Diffraction by a Semi-Infinite Parallel-Plate Waveguide with Five Different Material Loading

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The analysis of electromagnetic scattering by open-ended metallic waveguide cavities is important in the prediction and reduction of the radar cross section (RCS) of a target. Various diffraction problems involving two- and three-dimensional (2-D and 3-D) cavities have been analyzed thus far based on high-frequency techniques and numerical methods. However, the solutions obtained by these methods may not be uniformly valid for arbitrary dimensions of the cavities. In this paper, we shall consider a semi-infinite parallel-plate waveguide with five different material loading as a geometry that can form cavities, and analyze rigorously the plane wave diffraction for E polarizations by means of the Wiener-Hopf technique [1]

The geometry of the waveguide is shown in Figure 1, where the waveguide plates are perfectly conducting and of zero thickness, and ε_{rm} and μ_{rm} (m=1,2,3,4,5) are the relative permittivity and permeability of five different materials inside the waveguide, respectively. In the figure, ϕ^i denotes the incident field of E polarization. We define the total field by $\phi^t = \phi^i + \phi$ where ϕ is the unknown scattered field satisfying the 2-D Helmholtz equation. Taking the Fourier transform of the unknown scattered field and applying the boundary conditions in the transform domain, the problem can be reduced to the simultaneous Wiener-Hopf equations satisfied by the unknown spectral functions. The Wiener-Hopf equations are solved via the factorization and decomposition procedure leading to an exact solution. However, the solution is formal since an infinite number of unknowns are involved. By using the modified residual calculus technique [2] together with the edge conditions, a highly accurate, approximate solution is obtained. By taking the inverse Fourier transform of the solution in the complex domain, the scattered field in real space is derived. In particular, the field inside the waveguide is expressed in terms of the TE modes depending on the incident polarization, whereas the field outside the waveguide is evaluated asymptotically using the saddle point method. Numerical examples of the RCS are presented for various physical parameters and the far field scattering characteristics of the waveguide are discussed in detail. The results presented in this paper can be used as a reference solution for validating more general analysis methods.

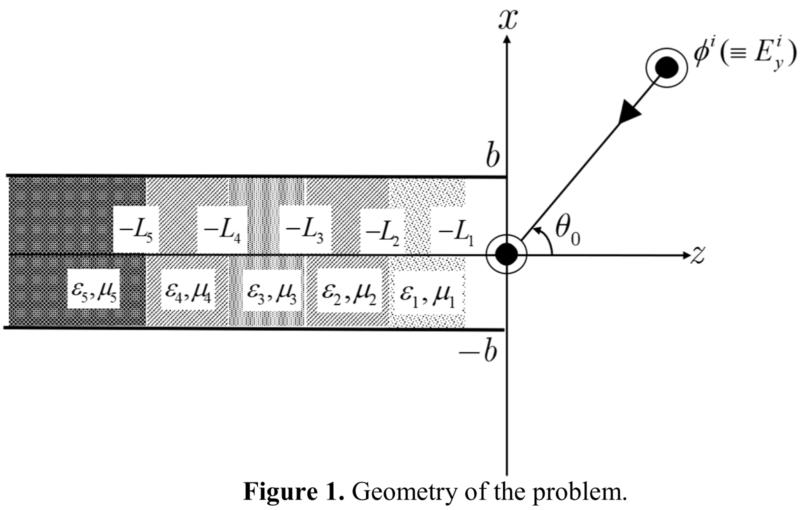

Figure 1. Geometry of the problem.

References

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