AP-ONE

FCC CONDUCTED DATA

SUMMARY		
Specification	**Requirement**	**Testing**
CFR 15.247 (a)	6 dB BW greater than 500 KHz	Pg. 1
CFR 15.247 (b)	Max Peak Output Power less than 1W	Pg. 3
CFR 15.247 (b)	Max Permissible Exposure	Pg. 5
CFR 15.247 (c)	-20dBc Spurious Emissions	Pg. 6
CFR 15.247 (d)	Peak PSD less than +8dBm in 3kHz BW	Pg. 8
	802.11 a (5725-5850 MHz) Data	Pg. 10

TESTING SETUP OVERVIEW

INSTRUMENTS USED			
Description	**Manufacturer**	**Model No.**	**Last Calibration**
Spectrum Analyzer	Rhode & Schwarz	ESIB 26	Nov, 2004

The AP-1 was placed in continuous transmit mode using the Atheros Radio Test (ART) software utility. Data was captured from the spectrum analyzer using a PC, a National Instruments GPIB/ENET hub, and a National Instruments Labview customized program.

TEST DATE: January 14, 2004

6 dB Bandwidth

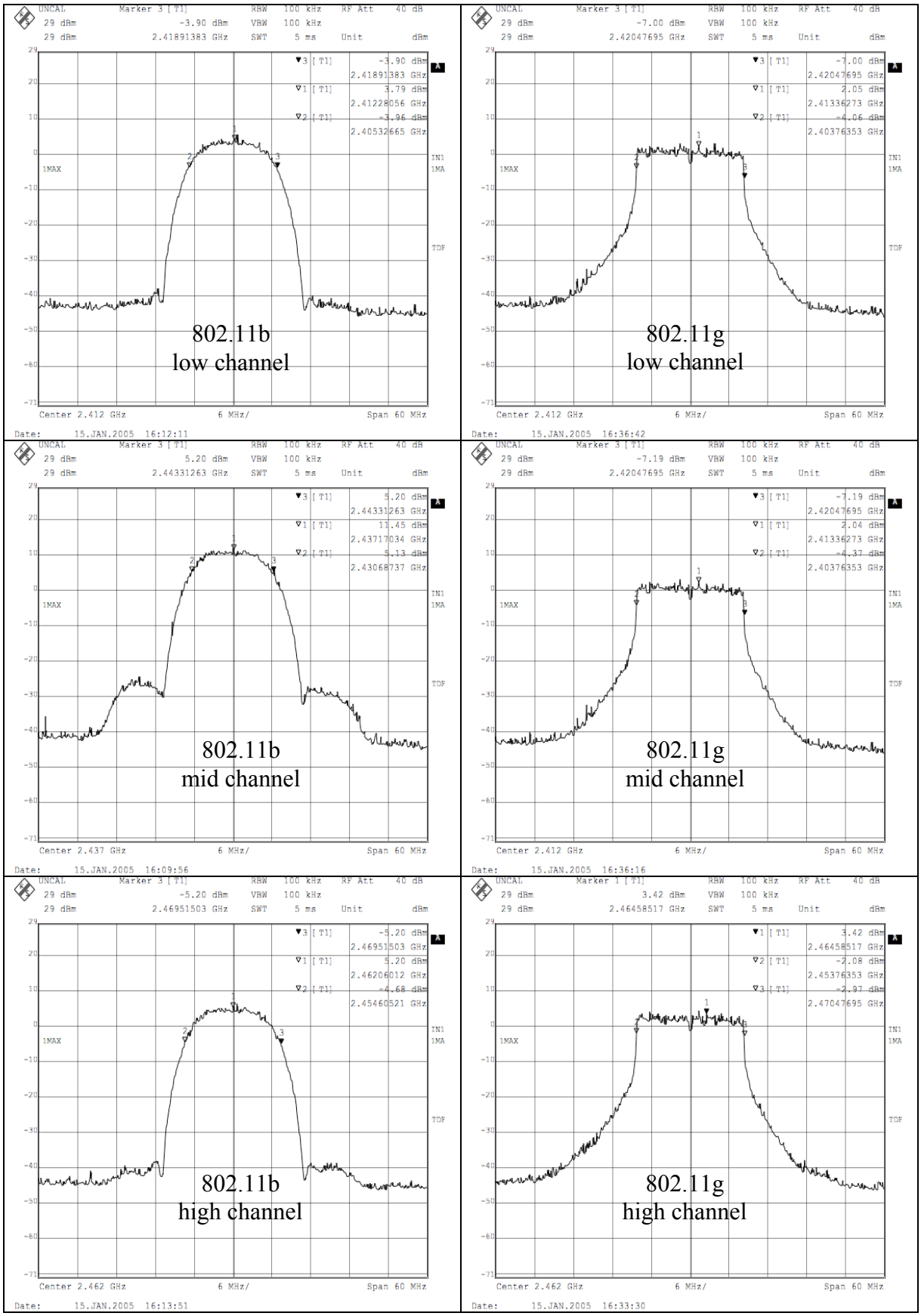
15.247(a) Requirement: For direct sequence systems, the minimum 6dB bandwidth shall be at least 500 kHz.

Test Setup: The antenna output is connected into the spectrum analyzer. RBW and VBW are each set to 100 kHz. The frequency is centered at the carrier center frequency with a 25 MHz span.

