Coupled symbolic-numerical model reduction using the hierarchical structure of nonlinear electrical circuits

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In this talk, we present a new algorithm that exploits a given hierarchical structure of electrical networks in order to couple symbolic[1] and numerical model reduction techniques. We further provide some example applications for this approach, where distinct parts of a circuit are reduced by different reduction methods. Part of these methods as well as our work have been developed and carried out within the project *SyreNe* (System Reduction for Nanoscale IC Design) which is supported by the German Federal Ministry of Education and Research (BMBF) under grant no. 03LAPAE6.

By a segmentation of the entire circuit according to its hierarchical subcircuit structure, distinct parts of the circuit can be reduced by different reduction methods. This approach also affords the highly complex symbolic reduction of large circuits. In considered test cases, the resulting overall system-size became even smaller compared to the direct non-hierarchical approach. In order to measure the influence of single subcircuits on the behavior of the entire system, a new concept of subcircuit sensitivity analysis has been invented. By keeping track of the error on the output of the entire system, the influence of a subcircuit on the entire system's behavior is measured. Based on this concept, a ranking of subsystem reductions is presented, which computes an order of subsystem reductions with the aim of achieving a high degree of reduction for the entire system. The entire hierarchical reduction process is controlled by making use of this ranking and appropriate reductions of single subcircuits are carried out in order to meet the user-specified accuracy for the overall reduction.

To a large extent, the algorithms have been automated and implemented in Analog Insydes, a software package developed by the Fraunhofer ITWM in Kaiserslautern, Germany. We apply them to electrical circuits typically used in industry and show the results. For the reduction of distinct subcircuits, we use different symbolic and numerical methods, which have partly been developed within different sub-projects of *SyreNe*.

References

[1] O. Schmidt, T. Halfmann, P. Lang, *Coupling of numerical and symbolic techniques for model order reduction in circuit design*, appears in Lecture Notes in Electrical Engineering, Springer

[2] O. Schmidt, *Structure-Exploiting Coupled Symbolic-Numerical Model Reduction For Electrical Networks*, Dissertation, Technische Unitversität Kaiserslautern, April 2010.

[1] Since the dominant parameters of the symbolically reduced parts of the circuit are maintained in their symbolic form in the overall reduced system, symbolic techniques allow to gain insights in the entire circuit's behavior.