Semi-explicit methods for coupled circuit/field problems

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The need of combining circuit simulation directly with complex device models to refine critical circuit parts becomes more and more urgent, since the classical circuit simulation can no longer supply sufficiently accurate results. The simulation of such coupled problems leads to large systems and therefore to high computing times.
We consider a set of differential-algebraic equations, which arise from an electric circuit modeled by the modified nodal analysis coupled with electromagnetic devices. While the normal circuit elements are 0d-elements, the electromagnetic devices are given by a three dimensional model. Therefore the number of variables can easily go beyond millions, if we refine the spatial discretization. Since we are confronted by a system of DAEs we can not make use of explicit methods in general. So we are forced to solve very large implicit systems.
We analyze the structure of the discretized coupled system and present a way to transform it into a semi-explicit system of differential-algebraic equations. In the process we make use of a new decoupling method for DAEs which results from a mix of the strangeness index and the tractability index. After this remodelling the electromagnetic part of the equation will be a system of ordinary differential equations with sparse matrices only.