Bandwidth Analysis of L Slot Loaded Patch Antenna through Artificial Neural Network

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Abstract— The analysis of slot loaded patch antenna for bandwidth through IE3D is a time taking process. Also for small variations in patch size or in slot length we have to investigate the whole structure again for maximum bandwidth which is very time consuming process. To overcome this problem here we adopt an artificial neural network approach (ANN). Basically here for different length of L slot we find the bandwidth through IE3D simulation software and then develop an artificial neural network that directly gives the bandwidth of path antenna for different slot lengths

Key words: L slot, enhance bandwidth, compact Microstrip Patch, gain, line feed

I. INTRODUCTION

As we know that bandwidth of micro strip patch antenna is the major issue in its analysis. The bandwidth of patch antenna is very low hence it is analyzed by any software for number of times for maximum bandwidth. Since it is very time consuming process so that to overcome this problem by an artificial neural network approach is adopted [1-3]. In the present work the L slotted [4] patch antenna is designed as a reference antenna as shown in figure 1.

Now the length L as shown in figure is varied between the limit 20mm to 30mm and width W is fixed 15mm length. In this way a set of 21 data of different length is generated which is shown in table 2 and then find the bandwidth through IE3D software for each corresponding length L which is shown in table 3. In this way the set of input data and target data is created. Now our next step is to develop a neural network that directly gives the bandwidth. For this purpose we use feed forward neural network with levenberg marquardt algorithm [1-3]. The proposed antenna has been designed on glass epoxy substrate (εr=4.4) [4].The substrate material has large influence in determining the size and bandwidth of an antenna. Increasing the dielectric constant decreases the size but lowers the bandwidth and efficiency of the antenna while decreasing the dielectric constant increases the bandwidth but with an increase in size. The design frequency of proposed antenna is 1.92 GHz.

II. ANTENNA DESIGN

For designing a rectangular Microstrip patch antenna, the length and width are calculated as below [5][6]

$$w=\frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (2.1)$$

Where c is the velocity of light, εr is the dielectric constant of substrate, fr is the antenna design frequency, W is the patch width, and the effective dielectric constant εreff is given as [5][6]

$$\varepsilon_{reff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (2.2)$$

At h=1.6mm

The extension length ΔL is calculated as [5] [6]

$$\frac{\Delta L}{h}=0.412\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+.264)}{(\varepsilon_{reff}-.258)(\frac{W}{h}+0.8)} \qquad (2.3)$$

By using the above mentioned equation we can find the value of actual length of the patch as [5], [6]

$$L=\frac{c}{2f_r\sqrt{\varepsilon_{reff}}}-2\Delta L \qquad (2.4)$$

The length and the width of the ground plane can be calculated a [5][6]

$$Lg=6h+L \qquad (2.5)$$

$$Wg=6h+W \qquad (2.6)$$

III. ANTENNA DESIGN SPECIFICATIONS

The design of proposed antenna is shown in figure1. The proposed antenna is designed by using glass epoxy substrate which has a dielectric constant 4.4 and the design frequency 1.92 GHz is taken. Antenna dimensions can be calculated by above giving equations. The calculated patch width and length are 48 mm and 36 mm respectively. The ground plane width and length are taken 58 mm and 46 mm respectively. Height of the dielectric substrate is 1.6 mm and loss tangent tan δ is .0013. Line feed is used to radiate the antenna.

Parameters	Values
Dielectric constant	4.4
Resonant frequency	1.92 GHz
Substrate height	1.6 mm
Ground plane width	58 mm
Ground plane length	46 mm
Patch width	48 mm
Patch length	36 mm

Table 1: Antenna Design Specifications

IV. ARCHITECTURE OF PROPOSED NEURAL NETWORK.

The architecture and training of proposed neural network is shown in figures 5 to 9 [7-8]

The other specifications of the proposed neural network are given as:

- Network type → Feed Forward Back Propagation.
- Number of layers → 2
- Number of neurons in hidden layer → 6
- Transfer function → TANSIG (sigmoid function).
- Training function → TRAINLM
- Adaption learning function → LEARNGDM
- Performance → MSE (mean square error).

