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Development of a Relation between Slot Lengths of Microstrip Antenna and Its Resonant Frequencies Using Soft Computing Tool

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Abstract
A new method of calculation of resonant frequency of a rectangular patch antenna using Artificial Neural Network (ANN) has been adopted in this paper. ANN model has been developed and tested in frequency range of 1GHz to 3GHz to analyze resonant frequency and slot length in rectangular Microstrip Patch Antenna. The results obtained using ANN, are compared to the results obtained using software FEKO and experiment.

Keywords
Microstrip patch antenna, artificial neural network (ANN), Multilayer feed-forward network, resonant frequency, Backpropagation algorithm

I. Introduction

Microstrip Antennas due to their many attractive features have drawn attention of industries for an ultimate solution for wireless antenna [1]. The existing era of wireless communication has led to the design of an efficient, wideband, lowcost and small volume which can readily be in corporate into a broad spectrum of systems. Due to increasing use of microtrip antenna in higher frequency regimes, numerous papers on the study of their characteristics have been published. Excellent summaries and reviews of the methods employed in the studies are given by the different authors [2-6]. To avoid the mathematical complexity and to generate the studies over a vast range of parameters, ANN model is introduced. ANN models developed for the evaluation of the input impedances of microstrip antennas are also available in the literature [7, 8].There is also a fast technique to evaluate the resonant frequency of microstrip antennas using neuro-fuzzy networks [9]. A three layer (input, hidden, output) ANN, with one hidden layer is trained with available data. A multilayer feedforward ANN with backpropegation algorithm is used to analyze resonant frequency.

In ANN, feed forward network contains two inputs as length of the slot and distance in X direction from origin, 3 neurons in hidden layer and resonant frequency is the one output in output layer. To analyze the resonant frequency slots have been cut in patch and ground plane.

II. Design and analysis with ANN model

The rectangular patch antenna is made up of rectangular patch with dimensions (w=46.8mm, L=33.2mm) with infinite ground plane as in Fig1. One slot has been cut on one of the edges in patch. Width (2mm) of the slot is fixed. Length is varied from 1mm to 30mm. patch is placed on dielectric substrate with permittivity (ε_r) =2.4. For each slot length resonant frequency has been measured.

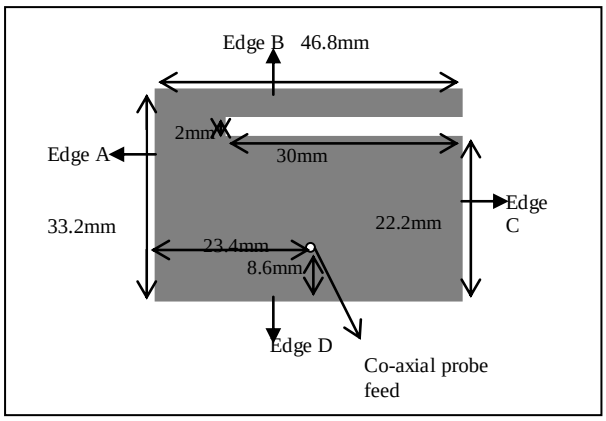

Fig1. Proposed antenna Design

In feedforward multilayer ANN model (Fig.2), there are two units in input layer, four units in hidden layer and one unit in output layer. All initial weights and biases are initialized randomly. In hidden layer function is sigmoid and in output layer function is linear.

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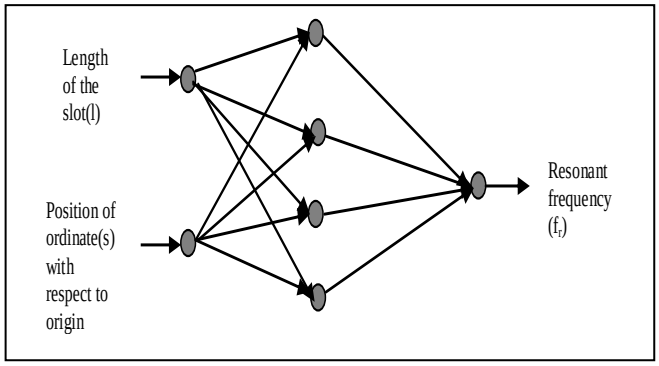

Fig.2. Structure of ANN model.

In this work, resonant frequency of the microstrip antenna is obtained as a function of input variables, which are length of the slot (l), position of the ordinate(s) with respect to origin using ANN techniques (Fig.2.). Origin is the intersection of diagonals of the patch. In the analysis side of the problem, the resonant frequency of the antenna is obtained from the output for each slot length.

III. Result analysis and discussion

In our work, without changing dimensions of the patch, resonant frequency is decreasing by increasing slot length as in Fig.3.1. The measured values, in FEKO, are trained in ANN model.

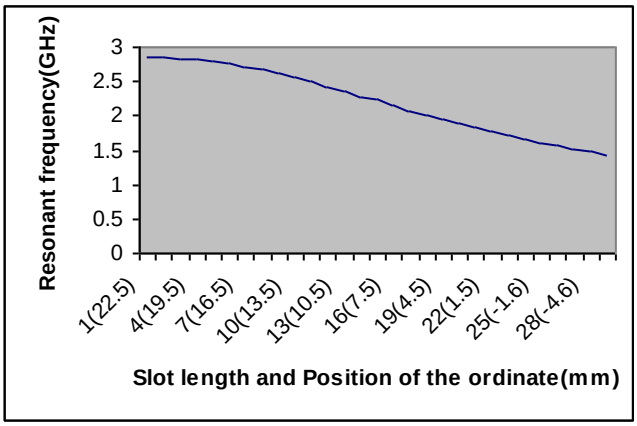

Fig.3.1. Simulated values

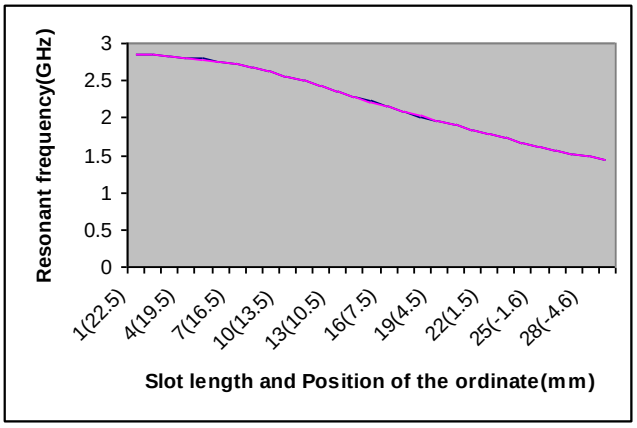

Fig.3.2. Comparison between measured and trained results

Comparison between results in FEKO® 5.5 and in ANN on non-trained data is shown in table 1.

Table.1: Results in FEKO®5.5 and in ANN on non-trained data

Length of the slot (mm)	Position of the ordinate with respect to origin (mm)	resonant frequency(GHz) in FEKO	resonant frequency(GHz) in ANN
1.5	22	2.843	2.846
2.6	21	2.837	2.833
3.4	20.1	2.824	2.824
4.5	19	2.803	2.803
5.3	18.2	2.78	2.78

IV. Conclusion

To reduce the size of the antenna slots or slits are loaded in patch and ground plane. Our work shows increasing slot length, resonant frequency is decreased. Till now there is no rule between length of the slot and resonant frequency. In our work, using ANN model one rule is established by the method of training. After establishment the rule it is checked for some unknown slot lengths. These results have been verified with the results obtained by FEKO®5.5 also.

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