Results:

802.11b MODE				
Channel	**Frequency (MHz)**	**6 dB BW (kHz)**	**Req. (kHz)**	**Margin (kHz)**
Low	2412	12 MHz	500	+11.5 MHz
Middle	2437	12 MHz	500	+11.5 MHz
High	2462	12 MHz	500	+11.5 MHz

802.11g MODE				
Channel	**Frequency (MHz)**	**6 dB BW (kHz)**	**Req. (kHz)**	**Margin (kHz)**
Low	2412	16 MHz	500	+15.5 MHz
Middle	2437	16 MHz	500	+15.5 MHz
High	2462	16 MHz	500	+15.5 MHz


802.11b
low channel
802.11g
low channel
802.11b
mid channel
802.11g
mid channel
802.11b
high channel
802.11g
high channel

Peak Power Output

15.247 (b) Requirement 1: For systems using digital modulation in the 2400-2483.5 MHz band, the maximum peak output power shall not exceed 1 watt.

15.247 (b) Requirement 2: If transmitting antenna of directional gain greater than 6dBi are used, the peak output power from the intentional radiator shall be reduced according to the following:

For point to multi-point systems: The total radiated power (transmit output + antenna gain) shall not exceed 36dBm total.

For point-to-point systems: The maximum peak output power limit shall be reduced by 1dB for every 3dB increase in antenna gain beyond 6dBi. (see table below)

Maximum Allowable Powers (Examples)

Point to Multi-Point Radio				Point-to-Point Radio		
TX Power	**Ant. Gain**	**EIRP**		**TX Power**	**Ant. Gain**	**EIRP**
30 dBm	6 dBi	36 dBm		30 dBm	6 dBi	36 dBm
27 dBm	9 dBi	36 dBm		29 dBm	9 dBi	38 dBm
24 dBm	12 dBi	36 dBm		28 dBm	12 dBi	40 dBm

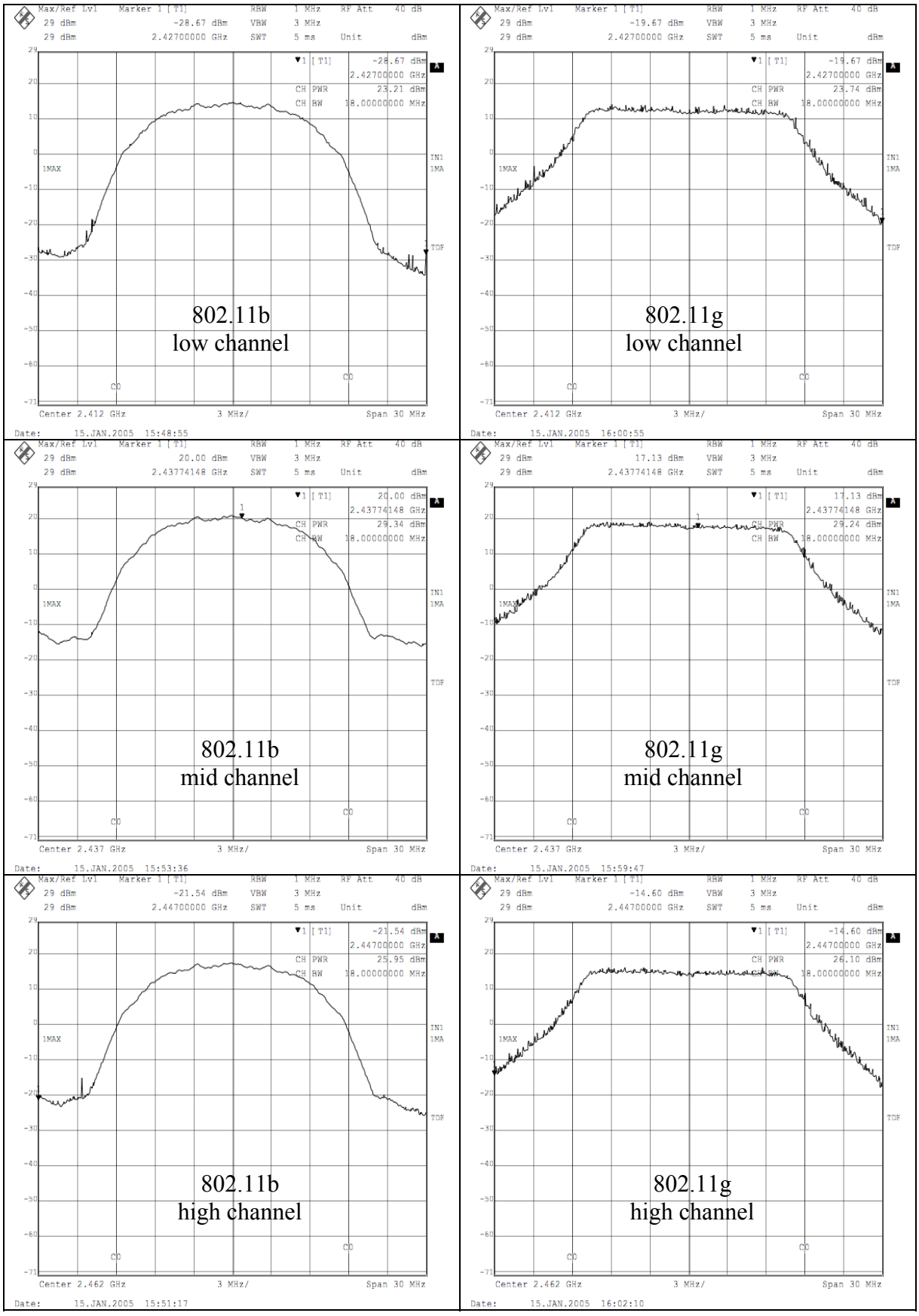
Test Setup: The antenna output is connected into the spectrum analyzer. RBW is set to 1 MHz; Video BW is set to 3 MHz. The channel power function is used on the spectrum analyzer with a 20 MHz channel bandwidth (equal to the 802.11 carrier transmission bandwidth).

