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# A Novel Approach for Analysis of Bandwidth of Microstrip Patch Antenna Using Neural Network

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***Abstract:** This paper presents the use of neural network for the estimation of bandwidth of a coaxial feed rectangular microstrip patch antenna. The results obtained using ANNs are compared with the IE3D simulation and found quite satisfactory. The designed antenna operates in the frequency range of 1.45 to 2.62 GHz having the optimum bandwidth of about 57.63% .The antenna is designed using glass epoxy as a dielectric substrate between the ground plane and patch. The simulation has been carried out using IE3D software and the results are compared with neural network tool of matlab.*

***Keywords:** Radial basis function, Neural Network, Broad band, 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 [1-3]. 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.[4-7] In modern communication system the microstrip patch antennas are widely used due to low profile, low weight, low cost However, the antennas suffered from narrow bandwidth and low gain. Therefore, different techniques have been proposed in the literature to increase the bandwidth. These techniques include cutting slots in the radiating patch, stacking geometry, shorting pins and introducing slots in ground plane [8-16]. In recent times, many novel planar antennas have been designed to satisfy the requirements of mobile cellular communication systems. These systems include global system for mobile communication (GSM; 890-960 MHz), digital communication system (DCS; 1710-1880 MHz), personal communication system (PCS; 1850-1990 MHz) and universal mobile telecommunication system (UMTS; 1920-2170 MHz). Some Microstrip antennas are also very good choice for applications in communication devices for global positioning system (GPS; 1575.24 MHz), and wireless local area network (WLAN) systems in the 2.4 GHz (2400-2484 MHz) and 5.2 GHz (5150-5350 MHz) bands [17-21]

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. 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

Figure 1 shows the proposed patch antenna geometry. The antenna is designed using glass epoxy substrate having dielectric constant of 4.4. Lg = 33.4 mm, Wg = 40.6 mm, L = 23.8 mm, W = 31 mm, $L_f$ = 10.8 mm, $W_f$ = 4 mm, $L_2$ = 19.8mm.The ground plane size is selected as 40 mm x 60 mm, and the relative dielectric constant and the thickness of the substrate are chosen as $\varepsilon_r$ = 4.4 and h = 1.6, respectively. For designing a rectangular microstrip patch antenna, the length and the width are calculated as below

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

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

The extension length Δl and actual length L is calculated from the equations (3) and (4) as given below

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

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

Where c is the velocity of light, $\varepsilon_r$ 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 $\varepsilon_{eff}$ given as,

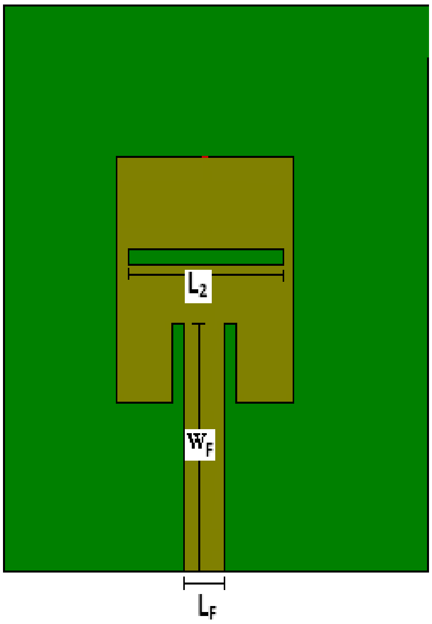


Fig 1: Geometry of proposed micro strip antenna

## III. RESULTS AND DISCUSSION

Figure 2 shows the return loss graph of microstrip antenna which is about -28db. The proposed antenna gives a bandwidth of 57.63% covering the range of 1.45 to 2.62 GHz making it suitable for PCS/DCS/WLAN applications. Figure 3 shows the return loss graph of presented 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 4 shows the Smith chart Vs Frequency plot which shows the input impedance and S11 parameter. The structure is simulated using IE3D simulation software.

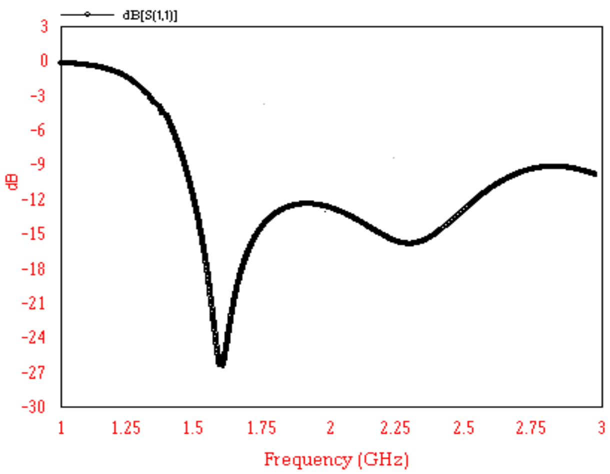


Figure 2. Optimum Return loss Vs frequency of proposed microstrip antenna

 

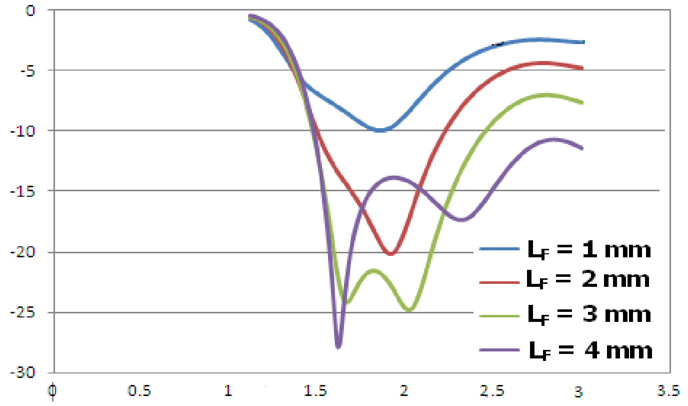


Figure 3. Comprative Return loss Vs frequency of proposed microstrip antenna

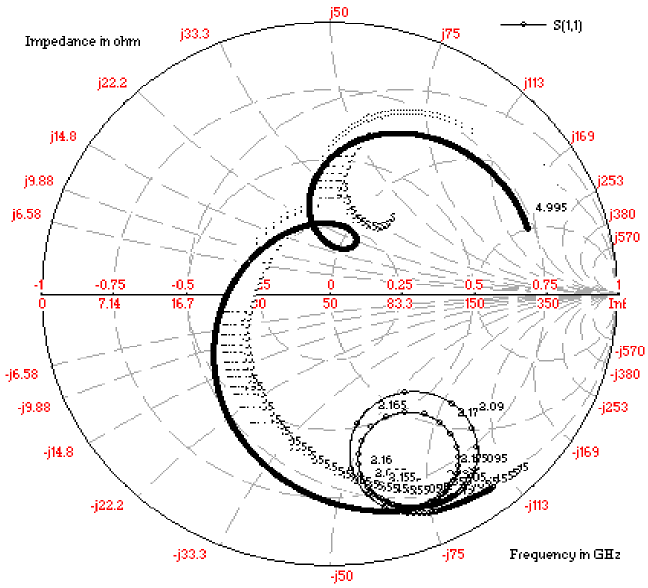


Figure 4.Smith chart of proposed microstrip antenna.

## IV. NETWORK ARCHITECTURE OF PROPOSED NEURAL NETWORK

The architecture and training of proposed neural network is shown in figures 5 to 8
Network detail: Epochs 5
Network type = feed forward back propagation
Training function = levenberg marquardt
Performance function = mean square error
Adaption learning function = LEARNGDM
Transfer Function = TANSIG
No of layers = 2
No of neurons = 16

**Table1. Comparison of results of IE3D and ANN**

**Table 2.** Comparison of results of IE3D and proposed ANN model

| S.No | Probe width ($L_F$) mm | Probe Length ($W_F$) mm | Band Width (%) through IE3D | Band Width (%) through ANN |
|---|---|---|---|---|
| 1 | 4.0 | 15 | 68.45 | 68.17 |
| 2 | 3.5 | 15 | 58.19 | 57.80 |
| 3 | 3.0 | 15 | 50.64 | 50.39 |
| 4 | 2.5 | 15 | 44.44 | 44.01 |
| 5 | 2.0 | 15 | 40.43 | 39.99 |
| 6 | 1.5 | 15 | 28.24 | 28.12 |
| 7 | 1.0 | 15 | 18.80 | 18.10 |
| 8 | 0.5 | 15 | 10.29 | 09.98 |

 

