Motorola
4.9 GHz Technical Recommendations

April 15, 2004
Meeting with FCC

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12/16/03 Motorola Ex Parte Highlights

- **Public Safety users would benefit by minimizing adjacent channel interference at the outset**
  - **Greater Capacity**
  - **Higher Quality**
  - **More Spectrally Efficient**
- **Manufacturers can meet FCC mask or DSRC-C mask by adding inexpensive filter <u>external</u> to COTS chipsets and/or by software changes**
- **Manufacturers building Japanese 4.9 band or U.S. U-NII products must modify equipment to serve U.S. Public Safety 4.9 market, regardless of FCC mask decision**
- **FCC should be proactive and minimize interference up front before the band is populated**

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Current Motorola Position with NPSTC

- **Leverage 5 GHz COTS devices and/or technology**
  - **Allow re-tuned and re-certified 5 GHz devices to be used at 4.9 GHz**
  - **Allow lower tier U-NII devices based on 802.11a mask into 4.9 GHz band**
  - **Base high tier devices on mask similar to 5.9 GHz DSRC Mask C**

- **Maintain in-band adjacent channel interference protection**
  - **Low tier devices, operate at lower power levels, using 802.11a mask**
  - **High tier devices, operate at higher power levels, using tighter mask**

- **Maintain bandwidth scalable mask, to accommodate 1 MHz to 20 MHz bandwidth channels.**

- **Continue dialogue to reach agreement on maximizing COTS use while maintaining adjacent channel protection**

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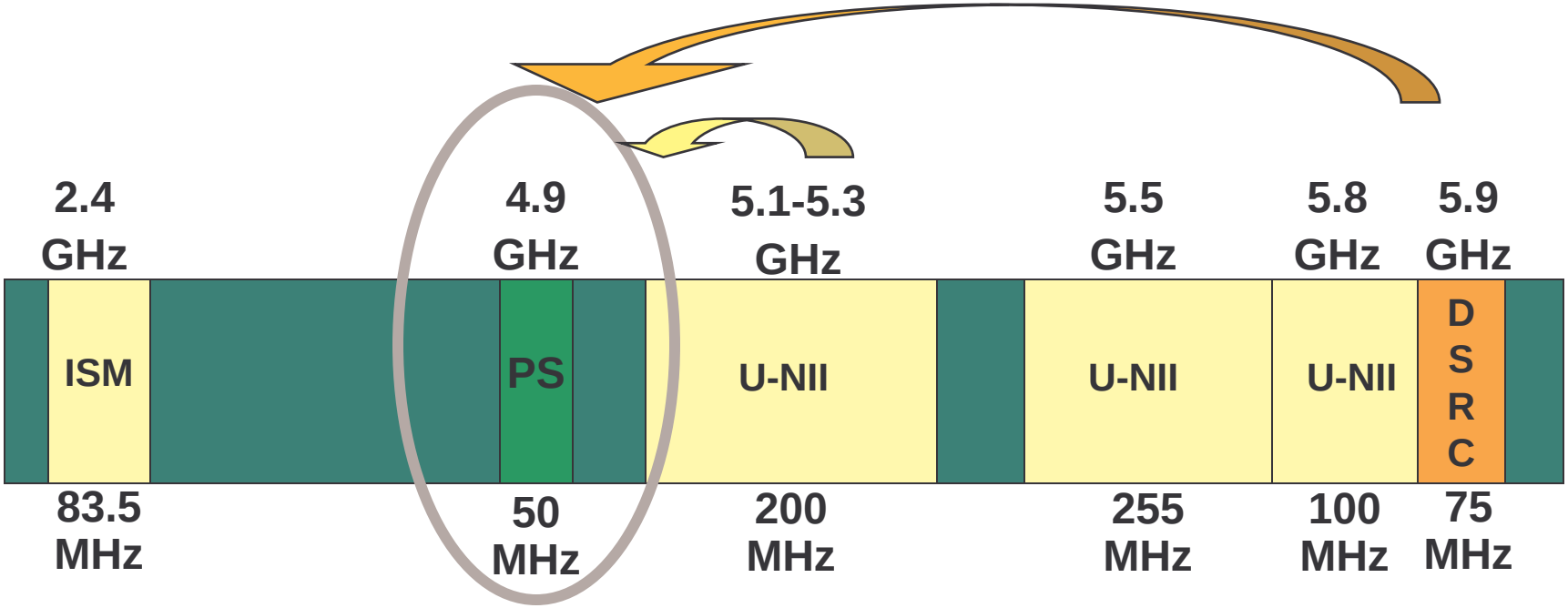
Leverage UNII and DSRC COTS Technology for 4.9 GHz



PS - Public Safety Licensed Spectrum

U-NII - Unlicensed Broadband Spectrum

DSRC - Digital Short Range Communications Spectrum

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Approaching Consensus

Position	NPSTC	Motorola
• PS needs its own band	Yes	Yes
• Leverage 5 GHz technology for 4.9 GHz	Yes	Yes
• Need a 4.9 industry standard (TIA)	Yes	Yes
• Need regional planning	Yes	Yes
• Leverage DSRC masks	Yes	Yes
• Tighter mask for higher power	Yes	Yes
• Adjacent channel protection necessary	No	Yes
• User scenario is key deciding factor for interference	Yes	Yes
• 4.9 Scenarios are established	Yes	No
• FCC Mask is significant issue for COTS re-use at 4.9 GHz	Yes	No

