

## 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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### **Revision History**

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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 SUBF	PART E NO NON-COMPLIANCE NOTED		

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

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

Approved & Released For CCS By:

Tested By:

MA

MICHAEL HECKROTTE ENGINEERING MANAGER COMPLIANCE CERTIFICATION SERVICES

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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 <u>http://www.ccsemc.com</u>.

# 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 2<sup>nd</sup> 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.

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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.

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# 5.3. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

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 wo	orst case 802.11a I	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 wo	orst case 802.11n 2	20 MHz CDD	
5190	802.11n 40MHz SDM	12.78	12.65	15.73	37.37

### 5150 to 5350 MHz Authorized Band

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 8.6	77 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	

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### 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 we	orst 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 we	orst 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

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## 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

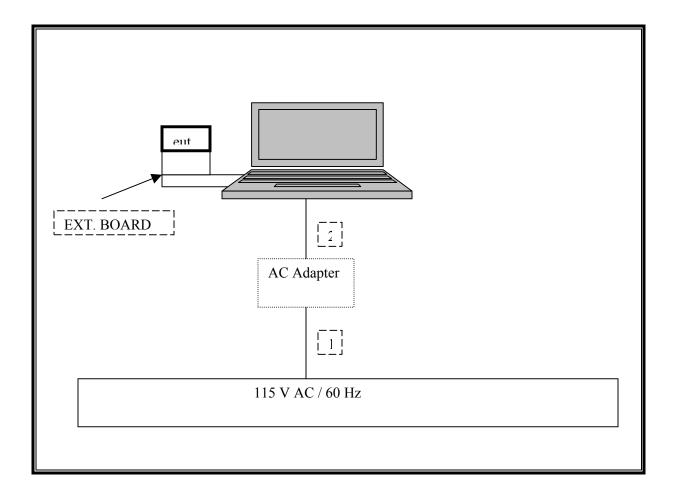
	I/O CABLE LIST							
Cable No.			Connector Type		Cable Length	Remarks		
1	AC	1	AC	Unshielded	1.2 m	N/A		
2	DC	1	DC	Unshielded	1.2 m	N/A		

### 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.

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#### SETUP DIAGRAM



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# 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			

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# 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) <u>Emission bandwidth</u>. 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.

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### **RESULTS**

No non-compliance noted:

#### 802.11a LEGACY MODE

Channel	Frequency	В	10 Log B
	(MHz)	(MHz)	(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

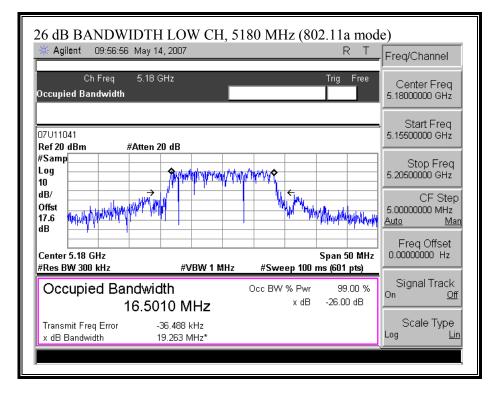
802.11a Mode

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

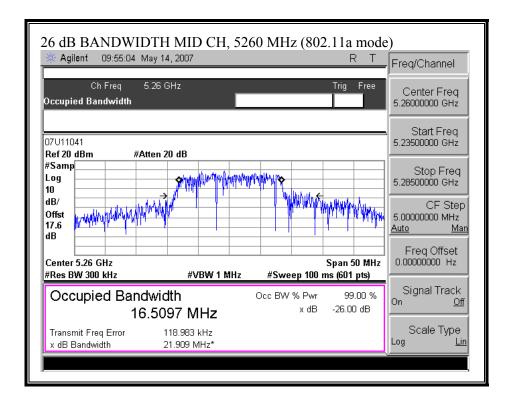
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#### 802.11a MODE

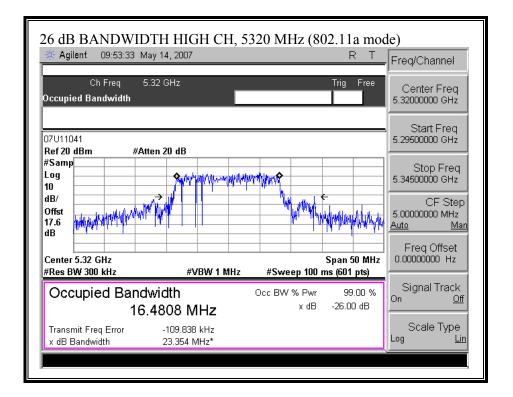
#### 26 dB EMISSION BANDWIDTH (802.11a MODE)



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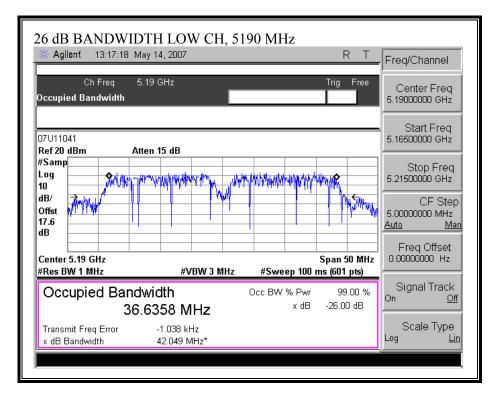
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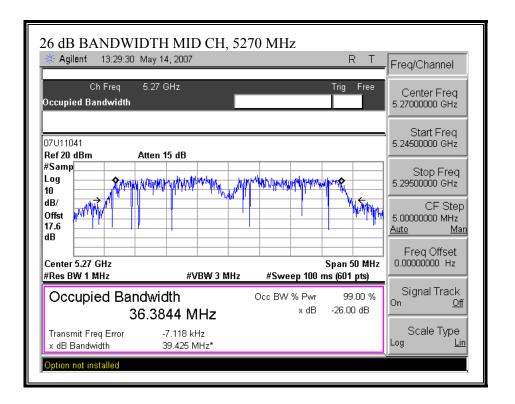
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#### 11n 40 MHz SISO MODE

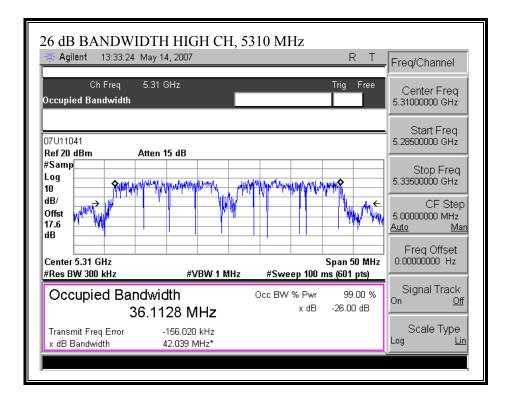
#### 26 dB EMISSION BANDWIDTH (802.11n 40MHz SISO MODE)



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## 7.1.2. PEAK POWER

### <u>LIMIT</u>

§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

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#### LIMITS AND RESULTS

No non-compliance noted:

#### 802.11a MODE

#### Limit in 5150 to 5250 MHz Band

Channel	Frequency	Fixed	В	4 + 10 Log	Antenna	Limit
		Limit		Limit	Gain	
	(MHz)	(dBm)	(MHz)	(dBm)	(dBi)	(dBm)
Low	5180	17	19.263	16.847	4.370	16.85

### Limit in 5250 to 5350 MHz Band

Channel	Frequency	Fixed	В	11 + 10	Antenna	Limit
		Limit		Limit	Gain	
	(MHz)	(dBm)	(MHz)	(dBm)	(dBi)	(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	Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(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	Fixed	В	4 + 10 Log	Antenna	Limit
		Limit		Limit	Gain	
	(MHz)	(dBm)	(MHz)	(dBm)	(dBi)	(dBm)
Low	5190	17	42.049	20.238	4.370	17.00

### Limit in 5250 to 5350 MHz Band

Channel	Frequency	Fixed	В	11 + 10	Antenna	Limit
		Limit		Limit	Gain	
	(MHz)	(dBm)	(MHz)	(dBm)	(dBi)	(dBm)
Mid	5270	24	39.425	26.958	6.230	23.77
High	5310	24	42.039	27.237	6.230	23.77

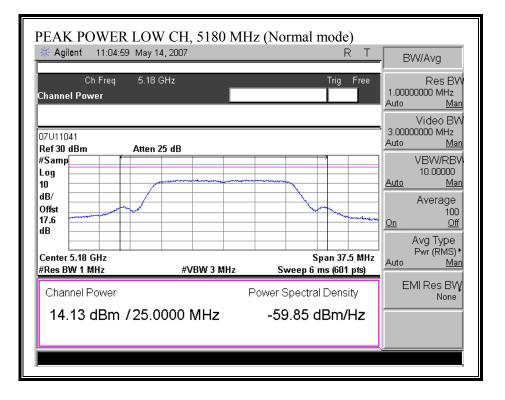
Results

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

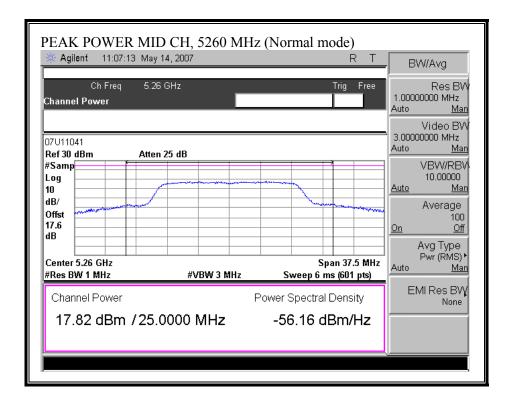
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#### 802.11a MODE

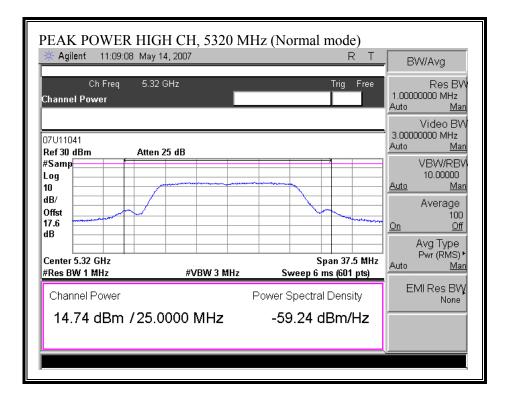
#### PEAK POWER (NORMAL MODE)



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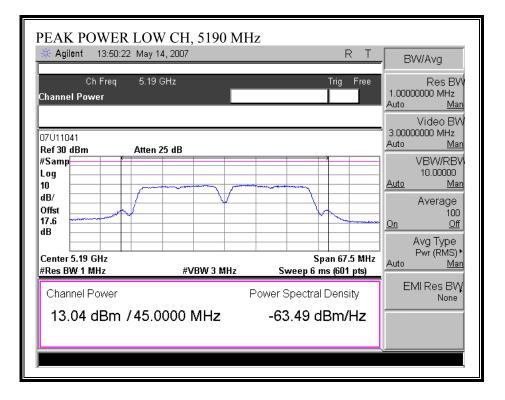
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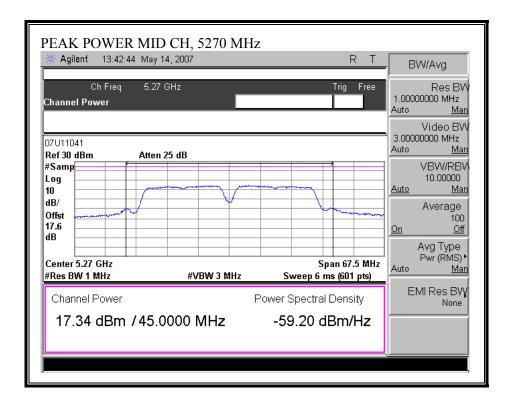
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#### 802.11n 40 MHz SISO MODE

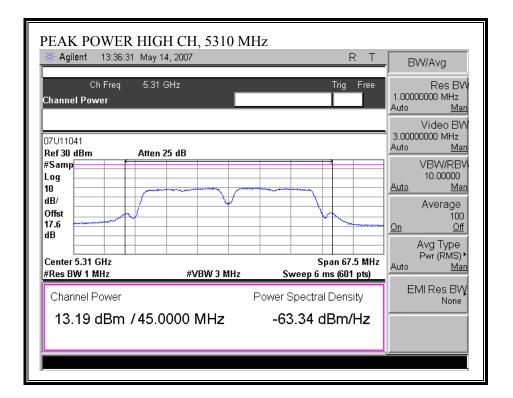
#### PEAK POWER (11n 40MHz SISO MODE)



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### 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.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm²)	Averaging time (minutes)	
(A) Limits for Occupational/Controlled Exposures					
0.3-3.0 3.0-30 30-300 300-1500 1500-100,000	614 1842/f 61.4	1.63 4.89/f 0.163	*(100) *(900/f²) 1.0 f/300 5	6 6 6 6	
(B) Limits	for General Populati	ion/Uncontrolled Exp	posure		
0.3–1.34 1.34–30	614 824/f	1.63 2.19/f	*(100) *(180/f <sup>2</sup> )	30 30	

TABLE 1-LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

#### 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/cm²)	Averaging time (minutes)
30–300 300–1500 1500–100,000	27.5	0.073	0.2 f/1500 1.0	30 30 30

f = frequency in MHz

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 exposure also apply in situations when an individual is transient through a location where occupational/controlled initis 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.

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#### 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 cmP = Power in dBmG = Antenna Gain in dBi $S = Power Density Limit in mW/cm^{2}$ 

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

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

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### <u>LIMITS</u>

From 1.1310 Table 1 (B), the maximum value of S = 1.0 mW/cm<sup>2</sup> in the 5.2 / 5.3 GHz band

#### **RESULTS**

No non-compliance noted

#### 802.11a LEGACY MODE

Mode	MPE	Output	Antenna	Power
	Distance	Power	Gain	Density
	(cm)	(dBm)	(dBi)	(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	Output	Antenna	Power
	Distance	Power	Gain	Density
	(cm)	(dBm)	(dBi)	(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

### <u>LIMIT</u>

§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

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### **RESULTS**

No non-compliance noted:

### <u>802.11a MODE</u>

802.11a Mode

Channel	Frequency	PPSD	Limit	Margin
	(MHz)	(dBm)	(dBm)	(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

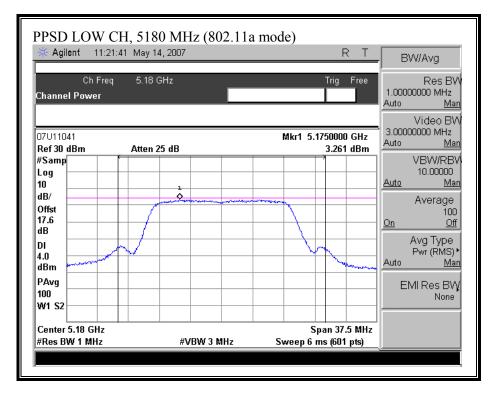
### 802.11n 40 MHz SISO MODE

802.11a Mode

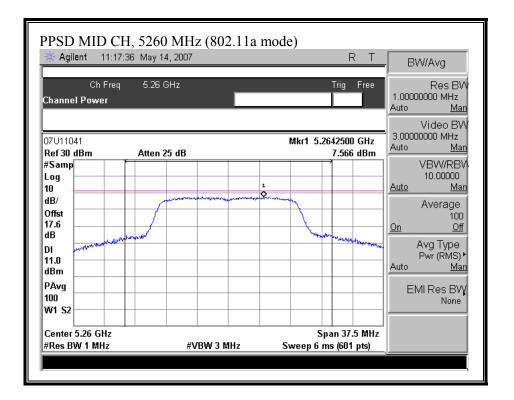
Channel	Frequency	PPSD	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	5190	-0.433	4.000	-4.43
Middle	5230	3.175	10.770	-7.60
High	5310	0.636	10.770	-10.13

#### 802.11a MODE

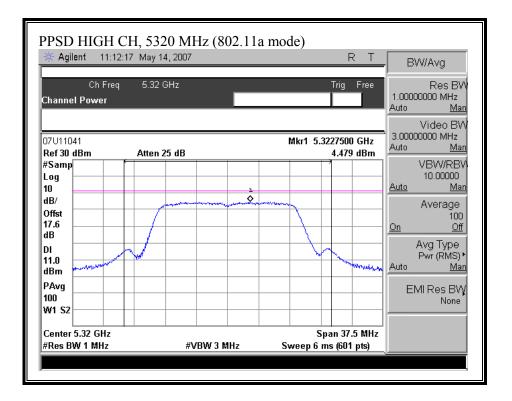
#### PEAK POWER SPECTRAL DENSITY (802.11a MODE)



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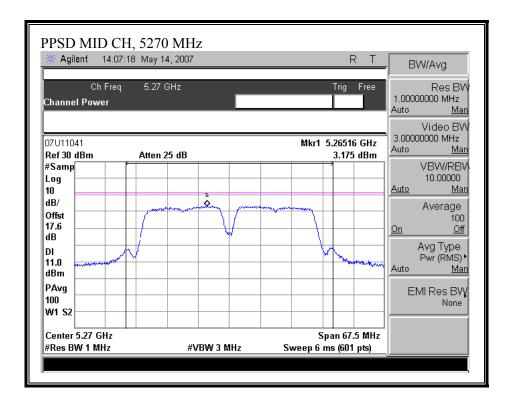
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#### 802.11n 40 MHz SISO MODE

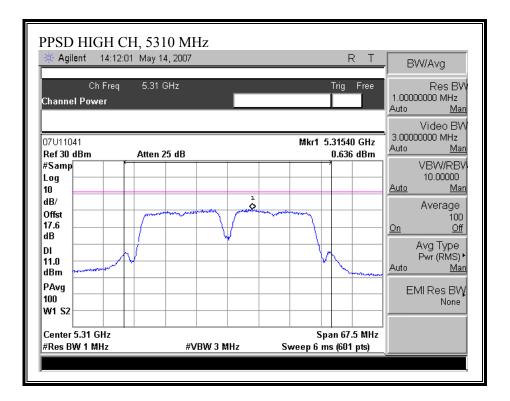
### PEAK POWER SPECTRAL DENSITY (802.11n 40MHz SISO MODE)



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# 7.1.5. PEAK EXCURSION

# <u>LIMIT</u>

§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.

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## **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

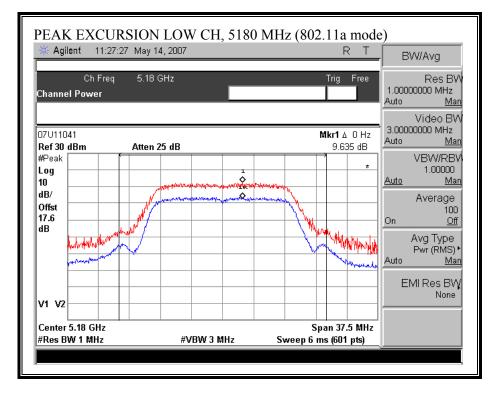
# 802.11n 40 MHz MODE

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

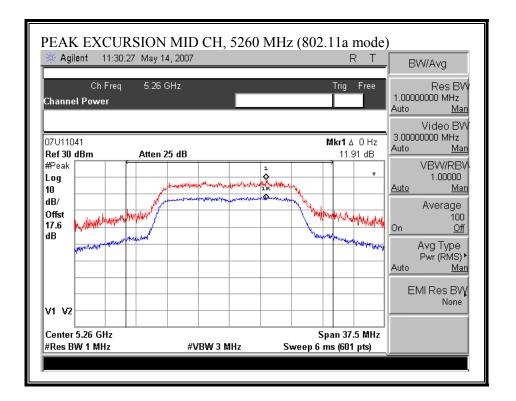
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#### 802.11a MODE

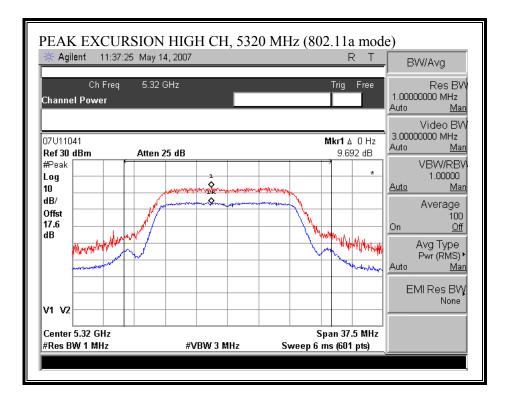
#### PEAK EXCURSION (802.11a MODE)



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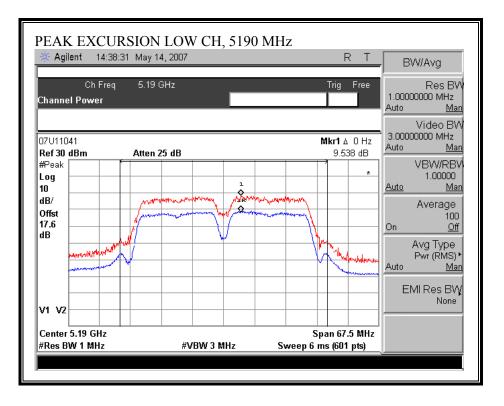
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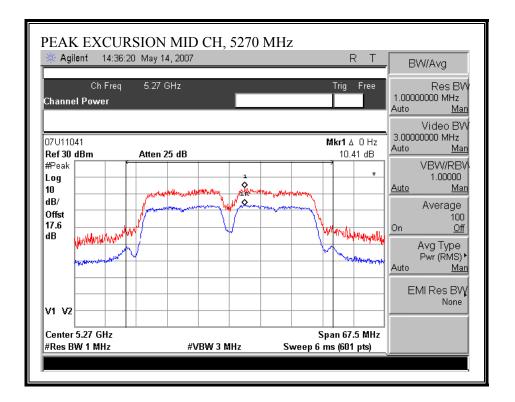
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#### 802.11n 40 MHz SISO MODE

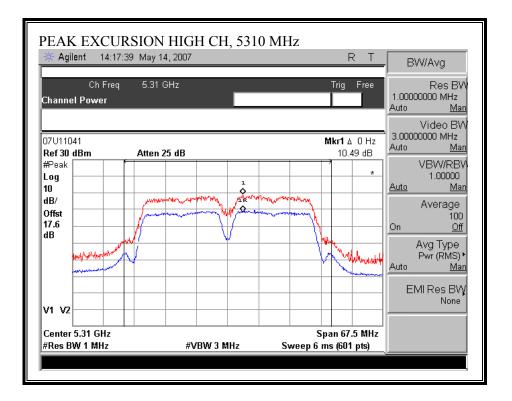
#### PEAK EXCURSION (802.11n 40MHz SISO MODE)



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# 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.

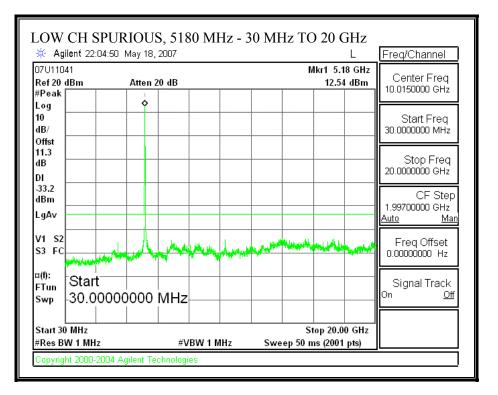
# **RESULTS**

No non-compliance noted:

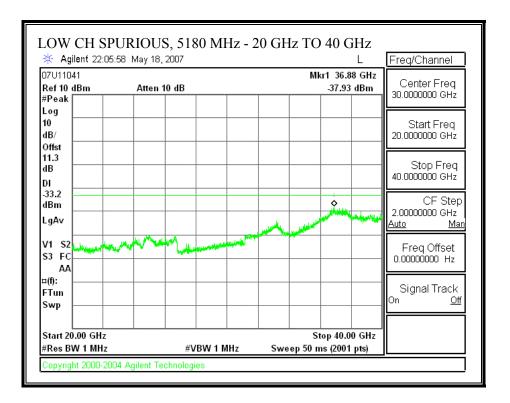
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#### 802.11a MODE

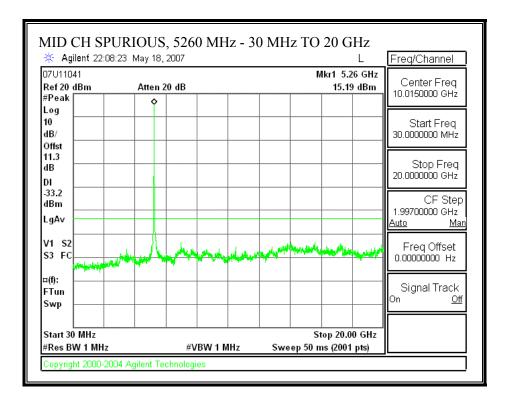
#### SPURIOUS EMISSIONS (802.11a MODE)



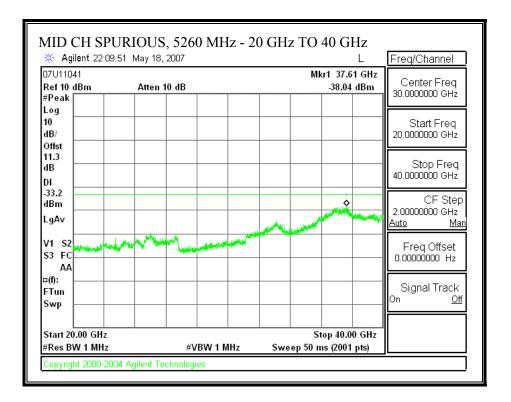
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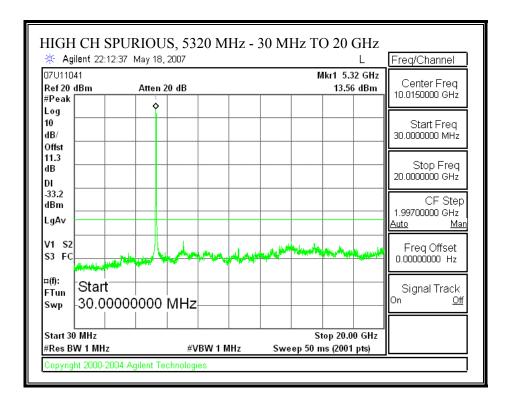
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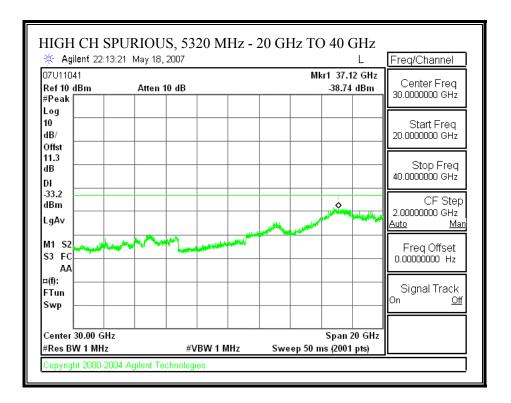
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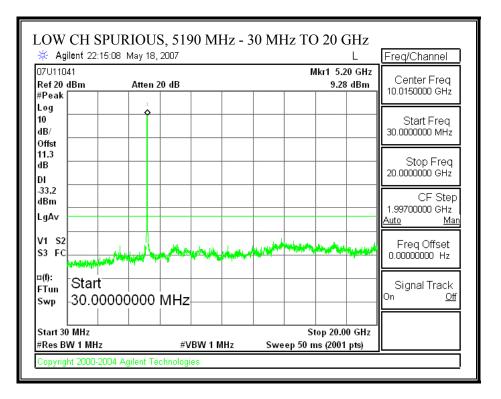
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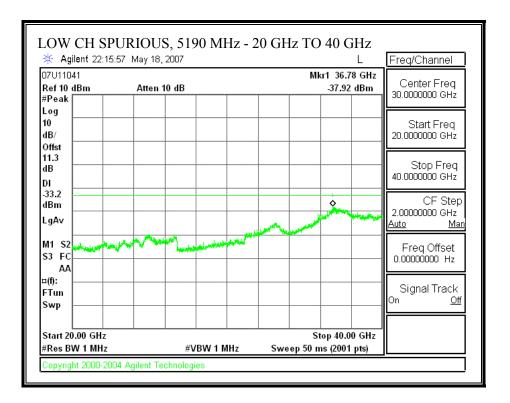
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#### 802.11n 40 MHz SISO MODE

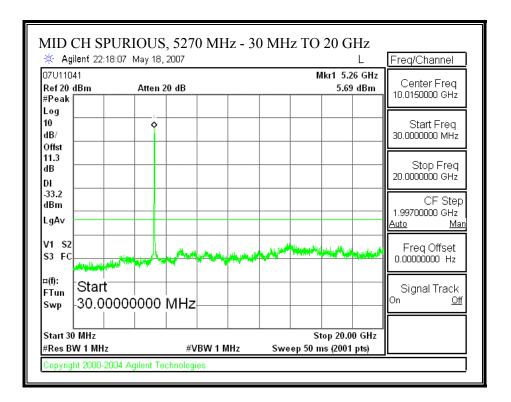
#### SPURIOUS EMISSIONS (802.11n 40MHz SISO MODE)



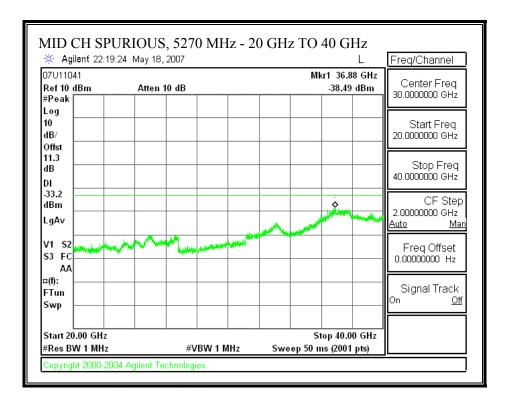
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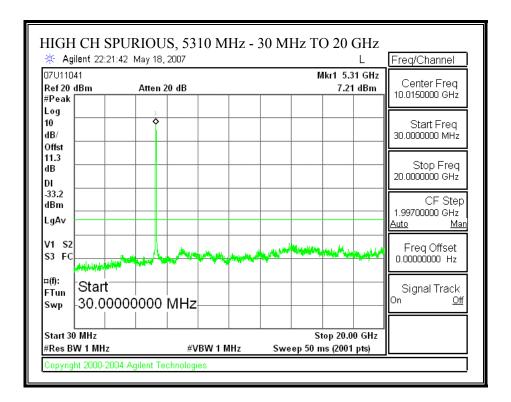
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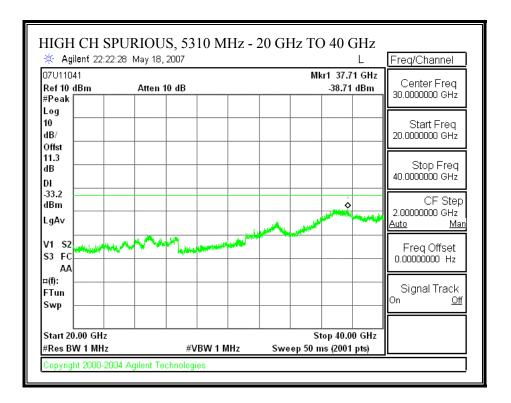
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# MIMO MODE

# 7.2. CHANNEL TESTS FOR THE 5150 TO 5350 MHz BAND

# 7.2.1. EMISSION BANDWIDTH

# LIMIT

§15.403 (i) <u>Emission bandwidth</u>. 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:

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

#### 802.11n 20 MHz CDD MCS 0

Channel	Frequency	В	10 Log B
	(MHz)	(MHz)	(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 0

#### 802.11 - 20 MHz Tx BANDWIDTH - CHAIN 1

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

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## 802.11n 40 MHz CDD MCS 32

802.11 - 40 MHz Tx BANDWIDTH - CHAIN 0

Channel	Frequency	В	10 Log B
	(MHz)	(MHz)	(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	В	10 Log B
	(MHz)	(MHz)	(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	В	10 Log B
	(MHz)	(MHz)	(dB)
Low	5190	43.780	16.413

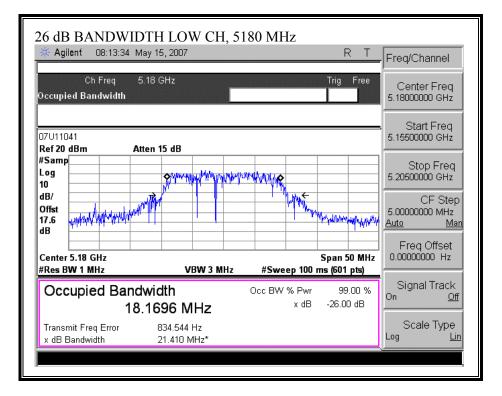
# 802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

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

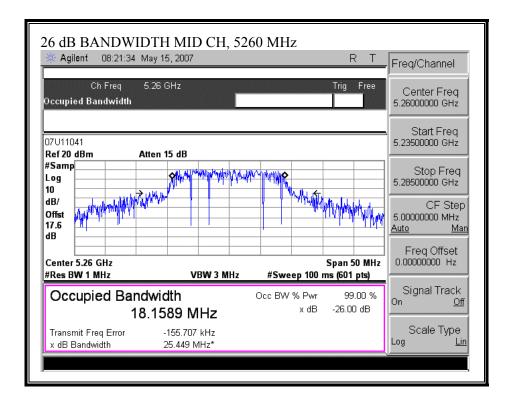
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#### 802.11n 20 MHz CDD MCS 0

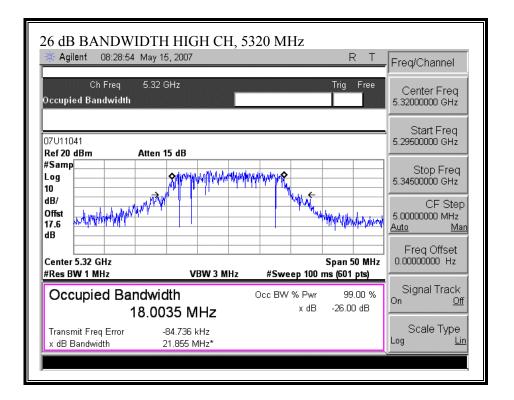
#### 26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 0)



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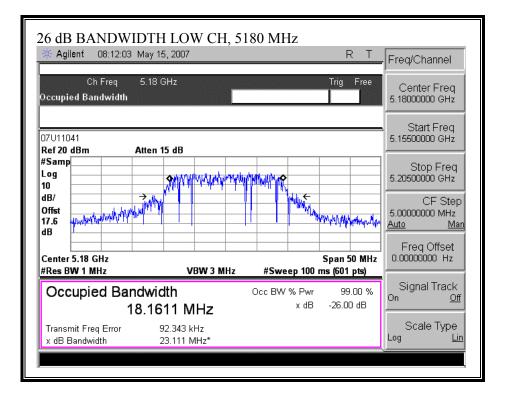


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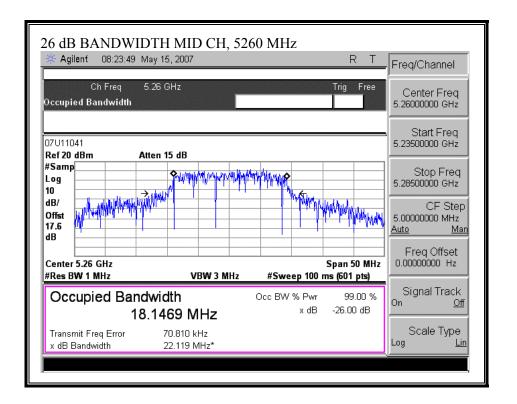


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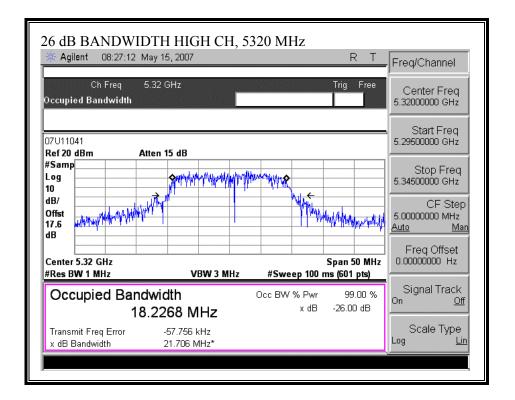
#### 26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 1)



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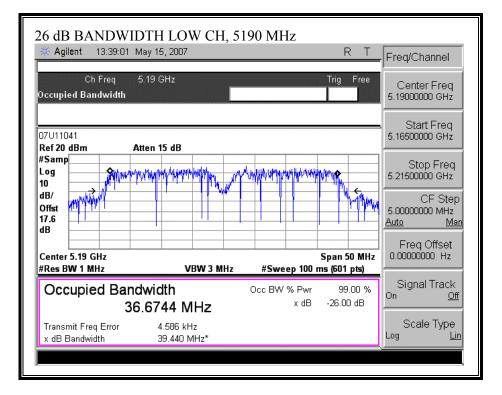
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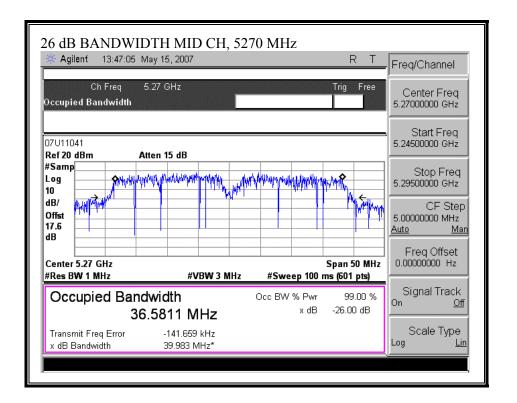
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#### 802.11n 40 MHz CDD MCS 32

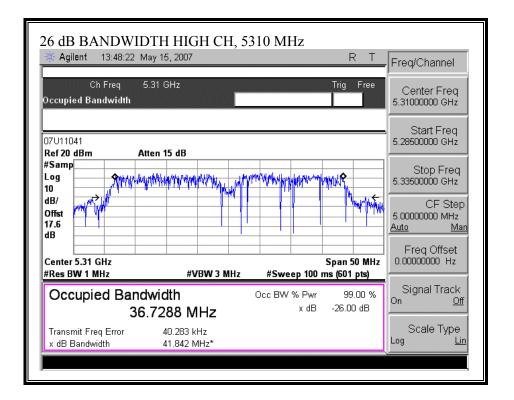
#### 26 dB EMISSION BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH- CHAIN 0)



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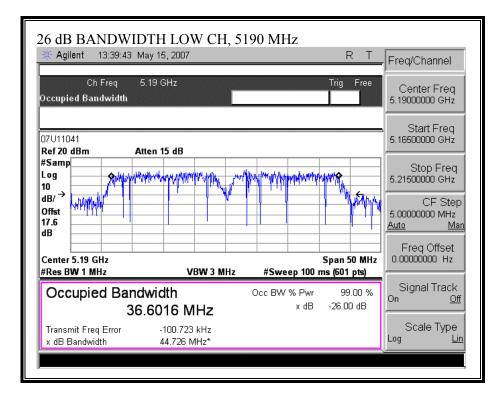


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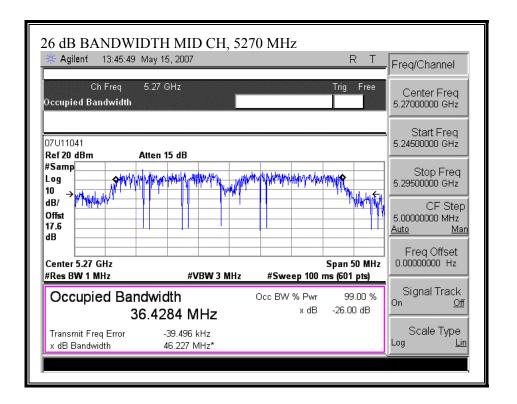


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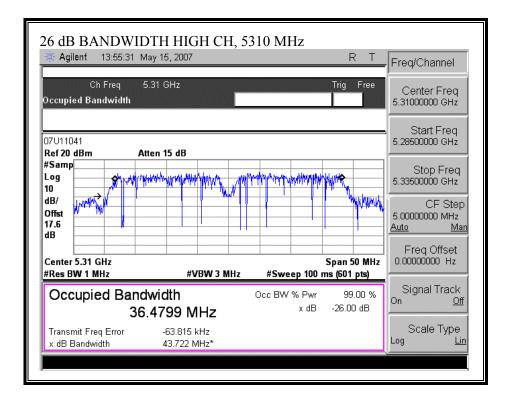
#### 26 dB EMISSION BANDWIDTH (802.11 - 40 MHz TX BANDWIDTH- CHAIN 1)



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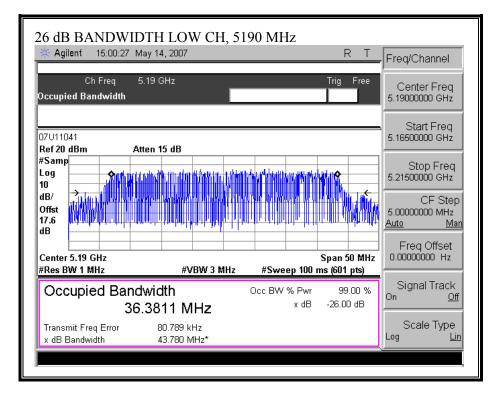
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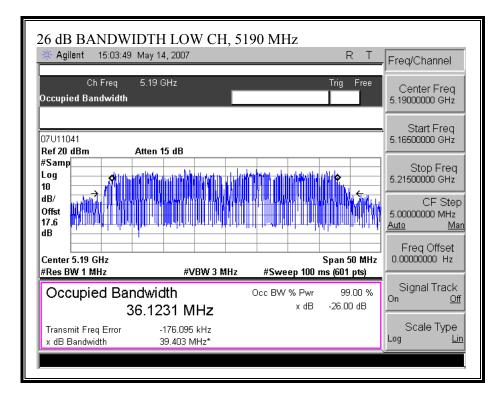
### 802.11n 40 MHz SDM MCS 15

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



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



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# 7.2.2. PEAK POWER

## <u>LIMIT</u>

§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

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### 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	Fixed	В	В	4 + 10 Log B	Antenna	Limit
		Limit	Chain 0	Chain 1	Limit	Gain	
	(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(dBm)
Low	5180	17	21.410	23.111	17.306	7.077	15.923

### Limit in 5250 to 5350 MHz Band

Channel	Frequency	Fixed	В	В	11 + 10 Log B	Antenna	Limit
		Limit			Limit	Gain	
	(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(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

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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	Fixed	В	В	4 + 10 Log B	Antenna	Limit
		Limit	Chain 0	Chain 1	Limit	Gain	
	(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(dBm)
Low	5180	17	21.410	23.111	17.306	6.00	17.00

## Limit in 5250 to 5350 MHz Band

Channel	Frequency	Fixed	В	В	11 + 10 Log B	Antenna	Limit
		Limit			Limit	Gain	
	(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(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	Power	Power	Total	Limit	Margin
	(MHz)	Chain 0	Chain 1	Power	(dBm)	(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

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### 802.11n 40 MHz CDD MCS 32

## 7.077dBi for low band & 8.677dBi for high band

_1		130 to 3230 lv	ITZ Danu					
	Channel	Frequency	Fixed	В	В	4 + 10 Log B	Antenna	Limit
			Limit	Chain 0	Chain 1	Limit	Gain	
		(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(dBm)
	Low	5190	17	39.440	44.726	19.959	7.077	15.923

## Limit in 5150 to 5250 MHz Band

## Limit in 5250 to 5350 MHz Band

Channel	Frequency	Fixed	В	В	11 + 10 Log B	Antenna	Limit
		Limit	Chain 0	Chain 1	Limit	Gain	
	(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(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

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#### <u>6dBi Antenna</u>

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	Fixed	В	В	4 + 10 Log B	Antenna	Limit
		Limit	Chain 0	Chain 1	Limit	Gain	
	(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(dBm)
Low	5190	17	39.440	44.726	19.959	6.00	17.00

Results

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

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### 802.11n 40 MHz SDM MCS 15

Limit in 5150 to 5250 MHz Band

Channel	Frequency	Fixed	В	В	4 + 10 Log B	Antenna	Limit
		Limit	Chain 0	Chain 1	Limit	Gain	
	(MHz)	(dBm)	(MHz)	(MHz)	(dBm)	(dBi)	(dBm)
Low	5190	17	43.780	39.403	19.955	6.23	16.77

Results

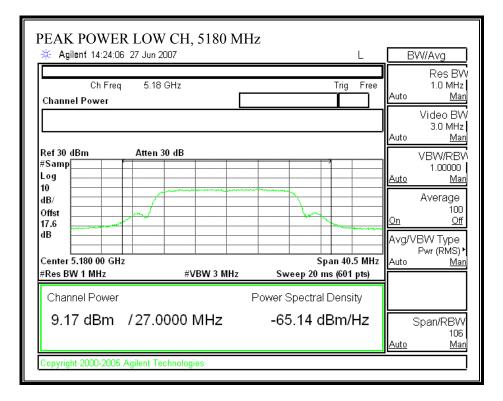
Channel	Frequency	Power	Power	Total	Limit	Margin
	(MHz)	Chain 0	Chain 1	Power	(dBm)	(dB)
		(dBm)	(dBm)	(dBm)		
Low	5190	12.78	12.65	15.73	16.77	-1.04

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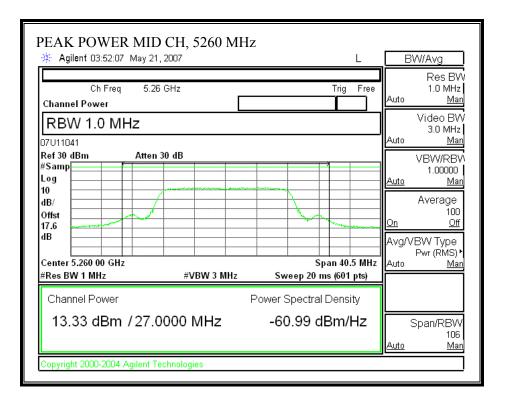
#### 802.11n 20 MHz CDD MCS 0

#### 8.677dBi Antenna

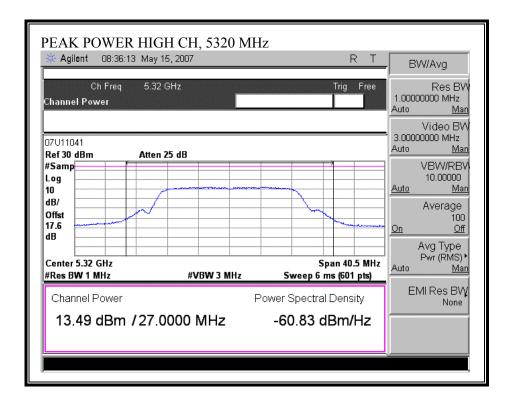
#### PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 0)



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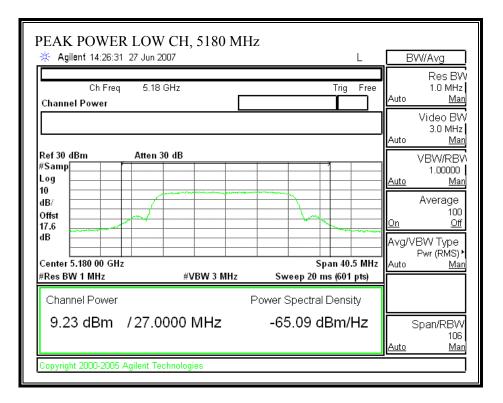


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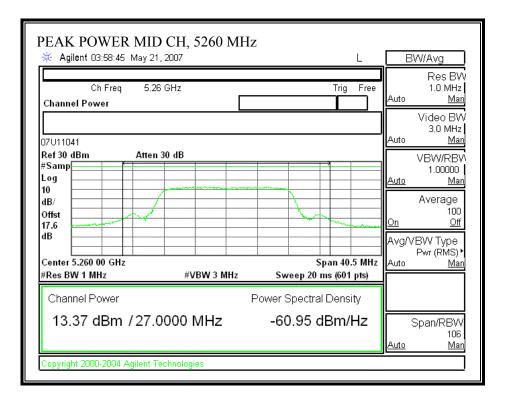


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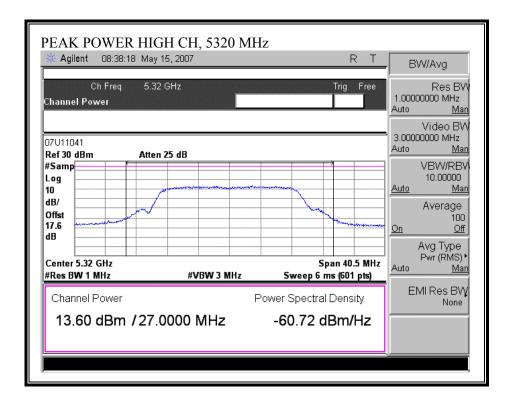
### PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 1)



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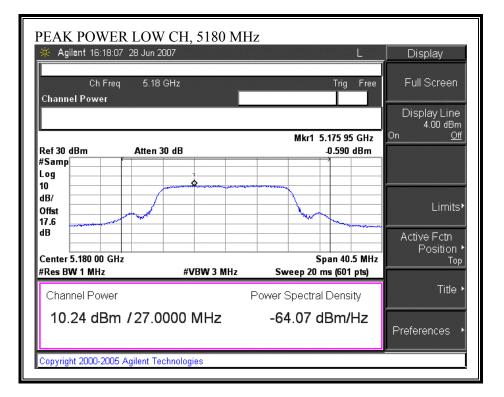
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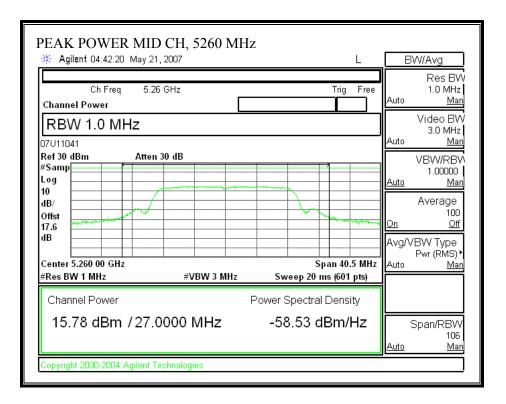
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#### <u>6dBi Antenna</u>

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

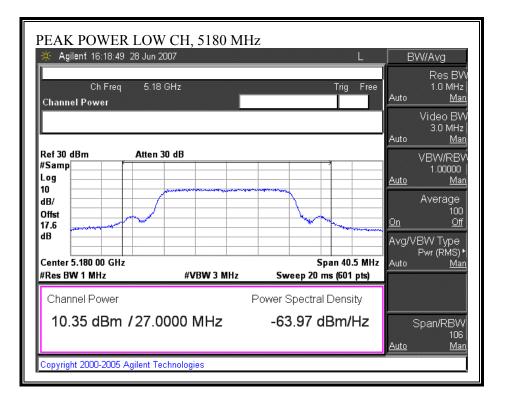


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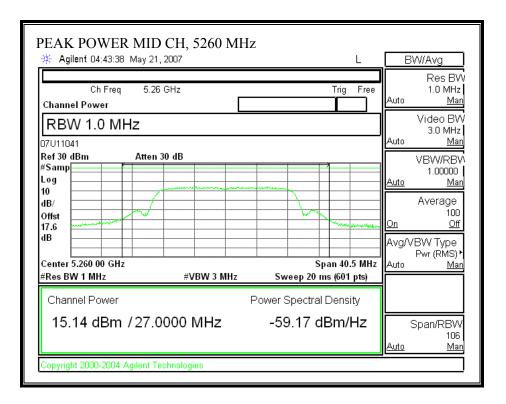


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### PEAK POWER (802.11 – 20MHz TX BANDWIDTH – CHAIN 1)



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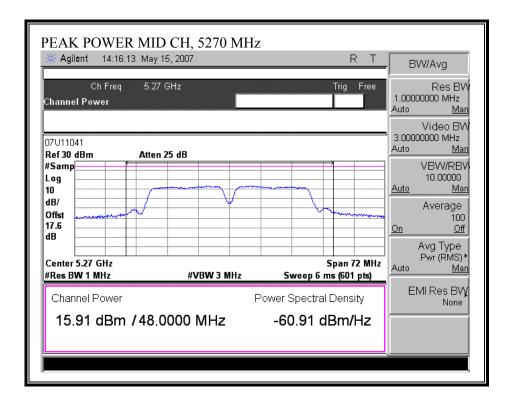
#### 802.11n 40 MHz CDD MCS 32

#### 8.677dBi antenna

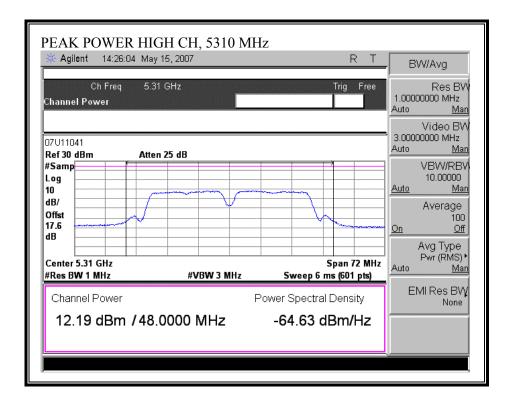
#### PEAK POWER (802.11 - 40MHz TX BANDWIDTH - CHAIN 0)

Agilent 00:15:32 May 18,	2007			BW/Avg
Ch Freq 5.19 Channel Power	GHz	Trig	Free Auto	Res BV 1.0 MHz Mar Video BV
)7U11041			Auto	3.0 MHz
Ref 30 dBm Atten #Samp	30 dB		Auto	VBW/RB\ 1.00000 <u>Mai</u>
dB/ Dffst 17.6			<u>On</u>	Average 100 <u>Off</u>
dB		•	72 MHz Auto	/VBW Type Pwr (RMS) <sup>(</sup> <u>Mai</u>
Channel Power	#VBW 3 MHz	Sweep 20 ms (601	pts)	1910
10.33 dBm / 48.0		Power Spectral Dens -66.48 dBm/		Span/RBV 106 Ma

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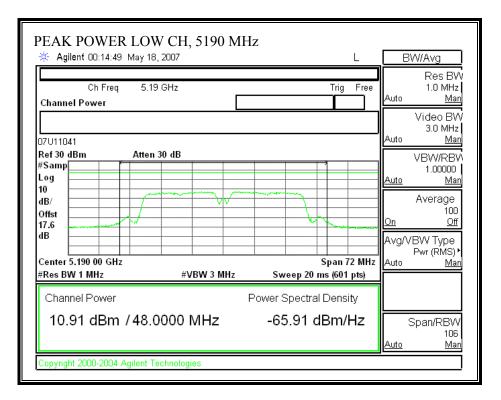


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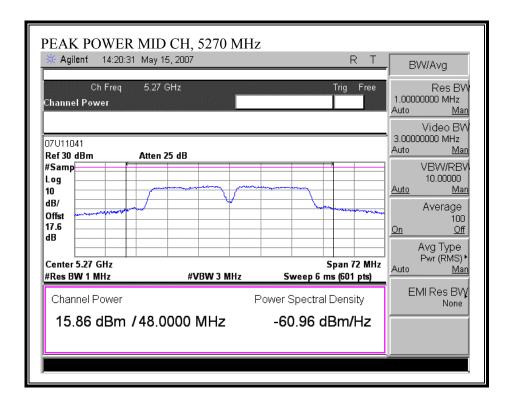


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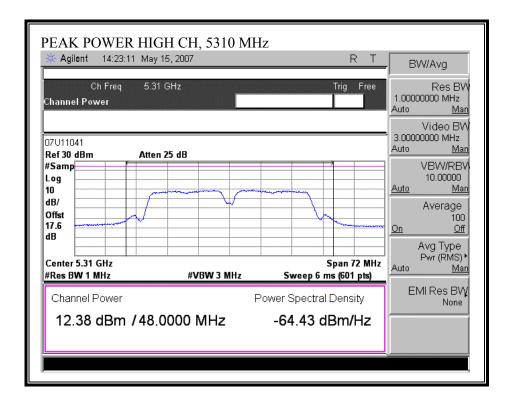
#### PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 1)



