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Wireless LANs

Some Thoughts on Modeling the Power Amplifier

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Abstract

This document addresses the modeling of power amplifiers and how improper choice of model parameters may bias the judgement regarding robustness to PA distortion.

Power Amplifier Model

We tried to be as rigorous as reasonable in order to make the comparison apples-to-apples. We covered the channel model, the phase noise model, ACI and CCI rejection, interference. Yet, there are parameters which we did not cover. One such parameter is the PA (power amplifier) model.

Lucent used in their comparison Rapp's model with the parameter value of P=3. The comparison we conducted indicates that the value of P has a strong effect on the backoff required for a given intermodulation level. Moreover, we argue that the value of P=3 is more typical of a linearized PA rather than of "typical" one. To support this claim, let us look at the third-order sidelobes in the two-tone intermodulation test. We can see that the growth of the intermodulation product (re each tone, backoff measured re power of both tones) behaves as (2*P)-th power of input signal.

Backoff	P=1	P=2	P=3
-1 dB	-19 dB	-21 dB	-21 dB
-3 dB	-22 dB	-25 dB	-29 dB
-5 dB	-25 dB	-31 dB	-38 dB
-10 dB	-33 dB	-50 dB	-67 dB
-15 dB	-42 dB	-69 dB	
-20 dB	-52 dB		
-25 dB	-62 dB		

This comparison, even though performed with two tones and not with data modulated signal, clearly indicates that when large sidelobe reduction is required (as in the U-NII upper band), the choice of the P value in the model can require quite a few decibell difference in PA backoff.

It can be seen that in the P=1 column the relative sidelobe level varies 2 dB per 1 dB (or the absolute level varies 3 dB per 1 dB), while with P=2 it varies 4 dB/dB (or 5 dB/dB absolute) and with P=3 it varies 6 dB/dB (7 dB/dB absolute). The common experience says that the third order intermodulation (the one corresponding to P=1) is dominant in amplifiers, unless special care is taken to linearize them. Amplifier linearization is a challenging procedure which is typically used with systems order of magnitude more expensive than we intend to cover. Therefore in my opinion P=1 or slightly higher should be used for comparison, but certainly not P=3.

This can be seen in the following graphs:

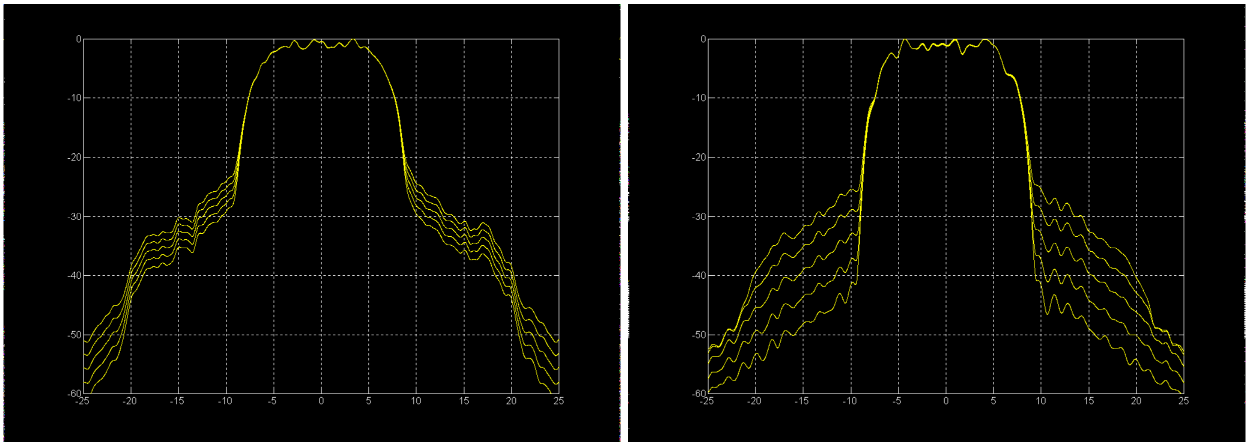

Fig. 1: OQPSK, SRRC with 40% rolloff , Backoff=-5 to -1 dB, left- P=1, right- P=3.

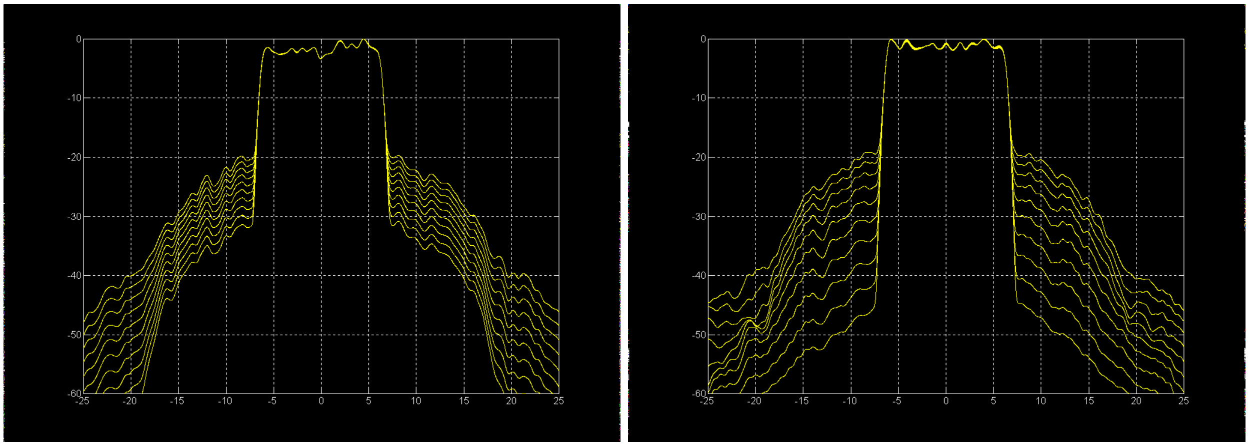

Fig. 2: OFDM-like signal , Backoff=-10 to -1 dB, left- P=1, right- P=3.

In figure 2 a Gaussian approximation to OFDM was used. We expect that employing a peak-reduction technique will make the difference between P=1 and P=3 even more pronounced.

The OFDM report mentions the need to reduce the power in channels close to the edge in order to pass the regulatory restrictions. If P=1 model is used as opposed to P=3 it may turn out that the power reduction needs to be much higher. Another point is that it may happen that in order to pass the regulations for out-of-band emissions with reasonable backoff we need to resort to patented methods for peak-to-average ratio reduction which are not covered by the standard.

Therefore, I call to readdress this issue and to conduct the comparison with Rapp’s Power Amplifier model with P=1 or close to it.