ADAPTIVE PREDISTORTION LINEARIZATION IN MODERN COMMUNICATION SYSTEMS

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Abstract - This paper is focusing on the nondesirable nonlinear effects of power amplifiers for wireless communication. One of the most-used methods for amplifier nonlinearities reducing – digital baseband adaptive predistortion is presented.

1 Introduction

New wireless communication systems like GSM-EDGE use modern digital modulation techniques like 8-PSK (EDGE), OFDM, etc. with non-constant envelope of modulated signal. These types of modulations are more sensitive to non-desirable effect of high-frequency power amplifiers, which cause spectral regrowth or increasing of bit-error-rate (BER).

There are a lot of methods (analog or digital) to reduce the effects of nonlinearities like feedforward, cartesian feedback, envelope elimination and restauration, in this paper we deal with one of them – digital adaptive predistortion.

2 Characterization of the effects of nonlinearities and Power amplifier model

These main parameters are used to characterize the impact of nonlinearities to digital communication systems:

- EVM (Error Vector Magnitude)
- ACPR (Adjacent Channel Protection Ratio)
- Power spectrum
- BER (Bit Error Rate)

Power amplifier was considered as a memoryless system which can be modeled by its AM/AM and AM/PM characteristics. Although this approach has some disadvantages (doesn’t take into account dynamic of the PA system and its frequency dependency), it is widely used for its simplicity. An example of AM/AM and AM/PM characteristics is shown in figure 1.

![AM/AM and AM/PM characteristics of LDMOS PA](image)

Fig.1 AM/AM and AM/PM of LDMOS PA

3 Digital predistortion
Using predistortion, the amplifier non-linearity is compensated by predistorting device which has inverse characteristics of the amplifier being linearized. Thus overall characteristics of predistorter and power amplifier are linear. The parameters of PA can change in time due to the aging of devices, changes of supply voltage, changes of temperature etc. So the predistorting device must be adaptable to PA parameters changes. In such case we speak about Adaptive predistortion.

The adaptive predistorters can have different architecture. They can be implemented in radio frequency, intermediate frequency or in the baseband. The predistortion function can be implemented using look-up-table (usually needs large memory), or for example by polynomial or spline function. The adaptation algorithms can differ in the error to minimize – some algorithms minimize the error between modulated signal and actual amplifier output, some of them finds the PA inverse function comparing the PA input and output.

Implemented and described baseband predistorter is using look-up-table with small number of points with linear interpolation of the values in between presented points. The predistorter’s function can be described by these equations:

$$A_p = A_i r, \ \ \ \ \phi = \phi_i + \psi$$

where $A_i, A_p, \phi_i, r, \psi$ are predistorter (PD) input amplitude, PD output amplitude, phase at PD input, phase at PD output, predistorter gain and its phase correction, respectively. The goal of its adaptation algorithm is to minimize the errors between desired ($K \cdot A_i, \phi$) and actual downconverted ($A_i, \phi$) amplifier output amplitude and phase, where $K$ is desired PA gain. More informations about adaptation algorithm can be found in [2].

4 Demonstration software

To allow to study the predistortion principle and its effects on nonlinearity of PA, a demonstration software in MATLAB environment was created. User can choose from different types of PA, can change number of points in predistorter’s table, number of iterations used for adaptation, convergence constant, etc. Results are in the form of power spectrum, amplitude and phase error between actual and ideally amplified signal, constellation diagram and EVM.

GSM-EDGE modulated signal was generated according standard proposal [1], the simplified schematic of simulated system is shown in Fig.2. Bits (in real system generated by higher layers) are modulated using 8-PSK scheme and then they are $3\pi/8$ rotated and shaped by pulse shaping filter (linearised GMSK pulse). Such constructed signal is then passed through model of PA (concatenated with predistorting lineariser). Its output signal is filtered by receiving filter (overall response of transmitting and receiving filter is raised cosine, so ideally there is no intersymbol interference), $3\pi/8$ derotated and 8-PSK demodulated. EVM is calculated for signal passing through system PA+predistorter as well as system without predistortion to find out the improvement. The main window of this demonstration software is shown in Fig.3.

![Fig.2 Schematic of simulated system](https://via.placeholder.com/150)
Some results of simulations for LDMOS PA can be seen from this figure: constellation diagram with and without linearisation; power spectrum of original signal, PA output with and without linearisation; amplifier and predistorter’s phase and amplitude characteristics; amplitude and phase error.

5 Conclusions

In this paper, the digital adaptive predistortion applied to GSM-EDGE system is presented. This method reduces in-band nonlinear effects, characterized by EVM but also out-of band effects, which can be seen regarding the power spectrum improvement. Now we are working on new methods of predistorter adaptation and we are going to apply the predistortion also on HIPERLAN 2 system.

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References