Abstract

Each generation of wireless communication systems is evolving to provide higher data rates with more services and accommodate more users within a limited radio-frequency (RF) spectrum. The wireless technologies, such as worldwide interoperability for microwave (WiMAX), Long Term Evolution (LTE), and Long Term Evolution-advanced (LTE-A) are being used to provide higher data rate wireless services. However, this places very challenging requirements for RF front-end specifications in terms of power efficiency and bandwidth for both base stations and hand-held devices. As the RF spectrum nowadays is shared by many users. Therefore, spectral efficient complex modulation schemes, such as orthogonal frequency-division multiplexing (OFDM), have to be used. In order to access these various schemes and services, the multi-band/multi-standard transceiver designs are used and getting enhanced in order to reduce power consumption, physical size and cost. The RF power amplifier (PA) is the main power consuming device in the multi-band and multi-input-multi-output (MIMO) transceivers and generates unwanted nonlinear distortion while operating close to the saturation region. The most optimum PA linearization technique is Digital Predistortion (DPD). The complexity and numerical stability of the DPD model is still a huge challenge.

The thesis investigates the issue of implementation complexity, numerical stability and feasibility of DPD model adaptation for low cost FPGAs for single band, multi-band and multi-channel transmission. Principal Component Analysis (PCA) based DPD technique is investigated as a solution to the numerical stability problem arising in lower-bits fixed-point digital signal processor/FPGA. It is reported with measurement results that PCA based model provides better linearization performance than memory polynomial (MP), orthogonal memory polynomial (OMP), and generalized memory polynomial (GMP) models in 16-bit fixed-point DSP operation.

Further, to enhance numerical stability of the state-of-the-art models, Independent Component Analysis (ICA) as a novel algorithm level solution is proposed for different carrier aggregated (intra-band contiguous, intra-band non-contiguous and inter-band noncontiguous) LTE signals. ICA technique is proposed for 12-bit fixed-point digital signal processor/FPGA implementation of DPD for intra-band and inter-band CA signals. The application of the ICA technique upon MP model reduces model complexity and improves numerical stability of the DPD model for CA LTE signals. The proposed MP-ICA requires lesser memory requirement as compared to the state-of-the-art low complexity models such as MP model, OMP model and PCA-based memory polynomial (MP-PCA) model for CA LTE signals.

A novel two-dimensional curtailed harmonic memory polynomial (2D-CHMP) model to capture harmonic interferences, cross-modulation distortions (CMDs) and intermodulation distortions (IMDs) in concurrent dual-band PA operating at harmonic frequencies is further purposed to reduce the complexity of the state-of-the art models. The 2D-CHMP model is constructed by simplifying the envelope terms of the state-of-the-art two-dimensional harmonic memory polynomial (2D-HMP) model. The model complexity and memory requirement of 2D-CHMP are very less as compared to the 2D-HMP model. In addition, the novel DPD models is proposed for linearization of a previously uninvestigated case of concurrent tri-band PA at harmonic frequencies. This work analyzes the IMD terms which are producing harmonic distortions and proposes three-dimensional harmonic memory polynomial (3D-HMP) and harmonic Volterra spline (3D-HVS) models for mitigation of in-band interferences, CMDs, and IMDs.

As an integral solution to compensate for crosstalk, PA nonlinearity, I/Q imbalance and dc offset imperfections simultaneously in MIMO transmitters, a neural network (NN)-based DPD models has been investigated. The proposed NN DPD model provides a single-model digital mitigation solution to multi-branches of MIMO transmitters, which is suitable for higher order MIMO operation. A less complex, novel polynomial-based DPD model is also proposed for linearizing higher dimension MIMO transmitters along with its characterization procedure. The proposed model performs comparably to the state-of-art DPD model parallel Hammerstein (PH) with lower number of coefficients and floating point operations (flops).