ASIVA14: Multi-Rate, MOR and Sensitivity in Circuit Simulation

Introduction

Faster and smaller electronic devices are more and more required by, e.g., the health care industry, the scientific research community and by the field of entertainment. There is a constant request to increase the simulation speed while keeping a high accuracy and reliability of the simulation. Here, we describe a number of important technical gaps that currently are being addressed within the ASIVA14 project (Analog Simulation and Variability Analysis for 14nm designs).

Three targets: accelerating the transient simulation for general, VLSI complex circuits (s.a. ICs and Printed Circuit Boards (PCBs)) and for nearly-periodic circuits (s.a. Phase-Locked Loop (PLL), Switching Power Supply (SPSs)), and speeding up the analysis of the effects of variability and uncertainty (originating from manufacturing, parasitics, etc…). The methodologies we are using, which can be also combined together, are: Multi-Rate, Model Order Reduction (MOR) to speed up the transient simulation, and Fast Adjoint techniques for the sensitivity analysis (eventually, together with MOR for parametric models).

MOR methods

During the numerical integration, the most expensive routines are in solving a set of n linear equations in n variables (dimension of the Full Order Model (FOM)) for each Newton’s iteration, and in evaluating nonlinearities (for the Jacobian and the Right-Hand Side (RHS)). We apply the Proper Orthogonal Decomposition (POD) method, combined with the Discrete Empirical Interpolation Method (DEIM) [1]. The idea (originally from [3]) is to compute the solutions of the FOM at selected discrete time points, for a certain period of the transient (say, from t = 0 to t_{TRAIN} = 1/3 of the stopping time), then we employ a Singular Value Decomposition (SVD) on the collected solutions, choose the order of reduction r and the number m of DIEM points (related to the nonlinearities to be updated/evaluated), based on a user-specified accuracy of the dynamics (e.g., tolPOD – DEIM = 10^{-9}), and we use the Reduced Order Model (ROM) for the remaining transient period. Fig.21 plots the dynamic of a node’s potential. One can see that the accuracy (RelErr) is satisfactory, achieving a speedup of around 2.5.

![Figure 21: FOM's dimension n = 100 (sparse matrices) and input s(t) = sin(10t); tolPOD – DEIM = 10^{-9}; t_{TRAIN} = 1/3; fixed time-step h = 10^{-2} during integration; order of reduction r = 19 and # of DEIM pts m = 18.](image)

References


Giovanni De Luca, Rakesh Jha, Anuj Tyagi
Department of Mathematics and Computer Science - CASA
Eindhoven University of Technology
Den Dolech 2, 5612 AZ, Eindhoven
The Netherlands
{G.De.Luca,R.Jha,A.K.Tyagi}@tue.nl