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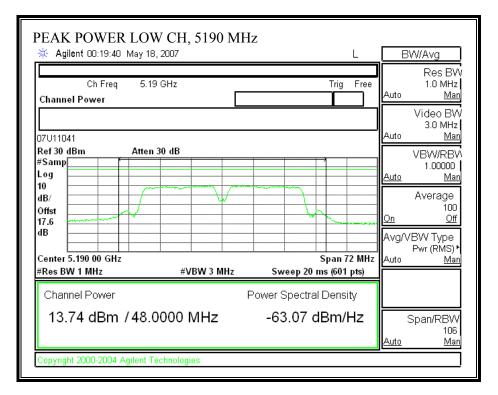
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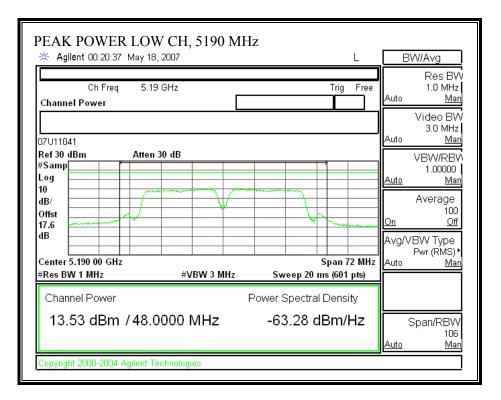
#### <u>6dBi antenna</u>

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



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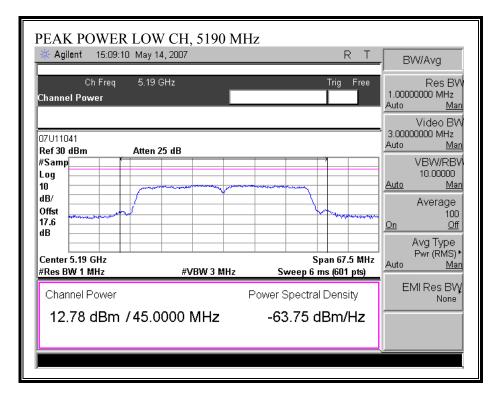
#### PEAK POWER (802.11 – 40MHz TX BANDWIDTH – CHAIN 1)



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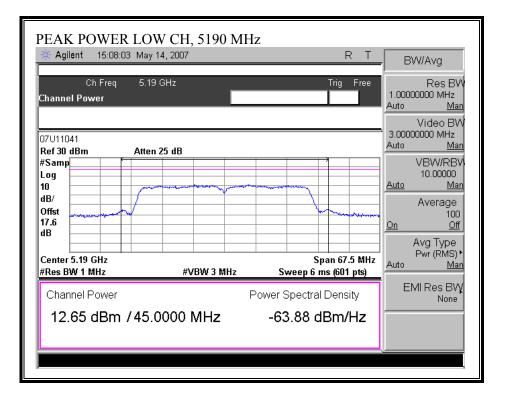
#### 802.11n 40 MHz SDM MCS 15

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



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



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## 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.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm²)	Averaging time (minutes)		
(A) Limits for Occupational/Controlled Exposures						
0.3-3.0 3.0-30 30-300 300-1500 1500-100,000	614 1842/f 61.4	1.63 4.89/f 0.163	*(100) *(900/f²) 1.0 f/300 5	6 6 6 6		
(B) Limits for General Population/Uncontrolled Exposure						
0.3–1.34 1.34–30	614 824/f	1.63 2.19/f	*(100) *(180/f <sup>2</sup> )	30 30		

TABLE 1-LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

#### 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/cm²)	Averaging time (minutes)
30–300 300–1500 1500–100,000	27.5	0.073	0.2 f/1500 1.0	30 30 30

f = frequency in MHz

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 exposure also apply in situations when an individual is transient through a location where occupational/controlled initis 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.

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# 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:

 $P(mW) = 10^{(Bm)} / 10)$  and  $G(numeric) = 10^{(G(dBi))} / 10)$ 

yields

 $d = 0.282 * 10^{(P+G)/20} / \sqrt{S}$ where d = MPE distance in cmP = Power in dBmG = Antenna Gain in dBi $S = Power Density \text{ Limit in } mW/cm^{2}$ 

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

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

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# **LIMITS**

From 1.1310 Table 1 (B), the maximum value of S = 1.0 mW/cm<sup>2</sup> 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	Total	Antenna	Power
	Distance	Power	Gain	Density
	(cm)	(dBm)	(dBi)	(mW/cm^2)
802.11n 20 MHz CDD	20.0	16.56	8.677	0.07

## 6dBi Antenna

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

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# 802.11n 40 MHz CDD

Mode	MPE	Total	Antenna	Power
	Distance	Power	Gain	Density
	(cm)	(dBm)	(dBi)	(mW/cm^2)
802.11n 40 MHz CDD	20.0	18.90	8.677	0.11

#### 6dBi Antenna

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

#### 802.11n 40 MHz SDM

Mode	MPE	Total	Antenna	Power
	Distance	Power	Gain	Density
	(cm)	(dBm)	(dBi)	(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.

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# 7.2.4. PEAK POWER SPECTRAL DENSITY

# <u>LIMIT</u>

§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

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# 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.

Channel	Frequency	PPSD Chain 0	PPSD Chain 1	PPSD Total	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dBm)	(dBm)	(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 (7.077 / 8.677dBi antenna)

# 802.11n 20 MHz CDD (6dBi antenna)

Channel	Frequency	PPSD	PPSD	<b>PPSD</b> Total	Limit	Margin
		Chain 0	Chain 1			
	(MHz)	(dBm)	(dBm)	(dBm)	(dBm)	(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	<b>PPSD</b> Total	Limit	Margin
	(MHz)	(dBm)	(dBm)	(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	<b>PPSD</b> Total	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	5180	3.812	4.000	-0.188
Middle	5260	9.175	11.000	-1.825

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## 802.11n 40 MHz CDD MODE

## 802.11n 40 MHz CDD

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

# 802.11n 40 MHz SDM - COMBINER

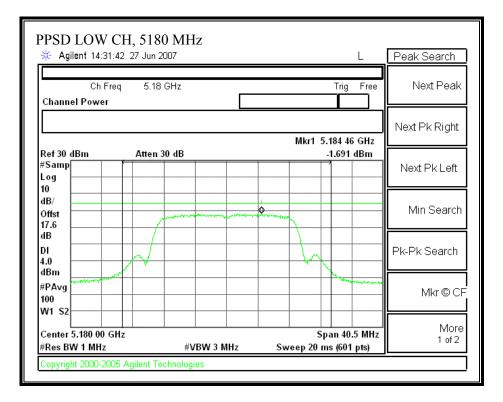
Channel	Frequency	<b>PPSD</b> Total	Limit	Margin
	(MHz)	(dBm)	(dBm)	(dB)
Low	5190	3.143	4.00	-0.86

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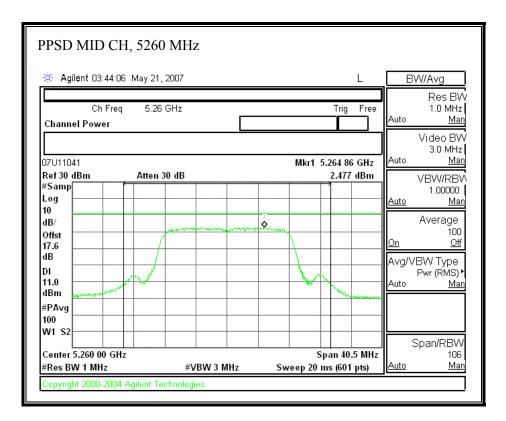
#### 802.11n 20 MHz CDD MCS 0

#### 8.677dBi Antenna Gain

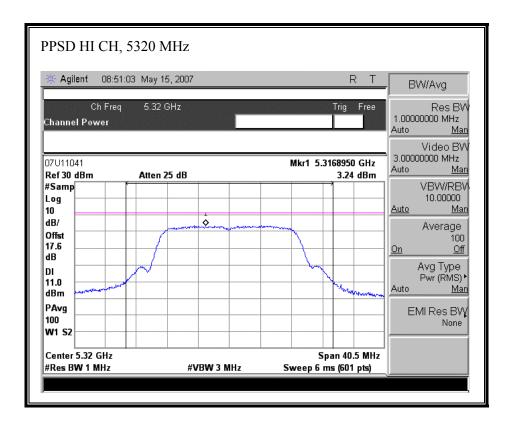
### PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH - CHAIN 0)



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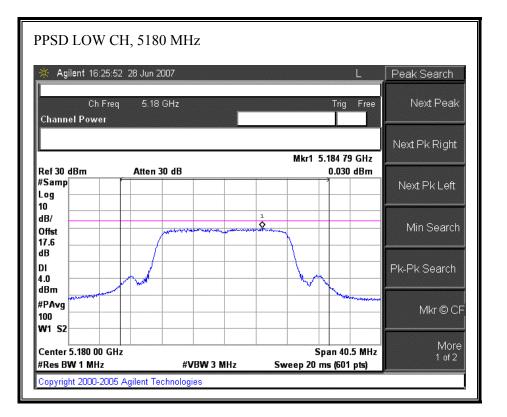


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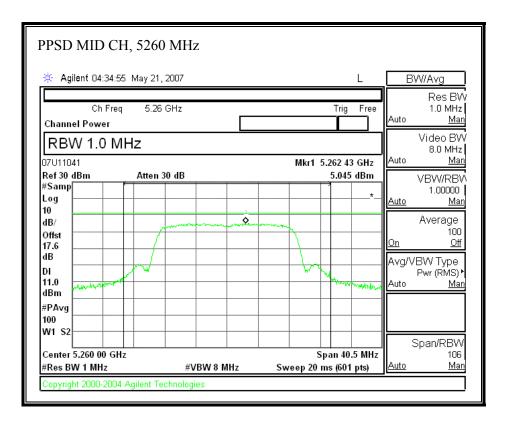


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#### 6dBi Antenna



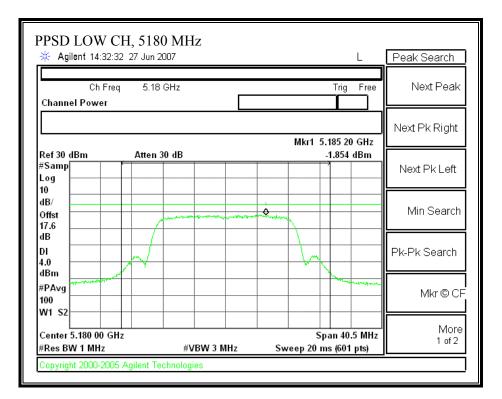
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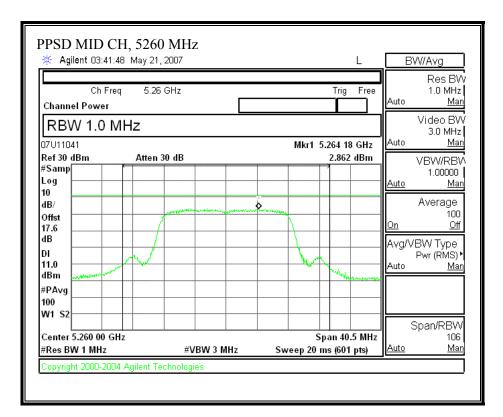
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#### 8.677dBi Antenna Gain

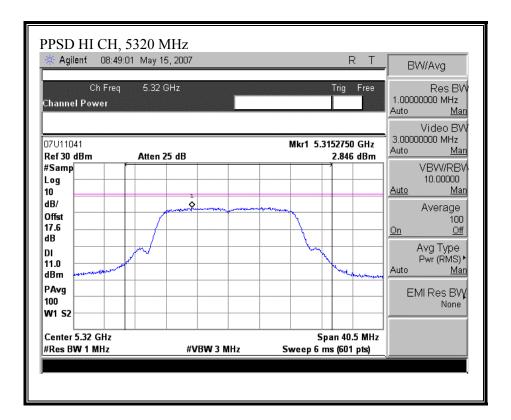
## PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH - CHAIN 1)



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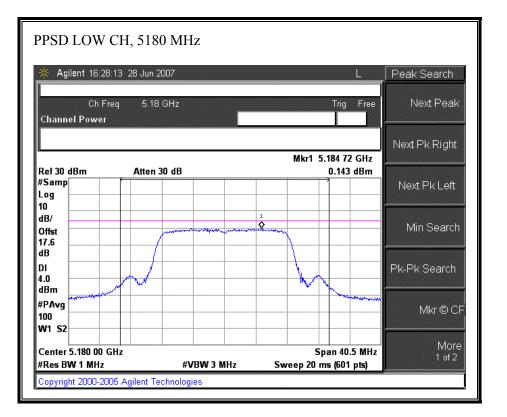


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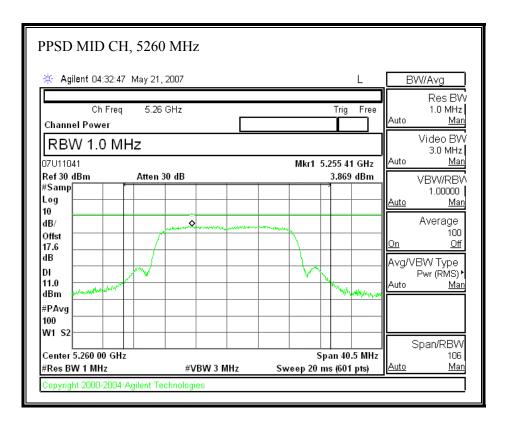


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#### 6dBi Antenna



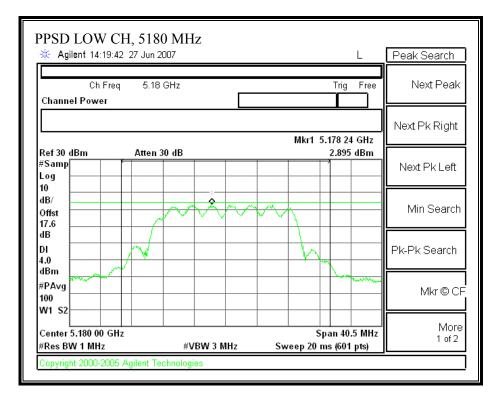
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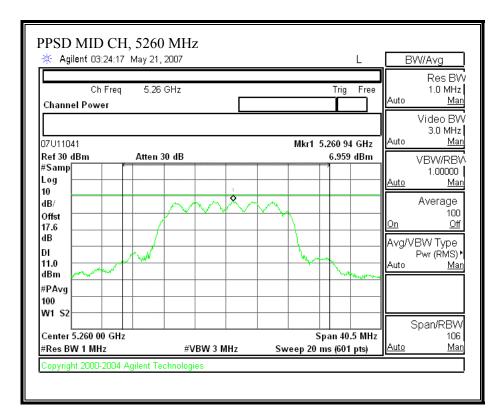
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#### 8.677dBi Antenna Gain

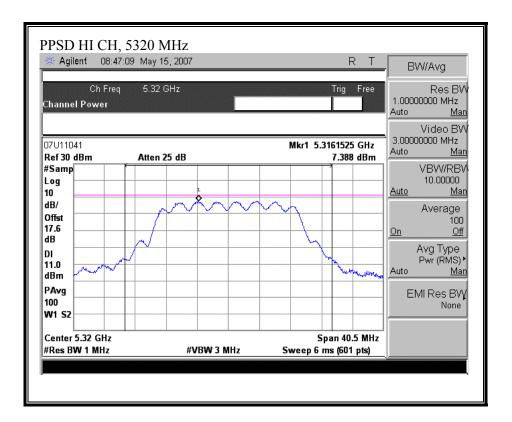
#### PEAK POWER SPECTRAL DENSITY (802.11 - 20 MHz TX BANDWIDTH – COMBINER)



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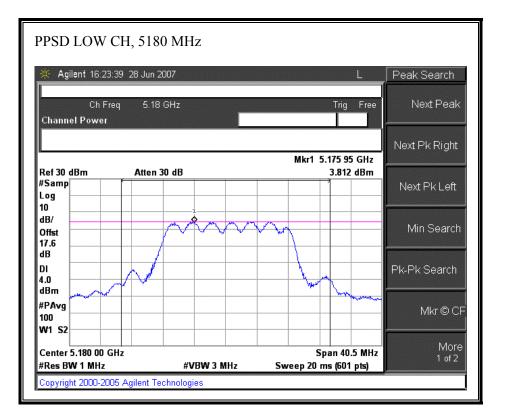


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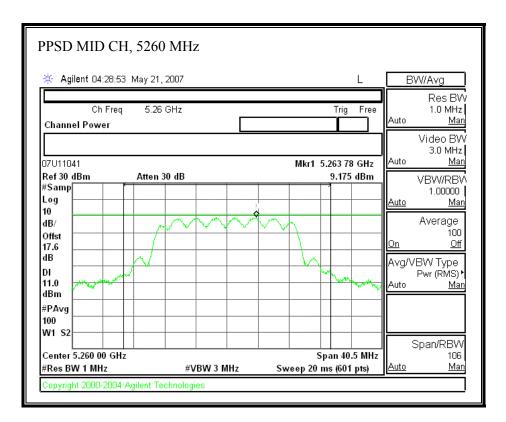


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#### 6dBi Antenna



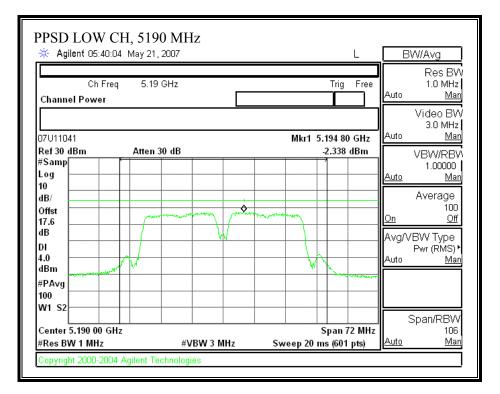
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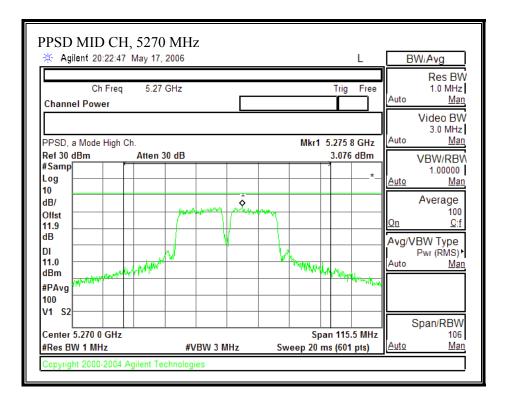
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## 802.11n 40 MHz CDD MCS 32

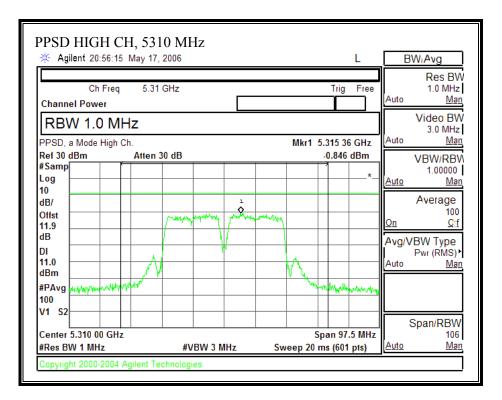
#### PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH - CHAIN 0)



