Flavio Canavero (Politecnico Torino, Italy) & Paolo Manfredi (Ghent University, Belgium)

Polynomial Chaos for Variability Assessment of Electronic and Microwave Designs

Numerical simulation of microwave and electronic circuits and devices is a fundamental step in the development of high-performance electronic products due to the urging necessity to perform right-the-first-time designs. Stochastic analysis is extremely useful in the early design phase for the prediction of the system performance and for setting realistic margins whenever manufacturing tolerances or uncertainties on design parameters cannot be neglected. With the scope of developing efficient design tools, outperforming classical but time-consuming sampling-based techniques like Monte Carlo, new techniques have been proposed recently. Among these, the methodology based on the polynomial chaos theory (ie., based on the representation of the stochastic solution of a dynamical circuit in terms of orthogonal polynomials) turns out to be accurate and much faster than the commonly adopted Monte Carlo method. Polynomial chaos, whose applications in several domains of Physics are known, is presented here in the context of the simulation of single and multiconductor transmission lines and lumped linear and nonlinear multiport circuits, representing the basic elements of microwave and electronic devices. Both frequency- and time-domain approaches are discussed, and a solution paradigm directly implementable in commercial circuit solvers is presented. Also, an extension that allows decoupling the polynomial chaos equations is presented. The methodology is based on a transformation that renders the polynomial chaos coefficients decoupled, so that the computation is performed via repeated non-intrusive simulations. The advocated method not only maintains comparable accuracy with respect to the state-of-the-art approaches, but it allows also the treatment of cases with a relatively large number of random parameters, thus making feasible the simulation of realistic designs, as illustrated by examples relevant to microwave and electrical applications.