Results:

802.11b MODE (11Mbps CCK)				
Channel	**Freq (MHz)**	**Peak Power (dBm)**	**Limit (dBm)**	**Margin (dBm)**
Low	2412	23.21	30 dBm	6.79
Middle	2437	29.34	30 dBm	0.66
High	2462	25.93	30 dBm	4.07

802.11g MODE (54 Mbps OFDM)				
Channel	**Freq (MHz)**	**Peak Power (dBm)**	**Limit (dBm)**	**Margin (dBm)**
Low	2412	23.74	30 dBm	6.26
Middle	2437	29.24	30 dBm	0.76
High	2462	26.10	30 dBm	3.90

***Note: The low and high channels were backed off to meet FCR 15.209 (a) band edge limits.*


802.11b
low channel
802.11g
low channel
802.11b
mid channel
802.11g
mid channel
802.11b
high channel
802.11g
high channel

Maximum Permissible Exposure

15.247 (b) Requirement: Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

In this case, the limit is S =1.0 mW / cm squared

CALCULATIONS:

Given: $E = \frac{\sqrt{(30 \bullet P \bullet G)}}{d}$ And $S = \frac{E^2}{3770}$

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 expressing distance as function of other variables:

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

Using the following:

$P(mw) = P(W)/1000$ and $d(cm) = 100 * d(m)$

Now,

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

$$d = 0.282 \bullet \sqrt{\frac{P \bullet G}{S}}$$

Where

D = Distance in cm.
P = Power in mW
G = Antenna gain (linear)

S = Power Density in mW / cm squared

Substitute the following for a logarithmic relationship:

$$P(mw) = 10^{\frac{P(dBm)}{10}} \quad \text{and} \quad G(linear) = 10^{\frac{G(dBi)}{10}}$$

Finally,

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

Where

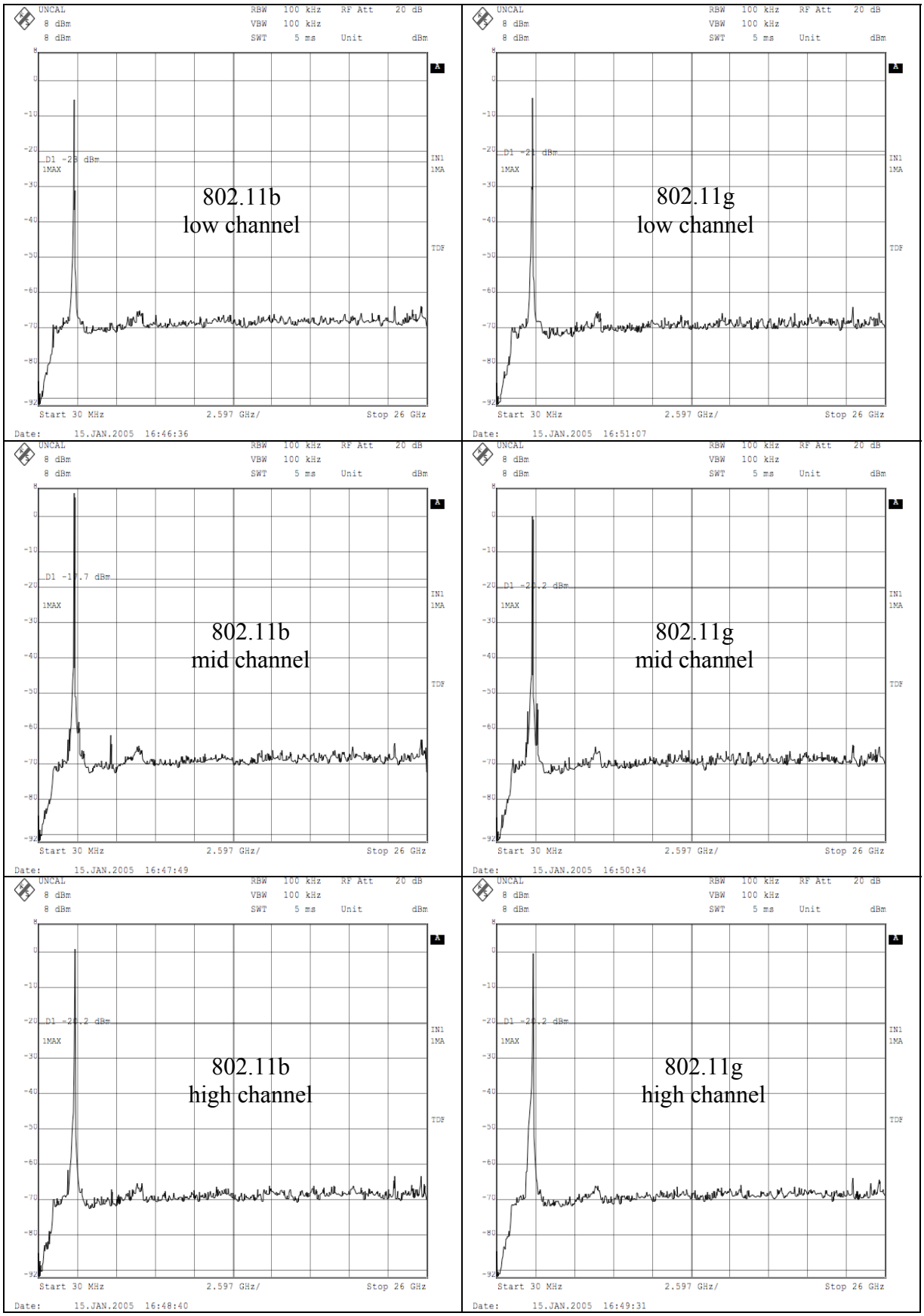
D = MPE distance in cm.
P = Power in dBm
G = Antenna Gain in dBi
S = Power Density Limit in mW / cm squared