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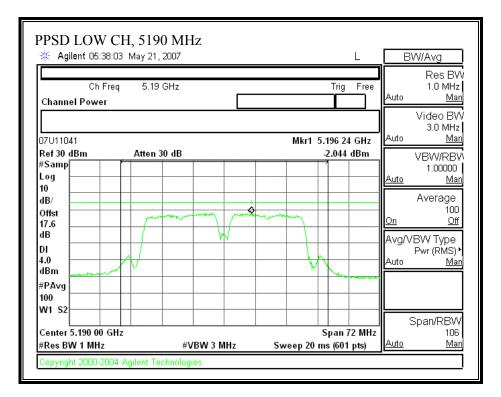


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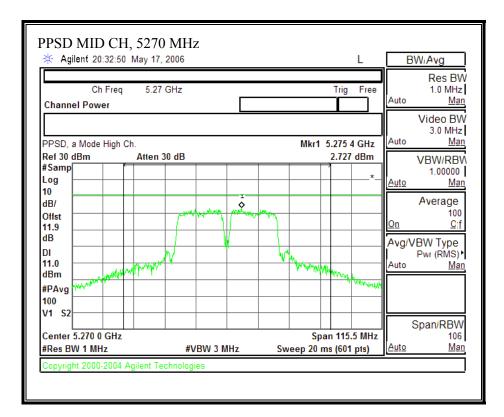


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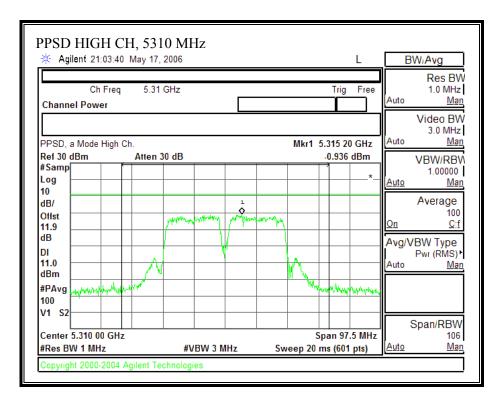
## PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH - CHAIN 1)



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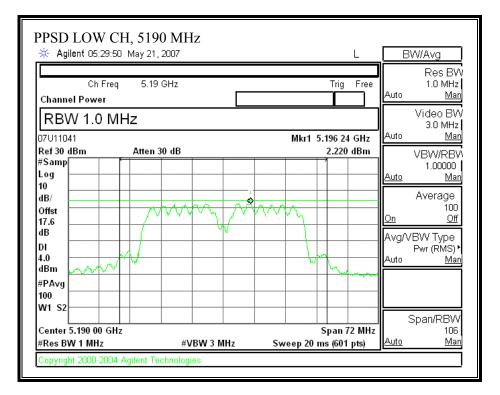
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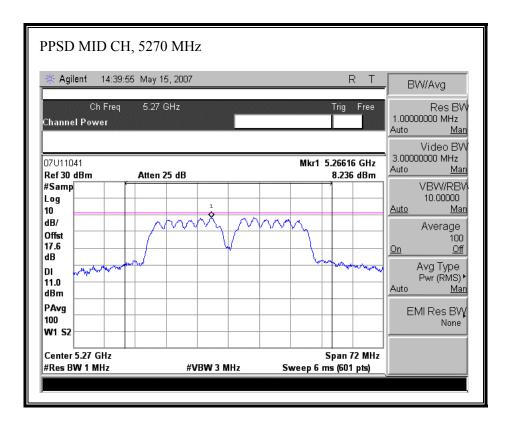
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#### 8.677dBi Antenna Gain

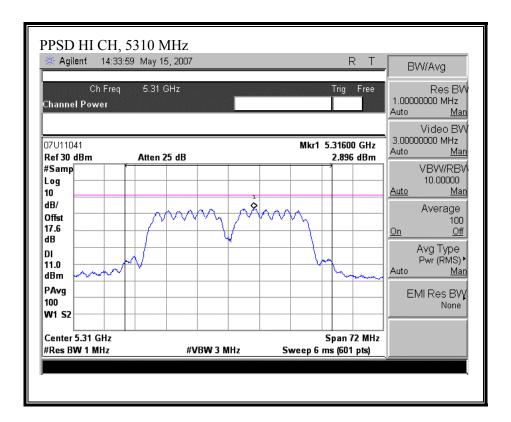
#### PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH – COMBINER)



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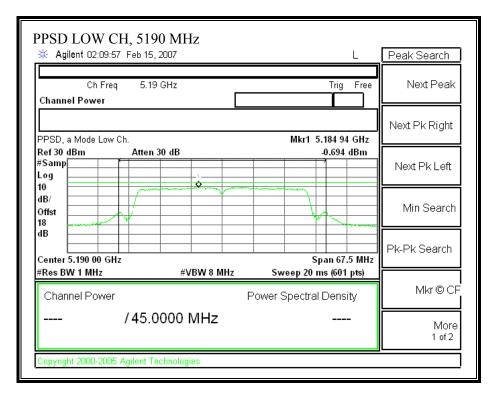
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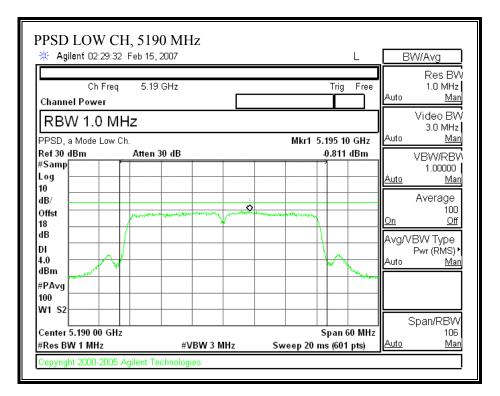
### 802.11n 40 MHz SDM MCS 15

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



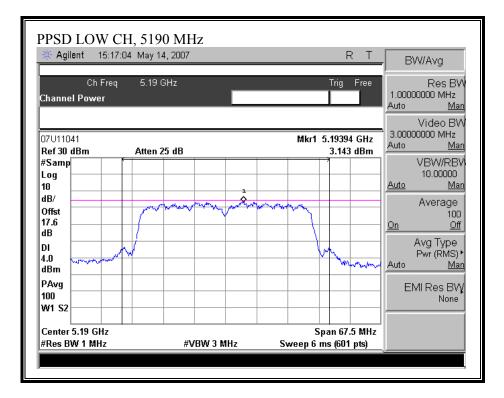
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### PEAK POWER SPECTRAL DENSITY (802.11 - 40 MHz TX BANDWIDTH - CHAIN 1)



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



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# 7.2.5. PEAK EXCURSION

# <u>LIMIT</u>

§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.

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## **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	Peak Excursion	Limit	Margin
	(MHz)	Chain 0 (dB)	(dB)	(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	Peak Excursion	Limit	Margin
	(MHz)	Chain 1 (dB)	(dB)	(dB)
Low	5180	9.517	13	-3.483
Middle	5260	10.990	13	-2.010
High	5320	9.741	13	-3.259

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# 802.11n 40 MHz CDD MCS 32

## 40 MHz TX BANDWIDTH - CHAIN 0

Channel	Frequency	<b>Peak Excursion</b>	Limit	Margin
	(MHz)	Chain 0 (dB)	(dB)	(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

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# 802.11n 40 MHz SDM MCS15

# 40 MHz TX BANDWIDTH - CHAIN 0

Channel	Frequency	Peak Excursion	Limit	Margin
	(MHz)	Chain 0 (dB)	(dB)	(dB)
Low	5190	10.580	13	-2.420

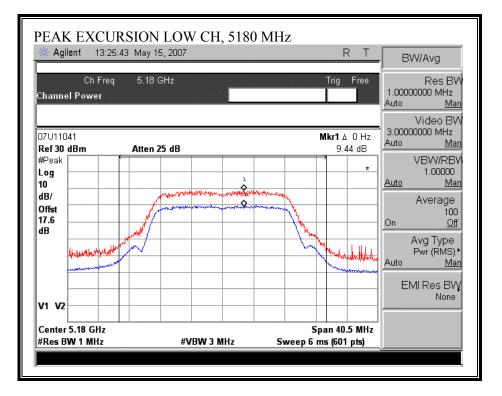
# 40 MHz TX BANDWIDTH - CHAIN 1

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

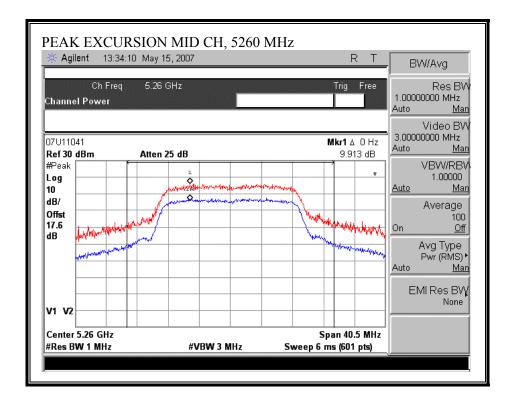
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### 802.11n 20 MHz CDD MCS 0

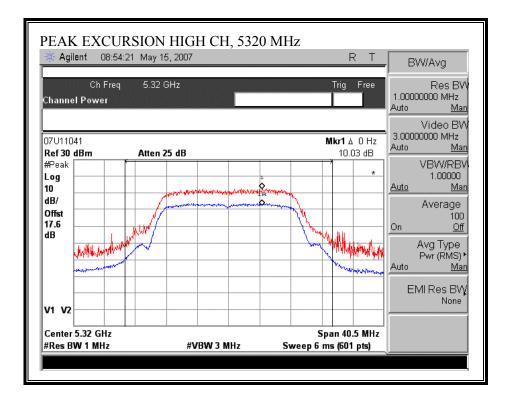
# PEAK EXCURSION (802.11 - 20 MHz TX BANDWIDTH - CHAIN 0)



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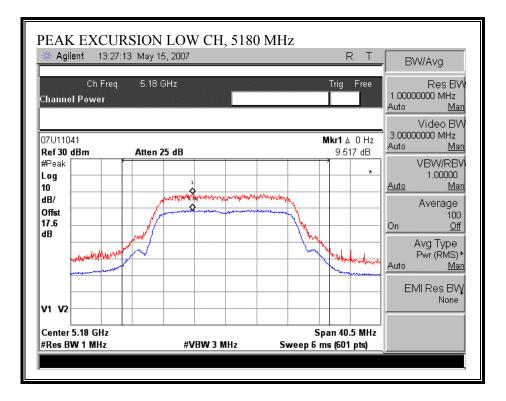


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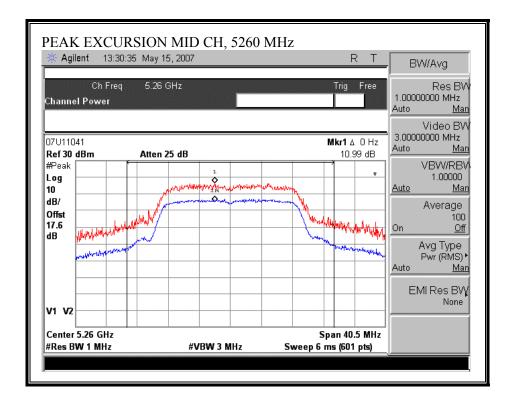


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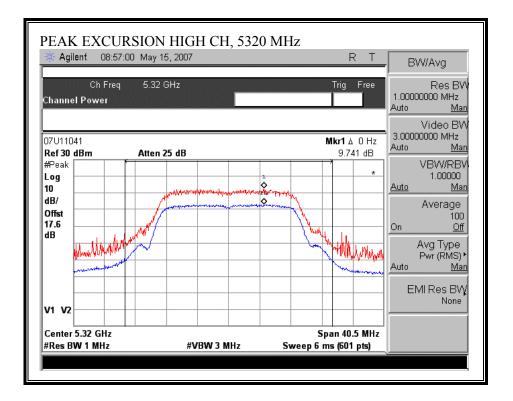
### PEAK EXCURSION (802.11 - 20 MHz TX BANDWIDTH - CHAIN 1)



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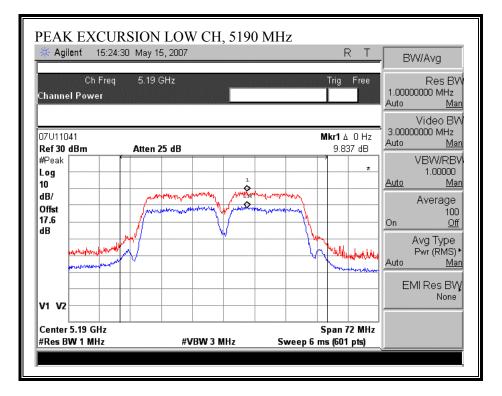
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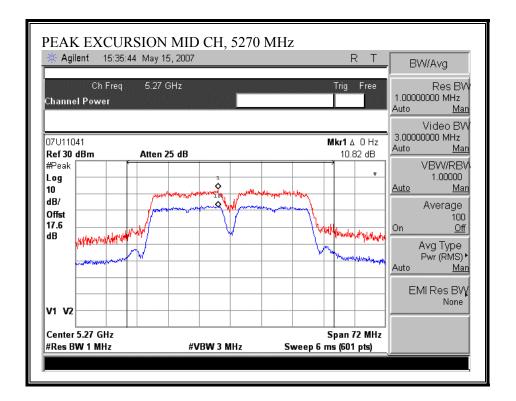
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### 802.11n 40 MHz CDD MCS 32

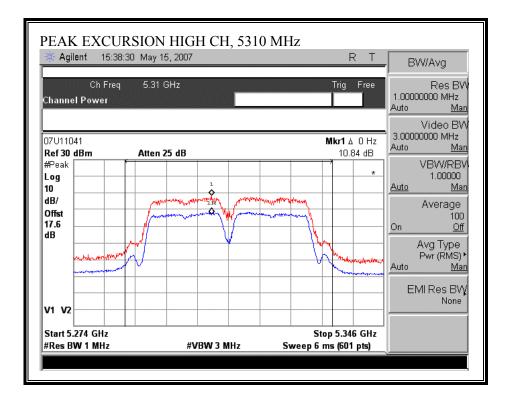
### PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH - CHAIN 0)



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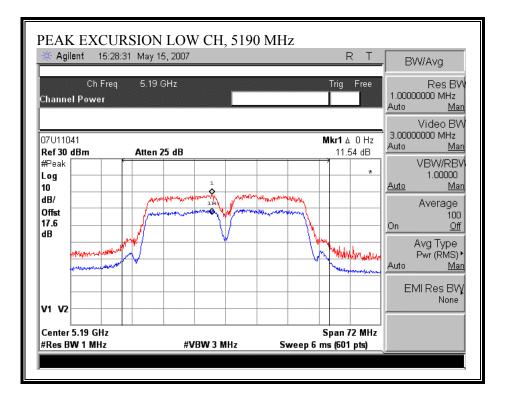


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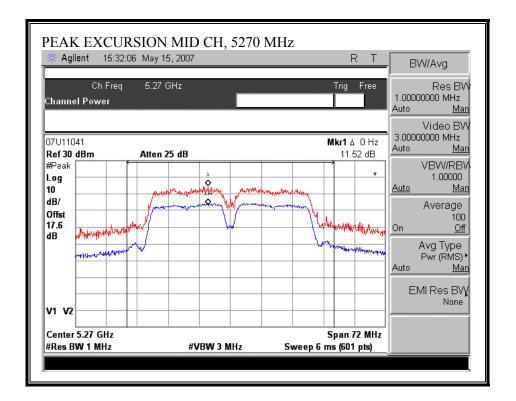


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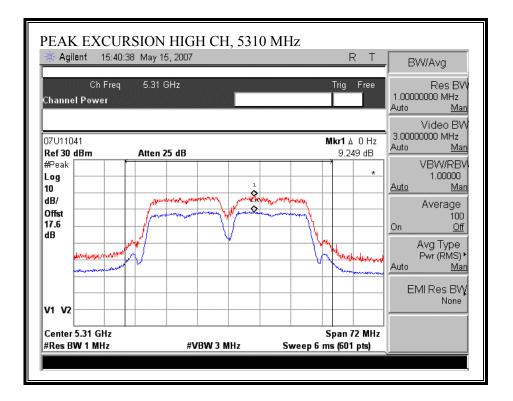
### PEAK EXCURSION (802.11 - 40 MHz TX BANDWIDTH - CHAIN 1)



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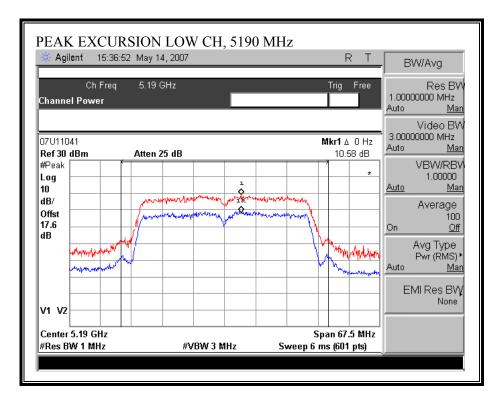
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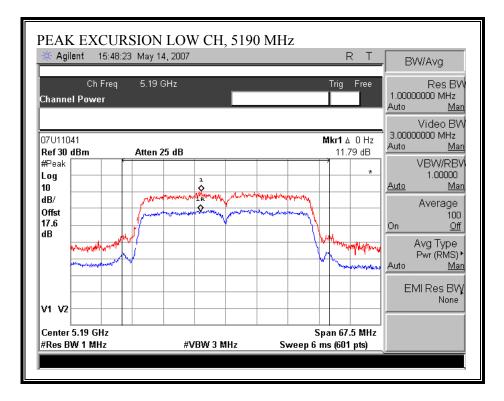
### 802.11n 40 MHz SDM MCS 15

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



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



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# 7.2.6. CONDUCTED SPURIOUS EMISSIONS

# <u>LIMITS</u>

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**

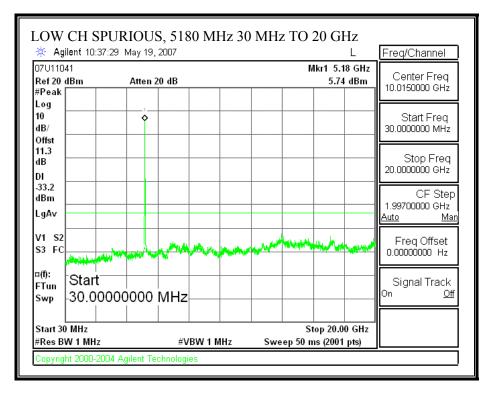
No non-compliance noted:

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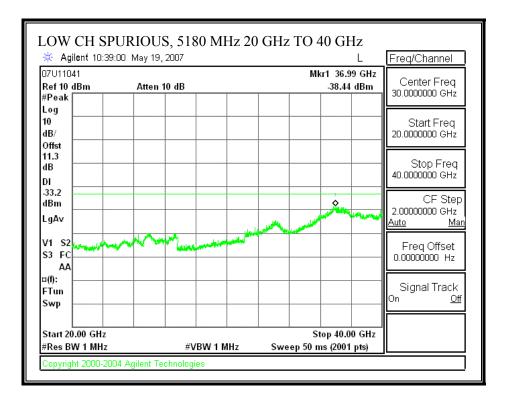
## 802.11a CDD is covered by worst case 802.11n 20 MHz CDD MCS 0

### 802.11n 20 MHz CDD MCS 0

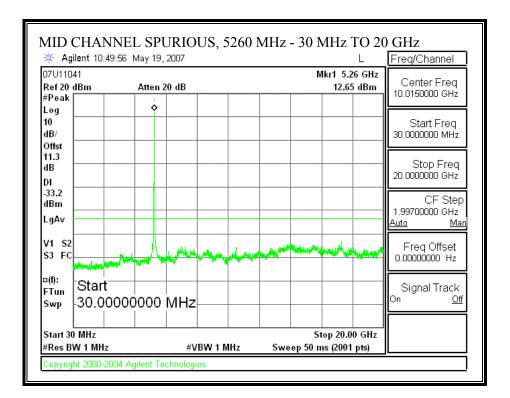
### SPURIOUS EMISSIONS - 802.11a -20 MHz TX BANDWIDTH - CHAIN 0



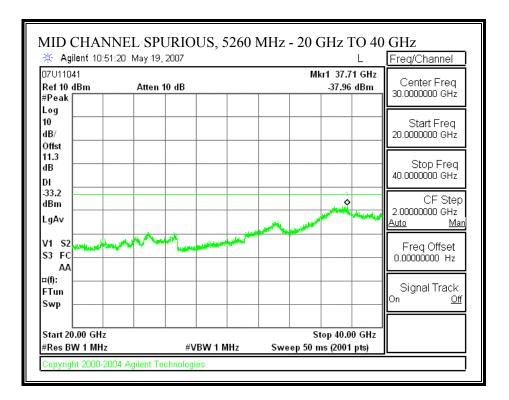
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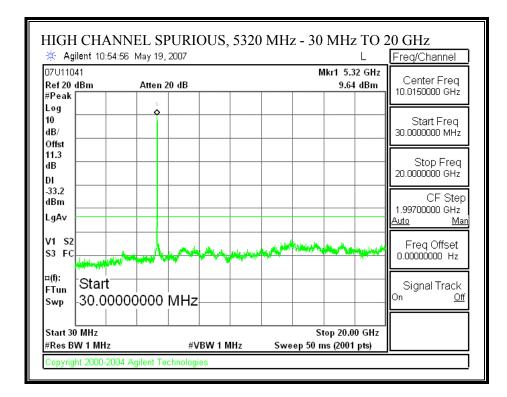
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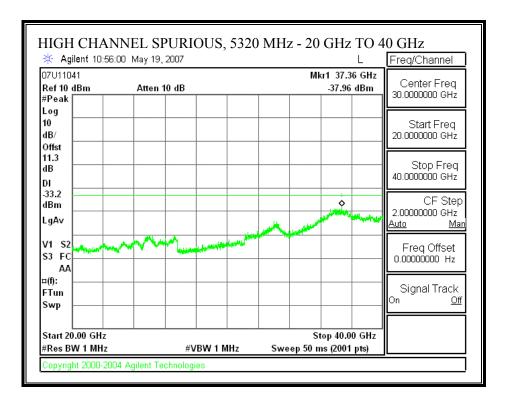
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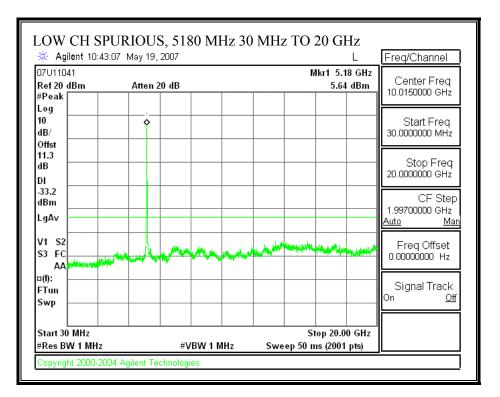


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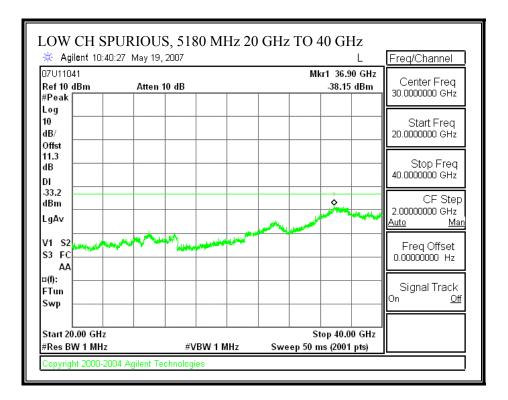


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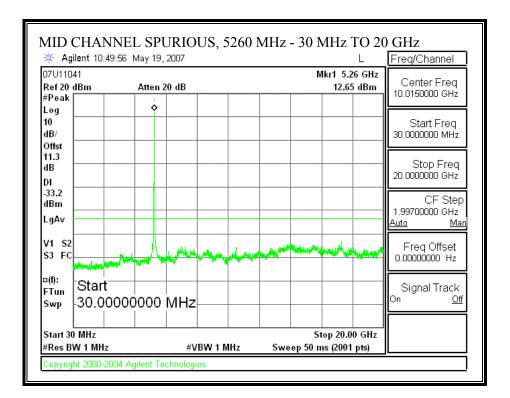
### SPURIOUS EMISSIONS - 802.11a - 20 MHz TX BANDWIDTH - CHAIN 1



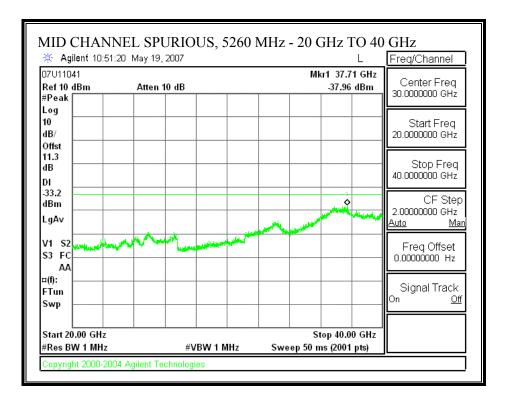
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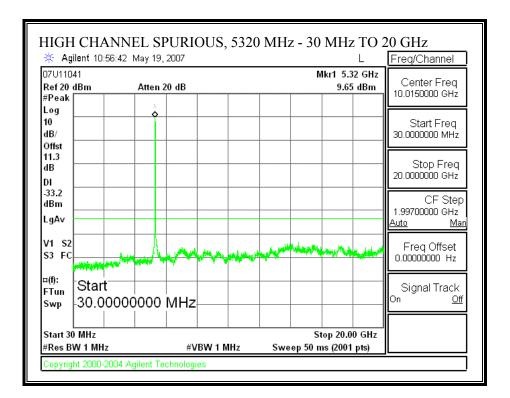
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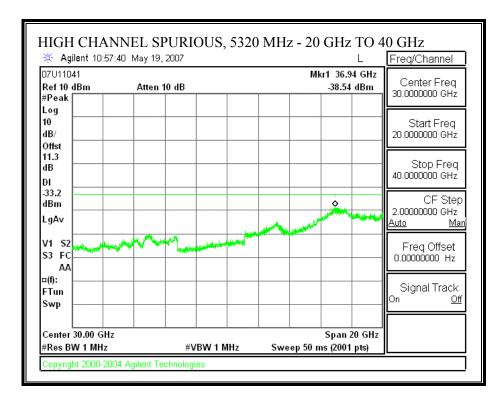
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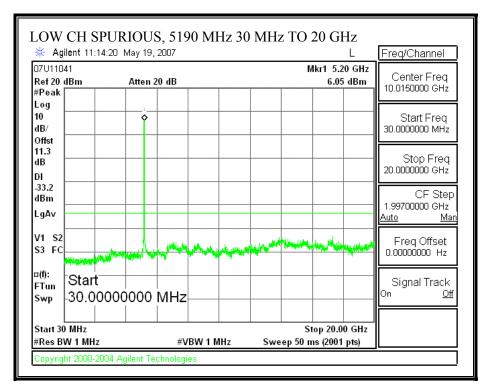
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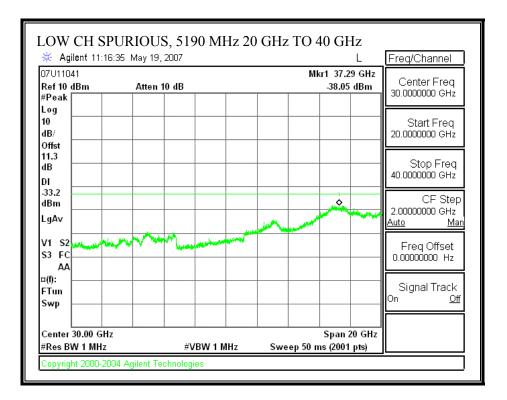
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### 802.11n 40 MHz CDD MCS 32

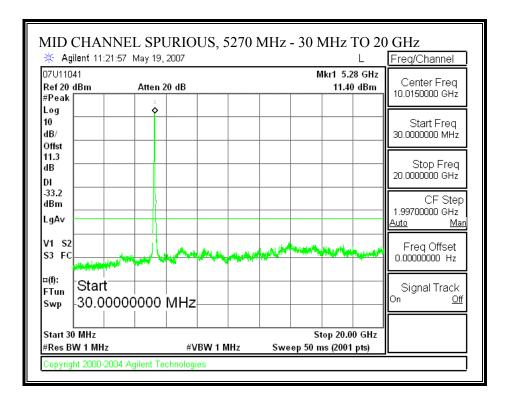
# SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 0



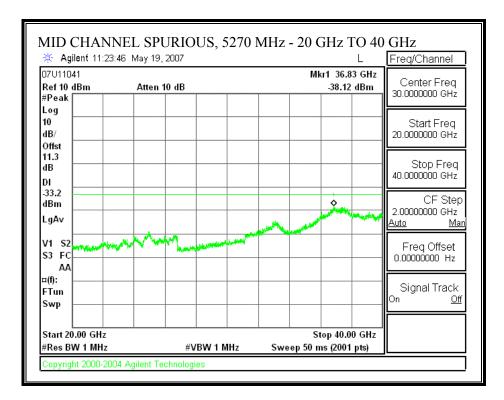
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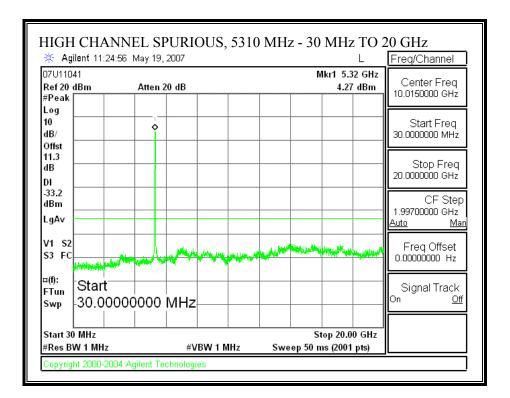
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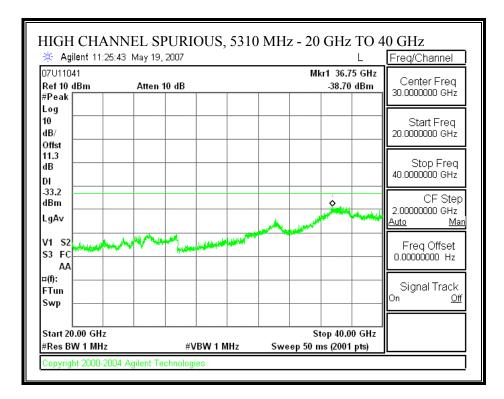
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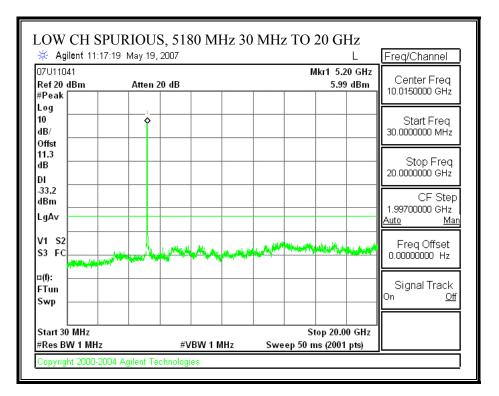
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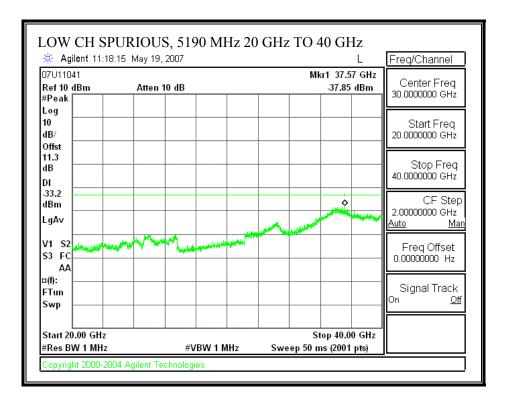
REPORT NO: 07U11041-2B

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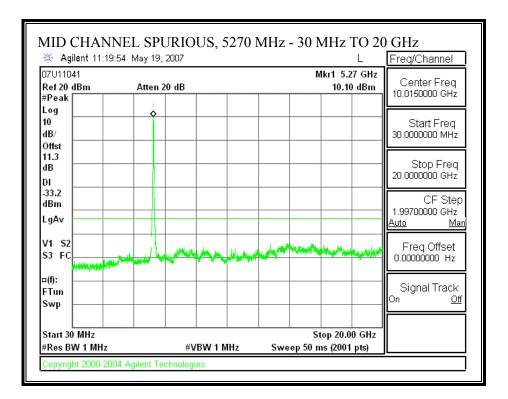
### SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 1



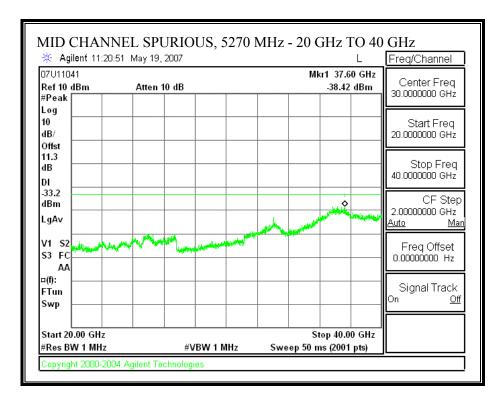
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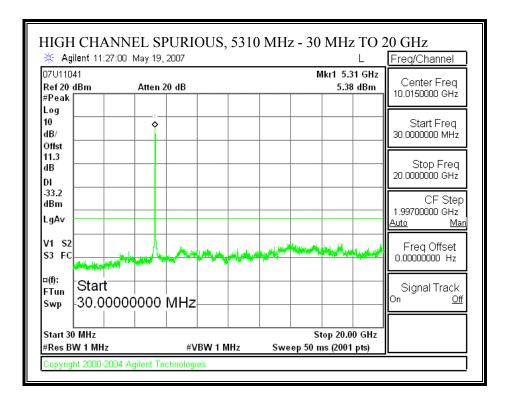
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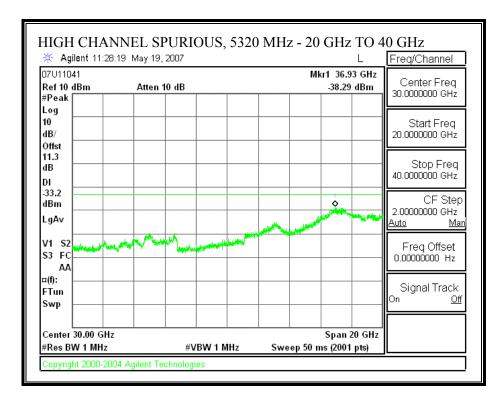
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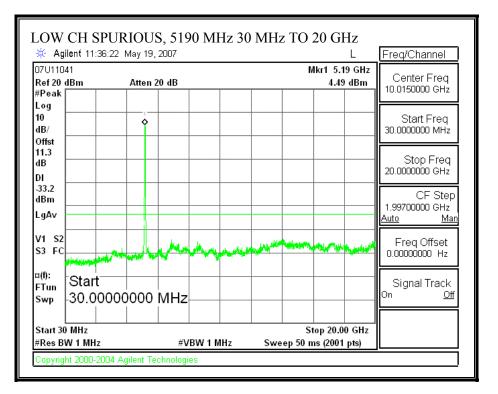


REPORT NO: 07U11041-2B

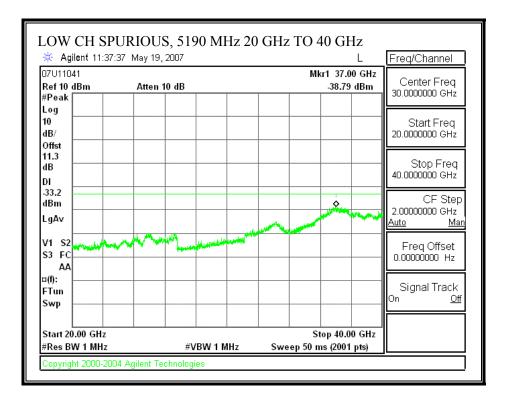
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#### 802.11n 40 MHz SDM MCS 15

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

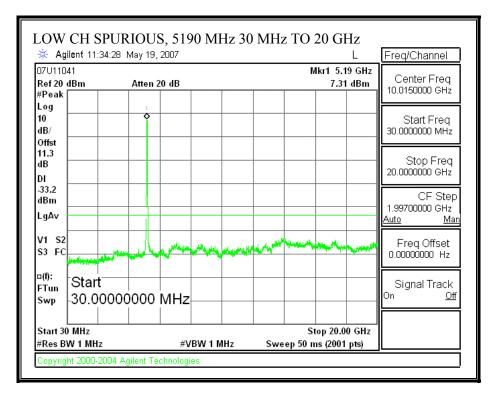


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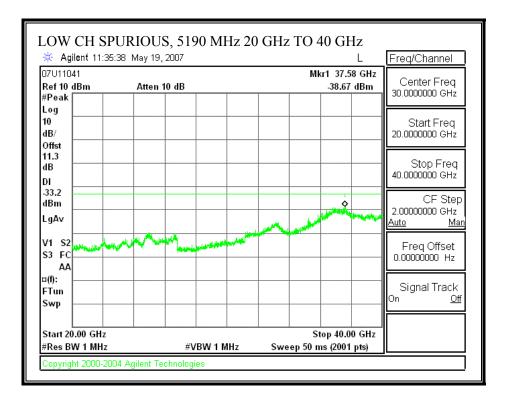


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#### SPURIOUS EMISSIONS - 802.11a -40 MHz TX BANDWIDTH - CHAIN 1



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# LEGACY MODE

# 7.3. CHANNEL TESTS FOR THE 5470 TO 5725 MHz BAND

# 7.3.1. EMISSION BANDWIDTH

# LIMIT

§15.403 (i) <u>Emission bandwidth</u>. 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.

