# Diffraction by a Semi-infinite Parallel-plate Waveguide with Five Different Material Loading

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The investigation of electromagnetic scattering by open-ended metallic waveguide cavities holds significant importance in predicting and mitigating the radar cross section (RCS) of a target. Numerous diffraction scenarios involving two- and three-dimensional (2-D and 3-D) cavities have been scrutinized using high-frequency techniques and numerical methods. However, the solutions derived from these approaches may lack uniform validity across arbitrary dimensions of the cavities. In this paper, our focus is on examining a semi-infinite parallel-plate waveguide with five distinct material loadings, serving as a cavity-forming geometry. We rigorously analyze plane wave diffraction for both E- and H-polarizations using the Wiener-Hopf technique [1].

The geometry of the waveguide is illustrated in Figure 1, featuring perfectly conducting plates with zero thickness. The materials within the waveguide are characterized by their respective relative permittivity $\varepsilon$ and permeability $\mu$, denoted as $\varepsilon_m$ and $\mu_m$, where $m$ ranges from 1 to 5. In the figure 1, $\phi^i$ represents the incident field. We define the total field as $\phi^t = \phi^i + \phi$, where $\phi$ is the unknown scattered field that satisfies the 2-D Helmholtz equation. The Fourier transform of the unknown scattering field is introduced, and the problem is formulated through simultaneous Wiener-Hopf equations, employing the boundary conditions in the transform domain. These equations are precisely solved using a factorization and decomposition procedure, yielding both exact and approximate solutions. The scattered field in real space is derived by performing the Fourier inverse of the solution in the transform domain. Within the waveguide, the scattered field is represented by the TE and TM modes. Beyond the waveguide, the field is asymptotically evaluated using the saddle-point method to obtain a far-field expression.

This paper provides numerical examples of Radar Cross Section (RCS) under various physical parameters for both E-polarization and H-polarization. The far-field scattering characteristics of waveguides for E-polarization and H-polarization are thoroughly discussed and compared. The results presented here serve as a reference solution for validating more general analysis methods. Main results of this paper are published in our previous paper [2,3].

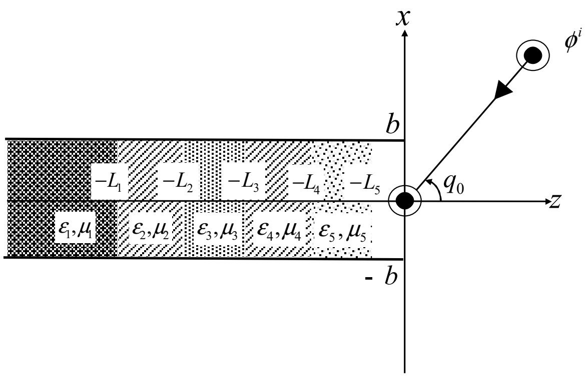


Figure 1. Geometry of the problem.

1. V. G. Danile and R. S. Zich, *The Wiener-Hopf Method in Electromagnetic,* Scitech Publishing, 2014
2. K. He and K. Kobayashi, "Diffraction by a Semi-Infinite Parallel-Plate Waveguide with Five-Layer Material Loading: Rigorous Wiener-Hopf Analysis" *Prog. Electromagn. Res. B*. **98**, Feb 2023 pp. 125–145.
3. K. He and K. Kobayashi, "Diffraction by a Semi-Infinite Parallel-Plate Waveguide with Five-Layer Material Loading: The Case of H-Polarization," *Applied Sciences*, **13**, no. 6, Mar 2023, pp. 3715.