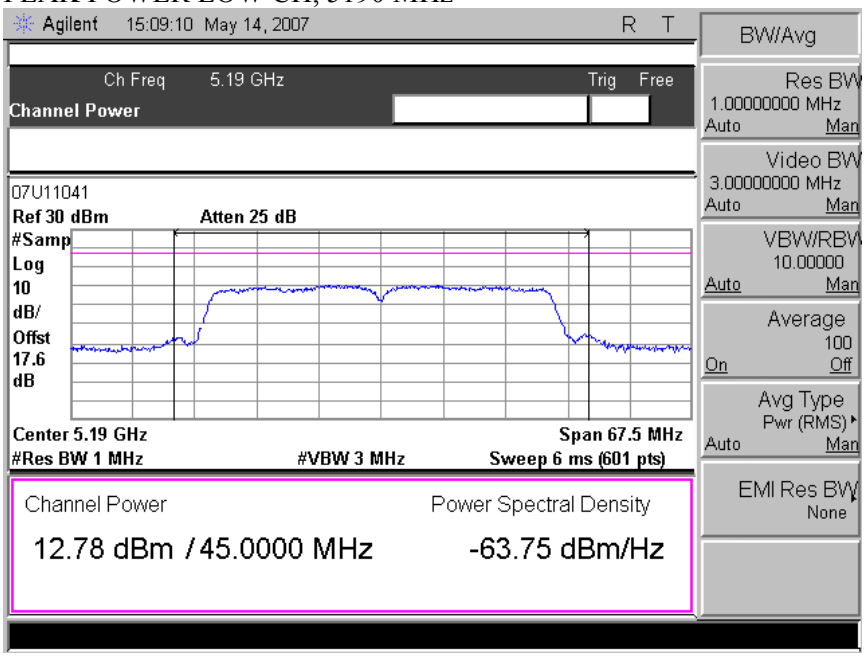
PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 1)



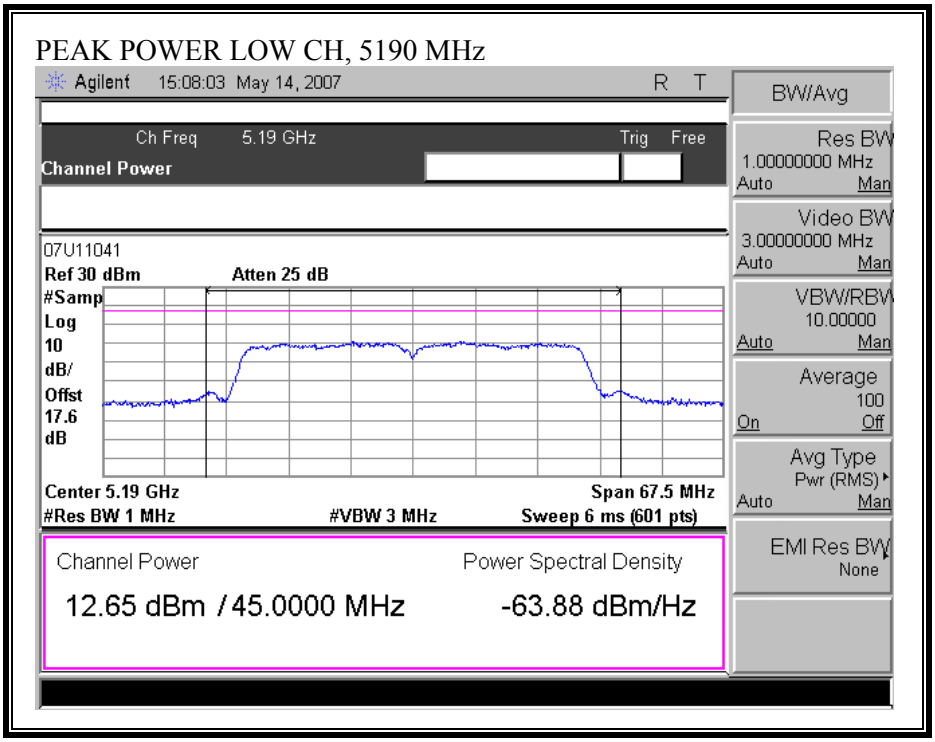
802.11n 40 MHz SDM MCS 15

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

PEAK POWER LOW CH, 5190 MHz



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 (mW) = P (W) / 1000 and
d (cm) =100 * d (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/cm^2

Substituting the logarithmic form of power and gain using:

P (mW) = 10 ^ (P (dBm) / 10) and
G (numeric) = 10 ^ (G (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/cm^2

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), the maximum value of S = 1.0 mW/cm^2 in the 5.2 / 5.3 GHz band

RESULTS

No non-compliance noted

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	16.56	8.677	0.07

6dBi Antenna

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 20 MHz CDD	20.0	18.48	6.00	0.06

802.11n 40 MHz CDD

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 40 MHz CDD	20.0	18.90	8.677	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	18.90	6.00	0.06

802.11n 40 MHz SDM

Mode	MPE Distance (cm)	Total Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2
802.11n 40 MHz SDM	20.0	18.90	4.37	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.

7.2.4. 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, 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.

Array gain = 10*log (10^ (main gain/10) + 10^ (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

Note: The high channel utilizes the same power level for all antennas; 6 dBi data below only show differences for low and mid channels.

802.11n 20 MHz CDD (7.077 / 8.677dBi antenna)

Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5180	-1.691	-1.854	1.239	2.923	-1.684
Middle	5260	2.477	2.862	5.684	8.323	-2.639
High	5320	3.240	2.846	6.058	8.323	-2.265

802.11n 20 MHz CDD (6dBi antenna)

Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5180	0.030	0.143	3.097	4.000	-0.903
Middle	5260	5.045	3.869	7.507	11.000	-3.493

802.11n 20 MHz CDD - COMBINER (7.077 / 8.677dBi antenna)

Channel	Frequency (MHz)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5180	2.895	2.923	-0.028
Middle	5260	6.959	8.323	-1.364
High	5320	7.388	8.323	-0.935

802.11n 20 MHz CDD - COMBINER (6dBi antenna)

Channel	Frequency (MHz)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5180	3.812	4.000	-0.188
Middle	5260	9.175	11.000	-1.825

802.11n 40 MHz CDD MODE

802.11n 40 MHz CDD

Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5190	-2.338	-2.044	0.822	2.923	-2.101
Middle	5270	3.076	2.727	5.915	8.323	-2.408
High	5310	-0.846	-0.936	2.120	8.323	-6.203

802.11n 40 MHz CDD - COMBINER

Channel	Frequency (MHz)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5190	2.220	2.923	-0.703
Middle	5270	8.236	8.323	-0.087
High	5310	2.896	8.323	-5.427

802.11n 40 MHz SDM MODE

802.11n 40 MHz SDM

Channel	Frequency (MHz)	PPSD Chain 0 (dBm)	PPSD Chain 1 (dBm)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5190	-0.694	-0.811	2.258	4.00	-1.74

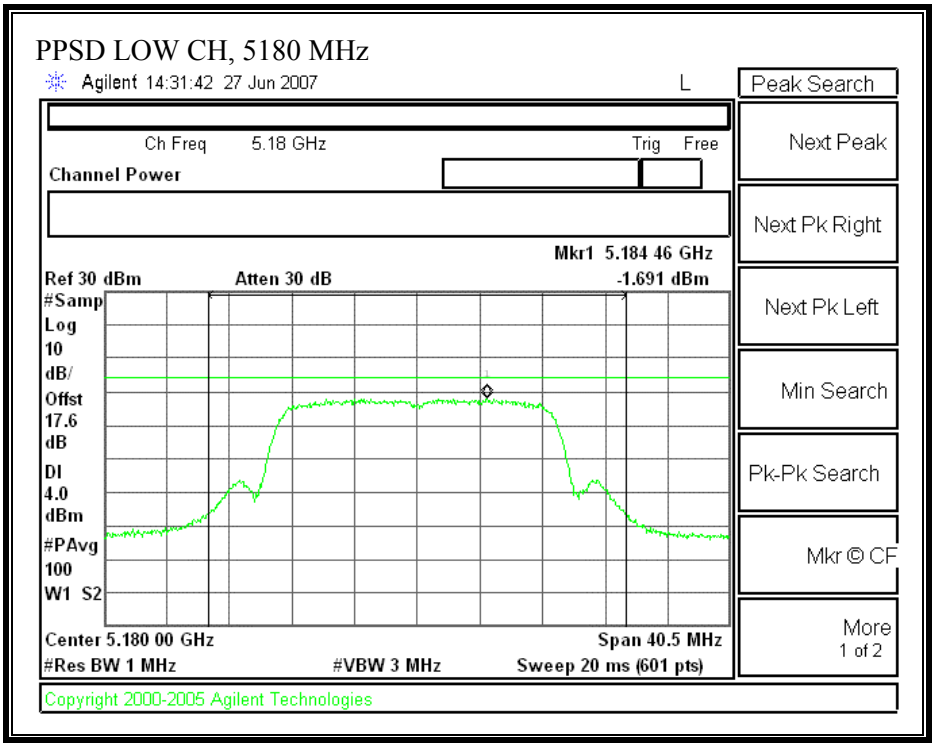
802.11n 40 MHz SDM - COMBINER

Channel	Frequency (MHz)	PPSD Total (dBm)	Limit (dBm)	Margin (dB)
Low	5190	3.143	4.00	-0.86

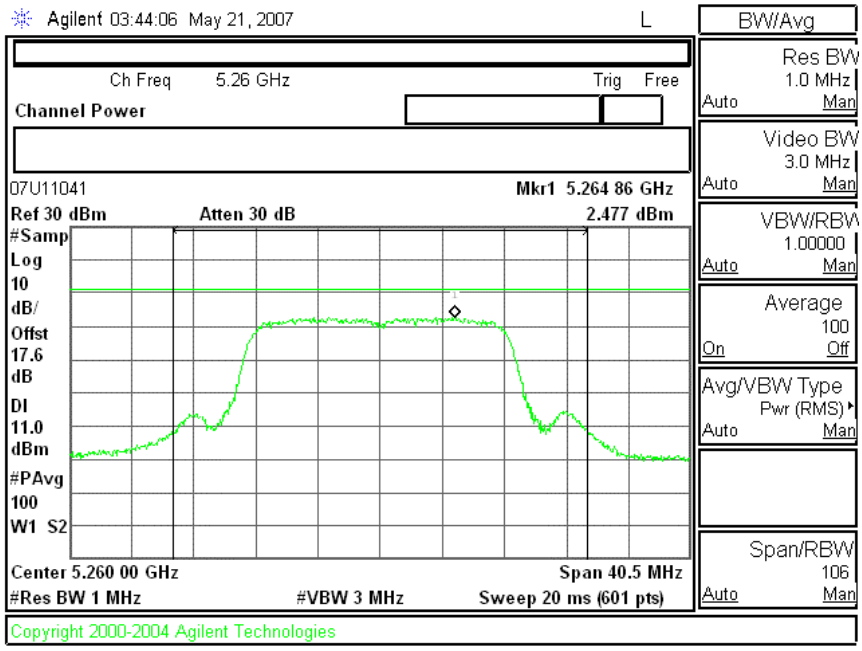
802.11n 20 MHz CDD MCS 0

8.677dBi Antenna Gain

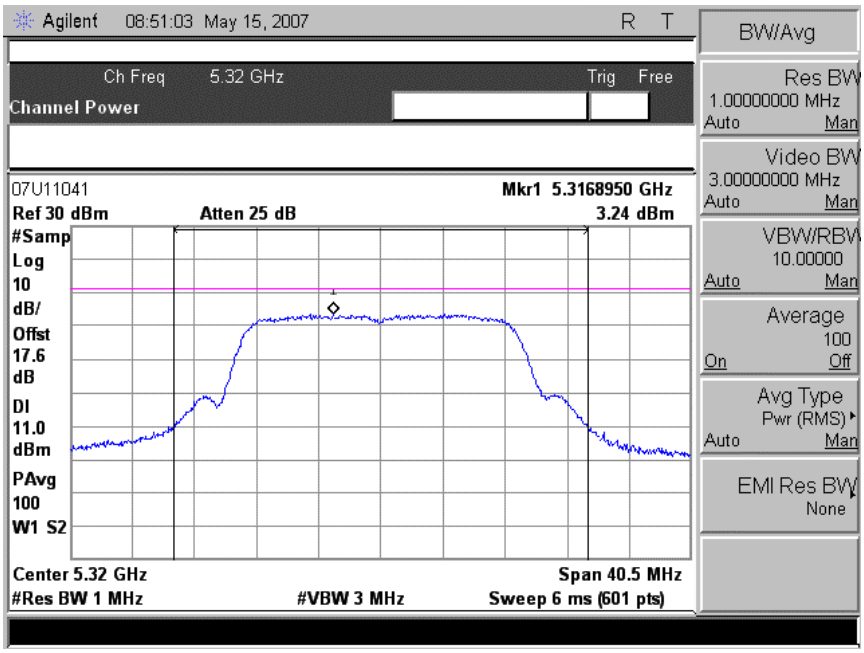
PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH – CHAIN 0)



PPSD MID CH, 5260 MHz

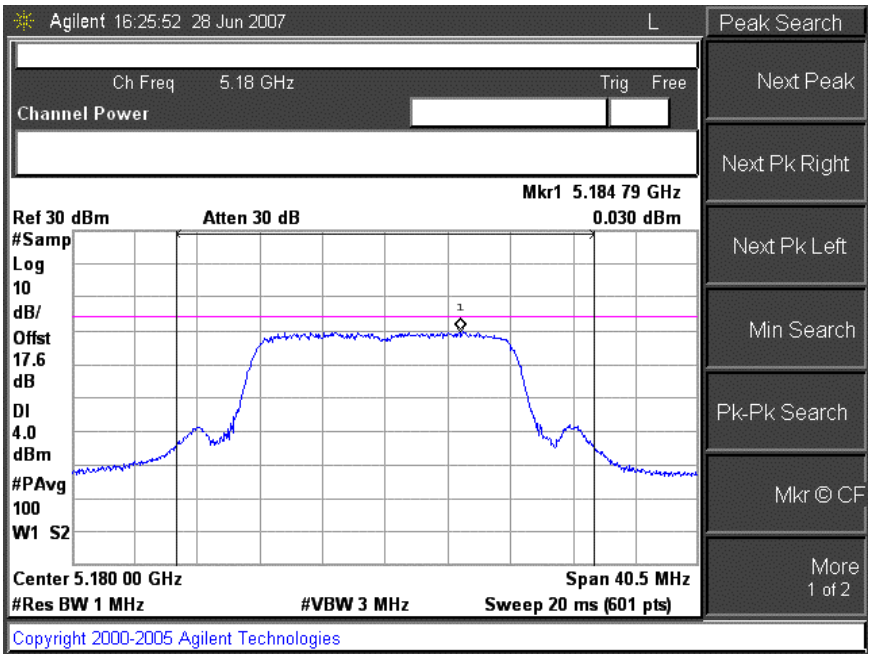


PPSD HI CH, 5320 MHz

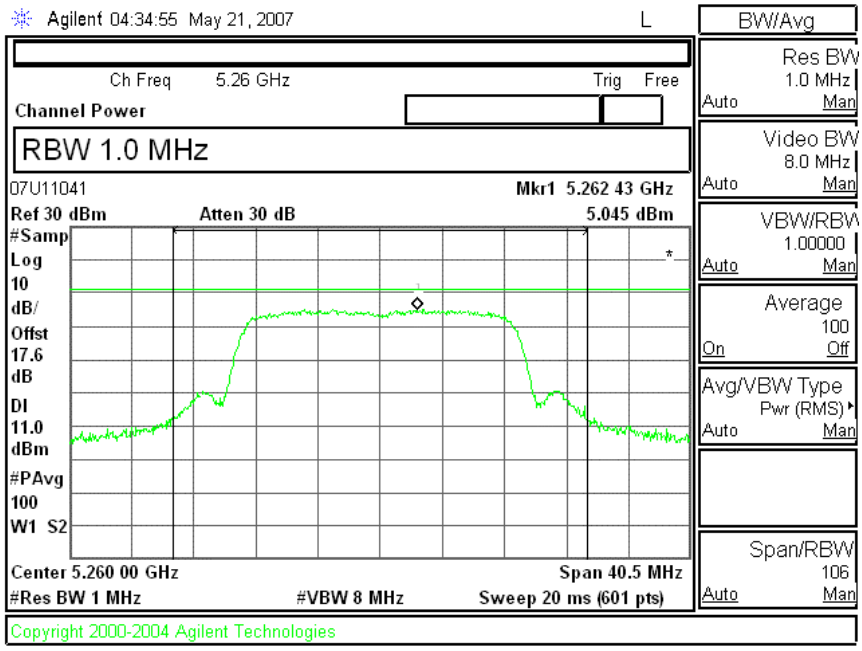


6dBi Antenna

PPSD LOW CH, 5180 MHz

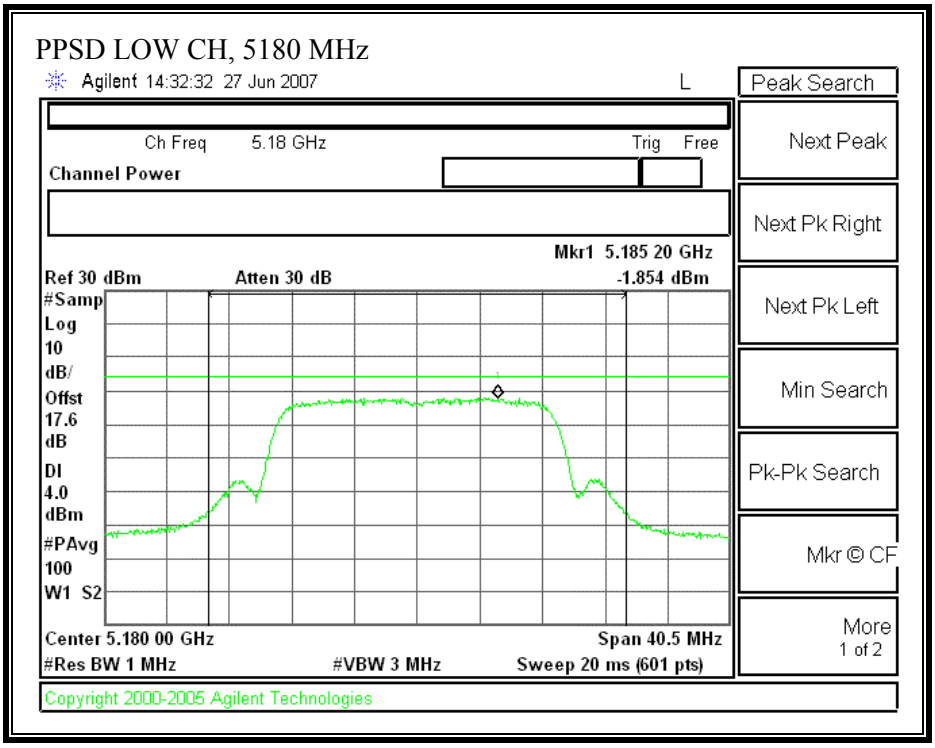


PPSD MID CH, 5260 MHz

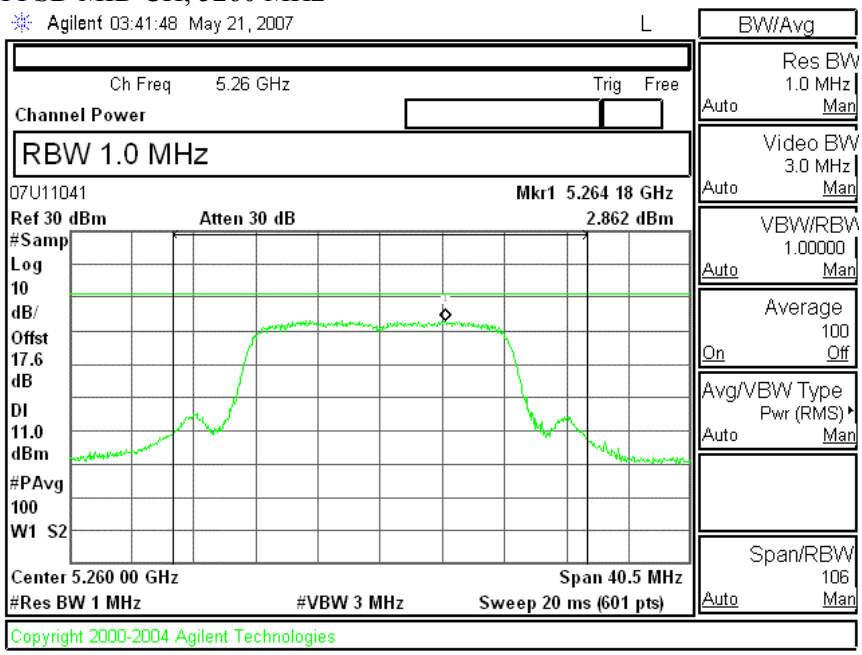


8.677dBi Antenna Gain

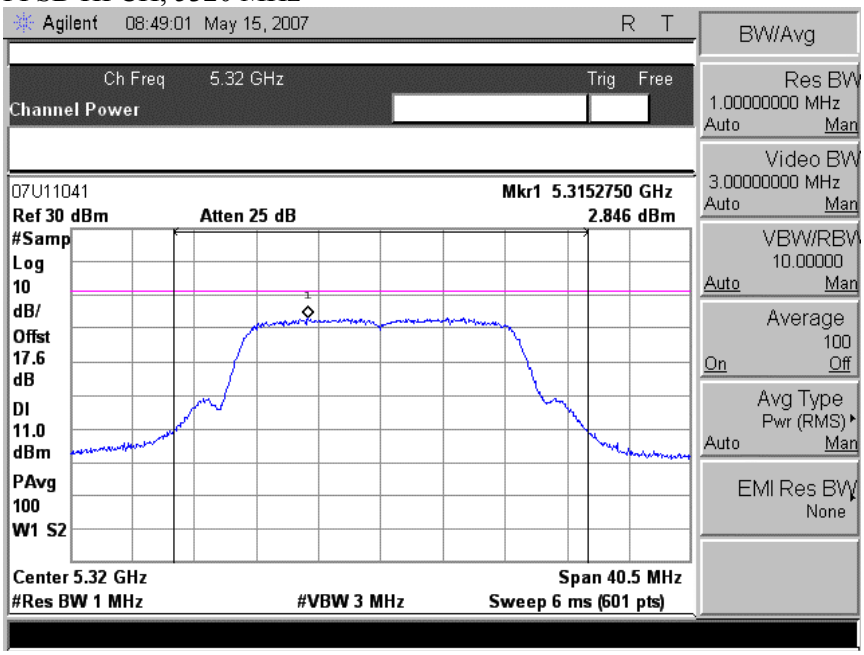
PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH – CHAIN 1)



PPSD MID CH, 5260 MHz

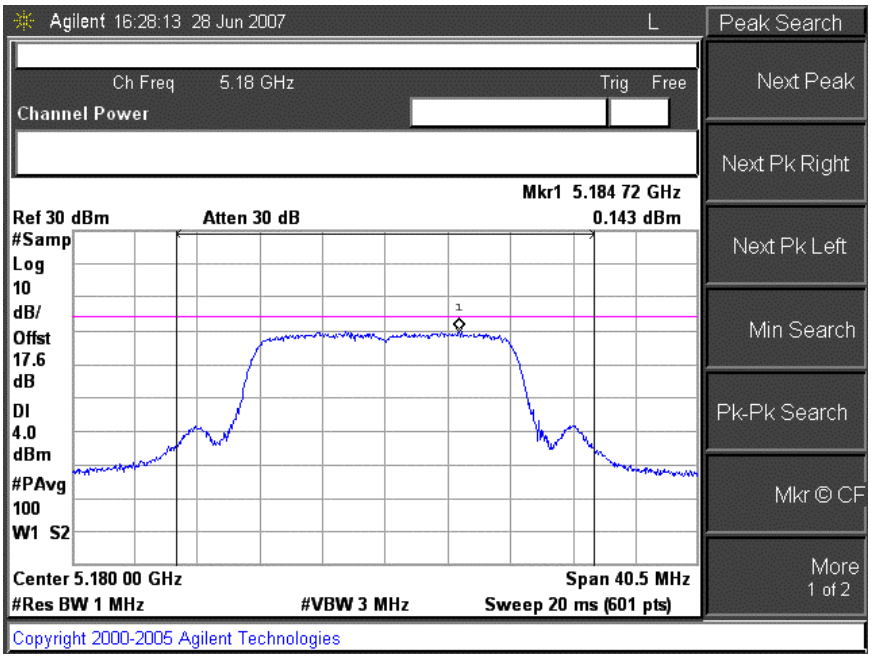


PPSD HI CH, 5320 MHz

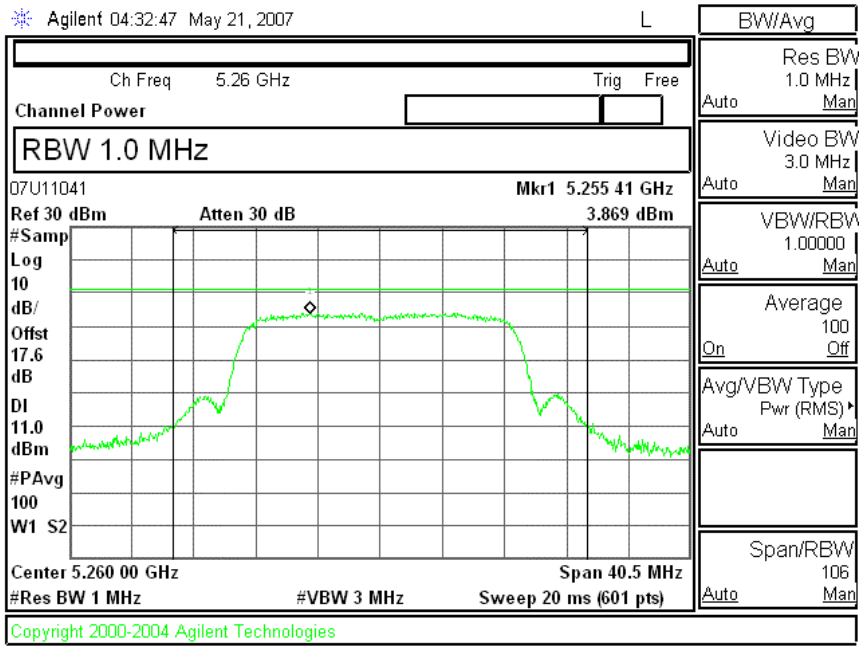


6dBi Antenna

PPSD LOW CH, 5180 MHz

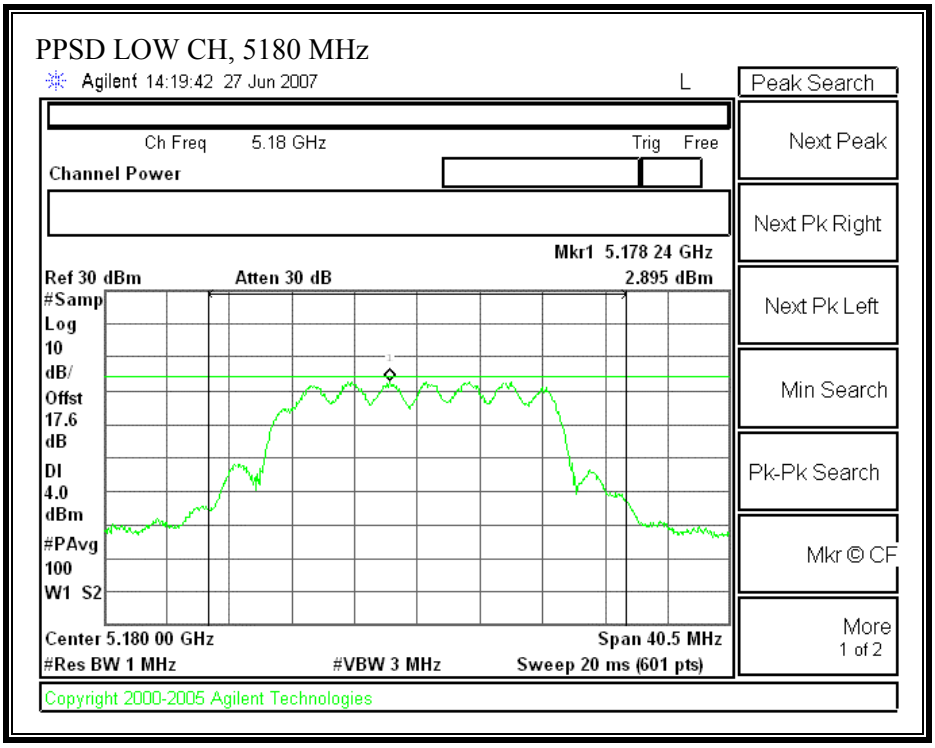


PPSD MID CH, 5260 MHz

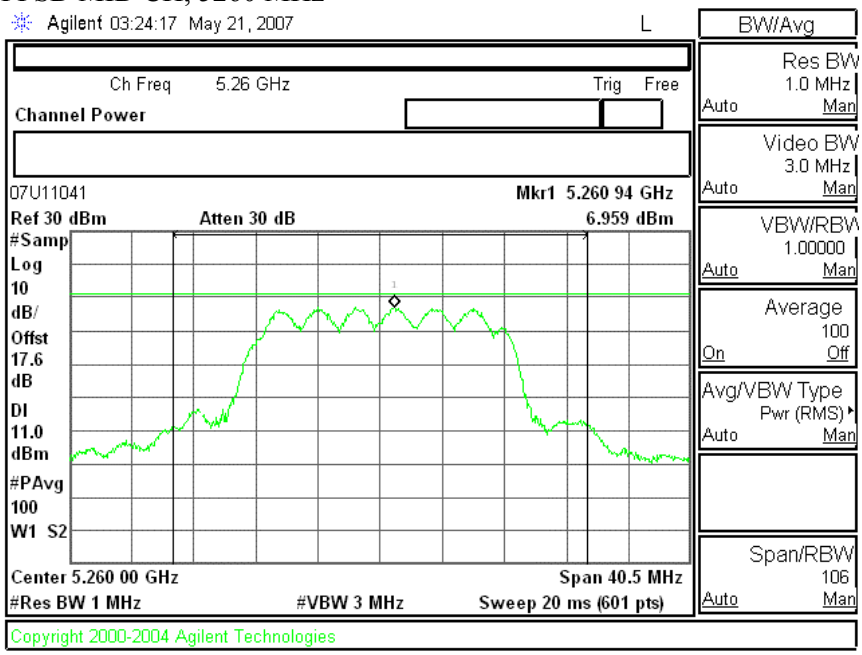


8.677dBi Antenna Gain

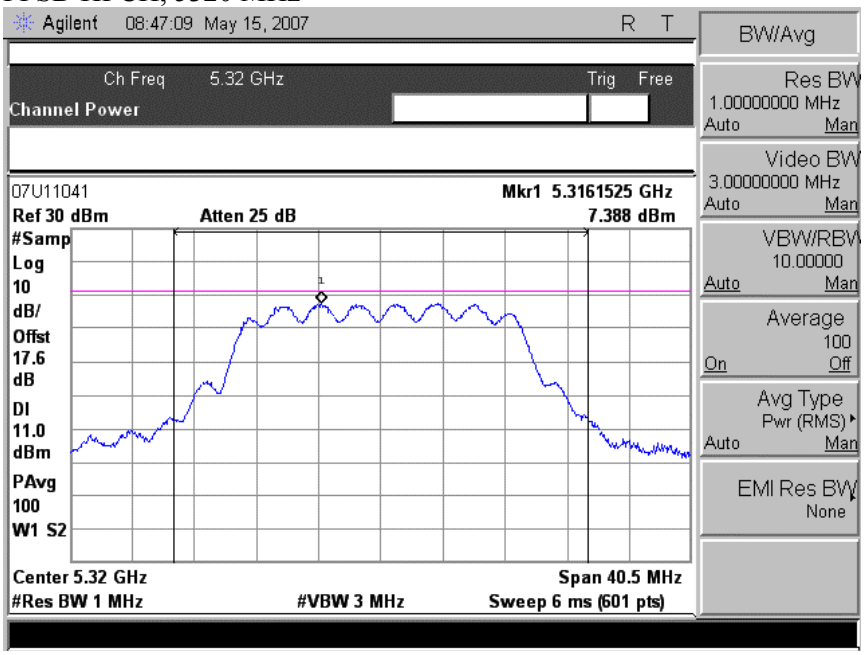
PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH – COMBINER)



