# The Alternating-Direction Implicit Finite-Difference Time-Domain (ADI-FDTD) Method and its Application to Simulation of Scattering from Highly Conductive Material


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The study of shielding effectiveness of natural and synthetic conductive material requires accurate modeling of the electromagnetic field distribution in the close proximity and within the material. At microwave frequencies, the skin depth of highly conductive materials is in the micrometer range. For accurate modeling, the field within the material must be resolved, which places heavy computational burden on most traditional electromagnetic solvers. The alternating-direction implicit finite-difference time-domain (ADI-FDTD) method offers a unique advantage in comparison to other time-domain volume-based methods in that the time step is not constrained by the smallest space-cell size (i.e., the Courant limit). This lack of time-step constraint is a direct product of the *implicitness* of the ADI-FDTD. However, and as reported in recent works, dispersion can be a direct casualty of time-step relaxation. To investigate the effectiveness of scattering interaction between non-conductive (lossless) and highly conductive media, we developed a multi-grid three-dimensional ADI-FDTD method. As a starting point, we simulated the classical problem of microwave frequency plane wave incidence on a highly conductive half-space. In this simulation, the smallest grid resolution of 0.1 μm was chosen within the material, while a grid resolution of 0.5mm was chosen in the lossless medium. Different time steps were chosen and their effect on the accuracy in general, and dispersion in particular was analyzed. The effect of multi-grid cell structure was also studied and comparison was made to theoretical calculation for simple half-space scattering problems. The current term ($J$) in Maxwell equations was implemented using two different approaches. In the first, the $E$ field was expressed using the Crank-Nicolson method. In the second, the $E$ field was treated implicitly. Discussion of the effect of all these factors will be addressed with the objective of determining the robustness of the ADI-FDTD method for the treatment of general highly conductive natural and synthesized structures.