Soft Computing Tool to Establish a Relation between Slot Length of a Microstrip Antenna and Resonant Frequency

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Abstract
In this paper, the design of multi-slot microstrip antenna has been studied. The FEKO®5.5, based on Method of Moment (MoM), is used to determine the simulated results. Artificial Neural Network (ANN) has been used to calculate resonant frequency of the antenna for the given slot length. The results are taken in the frequency range of 1GHz to 3GHz. The simulated results from FEKO®5.5 are compared to the results obtained from ANN model and results are good in agreement.

Keywords
Microstrip Patch Antenna, Artificial Neural Network (ANN), Backpropagation Algorithm, Resonant Frequency

I. Introduction
Microstrip antenna is being extensively used in mobile and other hand held communication devices. The conformal and planer nature of microstrip antenna makes it an ideal choice for this type of devices. The microstrip antenna can be fabricated on the same printed circuit board containing the electronic components of the device. This leads to efficient use of the available space and making the device compact. This shows that in the case of mobile or other small communicating devices, the size of the antenna plays a vital role. So by reducing the size of antenna [1-8], the overall size of the device can be reduced. In previous work [9], size reduction of the patch type microstrip antenna has been performed by different researchers. In our present work, two slots are being cut to analyze the resonant frequency. There are different methods of analysis for Microstrip patch antenna. To avoid mathematical complexity of the methods and to generalize the parameters, ANN model is introduced. ANN model is designed to establish the relation between length of the slot and resonant frequency. In our neuron model, multilayer feedforward network trained by Back propagation algorithm is used as they offer immense scope for exact representation of a broad class of input/output maps [10-11].

II. Antenna Design and Analysis

A. Antenna Design
Figure 1 shows the geometry of the proposed antenna. The figure has been drawn in third angle projection. The design of the antenna is asymmetrical in nature. The slit, width 2mm and length 9mm, is embedded in the ground plane parallel to the Edge A and at a distance of 30.6mm from Edge A. The radiating patch is co-axially probe-fed through a via hole in the ground plane at 17mm from Edge A and 40mm from Edge D. The size of the radiating patch is chosen 33.2mm×46.8mm. The antennas (antenna 1-21) with mentioned geometry has been constructed PTFE substrate (ε_r=2.4) with thickness 2.86mm.

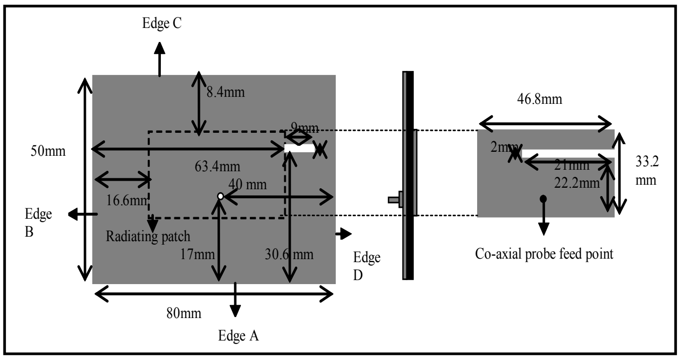

Fig. 1: Structure of Proposed Antenna

B. Analysis by ANN Model
In recent decades, neural network models have been developed especially for the calculation of resonant frequencies for the various shapes of antennas such as equilateral triangular, circular and rectangular microstrip antennas, respectively in [12-16]. Here we present (Fig. 2) a feedforward multilayer neural network with Backpropagation algorithm as learning algorithm for above antenna design. With this ANN model resonant frequency has been analyzed in output layer as the function of two input variables-(i) length of the slot (l), (ii) position of the ordinate(s) with respect to origin, in input layer. First hidden layer contains 4 neurons and second hidden layer contains 3 neurons. In the analysis side of the problem, the resonant frequency (f or fr) of the antenna is obtained from output unit for two input variables as discussed above. All initial weights & biases are set randomly with positive values between 0 and 1. The network is worked with activation functions sigmoid and linear in hidden unit and output unit respectively. Introducing ANN model, one rule between slot length and resonant frequency is established. Network is trained with available data. Now resonant frequency, for untrained slot length, is found by this rule easily.