PPSD MID CH, 5260 MHz

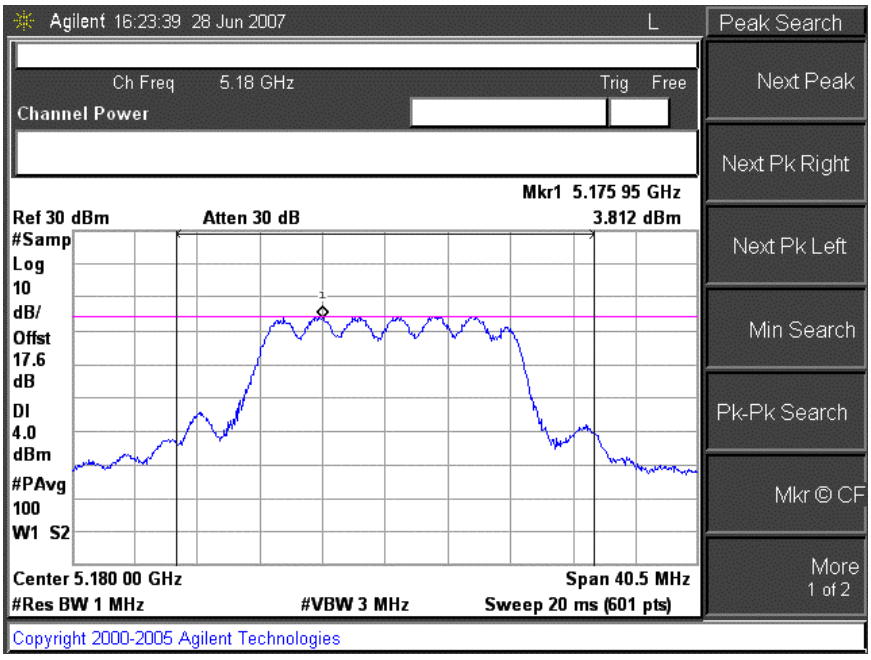


PPSD HI CH, 5320 MHz

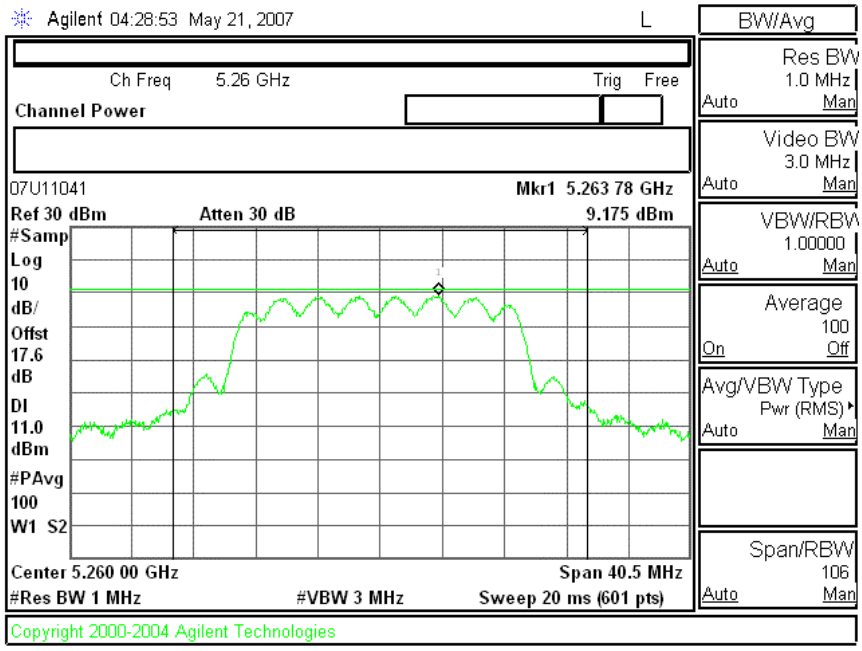


6dBi Antenna

PPSD LOW CH, 5180 MHz

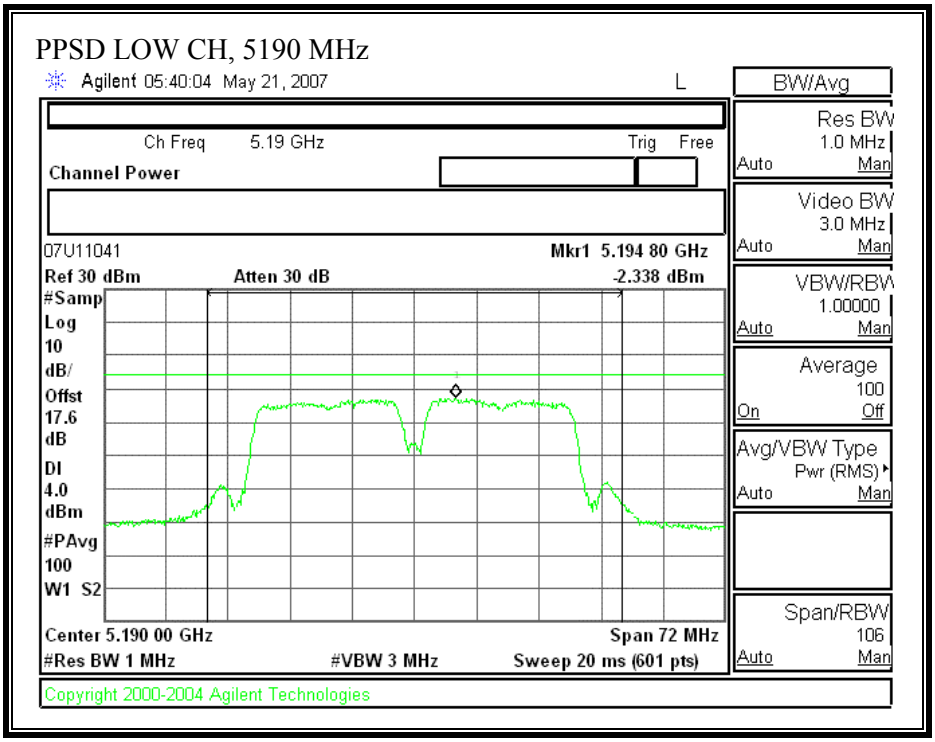


PPSD MID CH, 5260 MHz

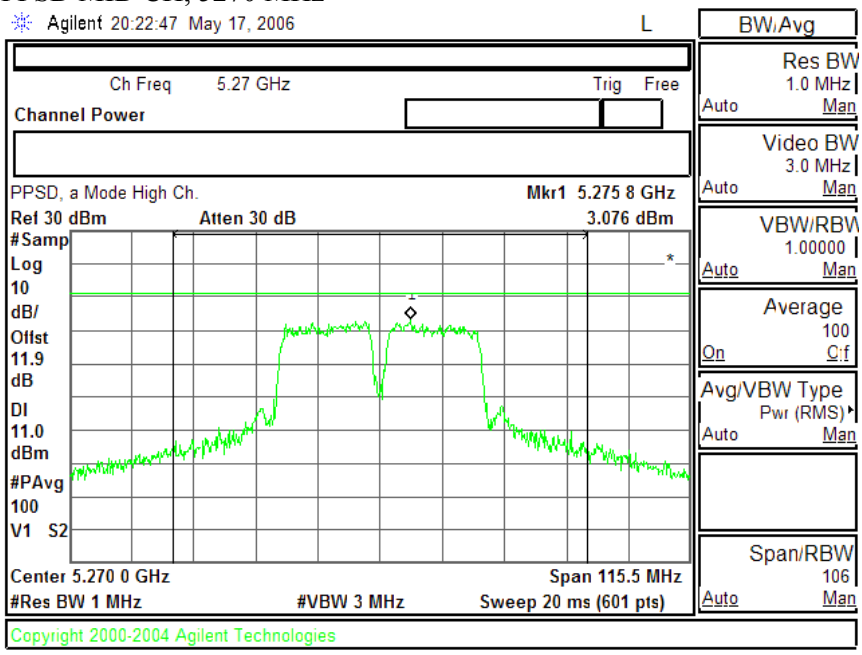


802.11n 40 MHz CDD MCS 32

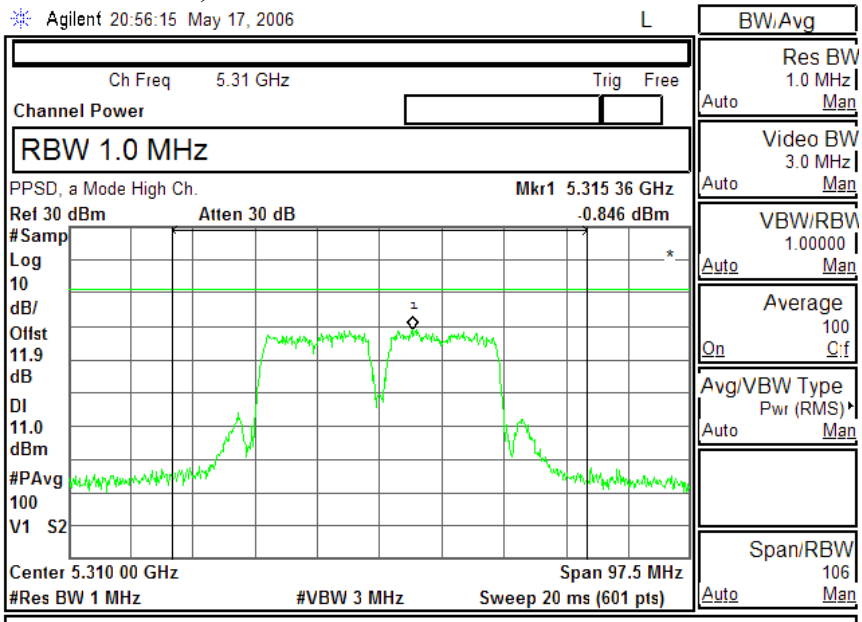
PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)



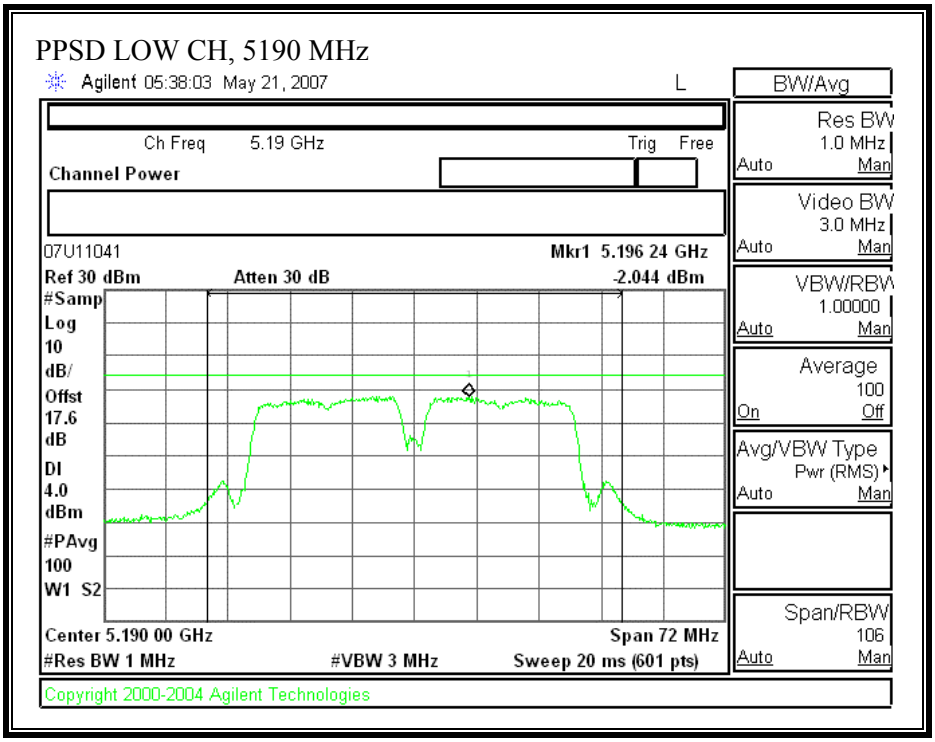
PPSD MID CH, 5270 MHz



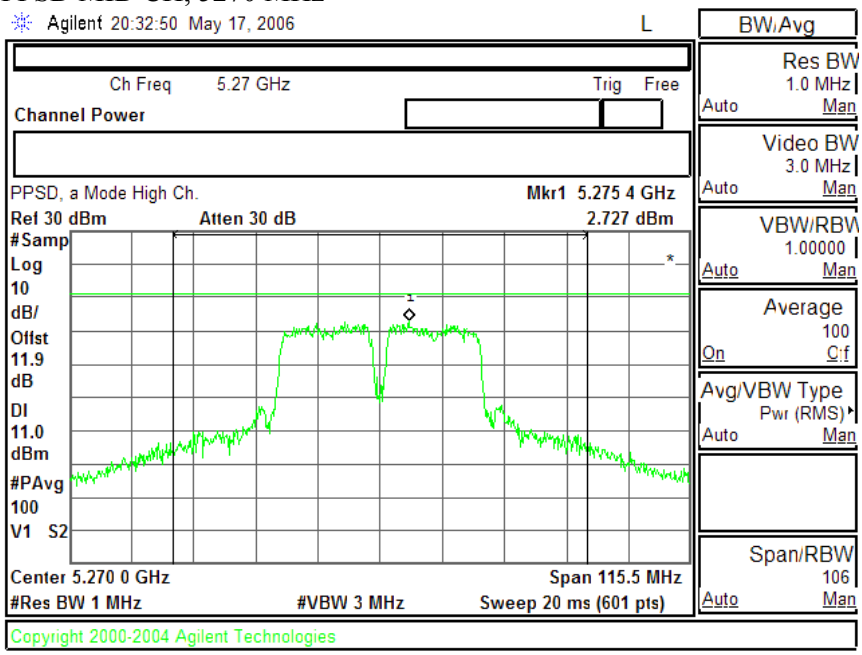
PPSD HIGH CH, 5310 MHz



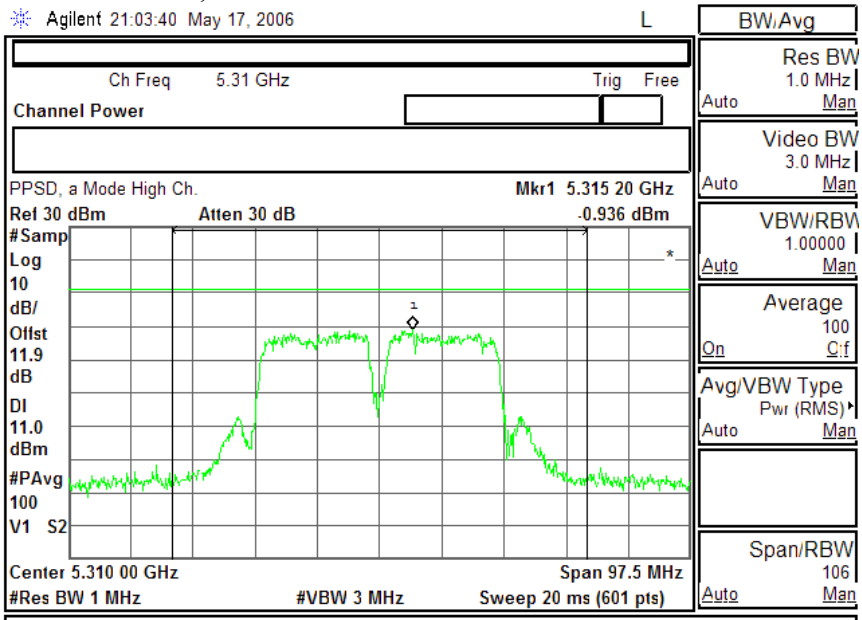
PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)



PPSD MID CH, 5270 MHz

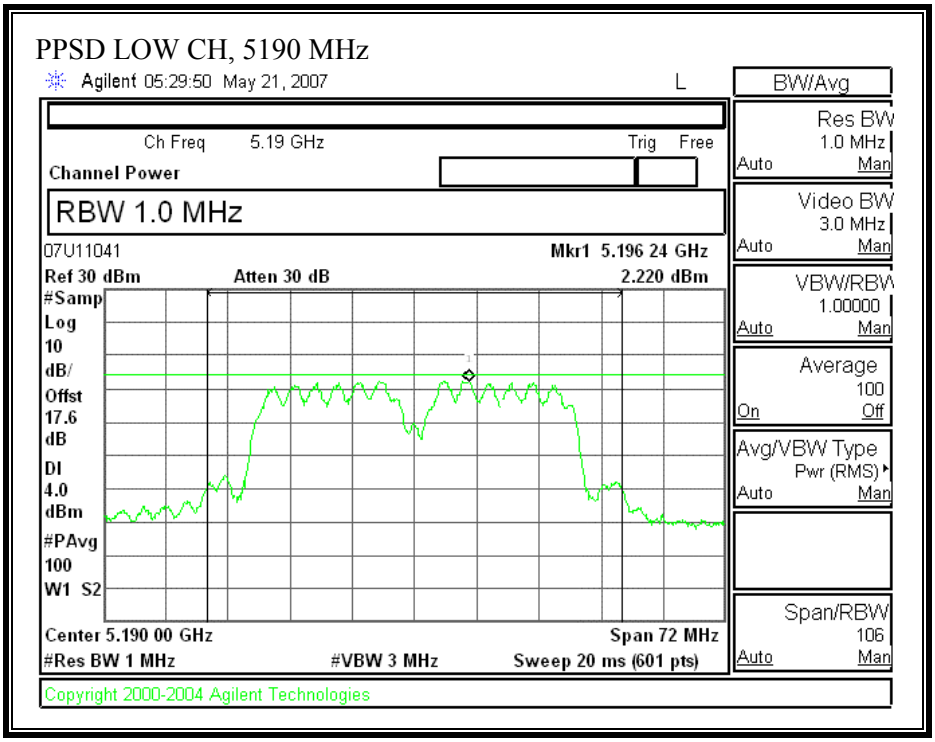


PPSD HIGH CH, 5310 MHz

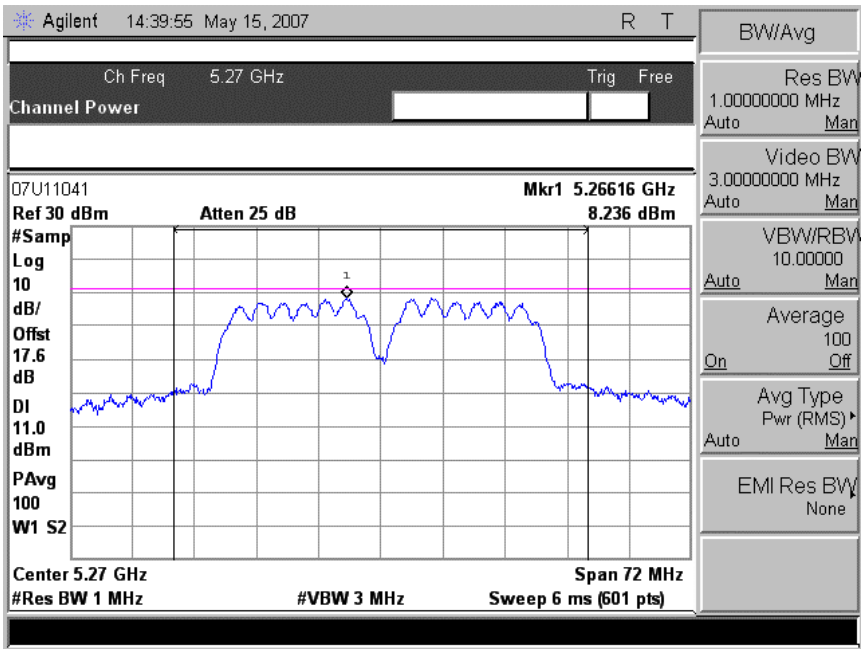


8.677dBi Antenna Gain

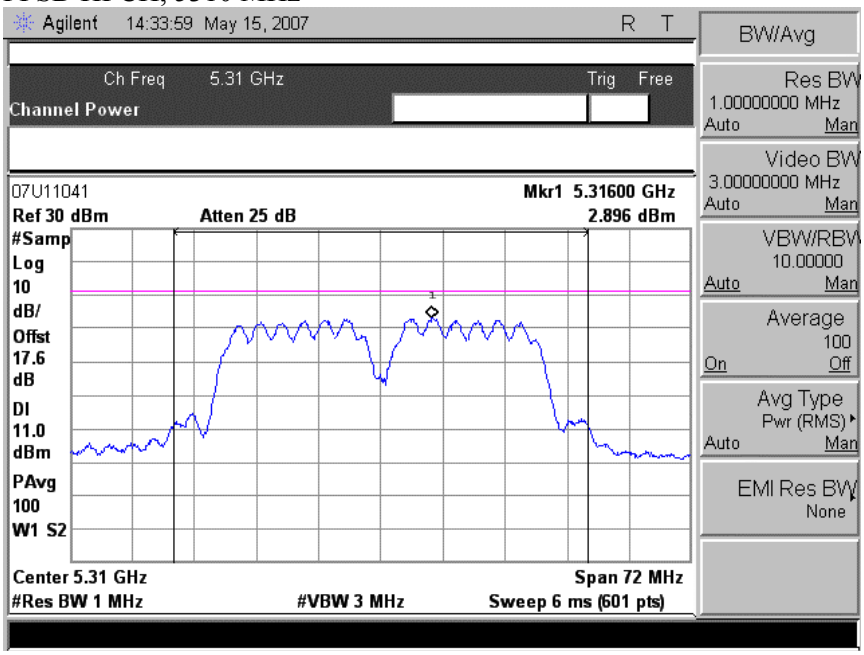
PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – COMBINER)



PPSD MID CH, 5270 MHz

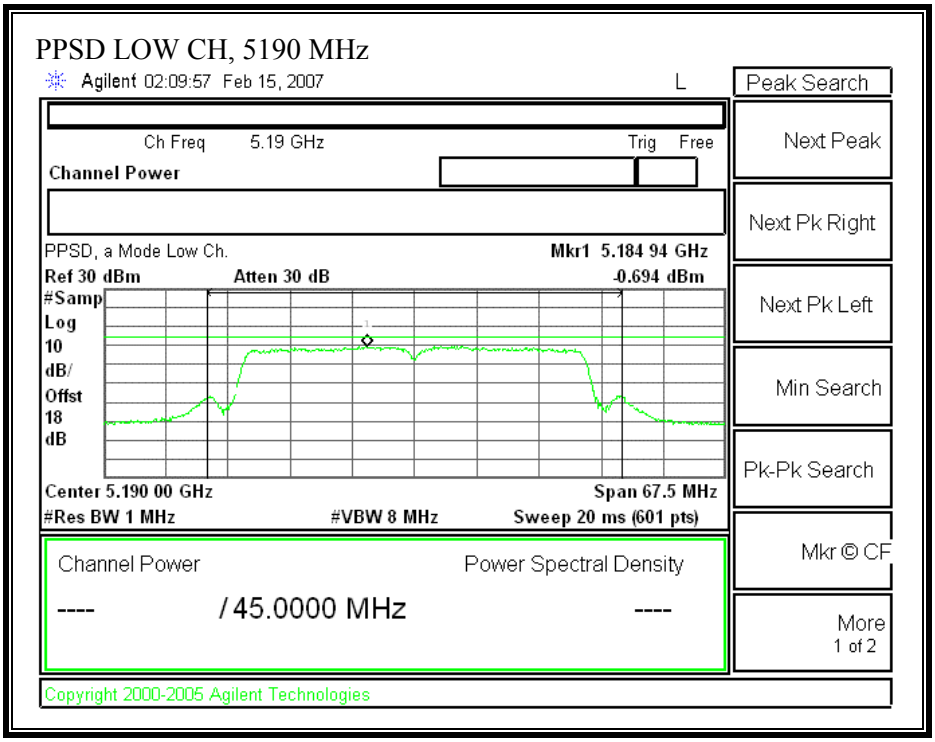


PPSD HI CH, 5310 MHz

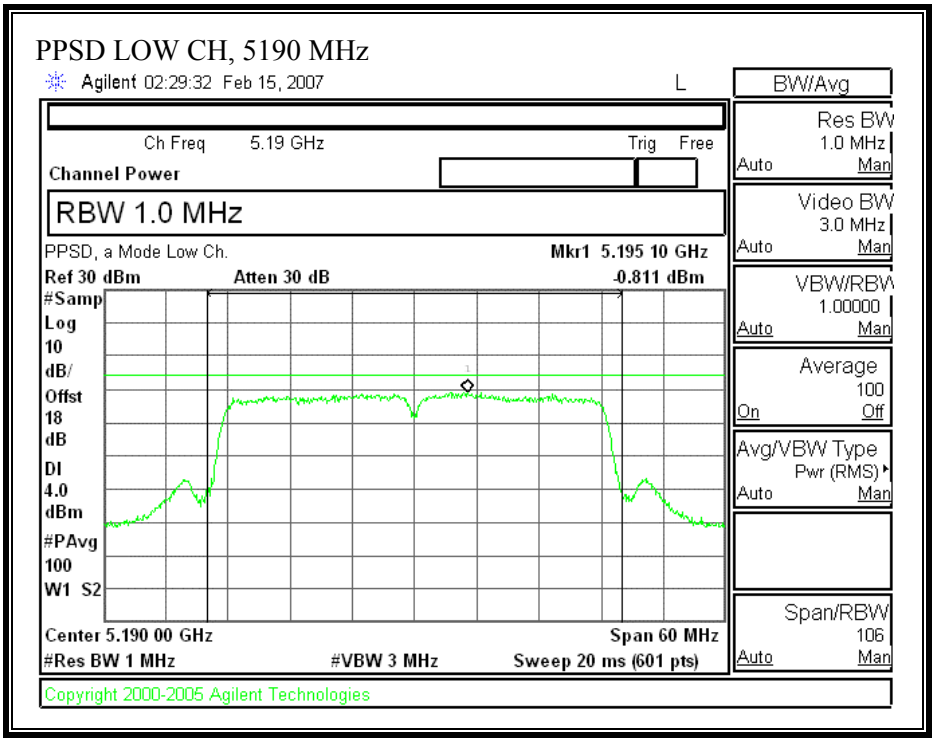


802.11n 40 MHz SDM MCS 15

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

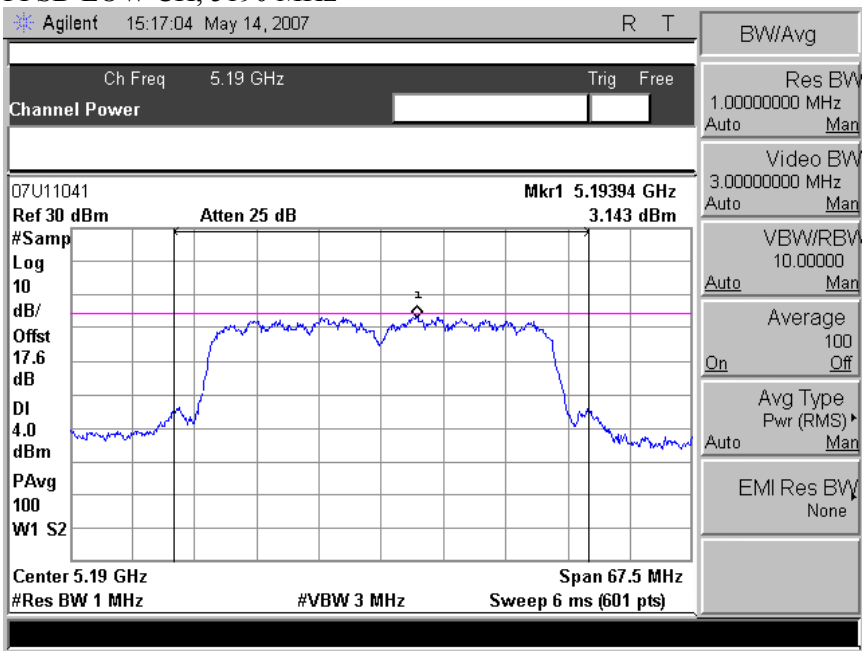


PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)