Worst Cases Reported (802.11b at mid-channel, 802.11g at mid-channel)				
Mode	Power Density Limit (mW/cm2)	Output Power (dBm)	Antenna Gain (dBi)	MPE distance (cm)
802.11b/g	1.0	29.34	5.5	15.57
802.11a	1.0	29.12	3	11.38

Conducted Spurious Emissions

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

Test Setup: Frequency range set to 30 Mhz-25Ghz, RBW=100kHz, VBW=100kHz. 802.11b/g and low/mid/high cases considered.


802.11b
low channel
802.11g
low channel
802.11b
mid channel
802.11g
mid channel
802.11b
high channel
802.11g
high channel

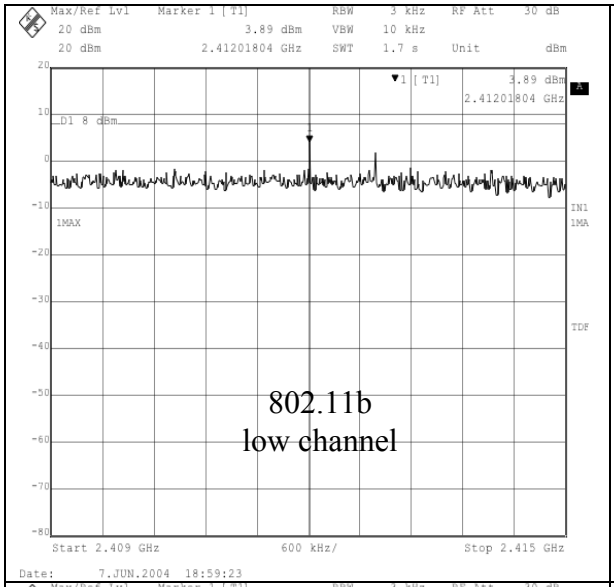
Peak Power Spectral Density

15.247 (d) requirement: For direct sequence systems, the peak power spectral density conducted from the intentional radiator shall not be greater than 8dBm in any 3 kHz band during any time interval continuous transmission.

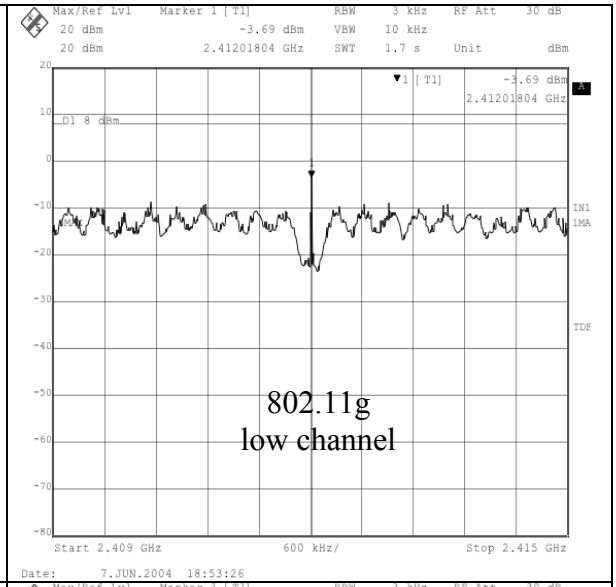
Test Setup: Spectrum analyzer RBW = 3kHz, VBW = 10kHz. Frequency span of 6 MHz used and centered at carrier center.

Results:

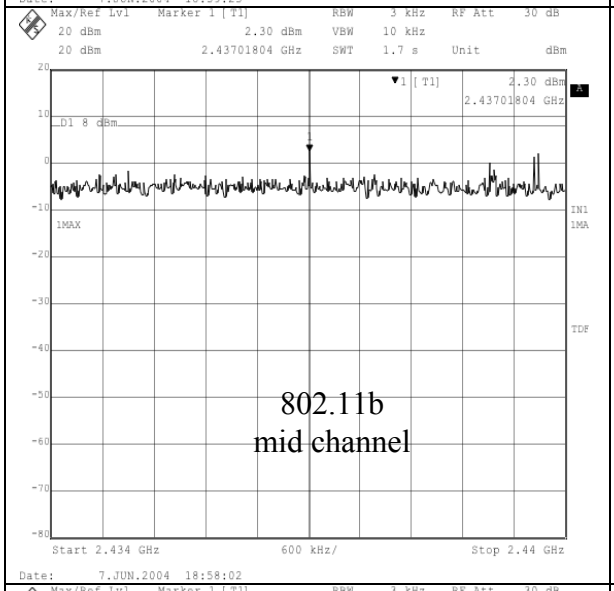
Mode	Channel	Freq (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
802.11b	Low	2412	2.30	8	5.70
802.11b	Mid	2437	3.89	8	4.11
802.11b	High	2462	2.66	8	5.34
802.11g	Low	2412	-3.69	8	11.69
802.11g	Mid	2437	-3.21	8	11.21
802.11g	High	2462	-3.51	8	11.51



