

Designing of E-Shaped Microstrip Antenna Using Artificial Neural Network

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Abstract— Now-e-days the area of microstrip antennas has some creative effort and is one of the premium vigorous fields of antenna theory. The microstrip antenna design is not an easy task to achieve. The E-shaped microstrip antenna (EMAs) is a type of microstrip antenna, which are design in this paper. The proposed antenna design by using IE3D Software based on method of moment (MOM). Find 144 resonant frequency of (EMAs) with various dimensions and electrical parameter. Apply artificial neural network (ANN) based on backpropagation (BP) algorithm multilayer perceptron (MLP) model of different learning methods to compute the resonant frequencies of EMAs. The 130 resonant frequencies and parameter of EMAs are used for training and 14 parameters are used for testing. Find the average percent error (APE) from different learning algorithm compared with each other in which the best result obtained by Levenberg Marquardt (LM) 0.1689%. Thus, the LM algorithm is the best algorithm, which give better accuracy. So the computed resonant by ANN is much closer to simulated resonant frequency of EMAs.

Keywords— E-shaped microstrip antenna (EMAs), artificial neural network (ANN), backpropagation (BP), multilayer perceptron (MLP).

I. INTRODUCTION

Microstrip antenna due to their many attractive feature have been drawn attention of industries for an ultimate solution for wireless communication. The existing era of wireless communication has led to the design of an effective, wide band ,low cost, and small volume antennas which can readily be merged into a broad spectrum of systems [1-2]. Microstrip antennas are used in an increasing number of applications, fluctuating from biomedical diagnosis to wireless communication [3]. They have the ability to work in dual and triple band operations but; narrow bandwidth came as the main drawbacks of microstrip antennas [4]. In this paper presented E-shaped microstrip antenna base on ANN.

There are different shaped of microstrip antennas such as rectangular circular, annular et.c.

The (EMAs) is a type of microstrip antenna which is much simpler to make by only modifying length, width and position of probe feed point. The leading objective of designing a EMAs is to optimized the base design and achieve higher bandwidth [5]. The EMAs is a miniaturized antenna fabricated with two identical parallel slots on the patch of rectangular by loading the slot technique. The modifying slot length and slot width of the EMAs that is attained acceptable performance [6].

Artificial neural networks are one of the popular clever methods in solving engineering difficulties. Neural network processing grants a different approach to store and manipulate knowledge. Artificial neural network is a model worked as a biological neural networks which are used to approximation the functions that are mostly depend upon the large number of inputs which is usually unknown .ANN is well-defined computing system organized by number of unpretentious, extremely organized handling elements, which process data by theirs exciting state reply to external inputs. ANN are the basic model of neural processing that are used as artificial intelligence in the brain [7]. Recently, ANN have been useful to microwave computer-aided design (CAD) and RF problems as well. Neural networks are first trained to model the electrical performance of active and passive components. These trained neural networks, often mentioned to as neural-network models , then can be used in advanced simulation and design, providing fast responses to the mission they have learned [8-9]. In the works, ANN models have been fabricated usually for the analysis of microstrip antennas in various forms such as circular ,rectangular and equilateral triangle patch antennas [10-14]. An ANN is trained frequently and at one point, it extents a stage where it has ‘learned’ a particular desired function. With accurate training, it can simplify; hence that even different data, which was not part of the training data, will yield the wanted output.In proposed antenna applied ANN based on MLP to trained ant the test the data of EMAs.

II. DESIGNING METHOD OF E-SHAPED ANTENNA USING IE3D SOFTWARE

In this paper, designed E-shaped microstrip antenna using IE3D Software to find resonant frequency. The E-shaped microstrip antenna is a miniaturized antenna, when to parallel slots are incorporated in to the rectangular microstrip patch antenna, it become E-shaped microstrip antenna. The (EMAs) is simpler in construction. The geometry is shown in Fig .1 as it can be seen from the geometry of antenna that’s have composition of L, W, ls, ws, thickness h height of the substrate

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and dielectric constant ϵ_r . To find out resonant frequency there are 144 different E-shaped microstrip antenna parameters with different combinations of L , W , l_s , w_s , h and ϵ_r .

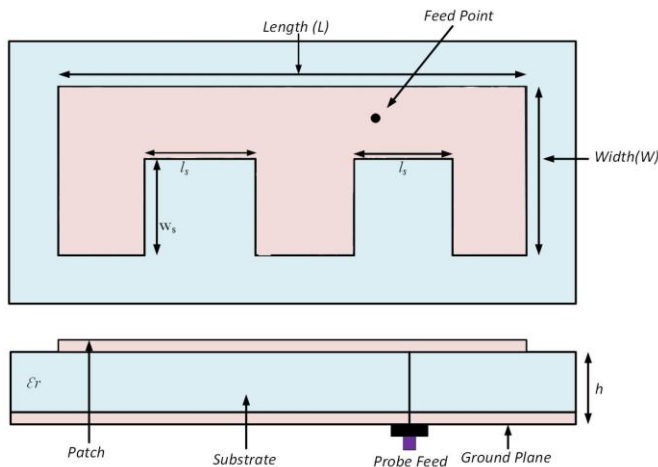


Fig. 1. Geometry of E-shaped microstrip antenna

To find out the designing method (EMAs) using IE3D. The software are design of certain thickness of that's z-axis parameters have great advantages of microwave devices is used for two dimensional mapping, simple user interface, high efficiency. Taking the data from Table 1 as an example which is $L = 25\text{mm}$, $W = 20\text{mm}$, $l_s = 2\text{mm}$, $w_s = 4\text{mm}$, $h = 1.57\text{mm}$ and $\epsilon_r = 2.33$. To designing antenna set the parameter first, the thickness "ztop" set to 1.57mm, which is height and dielectric constant Epsr ϵ_r is 2.33. Then click "ok" and save.

