Excitation of Plane Waves in Higher Order FDTD Grids

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Many EM applications involve a plane wave impinging on an object that can be either a receiving antenna or scatterers such as aircraft and ships in radar applications. Initiating a plane wave in a FDTD grid in order to simulate these real-life situations is of interest to the applied EM community. Different techniques exist for simulating this plane wave in a traditional FDTD grid, however the error-free and efficient technique has been the Discrete Planewave formulation (T.Tan and M.Potter, IEEE Trans. Antennas Propag., vol. 58, 2641-2648, 2010).

In this presentation, we will show how this technique, which uses the total field-scattered field formulation to implement plane wave incidence, is implemented for a 3D finite volumes-based, extended-stencil FDTD (FV24) algorithm. The FV24 method is based on the second-order in time and fourth-order in space finite-difference scheme whereas the conventional FDTD is obtained from second-order finite differences in both time and space.

Using the Discrete Planewave formulation, we can gain computational efficiency when the three-dimensional FV24 grid is converted, exploiting the plane wave properties, into an auxiliary one-dimensional grid along the direction of plane wave propagation. The field leakage errors are eliminated through the dispersion-match between the one and three dimensional grids. As a consequence, the field leakage errors into the scattered-field region are -300 dB below the incident field values and are observed to be independent of angle of incidence.

Time-stepping along the aforementioned one-dimensional grid and the three-dimensional FV24 grid are run in parallel. The consistency corrections needed for the update equations at the total field-scattered field boundary are made using the field values from the one-dimensional grid. In contrast with the consistency corrections needed for plane wave incidence in traditional FDTD grid, more corrections are needed in FV24 grid due to its extended stencil. The complicated mapping between the corresponding field locations on the one-dimensional grid and the main three-dimensional grid will be demonstrated.