New Conformal PEC FDTD Model With User-Defined Geometric Precision And Derived Stability Criterion

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Introduction and Objectives

The Finite-Difference Time-Domain (FDTD) method has proven its capabilities for solving complex electromagnetic (EM) engineering problems. However, for grid non-aligned surfaces the staircasing meshing can lead to inaccuracies in electromagnetic simulations. Conformal meshing and locally modified Yee update schemes can be used to overcome this shortcoming. The key requirements of the conformal FDTD models are therefore the accuracy gain and the robustness of the scheme.

The objectives of this study were the development and implementation of a new robust conformal PEC model. In contrast to already published conformal PEC models, the speed, i.e. the multiplications per update cycle and the memory consumption, are the same as for the conventional FDTD algorithm. The best case is targeted, i.e., to have a controlling parameter to favour either speed or accuracy while always guaranteeing stability even for complex EM simulations.

Methods

All implementations and comparisons were conducted within the 3-D TCAD platform SEMCAD X, which allows the processing of highly complex structures. A robust conformal mesher (S. Benkler et al., APS/URSI 2005) discretizes imported CAD models of multiple-thousand parts. The developed conformal PEC model can be formulated with the conventional FDTD update equation. In contrast to the Yu-Mittra scheme, both the reduction of the electric edge length and the reduction of the magnetic flux area were successfully incorporated into the updating scheme to benefit the most from geometrical details. With the derived criterion the stability is always guaranteed. Furthermore, the stability criterion is used to optimize the achievable accuracy depending on the controlling parameter CFL (ratio of chosen time step to conventional FDTD time step). Therefore the user can tradeoff accuracy versus speed with the chosen CFL. Even with the conventional FDTD time step (CFL=1), the conformal FDTD scheme profits from the geometrical details, since these are resolved up to the limit allowed by the stability criterion.

Results and Discussion

To show the performance and the robustness of the proposed scheme, canonical validations and real world applications were investigated. Based on comparisons to analytical solutions, the advantages of the proposed scheme compared to existing conformal methods are demonstrated regarding effectiveness and accuracy. Furthermore, a broadband low profile (circular) antenna was simulated, showing the benefit of this method compared to conventional FDTD. An FDTD simulation with $> 500'000$ cells takes more than 20 times longer than a simulation with the presented C-FDTD scheme with $< 20'000$ cells, with equivalent accuracy. Further, a CAD derived mobile phone was conformally discretized and simulated. A comparison of the results to reference and experimental data shows that the proposed scheme is highly suited for the simulation of advanced engineering problems.