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Transient interactions between tiny interfacial antennas on half-space lossless dielectric

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Abstract. The interfacial electric-field interaction subdivides into four cases: the HH, VV, HV, and VH cases. For each case, we derive the impulse-response solution of the interfacial electric field generated by an infinitesimal impulse current source at the same interface, using plane-time Fourier transform and a variant scheme of the Cagniard-de-Hoop method. We show that it is possible to obtain exact explicit-form solutions for the HH and VV cases, whereas we have to evaluate the electric fields only by numerical calculations for the HV and VH cases since the exact solutions are yet unavailable. Various aspects of the impulse-response solutions, such as the impulse radiation characteristics and the transient responses to time-Gaussian inputs, are investigated as well as the offset-differentiated field characteristics for the HV and VH cases. We also discuss the effect of the lower-medium loss on the transient waveforms and the effect of the interface that makes the interfacial interaction quite different from the interaction in free space.

1. Introduction

The analyses of transient fields in a planar-layered structure excited by an infinitesimal impulse source have been performed in several fields of science such as geology, seismology, and acoustics, as well as electromagnetics, through the methods like the wavenumber/frequency synthesis (or plane-time Fourier transform) technique, the Cagniard-de-Hoop method, and others based on the finite difference scheme or the Lanczos algorithm, and so forth [*Chew*, 1990; *Dai and Young*, 1997; *Ezzeddine et al.*, 1981; *Felsen*, 1976; *Frisk*, 1994; *Graff*, 1975; *Remis and van den Berg*, 1997; *Tygel and Hubral*, 1987]. Among these methods, the wavenumber/frequency synthesis technique stands as the most simple and classical method, since there always exists an explicit-form Green's function for a wavefield in the wavenumber/frequency domain (i.e., in the plane-time Fourier transform domain), and the only work to do is to perform three inverse Fourier transform integrations composed of two integrals of the plane transform (which can be reduced to one Hankel transform integral) and one integral of the time transform. The guided-wave poles of the Green's function can be handled properly by some contour deformation of the synthesis integration. For a multilayer problem in which the source or receiver antenna is located far from any interfaces, the electromagnetic fields can be evaluated most feasibly and rapidly by this synthesis method.

If, however, the offsets of the source and the receiver from an interface are small, then the synthesis of the space domain Green's function from the function in the wavenumber domain by numerical Hankel transform is very time-consuming, since the transform integral requires an extremely wide wavenumber bandwidth. In addition, the numerical inverse time transform requires a long computation time if the frequency bandwidth of the source is very wide, as for a short-duration pulse.

In this case, the Cagniard-de-Hoop method serves as a good alternative provided that the mediums are lossless. Although this method has its root in the wavenumber/frequency synthesis technique, the numerical calculations are performed in the plane-time domain, thus being invulnerable to such effects as the Gibbs phenomenon inherent in the synthesis technique (which makes undiminishable ripples

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