IEEE P802.11
Wireless LANs

U-NII Out-of-Band Emission Requirements

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Abstract

The U-NII band out-of-band emissions requirements are described. This includes a comparison of the U-NII power spectral density specification and the restricted band rules. The restricted band rules apply at the U-NIII lower and middle band edges and are more stringent than those otherwise required for the U-NII out-of-band emissions.

The effect of the out-of-band requirements are related to the necessary U-NII band channelization.

PURPOSE

Describe the U-NII Band Out-of-Band Emissions Requirement, Including

The U-NII Power Spectral Density Specification and

the Restricted Band Rules

Relate these to the U-NII Channelization Requirements

THE U-NII PSD DEFINITION

The Peak Power Spectral Density (PSD) is the maximum <u>average</u> power measured through a 1 MHz resolution bandwidth filter during a burst (packet) transmission with the measurement filter frequency set at the value that produces the maximum PSD.

PSD is also termed the <u>Burst Average Power</u> per MHz in the following charts.

The Formal Wording.

From the WINForum reconsideration petition. Expected to be included in the rules.

15.403(f) *Power Spectral Density.* The power spectral density is the total energy output per unit bandwidth from a pulse or sequence of pulses for which the transmit power is at its peak or maximum level, divided by the total duration of the pulses. This total time does not include the time between pulses during which the transmit power is off or below its maximum level.

15.403(g) *Peak Power Spectral Density.* The peak power spectral density is the maximum power spectral density, with the specified measurement bandwidth, within the U-NII device operating band.

U-NII Out-of-Band Emissions are specified in terms of <u>Peak Power Spectral Density</u> except in the <u>Restricted Bands.</u>

The bands immediately adjacent to the lower and middle U-NII bands are <u>Restricted Bands.</u>

THE RESTRICTED BAND RULES
15.35 (b), 15.205, and 15.209

Average E-Field Limit (100 ms) = 500 μv/m at 3 meters
Peak E-Field Limit = 5 mV/m at 3 meters
1 MHz measurement bandwidth

5 mv/m at 3 meters

$$\frac{E^2 r^2}{30} = \frac{\left(5 \times 10^{-3} \times 3\right)^2}{30} = 7.5 \times 10^{-6} \text{ Watts } = \text{ - 21.3 dBm PeP EIRP}$$

1 MHz resolution bandwidth (15.35 (b) in new editions)

100 milliseconds averaging time
    10 Hz video filter bandwidth for measuring
    Further correction allowed if lower duty cycle can be shown.

-21.3 dBm - Peak Envelope Power EIRP (PeP EIRP).