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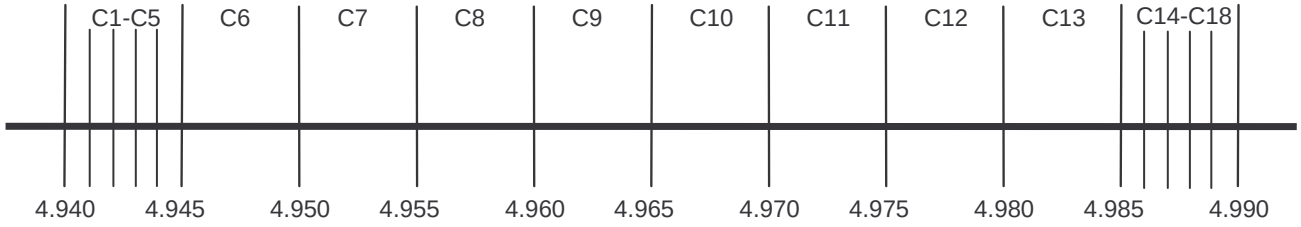
Interference Rules Need to Account for Channel/Use Flexibility

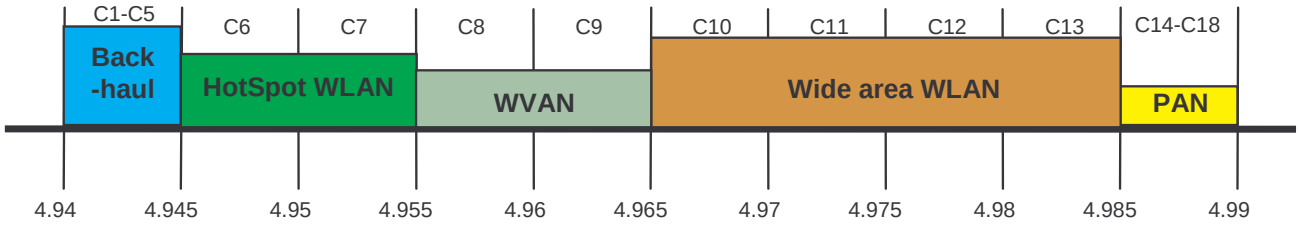
Adjacent channel users operating on multiple channel bandwidths and at various power levels

- FCC Bandplan

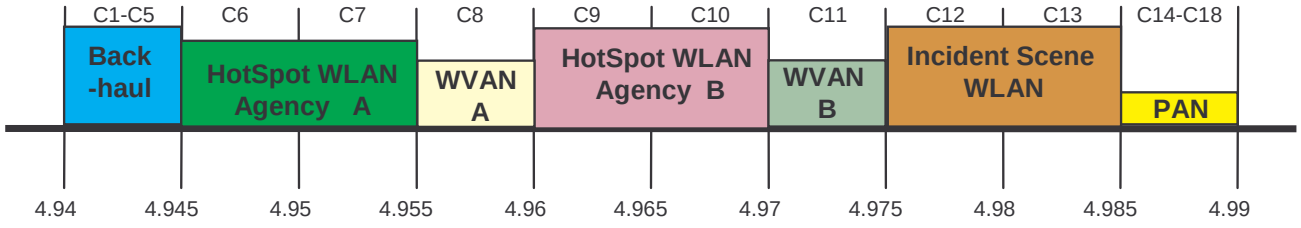


Sample Scenarios

- Multi-service/ Multi-agency (Fully Shared Networks)



- Multi-service/ Multi-agency (Partial Sharing)



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Approaches Under Discussion

- Motorola Recommendation: Dec. 16, 2003 FCC Presentation
  - DSRC Class A mask
    - Limit power to 0 dBm per 20 MHz channel
  - DSRC Class C mask
    - Devices with power in excess of 0 dBm per 20 MHz channel
- Other approaches discussed with NPSTC
  - Based on 802.11a mask instead of DSRC Class A mask
    - Max power 8 dBm per 20 MHz channel to provide adjacent channel protection; or
    - Max power 17 dBm per 20 MHz channel (4 dBm/MHz) with Part 15 OOBE limit adopted
      - NPSTC rejects need for OOBE limit
      - Motorola concerned about lower adjacent channel protection
  - DSRC Class C mask for higher power devices

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Existing U-NII Band Devices

Analysis of Maximum Power Allowed from Type Acceptance Grants

	5.150 to 5.250		5.250 to 5.350		5.725 to 5.825	
Max allowed	4	dBm/MHz	11	dBm/MHz	17	dBm/MHz
	17	dBm	24	dBm	30	dBm/MHz
	Assume 20 MHz bandwidth					
Maximum	4.00	dBm/MHz	11.00	dBm/MHz	15.55	dBm/MHz
on Grant	17.00	dBm	24.00	dBm	28.55	dBm
Average	2.83	dBm/MHz	4.81	dBm/MHz	7.63	dBm/MHz
on Grant	15.83	dBm	17.81	dBm	20.63	dBm
Samples	57		55		29	

Results:

1) Most devices in lower U-NII bands operating at less than maximum allowed power levels.
2) Many devices are certified in both 5.150-5.250 and 5.250-5.350 bands and are operating at different power levels. Which means output power is defined by operational frequency.

Therefore, power output level can be modified for devices being re-certified for 4.9 GHz band. 0 to 2 dB reduction for most devices.

