MODELING OF A REALISTIC PULSE DESENSITIZATION FACTOR CORRECTION FOR CALCULATING PEAK POWER INTERFERENCE POTENTIAL

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This document Models an ideal pulsed RF carrier waveform in the time domain and in the frequency domain. The model is then used to depict the effects of using a wide bandwidth receiver to view the actual line spectrum.

FCC rules indicate that the full pulse desensitization factor (PDF) needs to be applied even at the band edges of line spectrum measurements to account for what a worst-case wideband receiver might see as effective measured (interfering) peak power levels due to receiving multiple spectral lines.

HP Application Note 150-2 indicates that a resolution bandwidth of about 1/2 of the main lobe (1/pulsewidth) would be required to effectively measure the peak pulse power as predicted by adding the PDF to the power measured in line spectrum mode (actual CW component amplitudes). This is confirmed in the modeling below.

In the case of the Preview Radar, this would require a receiver bandwidth of about 125 MHz. But according to the FCC's proposed rulemaking for ultra-wideband devices (FCC 00-163, page 20), the "widest victim receiver bandwidth likely to be encountered" is only 50 MHz. Therefore, it is unfair to require application of the full PDF for our product.

The modeling below graphically demonstrates that for the Preview product the PDF correction should be reduced by about 7dB for a more realistic calculation of the threat peak power. Therefore a 21 dB PDF should more realistically be applied instead of the full theoretical 28 dB @ 5MHz PRF.

MATHEMATICAL EXPRESSION OF PULSED RF CARRIER - TIME DOMAIN

$A := 1$ Amplitude Factor (Peak Unmodulated Carrier Amplitude)

$\tau := 8\cdot 10^{-9}$ Pulsewidth

$\Psi := 200\cdot 10^{-9}$ Pulse Repetition Period $\pi := 3.14159$

$Fp := \frac{1}{\Psi}$ Pulse Repetition Frequency (Hertz)

$Frf := 5.8\cdot 10^{9}$ RF Carrier Frequency (Hertz)

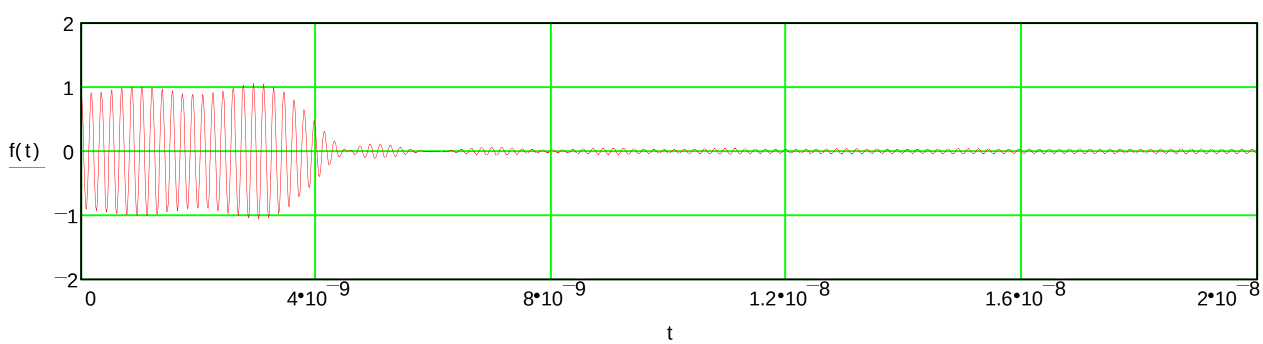
$t := 0, 0.1\cdot 10^{-10} .. 20\cdot 10^{-9}$ Time span for graphical evaluation

$$f(t) := \sum_{n=-100}^{100} \frac{A\cdot\tau}{\Psi}\cdot\frac{\sin\left(\frac{n\cdot\pi\cdot\tau}{\Psi}\right)}{\frac{n\cdot\pi\cdot\tau}{\Psi}}\cdot\cos(2\cdot\pi\cdot(Frf + n\cdot Fp)\cdot t)$$

Number of frequency summation terms is limited for practical calculation

TIME-DOMAIN PULSE WAVEFORM

An 8 nanosecond pulse centered at time=0 and repeating every 200 nanoseconds



PULSED RF CARRIER IN THE FREQUENCY DOMAIN

$rng := 100$ +/- Integer Number range of Frequency Components used in calculation above

$i := 0..(2\cdot rng)$ 2 * range to allow storage of all values in MCAD array

$$FA_i := \sum_{n=-1\cdot rng}^{rng} \frac{A\cdot\tau}{\Psi}\cdot\frac{\sin\left(\frac{n\cdot\pi\cdot\tau}{\Psi}+.000000001\right)}{\left(\frac{n\cdot\pi\cdot\tau}{\Psi}+.000000001\right)}\cdot\delta(n, i-rng)$$