- Number of epoch's → 250
- Iterations → 250
- Gradient → 1.48e-20

V. GENERATION OF INPUT DATA SET

The input data set is generated for different values of length L is shown in table 2.

Length **L**	20	20.5	……	32.5	33

Table 2: Input Data Set

VI. GENERATION OF TARGET DATA SET

The target data set is the corresponding values of bandwidth through IE3D for different values of length L is shown in table 3. In case of dual band or triple band only the maximum bandwidth is considered in any band.

ENGTH L (mm)	**%BW**	**LENGTH L(mm)**	**%BW**	**LENGTH L(mm)**	**%BW**
20	12	23.5	13.45	27	6.23
20.5	12	24	13.12	27.5	6
21	12	24.5	11.65	28	5.3
21.5	11.5	25	11.5	28.5	5
22	11.42	25.5	10.09	29	4.56
22.5	14.37	26	7.5	29.5	4.51
23	14.04	26.5	7.5	30	4.5

Table 3: Target Data Set

VII. SIMULATION RESULT AND DISCUSSION

The design of proposed antenna is shown figure 1 and 2. The length of the slot is 15mm and width of the slot is 20mm and 25mm respectively. The probe is placed at (7.5, 0.8) on strip line.

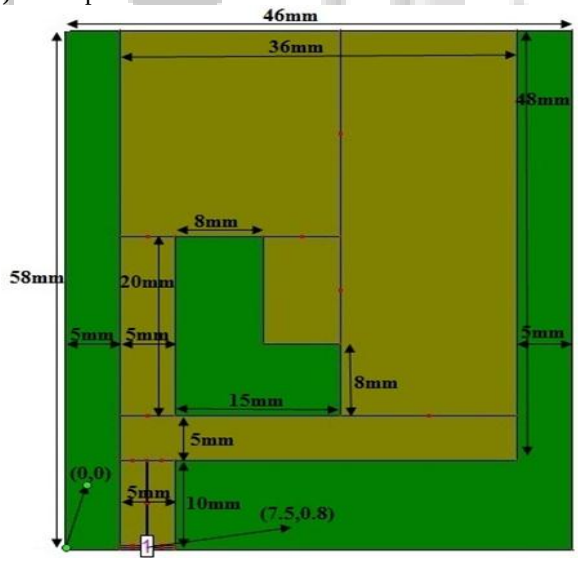

Fig. 1: Antenna of Slot Length 20mm

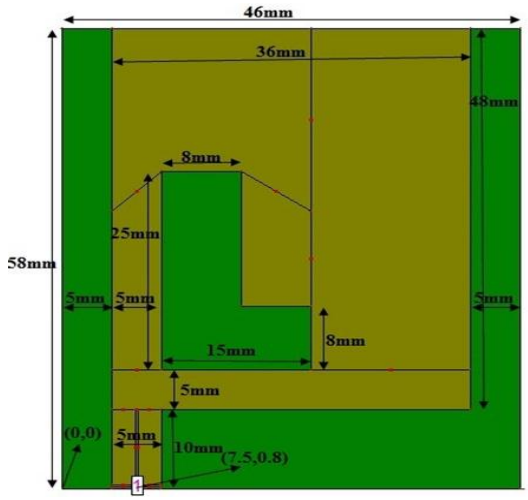

Fig. 2: Antenna of Slot Length 25mm

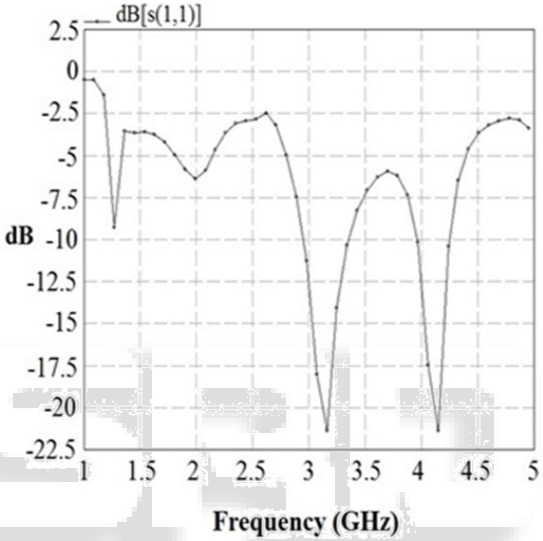

Fig. 3: Return Loss V/S Frequency for Length 20mm

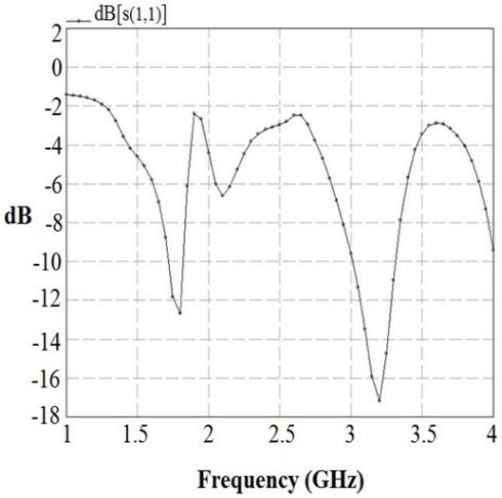

Fig.4. Return Loss V/S Frequency for Length 25mms

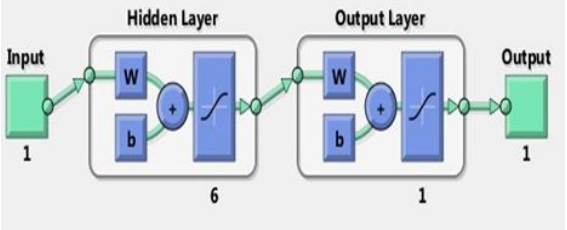

Fig. 5: Proposed Neural Network

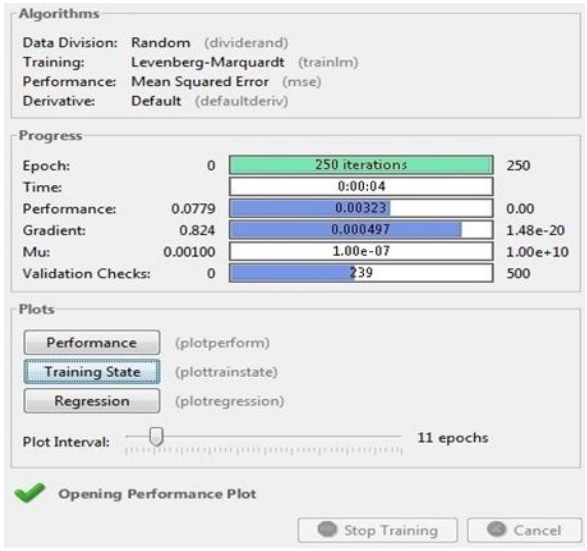

Fig. 6: Training of Neural Network

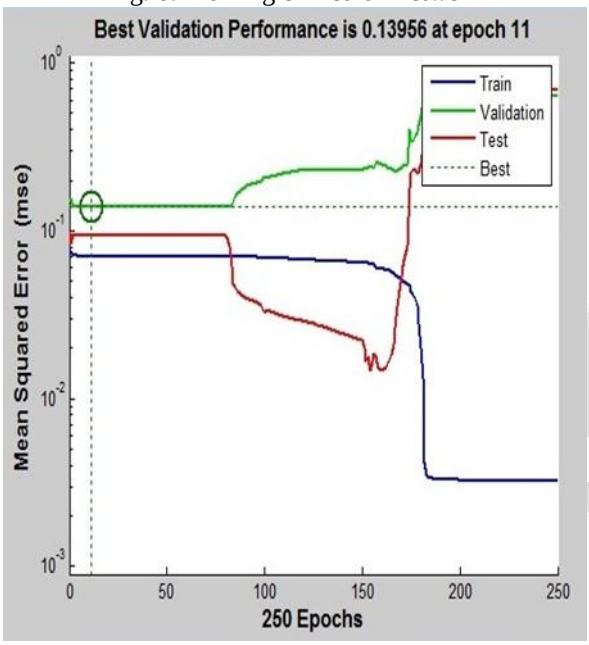

Fig. 7: Training Performances with Min MSE

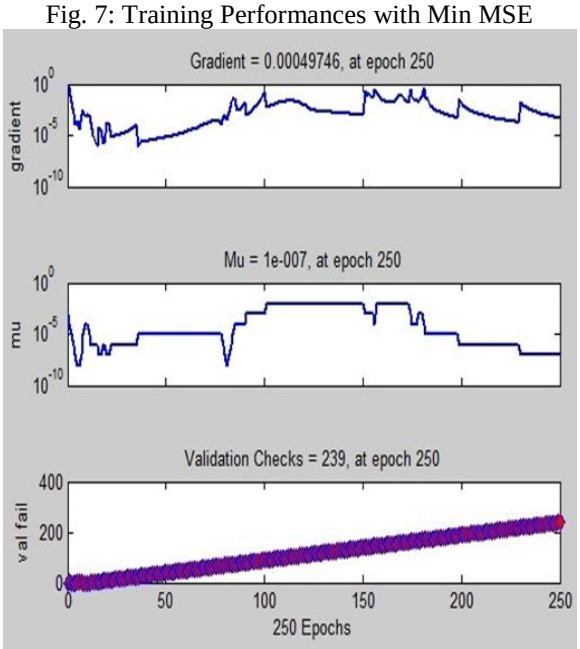

Fig. 8: Neural Network Training Result

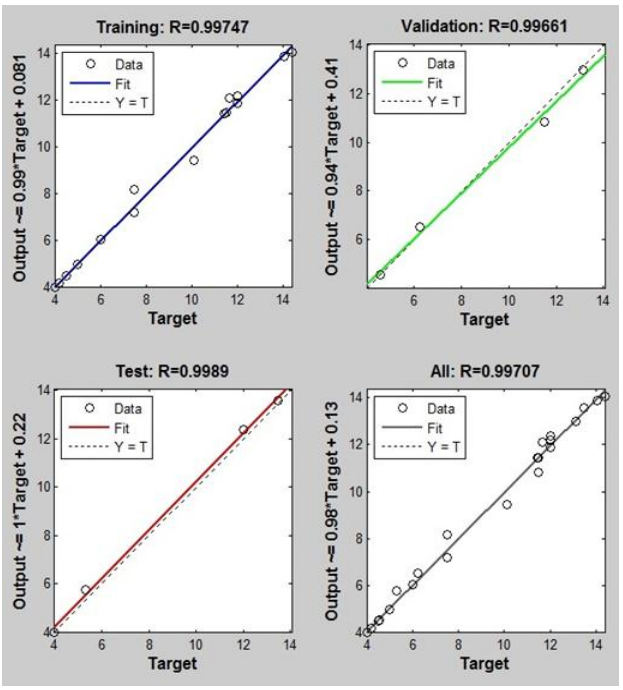

Fig. 9: Regression States

VIII. TESTING OF NEURAL NETWORK

The proposed neural network is tested for different values of slot length and the result from neural network is compared with the result of IE3D software and it is found that proposed neural network provides the result with high accuracy.

Length mm	%BW from proposed ANN	%BW from IE3D
18	12.72	12.5
26	7.02	7.5
36	4	3.88

Table 4: Neural Network Testing Result

IX. CONCLUSION

From the testing result it is clear that proposed neural network provides highly accurate result with in 2 or 3 seconds. So it is clear that with the help of ANN we can find the bandwidth of slotted antenna without using of IE3D thus save our time as well as to get rid of from the typical work that we have to do on antenna software.

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