Approximate Transient Field of Horizontal Electric Dipole on the Boundary Between a Homogeneous Isotropic Medium and One-Dimensionally Anisotropic Medium

Approximate solutions are carried out for the transient field of a horizontal electric dipole with a delta function excitation and Gaussian excitation located on the planar boundary between a homogeneous isotropic medium and one-dimensionally anisotropic medium. The derivations and analysis show that the components of the electric field consist of two delta function lateral pulses which decrease with the amplitude factor $1/\rho^2$ and travel along the boundary with different velocities and different amplitudes. With the Gaussian excitation, the final formulas of the transient field are expressed in terms of several fundamental functions. In particular, the Fresnel-integral terms in those formulas do not completely cancel for the electric field components.

9.1 Statements of Problem

The approximate transient field and its applications due to a dipole with delta function excitation and Gaussian excitation have been examined analytically (King, 1988; 1989; 1990). In this chapter, further investigation will be extended to the anisotropic uniaxially case.

Consider a $\hat{x}$-directed horizontal electric dipole as shown in Fig. 9.1 at $(0, 0, d)$ in the upper half-space (Region 1, $z \geq 0$) with a homogeneous isotropic medium. Region 2 ($z \leq 0$) is the remaining half-space with a one-dimensionally anisotropic medium characterized by a permittivity tensor of the form

$$
\hat{\varepsilon}_2 = \varepsilon_0 \begin{bmatrix}
\varepsilon_T & 0 & 0 \\
0 & \varepsilon_T & 0 \\
0 & 0 & \varepsilon_L
\end{bmatrix}.
$$

(9.1)

It is assumed that both regions are nonmagnetic so that $\mu_1 = \mu_2 = \mu_0$. The wave numbers of the two regions are

$$
k_1 = \omega \sqrt{\mu_0 \varepsilon_0 \varepsilon_1} = \frac{\omega \sqrt{\varepsilon_1}}{c},
$$

(9.2)
Approximate Transient Field of Horizontal Dipole on the Boundary

When the conditions

\[ |k_1| \geq 3|k_L|; \quad |k_1| \geq 3|k_T|, \]

are satisfied, the approximate formulas are obtained for the frequency-domain electromagnetic field generated by a horizontal electric dipole on or near the planar boundary between a homogeneous isotropic medium and one-dimensionally anisotropic medium in the 1985 Pan’s paper (Pan, 1985). By using Fourier’s transform techniques, the corresponding formulas for the transient electromagnetic pulse with delta function excitation and Gaussian excitation are derived readily (Li and Lu, 2005; Xu, Li, and Ren, 2007).

9.2 The Approximate Transient Field with Delta Function Excitation

In the mid 1980’s, the formulas were evaluated analytically for the frequency-domain field components generated by a horizontal electric dipole near the boundary between a homogeneous isotropic medium and one-dimensionally anisotropic medium (Pan, 1985). These approximate formulas for the three electric field components are rewritten in the following forms: