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Artificial Neural Network Model for Suspended Rectangular Microstrip Antennas

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Abstract

The broadband microstrip antenna is more commonly realized by fabricating the patch on lower dielectric constant thicker substrate. While using thicker substrate, close form expressions for calculating edge extension length due to fringing fields is not available. In this paper, an artificial neural network model for suspended rectangular microstrip antenna is proposed. The resonance frequency calculated by using the proposed neural network model closely agrees with simulated and measured results over wide frequency range and for varying thicker substrates. Thus the proposed model can be used to accurately calculate the side length of rectangular microstrip antenna.

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1. Introduction

The broadband microstrip antenna (MSA) is realized by fabricating the patch on lower dielectric constant thicker substrate [1 – 3]. In most of the reported literature, the patch is suspended in air thereby realizing dielectric constant of unity. The radiating patch in MSA can take any arbitrary shapes but more commonly regular radiating patch geometries like rectangular, circular, equilateral triangular, elliptical and isosceles have

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been used. In most of these patch geometries, while designing them on thinner substrates ($h \leq 0.03\lambda_0$), resonance frequency formulation is available [1 – 3]. While calculating resonance frequency, effective patch dimensions is needed to be considered, this accounts for fringing field extension present towards patch periphery. Depending upon the operating mode, for calculating resonance frequency in rectangular MSA (RMSA), an edge extension length is added to patch length or width. The expressions for them are available for thinner substrates. However they are not available while using thicker substrates and at different resonance frequencies. Therefore for designing broadband MSAs on thicker substrate ($h > 0.06\lambda_0$) patch dimensions cannot be accurately calculated. The artificial neural network (ANN) model for RMSA is reported, but they do not calculate patch dimensions over wide range of frequencies and substrate thickness [4, 5].

In this paper, ANN model for predicting the resonance frequency of RMSA at its fundamental TM_{10} mode is proposed. The ANN model is proposed for varying substrate thickness and over wide frequency range from 500 to 6000 MHz. At all the frequencies, while predicting resonance frequency (patch length) using ANN model, substrate thickness for RMSA is taken to be less than 0.1 λ_0. Since in most of the reported broadband RMSA configurations, an air substrate is used (as it helps in realizing larger gain and bandwidth), the same is used while developing ANN model. In the proposed work, first using resonance frequency equation for RMSA, and further by simulating the same using IE3D software, an edge extension length for different substrate thickness and over wide frequency range is calculated [6]. Further, parameters like, substrate thickness, fringing field extension length, dielectric constant at different resonance frequencies is given as input to the neural network model. Using the developed neural network model, patch side length at different resonance frequencies and for different substrate thickness is predicted. For realizing optimum gain, patch width is taken to be 1.2 times the patch length. The RMSA for predicted dimensions is further simulated using IE3D software. It is observed that the simulated frequency shows closer agreement with the predicted neural network value. Further to verify the predicted and simulated results, measurements were carried out. They show closer agreement with simulated and measured result. Similar ANN model is developed for suspended RMSA in which radiating patch is fabricated on glass epoxy substrate ($\varepsilon_r = 4.3$, $h_e = 0.16$ cm, $\tan\delta = 0.02$) which is suspended above the ground plane with an air gap 'Δ'. The model for suspended RMSA also shows closer agreement between simulated, measured and predicted values. Thus the proposed model can be used to accurately calculate the patch dimension in RMSA for given substrate thickness and frequency.

2. SUSPENDED RMSA

The coaxially fed RMSA on air substrate of thickness 'h' is shown in Fig. 1(a, b). The dimensions shown in figures and their captions are in cm. For the desired resonance frequency, patch length 'L' is calculated by using resonance frequency equation for RMSA as given in equation (1) [1 – 3].

$$f_r = \frac{c}{2\sqrt{\varepsilon_{re}}}\sqrt{\left(\frac{m}{L_e}\right)+\left(\frac{n}{W_e}\right)} \tag{1}$$

Where, f_r = RMSA resonance frequency (in Hz)
$c = 3 \times 10^8$ (m/s), velocity of light in free space
L_e = effective patch length, W_e = effective patch width, they include an extension in patch dimensions due to fringing fields towards open circuit patch edges (in cm)
m and n: mode indices, m = 1 and n = 0 for TM_{10} mode
ε_{re} = effective dielectric constant = 1, for air substrate

$$W_e = 1.2\, L_e \tag{2}$$