High-Directive Patch and Dipole Antennas using Biased Grounded Ferrite

A. Hassani Gangaraj, M. Tayarani, and A. Abdolali

Department of Electrical Engineering
Iran University of Science and Technology, Tehran, 1684613114, Iran
Ali.Gangaraj@gmail.com, m_tayarani@iust.ac.ir, abdolali@iust.ac.ir

Abstract — In this paper, a new perfect magnetic conductor (PMC) substrate for improving the directivity of patch and dipole antennas is introduced. We used biased grounded ferrite to construct this new substrate. The most important difference between this substrate and the other artificial magnetic conductor (AMC) structures is the homogeneity. A conventional electromagnetic AMC has a periodic nature and as a result it is not homogenous but this novel substrate is homogenous. The results show that the directivity of both the patch and the dipole antennas is improved surprisingly in the presence of this novel homogenous PMC substrate. The physical reasons for the improvements are also given. Moreover, at the last section, we have calculated the magnetic loss of this magnetic anisotropic substrate.

Index Terms — Biased-grounded ferrite, dipole antenna, directivity, Faraday rotation, magnetic loss, patch antenna.

I. INTRODUCTION

Gyrotropic and magnetic materials have brought a lot of advantageous such as antenna miniaturization or beam squint for antenna applications [1-3]. Biased ferrites or magnetic photonic crystals are some examples for these types of materials.

A perfect magnetic conductor (PMC) is a concept, dual to the perfect electric conductor (PEC), but the nature did not provide a PMC material due to lack of magnetic charges [4]. Too many attempts were made to design artificial PMCs using electromagnetic band-gap (EBG) structures [5-6]. Suppression of surface waves by a PMC surface results in higher efficiency, smoother radiation pattern, and less back lobe and side lobe levels in antenna applications particularly for microstrip antennas [7-9] like patch antenna.

A dipole antenna with low profile configuration is a main aim in wireless communications. In such a design, the overall height of the dipole antenna structure is usually less than one tenth of the operating wavelength [10]. Due to reverse image of antenna produced by a PEC ground plane the dipole antenna radiation efficiency encounters a dramatic reduction. [10]. To solve this problem, dipoles are located at a height of $0.25\lambda_{free\ space}$ or higher from the ground plane which is not practical for the wireless communication systems [10]. But in this paper we have reduced this height to $0.005\lambda_{free\ space}$.

Shahvarpour et al, in [11] has shown that the surface of a grounded biased ferrite can be used as a PMC surface. In this paper we have used this idea and asserted that a grounded biased ferrite can function as a new substrate for the patch antenna and as a new ground for the dipole antenna to solve the deficiencies of these antennas.

In Section II, we briefly explain the role of Faraday rotation in a grounded biased ferrite for creation of a PMC surface. In Section III, we explain the application of this PMC surface for increasing the directivity of patch antenna and furthermore, in Section IV, we use the property of grounded biased ferrite to increase the directivity of a dipole antenna and at last in Section V, we discus and calculate the magnetic loss of this magnetic anisotropic substrate.

II. GROUNDED BIASED FERRITE

A grounded ferrite is a ferrite which is backed with a PEC plane. As it is stated in [11], at the first, consider an electromagnetic wave with E and H directed along the $+y$ and $+z$ respectively as it

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