Bi-Conjugate Gradient FFT Method for Magnetodielectric Objects in Layered Media

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Scattering problem for magnetodielectric objects in the background of layered media has widespread applications, such as antenna analysis and unknown targets detection. Considering the fact that objects are usually inhomogeneous and have arbitrary shape, the volume integral equations are the more appropriate choice to solve. However, this work is very challenging because of the following two reasons: first, for the reason that both permittivity and permeability of the objects are different from the background, the electric field integral equation (EFIE) and the magnetic field integral equation (MFIE) should be solved simultaneously; second, the evaluation of the layered media Green's functions is one of the most important and time-consuming components of solving the integral equations.

In order to solve the EFIE and MFIE accurately, mixed order basis functions are used. For example, the first order divergence conforming basis functions are applied to the flux densities, whereas the second order curl conforming basis functions are utilized for vector potentials. To efficiently calculate the layered media Green's function, a recursive matrix method combined with an interpolation technique is applied. Besides the above mentioned improvements, the difference between the proposed method and the conventional methods also include that the BCGS-FFT method is able to iteratively solve the dense matrix associated with the volume integral equations in a highly efficient manner with the usage of FFT algorithm in all three directions, which is a result of the application of not only the convolution theorem in horizontal plane, but also that of the correlation theorem in vertical direction. The efficiency and accuracy of the proposed method are shown by several numerical examples of magnetodielectric objects in the background of layered media.