POD Model Order Reduction of Drift Diffusion Equations in Electrical Networks

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Abstract

In order to obtain a highly accurate model for integrated circuits (e.g. electrical networks containing semiconductors) it has been proposed by various authors to simulate the semiconductor components by drift-diffusion (DD) equations. The coupling with the network equations then yields a nonlinear partial-differential algebraic equation (PDAE).

We discretize the DD-equations in space by standard finite elements as well as by Raviart-Thomas elements and simulate the resulting high dimensional DAE. Snapshots of the semiconductor state variables are selected from one or multiple simulations with different sets of parameters (e.g. frequency of input source, length of semiconductor, doping). From these snapshots a reduced state space approximation is obtained by using proper orthogonal decomposition (POD). The projection of the DD-equations onto the reduced state space yields a nonlinear low-dimensional model for the DD-equations. This low-dimensional model then serves as surrogate for the DD-equations in the integrated circuit.

We numerically analyze the behaviour of the reduction in one dimension subject to different reduction levels. Furthermore we discuss an adaptive approach to construct POD models which are valid over certain parameter ranges. Finally, numerical investigations for the reduction of a 4-diode rectifier network are presented, which clearly indicate that POD model reduction delivers surrogate models for the diodes involved, which depend on the position of the semiconductor in the network.

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