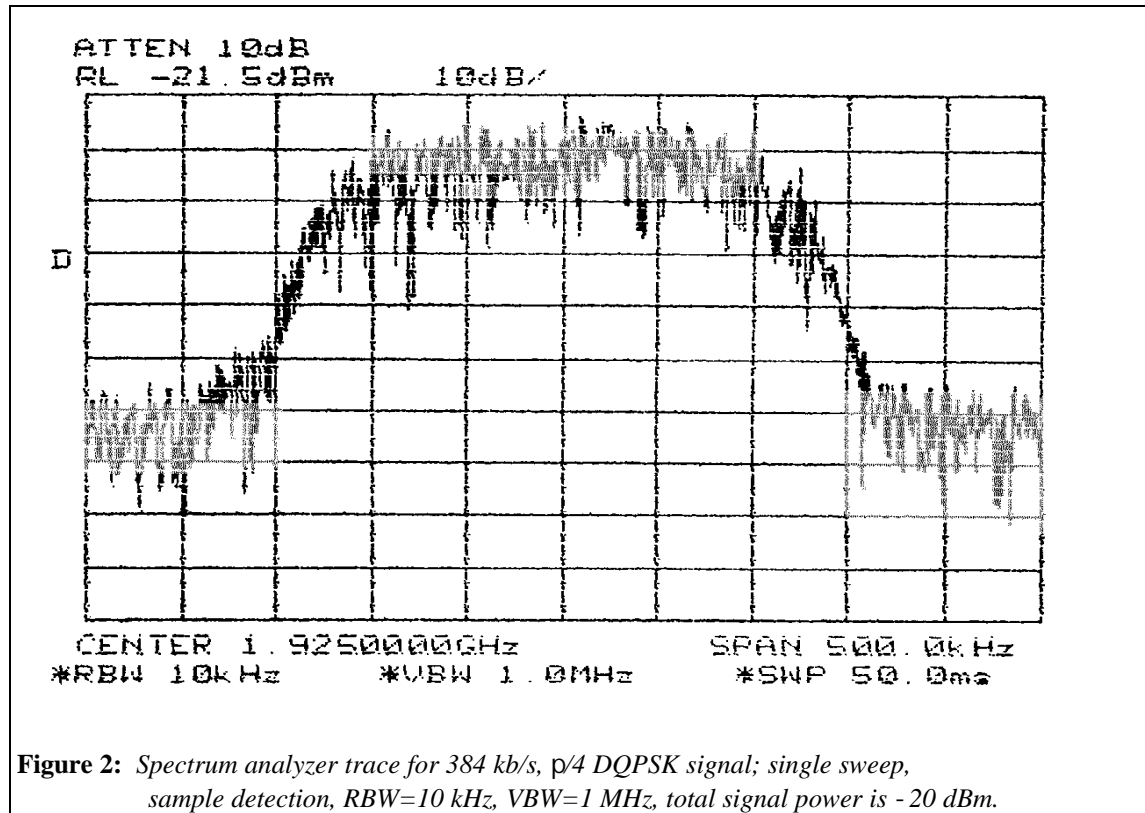**-40.3 dBm - Average E-field at Full Duty Cycle**
    Average E-Field (voltage) must be 20 dB less than the maximum PeP
     (1 dB advantage because measured as voltage average)

Worst case PSD is about -40.3 dBm

PEAK TO AVERAGE POWER RATIO WITH HIGH EMISSION BANDWIDTH TO RESOLUTION BANDWIDTH RATIO

From the WINForum Reconsideration Petition, Attachment A

Single Spectrum Analyzer Trace
$\pi/4$ DQPSK signal
6 dB bandwidth = 250 kHz
RBW = 10 kHz.
384 kb/s

Equivalent to:
6 dB bandwidth = 25 MHz
RBW = 1.0 MHz
38.4 Mb/s

Figure 2: *Spectrum analyzer trace for 384 kb/s,* p/4 *DQPSK signal; single sweep, sample detection, RBW=10 kHz, VBW=1 MHz, total signal power is - 20 dBm.*