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

PPSD LOW CH, 5190 MHz



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	9.440	13	-3.560
Middle	5260	9.913	13	-3.087
High	5320	10.030	13	-2.970

20 MHz TX BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	Peak Excursion Chain 1 (dB)	Limit (dB)	Margin (dB)
Low	5180	9.517	13	-3.483
Middle	5260	10.990	13	-2.010
High	5320	9.741	13	-3.259

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	9.837	13	-3.163
Middle	5270	10.820	13	-2.180
High	5310	10.840	13	-2.160

40 MHz TX BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	Peak Excursion Chain 1 (dB)	Limit (dB)	Margin (dB)
Low	5190	11.540	13	-1.460
Middle	5270	11.520	13	-1.480
High	5310	9.249	13	-3.751

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	10.580	13	-2.420

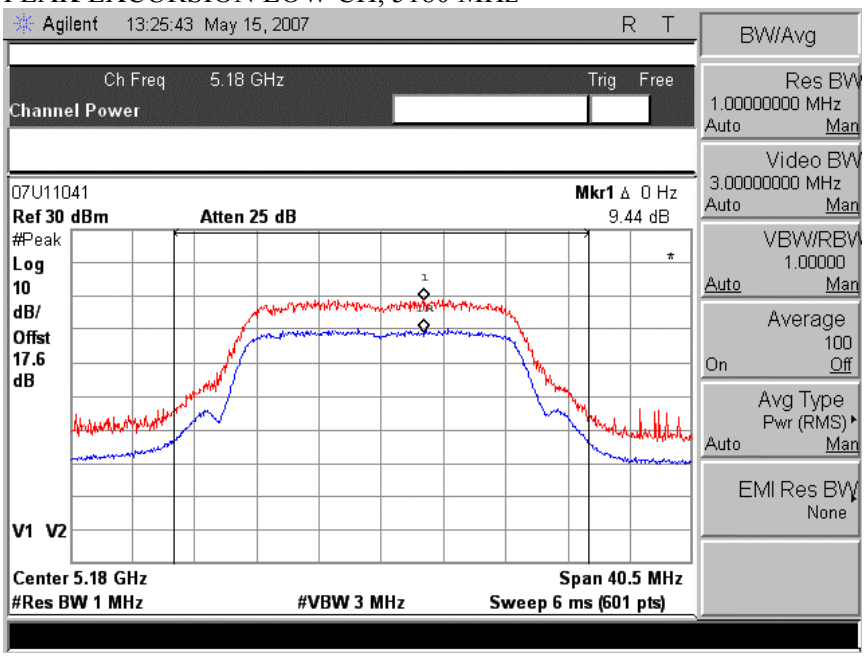
40 MHz TX BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	Peak Excursion Chain 1 (dB)	Limit (dB)	Margin (dB)
Low	5190	11.790	13	-1.210

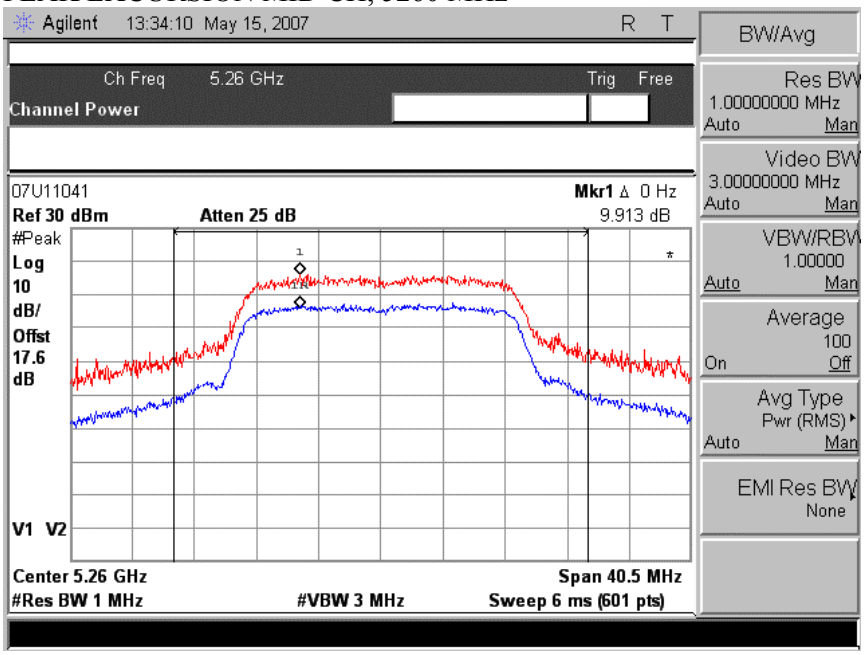
802.11n 20 MHz CDD MCS 0

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

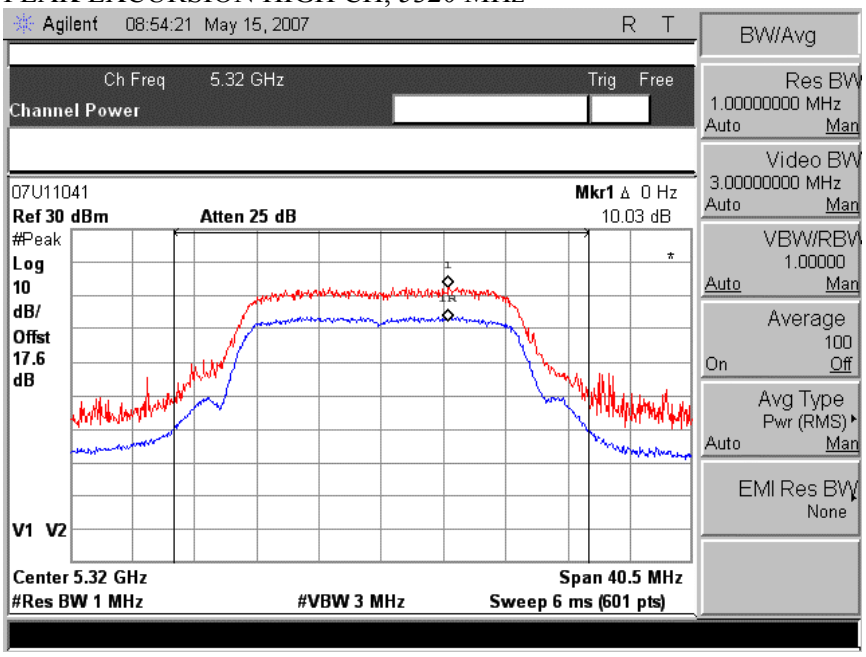
PEAK EXCURSION LOW CH, 5180 MHz



PEAK EXCURSION MID CH, 5260 MHz

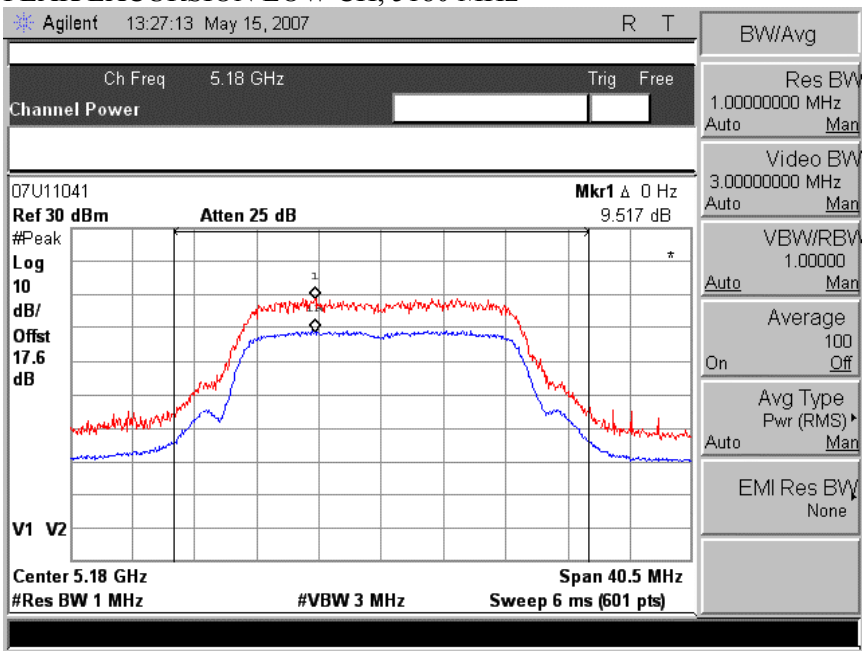


PEAK EXCURSION HIGH CH, 5320 MHz

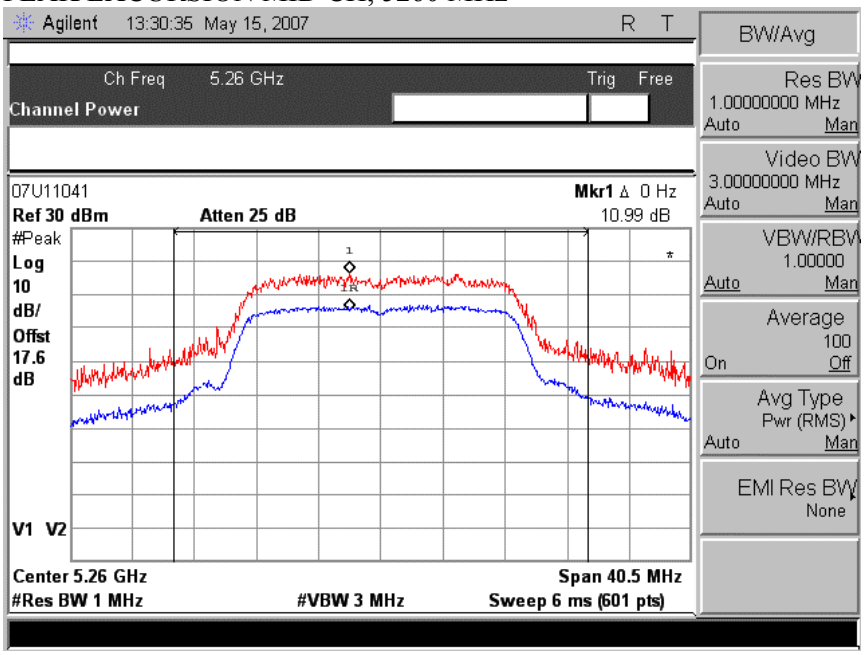


PEAK EXCURSION (802.11 - 20 MHz TX BANDWIDTH – CHAIN 1)

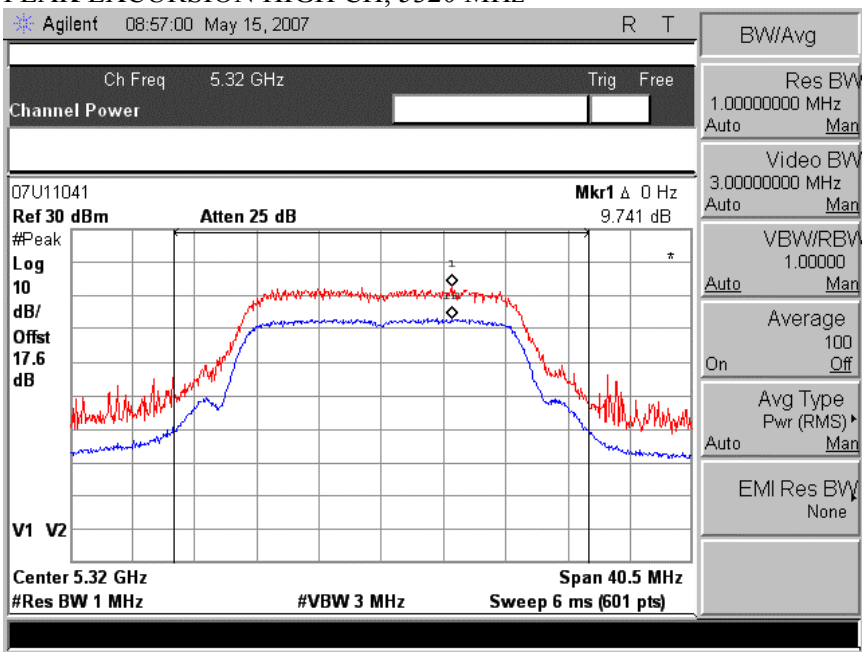
PEAK EXCURSION LOW CH, 5180 MHz



PEAK EXCURSION MID CH, 5260 MHz



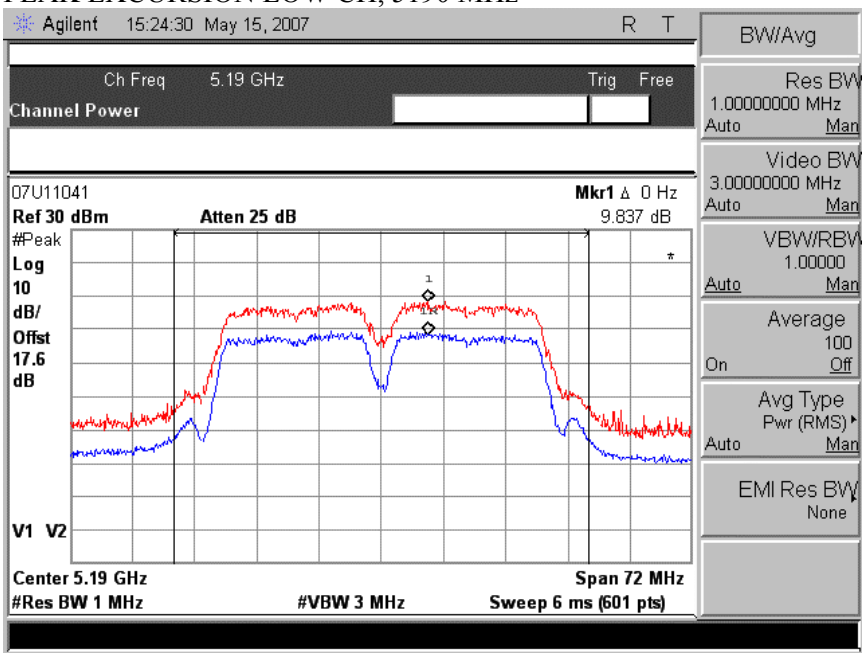
PEAK EXCURSION HIGH CH, 5320 MHz



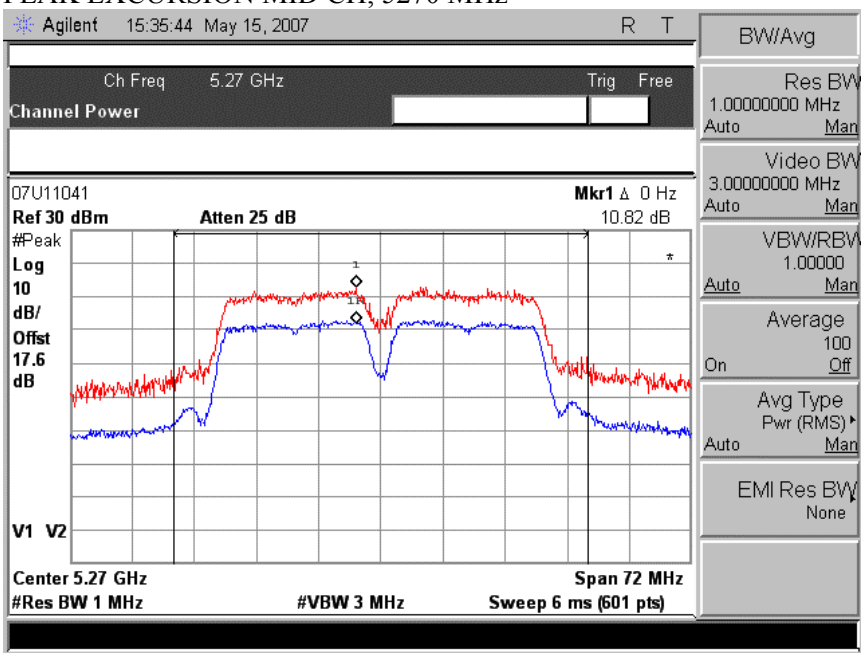
802.11n 40 MHz CDD MCS 32

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

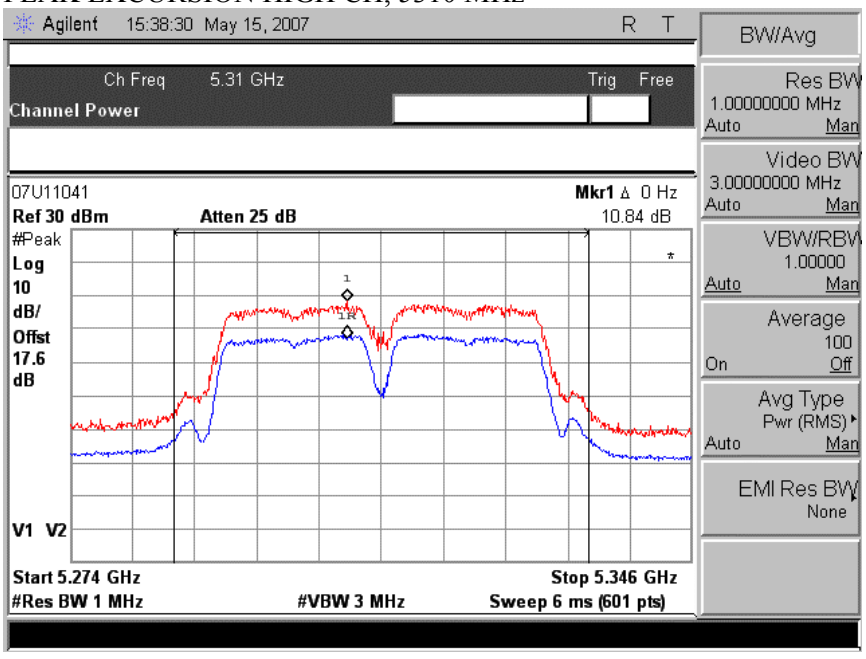
PEAK EXCURSION LOW CH, 5190 MHz



PEAK EXCURSION MID CH, 5270 MHz

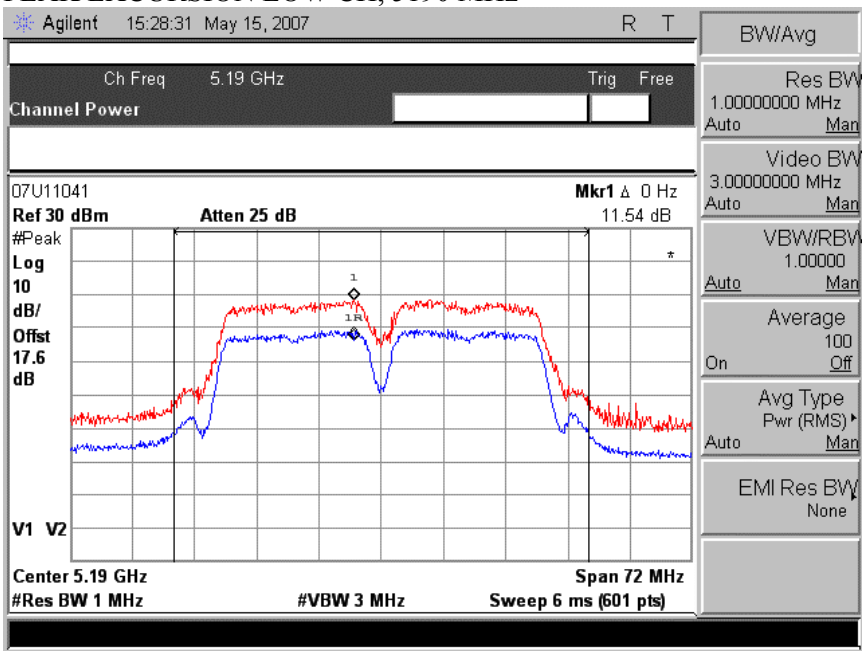


PEAK EXCURSION HIGH CH, 5310 MHz

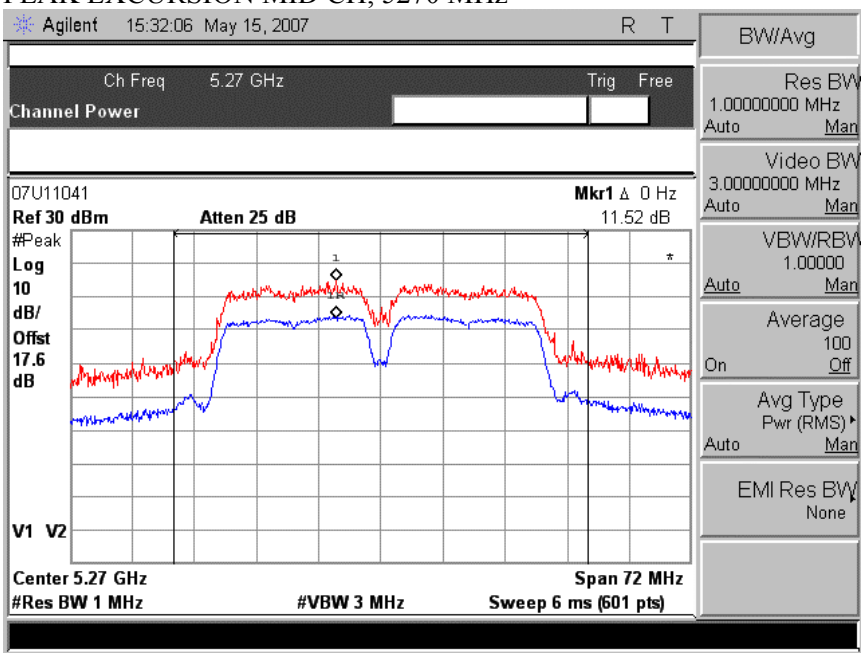


PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH – CHAIN 1)

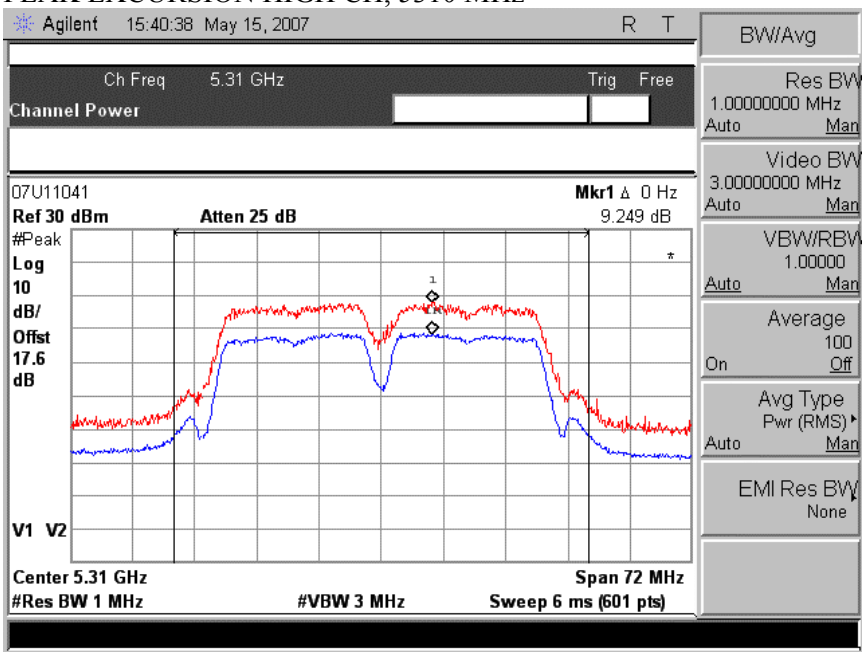
PEAK EXCURSION LOW CH, 5190 MHz



PEAK EXCURSION MID CH, 5270 MHz



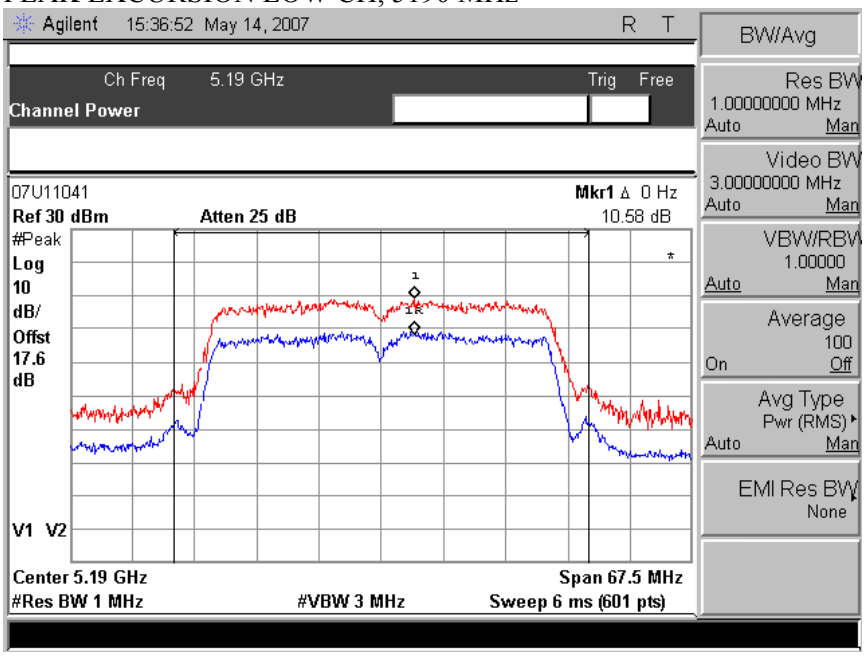
PEAK EXCURSION HIGH CH, 5310 MHz



802.11n 40 MHz SDM MCS 15

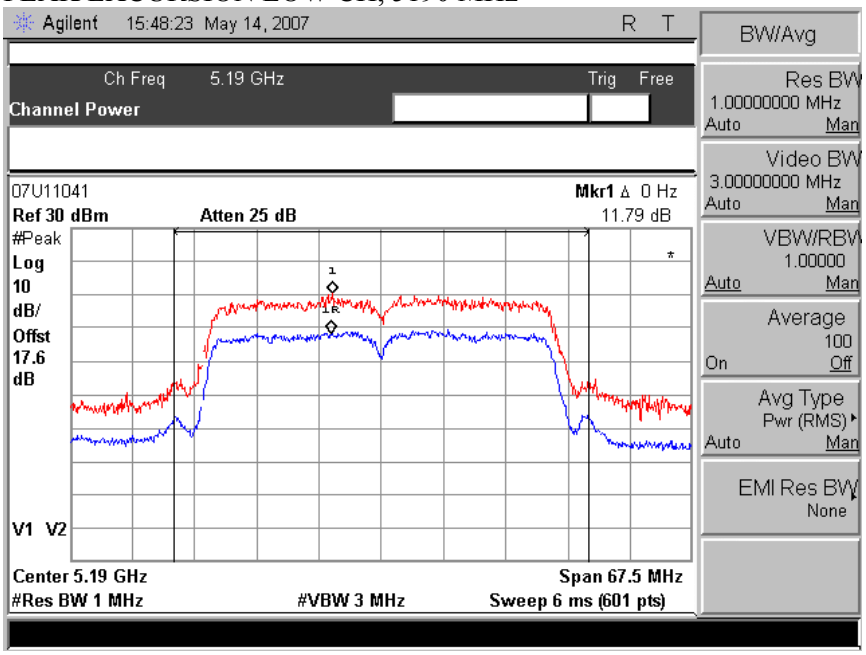
PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH – CHAIN 0)

PEAK EXCURSION LOW CH, 5190 MHz



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

PEAK EXCURSION LOW CH, 5190 MHz



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.

