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Bandwidth Analysis and Optimization of Ч shaped Microstrip Patch Antenna with Artificial Neural Network

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ABSTRACT: In this paper an artificial neural network optimization technique and models is used for analysis the bandwidth of Microstrip antenna. The Ч shaped Microstrip patch antenna designed and use operating frequency 6.83 GHz to analysis the bandwidth of antenna. Artificial neural network models used and varying the different parameters of Microstrip antenna to measure the bandwidth and its results is compared with artificial neural network results. The most common dielectric substrate Polyethylene =2.25. ANN is vey suited for analysis the proposed antenna and gives more easy calculation and design of microstrip patch antenna.

KEYWORDS: Microstrip Slot antenna; Simulation; Return loss; Bandwidth; Artificial neural network.

1 INTRODUCTION

Due to their many attractive features, Microstrip antenna has drawn the attention of researchers over the past work.

However, in recent year, researchers have offered various new Microstrip patch design to enhance the bandwidth of the Microstrip antenna [1]. This antenna is small in size, cost effective. In spite of all these advantages this antenna has some disadvantages also like narrow bandwidth and gain, poor polarization etc. For enhancing the bandwidth and gain many methods are used like using various patch shape[2],[3],[6],[7], varying patch size, changing substrate thickness, using different dielectric substrate[4], using array configuration and stack configuration[4],[5] etc. The microstrip patch antenna has been used in many wireless applications due to its various advantages such as light weight, low profile, easy fabrication and low cost. Therefore, this problem has been addressed by researchers and many configurations have been proposed for band width enhancement. Artificial Neural Network are developed for characterizing the **Ч** shaped patch antenna with multi band frequencies.ANN models is more accurate than other nonlinear models and provides more advantages[8-10] .Here the trained ANN data is used to find the different antenna characteristics by varying the structural input parameters of proposed antenna..The novelty of the work described here is that optimized the important characteristics, namely, resonant frequency, return loss, bandwidth and gain. In proposed work the multilayer back propagation is used to optimize the antenna structure as well as the antenna characteristics.

2 ANTENNA GEOMETRY AND DESIGN

In this paper the basic proposed structure is shown in Figure 1. Antenna is design using operating frequency f_r=6.83 GHz, height h= 3.17 mm, Polyethylene dielectric substrate ε_r = 2.25 and tangent $\tan\delta$= 0.0013.The different characteritics are return loss, VSWR, Gain and bandwidth are investigatd .These parameters are calculated by simulation software IE3D .

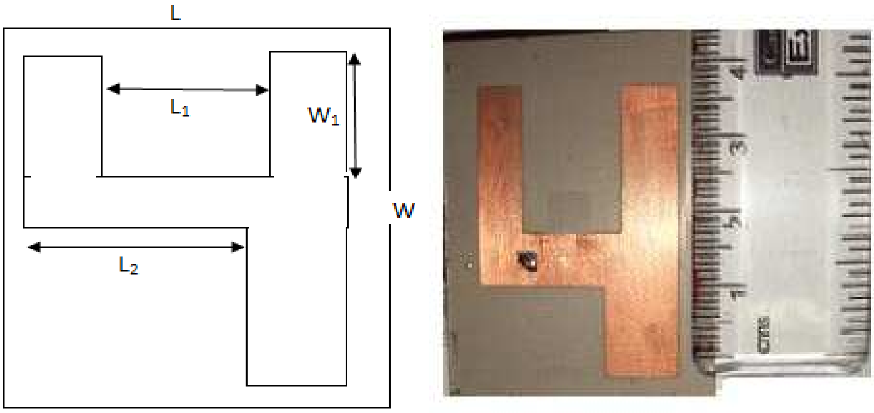

Figure 1. Geometry of the proposed antenna.

The patch has the dimension of 26 mm × 34 mm.Two rectangular slots are cut from the patch and obtained a Ч- shaped slotted microstrip patch which is mounted over the ground plane Lg × W_g = 45 mm × 53mm, shown in Fig 1.The coaxial probe feed of radius is 0.6 mm and feed of (x=-6) with respect to the centre (0,0). The parameters value for proposed antenna is shown Table1.

For a given resonance frequency (*f*) and dielectric substrate (ε_r) the parameters of proposed antenna are expressed as follows:

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

$$L = L_{eff} - 2\Delta L \qquad (2)$$

Where *eff* and ΔL are the effective and extended length of patch and expressed as:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \qquad (3)$$

$$(\Delta L) = 0.412h\,\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad (4)$$

ε_r is the effective dielectric constant of substrate is expressed as:

$$\varepsilon_{reff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (5)$$

Hence for this design the ground plane length (L_g) and width (W_g) would be given as:

L_g = 6h + L (6)

W_g = 6h + W (7) Where "h" is the thickness of substrate (in mm).

Table 1. Antenna design parameters

S. No.	Parameters	Values
1	h	3.17 mm
2	ε_r	2.2
3	W	34 mm
4	L	26 mm
5	L_1	14 mm
6	L_2	17 mm
7	W_1	15 mm

3 IE3D SIMULATED RESULTS

The bandwidthof proposed antenna for different values of length L_1 , width W_1 are calculated by simulation software IE3D which shown in Table 2.

