Accelerating Green's Functions for Uniaxial Anisotropic Layered Media Using Sommerfeld and Related Identities

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Fast and accurate evaluation of planar layered media Green's functions (LMGF) is a critical factor affecting solution efficiency for problems involving geophysical prospecting, microstrip antennas, and other applications. Layered media Green's functions can be expressed as generalized Sommerfeld integrals (SIs). Evaluation of these SIs is difficult due to the presence of poles and other singularities in the complex plane. In addition, the integrands are slowly decaying and oscillatory on the real axis. Extensive research has been conducted in recent decades to accelerate the convergence of SIs. Methods investigated include, for example, steepest-descent integration methods, the discrete complex image method (DCIM), the weighted average method, the fast Hankel transform, and others.

Another approach that can be used to accelerate computation of any component of the planar LMGF is to subtract their corresponding asymptotic forms in the spectral domain and then restore the removed terms in spatial domain form (Kummer acceleration). The restored terms should have closed-form expressions or be easily calculated. Such asymptotic extractions result in a spectral integrand that decays faster by a factor of k_t^2 or more, where k_t is the spectral integration wavenumber, and even renders some otherwise diverging integrands integrable when the observation point is in the source plane. Moreover, the subtraction process regularizes the spectral integral, and the resulting smoother function is suitable for interpolation, further reducing matrix fill time when solving 3-D problems using the method of moments.

In this work, a number of Sommerfeld and related identities that are used to accelerate SI's are extended to uniaxial anisotropic media. When lossy media are considered, the effective distance from the source to the observation point becomes a complex number depending on the anisotropic ratio of horizontal to vertical media parameters. The half-line source potential is also generalized to the complex domain through analytic continuation. In order to evaluate the generalized half-line source potential, the exponential integral representation and numerical integration approaches are extended to the complex domain.

The asymptotic extraction process described above is applied to the mixed-potential Green's function components for uniaxially anisotropic media (K. A. Michalski and J. R. Mosig, IEEE Trans. Antennas Propag., pp. 508-518, March 1997). The dyadic Green's functions relating dipole sources directly to the electromagnetic fields are also discussed.