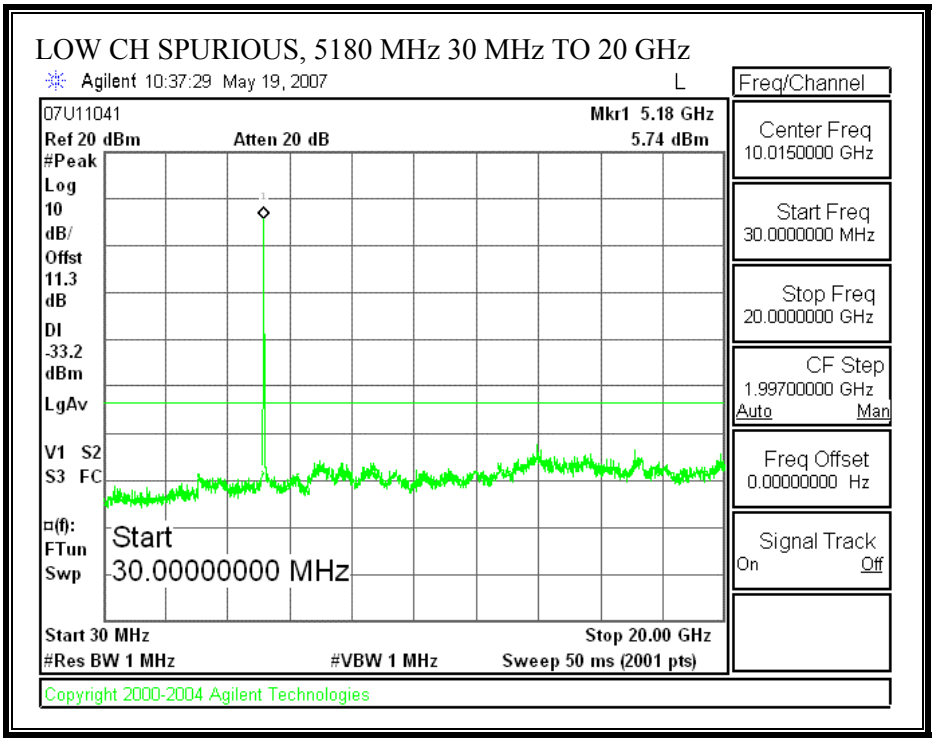
RESULTS

No non-compliance noted:

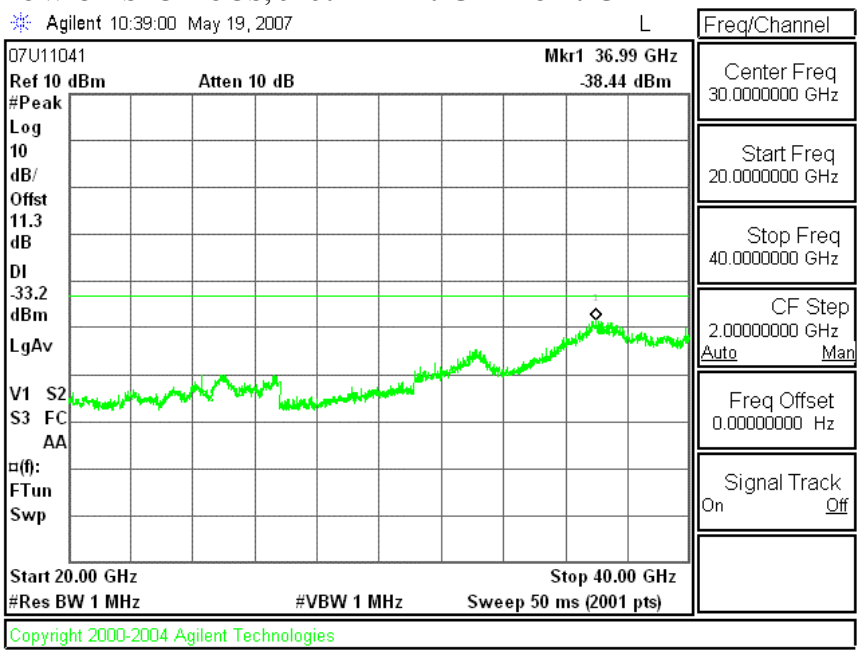
802.11a CDD is covered by worst case 802.11n 20 MHz CDD MCS 0

802.11n 20 MHz CDD MCS 0

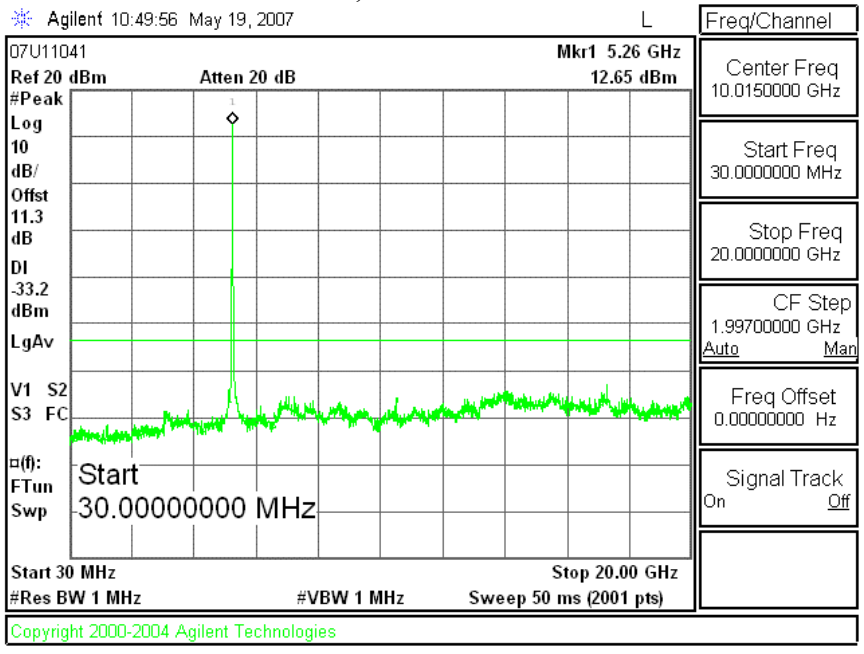
SPURIOUS EMISSIONS - 802.11a -20 MHz TX BANDWIDTH - CHAIN 0



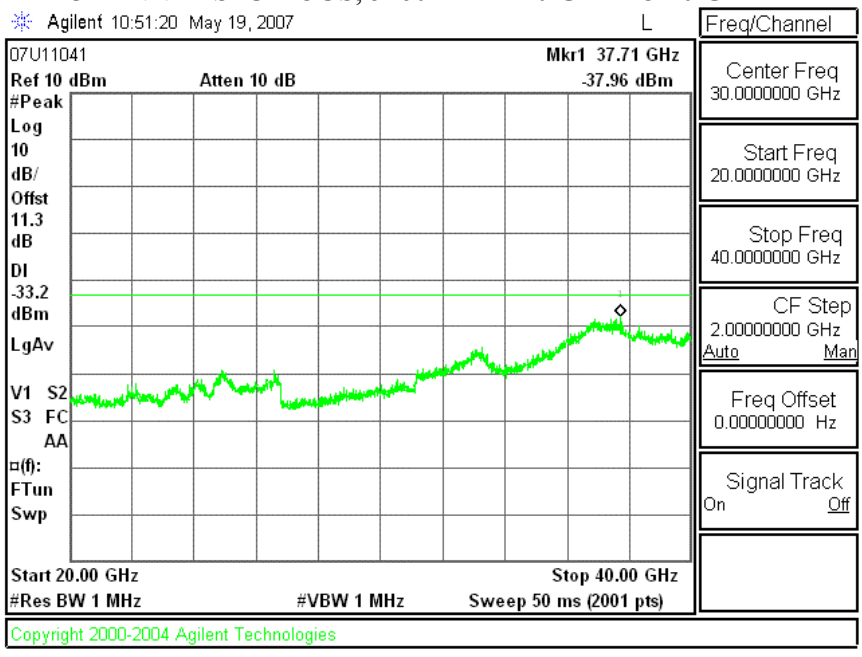
LOW CH SPURIOUS, 5180 MHz 20 GHz TO 40 GHz



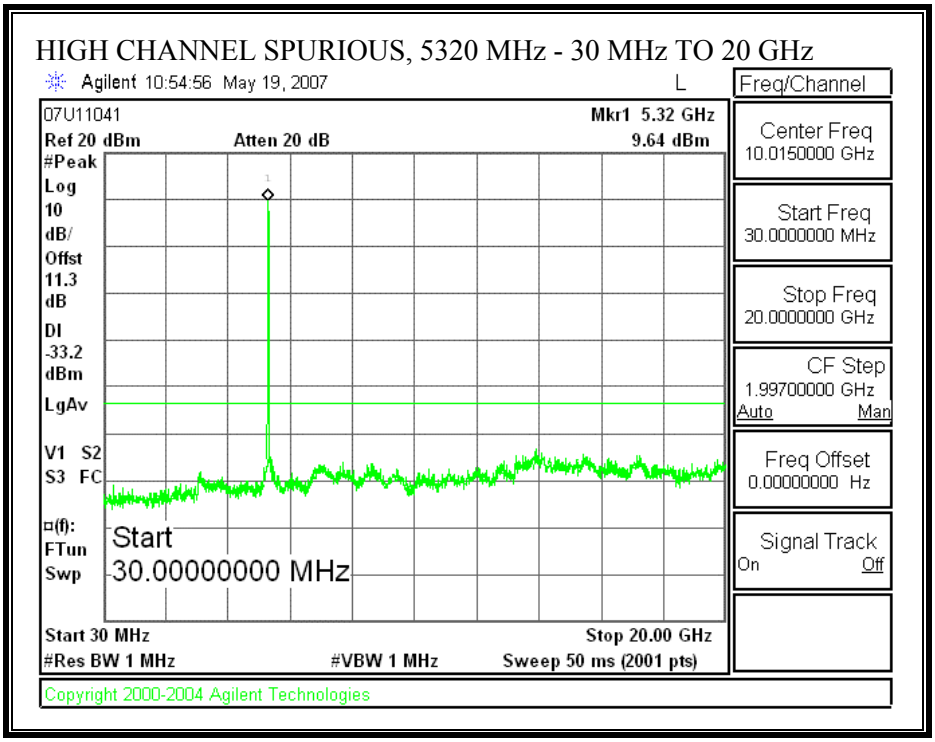
MID CHANNEL SPURIOUS, 5260 MHz - 30 MHz TO 20 GHz



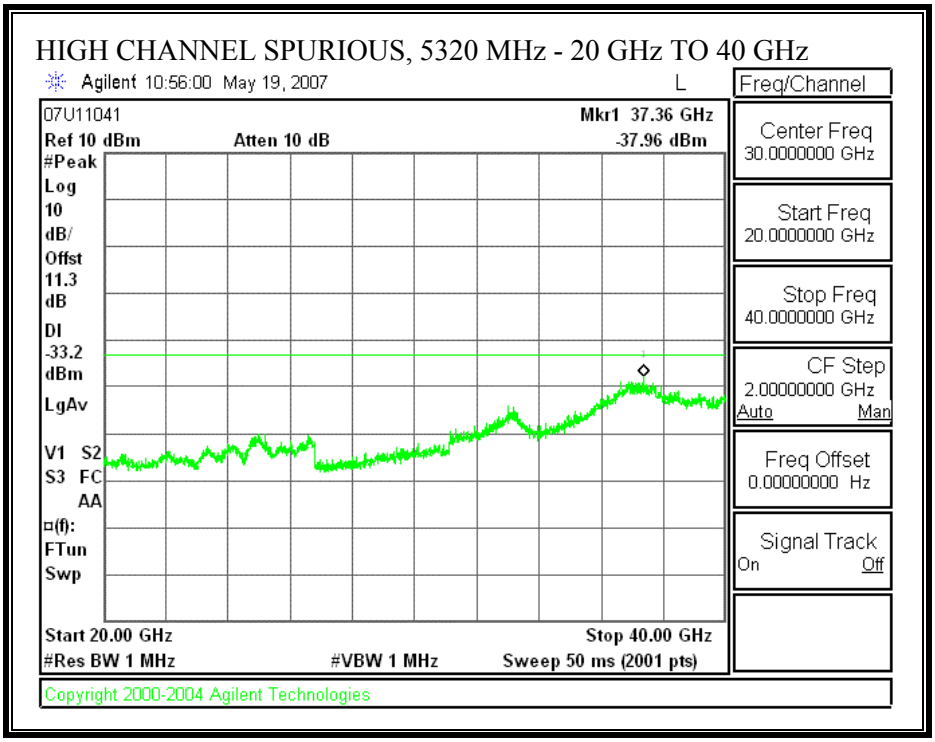
MID CHANNEL SPURIOUS, 5260 MHz - 20 GHz TO 40 GHz



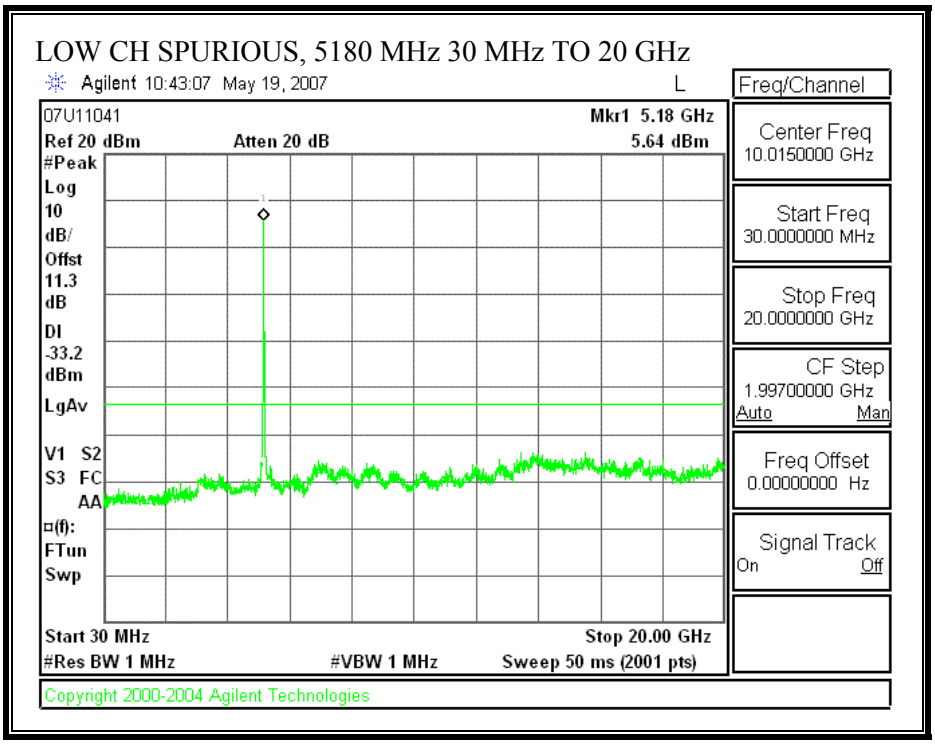
HIGH CHANNEL SPURIOUS, 5320 MHz - 30 MHz TO 20 GHz



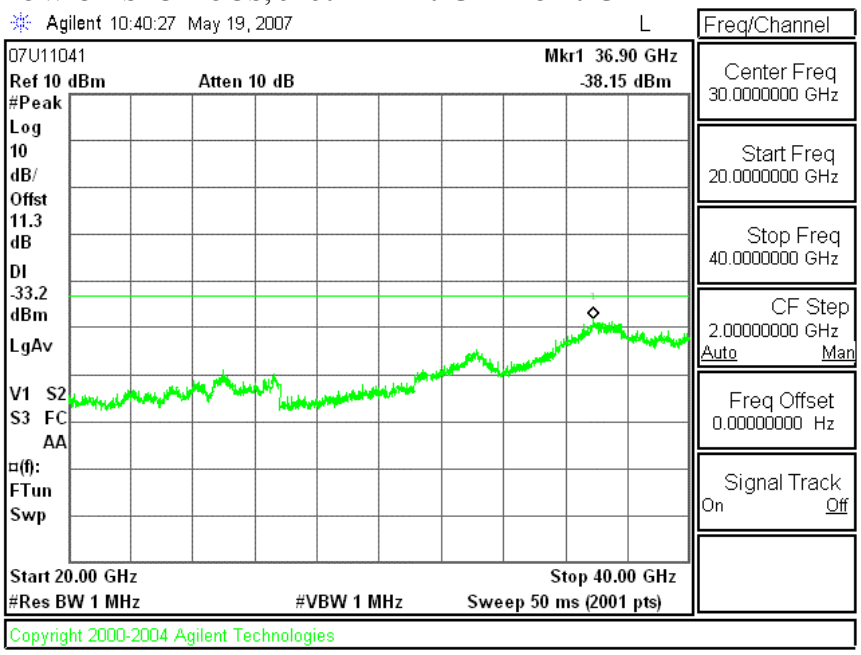
HIGH CHANNEL SPURIOUS, 5320 MHz - 20 GHz TO 40 GHz



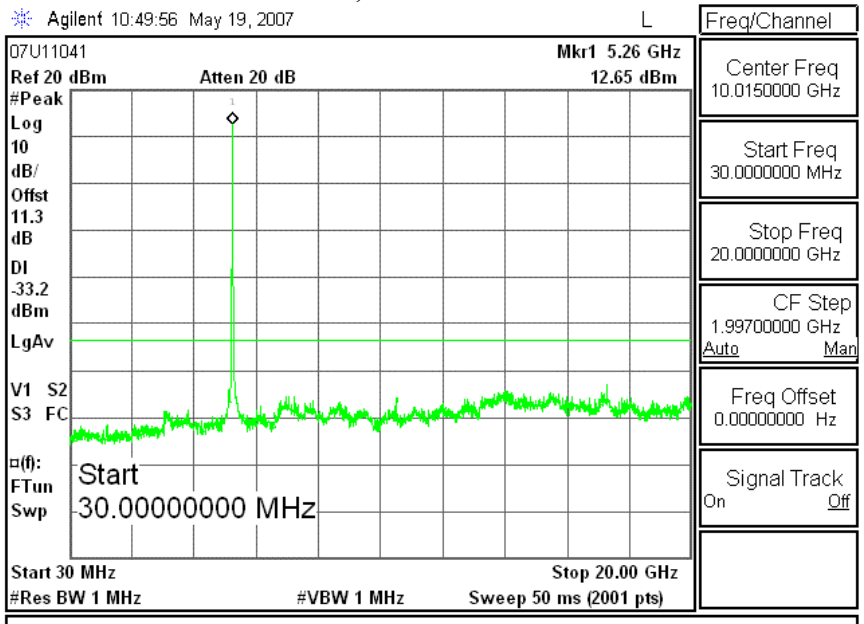
SPURIOUS EMISSIONS - 802.11a -20 MHz TX BANDWIDTH - CHAIN 1



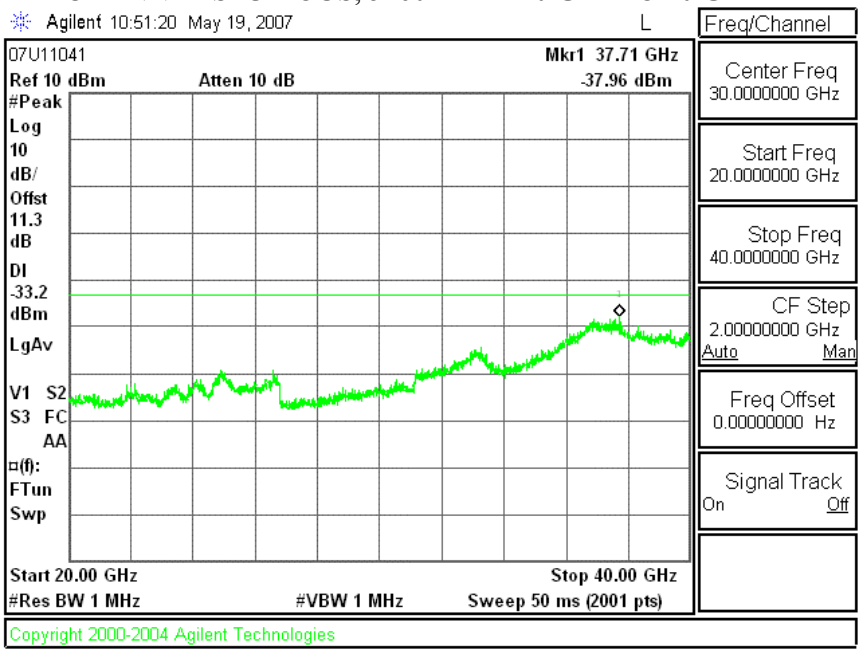
LOW CH SPURIOUS, 5180 MHz 20 GHz TO 40 GHz



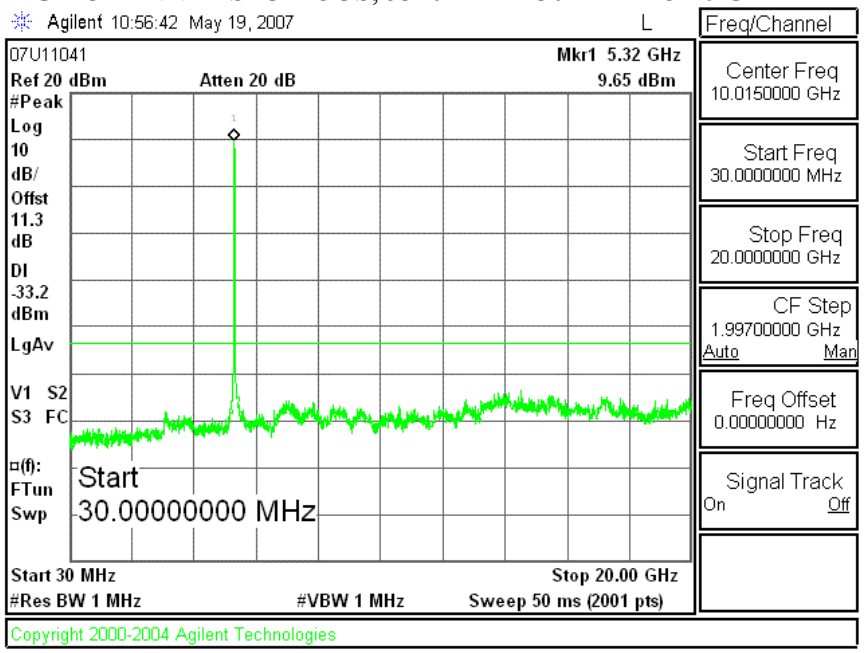
MID CHANNEL SPURIOUS, 5260 MHz - 30 MHz TO 20 GHz



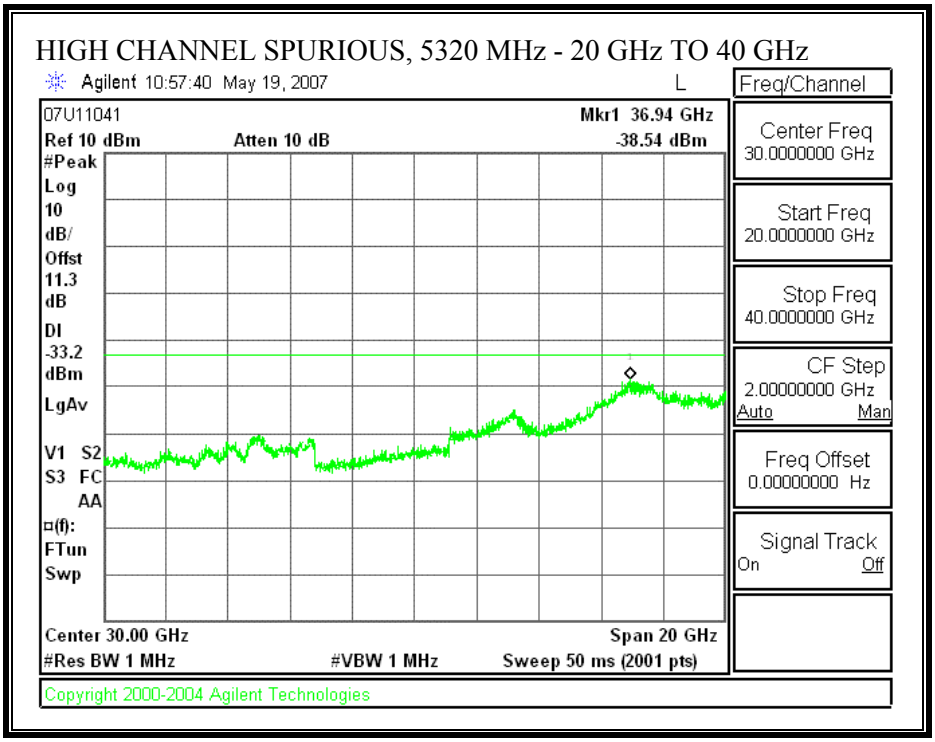
MID CHANNEL SPURIOUS, 5260 MHz - 20 GHz TO 40 GHz



HIGH CHANNEL SPURIOUS, 5320 MHz - 30 MHz TO 20 GHz

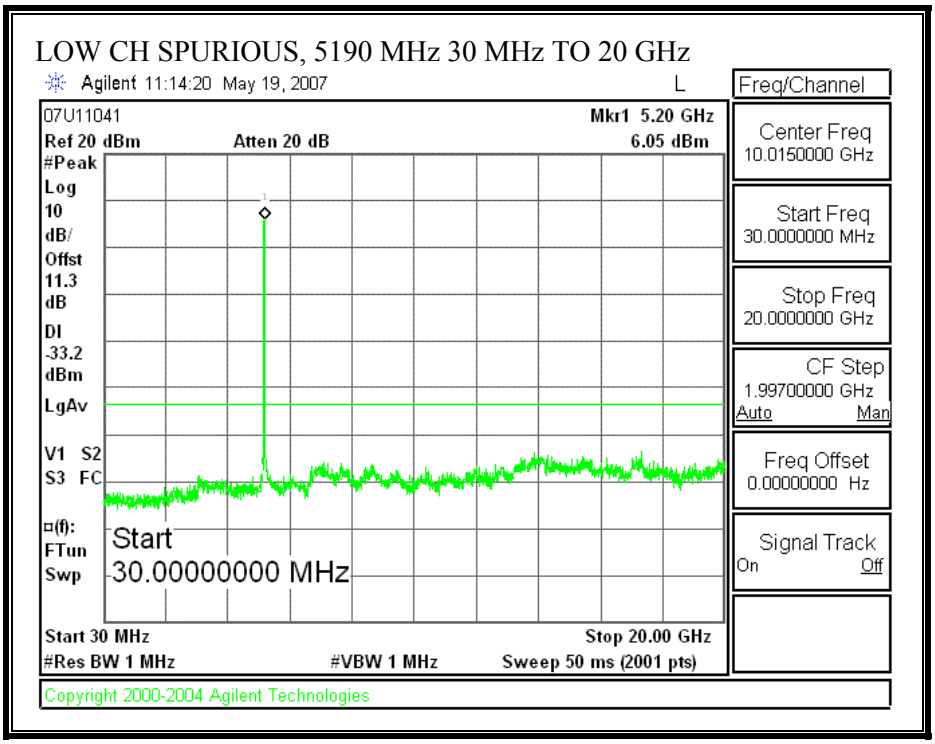


HIGH CHANNEL SPURIOUS, 5320 MHz - 20 GHz TO 40 GHz

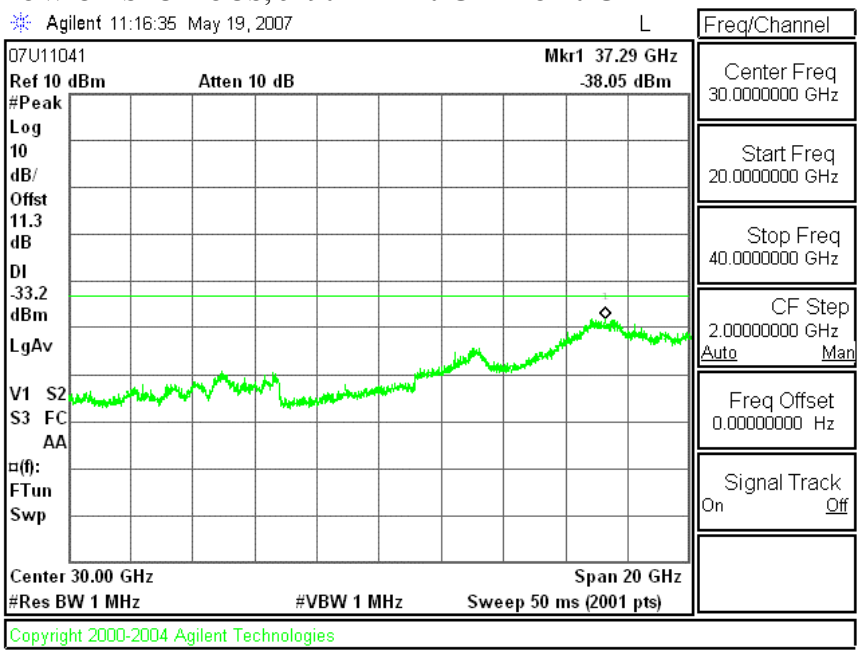


802.11n 40 MHz CDD MCS 32

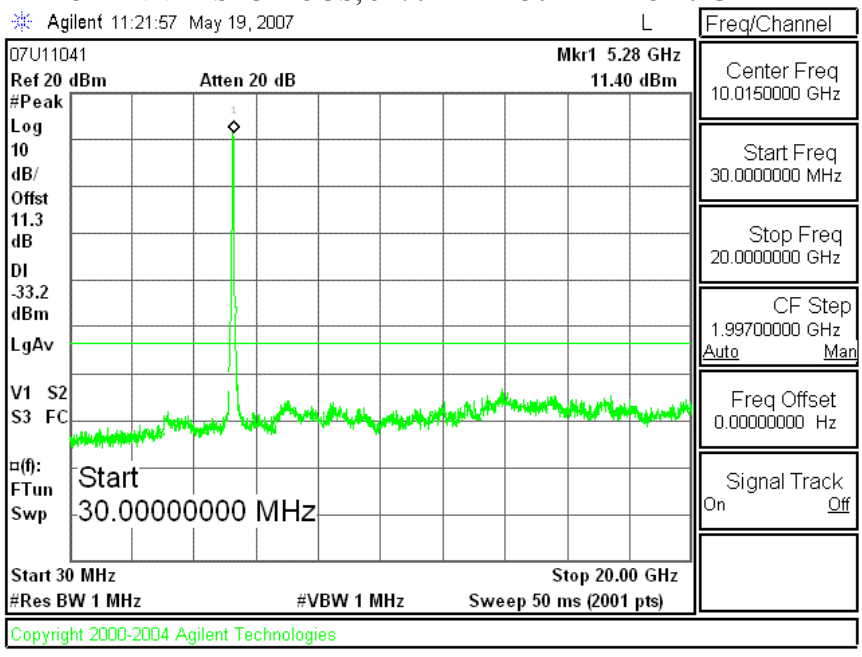
SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 0



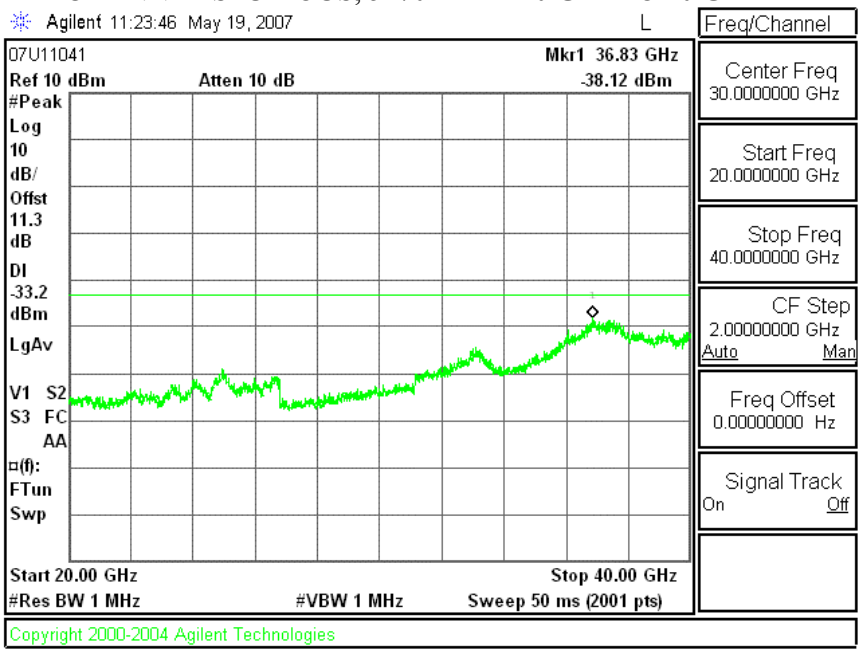
LOW CH SPURIOUS, 5190 MHz 20 GHz TO 40 GHz



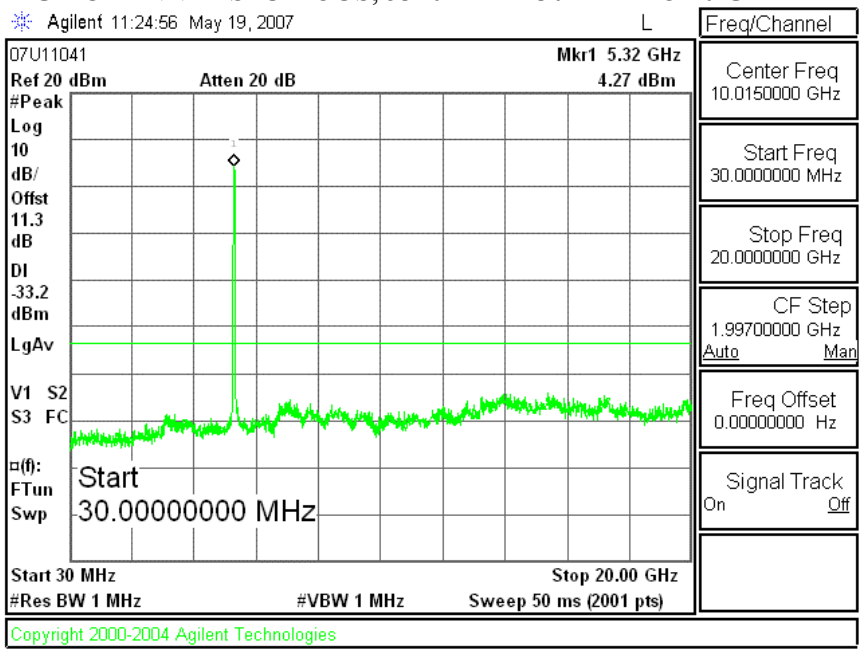
MID CHANNEL SPURIOUS, 5270 MHz - 30 MHz TO 20 GHz



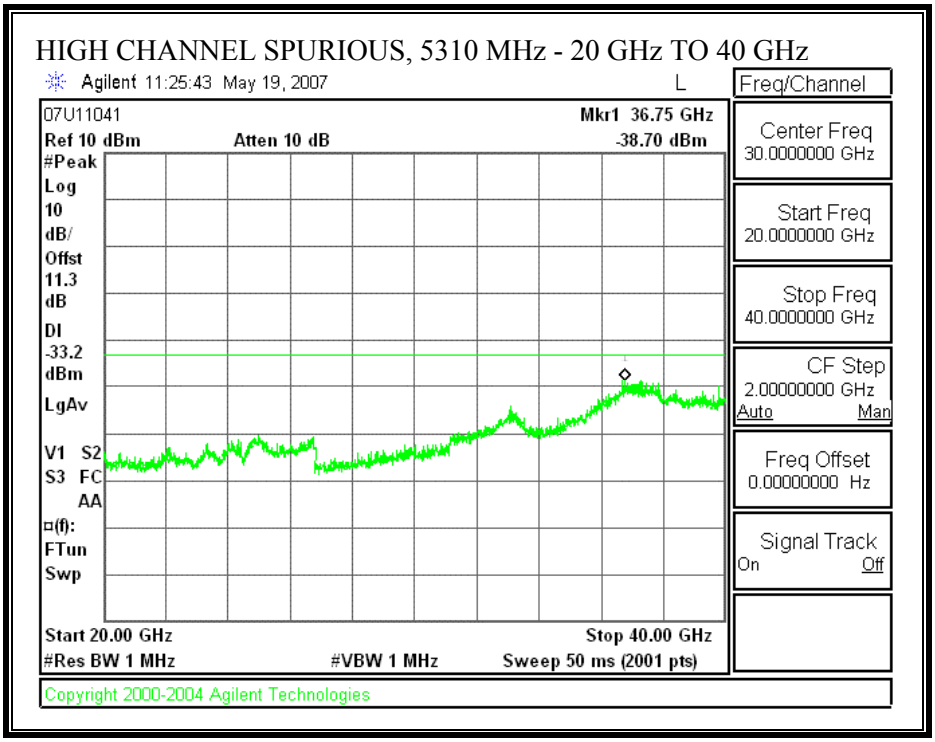
MID CHANNEL SPURIOUS, 5270 MHz - 20 GHz TO 40 GHz



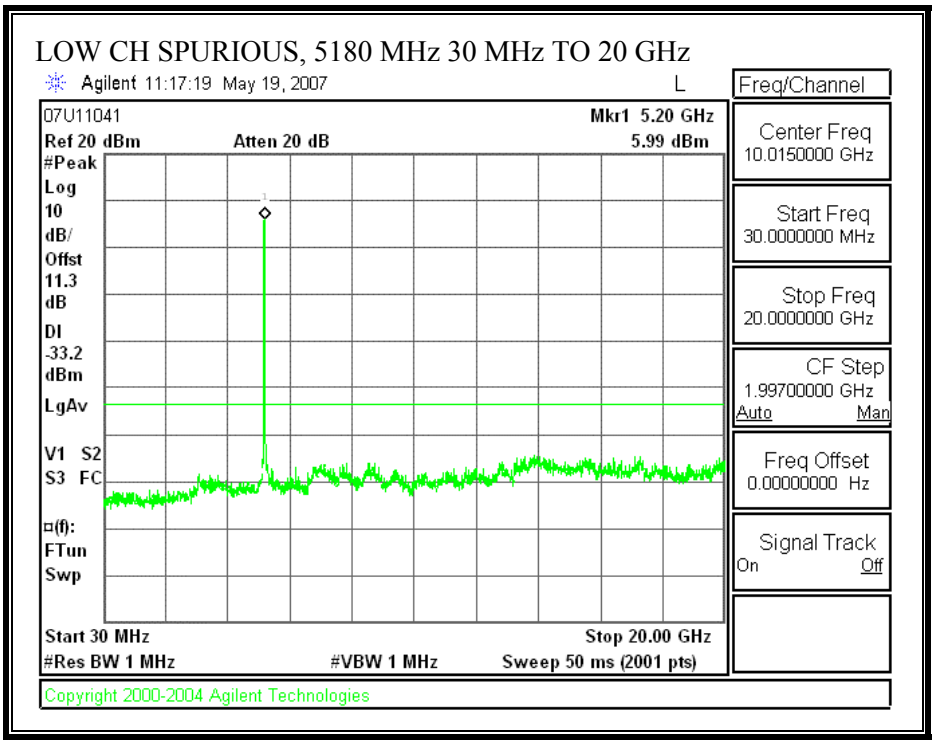
HIGH CHANNEL SPURIOUS, 5310 MHz - 30 MHz TO 20 GHz



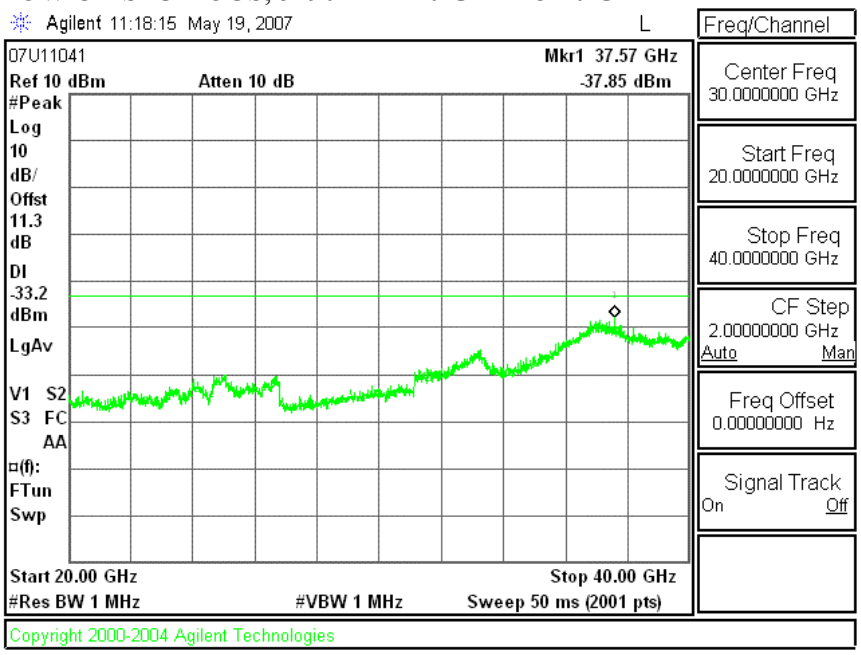
HIGH CHANNEL SPURIOUS, 5310 MHz - 20 GHz TO 40 GHz



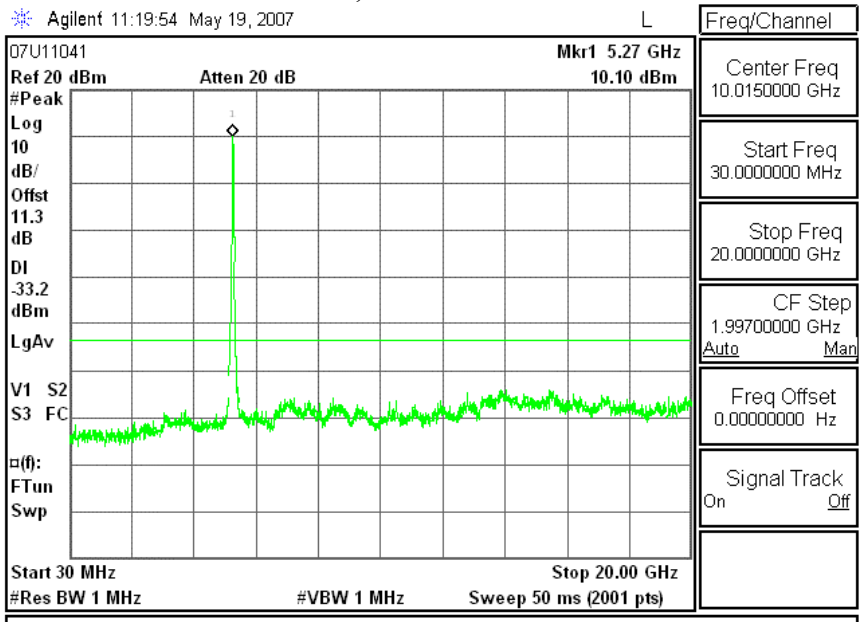
SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 1



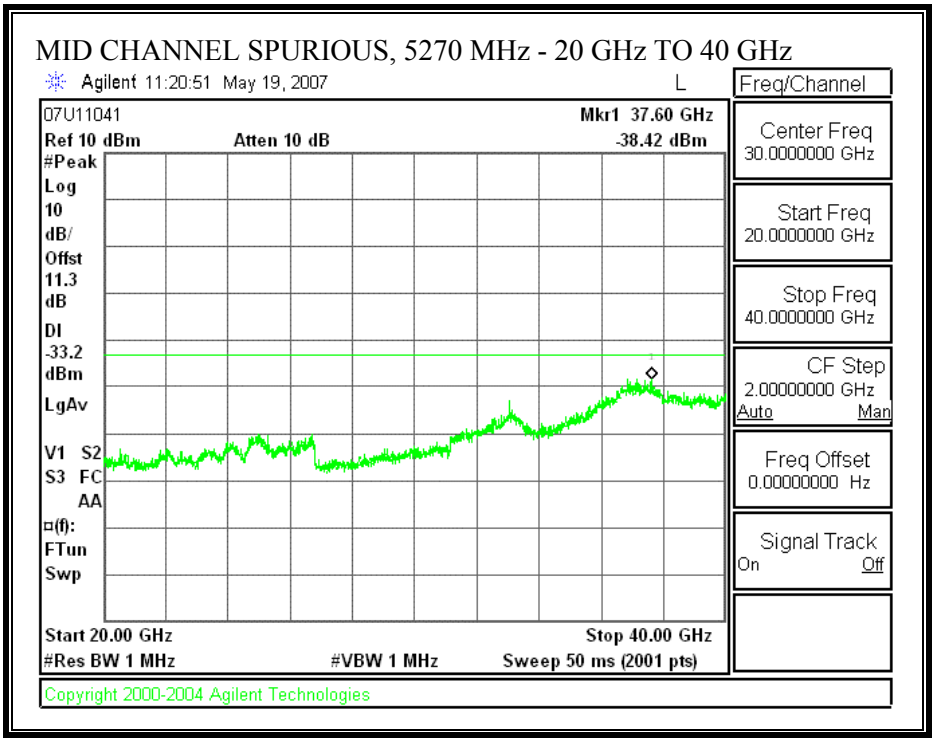
LOW CH SPURIOUS, 5190 MHz 20 GHz TO 40 GHz



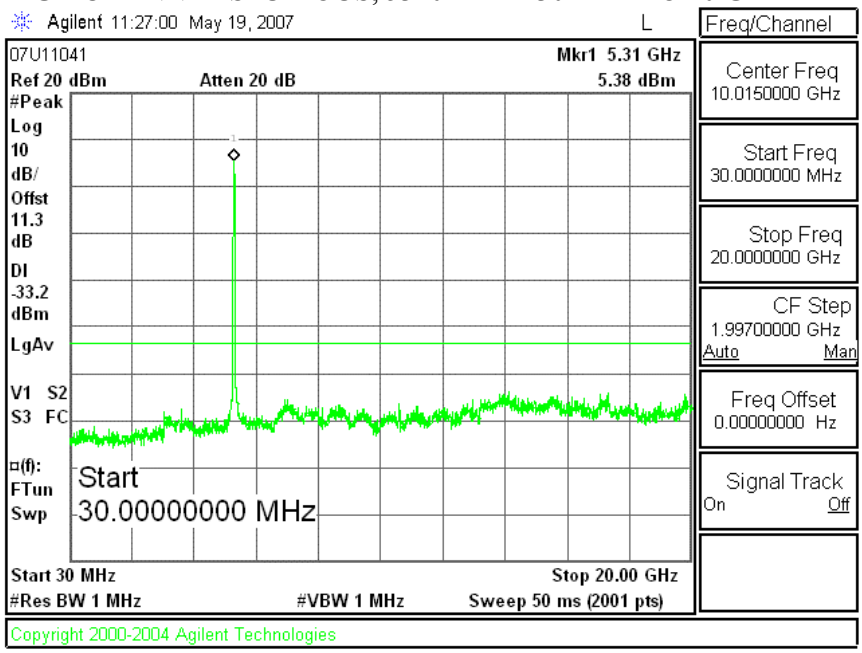
MID CHANNEL SPURIOUS, 5270 MHz - 30 MHz TO 20 GHz



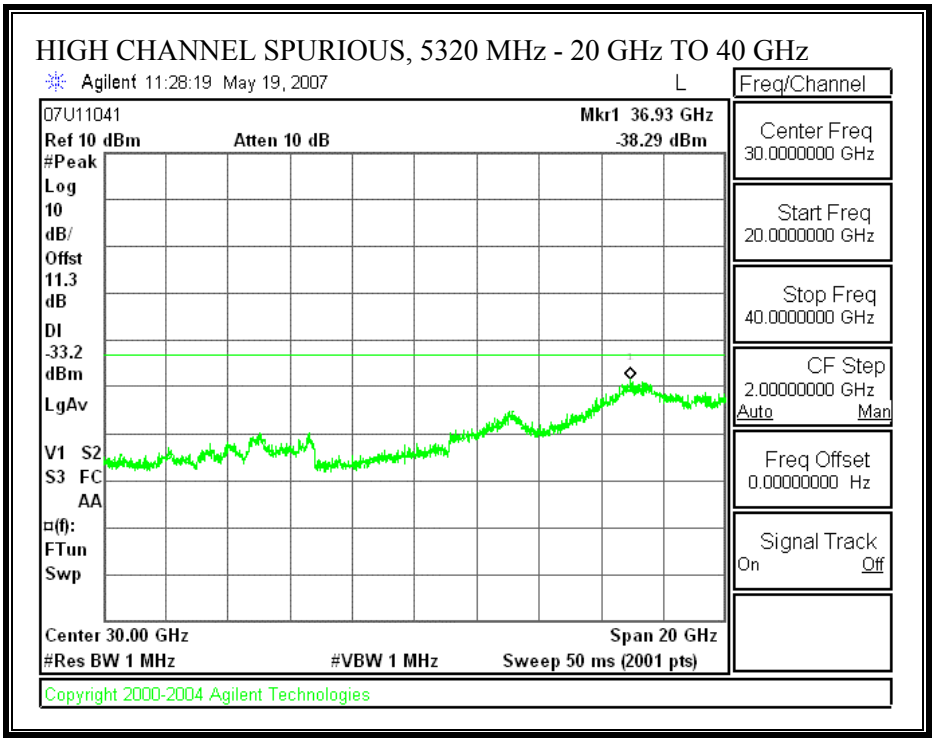
MID CHANNEL SPURIOUS, 5270 MHz - 20 GHz TO 40 GHz



HIGH CHANNEL SPURIOUS, 5310 MHz - 30 MHz TO 20 GHz

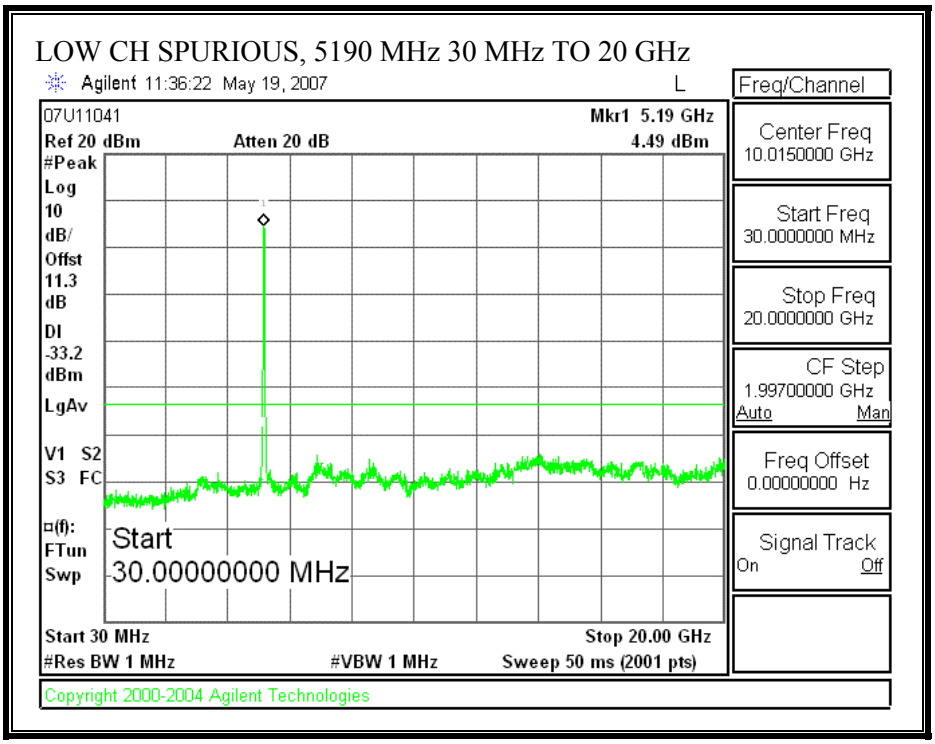


HIGH CHANNEL SPURIOUS, 5320 MHz - 20 GHz TO 40 GHz

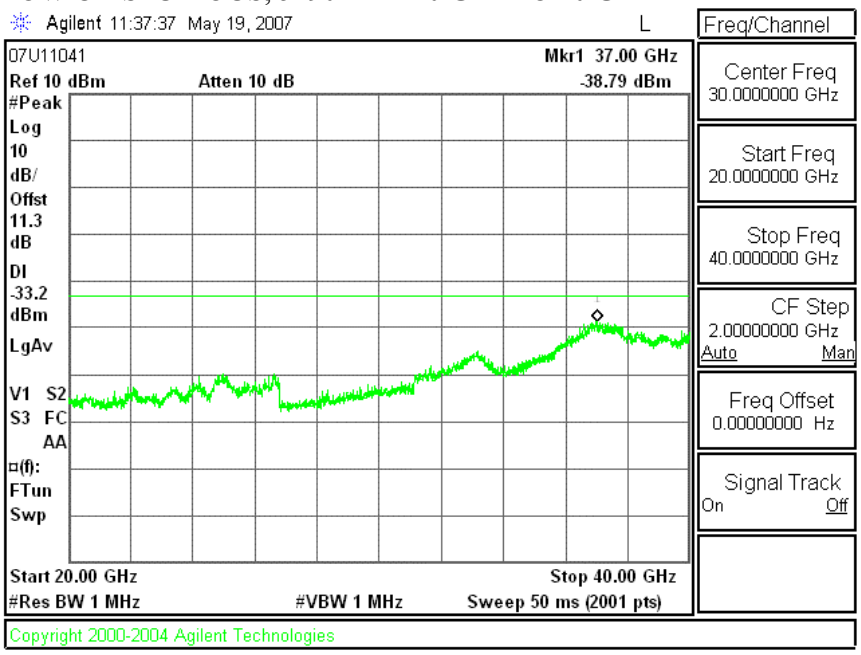


802.11n 40 MHz SDM MCS 15

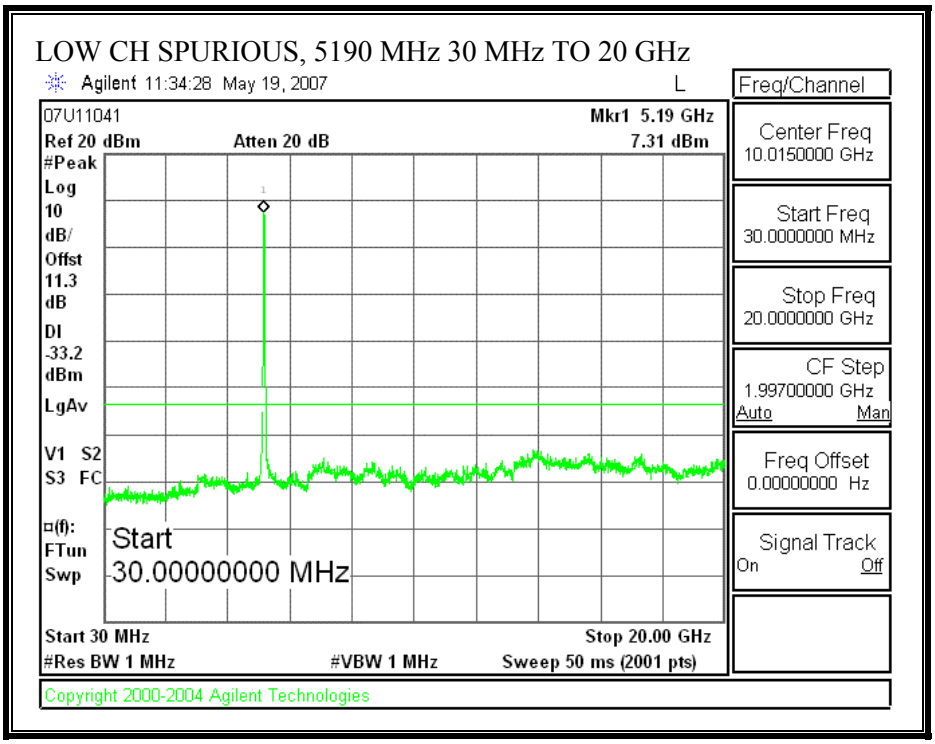
SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 0



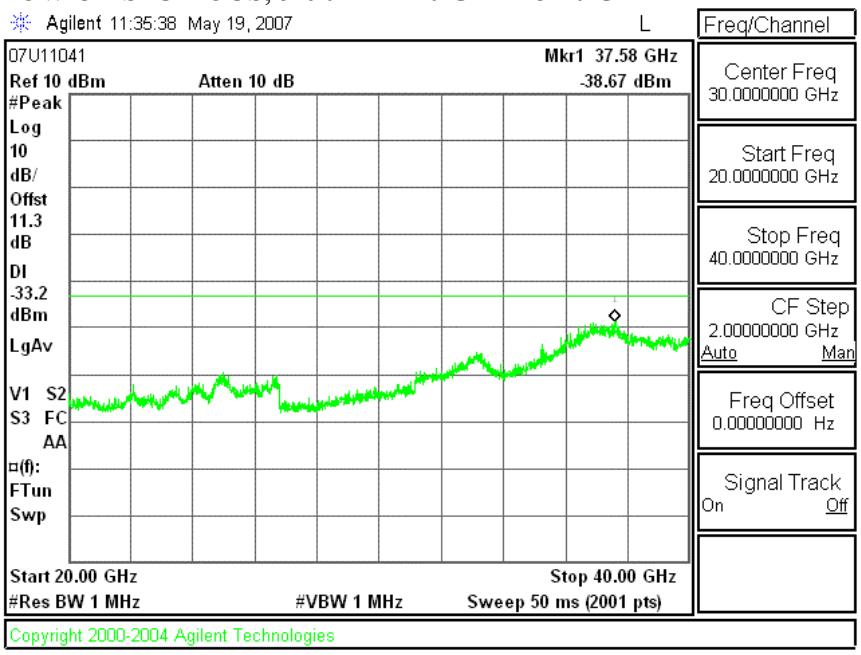
LOW CH SPURIOUS, 5190 MHz 20 GHz TO 40 GHz



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



LOW CH SPURIOUS, 5190 MHz 20 GHz TO 40 GHz



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	19.966	13.003
Middle	5600	22.978	13.613
High	5700	27.285	14.359

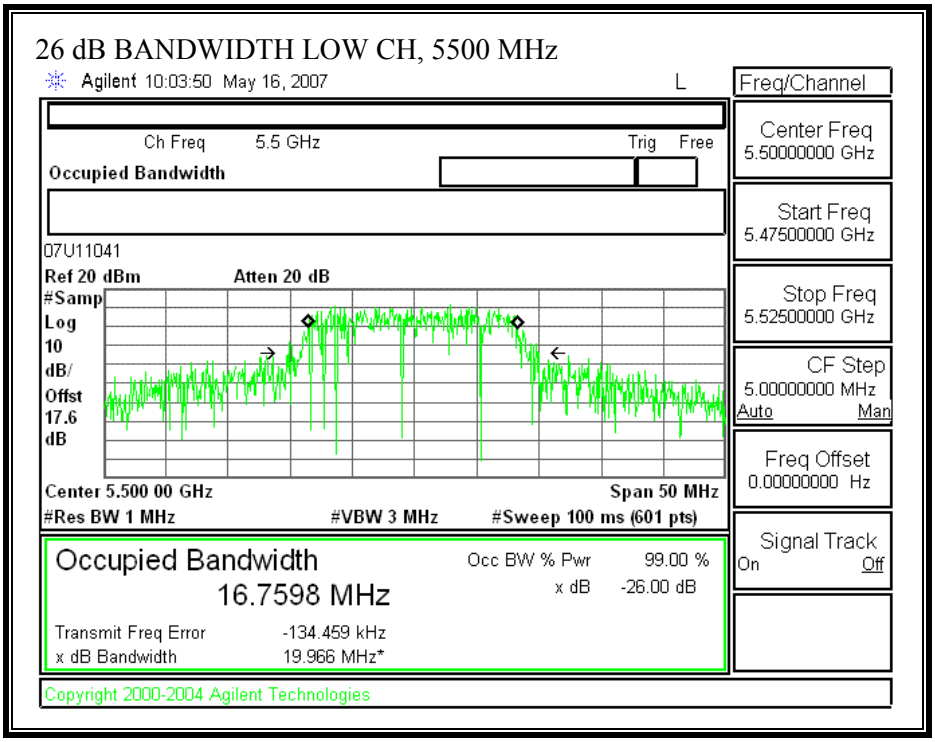
802.11n 20 MHz SISO MCS 0 MODE is covered by the worst case Legacy testing

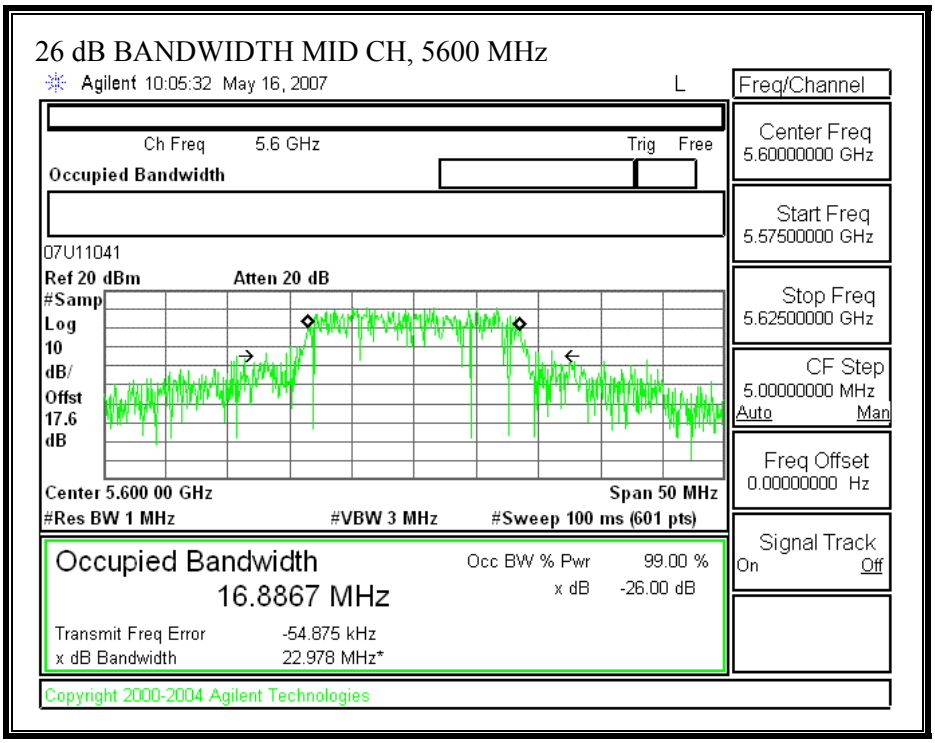
802.11n 40 MHz SISO MCS 0 MODE

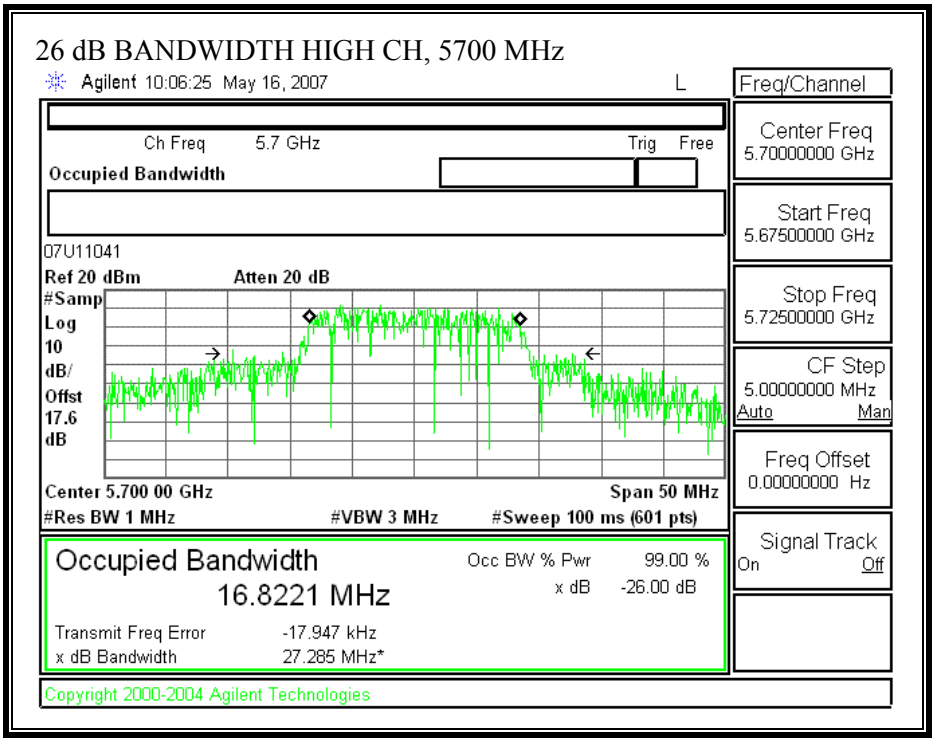
Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5510	44.976	16.530
Middle	5590	39.443	15.960
High	5670	41.797	16.211

802.11a MODE

26 dB EMISSION BANDWIDTH (802.11a MODE)

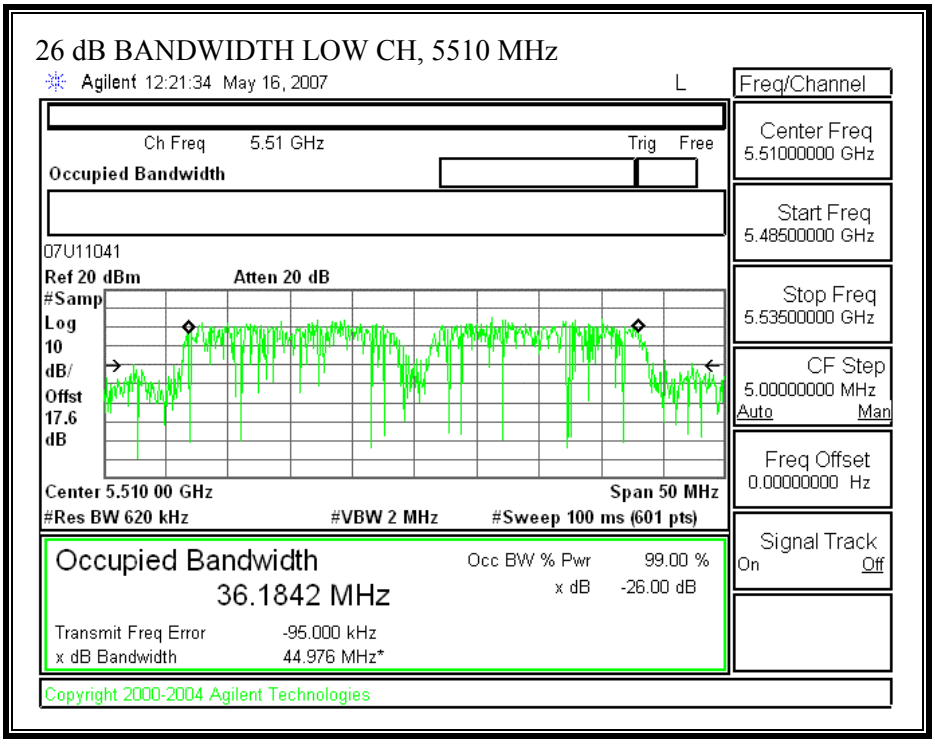


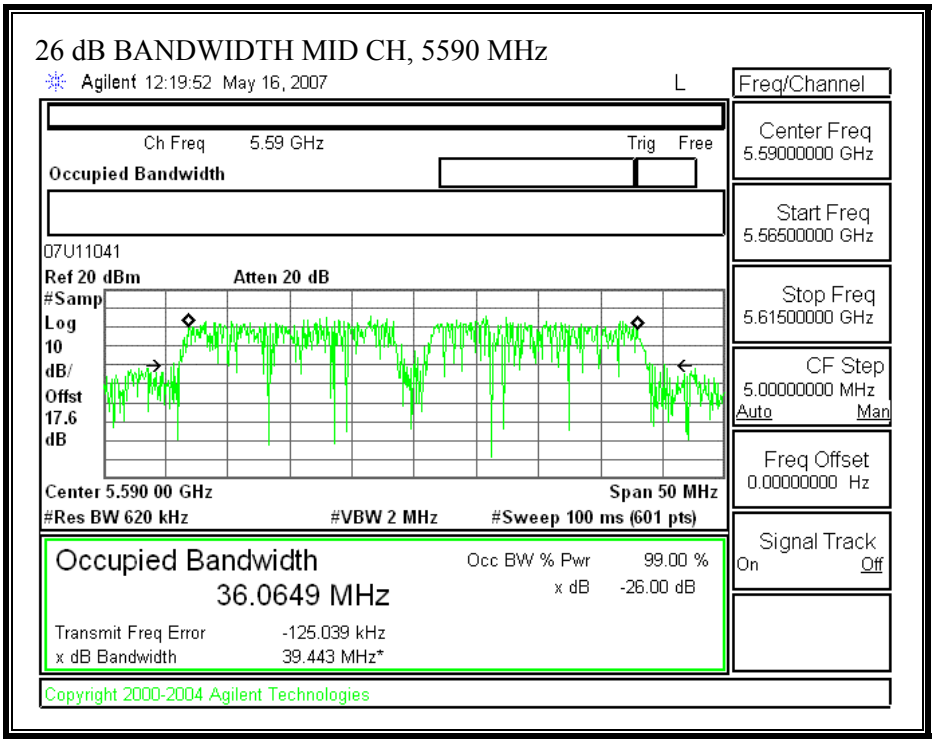




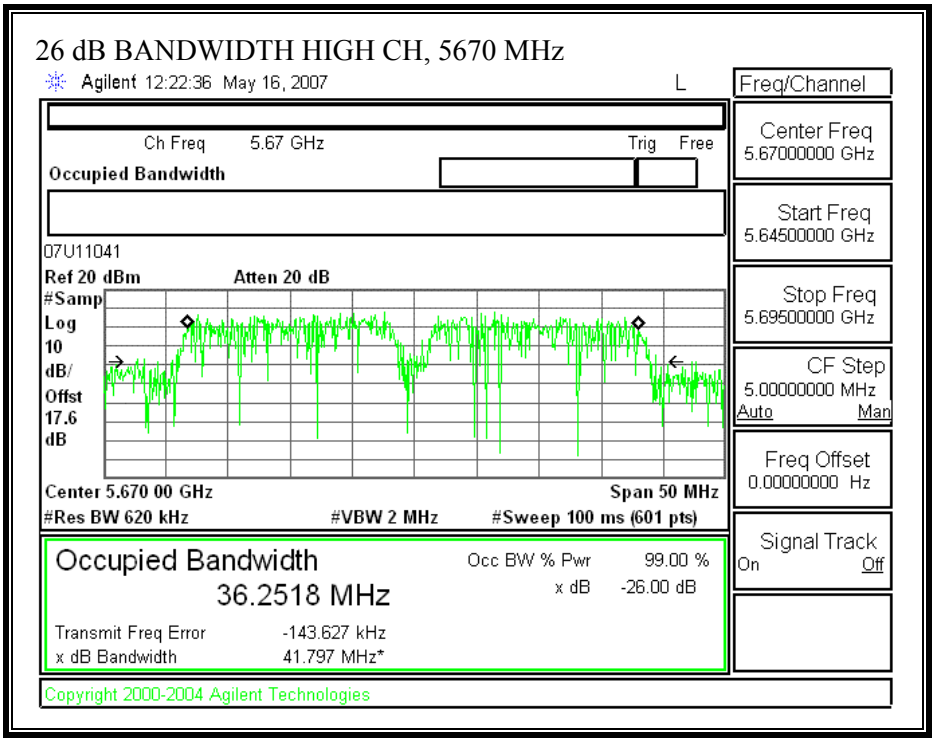
11n 40 MHz SISO MCS 32 MODE

26 dB EMISSION BANDWIDTH





26 dB BANDWIDTH HIGH CH, 5670 MHz



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 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:

5.470 – 5.725 GHz: 6.02 dBi

LIMITS AND RESULTS

No non-compliance noted:

802.11a MODE

Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	11 + 10 Log B Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Low	5500	24	19.966	24.003	6.020	23.98
Middle	5600	24	22.978	24.613	6.020	23.98
High	5700	24	27.285	25.359	6.020	23.98

Results

Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Low	5500	17.12	23.98	-6.86
Middle	5600	17.56	23.98	-6.42
High	5700	18.25	23.98	-5.73

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

802.11n 40 MHz SISO MCS 0 MODE

No non-compliance noted:

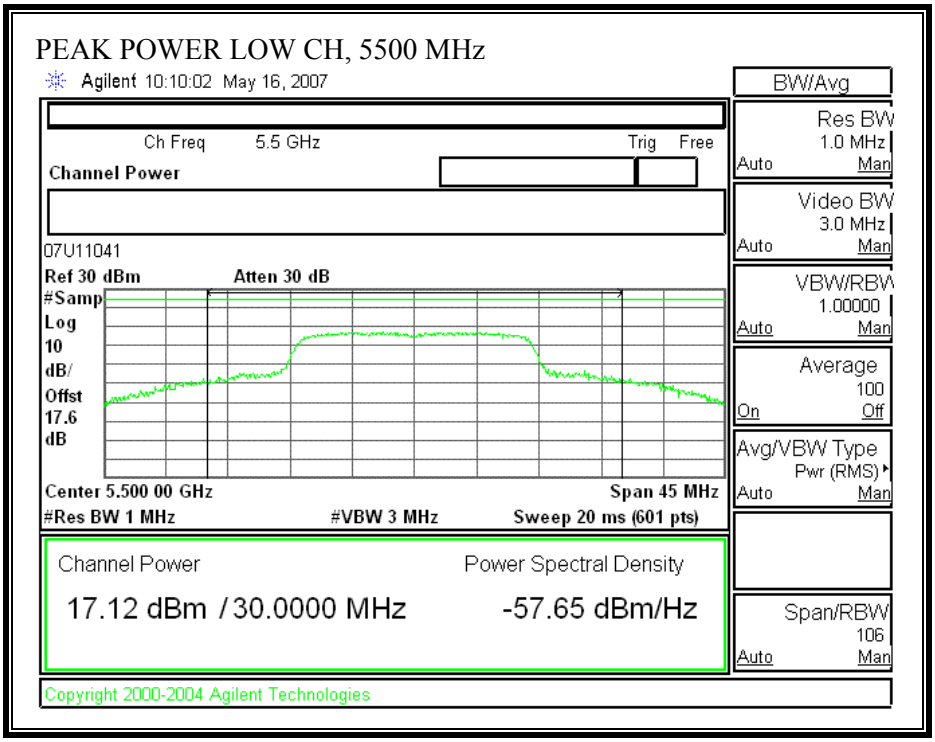
Channel	Frequency (MHz)	Fixed Limit (dBm)	B (MHz)	11 + 10 Log Limit (dBm)	Antenna Gain (dBi)	Limit (dBm)
Mid	5510	24	44.976	27.530	6.020	23.98
High	5590	24	39.443	26.960	6.020	23.98
High	5670	24	41.797	27.211	6.020	23.98

Results

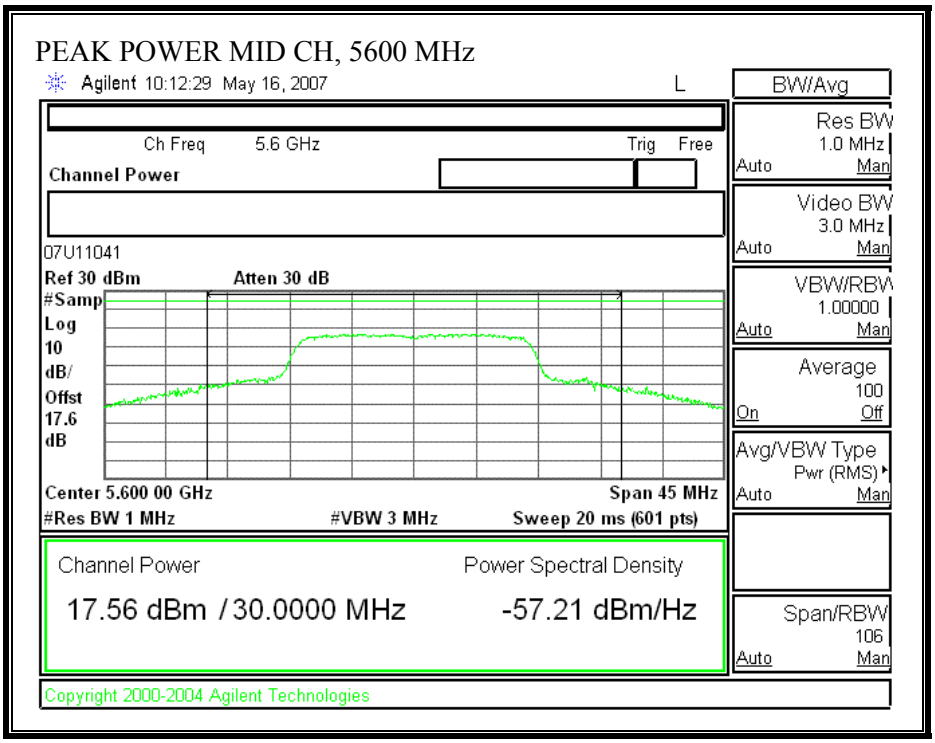
Channel	Frequency (MHz)	Power (dBm)	Limit (dBm)	Margin (dB)
Mid	5510	15.68	23.98	-8.30
High	5590	18.18	23.98	-5.80
High	5670	18.02	23.98	-5.96

802.11a MODE

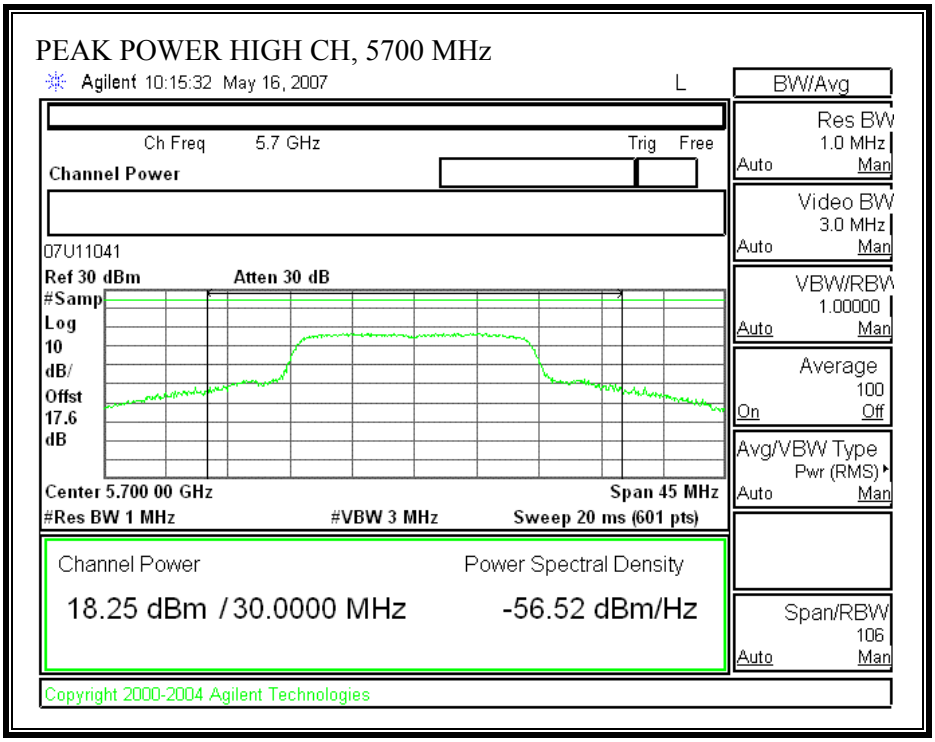
PEAK POWER



PEAK POWER MID CH, 5600 MHz

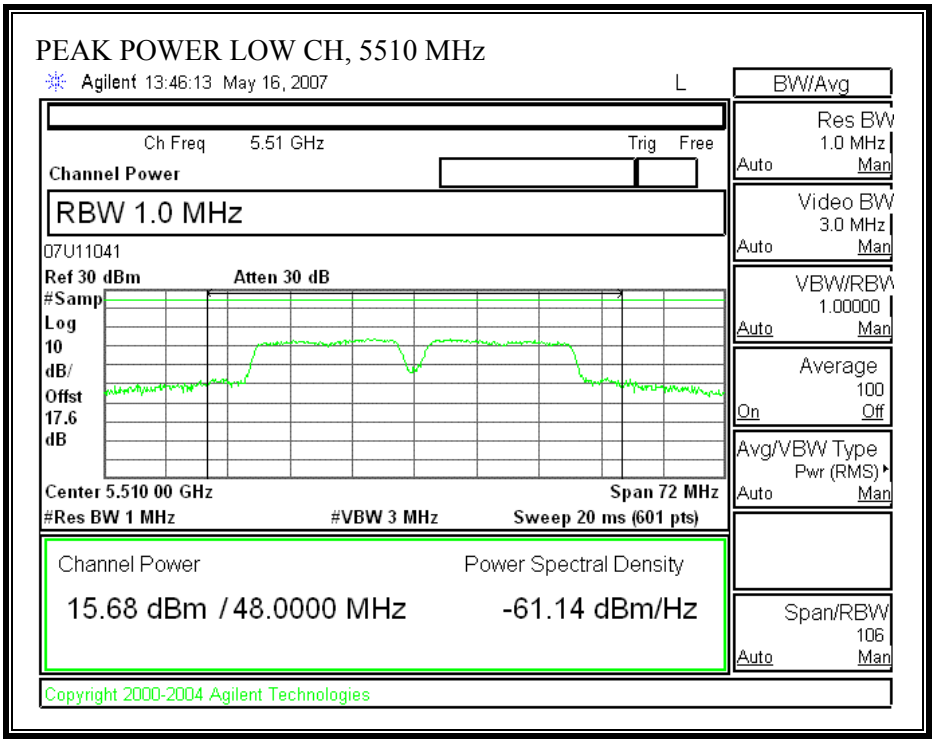


PEAK POWER HIGH CH, 5700 MHz

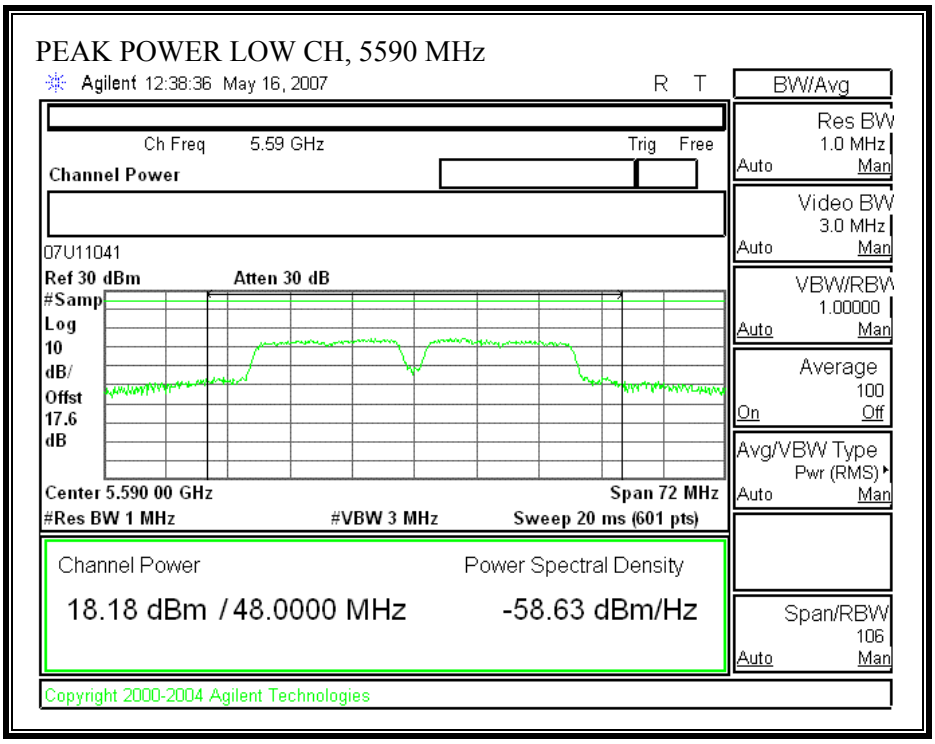


802.11n 40 MHz SISO MCS 0 MODE

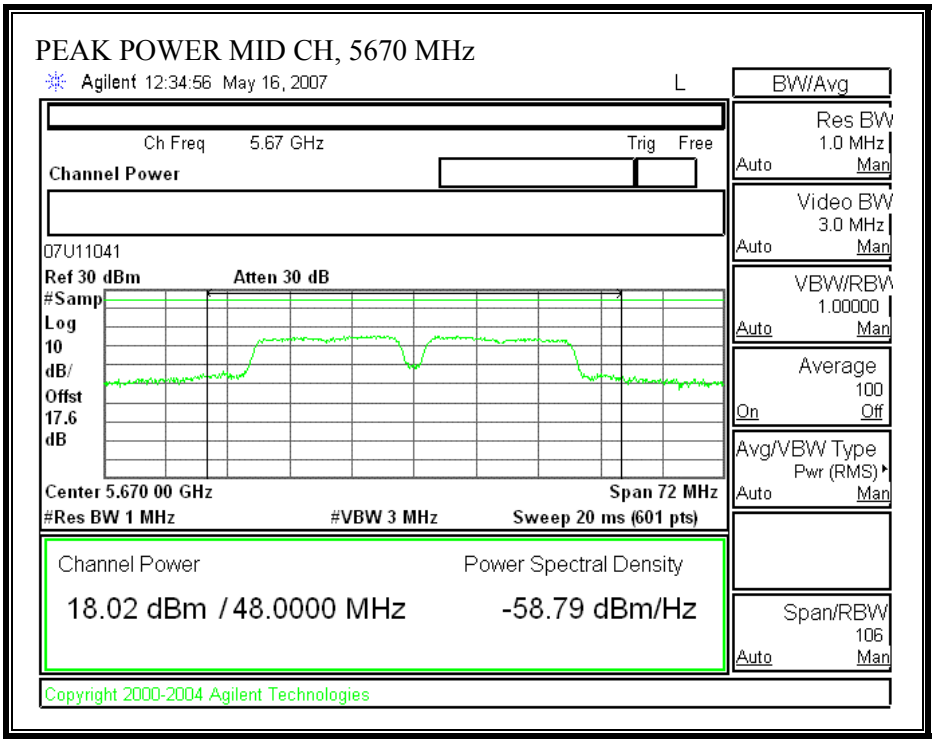
PEAK POWER



PEAK POWER LOW CH, 5590 MHz



PEAK POWER MID CH, 5670 MHz



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 (mW) = P (W) / 1000 and
d (cm) =100 * d (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/cm^2

Substituting the logarithmic form of power and gain using:

P (mW) = 10 ^ (P (dBm) / 10) and
G (numeric) = 10 ^ (G (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/cm^2

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), the maximum value of S = 1.0 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	18.25	6.02	0.05

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

802.11n 40 MHz SISO MCS 32 MODE

Mode	MPE Distance (cm)	Output Power (dBm)	Antenna Gain (dBi)	Power Density (mW/cm^2)
802.11n 40 MHz SISO	20.0	18.18	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.

The maximum antenna gain = 5.35dBi, therefore there is no 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.

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	7.029	10.980	-3.95
Middle	5560	7.454	10.980	-3.53
High	5570	6.339	10.980	-4.64

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

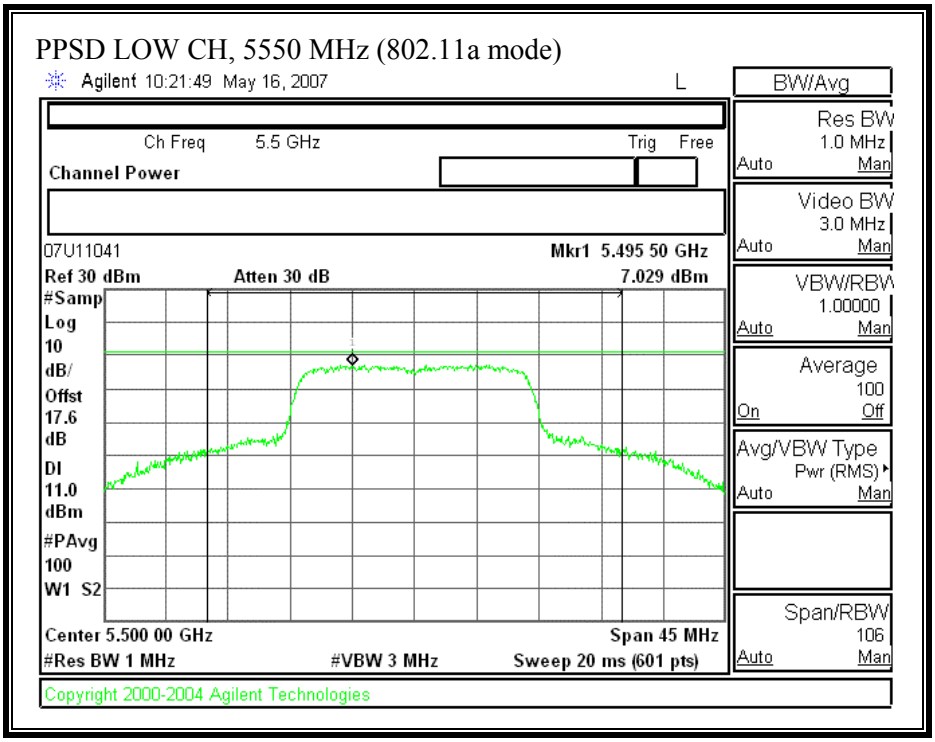
802.11n 40 MHz SISO MCS 32 MODE

802.11a Mode

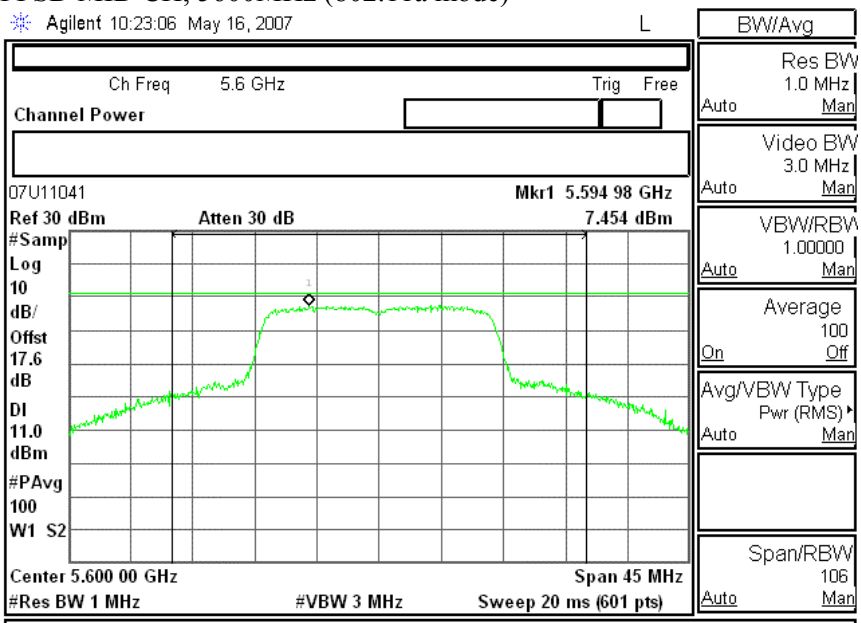
Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
Low	5510	3.526	10.980	-7.45
Middle	5590	3.028	10.980	-7.95
High	5570	4.928	10.980	-6.05

802.11a MODE

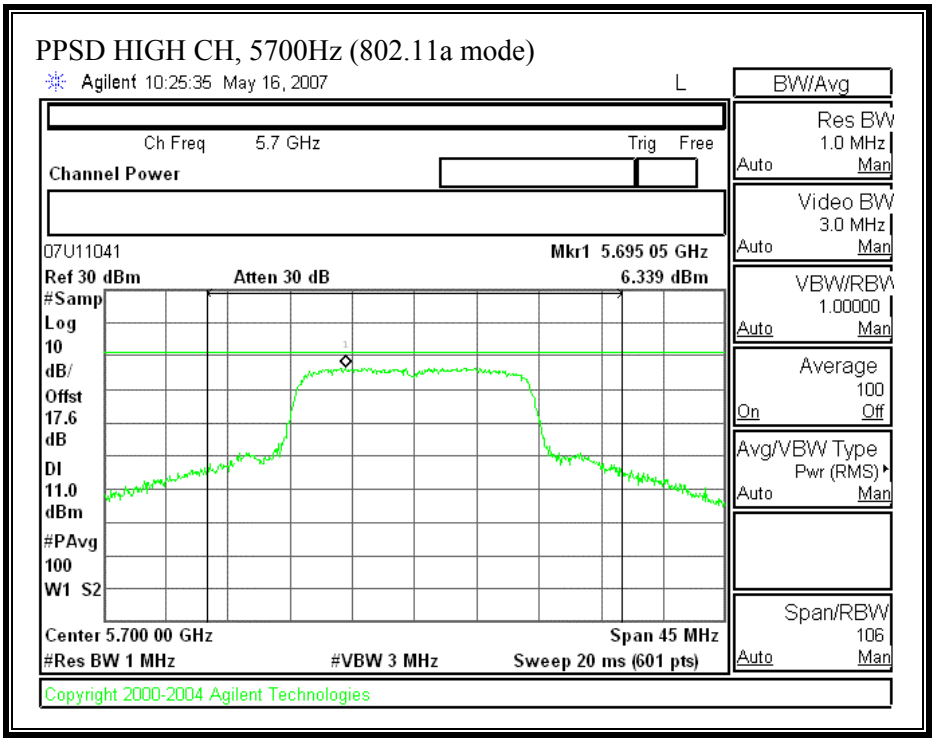
PEAK POWER SPECTRAL DENSITY (802.11a MODE)



PPSD MID CH, 5600MHz (802.11a mode)

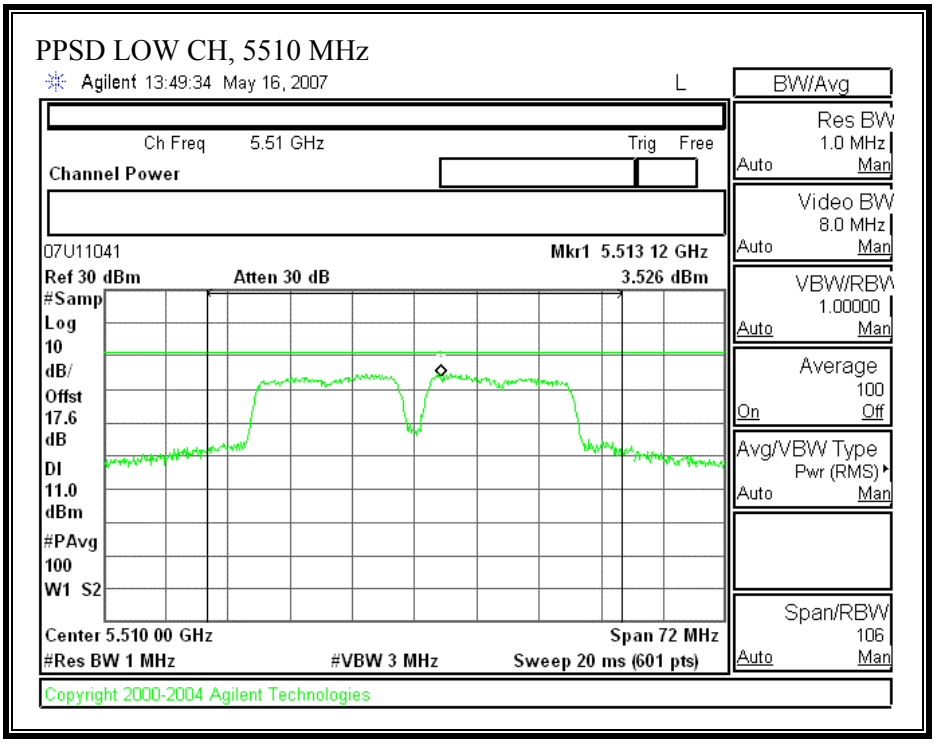


PPSD HIGH CH, 5700Hz (802.11a mode)

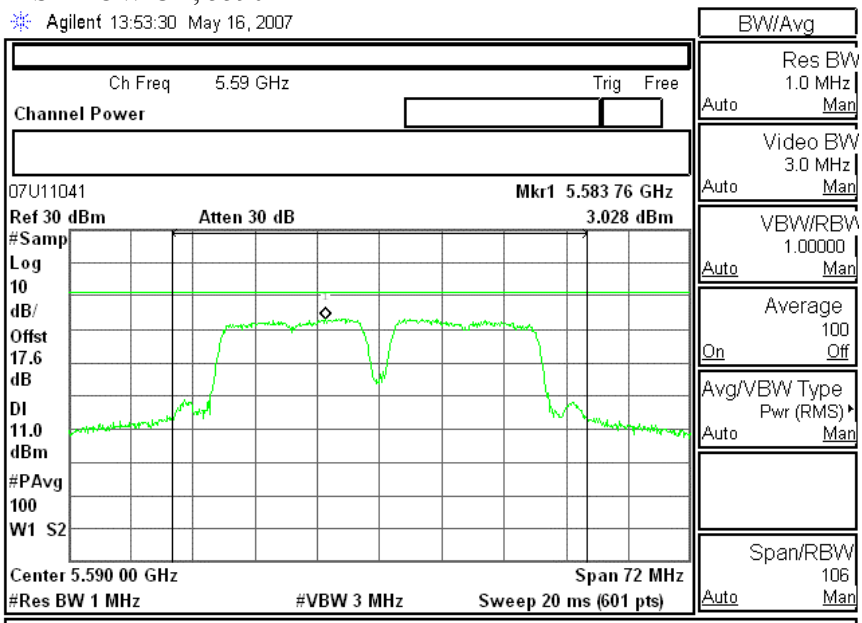


802.11n 40 MHz SISO MCS 32 MODE

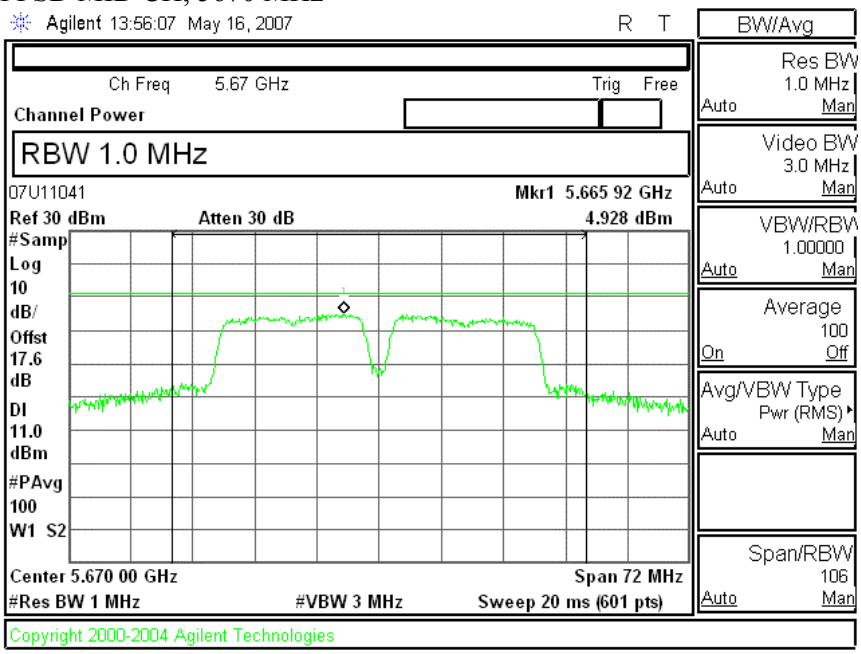
PEAK POWER SPECTRAL DENSITY



PPSD LOW CH, 5590 MHz



PPSD MID CH, 5670 MHz



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	11.580	13	-1.42
Middle	5600	10.820	13	-2.18
High	5700	9.040	13	-3.96

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

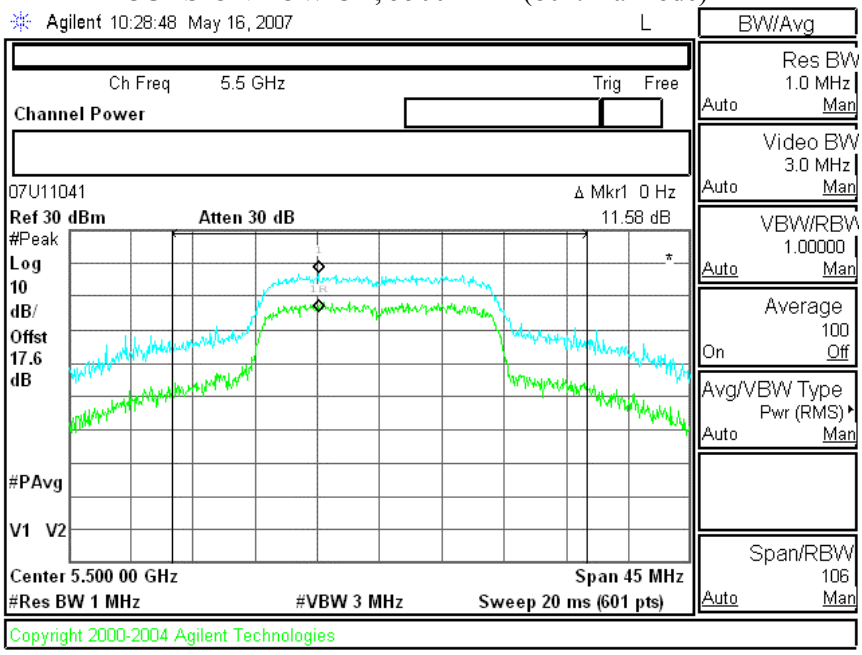
802.11n 40 MHz SISO MCS 32 MODE

Channel	Frequency (MHz)	Peak Excursion (dB)	Limit (dB)	Margin (dB)
Low	5510	9.760	13	-3.24
Middle	5590	8.890	13	-4.11
High	5670	11.890	13	-1.11

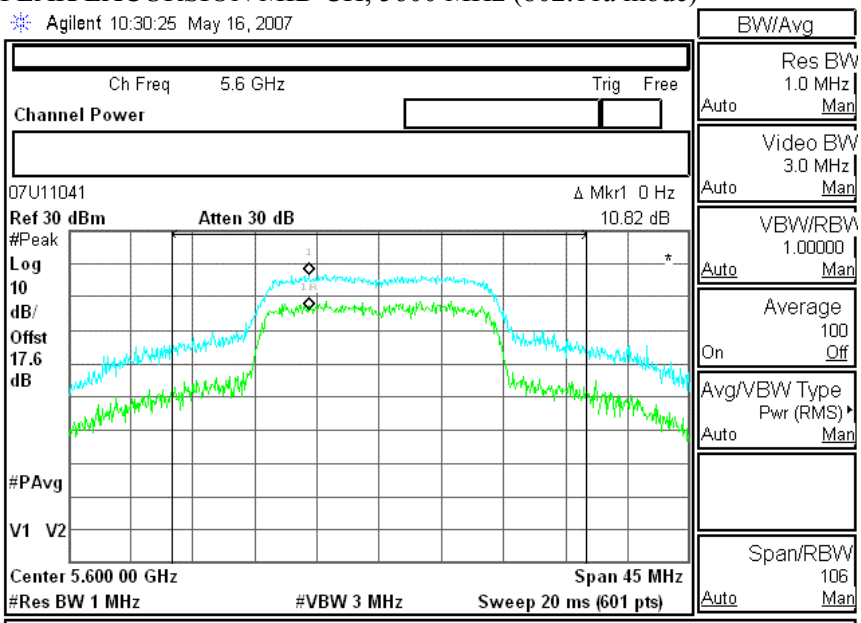
802.11a MODE

PEAK EXCURSION (802.11a MODE)

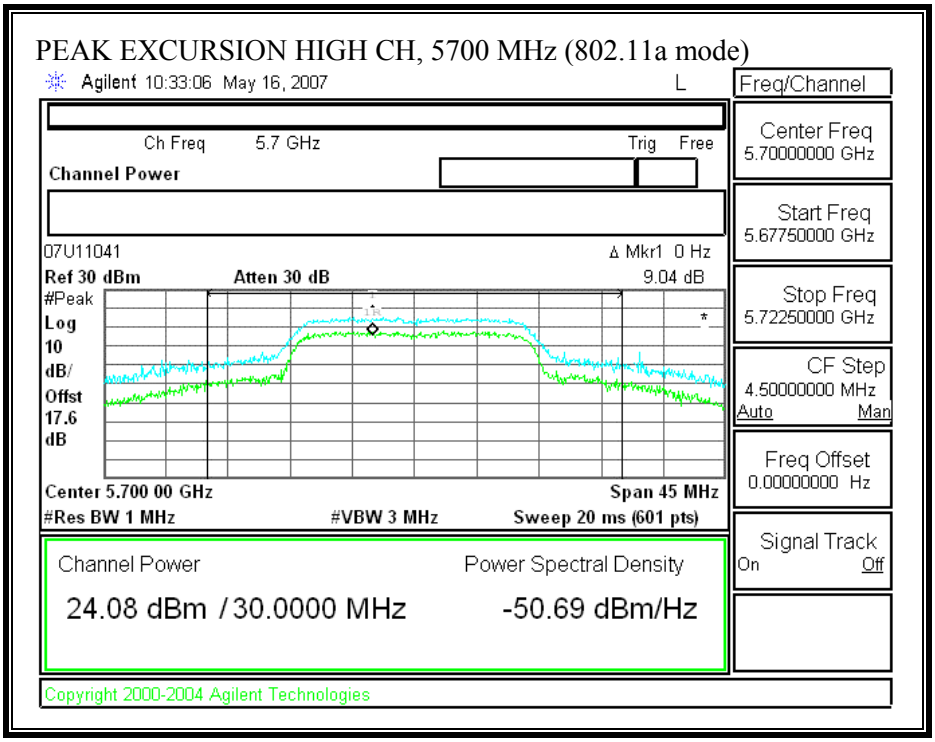
PEAK EXCURSION LOW CH, 5500 MHz (802.11a mode)



PEAK EXCURSION MID CH, 5600 MHz (802.11a mode)

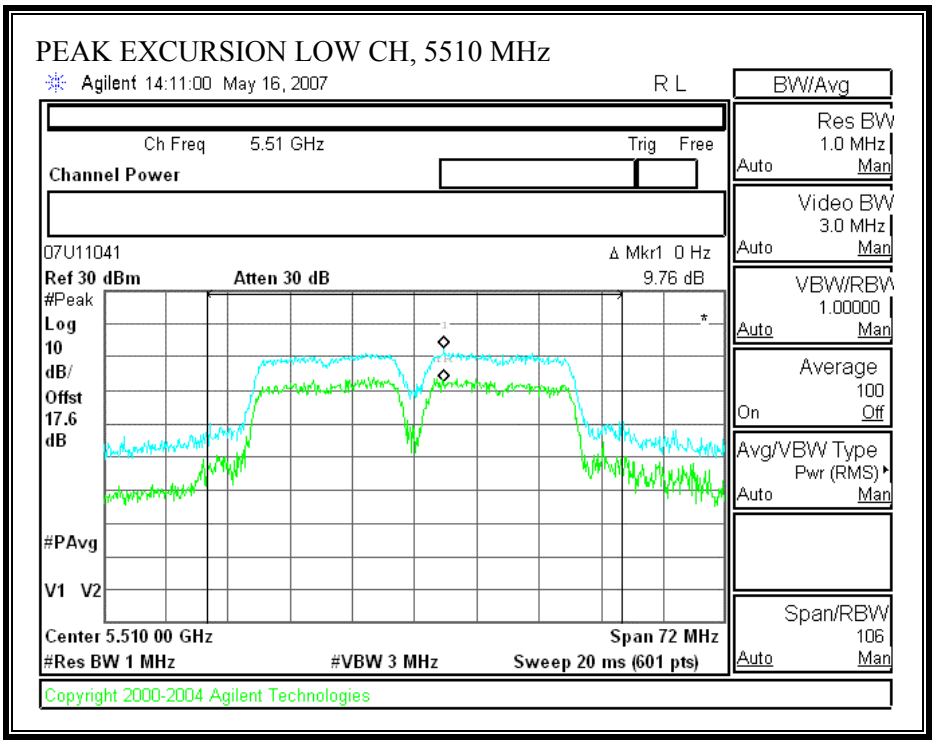


PEAK EXCURSION HIGH CH, 5700 MHz (802.11a mode)

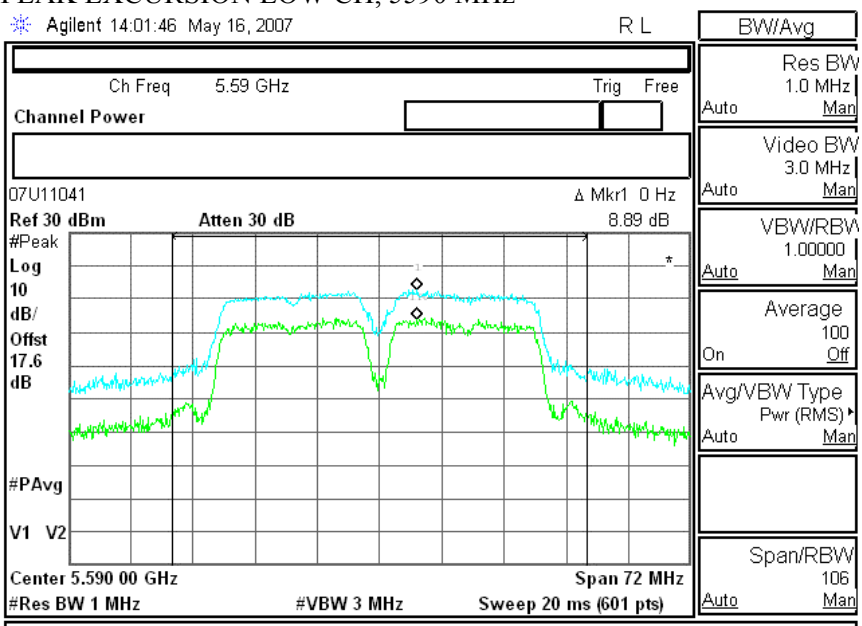


802.11n 40 MHz SISO MCS 32 MODE

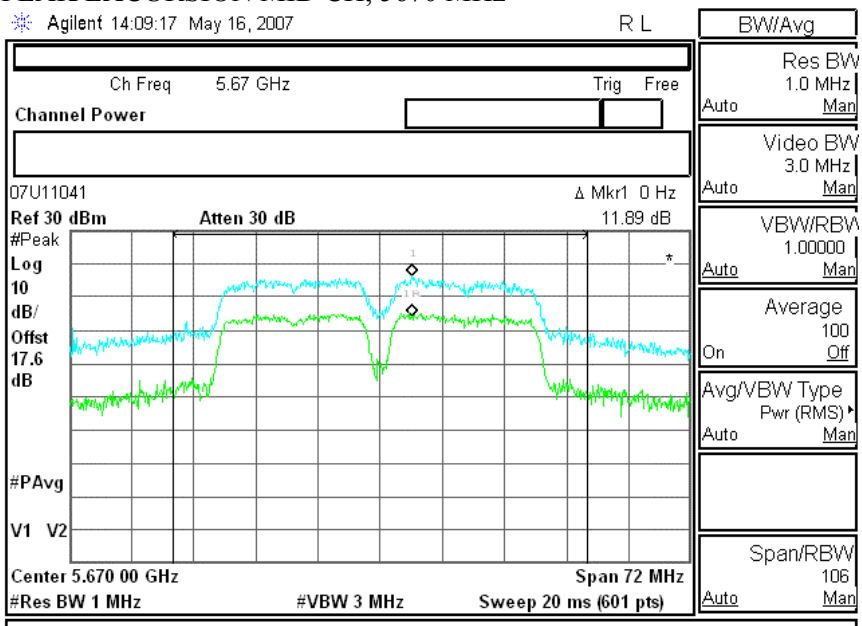
PEAK EXCURSION



PEAK EXCURSION LOW CH, 5590 MHz



PEAK EXCURSION MID CH, 5670 MHz



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.

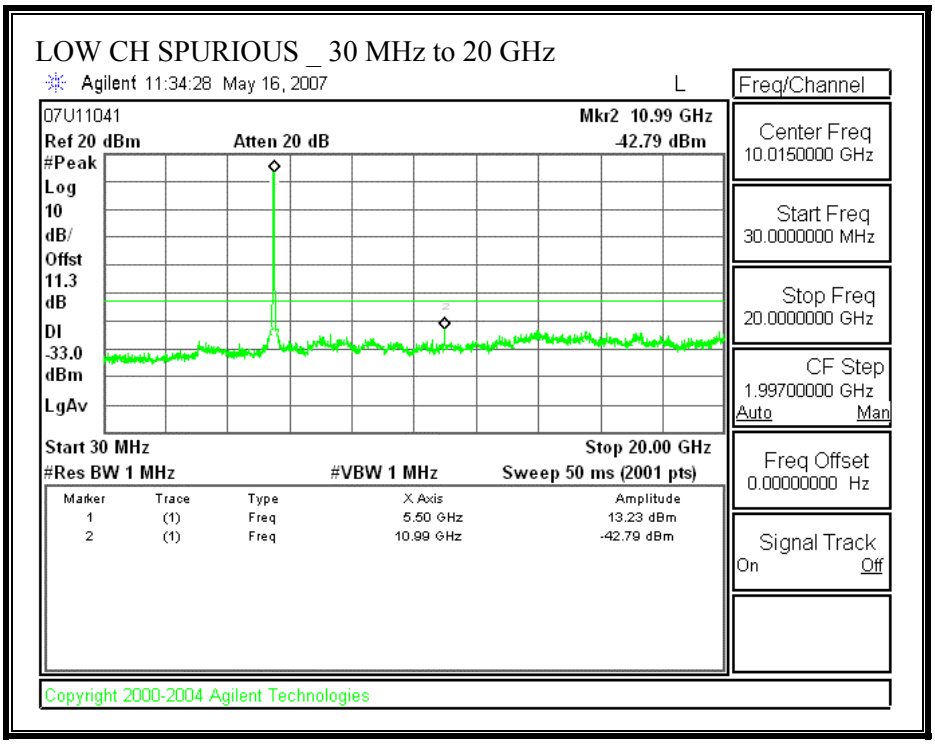
Measurements are made over the 30 MHz to 40 GHz range with the transmitter set to the lowest, middle, and highest channels.

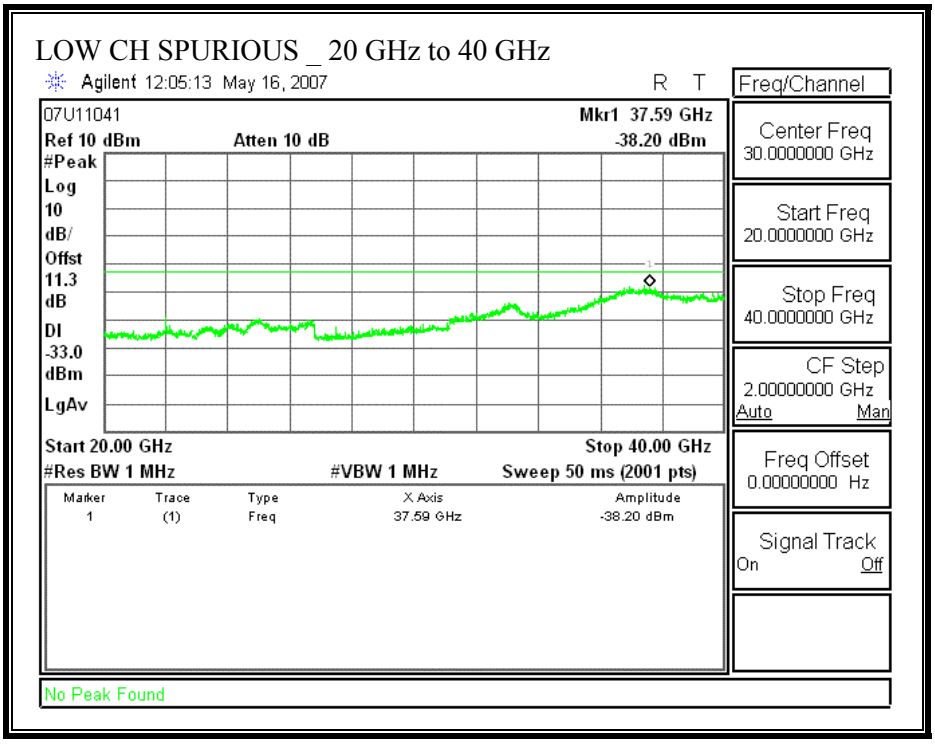
RESULTS

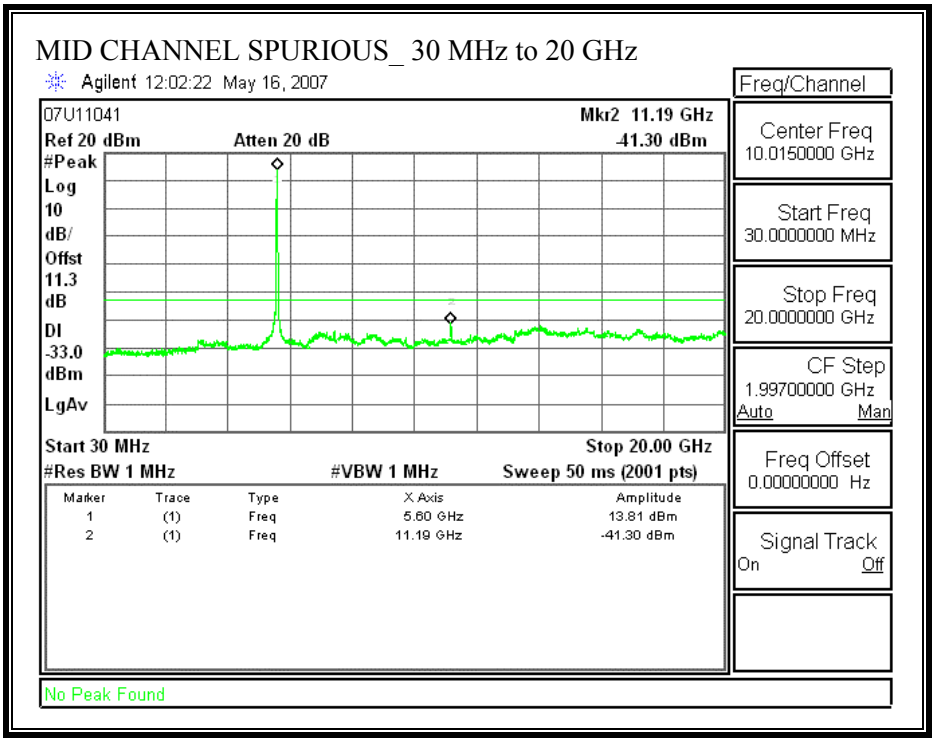
No non-compliance noted:

802.11a MODE

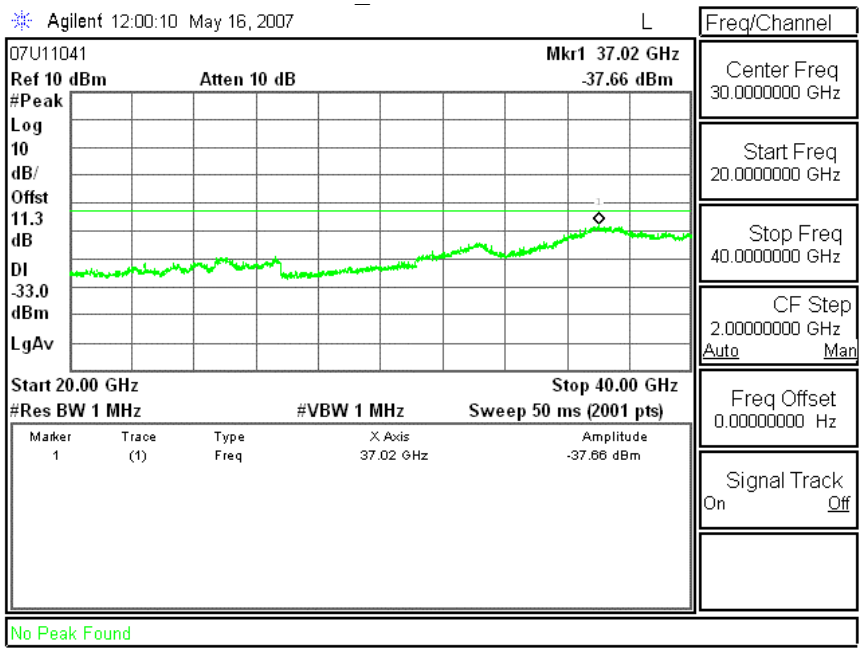
SPURIOUS EMISSIONS (802.11a MODE)

