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Fuzzy neuroconformal analysis of multilayer elliptical cylindrical and asymmetrical coplanar striplines

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ABSTRACT

In this paper, accurate and compact analytic closed-form expressions are presented in order to calculate the quasi-static parameters of symmetric/asymmetric multilayer planar coplanar stripline (MACPS), multilayer cylindrical (MCCPS), and multilayer elliptical (MECPS) by using the conformal mapping technique (CMT). The general form of the developed expressions can take into account an arbitrarily number of dielectric layers above and/or below the strips' interface. Models based on artificial neural networks (ANNs) and fuzzy systems (FSs) are implemented where the CMT being the reference in training process. The ANNs and FSs are trained using the back-propagation algorithm together with Levenberg–Marquardt (LM) and Takagi–Sugeno–Kang (TSK) methods, respectively. By writing efficient Matlab® R13 coding for implementation of the ANNs and FSs and performing adequate sampling of the input variables, the size of the input training matrix reaches 10,000 by 14 which ensures high accuracy of the two models. The results of the ANNs and FSs trained with their respective algorithms for the quasi-static parameters of the MACPS, MCCPS, and MECPS are in very good agreement with the results available in the literature.

1. Introduction

In practice, there are many circumstances in which the substrates are multilayer. For example, in integrated circuits, connections lines are either on or buried between dielectric layers [1]. The quasi-static parameters of the CPS with a single and multilayer dielectric substrates have been analyzed using the CMT which is the transformation of a region defined in a complex plane to a distinct region in the reference plane of another complex variable [2,3]. The CMT has been applied to the analysis of antennas and microwave circuits. Lambert et al. [4] used the CMT to calculate the characteristic impedance of TEM horn antennas. In [5], the CMT is used to convert an open microstrip structure into an enclosed waveguide for which the FDTD technique is used to calculate the scattering coefficients of the discontinuous waveguide. Zhu et al. used the CMT to derive analytical expressions for field distributions in supported CPS [6]. The Green's functions for the corrugated periodic structures have been derived using the CMT [7]. Recently, the CMT is used to estimate the quasi-static parameters of coplanar waveguide (CPW) [8,9].

ANNs are information processing systems with their design inspired by the studies of the ability of the human brain to learn from observations and to generalize by abstraction. They can be trained to learn arbitrary nonlinear input–output relationships from corresponding data. Suntives et al. used ANNs to model both linear RF elements as well as nonlinear subcircuits such as amplifiers, mixers and VCOs [10]. Based on the multilayered perceptrons network, a generalized method for accurate determination of the resonant frequencies of microstrip antennas of regular geometries is presented in [11]. In [12], Guney and Sarikaya calculated the input resistance of the circular microstrip antennas using ANN approach. An approach based on ANNs is introduced to determine the characteristic parameters of CPW sandwiched between two dielectric substrates [13]. Pascual Garcia et al. presented a technique based on ANN for the design of microwave filters in shielded printed technology [14]. A method based on adaptive-network-based fuzzy inference system (ANFIS) is presented for the analysis of conductor-backed asymmetric CPWs, where four optimization algorithms are used to design the parameters of the ANFIS [15].

Also it is proven that fuzzy systems are capable of approximating any real continuous function on a compact set to arbitrary accuracy. In [16], a method based on FISs for calculating the resonant

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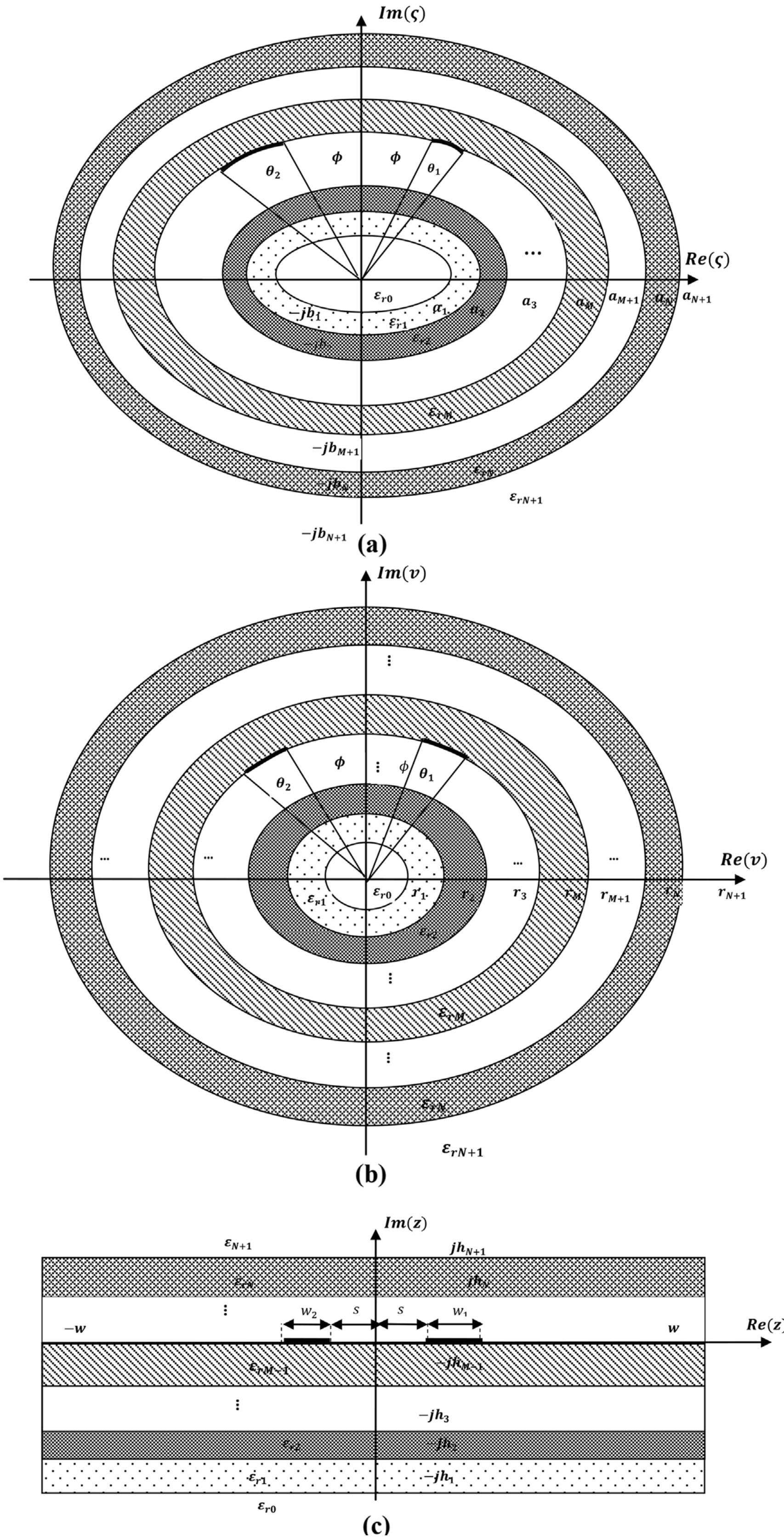

Fig. 1. Cross-section view of (a), MECPS, (b) MCCPS, (c) MACPS.