Scattering by a Slotted Semielliptical Channel Containing DNG Metamaterial

***Daniele Monopoli*[(1)], *Danilo Erricolo*[(2)], *Piergiorgio L. E. Uslenghi*[(2)], *Riccardo E. Zich*[(1)]**

(1) Politecnico di Milano, Piazza Leonardo da Vinci 32, 20138 Milano, Italy
daniele.monopoli@polimi.it, riccardo.zich@polimi.it

(2) Dept. of ECE, University of Illinois at Chicago, 851 South Morgan Street, Chicago, IL 60607, USA
erricolo@ece.uic.edu, uslenghi@uic.edu

Abstract

A semielliptical channel flush-mounted under a metal plane and filled with a DNG metamaterial is considered. The incident field is either a plane wave propagating perpendicular to the channel axis, or a line source parallel to the axis. The problem is solved in terms of infinite series of elliptic-cylinder wavefunctions, whose modal expansion coefficients are evaluated by matrix truncation. Numerical results are provided and compared to those obtained for the same channel and source geometry when the channel contains an isorefractive medium.

1. Description of Research

The geometry analyzed in this work consists of a metallic channel, or trench, of semi-elliptical cross section slotted along the interfocal segment and flush-mounted under a metallic infinite plane. The channel is filled with a double-negative (DNG) metamaterial, whose electric permittivity and magnetic permeability are real and negative. Under these conditions, it has been proven by Ziolkowski and Heyman [1] that causality requires that the refractive index of the DNG material be negative, whereas the intrinsic impedance of the DNG material must be positive. The electromagnetic fields in the half-space above the trench and inside the channel are expressed in terms of infinite series of elliptic-cylinder wave functions, involving products of radial and angular Mathieu functions. The determination of the modal expansion coefficients requires the inversion of an infinite matrix. An approximate solution is obtained by truncating the matrix, i.e. by considering only a finite number of terms in the field expansions.

The primary fields are either a plane wave of arbitrary polarization propagating in a direction perpendicular to the axis of the channel, or an electric or magnetic line source parallel to the axis and located above the channel or inside it. In particular, numerical evaluations are performed for the currents at the metal surfaces and for the far fields in the half-space above the channel. Extensive numerical results are shown and compared to those obtained for the same geometry and sources in [2-3] when the channel is filled with a material isorefractive to the medium occupying the half-space above the channel.

The calculations are extended to the case when the DNG material fills only a portion of the channel, consisting of a diaphragm whose cross section is bounded by the interfocal segment and a semiellipse having the same foci of the channel and lying inside it. In particular, the influence of the diaphragm thickness on the radar cross section of the channel is studied.

2. References

1. R. W. Ziolkowski and E. Heyman, *Phys. Rev. E*, **64**, Oct. 2001, pp. 056625(1)-056625(15).

2. D. Erricolo, M. D. Lockard, C. M. Butler, and P. L. E. Uslenghi, *Progress in Electromagnetic Research*, **53**, 2005, pp. 69-89.

3. -------, *IEEE Trans. Antennas Propagat.*, **53**, June 2005, pp. 2350-2356.