Previous analysis of smaller sample, using power levels of devices used for type acceptance testing:
- **Showed average of ~ 2 dBm/MHz power density in 5.150-5.250 band**
- **Showed average of ~ 4 dBm/MHz power density in 5.250-5.350 band**

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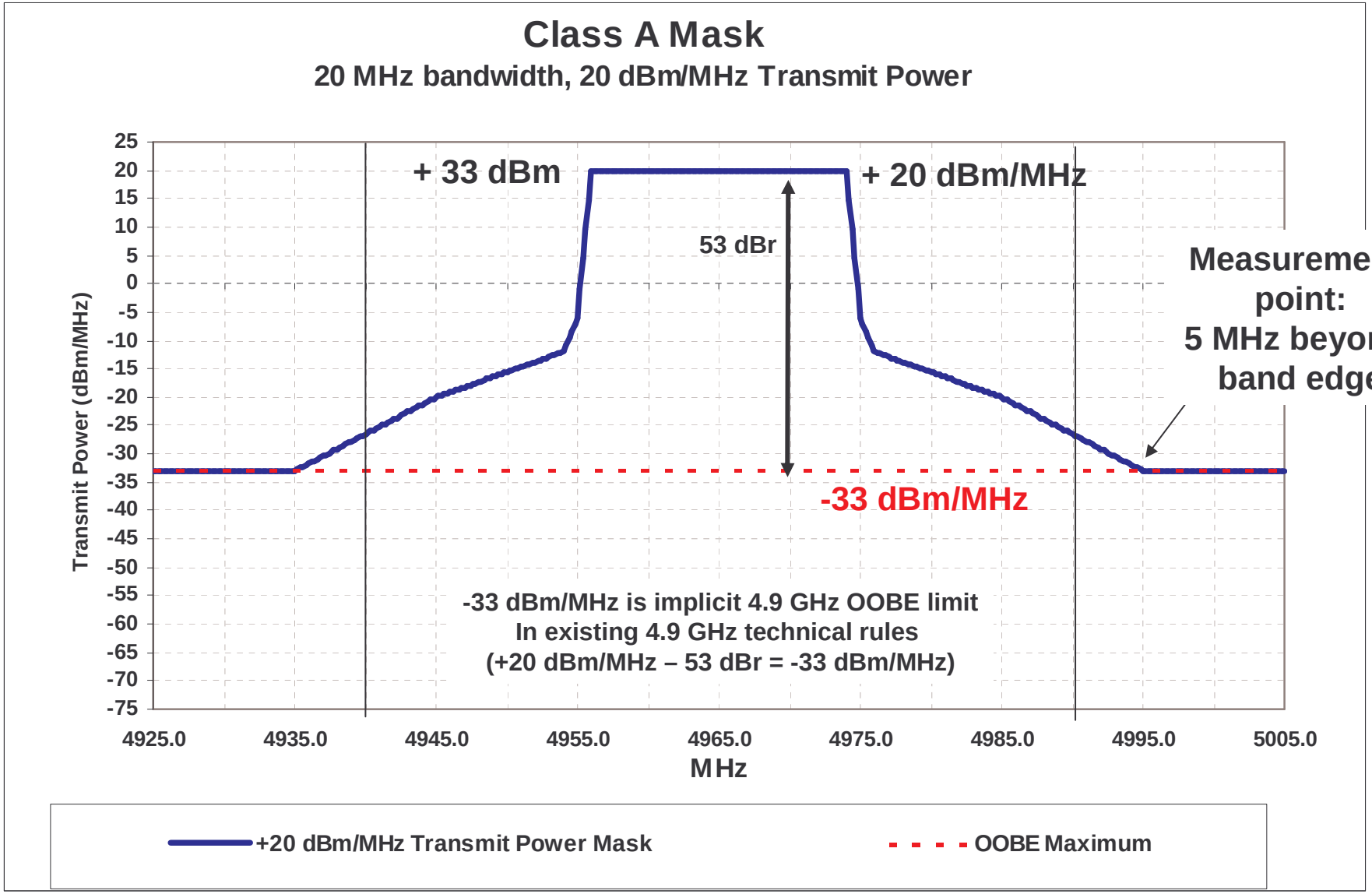
4.9 GHz DSRC C Mask Out-of-Band Emission Limit



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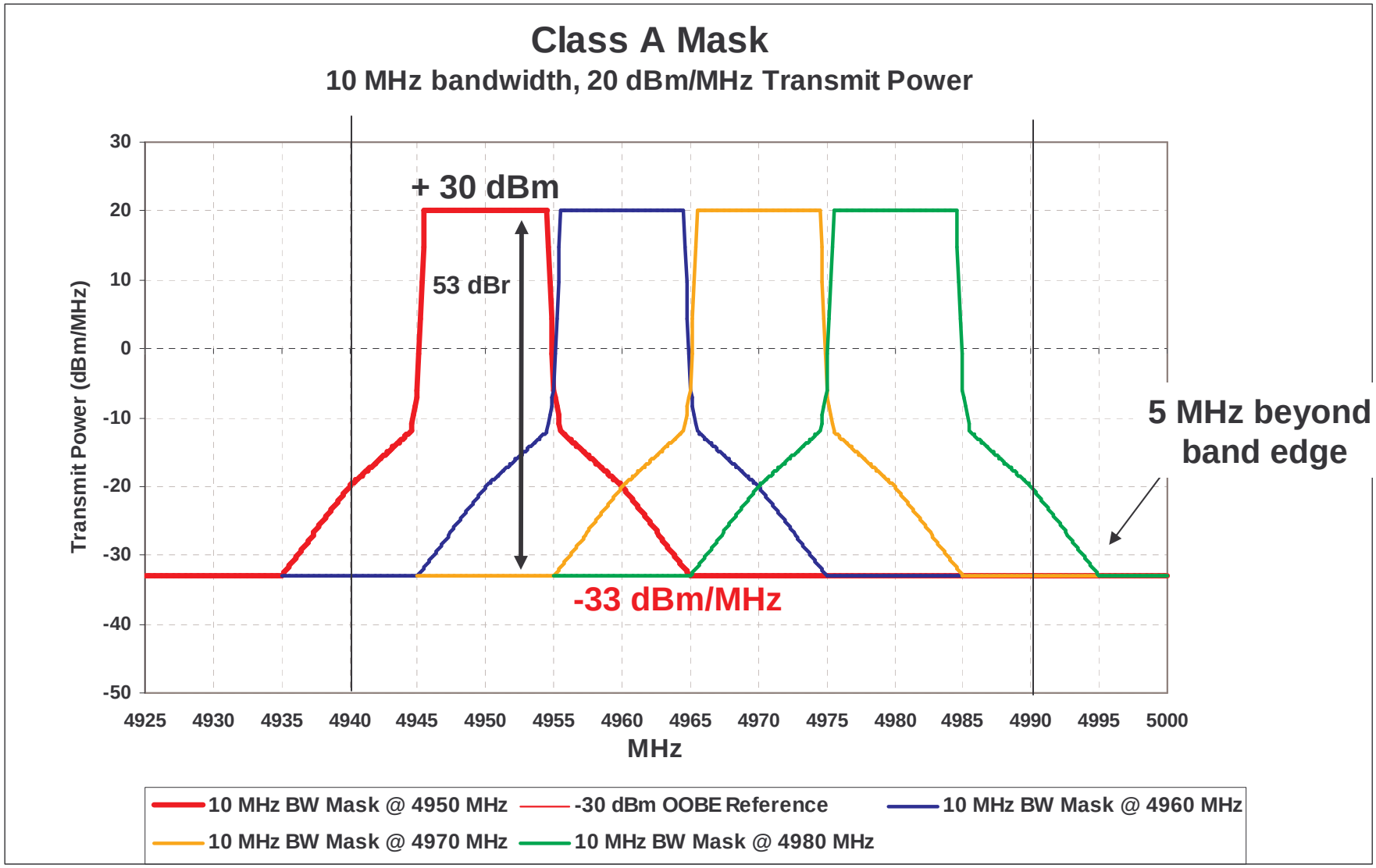
4.9 GHz DSRC C Mask Out-of-Band Emission Limit



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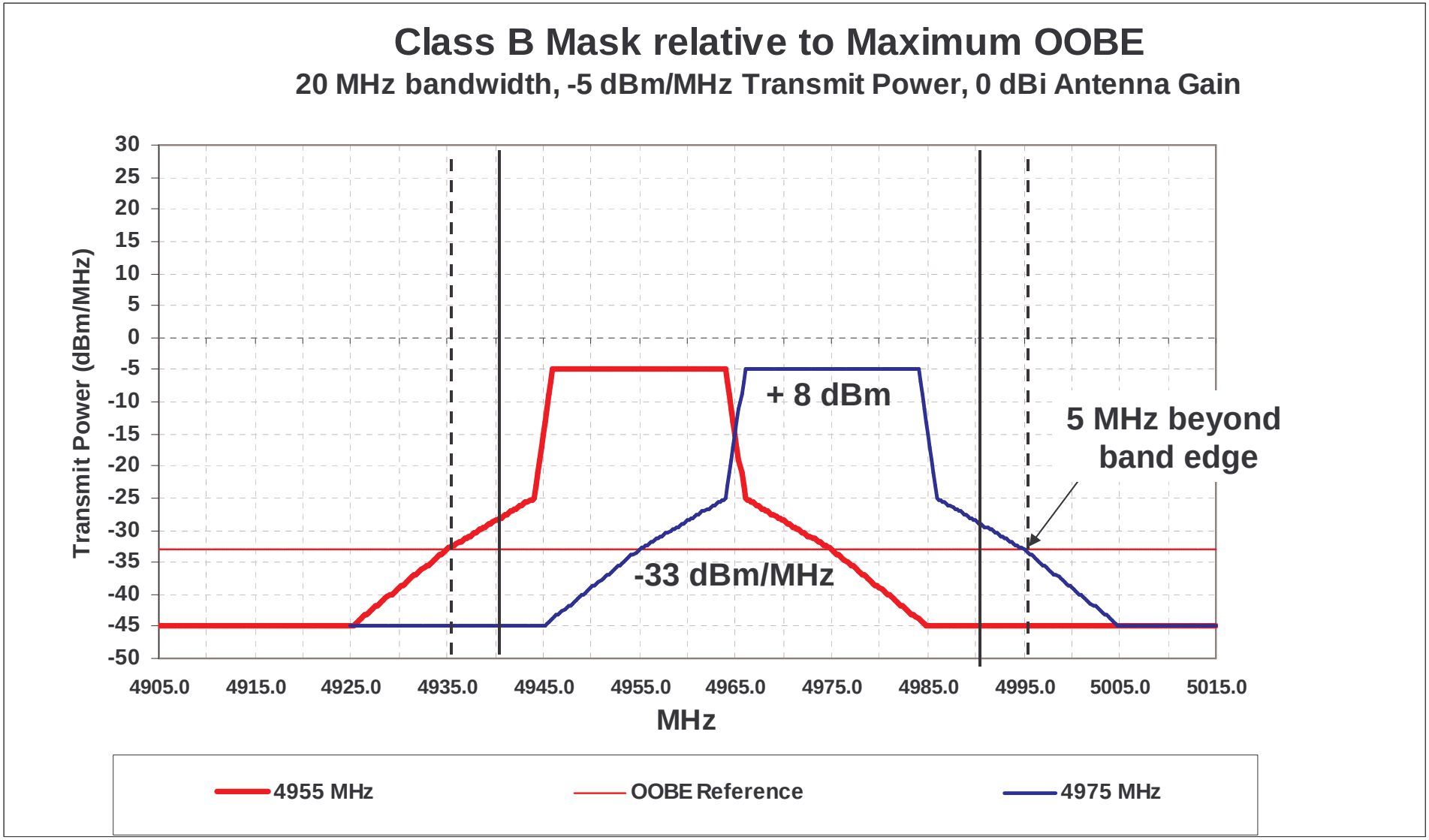
4.9 GHz 802.11a Out-of-Band Emission Limit



