A Novel Longitudinal-section FDTD algorithm for Simulating Large-size Electromagnetic Compatibility and Interference (EMC/EMI) Problems

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Abstract

In this paper we present a new Longitudinal-section FDTD algorithm, designed to solve field penetration problems involving electrically large structures that cannot be handled by a direct application of the method. This technique begins by dividing the structure into relatively small sections in the longitudinal direction, and then applying the conventional FDTD, successively progressively along that direction using the field distribution on the last plane of a sub-domain as the field input on the first plane of the following one. The field computation in each sub-region is carried out by terminating it with a PML layer. The magnitude and the phase of the field computed on the plane located at the interface between two slices are stored in the frequency domain. To investigate the problem of penetration inside a building, *i.e.*, to solve an EMI problem, these serial computations are successively applied until the back wall is reached. Following this, similar computations are used--once again--to track the reflected waves until they reach the observation plane. Multiple reflections between the walls are included on 'as needed' basis until the desired accuracy is achieved. Since the slices in the longitudinal dimension can be relatively small, and we place virtually no limits on the number of slices very large problems can be accommodated using a machine with only a moderate-size memory.

To validate the above Longitudinal-FDTD approach, we have investigated the problem of penetration of EM wave inside a room and have compared the results of this approach with the direct application of the FDTD. In this example, the operating frequency of the incident plane wave is 500 MHZ and the outer dimensions of this geometry are 2.25m x 2.25m x 3m. The walls have dielectric constant 6.25 and conductivity 4.17e-2 Mho/m, except the rear wall has a dielectric constant 4.0. We have divided the computational domain into two regions, we added a PML layers at the end of the first computational domain, to absorb the waves traveling in the y-direction at the end of the computational domain of this region. For this test example, the incident field is a plane wave, which impinges upon the room in a direction normal to the aperture in the front wall. Fig. 1 shows a comparison of the E_z-field along the central line (x=const) in an observation plane at f=500MHZ, derived by using the first two reflections. It can be noted from this figure that the domain decomposition results using the first two reflections agree well in the region of interest, which is the center region of the room, with those derived via a direct application of the FDTD. We have also used the newly developed serial FDTD technique to solve the problem of penetration of the fields radiated by a broadband antenna into an electrically large building, with a measurement probe located inside the building. In order to deal with wire-type antennas as well as lossy inhomogeneous structures, such as building walls, we have hybridized the FDTD method with the NEC code and have determined the field received by the probe antenna by using the reciprocity theorem. The visualization of the field inside the building and the field received by the probe will be presented.

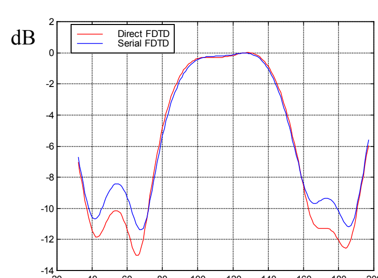

Fig. 1. Magnitude of the field distribution at the center line of the observation plane. The computed field by using two reflections is compared with that of the direct application of the FDTD. $\overline{E}^{inc} = E_0\, e^{-jk_0 y}\, \overline{a_z}$.