Efficient Computation of Green's Functions for One-Dimensional Periodic Structures in Layered Media

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The development of computationally efficient Green's functions in layered-media environments is important when applying the method of moments (MoM) using the mixed-potential integral equation (MPIE) formulation (K. A. Michalski and D. Zheng, IEEE Trans. Antennas Propag., vol. 38, pp. 335–344, Mar. 1990). However, their computation poses difficulties in terms of accuracy and computation time due to the presence of slowly converging integrals and/or series. Extensive work has been carried out to accelerate the Green's function computation for the case of a single dipole source in a layered media. Considerably less effort has been devoted to accelerate the Green's functions due to a one-dimensional (1-D) periodic arrangement of dipole sources. These are required to study 1-D periodic structures in layered media, including scattering structures and guiding structures such as leaky-wave antennas (LWAs) made from layered media.

When a 1-D periodic structure in a layered medium is planar so that the currents are horizontal, commonly used asymptotic extractions require the computation of homogeneous-medium periodic Green's functions for a 1-D array of horizontal dipoles. These Green's functions can be computed efficiently using well-known methods such as the Ewald summation method (F. T. Celepcikay, F. Capolino, D. R. Jackson, and D. R. Wilton, Radio Sci., vol. 43, 2008). On the other hand, if the structure contains vertical current elements, the extracted terms no longer correspond to an array of dipoles in a homogenous medium. Hence, new acceleration techniques are needed.

We focus here on the acceleration of Green's functions arising from vertical currents in a multilayered medium, using extractions of asymptotic terms. These extracted terms physically correspond to the potentials due to a 1-D periodic array of semi-infinite "half-line" currents. The efficient computation of the potentials due to these half-line currents is addressed through a modified Ewald method. Numerical results demonstrate the accuracy and enhanced convergence of the proposed acceleration scheme. The Green's function computation is implemented in a MoM code and applied to the study of the dispersion properties of 1-D periodic LWAs, providing a very good agreement with commercial software with a noticeable enhancement of computational efficiency.