PEAK TO AVERAGE POWER RATIO WITH HIGH EMISSION BANDWIDTH TO RESOLUTION BANDWIDTH RATIO CONTINUED
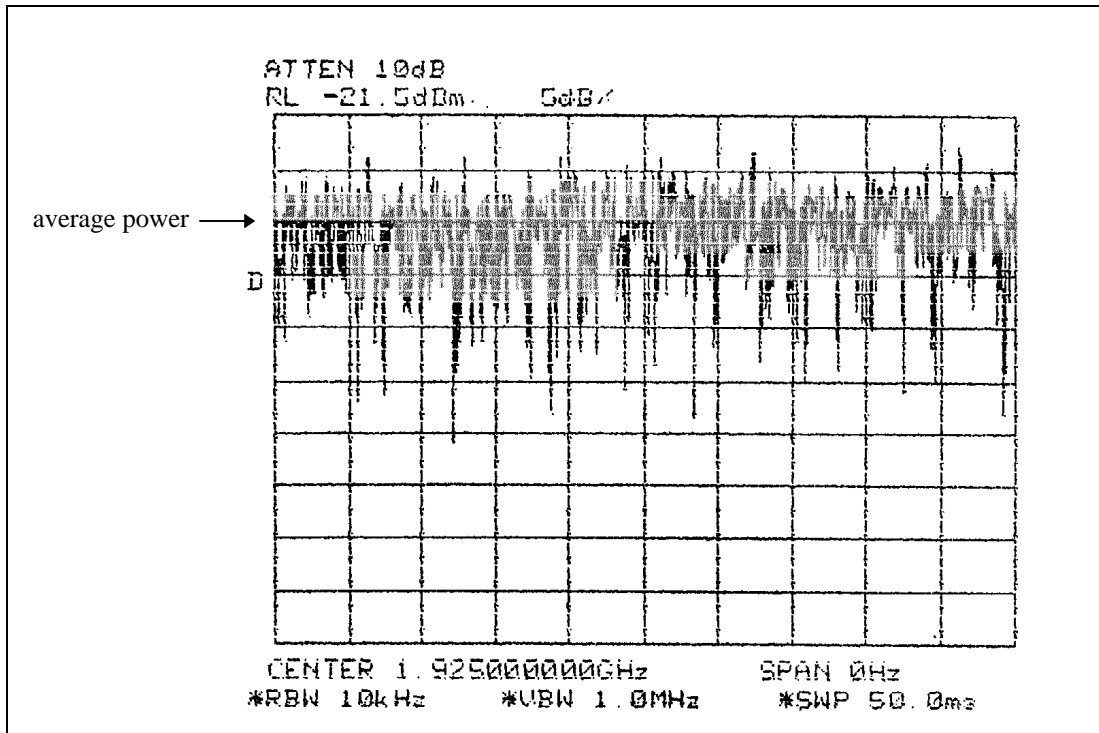

**Zero Span Trace of Previous Signal
at Center Frequency**

The peak to average power ratio is about 7 dB.

Amplitude distribution is approximately Gaussian

Figure 3: *Zero-span trace for same signal as in Fig. 2. The average power out of the resolution filter is - 31.5 dBm.*

