mor4ansys: Model Reduction for ANSYS Engineering Models

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Motivation

ANSYS

- Quite a popular Finite Element simulation package.
- Convenient graphical modelling.
- Widespread use in the engineering.
- However the time for transient and harmonic simulation is unacceptably long.

Model Order Reduction

- Reduction of simulation time is essential for design optimization and system-level simulation.
- Models of small dimension can be simulated in very short time.
- Moment matching via the Arnoldi process allows us to reduce the dimension of the original system by many orders of magnitude.
- The model reduction process is automatic as it is based on the formal procedure.

mor4ansys

Step 1: Reads system matrices from ANSYS

- First order ODEs $\mathrm{C}\dot{x}(t) + \mathrm{K}x(t) = \mathrm{B}u(t)$
- Second order ODEs $\mathrm{M}\ddot{x}(t) + \mathrm{C}\dot{x}(t) + \mathrm{K}x(t) = \mathrm{B}u(t)$
- Web-interface to upload ANSYS emat files.

Step 2: Performs model reduction

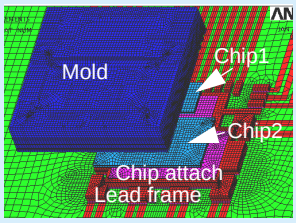
- Match Coefficients of Taylor Expansion of the transfer function $H(s) = \mathrm{L}^T(s^2\mathrm{M} + s\mathrm{C} + \mathrm{K})^{-1}\mathrm{B}$.
- The Arnoldi process finds a projection matrix $x = Vz + \varepsilon$.
- Projection produces the reduced model $\mathrm{V}^T\mathrm{M}\mathrm{V}\ddot{z}(t) + \mathrm{V}^T\mathrm{C}\mathrm{V}\dot{z}(t) + \mathrm{V}^T\mathrm{K}\mathrm{V}z(t) = \mathrm{V}^T\mathrm{B}u(t)$
- No user intervention is required.
- The dimension of the original model is up to 500 000.
- In many cases, the dimension of the reduced model up to 30 is already enough.

Step 3: Write a reduced model

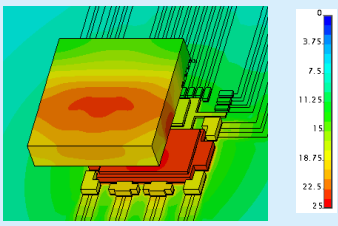
- Currently simulation with the reduced model is done in Mathematica.
- Can be written in Hardware Description Language.

Compact Electro-thermal Model of Motorola's Semiconductor Device with Multiple Heat Sources

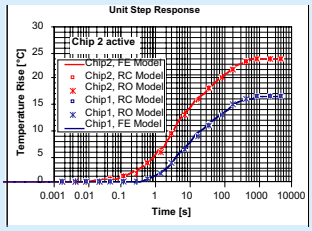
C. Bohm, T. Hauck, E. B. Rudnyi, J. G. Korvink. Submitted for publication in the Technical Proceedings of the EUROSIME2004 May 9-12, 2004, Leuven/ Brussels, Belgium.



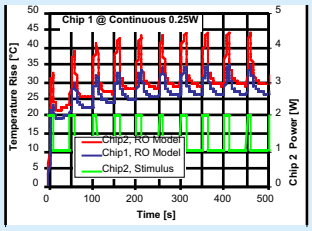
ANSYS model of the chips with PCB.



Temperature field solution.



Unit step response comparison.

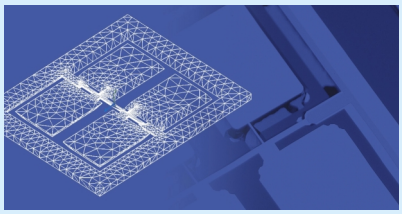


System-level simulation.

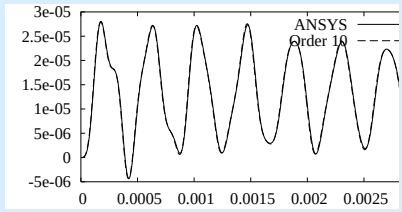
Compact Mechanical Model of Imego's Butterfly Gyroscope

Jan Lienemann, Dag Billger, Evgenii B. Rudnyi, Andreas Greiner, and Jan G. Korvink, submitted for publication in the Technical Proceedings of the 2004 Nanotechnology Conference and Trade Show, Nanotech 2004, March 7-11, 2004, Boston, Massachusetts, USA.

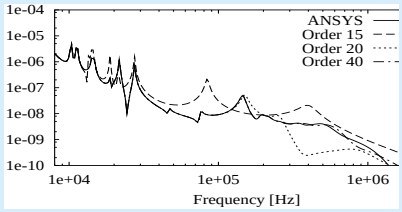
The Butterfly microgyroscope.



Finite element mesh.



Comparison of transient behavior.



Comparison of transfer functions.

More Information

- mor4ansys, also papers and preprints http://www.imtek.uni-freiburg.de/simulation/mor4ansys/
- Model reduction for Micropyros online http://www.imtek.uni-freiburg.de/simulation/pyros/
- Benchmarks for model reduction http://www.imtek.uni-freiburg.de/simulation/benchmark/

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