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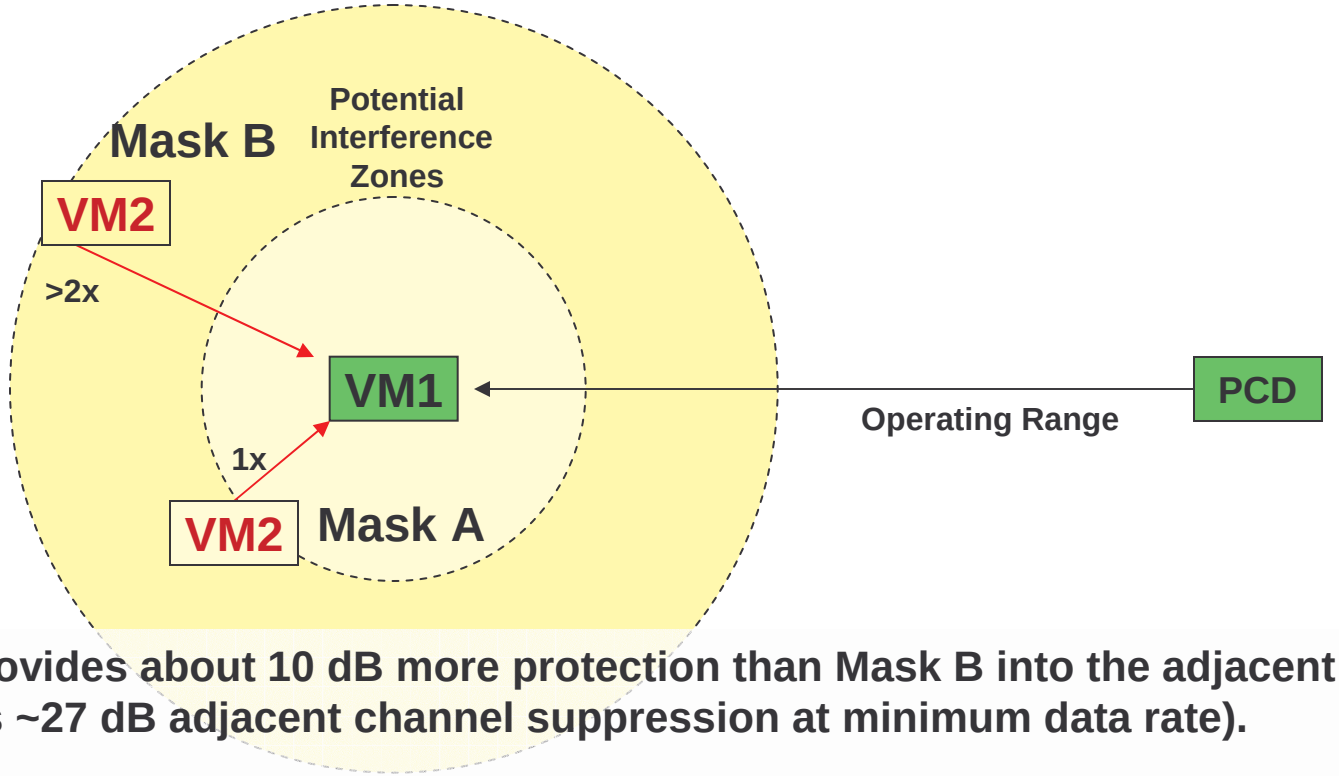
4.9 GHz Adjacent Channel Interference



Mask A provides about 10 dB more protection than Mask B into the adjacent channel (~37 dB vs ~27 dB adjacent channel suppression at minimum data rate).

Adjacent channel interference (from VM2) limits the maximum distance between the subscriber device (PCD) and the device it is communicating with (VM1).

For the same operational range of the subscriber device, the radius of interference for Mask B is double that of Mask A, i.e., interference area is 4X.

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Mask Impact on Adjacent Channel Interference

PSD	EIRP in 20 MHz (0 dBi antenna)	Operating Range	Adj. Channel Interference Range: FCC 4.9 Mask	Class A Mask	Class B Mask	
-13 dBm/MHz	0 dBm	19.3	1.5	2.2	4.6	
-3 dBm/MHz	10 dBm	41.7	3.3	4.6	10.0	
7 dBm/MHz	20 dBm	89.9	7.1	10.5	21.0	
-5 dBm/MHz	8 dBm	35.8	2.8	4.1	8.8	Two Class B within band @ 4955 and 4975 MHz
0.5 dBm/MHz	13.5 dBm	54.5	4.0	6.0	12.7	One Class B within band @ 4960 or 4970 MHz
4 dBm/MHz	17 dBm	71.3	5.2	7.6	16.7	One Class B within band @ 4965 MHz

From December 16, 2003 Motorola Ex-parte

18 dB C/I, -85 dBm Receiver Sensitivity, 30 dB Path Geometry, Class A mask @ 35 dB ACP, Class B mask @ 25 dB ACP

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Class A Emission Mask

Same as ASTM/DSRC Class C mask, except for point f5. Point f5 @ -53 dBr matches current FCC mask limit.

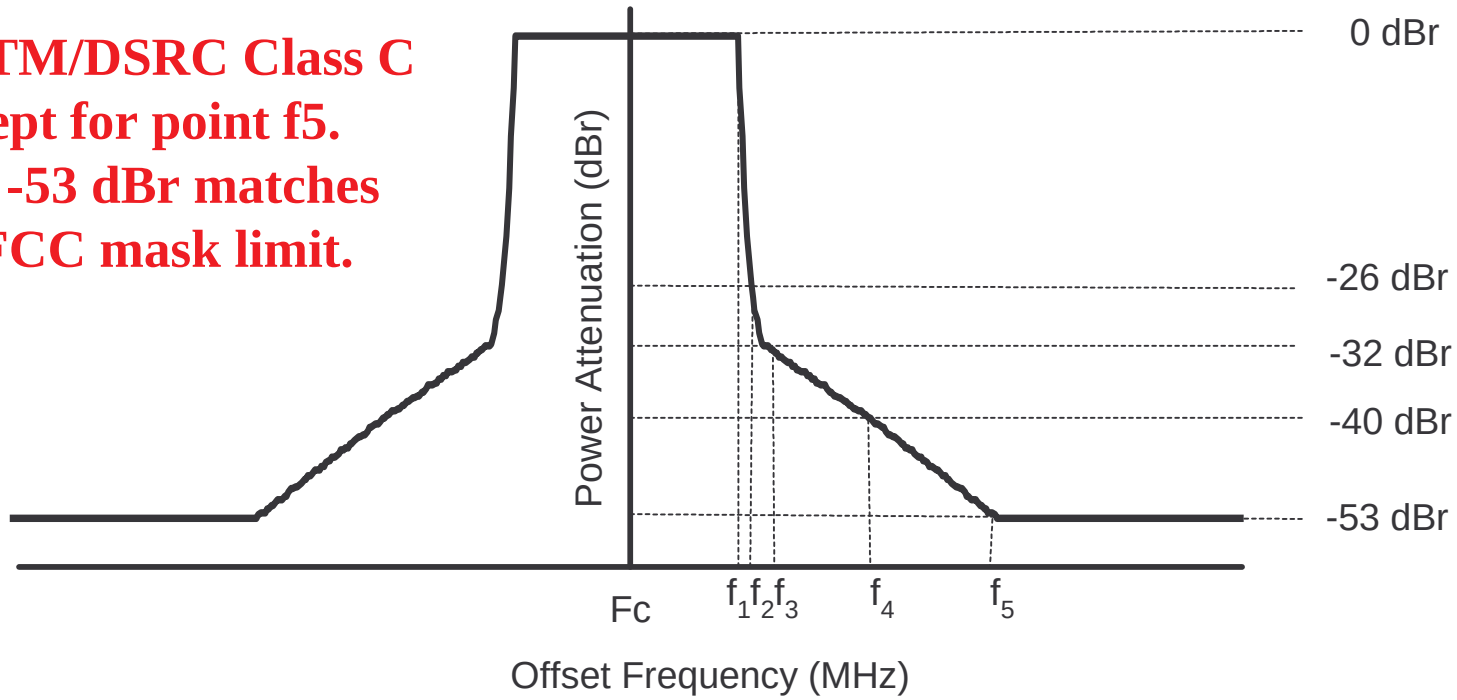

Figure 2

Fc – channel central frequency

f1 – Fc+/-0.45 times the channel bandwidth	**= 0 dBr**
f2 – Fc+/-0.50 times the channel bandwidth	**= -26 dBr**
f3 – Fc+/-0.55 times the channel bandwidth	**= -32 dBr**
f4 – Fc+/-1.0 times the channel bandwidth	**= -40 dBr**
f5 – Fc+/-1.5 times the channel bandwidth	**= -53 dBr**

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Class B Emission Mask

Same as 802.11a mask.