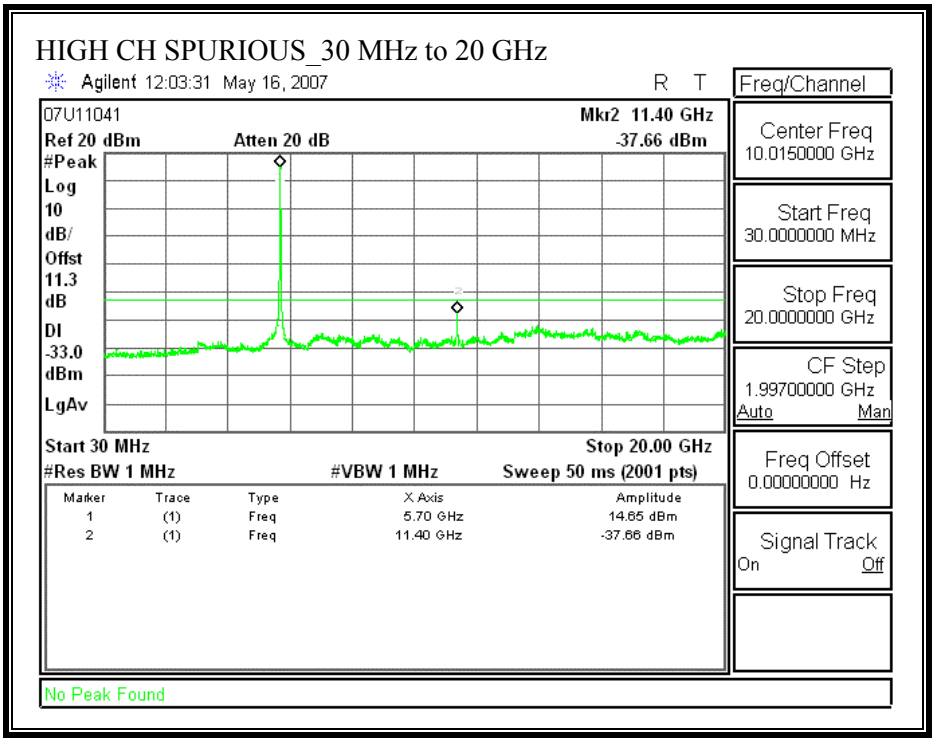


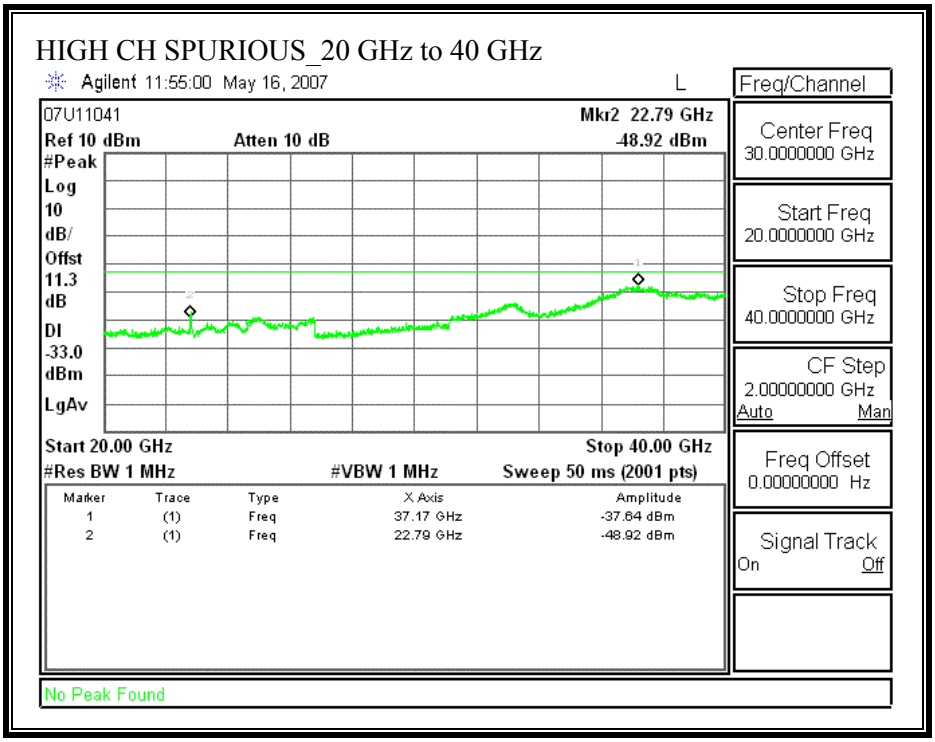




MID CHANNEL SPURIOUS_ 20 GHz to 40 GHz

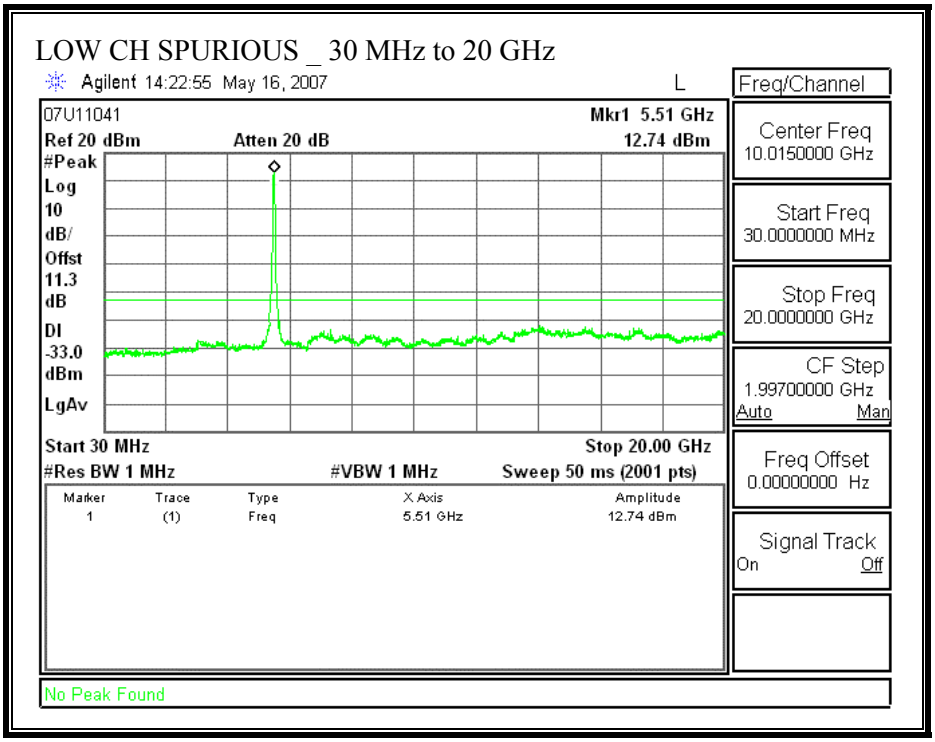


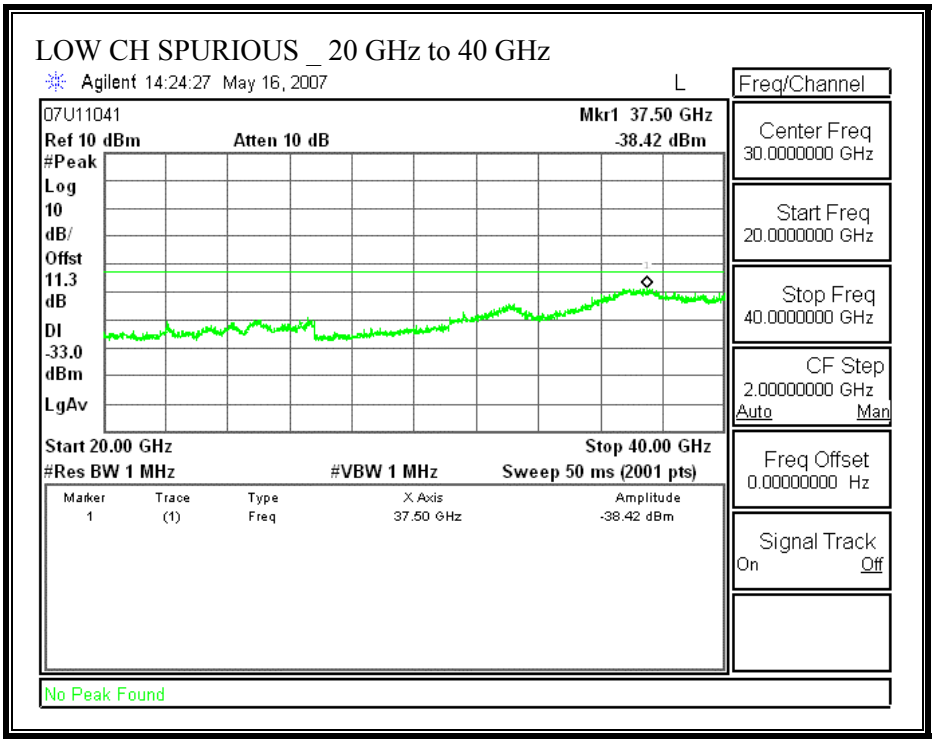




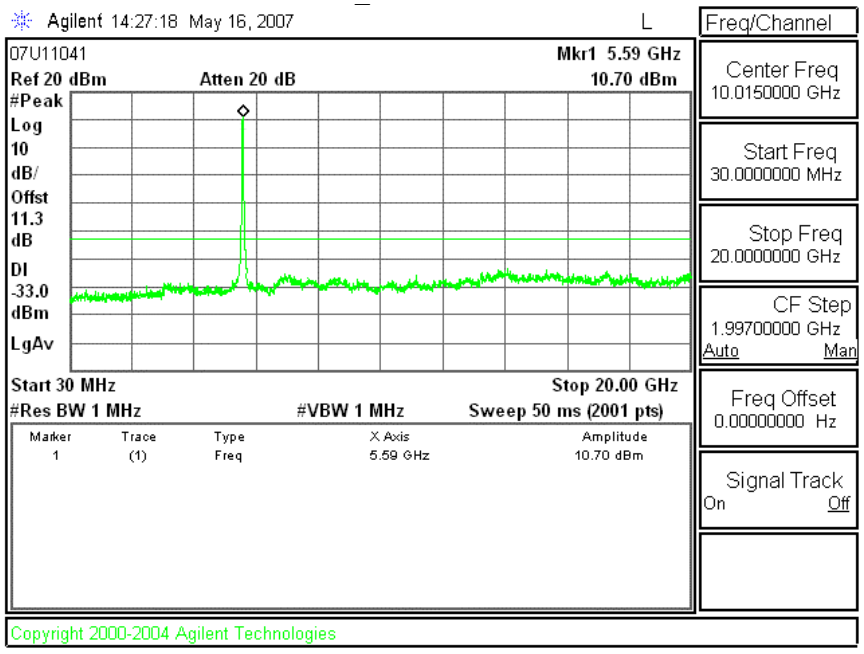
802.11n 40 MHz SISO MCS 32 MODE

SPURIOUS EMISSIONS

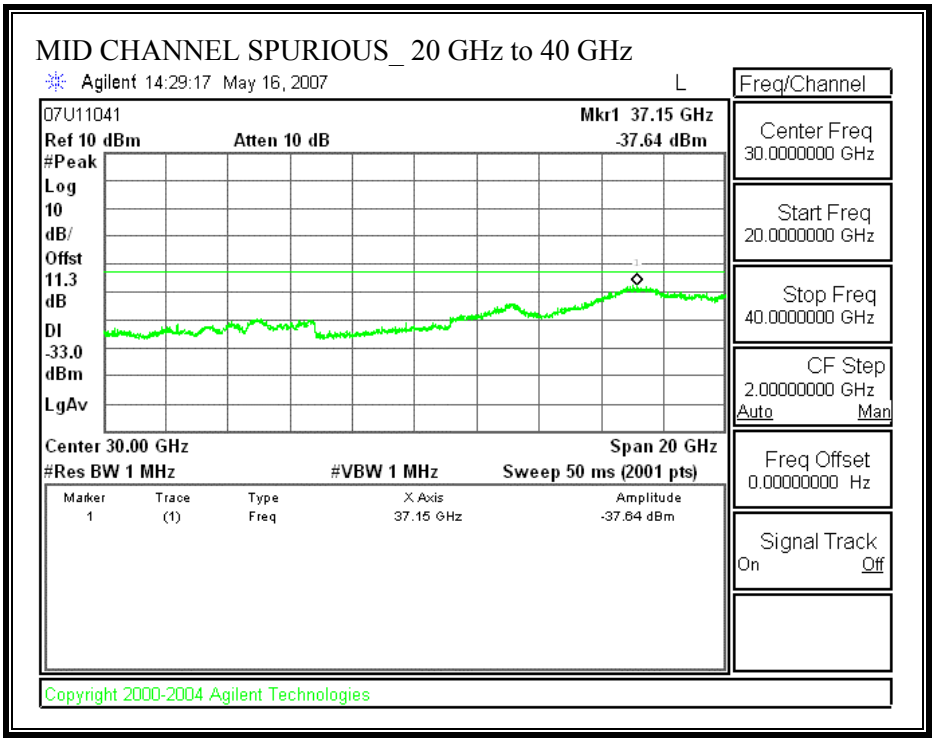


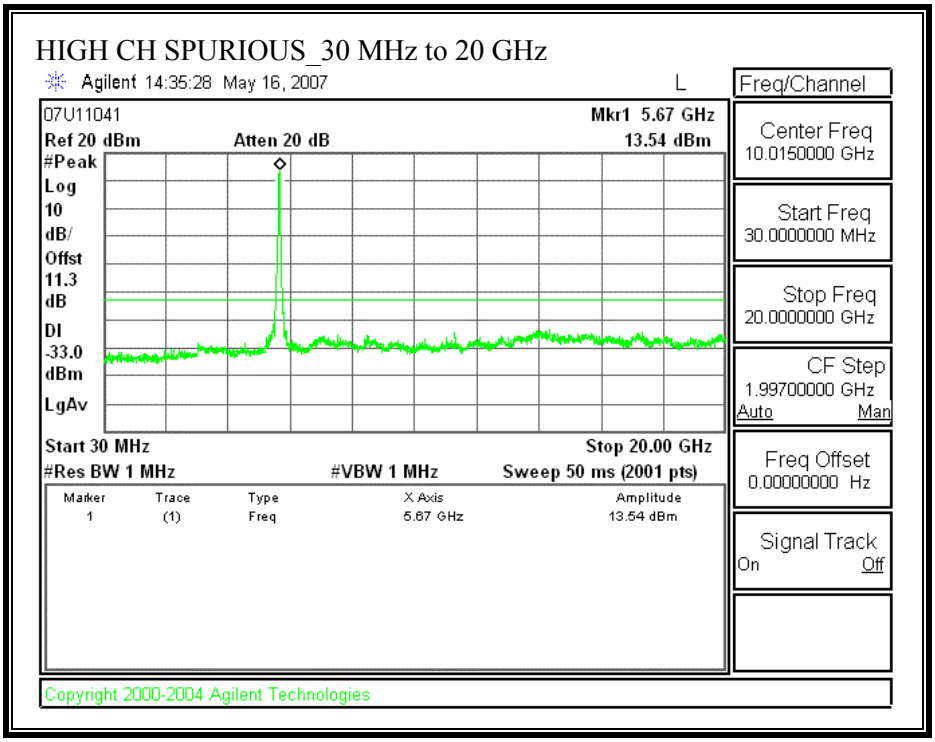


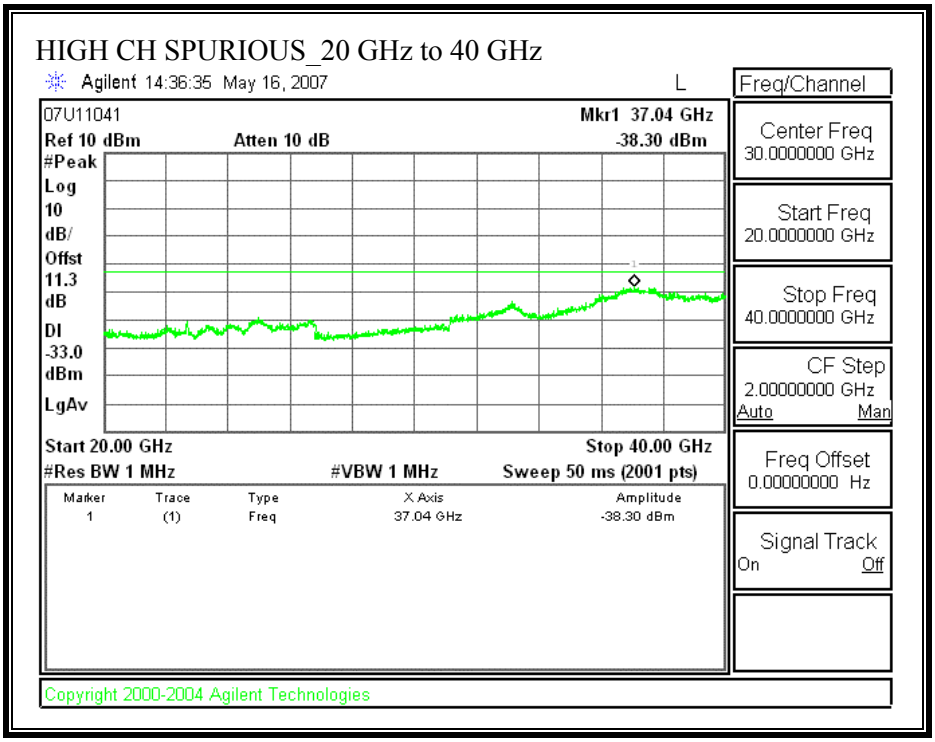
MID CHANNEL SPURIOUS_ 30 MHz to 20 GHz



MID CHANNEL SPURIOUS_ 20 GHz to 40 GHz







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	22.655	13.552
Middle	5560	23.011	13.619
High	5700	30.014	14.773

802.11 - 20 MHz Tx BANDWIDTH - CHAIN 1

Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5500	23.607	13.730
Middle	5560	26.739	14.271
High	5700	24.773	13.940

802.11n 40 MHz CDD MCS 32 MODE

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 0

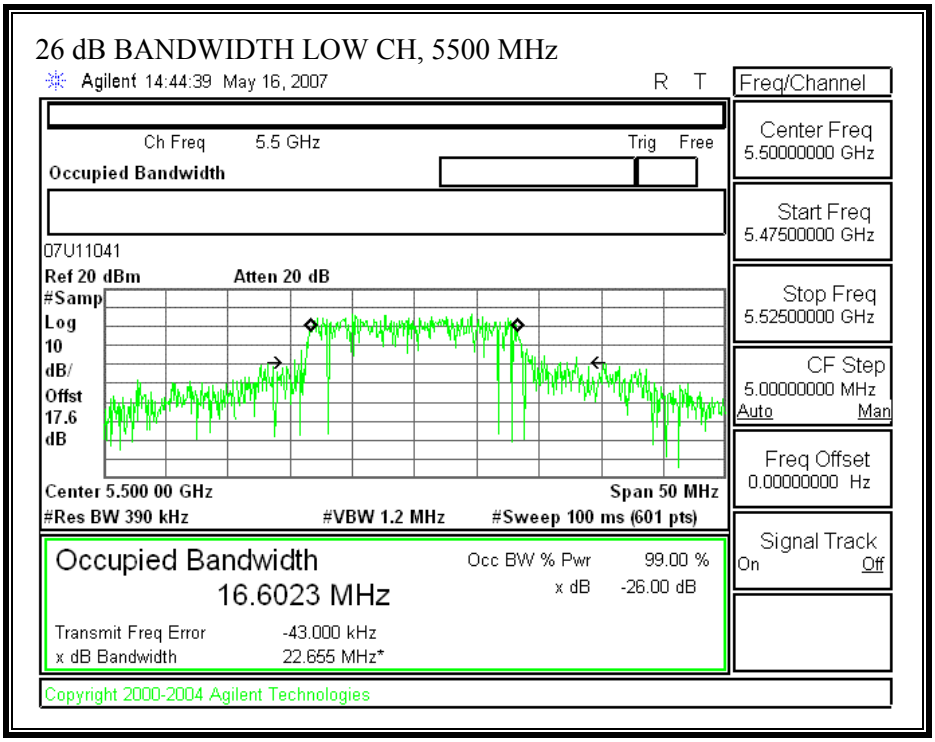
Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5510	38.925	15.902
Middle	5590	44.480	16.482
High	5670	47.317	16.750

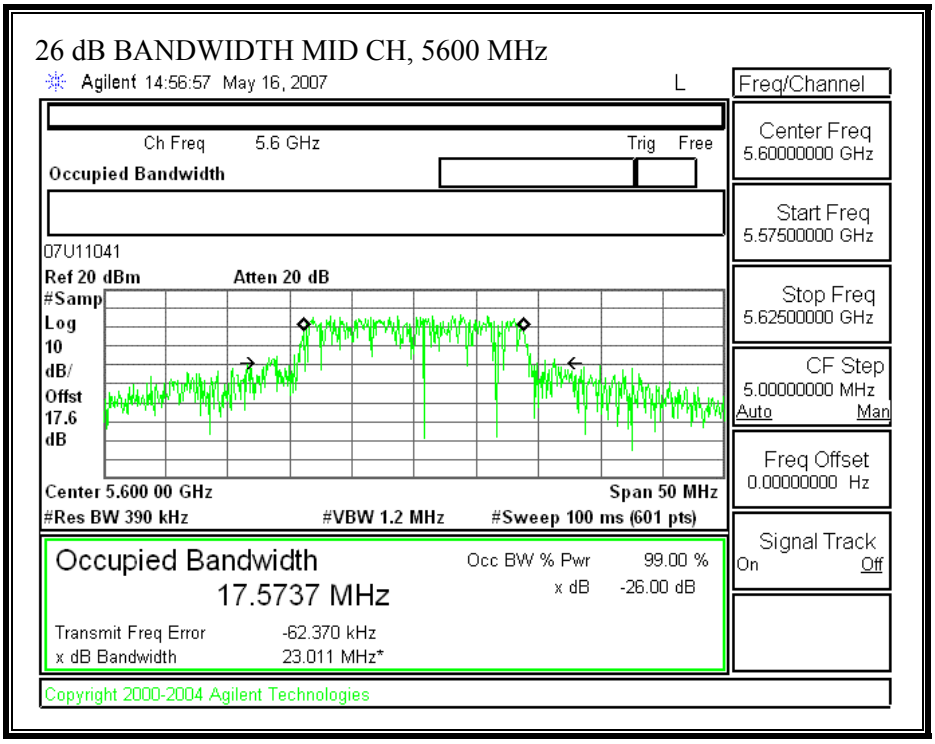
802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

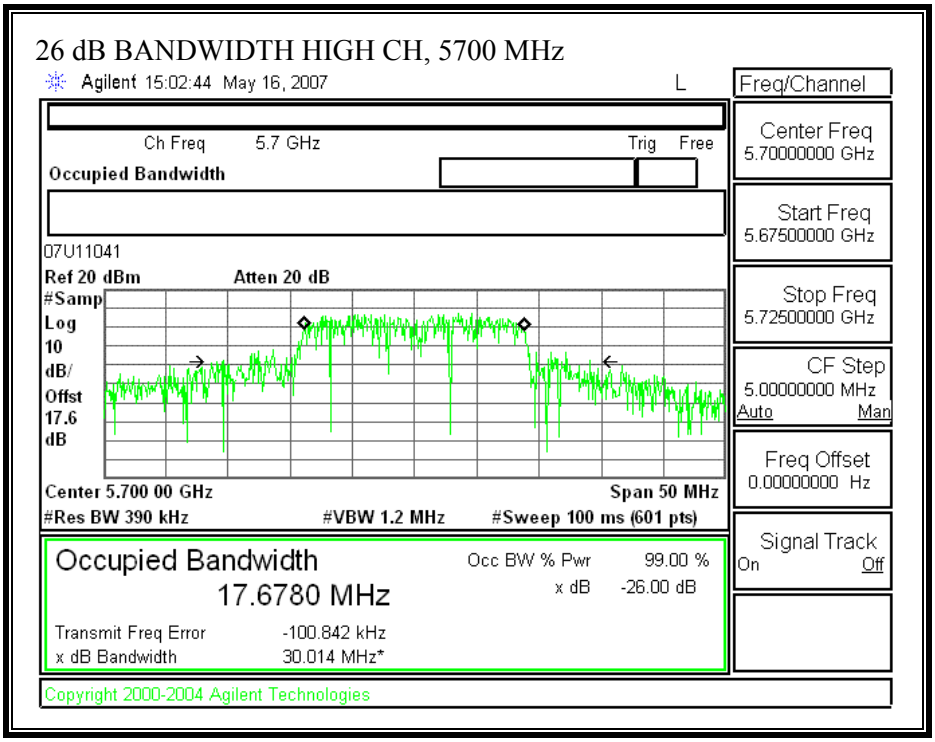
Channel	Frequency (MHz)	B (MHz)	10 Log B (dB)
Low	5510	38.118	15.811
Middle	5590	43.629	16.398
High	5670	44.396	16.473

802.11n 20 MHz CDD MCS 0

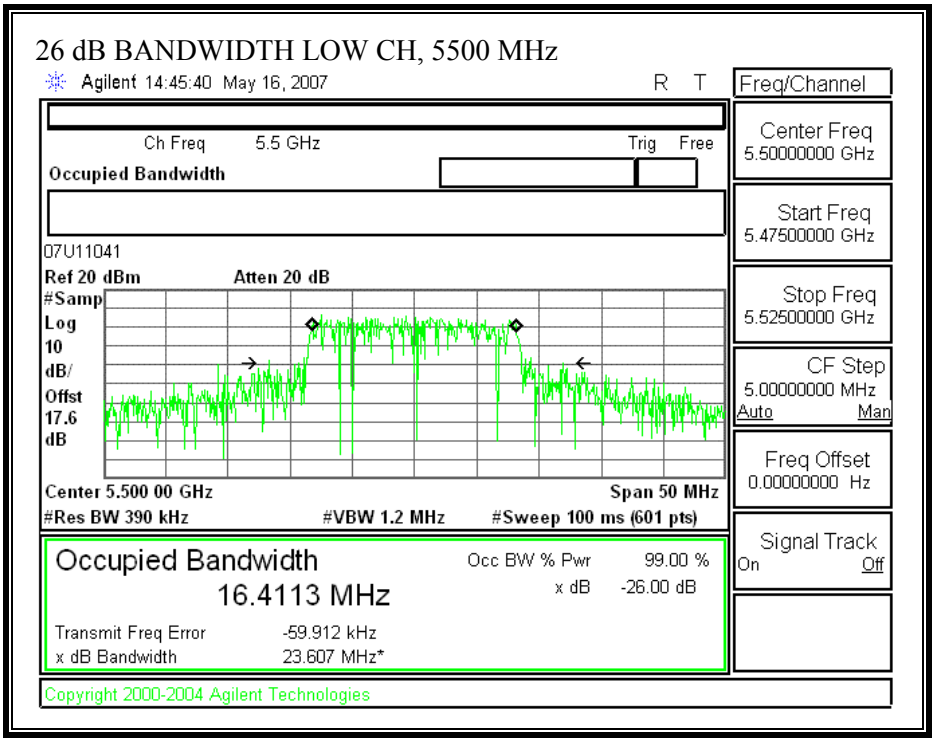
26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 0)

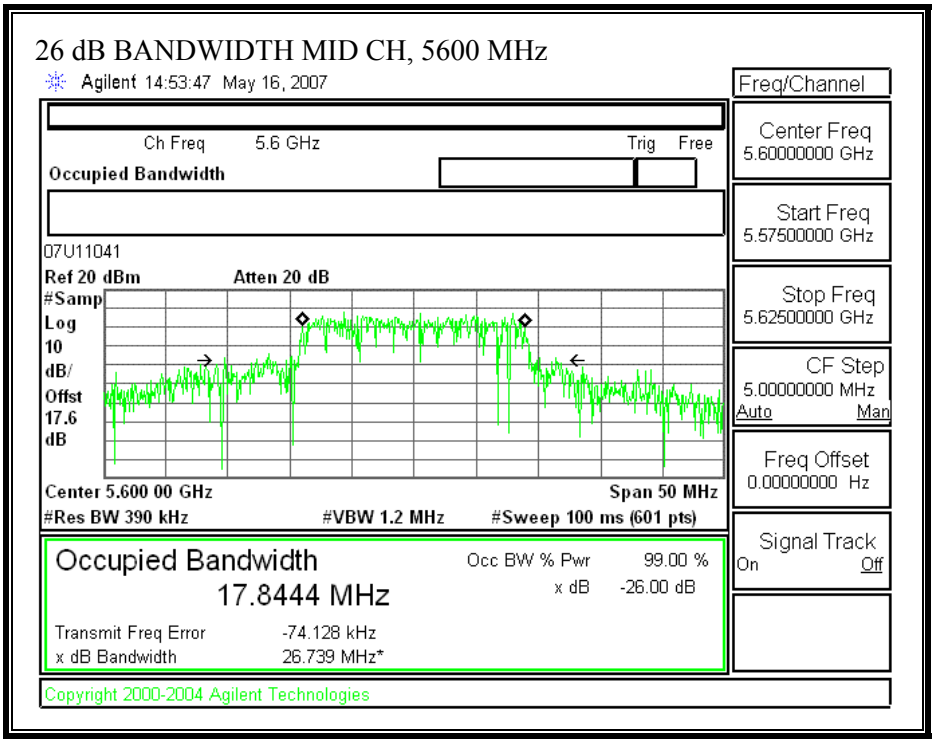


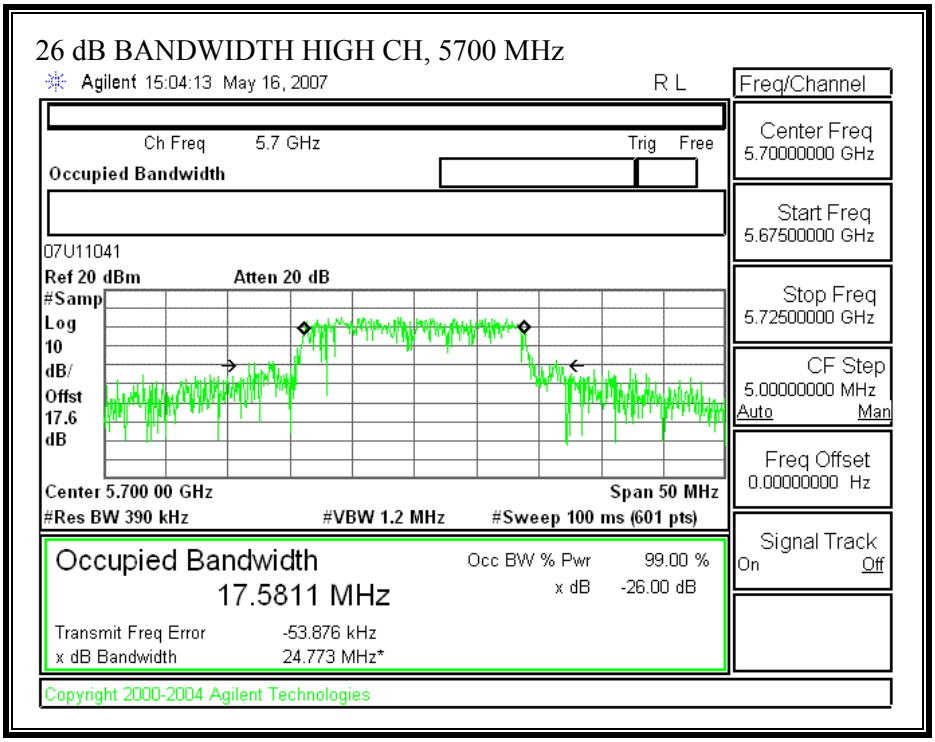




26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 1)







802.11n 40 MHz CDD MCS 32

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