A Simple Method to Calculate the Far-field Radiation of Hertzian Dipoles in a Multi-layered Dielectric Slab

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The radiation from electric or magnetic current sources with the presence of a multi-layered dielectric slab is a practical EM problem that interested scientists and engineers for long. Traditionally, a specific Green's function is derived for the multi-layered structure, to solve such problems. If only the far-field radiation from a horizontally polarized electric current source is of interest, Transmission Line method has been reported as an alternate and easy-to-master tool in stead of the Green's function. This paper generalize this method, to make it valid for arbitrarily polarized electric or magnetic Hertzian dipoles. The radiation problem is firstly transformed into an equivalent scattering problem with reciprocity theorem. Therefore, the far-field radiation can be obtained by evaluating the $\vec{E}$ or $\vec{H}$ at the same location and with the same polarization of the source current, due to a plane wave impinging on the dielectric slab. The multi-layered slab can be modeled as cascaded Transmission Line with different characteristic impedance that depends on both the dielectric material and the elevation angle of the incident plane wave. The horizontal fields ($\vec{E}_h$, $\vec{H}_h$) in the multi-layered structure can be obtained directly by evaluating V and I in the Transmission Line model. They can be further decomposed into forward ($\vec{E}_h^+$, $\vec{H}_h^+$) and backward ($\vec{E}_h^-$, $\vec{H}_h^-$) waves by calculating (V^+, I^+) and (V^-, I^-), respectively. The vertical electric fields $\vec{E}_v^+$ and $\vec{E}_v^-$ can be obtained with the values of $\vec{E}_h^+$ and $\vec{E}_h^-$, respectively, based on the fact that the vector summation of $\vec{E}_h^+$ and $\vec{E}_v^+$ is perpendicular to the propagation direction of the forward wave, and that of $\vec{E}_h^-$ and $\vec{E}_v^-$ is perpendicular to the direction of backward wave. Similarly, the $\vec{H}_v^+$ and $\vec{H}_v^-$ can be calculated. The Transmission Line method is implemented to obtain the far-field radiation, and the results are verified by the Green's function for multi-layered structure.