Discrete Complex Spectrum of 3D Open Omega Waveguides

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Unconventional complex media have new interesting electromagnetic properties that suggest its application in the design of devices and components for microwave and millimeter wave frequencies. The omega medium is obtained by doping a host isotropic medium with omega-shaped conducting microstructures, where the electric and magnetic fields induce both electric and magnetic polarizations perpendicular to each other.

The analysis of planar omega waveguides has been a topic of research in the past (N. Engheta, *Proc. Asia-Pacific Microwave Conference*, 99-111, Yokohama, 1998; A. L. Topa, C. R. Paiva, and A. M. Barbosa, *Progress In Electromagnetic Research*, **18**, EMW Publishing, 85-104, 1998). Emphasis has been put on the analysis of discrete real and complex modes on 2D structures (A. L. Topa, C. R. Paiva, and A. M. Barbosa, *Recent Advances in Electromagnetics of Complex Materials and Metamaterials*, Kluwer, 2003).

The present paper deals with the analysis of 3D omega waveguides. The analysis of 3D omega waveguides requires the characterization of step discontinuities. This problem was analyzed by the present authors using an approximate method, where a limited number of surface modes has been assumed to propagate in each region, coupling to each other at the step sides (A. L. Topa, C. R. Paiva, and A. M. Barbosa, *Proc. PIERS*, 95, Cambridge, 2000).

In this paper we extend the method of Peng and Oliner (S.-T. Peng and A. A. Oliner, *IEEE Trans. Microwave Theory Tech*., **MTT-29**, 843-855, 1981), which has been used for common dielectric waveguides, to omega waveguides, following the procedure of discretizing the continuous spectrum with a perfect conducting wall placed far above the waveguide. Two types of discrete modes are considered in the uniform planar regions: surface and higher order non-surface waves (some propagating and the remainder nonpropagating). To derive the modal equation of the hybrid modes propagating in the waveguide, the transverse resonance method was applied.

The numerical results show the effect of the inclusion of the omega particles in the propagation constant of the first leaky wave modes. Curves for the phase and leakage constants, as a function of the strip width, are presented for several values of the media parameters.