Far Field Characteristics of an Arbitrarily Oriented Electric Dipole Located above Layered Anisotropic Half Space

Cao Le(1), Wei Bing(1),He Qiong(2), Ge De-biao(1)
(1) School of Science, Xidian University, Xi'an, China
(2) National Supercomputing Center, Shenzhen, China
xidian_caole@163.com

In the early 20th century, the analytical result of the vertical and horizontal dipole above the half space is deduced by Sommerfeld. The EM waves radiated by the electric dipole above the half space consist of four parts: (1) directed wave, (2) reflected wave, (3) lateral wave and (4) surface wave. Research results show that that the main radiation far field of the electric dipole above the layered half space is the directed wave and reflected wave. In this paper, based on the reciprocity theorem, the far field formulation in the frequency domain of an arbitrarily oriented electric dipole located above the interface of the anisotropic medium half space is deduced.

Suppose an arbitrarily oriented electric dipole is located above the half space with a distance of h as it shown in Fig.1. The observed point is located at (θ,φ), and the electric dipole is located at (θ_0,φ_0). To obtain the far radiation field of E_φ and E_θ, the electric dipoles $\hat{\boldsymbol{\varphi}} I_{\varphi b} l_{\varphi b}$ and $\hat{\boldsymbol{\theta}} I_{\theta b} l_{\theta b}$ are put at the observation point P along the $\hat{\boldsymbol{\varphi}}$ and the $\hat{\boldsymbol{\theta}}$ direction, respectively. By using the reciprocity theorem, we have

$$E_\varphi(P) = \sin\theta_0 \sin(\varphi_0-\varphi)\left[1+R^{\mathrm{TE}} \mathrm{e}^{\mathrm{i}k\Delta}\right]\mathrm{i}\omega\mu Il \mathrm{e}^{\mathrm{i}kr}/4\pi r$$

$$E_\theta(P) = \frac{\mathrm{i}\omega\mu Il \mathrm{e}^{\mathrm{i}kr}}{4\pi r}\left[\left(1-R^{\mathrm{TM}}\right)\sin\theta_0\cos\theta\cos(\varphi_0-\varphi)-\left(1+R^{\mathrm{TM}}\right)\cos\theta_0\sin\theta\right]$$

where R^{TE} and R^{TM} are the reflection coefficients of TE wave and TM wave, Δ is the optical path difference of the directed wave and reflected wave
$(\Delta = h(1+\cos 2\theta)/\cos\theta)$.

The reflection coefficient R^{TE} and R^{TM} of the layered anisotropic half space is computed by the General Transmission Matrix (GTM) methods which is given by Zheng and Ge. Then the characteristics of the radiation field of an arbitrarily oriented electric dipole over layer anisotropic half space is discussed.

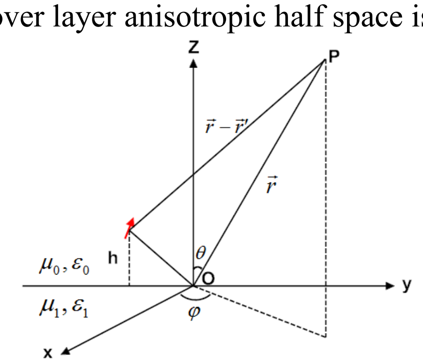

Fig1 An arbitrarily oriented electric dipole