From ANSYS to System Level Simulation: MOR for ANSYS

MATLAB/Simulink, Mathematica, Python, CASPOC and other system level simulation tools can be linked to ANSYS by the software MOR for ANSYS. Here is a brief overview about the tool and its value in order to couple structural and behavioral simulation tasks. The behavior of many manufactured products with complex structures is controlled by embedded electronics. Hence system level simulation is an important part of the product development. Such simulation includes circuit components combined with models of devices.

Nowadays finite element modeling enjoys widespread use and natural desire is to employ the FE models directly for system level simulation. This is possible in co-simulation, when different simulation tools are coupled during a single dynamic simulation. The difficulty is that the FE models are high dimensional and the integration in time in this case is just infeasible.

Common practice for system level simulation is to employ a compact or behavioral device model. Such a model is low-dimensional but it is supposed to approximate the dynamic response with good accuracy. The big problem along this way is evident – how one should actually obtain this model.

Model Order Reduction

Thus there is a gap in simulation practice. On one hand, there is an accurate finite element model that has been already developed; on the other hand, it is still necessary to invest time and efforts to develop a behavioral model for system level simulation. In other words, one should pay twice: to develop not only a finite element but also a compact model.

The modern development in mathematics bridges this gap (see Fig. 1). It allows us to start from a high dimensional system obtained by finite elements and then automatically generate a low dimensional approximation. The dimension of a reduced model is controlled by the approximation error specified by the user. In this article the software MOR for ANSYS [1] is presented. MOR for ANSYS applies new algorithms directly for ANSYS models.

MOR for ANSYS

MOR for ANSYS reads system matrices from ANSYS FULL files, runs a model reduction algorithm and then writes reduced matrices out. Typical time for model reduction is comparable with a couple of stationary solves for a given problem. The process of generating full files in Workbench is automated through scripting. The reduced matrices can be read directly in MATLAB/Simulink, Mathematica, Python, CASPOC and other system level simulation tools. It is also possible to write them down as templates for the use in Saber MAST, VerilogA and VHDL-AMS.

Thermal Models

We start with an electro-thermal simulation of an IGBT in a hybrid vehicle (see Fig. 1) [2]. An electrical model of the IGBT depends on temperature and the latter should be available during system level simulation. An IGBT module shown in the middle of Fig. 1 contains three DCPs with 12 IGBTs and 18 diodes, which define 30 heat sources. With the finite element model in ANSYS one obtains accurate temperature distribution that also takes into account thermal cross talk. MOR for ANSYS generates small matrices and one uses them in CASPOC for electro-thermal simulation [2]. Examples with electrothermal MEMS devices are available in the book [3] and in

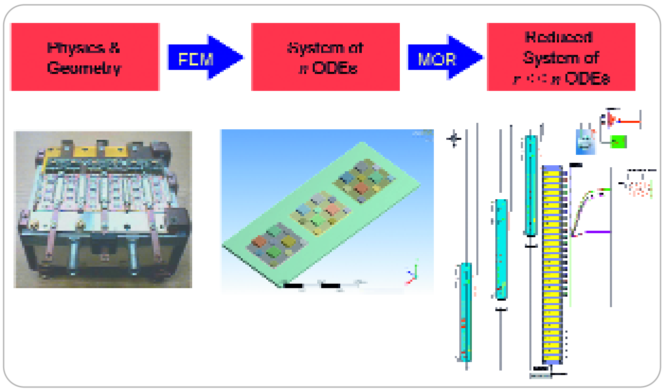


Fig. 1: Model order reduction is an efficient means to enable a system-level simulation. Figure shows an example of a compact model for an IGBT block [2].

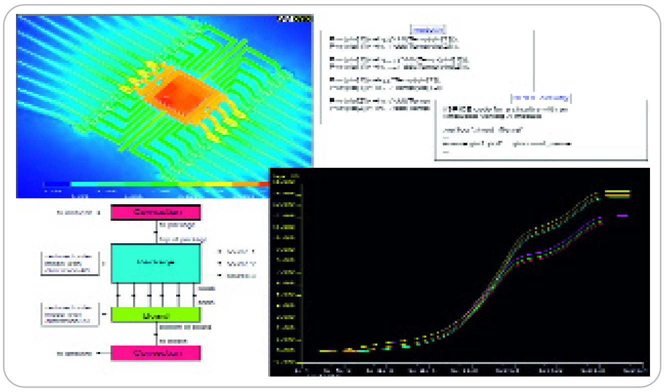
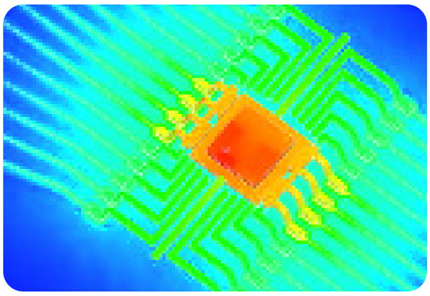


Fig. 2: Dynamic compact thermal model of a package [4]. Figure shows a stationary solution, a block scheme for system level simulation, fragments of the implementation in VerilogA and results at the system level.



