Dyadic Green's Functions for a Parallel Plate Waveguide Filled with Uniaxial Media

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The total dyadic Green's functions for magnetic and electric currents immersed in a parallel plate waveguide (PPWG) structure filled with dielectric-magnetic anisotropic uniaxial media are developed via a field-based approach. First, we derive the principal Green's function for the currents immersed in an unbounded uniaxial media. Then, the scattered Green's function is developed. Finally, the total Green's function is found by superposition of the principal and scattered solutions and subsequent application of the appropriate boundary conditions. The PPWG boundaries are assumed to be perfect electric conductors (PEC). The Green's functions are derived directly from Maxwell's equations, using a spectral domain analysis. The analysis reveals several key physical insights. First, we observe the expected longitudinal depolarization dyads. The depolarizing terms arise from the application of complex-plane analysis principles which allow us to carefully handle the source point singularity, ensuring the expressions are valid in all regions under consideration. Secondly, we note the identification and decomposition of the total Green's function into TE^z and TM^z field contributions. Thirdly, we are able to make some general observations on the overall physical mathematical form of the principal and total Green's functions, which are expected from Maxwell's equations.

The primary contribution of this paper is the detailed development, directly from Maxwell's equations, of the total Green's functions for a parallel plate waveguide containing a dielectric and magnetic uniaxial medium. Prior derivations only considered dielectric uniaxial media in a parallel-plate waveguide, due to the relative ease of analysis and readily available inverse identities (H.C. Chen, *Theory of Electromagnetic Waves: A Coordinate Free-Approach*, McGraw-Hill, 1983, pp 19-23). Inclusion of magnetic uniaxial media adds considerable mathematical effort (since no simplifying identities are available for this form of Maxwell's equations) and provides additional insight into the modal behavior, thus representing a significant contribution to the electromagnetic analysis of complex media. Finally, practical applications of the Green's functions are considered, such as the non-destructive electromagnetic characterization of a variety of anisotropic uniaxial media.