TABLE 1 E-SHAPED MICROSTRIP ANTENNA PARAMETERS

L(mm)	W(mm)	ls(mm)	Ws(mm)	h(mm)	ϵ_r
25	20	2,4,6,8	4,8,12,16	1.57	2.33,4.5,6.15
32.5	25	2.5,5,7.5,10	5,10,15,20	2.50	2.33,4.5,6.15
40	30	3,6,9,12	6,12,20,26	3.17	2.33,4.5,6.15

Design the pattern of E-type microstrip antenna as shown in Fig. 2. After it find the probe feed from the selecting data. The formula of finding the probe feed point is $x_f = 2(W - w_s)/3$ and $y_f = (2L - l_s)/3$. Then in the IE3D "build probe-feed port" set the probe point and click "ok". Finally simulate the resonant frequency as show in Figure 3. Which give the best return loss of -12.91db at 3.51GHz resonant frequency. The same method is used for all 144 E-type antenna only change the parameter to obtained different frequency of return loss $S_{11} < -10\text{db}$. Based on artificial neural network the resonant frequency of 144 E-type microstrip antenna 130 is used for training and the remaining 14 is used for testing to find out accuracy.

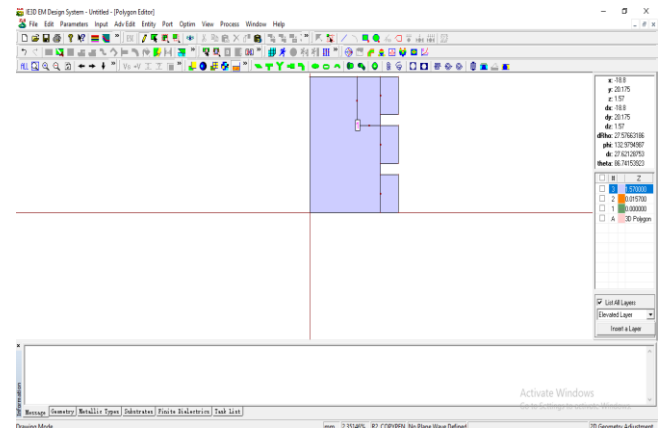


Fig. 2. Structure of E-shaped microstrip antenna

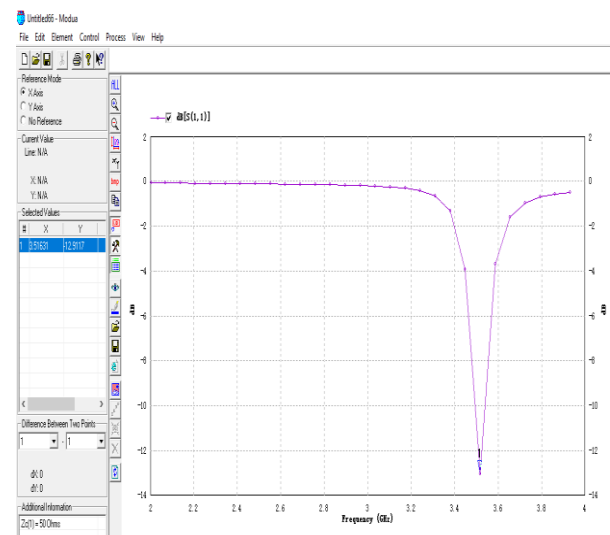


Fig. 3. Return loss for resonant frequency

III. ANN MODELING OF E- SHAPED MICROSTRIP ANTENNA

In this paper design E-shaped microstrip antenna based on artificial neural network. There are 144 different data, which are used for designing E- shaped microstrip antenna using IE3D software to find out resonant frequency. From 144 (L , W , l_s , w_s , h and ϵ_r and f_{IE3D}) data, 130 are used for training and 14 are used for testing to build network.

For the proposed antenna Multilayered Perceptron (MLP) model Backpropagation (BP) algorithm are used. The model are trained of 144 sets of input/output data, which are obtained by IE3D Software based on MOM. The model is trained and test for different value of parameter to get a desired resonant frequency. The model have three layers input layer, output layer and hidden layer. From the combination of data (L , W , l_s , w_s , h and ϵ_r) are given as input and the resonant frequency obtained from IE3D given as output as shown in Figure 4. In this network there are 6 input neurons 1 output neurons and 25 hidden neuron which depending on network accuracy. The different training algorithm is used in which are Levenberg-Marquardt (LM), Scaled Conjugate Gradient (SCG) and One Step Secant (OSS) for finding the error.

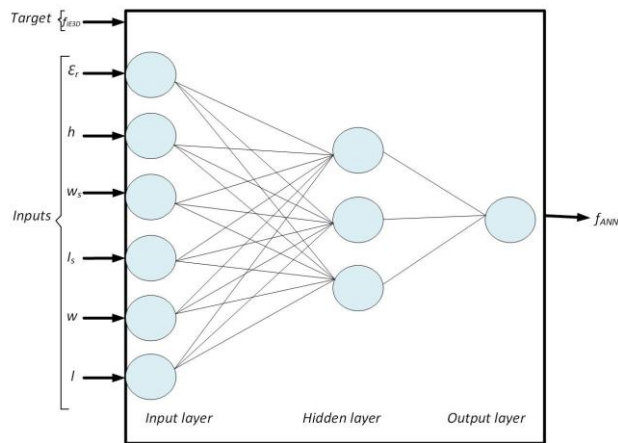


Fig. 4. ANN Model

neural network using MATLAB to train and tested the data. In ANN model training process, chosen (L , W , l_s , w_s , h , ϵ_r) of E-shaped microstrip antenna were introduced as input and simulated resonant frequency value f_{IE3D} were given as a target to ANN model as shown in Figure 4. The MLP model is used to train the network for the relationship between input and target value to obtain the resonant frequency f_{IE3D} for all parameters which are given in Table 1. The total of 144 E-shaped microstrip antenna data (130 data) are used for training and 14 data are used for testing which are selected randomly. The ANN model was separately trained with three different algorithms, which are LM, SCG, and OSS. By using average percent error (APE) equation, the best algorithm is found.

TABLE II RESONANT FREQUENCY OF ARMAS AND APE VALUE FOR TEST PROCESS

Antenna parameter						f_{IE3D}	f_{ANN}		
L	W	l_s	w_s	h	ϵ_r	f_{IE3D}	LM	SCG	OSS
25	20	6	4	1.57	2.33	3.49	3.488	3.468	3.408
25	20	4	8	1.57	2.33	2.97	2.988	2.980	2.956
25	20	8	4	1.57	2.33	3.524	3.523	3.499	3.526
25	20	6	4	1.57	4.5	2.578	2.584	2.531	2.550
25	20	2	12	1.57	6.15	1.597	1.602	1.616	1.664
32.5	25	7.5	5	2.5	2.33	2.66	2.659	2.676	2.684
32.5	25	2.5	10	2.5	4.5	1.739	1.738	1.741	1.760
32.5	25	7.5	20	2.5	4.5	1.17	1.170	1.151	1.188
32.5	25	7.5	20	2.5	6.15	1.009	1.008	0.997	1.016
40	30	3	20	3.17	2.33	1.5	1.499	1.527	1.523
40	30	3	26	3.17	4.5	0.899	0.893	0.891	0.890
25	20	8	8	1.57	4.5	2.31	2.307	2.223	2.301
40	30	3	6	3.17	6.15	1.4	1.402	1.381	1.379
40	30	9	12	3.17	6.15	1.22	1.221	1.230	1.223

APE% 0.1689 0.988 1.229

IV. MATLAB SIMULATION AND RESULTS OF NETWORK TRAINING AND TESTING

MATLAB is a kind of advanced computer language, which is applied to scientific research and build simulation to solve engineering problems. In this paper, designed E-shaped microstrip antenna by using IE3D Software to obtain resonant frequency. After simulation of IE3D, apply artificial

$$APE = \sum \left| \frac{f_{IE3D} - f_{ANN}}{f_{IE3D}} \right| \quad (1)$$

To test the performance of 14 data and simulated resonant frequency obtained from E-shaped microstrip antenna and resonant frequency from ANN of different algorithms as shown

in Table. 2. By using different algorithms the comparison of simulated data from IE3D and resonant frequency from LM are much closer as compare to other algorithm. The APE value of LM is 0.1689%, SCG is 0.988% and OSS is 1.229%. It means LM shows good accuracy. so we know that ANN model using MATLAB is best choice for antenna optimization.

V. CONCLUSION

The proposed antenna design in this paper is E-shaped microstrip antennas (EMAs). The EMAs are designed by using IE3D base on method of moment (MOM). The work designed 144 EMAs using different parameters obtained different resonant frequency. Apply artificial neural work (ANN) based on MLP for training and test the network. The 130 EMAs parameters are used for training and the remaining 14 parameters and resonant frequency of EMAs are used for test to build network. The parameter are test and trained by applied different learning algorithms in which the average percent error value (APE) are obtained. The best result give by Levenberg- Marquardt (LA) compare to other learning algorithms. The comparison of simulated resonant frequency from IE3D and from ANN are much closed to each other's. Therefore, in the conclusion remarks that ANN model are successfully used for determining the resonant frequency of microstrip antenna without any complex calculations. Now a day, ANN is commonly used in microwave modeling and design for its good learning capability and simplification. Generally, ANN hurts a huge number of samples to guarantee the accuracy, which significantly increases the assignment to establish ANN. The ANN model also gives fast and accurately result.

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