

RESEARCH PAPER

Neurospectral computation for the resonant characteristics of microstrip patch antenna printed on uniaxially anisotropic substrates

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Modeling and design of rectangular microstrip patch printed on isotropic or anisotropic substrate are accomplished in this paper. The use of spectral domain method in conjunction with artificial neural networks (ANNs) to compute the resonant characteristics of rectangular microstrip patch printed on isotropic or anisotropic substrates. The moment method implemented in the spectral domain offers good accurateness, but its computational cost is high owing to the evaluation of the slowly decaying integrals and the iterative nature of the solution process. The paper introduces the electromagnetic knowledge combined with ANN in the analysis of rectangular microstrip antenna on uniaxially anisotropic substrate to reduce the complexity of the spectral domain method and to minimize the CPU time necessary to obtain the numerical results. The numerical comparison between neurospectral and conventional moment methods shows significant improvements in time convergence and computational cost. Hence, the use of neurospectral approach presented here as a promising fast technique in the design of microstrip antennas.

Keywords: Microstrip antenna, Artificial neural networks, Modeling and design, Anisotropic substrate, Spectral domain analysis

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I. INTRODUCTION

The increase in complexity of device modeling has led to rapid growth in the computational modeling research arena. To accommodate computational complexity, several computer-aided design (CAD) modeling engines such as artificial neural networks (ANNs) were used [1, 2]. ANNs, emulators of biological neural networks, have emerged as intelligent and powerful tools and have been widely used in signal processing, pattern recognition, and several other applications [3]. ANN is a massively parallel and distributed system traditionally used to solve problems of nonlinear computing [4].

The microstrip antenna (MSA) is an excellent radiator for many applications such as mobile antenna, aircraft and ship antennas, remote sensing, missiles, and satellite communications [5]. It consists of radiating elements (patches) photo etched on the dielectric substrate. Microstrip antennas are low-profile conformal configurations. They are lightweight, simple and inexpensive, most suited for aerospace and mobile communication. Their low-power handling capability posits these antennas better in low-power transmission and receiving applications [6]. The flexibility of the MSA to

shape it in multiple ways, such as square, rectangular, circular, elliptical, triangular shapes, etc., is an added property.

Some dielectric substances exhibit anisotropy due to their natural crystal structures or as the result of their production processes [7]. Isotropic materials may also show anisotropy at high frequencies. In the design of microwave-integrated circuit components and microstrip patch antennas, anisotropic materials have been progressively popular. Especially the effects of uniaxial-type anisotropy have been investigated [7–11] due to the availability of this kind of materials such as Sapphire, Magnesium fluoride, and Epsilam-10. In these works, the physical parameters of the antenna are replaced with effective ones in order to line up the obtained theoretical results with the measured data. Although, the moment method provides better accuracy, but its computational cost is high due to the evaluation of the slowly decaying integrals and the iterative nature of the solution process. Even though all the losses can be directly included in the analysis, produced results may not provide satisfactory accuracy for all the cases [12]. Because of these problems, Mishra and Patnaik have introduced the use of neural networks in conjunction with spectral domain approach (SDA) to calculate the complex resonant frequency [13] and the input impedance of rectangular microstrip resonators [14], this approach is named the neurospectral method. In [13], the computational complexity involved in finding the complex root is reduced, whereas, in [14], the neural network method evaluates the integrals appearing in the matrix impedance. Later on Mishra and Patnaik [15] demonstrated the force of the neurospectral approach in patch antenna design using the reverse modeling

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