Quad Staircase Shaped Microstrip Patch Antenna using ANN

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Abstract: As the size of communication devices is decreasing day by day, small size multiband antennas are in great demand for both commercial and military applications. This paper presents miniaturization by introducing staircase shape at each edge of the patch of Microstrip Patch Antenna. The Rogers RT/Duroid 5880 with relative permittivity 2.2 and height 1.6 mm is used as substrate material for design of proposed antenna. Artificial neural network based approach is used for calculating the resonating frequency of the antenna. The back propagation algorithm is used and the results obtained using artificial neural network is compared with the simulated results obtained by using IE3D software.

Keywords: Microstrip Antennas, Artificial Neural Networks, IE3D, Resonant frequency.

Introduction

Microstrip antennas are used in a wide range of mobile communication applications which demands multi band and/or wideband frequency operations, high power gain Omni directional radiations patterns etc. Therefore design of printed antennas to meet the requirements of multiple operational services becomes a difficult task. This warrants in the very high accuracy of the calculation of various design parameters of microstrip patch antennas [1]. Patch dimensions of a rectangular microstrip antenna is a vital parameter in deciding the performance and the utility of an antenna. In the present work, co-axial feeding is taken as a preferred method of feeding the input power to the antenna. The calculation of exact patch dimensions of microstrip patch antenna becomes extremely important where the antenna size is drastically small. In this paper, an attempt has been made to exploit the capability of artificial neural networks (ANN) to calculate the frequency of a quad staircase microstrip patch antenna. The results are in good agreement with the simulation findings. ANNhave recently gained attention as a fast and flexible vehicle to EM /Microwave modeling, simulations and optimization [5].

Staircase Patch Antenna

In this design, microstrip antenna is used due to its light weight, thin size and shape of the patch resembles the staircase shape hence the name “Staircase shaped patch antenna” is given. The advantage of the proposed antenna shape is that a size reduction of 37% is achieved by cutting the staircase at each side of the patch. Geometry of proposed antenna is shown in Fig. 1

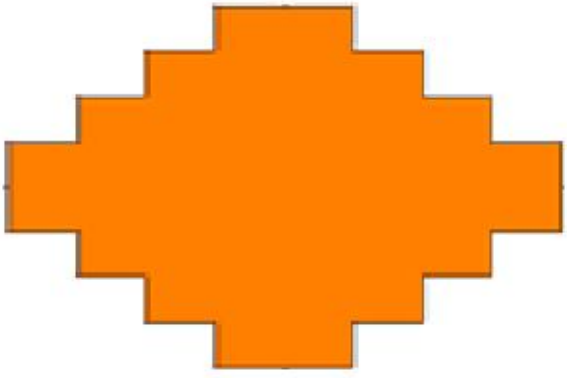

Fig.1 Quad Staircasepatch Antenna

This antenna is etched on a RT- duroid substrate with relative permittivity 2.2 and thickness of 1.6 mm. Coaxial probe feed is employed to feed the proposed antenna in which the inner conductor is soldered to the patch and outer conductor is soldered to the ground plane. Coaxial probe feed has low spurious radiation and easy to fabricate. The length of the patch is L which varies from 8mm to 64 mm and the width of the patch is W which varies from 12 to 68.

Artificial Neural Networks Model

ANN model is a system that is built in accordance with the humanbrain. Therefore, an ANN consists of a few types of many, simple, nonlinear functionalblocks, which are called neurons. Neurons are organized into layers, which are mutuallyconnected by highly parallel synaptic weights. Due to its nonlinearity, the ANNare able tosolve problems which are unsolvable by linear systems. Due to the massive parallelism, theANN exhibits a very high operational speed. An ANN model can be developed by learning from measured/simulatedantenna data, through a training process. The aim of the training process is to minimize thetraining error between the target output and the actual output of the ANN. The trained ANNmodel can be used during antenna design to provide instant answers to the task it learned. Here back propagation algorithm is used for training the ANN model.

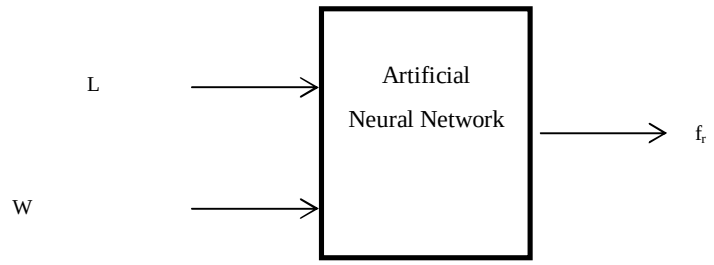

Figure 2 ANN model showing input and output

Results

Back propagation algorithm is used for training the ANN model. 'traingd' training function is used for training the network. The weights and biases areupdated in the direction of the negative gradient of the performance function. There are two input neurons, three hidden neurons and one output neuron in the ANN network. The data set generated from IE3D software with 20 values of L and W of proposed antenna. Resonant frequency (f_r) is calculated for each value of L and W. This data set is used for training the ANN network and it is tested for some different values of L and W. The tested outputs of ANN model is compared with the simulation resultsof IE3D software for the same values of L and W as shown in the table. The error between the ANN outputs and IE3D simulations are also shown in the table. The average percentage error calculated is 1.56 percent only. The ANN results are also compared graphically with the simulation results.

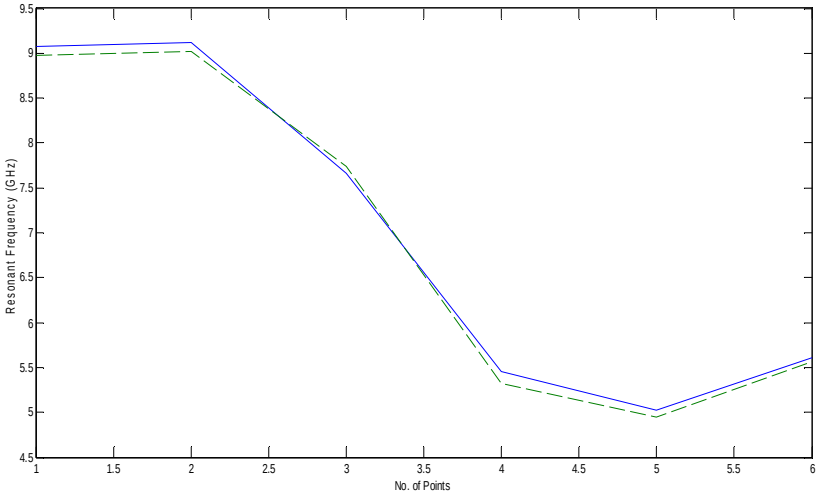

Figure 3: Comparison of ANN result for resonant frequencies with simulated results

Table 1 .Comparison of Simulated and ANN results

S no.	L (mm)	W (mm)	Simulatedoutput f_r(GHz)	ANN output f_r(GHz)	Percentage Error
1	12	16	9.074	8.974	1.1
2	28	32	9.115	9.021	1
3	32	36	7.662	7.734	1
4	44	48	5.452	5.3261	2.2
5	52	56	5.027	4.951	1.5
6	64	68	5.610	5.562	0.8

Conclusion

A Quad staircase shaped microstrip patch antenna is analyzed in this paper using an ANN model. The advantage of using the proposed technique is that it is very easy to find the resonant frequency for the given dimensions. Once we have the trained ANN model. The low value of percentage error validates the proposed technique.

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