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# **RESULTS**

No non-compliance noted:

# 802.11a LEGACY MODE

Channel	Frequency	В	10 Log B
	(MHz)	(MHz)	(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

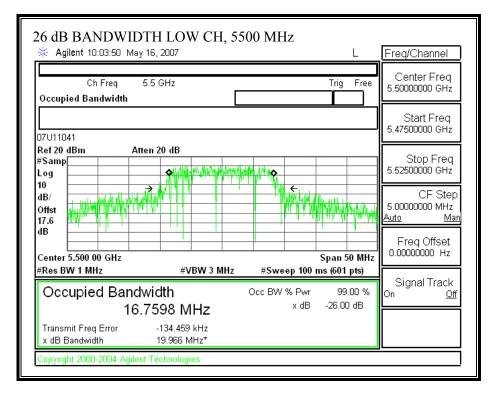
#### 802.11n 40 MHz SISO MCS 0 MODE

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

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#### 802.11a MODE

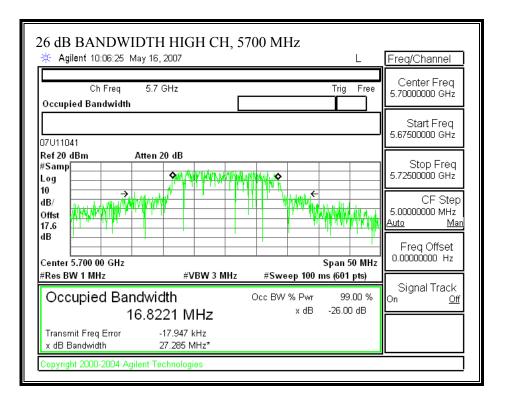
#### 26 dB EMISSION BANDWIDTH (802.11a MODE)



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26 dB BANDWIDTH MID CH, 5600 MHz	Freq/Channel
Ch Freq 5.6 GHz Trig Free Occupied Bandwidth	Center Freq 5.60000000 GHz
07U11041	Start Freq 5.57500000 GHz
Ref 20 dBm Atten 20 dB #Samp Log	Stop Freq 5.62500000 GHz
10 dB/ Offst 17.6	CF Step 5.00000000 MHz <u>Auto Man</u>
Center 5.600 00 GHz Span 50 MHz	Freq Offset 0.00000000 Hz
#Res BW 1 MHz         #VBW 3 MHz         #Sweep 100 ms (601 pts)           Occupied Bandwidth         Occ BW % Pwr         99.00 %           16.8867 MHz         × dB         -26.00 dB	Signal Track On <u>Off</u>
Transmit Freq Error -54.875 kHz x dB Bandwidth 22.978 MHz*	
Copyright 2000-2004 Agilent Technologies	

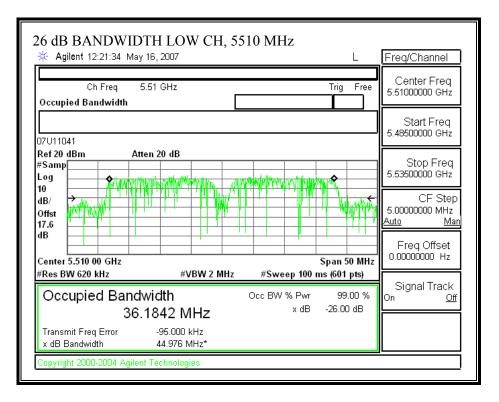
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### 11n 40 MHz SISO MCS 32 MODE

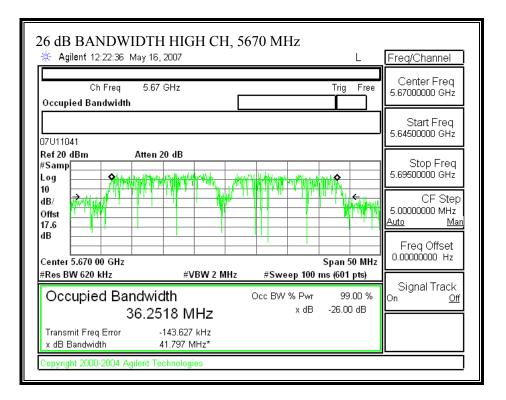
#### 26 dB EMISSION BANDWIDTH



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26 dB BANDWIDTH MID CH, 5590 MHz	Freq/Channel
Ch Freq 5.59 GHz Trig Free Occupied Bandwidth	Center Freq 5.59000000 GHz
07U11041	Start Freq 5.56500000 GHz
Ref 20 dBm Atten 20 dB #Samp	Stop Freq 5.61500000 GHz
10 dB/ Offst 17.6	CF Step 5.00000000 MHz <u>Auto Man</u>
dB	Freq Offset 0.00000000 Hz
#Res BW 620 kHz #VBW 2 MHz #Sweep 100 ms (601 pts)	Signal Track
Occupied Bandwidth Occ BW % Pwr 99.00 % 36.0649 MHz <sup>x dB</sup> -26.00 dB	On <u>Off</u>
Transmit Freq Error -125.039 kHz x dB Bandwidth 39.443 MHz*	
Copyright 2000-2004 Agilent Technologies	

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# 7.3.2. PEAK POWER

# <u>LIMIT</u>

§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

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#### LIMITS AND RESULTS

No non-compliance noted:

#### 802.11a MODE

Channel	Frequency	Fixed	В	11 + 10 Log B	Antenna	Limit
		Limit		Limit	Gain	
	(MHz)	(dBm)	(MHz)	(dBm)	(dBi)	(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	Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(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

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# 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	Fixed	В	11 + 10 Log	Antenna	Limit
		Limit		Limit	Gain	
	(MHz)	(dBm)	(MHz)	(dBm)	(dBi)	(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	Power	Limit	Margin
	(MHz)	(dBm)	(dBm)	(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

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# 802.11a MODE

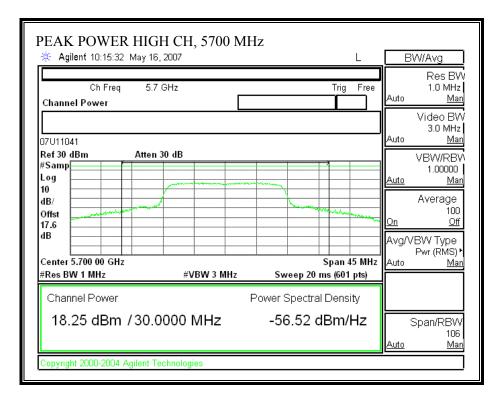
#### PEAK POWER

Ch Freq       5.5 GHz       Trig       Free       1.0         Channel Power       Image: Channel Power	BW/Avg	Hz	CH, 5500 M 7	LOW May 16, 20			
3.0           07U11041           Ref 30 dBm         Atten 30 dB           #Samp         Image: Constraint of the second s		Trig Free	: Г	5.5 Gł	•		Chann
#Samp Log 10 dB/ Offst 17.6 dB Center 5.500 00 GHz #Res BW 1 MHz Channel Power Channel Power Channel Power	Video BV 3.0 MHz Auto <u>Mar</u>					41	07U110
Center 5.500 00 GHz     Span 45 MHz     Auto       #Res BW 1 MHz     #VBW 3 MHz     Sweep 20 ms (601 pts)       Channel Power     Power Spectral Density	Average 100 <u>On Off</u> Avg/VBW Type		B				#Samp Log 10 dB/ Offst 17.6
		•	#VBW 3 MHz				
Auto	Span/RBV 106 <u>Auto Mar</u>		0 MHz	/30.00			

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PEAK POWER MID		Z	BW/Avg
Ch Freq 5.6 Channel Power	GHz	Trig Free	Res BW 1.0 MHz Auto <u>Man</u>
07U11041			Video BW 3.0 MHz Auto <u>Man</u>
Ref 30 dBm Atten #Samp Dog Log dB/ Offst description of the second secon	30 dB		VBW/RBW 1.00000 <u>Auto Man</u> Average 100
17.6 dB Center 5.600 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 45 MHz Sweep 20 ms (601 pts)	On Off Avg/VBW Type Pwr (RMS)► Auto <u>Man</u>
Channel Power		Power Spectral Density	
17.56 dBm /30.0	0000 MHz	-57.21 dBm/Hz	Span/RBW 106 <u>Auto Man</u>
Copyright 2000-2004 Agilent To	echnologies		

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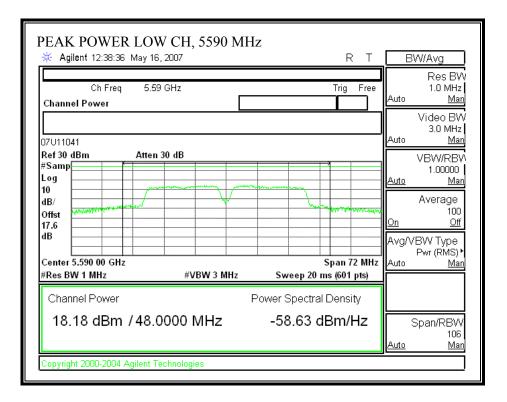
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# 802.11n 40 MHz SISO MCS 0 MODE

# PEAK POWER

PEAK POWER LOW CH * Agilent 13:46:13 May 16, 2007	H, 5510 MHz		L	BW/.	Ava
Ch Freq 5.51 GHz Channel Power		Tri	ig Free		Res BW 1.0 MHz <u>Man</u>
RBW 1.0 MHz					deo BW 3.0 MHz <u>Man</u>
Ref 30 dBm Atten 30 dB #Samp Log 10					3VV/RBV 1.00000 <u>Man</u>
dB/ Offst 17.6 dB			n) - Manily and	A' <u>On</u>	verage 100 <u>Off</u>
Center 5.510 00 GHz	#VBW 3 MHz	Span Sweep 20 ms (6	n 72 MHz 01 pts)	Avg/VBV Pw Auto	V Type rr (RMS) ► <u>Man</u>
Channel Power		wer Spectral Der	· ·		
15.68 dBm / 48.0000	) MHz	-61.14 dBm	า/Hz	Spa <u>Auto</u>	an/RBW 106 <u>Man</u>
Copyright 2000-2004 Agilent Technolo	ogies				

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			Res E	
Ch Freq 5.1 Channel Power	57 GHz	Trig Fr	ree 1.0 MH Auto <u>M</u>	Hz /lan
07U11041	L		Video E 3.0 MH Auto M	
Ref 30 dBm Atte	n 30 dB			ΒV
#Samp Log 10			1.0000	
dB/	Ψ			00
17.6 dB			Avg/VBW Type	<u>Off</u> e
Center 5.670 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 72 M Sweep 20 ms (601 pts	Pwr (RMS IHz Auto M	
Channel Power		Power Spectral Density		
18.02 dBm /48	0000 MHz	-58.79 dBm/Hz		3VV 06
			Auto M	/an

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# 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.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm²)	Averaging time (minutes)
(A) Lim	its for Occupational	/Controlled Exposu	res	
0.3–3.0 3.0–30 30–300 300–1500 1500–100,000	614 1842/f 61.4	1.63 4.89/f 0.163	*(100) *(900/f²) 1.0 f/300 5	6 6 6 6
(B) Limits	for General Populati	on/Uncontrolled Exp	posure	
0.3–1.34 1.34–30	614 824/f	1.63 2.19/f	*(100) *(180/f²)	30 30

#### TABLE 1-LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

#### 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/cm²)	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

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 occu-pational/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 ex-posed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure.

exposure or can not exercise control over their exposure.

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# 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:

 $P(mW) = 10^{(Bm)} / 10)$  and  $G(numeric) = 10^{(G(dBi))} / 10)$ 

yields

 $d = 0.282 * 10^{(P+G)/20} / \sqrt{S}$ where d = MPE distance in cmP = Power in dBmG = Antenna Gain in dBi $S = Power Density \text{ Limit in } mW/cm^{2}$ 

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

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

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# <u>LIMITS</u>

From 1.1310 Table 1 (B), the maximum value of S = 1.0 mW/cm<sup>2</sup> in the 5.6 GHz band

### **RESULTS**

No non-compliance noted

# 802.11a LEGACY MODE

Mode	MPE	Output	Antenna	Power
	Distance	Power	Gain	Density
	(cm)	(dBm)	(dBi)	(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	Output	Antenna	Power
	Distance	Power	Gain	Density
	(cm)	(dBm)	(dBi)	(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.

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# 7.3.4. PEAK POWER SPECTRAL DENSITY

# <u>LIMIT</u>

§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

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### **RESULTS**

No non-compliance noted:

# 802.11a MODE

802.11a Mode

Channel	Frequency	PPSD	Limit	Margin
	(MHz)	(dBm)	(dBm)	(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

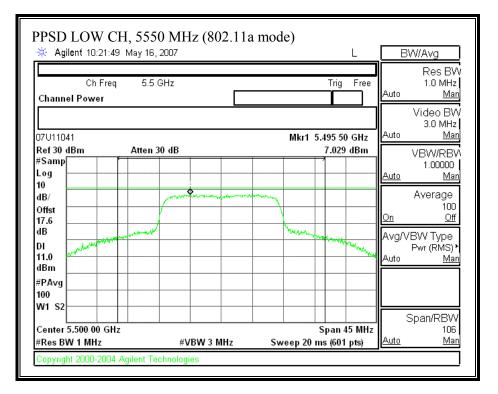
802.11a Mode

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

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#### 802.11a MODE

#### PEAK POWER SPECTRAL DENSITY (802.11a MODE)



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🔆 Agilent 10:23:06 May 1	6,2007	L	BW/Avg
Ch Freq 5 Channel Power	6 GHz	Trig Free	Res BW 1.0 MHz Auto <u>Man</u>
07U11041		Mkr1 5.594 98 GHz	Video BW 3.0 MHz Auto <u>Man</u>
Ref 30 dBm Atte #Samp Log 10	n 30 dB	7.454 dBm	VBW/RBV 1.00000 <u>Auto Man</u>
dB/ Offst 17.6	fund the second		Average 100 <u>On Off</u>
dB DI 11.0 dBm		and a second and a	_ Avg/VBW Type Pwr (RMS)↑ * Auto <u>Man</u>
#PAvg 100 W1 S2			_
Center 5.600 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 45 MHz Sweep 20 ms (601 pts)	Span/RBW 106 Auto Man

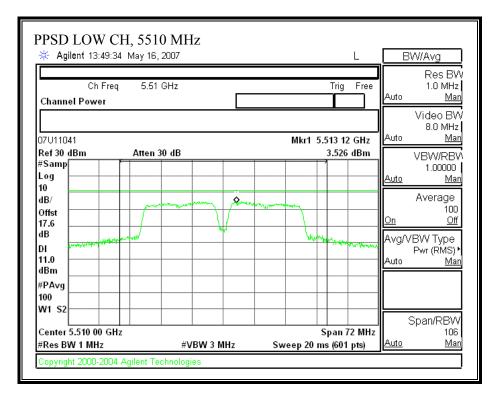
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PSD HIGH CH, 5 Agilent 10:25:35 May		Ĺ	BW/Avg
Ch Freq 5	5.7 GHz	Trig Free	Res BW 1.0 MHz Auto <u>Man</u>
07U11041	_	Mkr1 5.695 05 GHz	Video BW 3.0 MHz Auto <u>Man</u>
Ref 30 dBm         Atte           #Samp	an 30 dB	6,339 dBm	VBW/RBV 1.00000 <u>Auto Man</u> Average 100
17.6 dB DI 11.0 dB dB			On Off Avg/VBW Type Pwr (RMS) Auto Man
#PAvg		Span 45 MH:	Span/RBW
#Res BW 1 MHz	#VBW 3 MHz	Sweep 20 ms (601 pts)	Auto Man

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#### 802.11n 40 MHz SISO MCS 32 MODE

#### PEAK POWER SPECTRAL DENSITY



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🔆 Agilent 13:53:30 May 1	6, 2007		BW/Avg
Ch Freq 5. Channel Power	59 GHz	Trig Free	Res BV 1.0 MHz Auto <u>Mar</u>
07U11041		Mkr1 5.583 76 GHz	Video BV 3.0 MHz Auto <u>Mar</u>
Ref 30 dBm Atte #Samp Log 10	n 30 dB	3.028 dBm	VBW/RBV 1.00000 <u>Auto Mar</u>
dB/ Offst 17.6			Average 100 <u>On Off</u>
dB Dl 11.0 dBm			Avg/VBW Type Pwr (RMS) • Auto <u>Mar</u>
#PAvg 100 W1 S2			-
Center 5.590 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 72 MHz Sweep 20 ms (601 pts)	Span/RBW 106 <u>Auto Mar</u>

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🔆 Agilent 13:56:07 May 1	6, 2007	RT	BW/Avg
Ch Freq 5.6 Channel Power	67 GHz	Trig Free	Res BV 1.0 MHz Auto <u>Mar</u>
RBW 1.0 MHz		Mkr1 5.665 92 GHz	Video BV 3.0 MHz Auto <u>Mar</u>
#Samp Log	n 30 dB	4.928 dBm	VBVV/RBV 1.00000 <u>Auto Mar</u>
10 dB/ Offst 17.6 dB		transmin	Average 100 <u>On Off</u>
dB Dl +************************************		Landa prata and an and an	Avg/VBW Type Pwr (RMS) • Auto <u>Mar</u>
#PAvg 100 W1 S2			- Span/RBW
Center 5.670 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 72 MHz Sweep 20 ms (601 pts)	

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# 7.3.5. PEAK EXCURSION

## <u>LIMIT</u>

§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.

