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RESEARCH PAPER

Neurospectral modeling of rectangular patch with rectangular aperture in the ground plane

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In this study, we propose an artificial neural network in conjunction with spectral domain approach (SDA), for fast and accurate determination of the resonant frequency and half-power bandwidth of rectangular patch over the ground plane with rectangular aperture. The performances evaluation of the neurospectral method reveals superiority over the conventional SDA model in terms of errors and time. The results obtained from the neurospectral method are in very good agreement with the experimental and theoretical results available in the literature. Finally, numerical results for the effect of rectangular aperture dimensions on the resonant characteristics of the rectangular patch are also investigated.

Keywords: Microstrip antenna, Artificial neural network, Design and modeling, Spectral domain

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I. INTRODUCTION

Microstrip patch antennas are used in the wide range of applications such as aircraft, satellite, missiles, and land vehicles and in small portable wireless communication equipment's due to their compactness, light weight, low-profile, and relative ease of fabrication method [1–3]. The main shortcomings of these antennas are narrow bandwidth and low gain. These shortcomings can be overcome in by proper design of an antenna, and especially using proper substrate thickness and dielectric constant as well as a proper way of feeding [4]. Various techniques have been proposed to improve the bandwidth operation of the microstrip elements, and the most common technique using feeding according element through an aperture cut in a microstrip line ground plane [5, 6]. Alternatively, aperture-coupling feeds are gaining popularity owing to a number of advantages, such as a greater bandwidth and efficiency, weak parasitic radiation in the useful direction with respect to conventionally feed antennas and optimal performance for both the feeding network and antenna element [5]. With the increasing complexity of geometry and material property, designing these antennas requires more and more dedicated and sophisticated computer-aided-design (CAD) tools to predict the characteristics [7]. Various methods and commercial software are available for analysis and synthesis of microstrip antennas. These commercial design packages use computer intensive numerical methods such as, finite-element method, method of moment (MoM), finite-difference time-domain method, etc. These techniques require high computational resources and also take lots of computation time [8]. In the present-day scenario, neural network models are used extensively for wireless communication engineering, which eliminate the complex and time-consuming mathematical procedure of designing, such as the MoMs [9]. The neural networks in conjunction with spectral domain approach (SDA) was firstly proposed by Mishra and Patnaik [10], to calculate the complex resonant frequency and the input impedance [11] of rectangular microstrip antenna, this approach is named neurospectral method [12]. This is the main reason for selecting the neurospectral to estimate the resonant frequency and half-power bandwidth of a rectangular microstrip patch over the ground plane with rectangular aperture. To the best of the author's knowledge, the artificial neural network (ANN) models for predicting the characteristics of microstrip patches over the ground plane with rectangular aperture have not been thoroughly reported in the open literature.

The objective of this work is to present an integrated approach based on ANNs and SDA. We introduce the ANNs in the analysis of a rectangular microstrip patch over a ground plane with rectangular aperture to reduce the complexity of the spectral approach and to minimize the central processing unit (CPU) time necessary to obtain the numerical results. The neurospectral model is simple, easy to apply, and very useful for antenna engineers to predict both resonant frequency and half-power bandwidth.

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II. THEORETICAL FORMULATION

The geometry of the considered structure is shown in Fig. 1. We have a rectangular microstrip patch of length L_p along