Time-Domain Simulation of Noise in Dynamic Non-linear Circuits

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We discuss simulation techniques for the prediction of stochastic noise phenomena in electronic circuits like oscillators, mixers and AD converters. These techniques have to deal with a complex combination of large-signal non-linear dynamic behaviour and small-signal stochastic processes. The applicability of some noise simulation techniques is illustrated by examples of an ideal oscillator and a relaxation oscillator.

An accurate mathematical modelling of the noise sources and the non-linear circuit behaviour proves to be essential for a reliable prediction of noise effects. Furthermore, in case of non-linear large-signal behaviour, frequency intermodulation effects have to be taken into account.

Simulation tools for the analysis of noise in dynamic non-linear circuits have recently become available. We will concentrate on aspects for simulating noise in the time-domain. Time-domain simulation techniques can be applied to predict noise effects with a reasonable accuracy. Of the several approaches we will discuss implementational aspects as well as address questions with respect to numerical behaviour.

Quality of noise simulation approximation is achieved by correct modelling of the correlation between noise sources and the suppression of aliasing effects. Timedomain techniques will be based on the utilisation of transient noise sources (compound or pseudo-random signals) and an accurate time-domain analysis. Weighting with an ideal reconstructor ensures an almost ideal noise spectrum. The resulting smooth signals allow efficient time integration.