Modeling memory effects in RF power amplifiers applied to a digital pre-distortion algorithm and emulated on a DSP-FPGA board

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An emulation tool with the capability of modeling the nonlinearity order and memory effects for real power amplifier’s (PAs) conversion curves, is introduced. The proposed tool comprises special cases of Volterra series as the Memory Polynomial Model and a learning technique like artificial neural networks. The proposed system is a novel integrated one able to model the real behavior of radio frequency (RF)-PAs under different memory models. The developed system starts from a test bed able to acquire AM–AM and AM–PM distortion curves measurements. This procedure can predict the behavior and improve the analysis using it as a design tool.

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1. Introduction

With the explosive growth of the high data-rate transmission, the radio frequency (RF) Spectrum is becoming an increasingly scarce resource. Such scarcity is due to existing licensing regimen. Additionally, there is an increasing concern that higher performing requirements drives to use faster frequencies for digitally modulated signals, such as in wideband wireless communication systems, e.g. wideband code division multiple access (WCDMA), Worldwide interoperability for microwave access (WiMAX), etc. [1]. In those systems, the transmitter chain includes a power amplifier (PA) as the main device. Unfortunately, its inherent nonlinearity causes in-band distortion and intermodulation products that spreads out over neighbor channels. That way, to mitigate undesired intermodulation and distortion effects, recent advances related to linearization techniques have been developed, mainly to compensate memory effects induced by real PAs [2,3]. These issues have been partially solved introducing modeling techniques for PAs, such as: memory or memoryless models [4,5], polynomial models [6], neural networks [7,8], others techniques taking into account memory effects based on Volterra series [9–13], etc., all of them providing a proper way to capture the nonlinearity order and memory depth.

Important efforts related to PAs linearization improving memory effects have been developed in [14–19]. Other works make use of commercially available design tools, e.g. DSP Builder [20–23], exhibiting a proper way to model nonlinear behaviors. The existing research opens a bridge between the modeling through software and emulation in field programmable gate arrays (FPGAs) [24,25], which flexible characteristics give a precise estimation of real PAs behavior. In this manner, this work introduces a modeling approach based on a special case of Volterra series as memory polynomial model (MPM), which is successfully compared with a learning technique, as artificial neural networks (ANNs). The system has the flexibility to model a real PA behavior and a digital pre-distortion (DPD) module implementation that are fully controlled by Matlab.

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