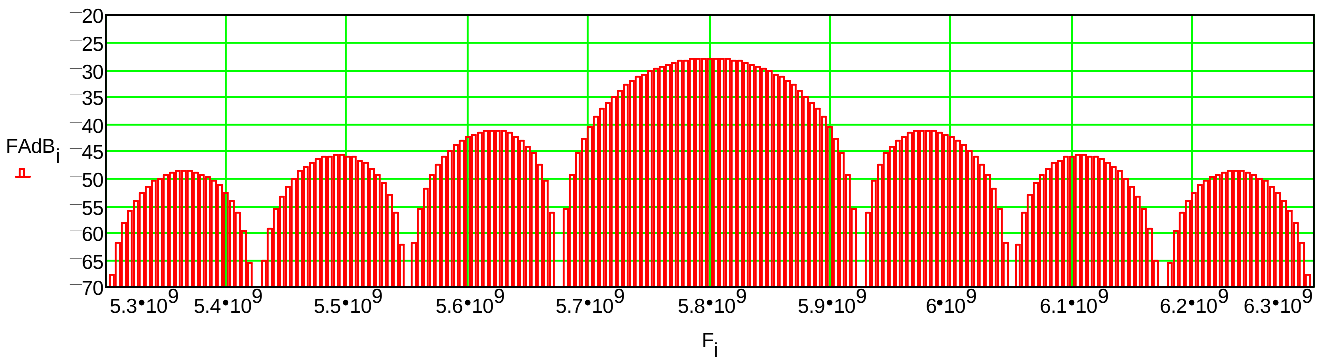
The Amplitudes of all of the Frequency Components above. (Slightly off-center sinc-function) (value needed to avoid a MCAD) (induced singularity at n = 0 term)

$F_i := Frf + (i - rng)\cdot Fp$ The Frequency Components (Hertz)

$FAdB_i := 20\cdot\log\left(FA_i\right)$ Frequency Component Amplitudes in decibels

APPROX. IDEAL TRANSMIT OUTPUT POWER LINE SPECTRUM

An 8 nanosecond pulse centered at time=0 and repeating every 200 nanoseconds



RELATIONSHIP OF POWER SPECTRUM TO PULSE DESENSITIZATION FACTOR

$PDFdB := 20\cdot\log(\tau\cdot Fp)$ Definition of PDF in decibels

$PDFdB = -27.959$

Since peak amplitude = 1 (0 dB), the center frequency term above has theoretical amplitude equal to (0 - PDF) dB. This is confirmed above.

EFFECT OF WIDE-BAND MEASUREMENT EQUIPMENT & RECEIVERS

From HP Application Note 150-2, the resolution bandwidth of a spectrum analyzer (or receiver bandwidth) must be less than 0.3 * PRF to accurately resolve the amplitudes of the line spectral components shown above.

For RBW > PRF, the receiver "sees" multiple spectral components which results in a higher perceived power.

HP Application Note 150-2 suggests that a RBW equal to about 1/2 of the main lobe will effectively result in measuring the peak amplituded of the unmodulated RF carrier (0 dB in this case).

The equations below effectively sweep a wideband receiver across the actual line spectrum obtained above and adds multiple spectral lines together to obtain a perceived power just as an actual spectrum analyzer would do.

The validity of the equations below may be checked by using a resolution bandwidth right at the edge of still being valid for obtaining a line spectrum (compare to above plot) and by using a resolution bandwidth equal to 1/pulsewidth. For the later case, a peak amplitude very near 0 dB should be observed.

$rbw := 2 \cdot 10^6$ Measurement Resolution Bandwidth (Hertz) - This value is at the edge of being valid for line spectrum mode. (Must be an even number for MCAD to avoid integer errors below.)

$numF := floor\left(\frac{rbw}{Fp}\right)$ Integer Number of Spectral Components Encompassed by Resolution Bandwidth (Hertz)

$j := \left(\frac{numF}{2}\right) .. \left(2 \cdot rng - \frac{numF}{2}\right)$ New array size of Wideband Measured Spectral Components

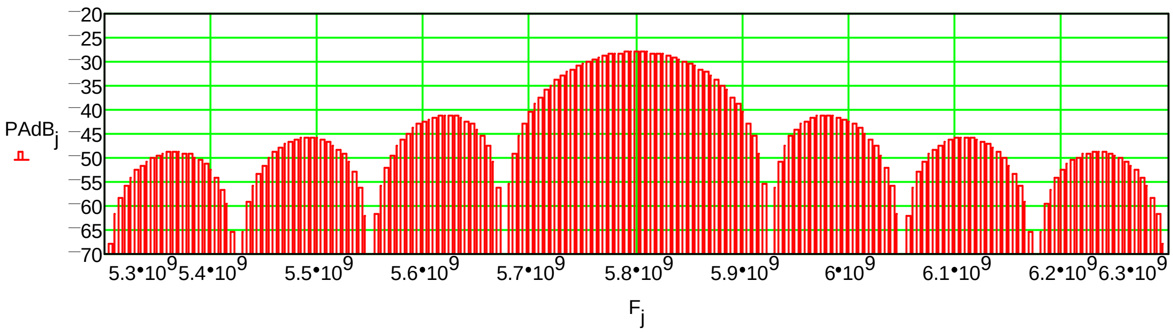
$$PA_j := \sum_{n = j - \frac{numF}{2}}^{j + \frac{numF}{2}} FA_n$$

