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A Neural Network Approach to study the Bandwidth of Microstrip Antenna

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***Abstract: This paper presents the use of neural network for the estimation bandwidth of a coaxial feed rectangular microstrip patch antenna. The results obtained using ANNs are compared with the IE3Dsimulation and found quite satisfactory. The designed antenna operates in the frequency range of 1.90 to 2.27 GHz and 3.052 to 3.570 GHz. The antenna is designed using air as a dielectric substrate between the ground plane and patch and simulated on the Zeland IE3D software and the results are compared with neural network tool of matlab*.**

***Keywords:* Radial basis function, Neural Network, Microstrip Antenna.**

I. INTRODUCTION

.Microstrip antennas are being frequently used in Wireless application due to its light weight, low profile, low cost and ease of integration with microwave circuit. However standard rectangular microstrip antenna has the drawback of narrow bandwidth and low gain. The bandwidth of microstrip antenna may be increased using several techniques such as use of a thick or foam substrate , cutting slots or notches like U slot , E shaped , H shaped patch antenna, introducing the parasitic elements either in coplanar or stack configuration, and modifying the shape of the radiator patch by introducing the slots.

In the present work an Artificial Neural Network (ANN) model is developed to analyse the bandwidth of the microstrip antenna. The Method of Moments (MOM) based IE3D software has been used to generate training and test data for the ANN. It is a computational EM simulator based on method of moment numerical method. It analyses 3D and multilayer structures of general shapes. The feed point must be located at that point on the patch, where the input impedance of patch matched with feed for the specified resonating frequency. The return loss is recorded and that feed point is selected as the optimum one where the RL is most negative i.e. less than or equal to -10dB.

II. ANTENNA DESIGN LAYOUT

For designing a rectangular microstrip patch antenna, the length and the width are calculated as below

$$W = \frac{c}{2f\sqrt{(\varepsilon_r + 1)/2}} \qquad (1)$$

Where c is the velocity of light, ε_r is the dielectric constant of substrate, f is the antenna working frequency, W is the patch non resonant width, and the effective dielectric constant is ε_{eff} given as,

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 10\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (2)$$

The extension length Δl is calculates as,

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.300)\left(\frac{W}{h} + 0.262\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.813\right)} \qquad (3)$$

By using the mentioned equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta l \qquad (4)$$

Figure 1 shows the designed antenna geometry. The antenna is designed using air dielectric of height 10 mm. The length and width of the patch is 52 mm and 71 mm. On this patch a C slot is digged of dimensions 39 mm by 4 mm. The slot cutting is done to improve the bandwidth of the microstrip antenna.

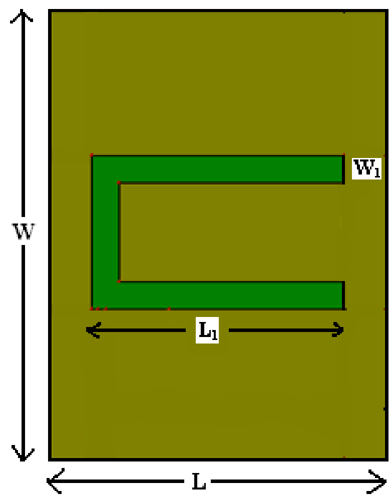

Figure 1. Geometry of proposed microstrip antenna.

III. NETWORK ARCHITECTURE AND TRAINING: RADIAL BASIS FUNCTION NETWORK

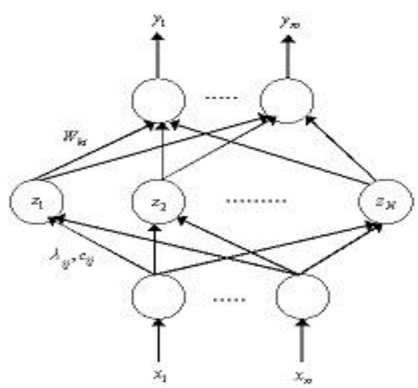

Figure 2 Neural Network approach (Radial Basis Function Network).

