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Frequency-dependent radiation properties of negative permittivity metamaterial reflector antenna

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Abstract

This paper reports a novel type of microwave reflector antenna that uses the frequency-dependent properties of an epsilon negative (ENG) metamaterial medium. The frequency-dependent characteristics of this artificial plasma medium is analyzed using the dispersive auxiliary differential equation finite difference time domain (ADE-FDTD) method by employing a Gaussian pulse and the results are verified experimentally using an artificial plasma medium fabricated by an array of thin conducting wires. The radiation pattern of plain and corner plasma reflector antennas modeled using Drude equations are obtained and are compared with a plasma reflector and conventional metallic reflector antennas. The results obtained for the plasma reflector antenna is experimentally verified using a 90° corner reflector antenna fabricated using wire medium. This new class of plasma antennas show marked variations in radiation pattern for frequencies above and below plasma frequency, which may find potential use in various frequency selective applications.

Keywords: negative permittivity, FDTD, dispersive medium, artificial plasma, reflector antenna, metamaterials

(Some figures may appear in colour only in the online journal)

1. Introduction

Metamaterials are artificially fabricated composites that exhibit unusual and unique electromagnetic properties due to negative values for permittivity, permeability and refractive index. This new class of materials was first proposed by Russian physicist Victor G. Veselago in 1968 [1]. In the beginning of this millennium, the proposed medium was realized in the form of a bulk medium by the periodic arrangement of structures having intrinsic negative values of permittivity and permeability. It was Pendry *et al* who, for the first time, realized both these negative permittivity and permeability materials using a periodic array of thin conducting wires and split ring resonators (SRRs) in 1996 and 1999 respectively [2, 3]. By combining both these structures in a specialized manner, the negative refractive index medium, also called the backward wave medium or left-handed medium (LHM), was actualized in the year 2000 by Smith and his colleagues for microwave frequencies [4]. Since the periodicity of the constituent metamolecules in the composite is very much less than the interacting wavelength, the medium exhibits homogeneous properties. Owing to their exotic characteristics such as the reversal of Snell's law, inverse Doppler effect, cloaking etc shown by this group of materials, immense research is going on in this field for a wide variety of applications for the support of the state of the art technology. Active research is taking place for realizing different variants of both single negative (SNG) and double negative (DNG) metamaterials for a wide variety of applications like

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