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Neurocomputational models for Parameter Estimation of Circular Microstrip Patch Antennas

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Abstract

Neurocomputational models eliminates the complex, lengthy and time consuming mathematical procedures for design, analysis and calculating performance parameters of Microstrip antenna. No single ANN based model has been proposed till date for calculating all parameters of circular microstrip antennas simultaneously. This paper presents a Neuro-Computational (NC) approach for estimation of all performance parameters such as Return Loss (RL), Voltage Standing Wave Ratio (VSWR), resonant frequency (f_r), Band-Width (BW), Gain(G), Directivity(D) and antenna efficiency(η) of Circular Microstrip Patch Antenna (CMPA) simultaneously. The difficulty in calculating the parameters of these antennas lies due to the involvement of a large number of physical parameters including their associated optimal values. It is indeed very difficult to formulate an exact numerical solution merely on practical observations based empirical studies. In order to circumvent this problem, an alternative solution is achieved using artificial neural network (ANN). Feed-Forward Back-Propagation Artificial Neural Network (FFBP-ANN) trained with Levenberg-Marquardt algorithm is used for estimation of different performance parameters of CMPA. The results of NC estimation are in very agreement with simulated, measured and theoretical results.

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Keywords: Gain; Neurocomputational Model; Antenna; Bandwidth; Frequency; Directivity

1. Introduction

In recent years, Microstrip Patch Antenna (MPA) has become important for antenna designer because of its advantage such as, simple configuration, low cost, ease of fabrication, mechanically strong and compatibility with

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integrated circuits [1].NC models are useful tool for microwave modeling and antenna design. Applications of ANNs in Microstrip antenna design and analysis are more than one decade old [2]. In area of microwave applications, ANNs have been design multi slot antenna [3] and CMPA [7], and analysis of circular [5-6], [4], elliptical [8] and multi-slot antenna [9]. Table1. Compares number of parameters of circular microstrip antenna estimated simultaneously using ANN more than one decade old. From Table1 It is clear that ANNs have been used for estimation of at most two parameters of CMPA simultaneously. No single NCM has been proposed till date for calculating all parameters of CMPA simultaneously. This paper suggests a feed-forward NCM for calculating all performance parameters (seven) return loss (RL), voltage standing wave ratio (VSWR), resonant frequency (f_r), bandwidth (BW), gain, directivity and antenna efficiency simultaneously. The section 2 describes the procedure to obtain a data dictionary for training and validation of NCM. Section 3 explains the development of NCM for performance parameter estimation of CMPA. Section 4 describes the result and the conclusion is presented in section 5 of this paper.

Table 1.Cpmerision of number of parameters of CMPA estimated simultaneously using ANN.

Paper no	Antenna Type	Parameter	Ann out-put
6	Circular	Resonant Frequency	Single
		Radius	Single
3	Multi-Slot Microstrip	Scattering Parameter	Single
8	elliptically	Resonant frequency and Return loss	Two
9	Multi-Slot Microstrip	Resonant frequencies	Two
7	Circular	Resonant frequency	Single
		radius	Single
5,6	Circular	Resonant frequency	Single

2. Data Dictionary

The first step in developing in NCM is collection of different parameter of CMPA. In microwave applications, there are two ways to produce the data for generating data dictionary for training and validation of NCM. These are simulations and experimentation. The selection of data producer depends on availability and application [10]. Simulation method has advantages over experimental method. In simulation method input parameter can be changed easily because in this only a mathematical change and does not involve modification in physical parameter. Experimental method has more error in producing data than simulation method due to tolerance of apparatus used in experiment [11]. In this paper IE3D software has been used for generating data dictionary. A set of forty three CMPA has been designed of which twenty eight antennas have used for training and remaining fifteen have been used for validation of NCM. Resonant frequency of CMPA can be calculated theoretically if parameter of CMPA such as radius of patch 'a', dielectric constant of substrate ε_r , and height of substrate (h) is known in advance. Effective radius of circular microstrip antenna can be calculated by using [1].Then by using [2] resonant frequency of antenna is calculated theoretically.

$$a_e = a\left\{1 + \frac{2h}{\pi a \varepsilon_r}\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{\frac{1}{2}} \tag{1}$$

$$f_r = \frac{1.8412 v_o}{2\pi a_e \sqrt{\varepsilon_r}} \tag{2}$$

Theoretically calculated results are then compared with results obtained using NCMs. Then a set of three CMPA are fabricated on different substrates Roger 5880, Roger 5870 and glass epoxy FR4for testing NCM.