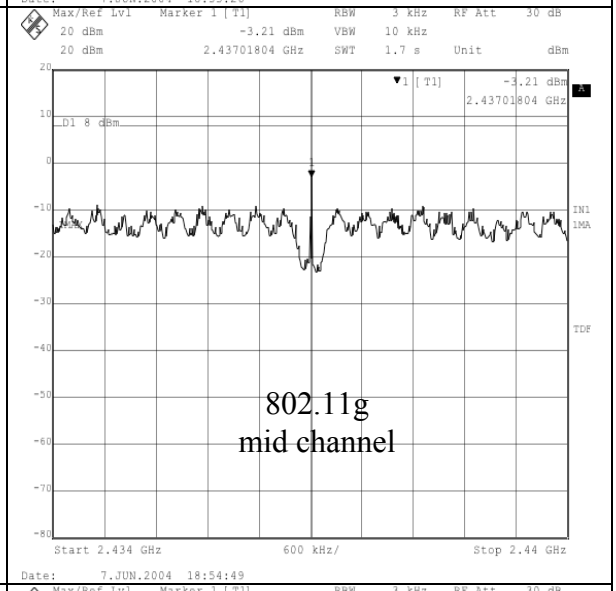
802.11b
low channel



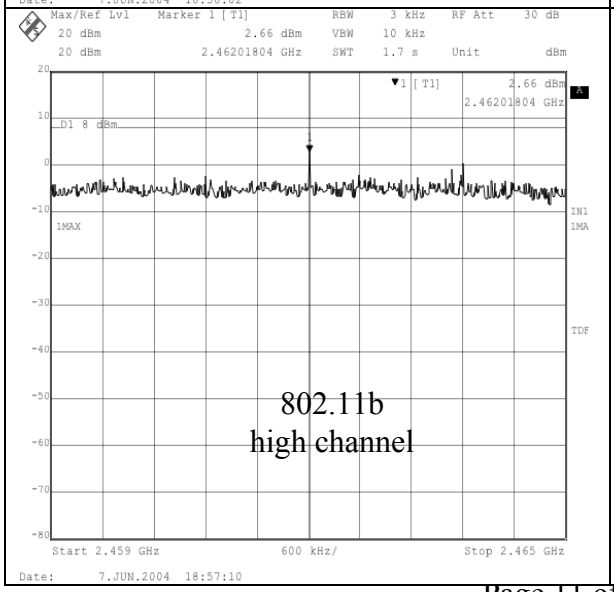
802.11g
low channel



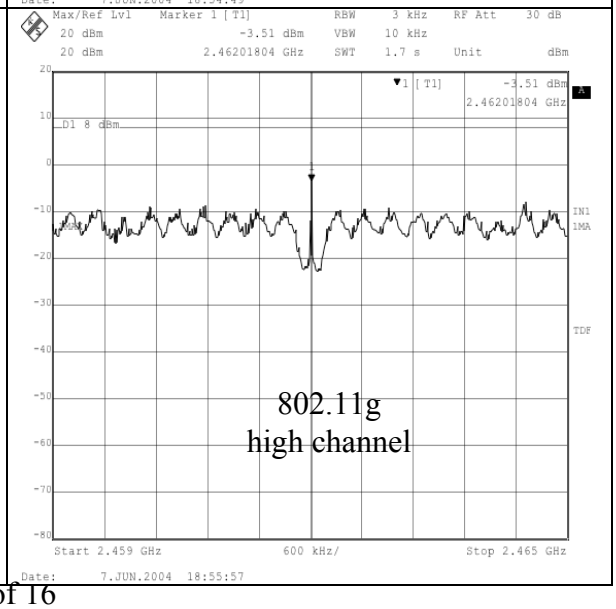
802.11b
mid channel



802.11g
mid channel



802.11b
high channel

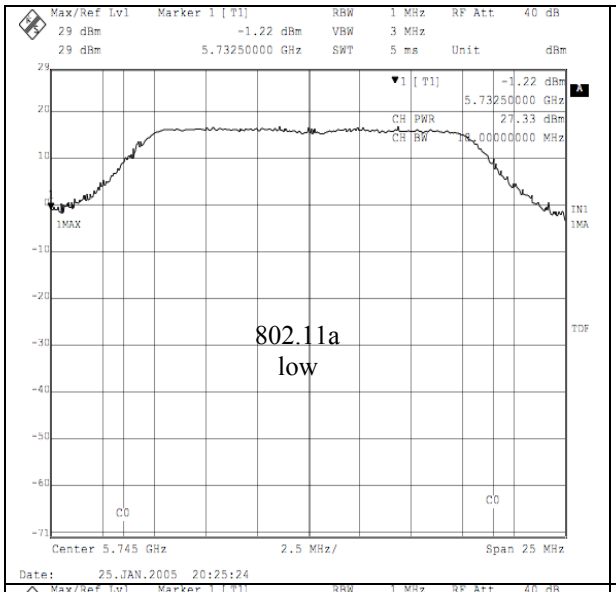


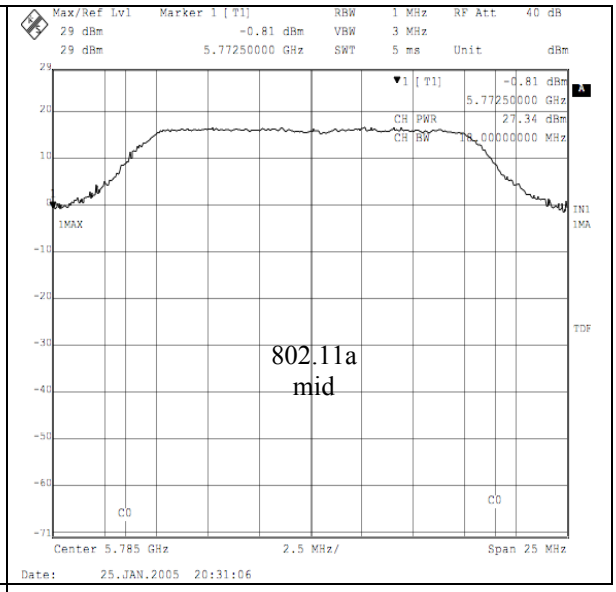
802.11g
high channel

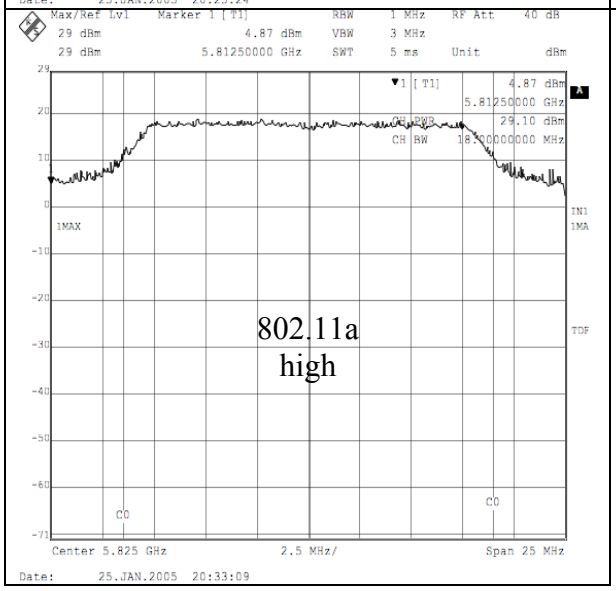
5725-5850 MHz DATA (802.11a)

PEAK OUTPUT POWER

802.11a MODE (54 Mbps OFDM)				
Channel	**Freq (MHz)**	**Peak Power (dBm)**	**Limit (dBm)**	**Margin (dB)**
Low	5745 MHz	27.33	30 dBm	2.67 dB
Mid	5785 MHz	27.34	30 dBm	2.66 dB
High	5825 MHz	29.12	30 dBm	0.88 dB