In this paper, radial basis function (RBF) neural network is used to design and analyse C Shape microstrip patch antenna. Radial basis function network is a feed forward neural network with a single hidden layer that use radial basis activation functions for hidden neurons. RBF networks are applied for various microwave modeling purposes.

The RBF neural network has both a supervised and unsupervised component to its learning. It consists of three layers of neurons – input, hidden and output. The hidden layer neurons represent a series of centers in the input data space. Each of these centers has an activation function, typically Gaussian. The activation depends on the distance between the presented input vector and the centre. The further the vector is from the centre, the lower is the activation and *vice versa*. The generation of the centers and their widths is done using an unsupervised *k*-means clustering algorithm. The centers and widths created by this algorithm then form the weights and biases of the hidden layer, which remain unchanged once the clustering has been done. A typical RBF network structure is given in figure 2 and model of ANN is shown in figure 3

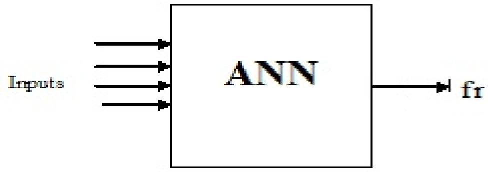

Figure 3. ANN Model.

The parameters c_{ij} and λ_{ij} are centers and standard deviations of radial basis activation functions. Commonly used radial basis activation functions are Gaussian and multiquadratic.

Given the inputs **x**, the total input to the i_{th} hidden neuron γ_i is given by

$$\gamma_i = \sqrt{\sum_{j=1}^{n} \left(\frac{x_j - c_{ij}}{\lambda_{ij}} \right)^2}, i = 1,2,3,..........N$$

Where N is the number of hidden neurons, The output value of the i_{th} hidden neuron is$z_{ij} = \sigma(\gamma i)$,

Where(γ)is a radial basis function. Finally, the outputs of the RBF network are computed from hidden neurons as

$$y_k = \sum_{i=0}^{N} w_{ki} z_{ki}$$

Where w_{ki} is the weight of the link between the i_{th} neuron of the hidden layer and the k_{th} neuron of the output layer.Training parameters w of the RBF network include w_{k0}, w_{ki} , c_{ij} , λ_{ij}, k = 1 ,2, . . . , m,
i = 1,2, ...,N, j = 1,2, . . . n

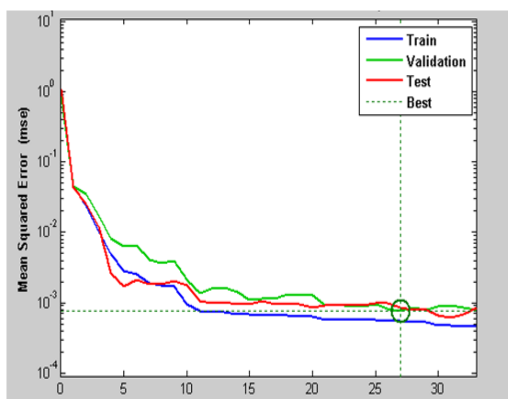

Figure 4. Training performance showing minimum MSE.

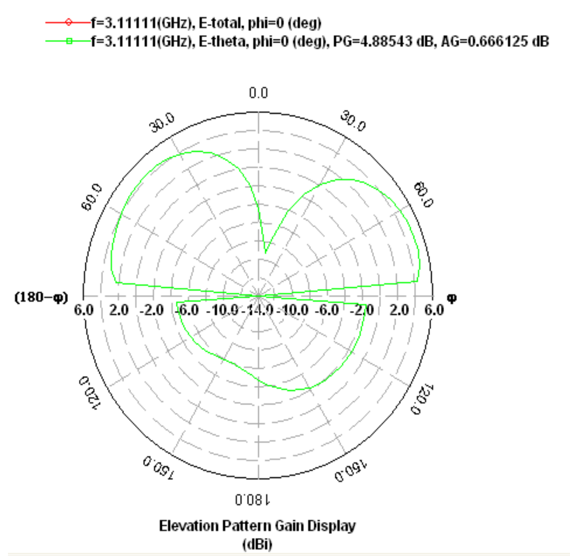

Figure 5 Radiation Pattern of the proposed microstrip Antenna.