PEAK TO AVERAGE POWER RATIO WITH HIGH EMISSION BANDWIDTH TO RESOLUTION BANDWIDTH RATIO CONTINUED

Figure 4: *Simulation results for 600 uncorrelated exponentially-distributed random variables.*
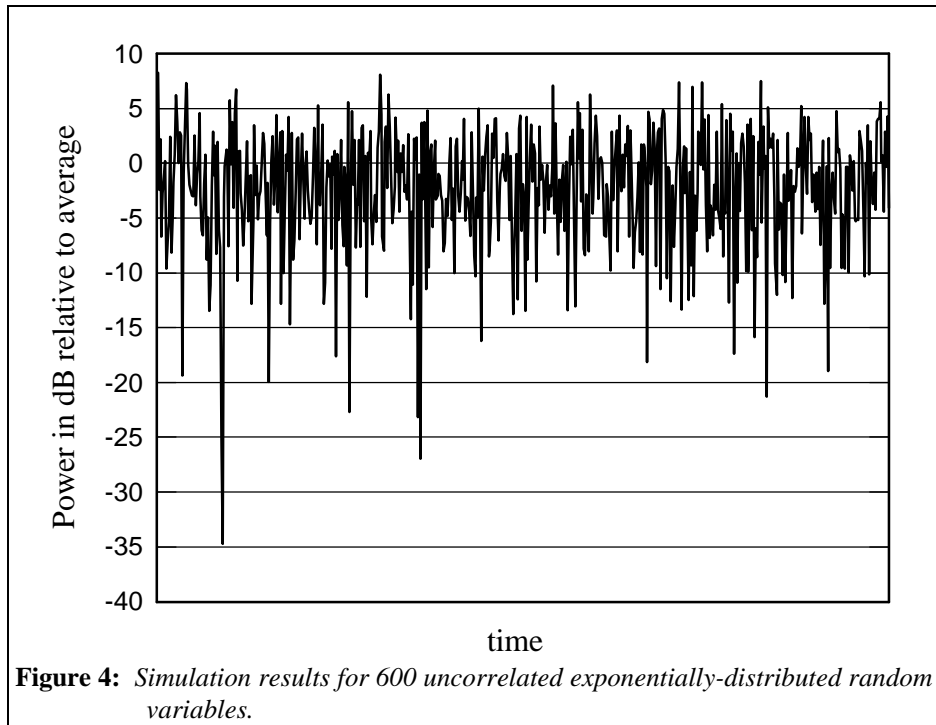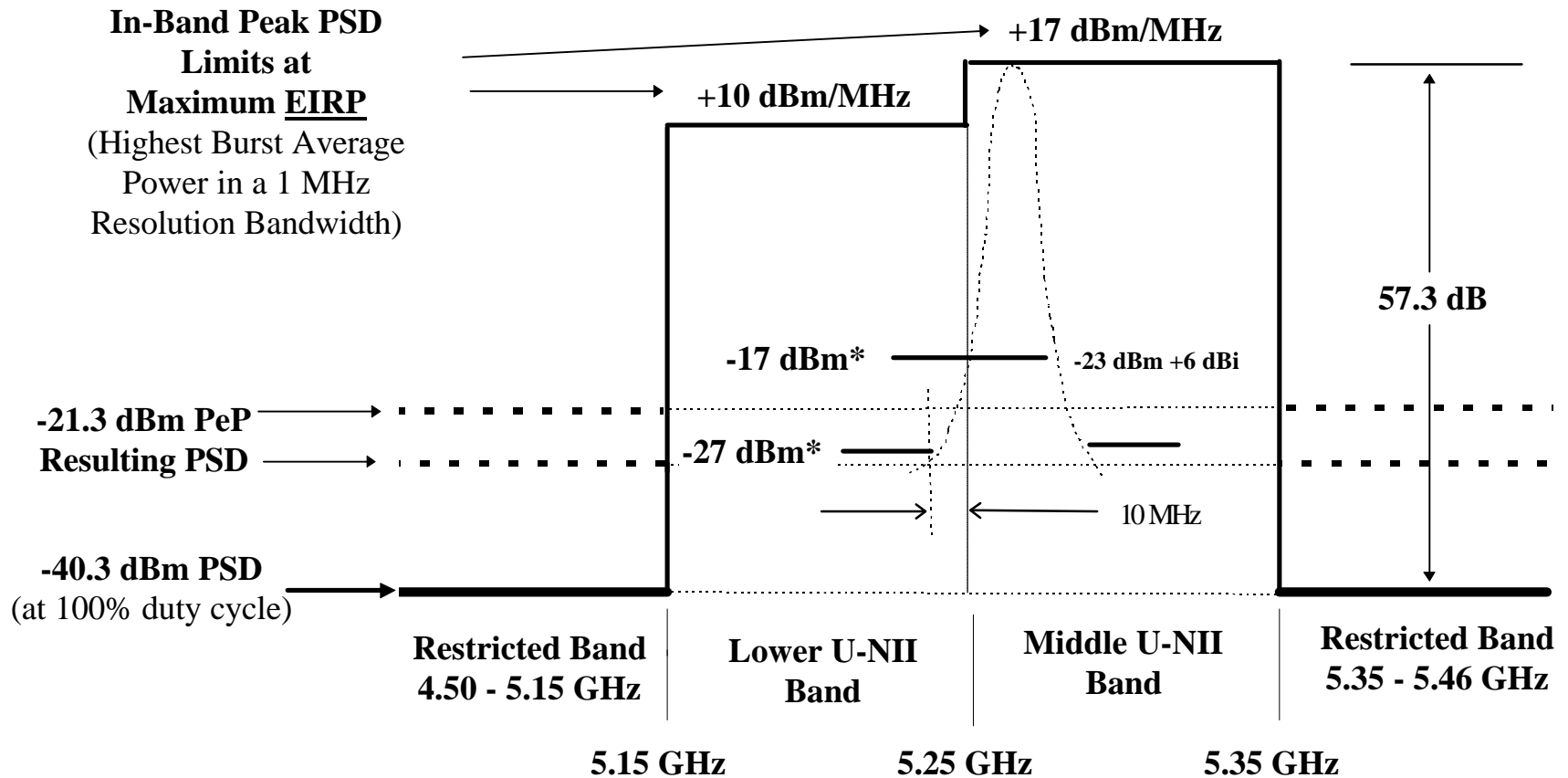
Simulation Results for 600 uncorrelated exponentially distributed random variables.

