Efficient Reduction of Electrical Network Models with Internal Sources

S. Ludwig[1,2] and W. Mathis[1]

[1] Leibniz University Hannover
Institute of Electromagnetic Theory
Hannover
ludwig@tet.uni-hannover.de
mathis@tet.uni-hannover.de

[2] Fraunhofer Research Institution
for Electronic Nanosystems
Department Advanced System Engineering
Paderborn
stefan.ludwig@enas-pb.fraunhofer.de

Abstract

Linear electrical networks are widely used to model the physical behaviour of structures. The state of the art technique is the reduction of the networks of passive structures. For example the electromagnetic behaviour of packages and transmission lines is modelled by passive RLC-networks. Another example is the electro-thermal modelling of semiconductor devices which are also modelled by passive networks. Typically the resulting networks have a high number of elements and nodes, resulting in large ODE systems. By reducing the number of equations of the ODE with the help of model order reduction techniques a smaller ODE system is found, which approximates the large system. Synthesizing the reduced ODE into an electrical network and replacing the original network enables faster simulations.

It is more and more common that structures with additionally included internal sources are modelled in most recent applications.. For example in models of the electromagnetic behaviour of complete ICs the internal currents can be modelled as independent current sources. Noise in electronic circuits can also be modelled by internal noise sources. Further examples are thermal models, where the heating inside the device can be modelled with internal sources.

For model reduction these sources are treated as inputs of the system in the standard method. This leads to a high number of inputs of the system for networks with a large number of internal sources. The high number of inputs limits the reduction, resulting in low or no computational savings by using the reduced model. In this presentation a method is proposed which uses the determined behaviour of the internal sources to reduce the number of necessary inputs of the system. The proposed method is based on a network alteration with controlled sources. Network properties like passivity and reciprocity are preserved in the proposed method. The method can be used for networks with internal sources with equivalent or proportional waveforms or for networks with internal sources with arbitrary waveforms.

The efficiency of the proposed method is shown by reducing a network of the electromagnetic behaviour of the Infineon 32 Bit automotive microcontroller TriCore1796. The size of the reducible network is around 35000 RLC elements which model the electromagnetic coupling and more than 300 independent current sources modelling the internal activity of the IC due to switching currents. It is shown that with the standard method no essential simulation speed-up can be achieved with model order reduction, while with the proposed method a significant speed-up is possible.