Table2 Comparison of results of IE3D and ANN

SLOT LENGTH (L_1)	SLOT WIDTH (W_1)	PROBE (X_1,Y_1)	BW IE3D (GHz)	BW RBF (GHz)	BW WITH OUT SLOT (GHz)
39	4.2	8,14	0.370, 0. 519	0.368, 0.515	0.330, 0.452
39	4.2	9, 14	0.389, 0. 551	0.385, 0.553	0.330, 0.452
39	4.2	10, 14	0.253, 0. 518	0.250, 0.514	0.330, 0.452
39	4.2	11, 14	0.392, 0. 507	0.396 0.509	0.330, 0.452
39	4.2	12, 14	0.355, 0. 471	0.355, 0.472	0.330, 0.452
39	4.2	13, 14	0.296, 0.343	0.299, 0.340	0.330, 0.452

IV. RESULTS AND DISCUSSIONS

Figure 7 shows the return loss graph of microstrip antenna for different positions of probe feed. The results are also depicted in Table 1. From the table it is evident that the result obtained from IE3D and ANN tool is very close by and hence giving accurate results after several trainings. The Length and width of the patch is kept constant and probe position is changed and the network is trained for the same adjustment. Further it is seen that the network analyzes the almost same bandwidth as obtained from the simulator. The ANN tool is just used to study the bandwidth of microstrip antenna which is in good agreement with the results obtained from Zeland IE3D software.

Figure 6 shows the return loss graph of microstrip antenna which is about -38db. The proposed antenna gives a bandwidth of 17.78% covering the range of 1.90 to 2.27 GHz and 15.67% covering the range of 3.052 to 3.570 GH_Z making it suitable broadband applications.

Figure 5 & 7 shows the 2D radiation pattern and the 3D radiation pattern. The radiation pattern at 3.11 GHz frequency is shown in the figure. The component E theta at phi = 0 is shown giving a power gain of 1.56117dB.Figure 6 shows the 3D structure of proposed antenna. Figure 8 shows the Smith chart Vs Frequency plot which shows the input impedance and S11 parameter. The structure is simulated using IE3D simulation software.