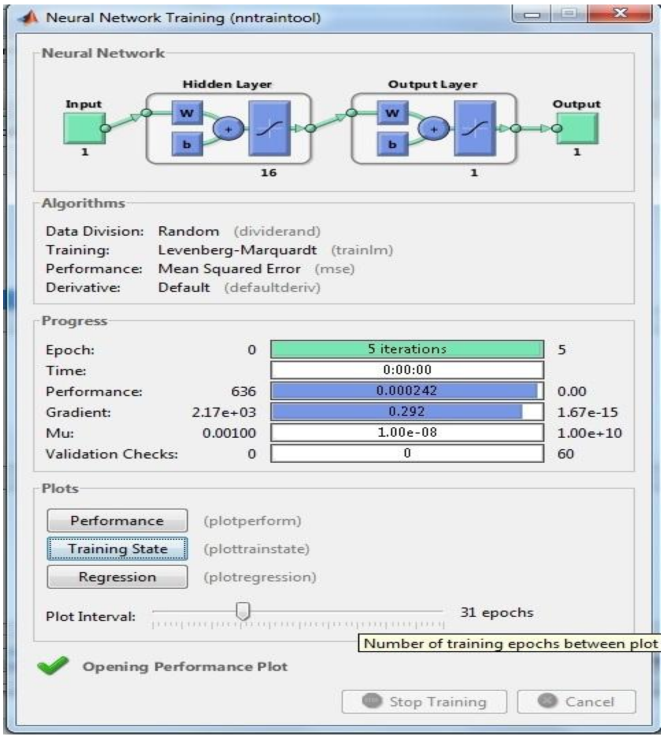


Figure 5. Training of Neural Network

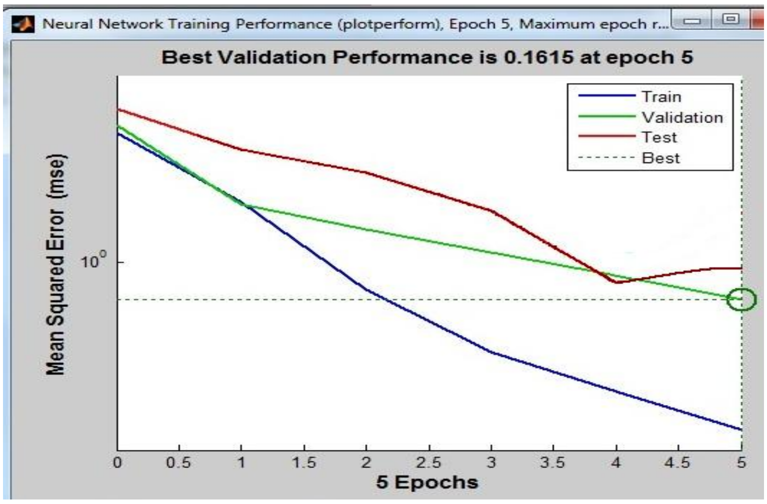


Figure 6. Training performances showing minimum MSE

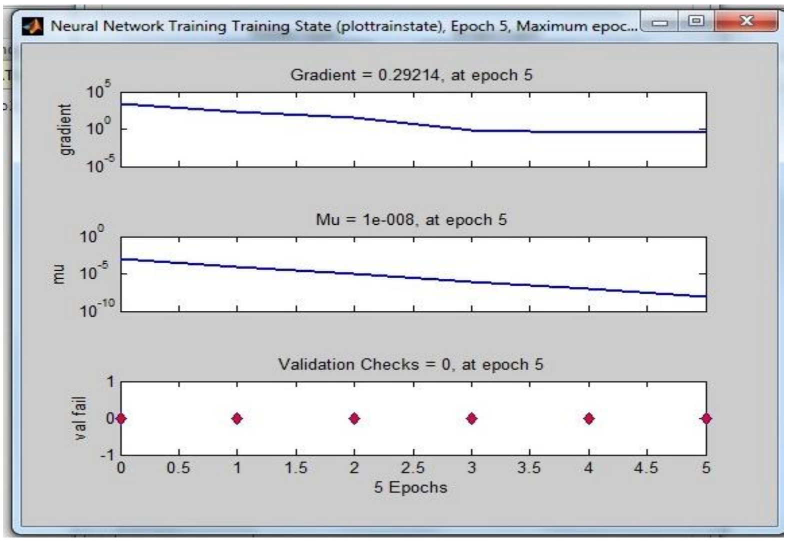


Figure7. Neural network training result

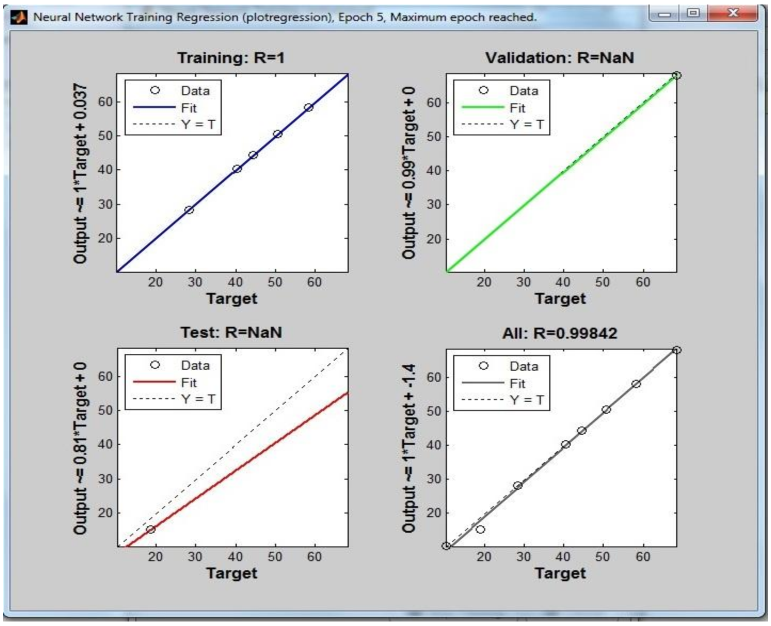


Figure 8 Regression states

## 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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