Electromagnetic Diffraction by an Impedance Cylinder Buried Halfway between Two Half-Spaces

***Mohamed A. Salem*[1], and Aladin H. Kamel[2]**

[1]Division of Physical Sciences and Engineering
King Abdullah University of Science and Technology (KAUST)
4700 KAUST, Thuwal 23955-6900, Kingdom of Saudi Arabia
e-mail: mohamed.salem02@kaust.edu.sa

[2]Advanced Industrial, Technological and Engineering Center
PO Box 433, Heliopolis Center, 11757 Cairo, Egypt
e-mail: ahk_75@yahoo.com

Abstract

We consider the problem of electromagnetic diffraction from a cylinder with impedance surface and half-buried between two dielectric media. An arbitrary located electric dipole provides the excitation. The harmonic solution is presented as a series sum over a spectrum of a discrete-index Hankel transform, and the spectral amplitudes are determined by solving an infinite linear system of equations, which is constructed by applying the orthogonality relation of the 1D Green's function.

1. Introduction

To investigate the features of various media by means of electromagnetic radiation it is necessary to know the field scattered by inhomogeneities of these media. This problem can be tackled by using as a basis a rigorous solution of a basic structure. One of the basic structures is the one considered in this letter. The problem under consideration has also acquired practical relevance in fields of optical engineering such as the study of contaminated surfaces and the detection of defects. Additionally the solution of canonical problems such as the one under consideration is important in the sense of scattering and diffraction theories.

The aim of this work is to present solutions, in terms of a discrete index of Hankel function transform, to the problem of the scattering of electromagnetic waves by a circular impedance cylinder immersed halfway between two half spaces of different electromagnetic properties. Other configurations of cylinder and two half spaces have been dealt with before in [1, 2] using Fourier series expansions on the angular variable and in [3] using integral equations methods, but the one discussed in this work, to the best of the authors knowledge, has not been addressed before.

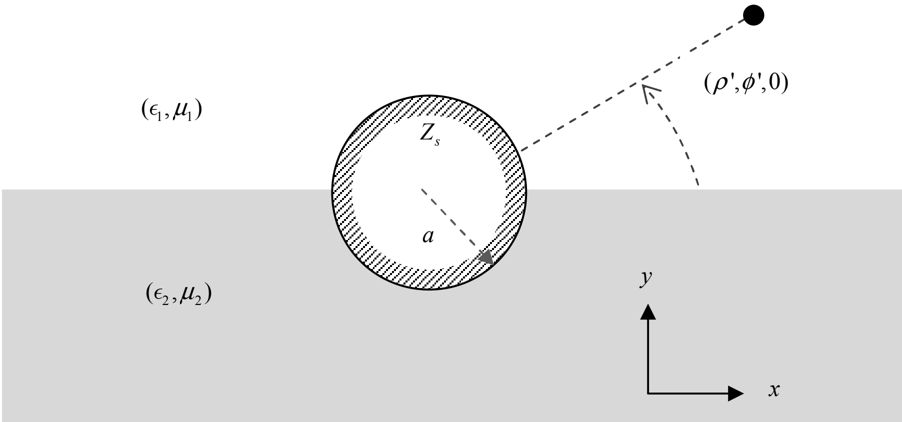

Figure 1 A schematic of the geometry of the problem.

978-1-4244-6051-9/11/$26.00 ©2011 IEEE

We look into the problem of diffraction by an impedance cylinder, of surface impedance Z_s, radius a; and located at the origin of the coordinate system, with half of which in medium one and the other half in medium two. The interface between the two media is along the x-axis. The axis of the cylinder is the z-axis of the coordinate system. The cylinder is infinite in the z-direction. k_1, ϵ_1, and μ_1 are respectively the wave number, permittivity, and permeability in medium one. k_2, ϵ_2 and μ_2 are corresponding quantities in medium two. An electric dipole current source in the z-direction located at $(\rho', \phi', 0)$ in cylindrical coordinates in medium one provides the excitation for the problem. We look for harmonic solutions that are proportional to $\exp(i[k_z z - \omega t])$. Figure 1 shows a schematic of the geometry of the problem.

The solution of the problem is formulated in terms of the discrete index Hankel transform. This results in an infinite linear system of equations in the unknown spectral amplitudes of the solution. We propose to solve the linear system by transforming into a reproducing kernel space [4], which guarantees the convergence of the truncated solution. Field expressions in the near field, far field and due to a plane wave excitation are given in series sum forms, which are to be understood in their asymptotic sense. The special cases of isovelocity media, and perfect electric conductor (PEC) and perfect magnetic conductor (PMC) cylinders are discussed separately.

2. References

1. T. C. Rao and R. Barakat, “Plane-wave scattering by a conducting cylinder partially buried in a ground plane. I. TM case,” *J. Opt. Soc. Am. A*, **6**, September 1989, pp. 1270-1280.

2. T. C. Rao and R. Barakat, “Plane-wave scattering by a conducting cylinder partially buried in a ground plane. II. TE case,” *J. Opt. Soc. Am. A*, **8**, December 1991, pp. 1986-1990.

3. J. M. Saiz, P. J. Valle, F. González, E. M. Ortiz, and F. Moreno. “Scattering by a metallic cylinder on a substrate: burying effect,” *Opt. Lett.*, **21**, September 1996, pp. 1330-1332.

4. L. Yingzhen, C. Minggen and Zh. Yi, “Representation of the exact solution for infinite system of linear equations,” *Appl. Math. Comput.*, **168**, September 2005, pp. 636-650.