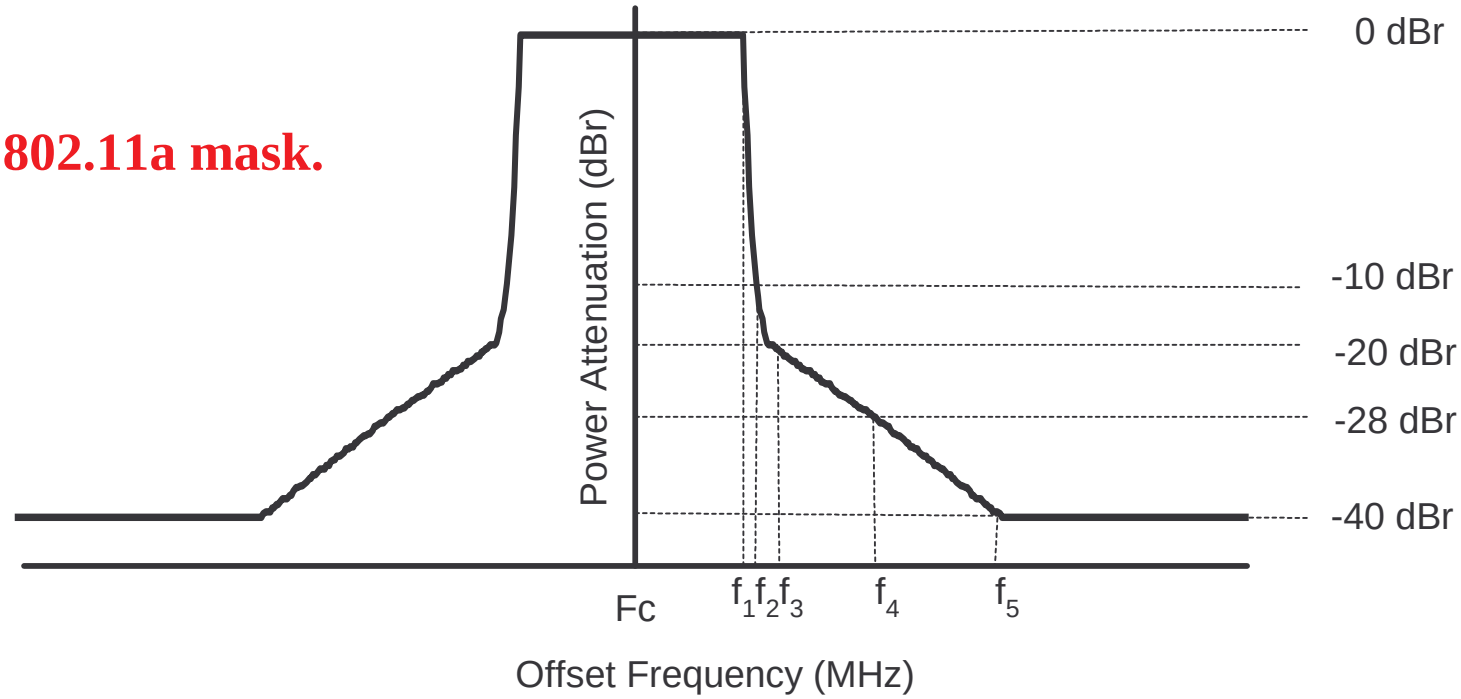

Figure 1

Fc – channel central frequency
f1 – Fc+/-0.45 times the channel bandwidth = 0 dBr
f2 – Fc+/-0.50 times the channel bandwidth = -10 dBr
f3 – Fc+/-0.55 times the channel bandwidth = -20 dBr
f4 – Fc+/-1.0 times the channel bandwidth = -28 dBr
f5 – Fc+/-1.5 times the channel bandwidth = -40 dBr

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Back-up Slides

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Technical Comparison

5 GHz U-NII and 4.9 GHz Public Safety

Band	In-band Mask	Out-of Band Limit	Frequency Bands	Power Limits (Tx Pwr Out)	Channel Width	Closest Ch. Center to Band Edge Spacing[1]
5 GHz U-NII	In 802.11 standard	In FCC rules -27 dBm/MHz EIRP	5.150 - 5.250 5.250 - 5.350 5.470 - 5.725 5.725 - 5.825	4 dBm/MHz 11 dBm/MHz 11 dBm/MHz 17 dBm/MHz	20 MHz 20 MHz 20 MHz 20 MHz	30 MHz[4] 30 MHz[2] 30 MHz[2] 20 MHz[3]
Current 4.9 GHz Rules						
4.9 GHz P.S.	In FCC rules	None[5] -33 dBm/MHz implied	4.940-4.990	20 dBm/MHz Tx Pwr Out	1, 5, 10, 20 MHz	> ½ Channel Bandwidth

1 Closest spacing to meet OOBE limit using max power, max antenna gain, and 802.11a mask
2 802.11a mask emissions reduced by 4 dB to meet OOBE limit at max power and antenna gain.
3 5.725-5.825 band OOBE specification reduced by 10 dB to -17 dBm/MHz at band edge, and -27 dBm/MHz at 10 MHz beyond band edge. 802.11a mask emissions reduced by 10 dB to meet OOBE limit at max power and antenna gain.
4 802.11a mask emissions reduced by 3 dB to meet OOBE limit at max power and antenna gain.
5 No OOBE limits defined in current 4.9 GHz band rules (implicit level of -33 dBm/MHz).

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5 GHz U-NII Device Type Certification Grant Data

Vendor	FCC ID	Date	Device Type	5.150 to 5.250	5.150 to 5.250	5.250 to 5.350	5.250 to 5.350	5.725 to 5.825	5.725 to 5.825	Antenna Gain
				watts	dBm	watts	dBm	watts	dBm	dBi (peak)
Harris								0.0830	19.19	
Senao				0.0310	14.91	0.0300	14.77	0.0770	18.86	0.0
Proxim	HZB-8460	10/31/2002	802.11 card	0.0900	17.00			0.1000	20.00	
Proxim	IMK-8455	12/6/2002	802.11 card	0.0460	16.63			0.1000	20.00	
Proxim	IMK-CAWCB500	1/8/2002	U-NII Card	0.0229	13.60	0.0229	13.60			
Proxim	HZB-C38WCW	9/4/2003	802.11 AP	0.0495	16.95	0.0831	19.20			
Proxim	HZB-A13QBFPC	6/26/2003	802.11 AP					0.0390	15.91	5.0
Proxim	HZB-A13QBFPC	5/30/2003	802.11 AP	0.0440	16.43	0.0510	17.08			
Proxim	HZB-8482WD	6/12/2003	802.11 PCI	0.0500	16.99	0.0500	16.99	0.0310	14.91	5.0
Proxim	HZB-A09UCF	8/15/2003	AP					0.1220	20.86	
Proxim	IMK-AP5	11/10/2001	AP	0.0410	16.13	0.0490	16.90			
Atheros	PPD-AR5BAP-00030	11/7/2001	AP	0.0400	16.02	0.1290	21.11			6.0
Atheros	PPD-AR5BAP-00032	10/29/2001	AP	0.0460	16.63	0.1250	20.97	0.7160	28.55	4.0
Atheros	PPD-AR5BCB-00012	10/29/2001	802.11 PCI	0.0220	13.42	0.0220	13.42			
Atheros	PPD-AR5BCB-00013	2/26/2002	802.11 PCI	0.0410	16.13	0.1740	22.41			
Atheros	PPD-AR5BCB-00021	11/26/2002	802.11 PCI	0.0460	16.63	0.1260	21.00			
Atheros	PPD-AR5BCB-00021	8/20/2002	802.11 PCI					0.1250	20.97	
Atheros	PPD-AR5BCB-00022	9/11/2002	802.11 PCI	0.0900	17.00	0.0900	19.54	0.1360	21.34	
Atheros	PPD-AR5BCB-00032	8/22/2003	802.11 PCI	0.0590	17.00	0.0590	17.71	0.1750	22.43	
Toshiba	CJ6UPA3234WL	11/13/2003	802.11 PCI	0.0450	16.53	0.0540	17.32			
Toshiba	CJ6UPA3233WL	11/13/2003	802.11 PCI	0.0500	16.99	0.0500	16.99			
Toshiba	CJ6UPA3233WL	11/13/2003	802.11 PCI					0.2040	23.10	
Toshiba	CJ6UPP350WL2	3/12/2003	802.11 PCI	0.0500	16.99	0.0500	16.99			
Toshiba	CJ6UPP350WL2	3/12/2003	802.11 PCI					0.2040	23.10	
Toshiba	CJ6UPA3297WL	11/13/2003	802.11 PCI	0.0480	16.81	0.0470	16.72	0.1320	21.21	
Toshiba	CJ6UZPCN064WL	8/8/2003	802.11 AP	0.0410	16.13	0.0400	16.02	0.0960	19.82	4.5
Accton	HEDWN6301BAC	8/25/2003	802.11 PCI	0.0590	17.00	0.0590	17.71	0.1750	22.43	
Accton	HEDWN6301ACC	5/30/2003	802.11 PCI	0.0480	16.81	0.0510	17.08	0.0800	19.03	
Accton	HEDWA610260	2/19/2004	802.11 AP	0.0360	15.56	0.0980	19.91	0.1260	21.00	
Accton	HEDWA6101BACC	4/23/2003	802.11 AP	0.0500	16.99	0.1010	20.04	0.0790	18.98	
Accton	HEDSMC2555WA	10/20/2003	802.11 AP	0.0357	15.53	0.0977	19.90	0.1260	21.00	
Accton	HEDSMC2555W	9/17/2003	802.11 AP	0.0357	15.53	0.0361	15.58	0.0357	15.53	
Accton	HEDACCWA5001	12/19/2001	802.11 AP	0.0400	16.02	0.1290	21.11			
Accton	HED3CRWE870075	5/5/2003	802.11 AP	0.0490	16.90	0.2010	23.03	0.2190	23.40	
Accton	HEDWA6101ACC		802.11 AP	0.0491	16.91	0.0948	19.77	0.0805	19.06	