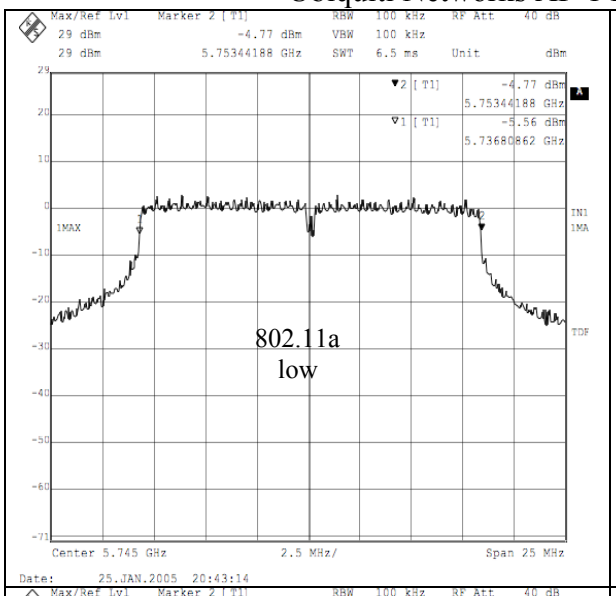


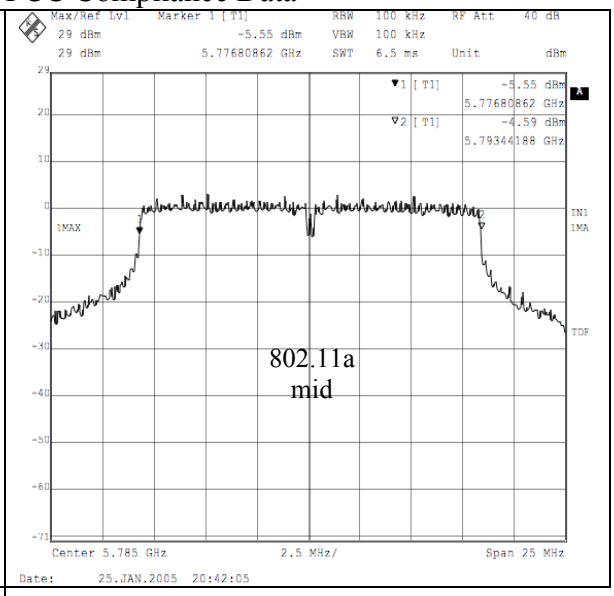


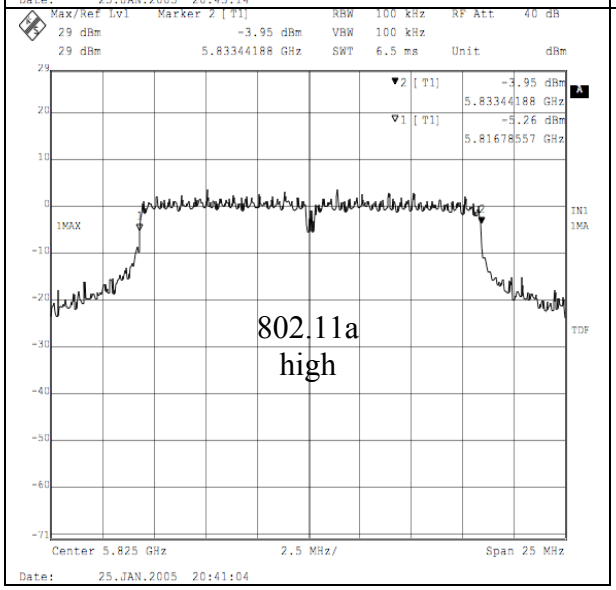


6 dB Bandwidth

802.11a MODE				
Channel	**Frequency (MHz)**	**6 dB BW (kHz)**	**Req. (kHz)**	**Margin (kHz)**
Low	5745	16 MHz	500	+15.5 MHz
Mid	5785	16 MHz	500	+15.5 MHz
High	5825	16 MHz	500	+15.5 MHz

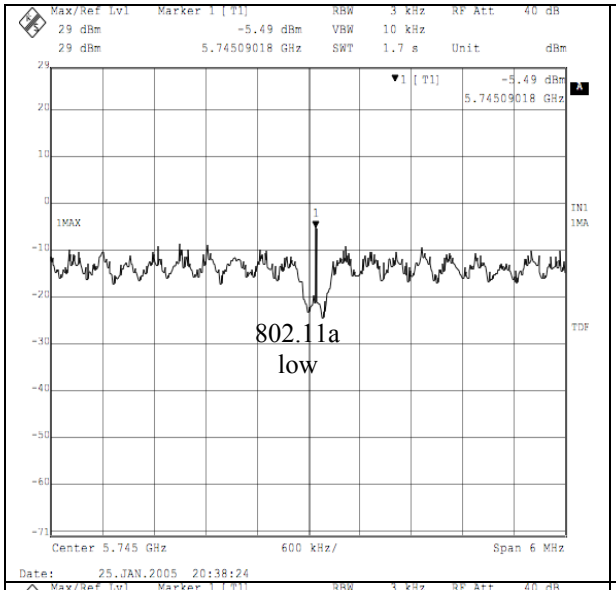


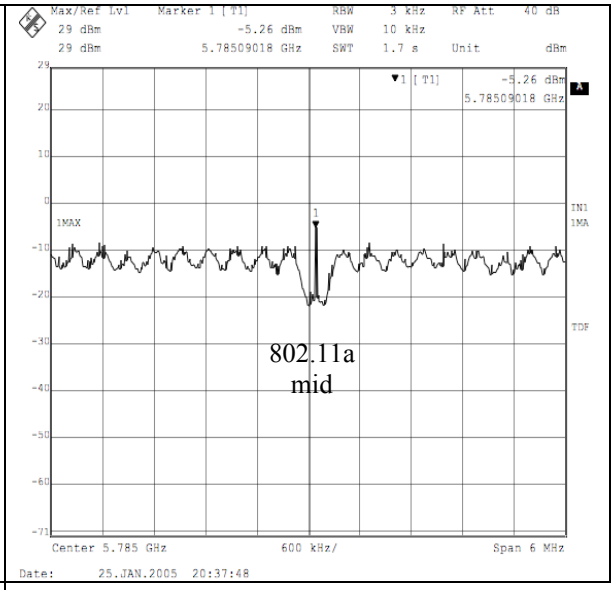


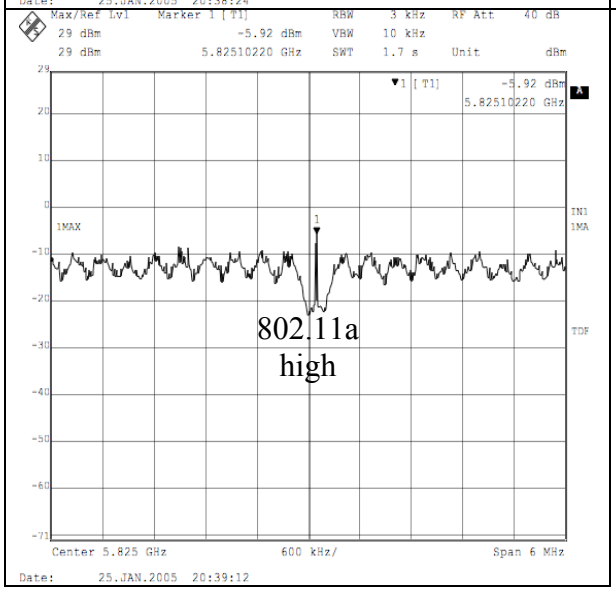


PEAK POWER SPECTRAL DENSITY

Mode	Channel	Freq (MHz)	PPSD (dBm)	Limit (dBm)	Margin (dB)
802.11a	Low	5745	-5.49	8	13.49
802.11a	Mid	5785	-5.24	8	13.24
802.11a	High	5825	-5.02	8	13.02

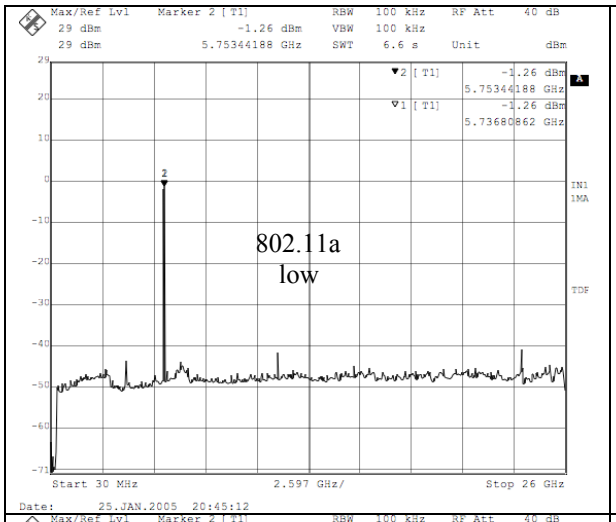


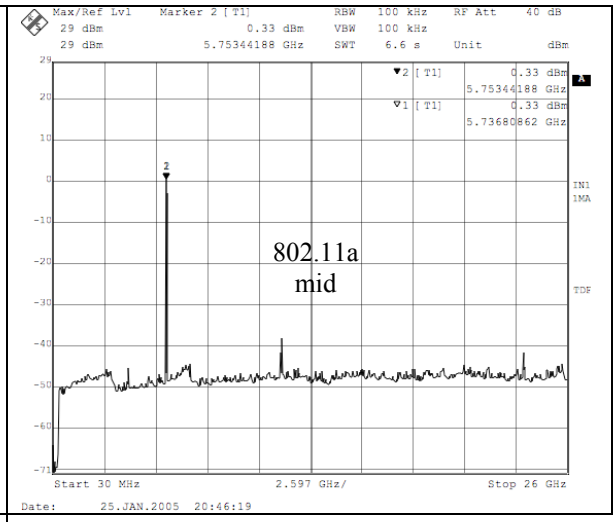


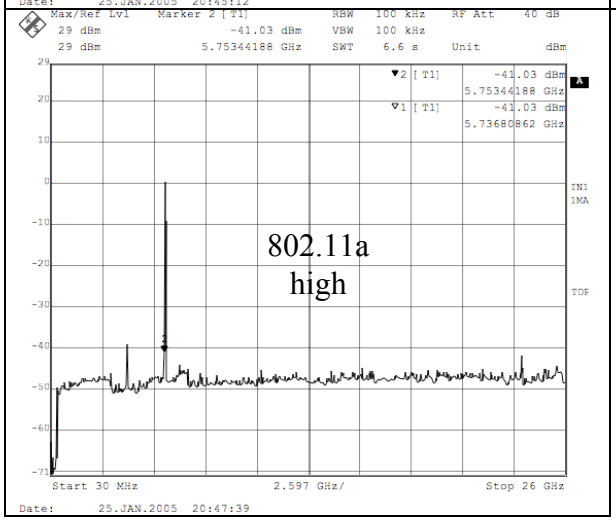


SPURIOUS EMISSIONS

No spurious emissions found greater than -20dBc


Max/Ref Lvl
Marker 2 [T1]
RBW 100 kHz
RF Att 40 dB
29 dBm
-1.26 dBm
VBW 100 kHz
29 dBm
5.75344188 GHz
SWT 6.6 s
Unit dBm
▼2 [T1] -1.26 dBm
5.75344188 GHz
▽1 [T1] -1.26 dBm
5.73680862 GHz
802.11a
low
Start 30 MHz
2.597 GHz/
Stop 26 GHz
Date: 25.JAN.2005 20:45:12


Max/Ref Lvl
Marker 2 [T1]
RBW 100 kHz
RF Att 40 dB
29 dBm
0.33 dBm
VBW 100 kHz
29 dBm
5.75344188 GHz
SWT 6.6 s
Unit dBm
▼2 [T1] 0.33 dBm
5.75344188 GHz
▽1 [T1] 0.33 dBm
5.73680862 GHz
802.11a
mid
Start 30 MHz
2.597 GHz/
Stop 26 GHz
Date: 25.JAN.2005 20:46:19


Max/Ref Lvl
Marker 2 [T1]
RBW 100 kHz
RF Att 40 dB
29 dBm
-41.03 dBm
VBW 100 kHz
29 dBm
5.75344188 GHz
SWT 6.6 s
Unit dBm
▼2 [T1] -41.03 dBm
5.75344188 GHz
▽1 [T1] -41.03 dBm
5.73680862 GHz
802.11a
high
Start 30 MHz
2.597 GHz/
Stop 26 GHz
Date: 25.JAN.2005 20:47:39