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## **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

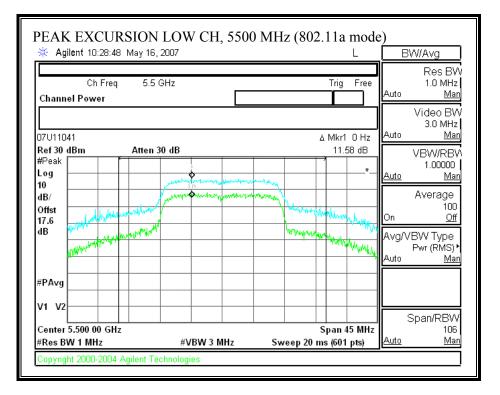
## 802.11n 40 MHz SISO MCS 32 MODE

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

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#### 802.11a MODE

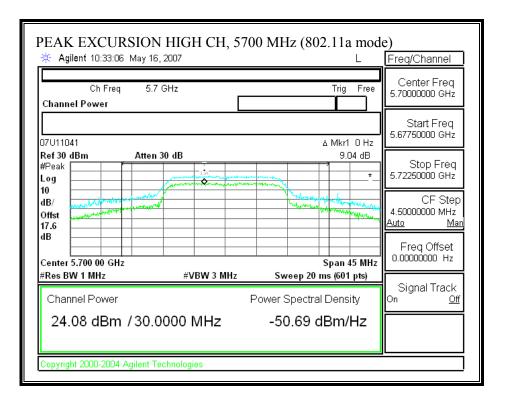
### PEAK EXCURSION (802.11a MODE)



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🔆 Agilent 10:30:25 May 16,	2007		BW/Avg
Ch Freq 5.6 Channel Power	GHz	Trig Fre	e Res BW 1.0 MHz Auto <u>Man</u>
07U11041		Δ Mkr1 O H;	Video BW 3.0 MHz z Auto <u>Man</u>
Ref 30 dBm         Atten           #Peak	30 dB	10.82 dB	
dB/ Offst	Carrow Martine and Martine	White White warman and	Average 100 On <u>Off</u>
dB		Unin nul Man in	Avg/VBW Type Pwr (RMS) ► Auto <u>Man</u>
#PAvg			
V1 V2			
Center 5.600 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 45 MH Sweep 20 ms (601 pts)	L Span/RBW Iz 106 Auto Man

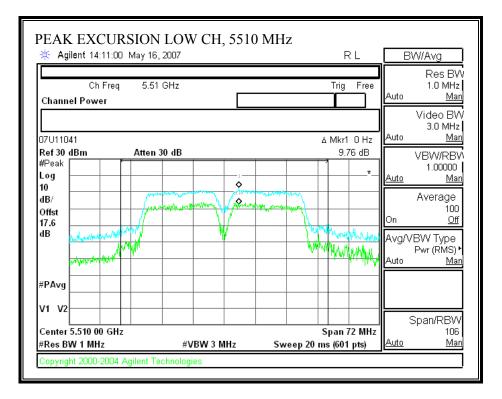
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### 802.11n 40 MHz SISO MCS 32 MODE

### PEAK EXCURSION



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🔆 Agilent 14:01:46 May	16, 2007	RL	BW/Avg
Ch Freq 5 Channel Power	59 GHz	Trig Fre	ee Res BV ee 1.0 MHz Auto <u>Mar</u>
07U11041	_	∆ Mkr1 O H	Video BW 3.0 MHz Iz Auto <u>Mar</u>
Ref 30 dBm         Atte           #Peak	en 30 dB	8.89 dE	3 VBW/RBV *- <u>Auto Mar</u>
dB/ Offst 17.6	and the second state of th	Mary Mary Carl	Average 100 On <u>Off</u>
dB multisher multisher to	V/	What will work and	
#PAvg			
V1 V2			Span/RBW
Center 5.590 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 72 M Sweep 20 ms (601 pts)	Hz 106

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🔆 Agilent 14:09:17 May	16, 2007	RL	BW/Avg
Ch Freq 5. Channel Power	67 GHz	Trig Free	Res BW 1.0 MHz Auto Man
07U11041 Ref 30 dBm Atte	- 20 JD	Δ Mkr1 0 Hz	Video BW 3.0 MHz Auto <u>Man</u>
#Peak Log	1 30 dB	11.89 dB	VBW/RBV 1.00000 <u>Auto Man</u>
dB/ Offst 17.6		warren and march and a second	
dB		When the second of the second	Avg/VBW Type Pwr (RMS)▲ Auto <u>Man</u>
#PAvg			
V1 V2			Span/RBW
Center 5.670 00 GHz #Res BW 1 MHz	#VBW 3 MHz	Span 72 MHz Sweep 20 ms (601 pts)	

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# 7.3.6. CONDUCTED SPURIOUS EMISSIONS

# <u>LIMITS</u>

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.

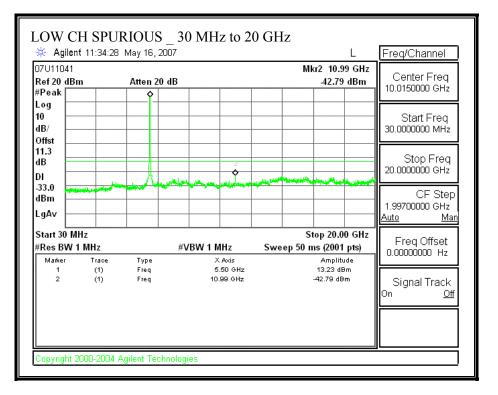
## **RESULTS**

No non-compliance noted:

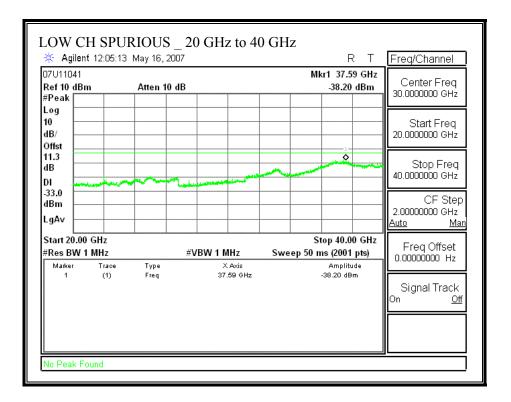
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#### 802.11a MODE

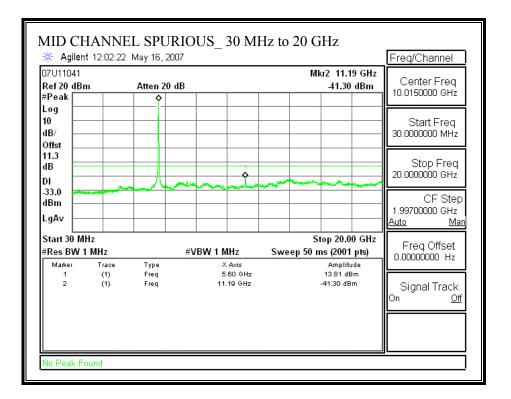
#### SPURIOUS EMISSIONS (802.11a MODE)



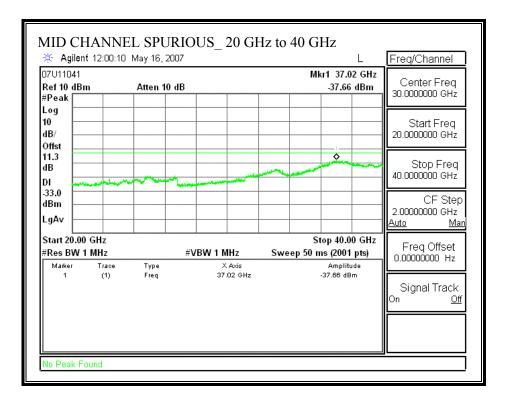
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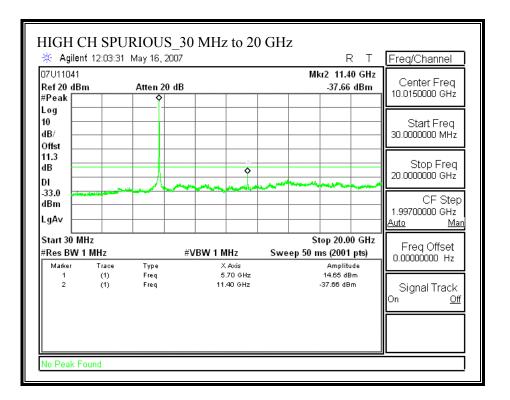
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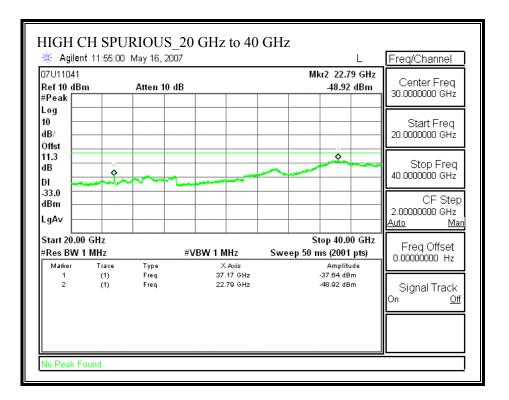
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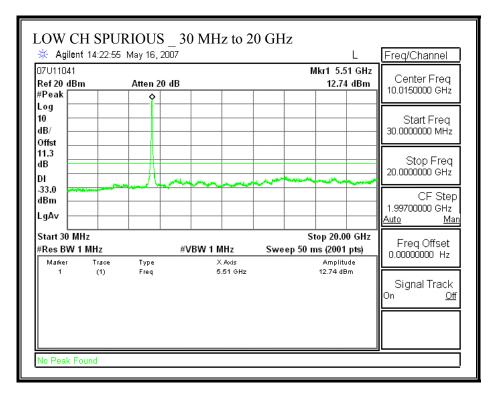
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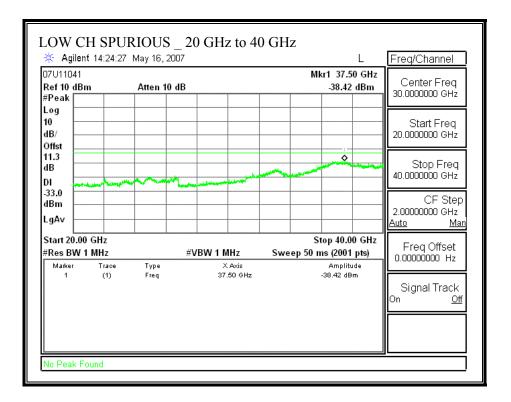
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### 802.11n 40 MHz SISO MCS 32 MODE

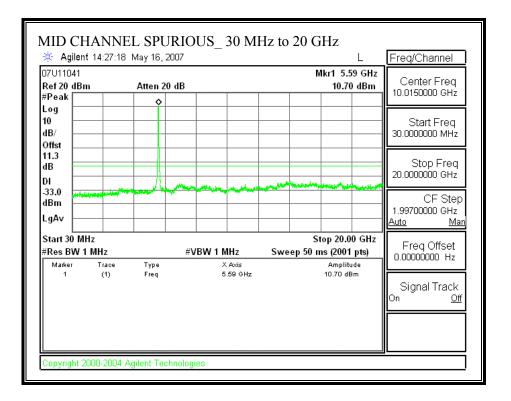
### SPURIOUS EMISSIONS



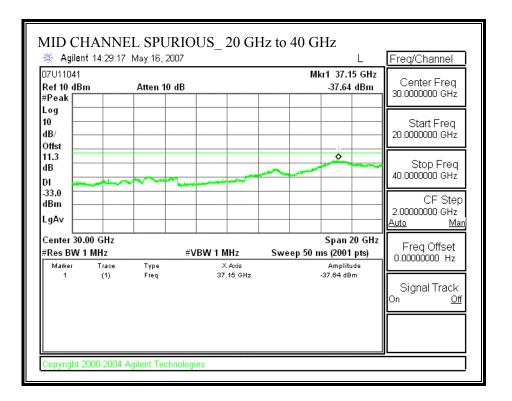
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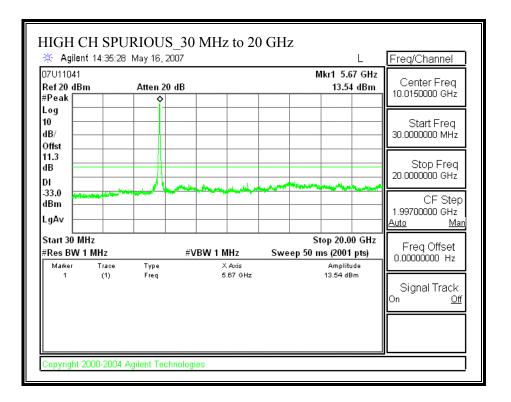
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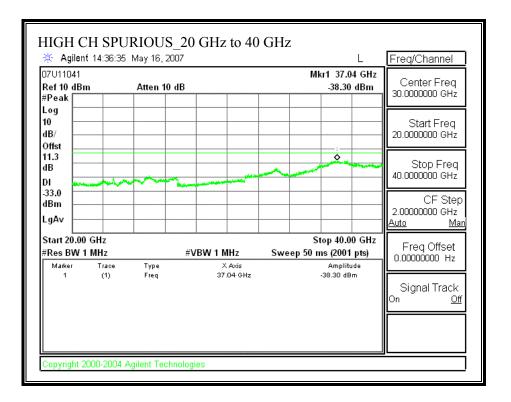
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# MIMO MODE

# 7.4. CHANNEL TESTS FOR THE 5470 TO 5725 MHz BAND

# 7.4.1. EMISSION BANDWIDTH

## LIMIT

§15.403 (i) <u>Emission bandwidth</u>. 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:

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

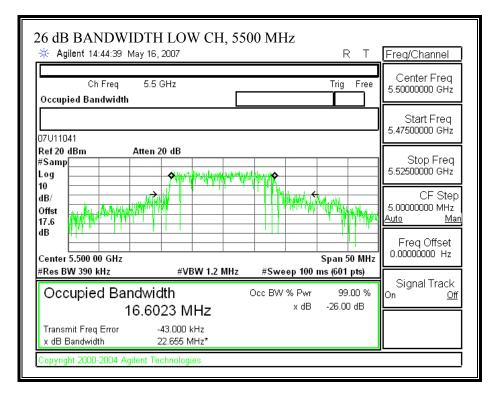
### 802.11 - 40 MHz Tx BANDWIDTH - CHAIN 1

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

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### 802.11n 20 MHz CDD MCS 0

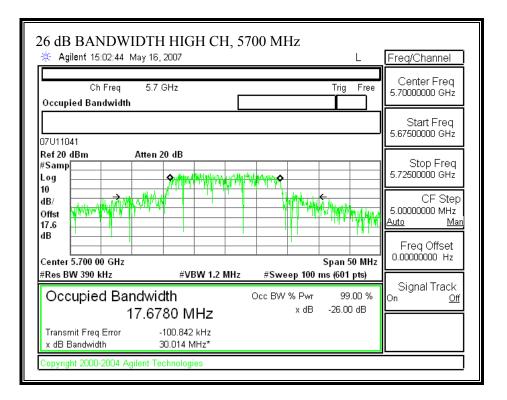
#### 26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 0)



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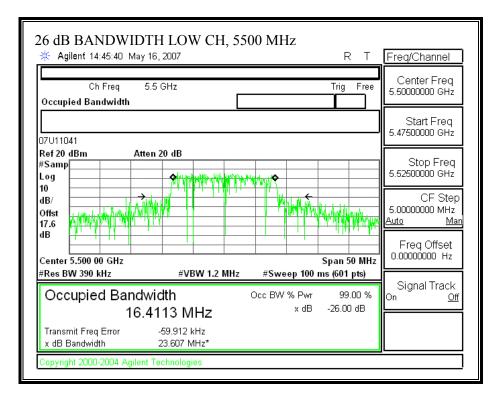
26 dB BANDWIDTH MID CH, 5600 MHz	Freq/Channel
Ch Freq 5.6 GHz Trig Free Occupied Bandwidth	Center Freq 5.6000000 GHz
07U11041	Start Freq 5.57500000 GHz
Ref 20 dBm Atten 20 dB #Samp	Stop Freq 5.62500000 GHz
	CF Step 5.00000000 MHz <u>Auto Man</u>
dB Center 5.600 00 GHz Span 50 MHz	Freq Offset 0.00000000 Hz
#Res BW 390 kHz #VBW 1.2 MHz #Sweep 100 ms (601 pts) Occupied Bandwidth Occ BW % Pwr 99.00 %	Signal Track
17.5737 MHz × dB -26.00 dB	On <u>Off</u>
Transmit Freq Error -62.370 kHz x dB Bandwidth 23.011 MHz*	
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#### 26 dB EMISSION BANDWIDTH (802.11 - 20 MHz TX BANDWIDTH- CHAIN 1)



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26 dB BANDWIDT	,			Freq/Channel
Ch Freq 5.6 Occupied Bandwidth	6 GHz		Trig Free	Center Freq 5.6000000 GHz
07U11041				Start Freq 5.57500000 GHz
			MAN AN ANA ANA	Stop Freq 5.62500000 GHz CF Step 5.00000000 MHz Auto Man
dB Center 5.600 00 GHz #Res BW 390 kHz	#VBW 1.2 MHz	#Sweep 100 r	Span 50 MHz ns (601 pts)	Freq Offset 0.00000000 Hz
Occupied Bandwi 17.8	idth 444 MHz	Occ BW % Pwr x dB	99.00 % -26.00 dB	Signal Track On <u>Off</u>
Transmit Freq Error x dB Bandwidth	-74.128 kHz 26.739 MHz*			

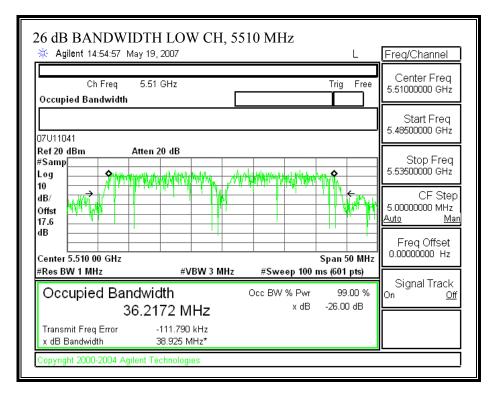
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26 dB BANDWIDTH HIGH CH	r, 5700 MHz R L	Freq/Channel
Ch Freq 5.7 GHz Occupied Bandwidth	Trig Free	Center Freq 5.70000000 GHz
07U11041		Start Freq 5.67500000 GHz
Ref 20 dBm Atten 20 dB #Samp	69%xgf64xg	Stop Freq 5.72500000 GHz
10 dB/ Offst 17.6		CF Step 5.0000000 MHz <u>Auto Man</u>
dB	Span 50 MHz	Freq Offset 0.00000000 Hz
#Res BW 390 kHz #VBW 1.2 M		Signal Track
Occupied Bandwidth 17.5811 MHz	Occ BW % Pwr 99.00 % x dB -26.00 dB	On <u>Off</u>
Transmit Freq Error -53.876 kHz x dB Bandwidth 24.773 MHz*		
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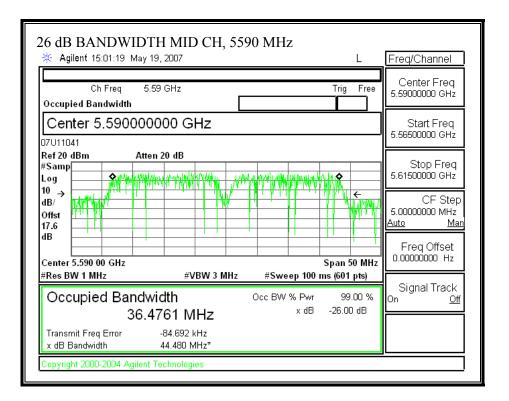
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### 802.11n 40 MHz CDD MCS 32

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



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