# Numerical Simulation of Nonlinear Interference in Radio Systems

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***Introduction.***

Nowadays the extensive growth in radio systems, especially in mobile communication systems, greatly increases the risk of inter- and intra-system electromagnetic interference (EMI). Using appropriate analysis and simulation tools from the first design steps allows one to optimize the radio system design and performance from viewpoint of EMI and to reduce significantly the cost of interference removal. This paper presents a behavioral or system –level numerical simulation technique which can be used for the nonlinear modeling of complex radio systems over wide dynamic and frequency range in a computationally-efficient way. Using this technique and a PC, an entire mobile communication system can be simulated in a reasonable time with a circuit-level accuracy.

***The quadrature modeling technique and the discrete technique.***

The main idea of the quadrature modeling technique is to use complex envelope instead of a real narrowband signal [1]. The in-phase and quadrature-phase channels are used during the simulation in order to model amplitude-to-amplitude (AM-AM) conversion as well as amplitude-to-phase (AM-PM) one. Complex amplitudes of the signals rather than instantaneous values are used during the simulation. Thus, using this technique, only narrow-band signals and systems can be modeled over only narrow frequency range and the system frequency response can not be taken into account.

The basis of the discrete technique is a representation of a system as a block diagram of linear filters and memoryless nonlinear elements connected in series, or in parallel, or both [2]. The process of signal passage through linear filters is simulated in the frequency domain using the complex transfer factor of the filter. The process of signal passage through a nonlinear memoryless element is simulated in the time domain. The transition from the time domain to the frequency domain and vise versa is made with the use of the direct and inverse fast Fourier Transform (FFT). Special measures must be used in order to avoid spectrum aliasing. Unfortunately, the AM-PM conversion can not be taken into account using the discrete technique.

***The "instantaneous" quadrature technique.***

Here we propose to combine the quadrature modeling technique and the discrete technique in order to build the combined "instantaneous" quadrature modeling technique which can model the system behavior over wide frequency range taking into account AM-AM and AM-PM conversion. The simulation process consists of the following items: (1) linear filter simulation is carried in the frequency domain (the same as for discrete technique), (2) nonlinear element simulation is carried out in the time domain using the quadrature technique, but the instantaneous signal values are used, not the complex envelope, (3) transform from the frequency (time) domain to the time (frequency) domain is made by IFFT (FFT), (4) Hilbert transform in the frequency domain is used to calculate the signal amplitude, and in-phase and quadrature-phase components, (5) a system of two integral equations is used in order to convert the envelope transfer function into the instantaneous ones.

***References.***

[1] M.C. Jeruchim, P. Balaban, K.S. Shanmugan, Simulation of Communication Systems, Plenum Press: New York, 1992.

[2] S.L. Loyka,. V.I Mordachev, Computer-aided nonlinear simulation at the system level, Proc. of 5th Inter. Confer. on Electromagnetic Interference and Compatibility (INCEMIC'97), Dec. 3-5, Hyderabad, India, 1997, pp. 93-98.