A Finite Volumes-Based FDTD Material Dispersion Modeling

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The conventional FDTD, based on second-order central difference formula, is useful only so long as the electrical size of the structure is small. Phase error accumulates in the field calculations as the dimensions of the numerical FDTD lattice become larger. The Finite Volumes-Based 3-D second-order in time, fourth-order in space (FV24) modeling is highly capable of controlling such phase errors. Therefore, it is suitable for electrically large problems at coarse grid resolutions.

This work models the frequency dependence of material losses using an Auxiliary Differential Equation (ADE), a technique extensively discussed in the literature. (Elsherbeni and Demir, 2016.) To account for material dispersion, the derivation of ADE is extended for FV24 by modifying the electric field update equations. A Multi-pole Debye model, which provides an auxiliary differential equation in time domain and also produces a causal response, is used in the current analysis. This model, suitable for FDTD simulations, can simulate relative permittivity and conductivity of materials with high degree of accuracy over a wide bandwidth.

For the present study, a simple dielectric scatterer is used as the problem space. The planewave excitation is provided using the total field/scattered field-based leakage free technique. (R. C. Bollimuntha et al., *IET Microwaves, Antennas and Propagation*, 2016.) The FV24 algorithm, being accurate even at coarse discretizations, provides excellent wideband performance. Keeping low number of cells per wavelength provides a substantial decrease in floating-point operations per wavelength, enabling faster computation. This fact allows significant reduction in memory usage. This feature of FV24 renders it relatively less expensive than FDTD to model three-dimensional (3-D) problems that are hundreds of wavelengths large. A comparison of accuracy and performance in terms of memory usage and simulation time of conventional FDTD versus FV24 will be presented.