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E-polarized Plane Wave Diffraction by a Finite Parallel-Plate Waveguide Cavity with Perfect Electric Conductor Loading

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In radar-based target identification, electromagnetic diffraction and scattering by open-ended waveguide cavities remain a fundamental research focus. Previous studies have extensively investigated radar cross-section (RCS) characteristics of both two- and three-dimensional cavities through high-frequency ray techniques and numerical methods. Nevertheless, these approaches often yield solutions that lack uniform validity across the entire spectrum of cavity dimensions. The Wiener-Hopf technique has emerged as a powerful analytical method, providing rigorous solutions that maintain validity for arbitrary target dimensions. Our previous research examined the electromagnetic scattering from a semi-infinite parallel-plate waveguide with partial material loading [1]. The present study extends this analysis by investigating E-polarized plane wave diffraction from a finite parallel-plate waveguide cavity with perfect electric conductor loading. We employ the Wiener-Hopf method to derive a rigorous solution for this cavity-like geometry.

The waveguide geometry, illustrated in Figure 1, consists of perfectly conducting plates that are infinitely thin and uniform along the y-direction. In the figure, f^i is the incident field of E polarization, and PEC is loaded in the region $D_2 < z < D_1$. The analytical solution procedure begins by applying a Fourier transform to the unknown scattered field. Through the implementation of boundary conditions in the transform domain, the problem is reformulated into simultaneous Wiener-Hopf equations governed by unknown spectral functions. These equations are subsequently solved through the factorization and decomposition procedure, yielding an exact solution. The resulting solution, while mathematically complete, remains in a formal state due to its dependence on an infinite set of unknowns. To address this limitation, we develop approximate methodologies for determining these unknowns. The scattered field in real space is then obtained through an inverse Fourier transform of the transform-domain solution. Notably, the field distribution inside the waveguide is characterized in terms of TE modes, while the external field is evaluated asymptotically using the saddle point method. In Figure. 2, we present the RCS oscillation curves at four different frequencies. The blue line corresponds to $kb = 1.57$, the orange line represents $kb = 3.14$, the green line represents $kb = 15.7$, the purple line represents $kb = 31.4$. Finally, numerical examples of the bistatic RCS will be presented for various physical parameters and backscattering characteristics of the waveguide will be discussed. Main results of this paper are published in our paper [2].

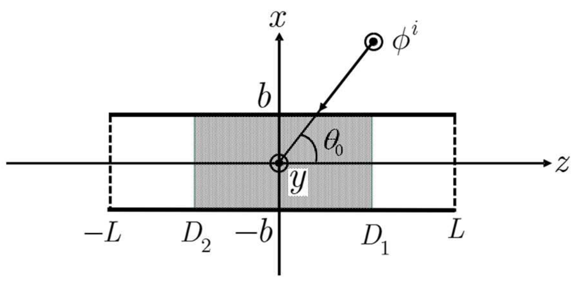

Figure 1. Geometry of the waveguide.

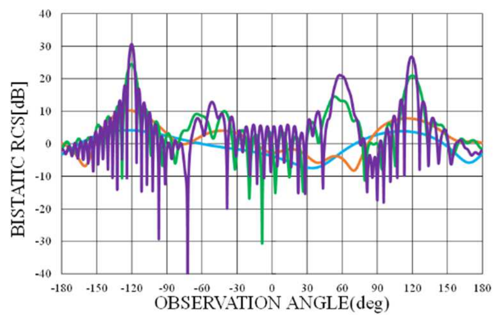

Figure 2. RCS of $L/b = 1.0$, $D_2 = -0.5L$, $D_1 = 0.5L$.

1. T. Zhang, and K. Kobayashi, “Diffraction by a Semi-Infinite Parallel-Plate Waveguide with Partial Material Loading: A Combined Wiener-Hopf and MRCT Solution,” *IEICE Trans. Electron*, **E108-C**, 5, May 2025, doi:10.1587/transele.2024ECP5041. (in press)
2. T. Zhang, and K. Kobayashi, “Diffraction by a Finite Parallel-Plate Waveguide Cavity with Perfect Electric Conductor Loading: The Case of E Polarization,” *IET Microw. Antennas Propag*, **19**, 1, January 2015, doi: 10.1049/mia2.70002. (in press)