New Wideband Measured Spectral Components

$PAdB_j := 20 \cdot \log\left(PA_j\right)$ Frequency Component Amplitudes in decibels

APPROX. MEASURED OUTPUT POWER SPECTRUM

Resolution Bandwidth = 2MHz -> Confirmed Still Essentially Line Spectrum)



Resolution Bandwidth configured for Full Pulse Spectrum in Accordance with App-Note 150-2

(Note: Must repeat entire equation set for MCAD to recalculate)

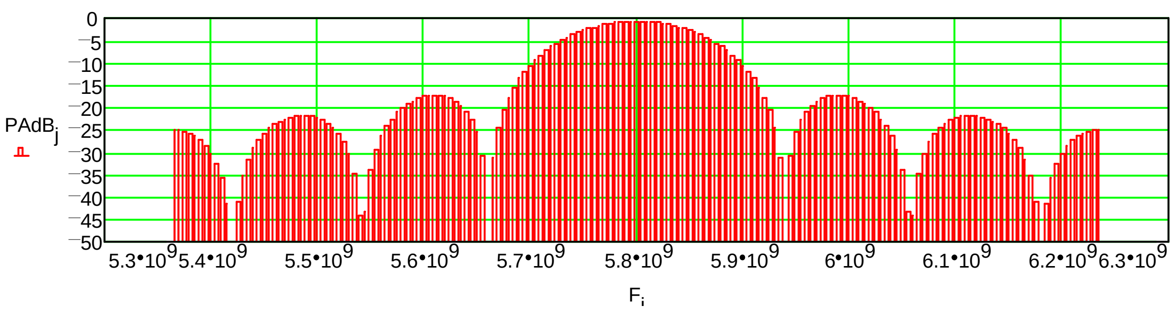
$rbw := 130 \cdot 10^6$ Measurement Resolution Bandwidth (Hertz)

$numF := floor\left(\frac{rbw}{Fp}\right)$ $j := \left(\frac{numF}{2}\right) .. \left(2 \cdot rng - \frac{numF}{2}\right)$

$$PA_j := \sum_{n = j - \frac{numF}{2}}^{j + \frac{numF}{2}} FA_n \qquad PAdB_j := 20 \cdot \log\left(PA_j\right)$$

APPROX. MEASURED OUTPUT POWER SPECTRUM

Resolution Bandwidth = 130MHz (Full Pulse Spectrum) -> Confirms App-Note 150-2



Resolution Bandwidth configured for Worst-Case Victim Receiver Bandwidth = 50 MHz

(Note: Must repeat entire equation set for MCAD to recalculate)

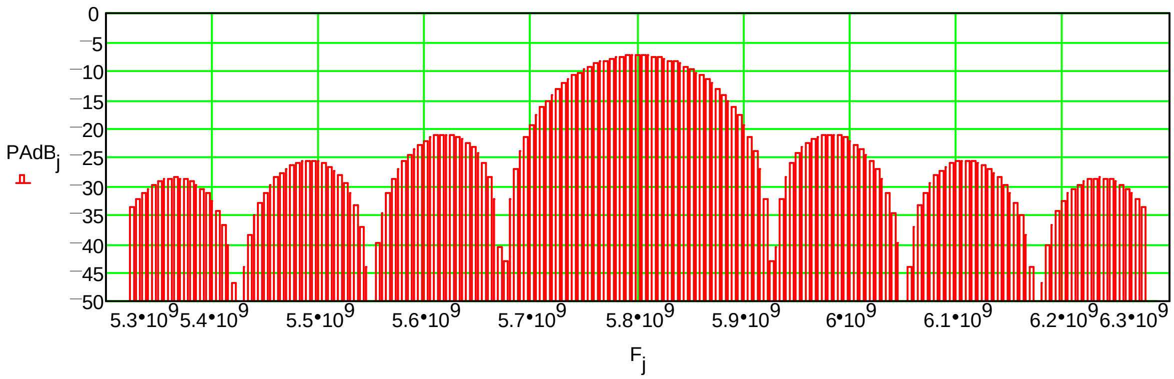
$rbw := 50 \cdot 10^{6}$ Measurement Resolution Bandwidth (Hertz)

$numF := \mathrm{floor}\left(\frac{rbw}{Fp}\right)$ $\qquad j := \left(\frac{numF}{2}\right) .. \left(2 \cdot rng - \frac{numF}{2}\right)$

$$PA_{j} := \sum_{n = j - \frac{numF}{2}}^{j + \frac{numF}{2}} FA_{n} \qquad PAdB_{j} := 20 \cdot \log\left(PA_{j}\right)$$

APPROX. MEASURED OUTPUT POWER SPECTRUM

Resolution Bandwidth = 50MHz (Realistic Pulse Spectrum)



This graph indicates that about a -7 dB correction to the theoretical PDF is valid for a more realistic threat appraisal of a victim receiver with a worst-case bandwidth of about 50 MHz.