The power level of a Gaussian signal is exponentially distributed.

The peak to average power ratio is about 8 dB.

U-NII OUT-OF-BAND POWER LEVELS
Compared to In-Band Maximum Levels

In-Band Peak PSD
Limits at
Maximum EIRP
(Highest Burst Average
Power in a 1 MHz
Resolution Bandwidth)

+17 dBm/MHz

+10 dBm/MHz

57.3 dB

-17 dBm*   -23 dBm +6 dBi

-21.3 dBm PeP

Resulting PSD   -27 dBm*

10 MHz

-40.3 dBm PSD
(at 100% duty cycle)

| Restricted Band 4.50 - 5.15 GHz | Lower U-NII Band | Middle U-NII Band | Restricted Band 5.35 - 5.46 GHz |

5.15 GHz   5.25 GHz   5.35 GHz

* The Current R&O specifies the -17 dBm and - 27 dBm levels as 34 dB and 44 dB below in-band
respectively. The WINForum petition requests that they be specified as absolute levels as shown.

DUTY CYCLE EFFECT

Let

   R_{pa} =   The peak power to average power ratio during a packet in dB.

   P_{a0} =   The PSD as defined previously

   D =   The duty cycle, as a decimal value, during the 100 ms at which the average is highest.

Then

   $P_{a0} \leq -21.3 - R_{pa}$ dBm   is the peak power constraint,

   $P_{a0} \leq -40.3 - 20\log D$ dBm   is the average constraint .

With D_c the value of duty cycle which makes the constraints equal,

$$D_c = 10^{\frac{R_{pa}-20}{20}} .$$

R_{pa} (dB)	D_c (%)	R Band limit for $D<D_c$ (dBm EIRP)	Necessary PSD attenuation for lower band with $D<D_c$ (dB)	Necessary PSD attenuation for middle band with $D<D_c$ (dB)
6	20.0	-27.2	37.2	44.2
7	**22.4**	**-28.2**	**38.2**	**45.2**
8	**25.1**	**-29.2**	**39.2**	**46.2**
9	28.2	-30.2	40.2	47.2
10	31.6	-31.2	41.2	48.2

**Table 4-2. Critical Values of Duty Cycle and Corresponding
Necessary Out-of-Band Emission Suppression**

**The necessary PSD attenuation
for 100% duty cycle:**

50 dB Lower Band

57 dB Middle Band

DUTY CYCLE EFFECT SUMMARY
At Maximum Power and Antenna Gain

Full Duty Cycle

Lower Band 50 dB
Middle Band 57 dB

Low (Below Critical) Duty Cycle

Lower Band 37 - 41 dB
Middle Band 44 - 48 dB

UPPER U-NII BAND
5.725 to 5.825 GHz

The Out-of-Band Suppression at the Upper Band Edges is Specified by the U-NII Rules

   The upper band is not adjacent to a restricted band

	Maximum PSD (EIRP)	Corresponding Suppression
In-Band PSD	23 dBm	
Band Edge	-17 dBm	40 dB
Band Edge plus 10 MHz	-27 dBm	50 dB

SUMMARY

- ♦ **Up to 57 dBr emission suppression is necessary to meet the restricted band levels at the upper edge of the middle U-NII band**

- ♦ **Up to 50 dBr emission suppression is necessary to meet the restricted band levels at the lower edge of the lower U-NII band**

- ♦ **The restricted band requirements are less severe for limited duty cycle operation.**

- ♦ **Up to 34 dBr suppression is necessary for middle band signals at the lower-middle band boundary**

- ♦ **Up to 40 dBr emission suppression is necessary to meet the restricted band levels at the edges of the upper U-NII band and 50 dBr is needed 10 MHz outside the upper U-NII band.**

- ♦ **All suppression values can be met by limiting power or EIRP <u>if the WINForum petition is accepted</u>.**