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UNIVERSITY OF COLOGNE, INSTITUTE OF MATHEMATICS

Fully Coupled Circuit and Device Simulation with Exploitation of Algebraic Multigrid Linear Solver

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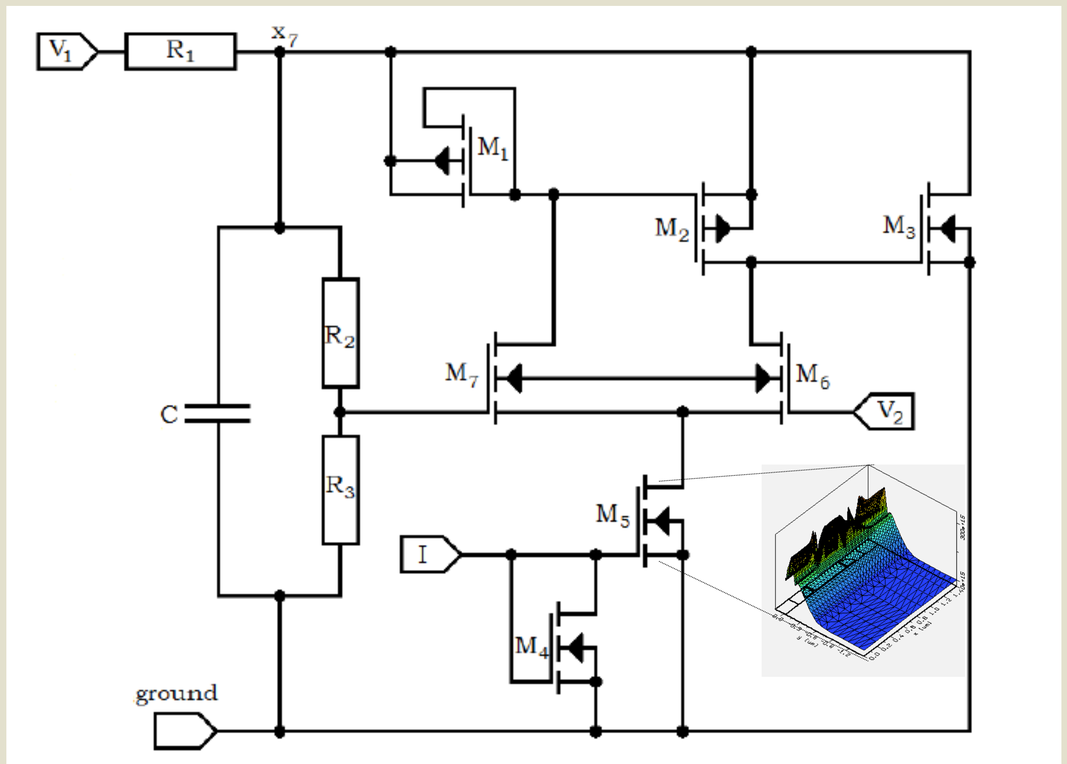
WHAT WE ARE DOING

We solve coupled systems of differential-algebraic equations (DAEs) and partial differential equations (PDAEs). With MECS we implemented a combined circuit/device simulation framework with a calling interface to Minimos-NT.



Circuit with one device fully discretized and all others computed by compact models

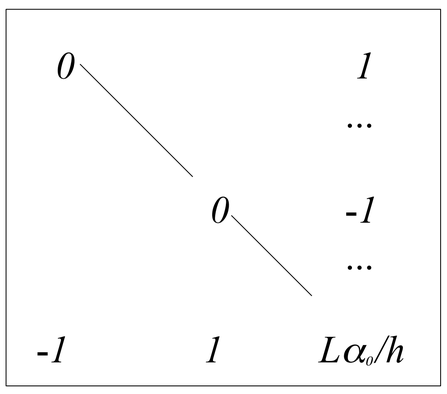
AVOIDING ZERO ENTRIES ON THE DIAGONAL

- Problem:

  MNA generates zero entries on the diagonal of the Jacobian.
  Zero diagonal should be avoided for algebraic multigrid method.

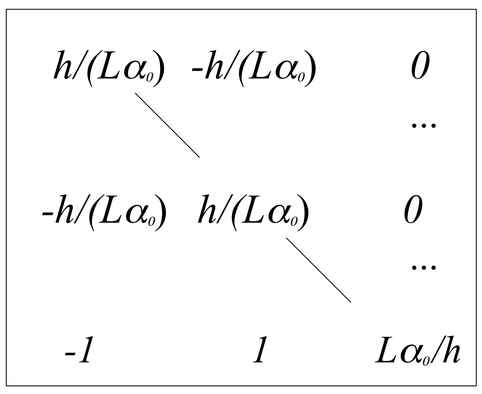
- Approach:

  Origin of non-zeros are: voltage sources and inductivities.
  Voltage source equations can be eliminated by substitution.
  Inductivity equations can be equivalently transformed:



Modified Nodal Approach (MNA)

=>



Jacobian part after transformation

- Result:

  MNA matrices can be transformed to non-zero diagonal form which is much more suitable for algebraic multigrid linear solver.

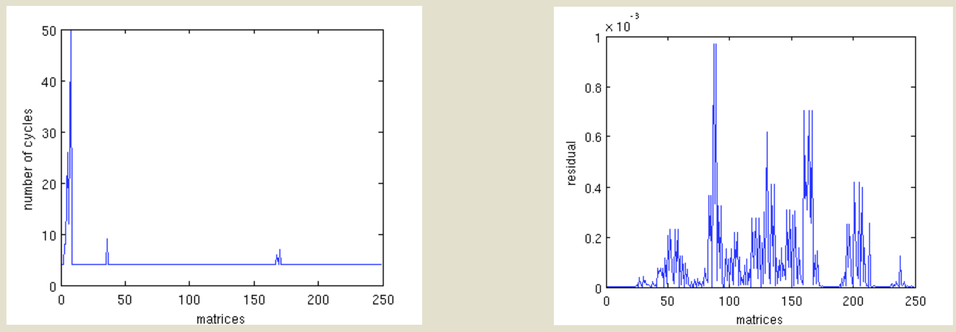
FIELDS OF APPLICATION

- Fully coupled electrical and device simulation
- Integration of Spice3 (BSIM) for compact transistor models
- Integration of Minimos-NT for the device parts
- Integration of field solver Magwel for electromagnetic devices
- Special variants for simulation of water or gas networks
- Sensitivity analysis of parameter variations (DesParO)

Graphical user's interface of DesParO explorer

RESULTS

First tests with SAMG solver with two fully discretized devices:



Cycle numbers (left) and residuals after convergence (right) for algebraic multigrid solver (SAMG)

CONCLUSION

Algebraic multigrid solvers can be successfully applied to coupled circuit/device simulation. Larger problems will considerably benefit since computational complexity is linear.

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References

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