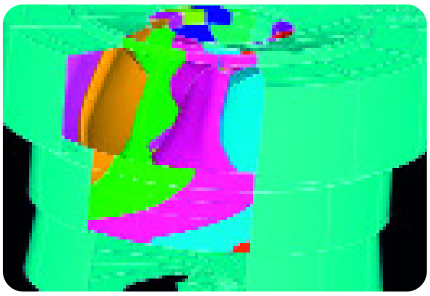


Fig. 2 there is an example of a package from Freescale [4] where system level simulation has been performed in VerilogA.

Applications for Structure, Acoustics and Optimization

MOR for ANSYS is also applicable for structural models. Fig 3 shows as an example a harmonic simulation for the Tool Center Point of a machining center developed at ETH Zurich and the vision of IWF/inspire at ETH on how a model reduction will be used to develop a machining tool.

It was already mentioned that the model reduction process with MOR for ANSYS is much faster than a dynamic simulation in ANSYS with the original model. This way it is possible to use MOR for ANSYS as a fast solver for transient or harmonic simulation. Let us consider a model developed at Voith Siemens Hydro Power Generation (see Fig 4). The goal of the simulation is to study the dynamic excitation of turbine rotors by rotating pressure field caused by rotor-stator interaction. A reduced model of dimension 100 approximates very accurately the harmonic response of the original ANSYS model. However, the time to generate the reduced model and to make a harmonic simulation with it is orders of magnitude faster than to perform a harmonic response simulation in ANSYS.

This allows us to employ model reduction as a fast solver in the optimization process. The use of MOR for ANSYS for the optimization of an accelerometer is documented in [5] and for structural acoustic optimization to improve acoustic characteristics of a vehicle (NVH – Noise, Vibration, Harshness) in [6].

Finally it should be mentioned that MOR for ANSYS is applicable for any linear model developed in ANSYS either as a tool to automatically generate a compact dynamic model for system level simulation or a fast solver for dynamic simulation. <<

Sources

[1] MOR for ANSYS, http://ModelReduction.com.
[2] A. Dehbi, W. Wondrak, E. B. Rudnyi, U. Killat, P. van Duijsen. Efficient Electrothermal Simulation of Power Electronics for Hybrid Electric Vehicle. Eurosime 2008.
[3] T. Bechtold, E. B. Rudnyi, J. G. Korvink. Fast Simulation of Electro-Thermal MEMS: Efficient Dynamic Compact Models, Springer 2006, ISBN: 978-3-540-34612-8.
[4] A. Augustin, T. Hauck. Transient Thermal Compact Models for Circuit Simulation. Paper 2.5.3. 24th CADFEM Users' Meeting 2006.
[5] J. S. Han, E. B. Rudnyi, J. G. Korvink. Efficient optimization of transient dynamic problems in MEMS devices using model order reduction. Journal of Micromechanics and Microengineering 2005, v. 15, N 4, p. 822-832.
[6] R. S. Puri. Krylov Subspace Based Direct Projection Techniques for Low Frequency, Fully Coupled, Structural Acoustic Analysis and Optimization. PhD Thesis, 2008, Oxford Brookes University.

Authors

Author and Contact Person
Dr. Evgeny Rudnyi, CADFEM GmbH Grafing
Phone +49 (0) 80 92-70 05-82
E-Mail erdudnyi@cadfem.de

Information

More information on MOR for ANSYS
http://ModelReduction.com

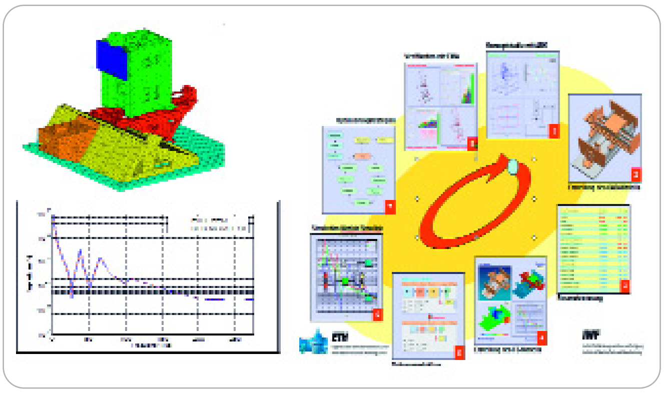


Fig. 3: Harmonic response of the Tool Center Pointer for a machining center and a vision of IWF/inspire at ETH for the use of model reduction to develop a machining tool.

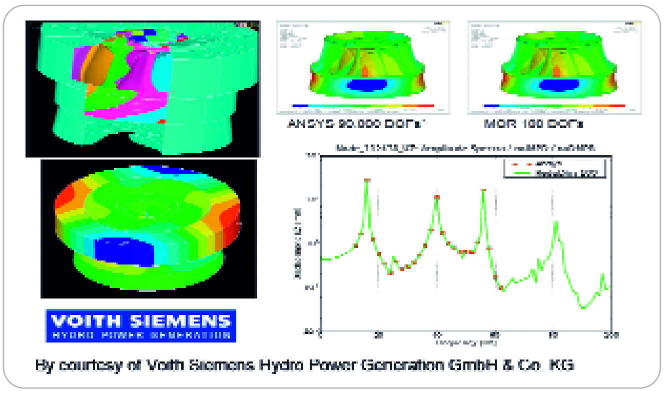


Fig. 4: Model reduction for a FSI problem. The figure shows the dynamic excitation of turbine rotors by rotating pressure field caused by rotor-stator interaction.