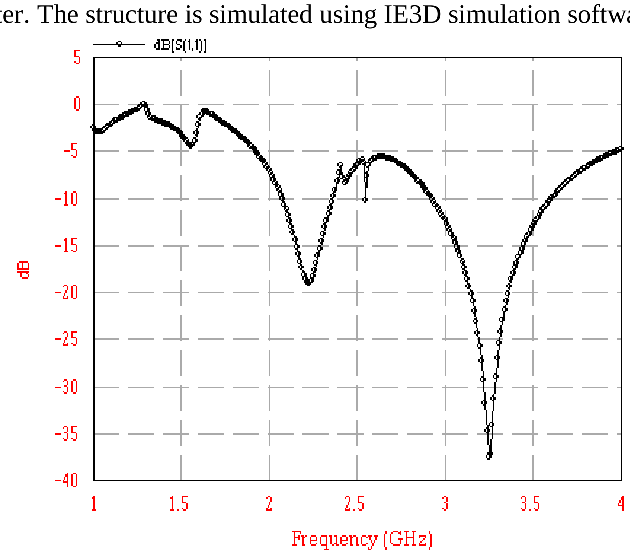

Figure 6. Return loss Vs frequency plot of proposed microstrip antenna

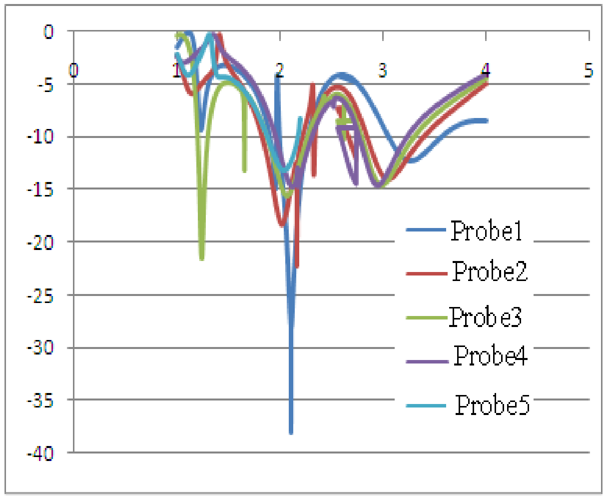

Figure 7. Return loss Vs frequency plot of proposed microstrip antenna

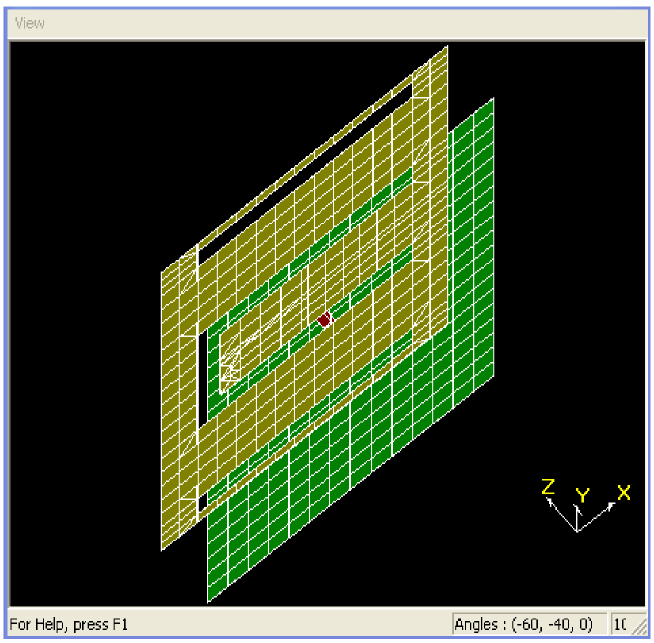

Figure 6 3D structure of the proposed microstrip Antenna.

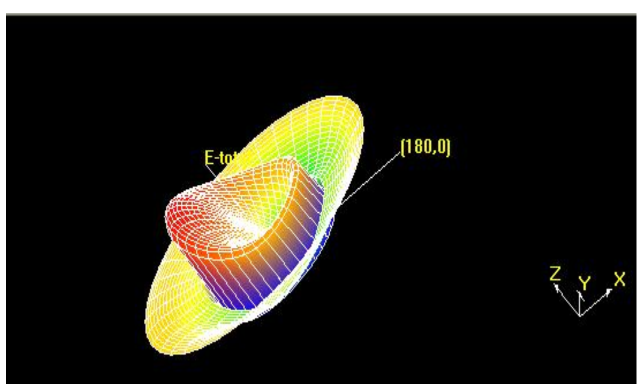

Figure 7 3D radiation pattern of the proposed microstrip Antenna.

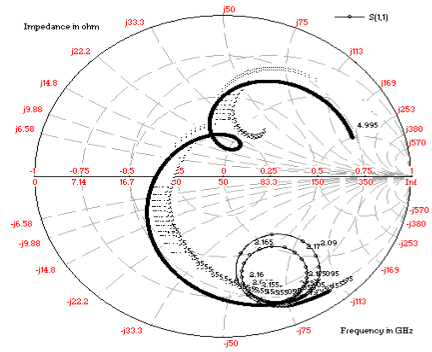

Figure 8.Smith chart of proposed microstrip antenna.

V. CONCLUSION

In this work ANN is used as a tool to study the bandwidth of Microstrip Antenna. The results obtained from IE3D and those obtained from ANN are in good agreement and shows almost 99% accuracy. The training and test set has been designed with the data obatined from IE3D simulator.

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