ENHANCED EM SOFTWARE FOR PLANAR CIRCUITS

An efficient Multilevel Fast Multipole Algorithm based on the use of Perfectly Matched Layers

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Abstract: The most successful simulation technique for planar circuits embedded in layered media is the integral equation approach solved with the Method of Moments (MoM). The kernel in the integral equation is a Green’s function of the layered medium. The MoM leads to the solution of a dense linear system of equations. For large and complex circuits this soon leads to systems with a huge number of unknowns \( N \). Storing and solving the linear system requires \( O(N^2) \) memory and \( O(N^3) \) CPU time respectively. Using iterative solution techniques the cost for solving the linear system can be reduced to \( O(PN^2) \), with \( P \) the number of iterations. The calculation of the Green’s functions for layered media demands the numerical evaluation of Sommerfeld-integrals. By making use of the excellent absorbing properties of Perfectly Matched Layers (PML) it is possible to obtain a series representation for these Green’s functions. The terms in this series allow for the application of a Multilevel Fast Multipole Algorithm (MLFMA) which can reduce the memory and computational complexity of the algorithm to \( O(N) \) for dense geometries. In this chapter the combined PML-MLFMA is outlined. It is numerically demonstrated that this technique allows for the analysis of very large planar structures. An extension to small circuits with much geometric detail is also presented.

Key words: Microstrip Structure; Planar Antenna Array; Perfectly Matched Layer; Multilevel Fast Multipole Algorithm.

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1. INTRODUCTION 223
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2.1 DNG Metamaterials 225
The impressive growth in Information Technology (IT) is opening new challenging frontiers for computational electromagnetics (EM). Indeed, parallel and distributed computing play a relevant role in the solution of large or complex EM numerical problems. They also represent the ideal starting point to approach the world of grid computing and service-oriented architectures, probably the most attractive and promising area of IT research in the next future.

Advances in Information Technologies for Electromagnetics offers a broad panorama on recently achieved and potentially obtainable advances in electromagnetics with innovative IT technologies.

Simple tutorial chapters introduce the reader to cutting edge technologies, such as parallel and distributed computing, object-oriented technologies, grid computing, semantic grids, agent based computing and service-oriented architectures.

On such bases, a variety of EM applications is proposed:
- parallel FDTD codes (both for antenna analysis and for metamaterial applications),
- grid computing for computational EM (CEM) (with applications to antenna arrays, wireless and remote-sensing systems)
- mobile agents for parametric CEM modeling
- complex/hybrid EM software environments (with applications to planar circuits, quasi-optical systems,...)
- semantic grids for CAE of antennas arrays.

This way the reader, after learning from very schematic tutorials the most relevant features of IT tools, has an immediate feeling of their impact on daily EM research.

Throughout the book, the reader is also stimulated to infer other potential new EM applications for IT, thus maturing a critical attitude to estimate the appeal of possible future IT innovations for EM research.