FAST FINITE ELEMENT ANALYSIS OF MICROWAVE DEVICES BY DOMAIN DECOMPOSITION AND MODEL ORDER REDUCTION

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Notwithstanding the immense computing power available nowadays, numerical parametric studies, optimization or tolerance analyses based on full-wave techniques like, among others, the finite element method (FEM) are still too time consuming.
Among the many possible ways to obtain faster analyses, model order reduction techniques (MOR) and domain decomposition methods (DD) represent quite complementary approaches. The goal of MOR is the efficient characterization of a system over a whole parameter space by reducing the dimension of the discretized model. While MOR was originally applicable to single-parameter systems only, it has recently been extended to the multi-parameter case. MOR approaches can be classified as either single-point [1] or multi-point methods [2]. Multi-point schemes are more robust but come along with the drawback of requiring a full FEM solution at each sampling point. DD, on the other hand, is a technique for reducing a large problem, which would not be numerically solvable as a whole, to a set of smaller, coupled, problems which can be solved one-by-one in a divide-and-conquer scheme.
In this contribution, the two MOR and DD techniques are combined in the following way: first, the model is partitioned so that all parameter-dependent features are located in a single, not necessarily simply connected, subdomain [3]. Then, the DD technique is employed to reduce the FEM system to this subdomain only, and, finally, a multi-point MOR method is applied to produce a low-dimensional model for this region, which can then be evaluated efficiently at any point in parameter space.
At the conference test cases will be presented, comprising passive waveguide devices which, for the sake of simplicity, are uniform either along the E-plane or the H-plane, i.e. devices that can be solved by 2D FEM. These devices comprehend dielectric slabs or posts. Sweep on the material parameters of these items will be performed and presented, assessing the speed up attained with the proposed technique.

[1] O. Farle, V. Hill, P. Ingelström, R. Dyczij-Edlinger, "Multi-parameter polynomial order reduction of linear finite element models", *Mathematical and Computer Modelling of Dynamical Systems*. – accepted for publication.

[2] D. S. Weile, E. Michielssen, "Analysis of frequency selective surfaces using two-parameter generalized rational Krylov model-order reduction", *IEEE Trans. Antennas Propag*. 49 (2001), November, S. 1539–1549.

[3] G. Guarnieri, G. Pelosi, L. Rossi, S. Selleri, "A new FEM/BEM domain decomposition approach for solving high diversity electromagnetic problems," 8th International Workshop on Finite Elements for Microwave Engineering, 25-26 May 2006, Stellenbosh (South Africa), p. 60.