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Plane Wave Diffraction by a Perfectly Conducting Rectangular Cylinder: Rigorous Solution by the Wiener-Hopf Technique

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Research on rigorous full-wave solutions to electromagnetic wave diffraction by canonical structures has been a central research topic in electromagnetic field theory for decades. Among the rigorous analytical techniques used in solving boundary value problems, the Wiener-Hopf technique [1] offers a mathematically exact and rigorous framework. While previous investigations have offered substantial insights into the scattering behavior of such cylinders via high-frequency and numerical methods, the resulting solutions are often not uniformly valid for cylinders with arbitrary dimensions. In this work, we present a rigorous RCS analysis of the diffraction of an H-polarized plane wave by a perfectly conducting rectangular cylinder using the Wiener-Hopf technique [1]. Main results in this paper are published elsewhere [2].

The geometry of the problem is depicted in Figure 1. By introducing the Fourier transform for the scattered field and enforcing boundary conditions in the transform domain, the problem is cast into a system of simultaneous Wiener-Hopf equations, which can be formally solved via factorization and decomposition. However, it should be noted that the resulting formal solution contains branch-cut integrals with unknown integrands as well as infinite series with unknown coefficients. To address this issue, rigorous asymptotic analysis, facilitated by the edge condition, is employed to derive approximate expressions for the branch-cut integrals and the infinite series, thereby leading to an efficient approximate solution of the Wiener-Hopf equations. Subsequently, the scattered field in real space is obtained by taking the inverse Fourier transform of the solution in the transform domain and applying the saddle-point method. Finally, illustrative numerical results are presented, as shown in Figure 2, to demonstrate the validity and effectiveness of the proposed approach. Furthermore, for a perfectly conducting rectangular cylinder of the same dimensions, the proposed method requires fewer unknowns compared to numerical methods such as the method of moments, thereby exhibiting superior convergence.

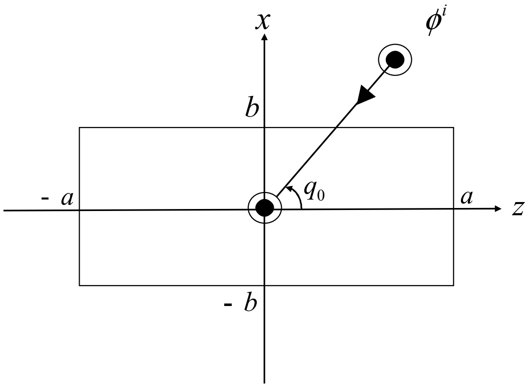

Figure 1. Geometry of the problem.

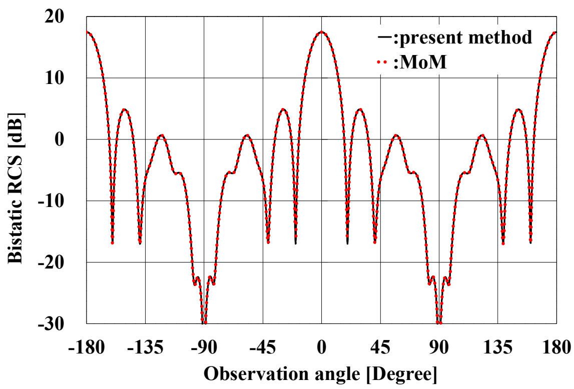

Figure 2. Comparison of Bistatic RCS for a square cylinder, $\theta_0 = 0^\circ$, $2a$=$2b$=3λ, with The Method of Moments (MoM). [3]

1. V. G. Danile and R. S. Zich, The Wiener-Hopf Method in Electromagnetics, Scitech Publishing, 2014.

2. K. W. He, K. Kobayashi, "Wiener-Hopf Analysis of the Plane Wave Diffraction by a Perfectly Conducting Rectangular Cylinder: The Case of H Polarization", IEICE Trans. Electron., vol. E108-C, No.5, May 2025. doi:10.1587/transele.2024ECP5036. (in press)

3. J. M. Jin, Theory and Computation of Electromagnetic Fields, John Wiley & Sons, New York, USA, 2015.