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5 GHz U-NII Device Type Certification Grant Data (cont)

Vendor	FCC ID	Date	Device Type	5.150 to 5.250	5.150 to 5.250	5.250 to 5.350	5.250 to 5.350	5.725 to 5.825	5.725 to 5.825	Antenna Gain
				watts	dBm	watts	dBm	watts	dBm	dBi (peak)
Xircom	J3OWSAP5000	11/30/2001	802.11 AP	0.0230	13.62	0.0370	15.68			1.8 omni
Xircom	J3OWPCI5000	3/27/2002	802.11 PCI	0.0490	16.90	0.1260	21.00			2.0
Xircom	J3OWM3A5000	5/24/2002	802.11 PCI	0.0416	16.19	0.0912	19.60			2.0
Xircom	J3OWDAP5000	12/18/2001	802.11 AP	0.0490	16.90	0.1250	20.97			1.8 omni
Xircom	J3OWCB5000A	4/19/2002	802.11 PCI	0.0350	15.44	0.0350	15.44			3.9 omni
RF Micro	RFN5405RDK0401	1/9/2004	802.11 PCI	0.0450	16.53	0.0450	16.53			
Broadcom	QDS-BRCM1007	2/20/2004	802.11 AP	0.0389	15.90	0.1580	21.99			5.6
Intersil/Conexant	OSZ39300A	9/8/2003	802.11 AP	0.0480	16.81	0.0800	19.03			
Intersil/Conexant	OSZ39200C1	12/9/2003	802.11 PCI	0.0490	16.90	0.0950	19.78			
Intersil/Conexant	OSZ39001C	10/30/2003	802.11 PCI	0.0398	16.00	0.0794	19.00			
Intersil/Conexant	OSZ39000C	10/20/2003	802.11 PCI	0.0398	16.00	0.0794	19.00			
Intersil/Conexant	OSZ39000M1	8/21/2003	802.11 PCI	0.0488	16.88	0.0575	17.60			
Intersil/Conexant	OSZ39000M	10/20/2003	802.11 PCI	0.0488	16.88	0.0575	17.60			
Intersil/Conexant	OSZ37704M	5/22/2003	802.11 PCI	0.0370	15.68	0.0740	18.69			
Intersil/Conexant	OSZ37704C	12/17/2002	802.11 PCI	0.0490	16.90	0.0692	18.40			
Cisco	LDK102045	8/13/2002		0.0250	13.98	0.0370	15.68			
Cisco	LDK102044	6/27/2002		0.0210	13.22	0.0200	13.01			
Cisco	LDK102047	5/7/2003						0.275	24.39	
Cisco	LDK102051	11/21/2003		0.0320	15.05	0.0320	15.05	0.1	20.00	
Cisco	LDK102050	10/16/2003						0.175	22.43	
Cisco	LDK102045	9/24/2003		0.0250	13.98	0.0370	15.68			
Cisco	LDK102047P	5/7/2003						0.275	24.39	
Cisco/Linksys	PKW-WPC51AB	1/15/2003		0.0900	17.00	0.0900	19.54	0.136	21.34	
Cisco/Linksys	PKW-WAP51AB	12/19/2002		0.0210	13.22	0.3200	24.00			
Cisco/Linksys	PKW-WMP51AB	12/4/2002		0.0460	16.63	0.0420	16.23			
Cisco/Linksys	PKW-WRT51AB	11/9/2002		0.0250	13.98	0.0330	15.19			
Cisco/Linksys	PKW-WRT55AG	3/13/2003		0.0250	13.98	0.0330	15.19			
Cisco/Linksys	PKW-WAP-55AG	3/12/2003		0.0210	13.22	0.0320	15.05			
Cisco/Linksys	PKW-WMP55AG	3/7/2003		0.0460	16.63	0.0420	16.23	0.032	15.05	
Cisco/Linksys	PKW-WAP54A	4/17/2002		0.0303	14.81	0.0303	14.81			
Cisco/Linksys	PKW-WPC54A	7/29/2002		0.0123	10.89	0.0123	10.89			

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