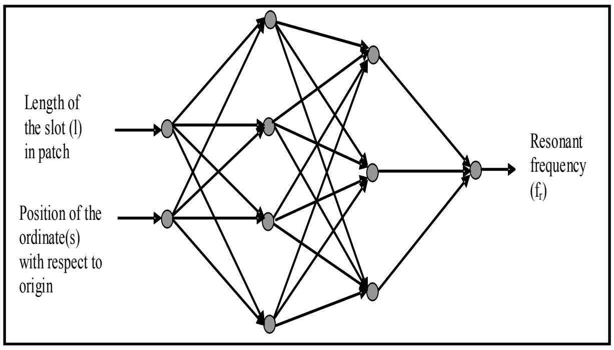

Fig. 2: ANN Model for Proposed Antenna

III. Results and Discussion
In our work, keeping the length of slot in ground plane fixed (9mm), slot length in patch is increased(from 1mm to 21mm) keeping position same w.r.t the position of slot in ground plane. Without changing dimensions of the patch, resonant frequency is decreasing by increasing slot length in the patch. Simulated results in FEKO® 5.5 are shown in fig. 3. Simulated results, for each slot

length, are trained by above ANN model. Comparison between simulated results and trained results is shown in fig. 4.

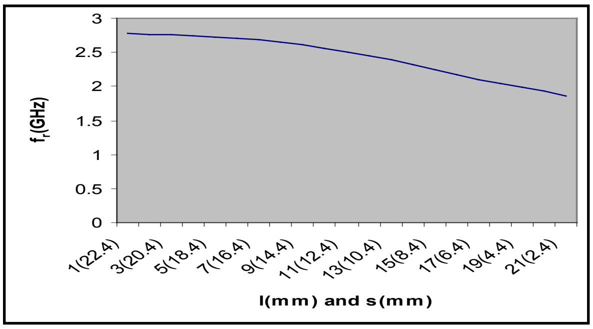

Fig. 3: Simulation Results

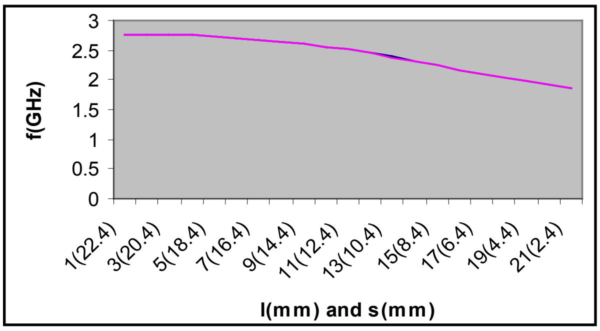

Fig. 4: Comparison between Simulated and Trained Results

Table 1 shows results in FEKO® 5.5 and predicted results by ANN on untrained data.

Table 1: Results of Untrained Data

l(mm)	s(mm)	FEKO results (GHz)	ANN results (GHz)
1.6	21.8	2.7706	2.7702
4.2	19.2	2.7434	2.7443
6.5	16.9	2.6967	2.6958
8.3	15.1	2.6356	2.6365

IV. Conclusion

Slots or slits are loaded on the patch or ground plane of a microstrip antenna for decreasing the resonant frequency or size reduction of the antenna. It is also used for enhancement of Bandwidth and multifrequency operation. But till date there is no fixed relation between length of the slot or position of the slot and resonant frequency. Here by the method of training (ANN) an effort has been exercised to build up a relation between them. After building up the relation it is also checked for some unknown slot lengths. These results have been verified with the results obtained by FEKO also. Results are in good parity.

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