HUT IRC Radio Communications Research Workshop, October 17, 1997

BEHAVIOURAL HIGH POWER AMPLIFIER MODEL FOR ACCURATE ADJACENT CHANNEL POWER SIMULATION

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Abstract - A semi-physical behavioural high power amplifier model to characterize nonlinear distortion in mobile communication systems was introduced in [1]. The functional model is able to copy the low-voltage features of a real amplifier causing crossover distortion. Hence it gives an improved description of the nonlinearity of Class AB amplifiers widely used in mobile phones employing a linear modulation scheme. The model is compared to a real mobile phone high power amplifier by means of two-tone test and spectrum regeneration simulations, and it is found to give a very good match in both cases.

The rapidly increasing number of mobile phone users necessitates more efficient usage of the spectrum. Spectrum efficiency can be improved by utilising linear modulation schemes with a varying signal envelope instead of constant envelope modulation methods. However, the fluctuating envelope together with the nonlinearities in the high power amplifier (HPA) produce signal distortion which causes in-band interference and spectral regrowth. In order to study the effect of nonlinear distortion to the system performance and to consider the trade-off between HPA linearity and efficiency on the system level, accurate and simple tools to model nonlinearities in radio communication systems are required.

The developed functional HPA model for radio communication system simulations has a semi-physical basis, and it contains only a few parameters whose significance to the transfer characteristics is easily understood. Due to the bandpass nature of the signals of interest, an equivalent lowpass system approach is employed. The mathematical derivation of the functional nonlinear amplitude and phase distortion models is given in [1].

The model is verified with a comparison between simulated and measured intermodulation distortion (IMD) in a two-tone test. Additionally, since the amplitude and frequency distributions of a two-tone signal differ quite remarkably from those of a real modulated information-bearing signal, also the spectral regrowth of a $\pi/4$-DQPSK modulated signal is investigated to evaluate the model. The model parameters used in the simulations were optimised with the golden section method [2] in order to fit the gain and phase shift provided by the model to the measured gain and phase shift of a Class AB mobile phone amplifier.

In the two-tone test, third-order and fifth-order intermodulation products of the proposed model are very close to the measured ones, as shown in Fig. 1. The seventh-order IMD product is not modeled as well as the lower ones, but, on the other hand, its power is much smaller than that of the lower ones and thus its significance is of less importance. The most important observation is that the proposed model is capable of characterizing the notch of the third-order IMD product near the saturation. The excellent match between the measured and simulated spectral regrowth is illustrated in Fig. 2. This resemblance suggests that the model copies the characteristics of a real HPA accurately, and thus it gives a good estimate of spectral regrowth in real systems.

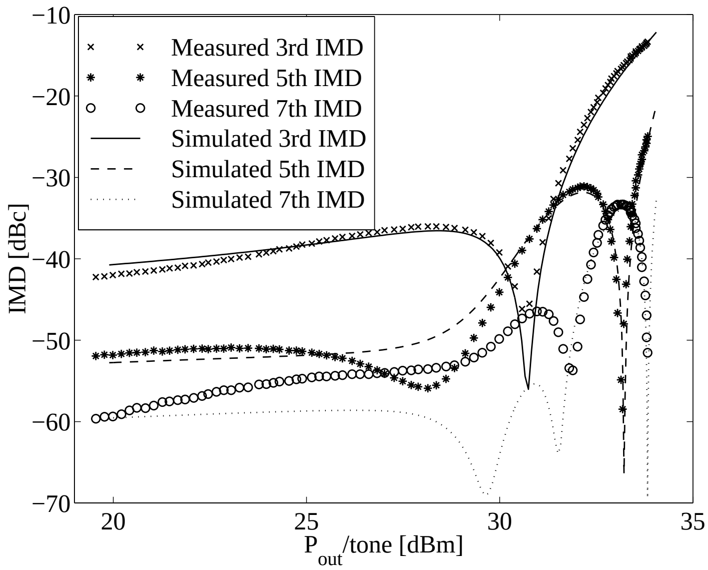

Figure 1: Simulated and measured two-tone test intermodulation distortion of a Class AB mobile phone amplifier.

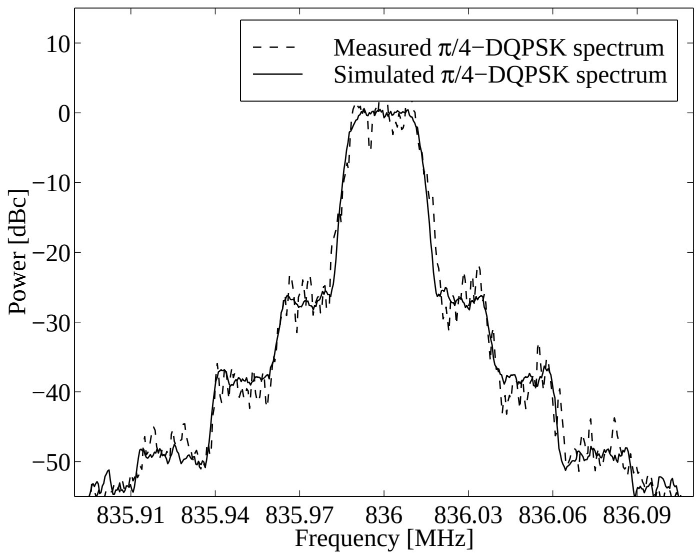

Figure 2: Measured and simulated spectral regrowth of root-raised cosine filtered (roll-off $\alpha = 0.35$) $\pi/4$-DQPSK IS-54 signal due to the high power amplifier.

REFERENCES

[1] M. Honkanen and S.-G. Häggman, "New Aspects on Nonlinear Power Amplifier Modeling in Radio Communication System Simulations", *Proceedings of IEEE PIMRC '97*, Helsinki, Finland, September 1-4, 1997

[2] M. S. Bazaraa, H. D. Sherali and C. M. Betty, *Nonlinear Programming, Theory and Algorithms*, New York: Wiley, 1993, ch. 8, pp. 270-272.