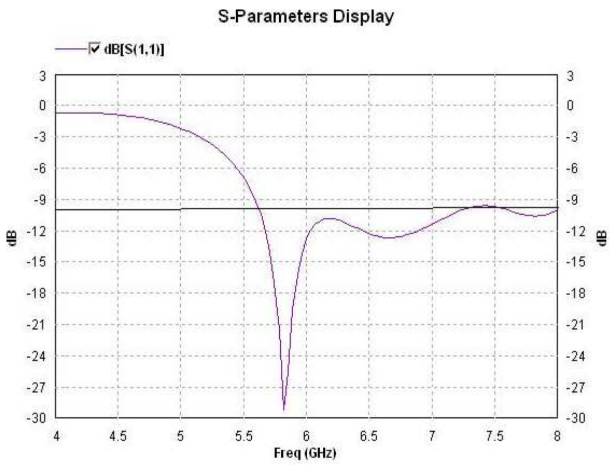

Figure 2. Simulated Return loss vs. Frequency graph

This graph shows the bandwidth 28.17% of proposed antenna covering the frequency range from 5.61GHz to 7.25GHz. This frequency range is most suitable for WLAN/WiMAX and many wireless communication systems.It gives maximum return loss is -28.53 dB at centre frequency 5.82GHz.The simulated current distributions of Ч –shaped microstrip patch antenna shown in Figure 3.Form current current distribution characteristics of Figure 3, it is observed that current is equaly distributed from the two similar end of proposed antenna.

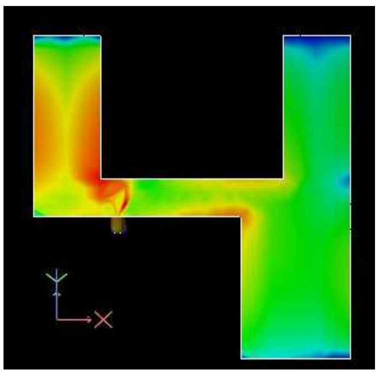

Fig 3. Current distribution pattern of proposed antenna

4 DESIGNING AND ARCHITECTURE OF NEURAL NETWORK

Neural network is consists of input layer,output layer and hidden layers.The architechture of ANN shown in figure 4. The Levenberg-Marquardt to neural network training is discussed in [11,12]. The Levenberg–Marquardt Back Propagation (LMBP) algorithm has been shown to be the fastest method for training moderate sized feed-forward neural networks (a few hundred weights). It also useful for accurate training but some cases the LMBP is produces small amount of mean square errors than other ann algorithms tested. Since the solution of the matrix equation is a built-in function. In order to make sure that the approximated Hessian matrix **H** and Jacobian matrix **J** can be rewritten as $\mathbf{J^TJ}$ is invertible; Levenberg–Marquardt algorithm introduces another approximation to Hessian matrix:

$$\mathbf{H \approx J^T J + \mu I} \qquad \textbf{(a)}$$

Where **μ** is always positive, called combination coefficient **I** is the identity matrix. The update rule of the Gauss–Newton algorithm is presented as

$$\mathbf{W_{k+1} = W_k - (J_k{}^T J_k)^{-1} J_k e_k} \qquad \textbf{(b)}$$

By combining Equations (a) and (b), the update rule of Levenberg–Marquardt algorithm can be presented as

$$\mathbf{W_{k+1} = W_k - (J_k{}^T J_k + \mu I)^{-1} J_k e_k} \qquad \textbf{(c)}$$

As the combination of the steepest descent algorithm and the Gauss–Newton algorithm, the Levenberg– Marquardt algorithm switches between the two algorithms during the training process. When the combination coefficient μ is very small (nearly zero), Equation (c) is approaching to Equation (b) and Gauss–Newton algorithm is used. When combination coefficient μ is very large, Equation (c) approximates to Equation (a) and the steepest descent method is used.In this neural network architecture consists of two input nodes, one output nodes and four hidden layers (twenty five nodes each layer). Two input variables are L_1 and W_1.

The training is done by Levenberg–Marquardt algorithm (LM) and epoch 500 as shown in Figure 4. For the analysis of antenna total 46 numbers of different samples parameters are used. Among these 40 data sets designed for training purpose and 6 data sets are used for testing which are not included in the training samples.

5 GENERATION OF TRAINING DATA

Input data set for proposed neural network is generated for optimization by varying the two parameters L_1 and W_1.and get the different values of Bandwidth shown in Table 2. Here the parameters L_1 and W_1 boths are varied with increment of 0.5mm. (-5 to +5).Training and testing data sets are found by varying the antenna parameters L_1 and W_1 which is obtained through IE3D simulation software based on methods of moments(MOM).

Table 2. Input and Target data set found from IE3D

SL No	Input Data		Train Data (IE3D)
	L_1	W_1	(BW %)
1	14	10	26.22
2	14	10.5	24.19
3	14	11	24.12
4	14	11.5	27.15
5	14	12	22.18
6	14	12.5	21.63
7	14	13	27.42
8	14	13.5	22.74
9	14	14	28.10
10	14	14.5	21.28
11	14	15	27.44
12	14	15.5	26.01
13	14	16	22.78
14	14	16.5	20.12
15	14	17	20.63
16	14	17.5	27.21
17	14	18	26.43
18	14	18.5	26.11
19	14	19	26.34
20	14	19.5	27.11
21	10	15	25.25
22	10.5	15	22.13
23	11	15	24.08
24	11.5	15	27.16
25	12	15	25.35
26	12.5	15	27.45
27	13	15	25.90
28	13.5	15	26.28
29	14	15	23.79
30	14.5	15	28.12
31	15	15	28.17
32	15.5	15	24.31
33	16	15	22.12
34	16.5	15	23.41
35	17	15	25.72
36	17.5	15	24.56
37	18	15	24.63
38	18.5	15	25.21
39	19	15	24.89
40	19.5	15	26.21

6 NEURAL NETWORK RESULTS

In Figure 4 shows the training performance of training and test results which are very close to each other. The performance is 0.0036413 which is reached at the end of 500 epochs.

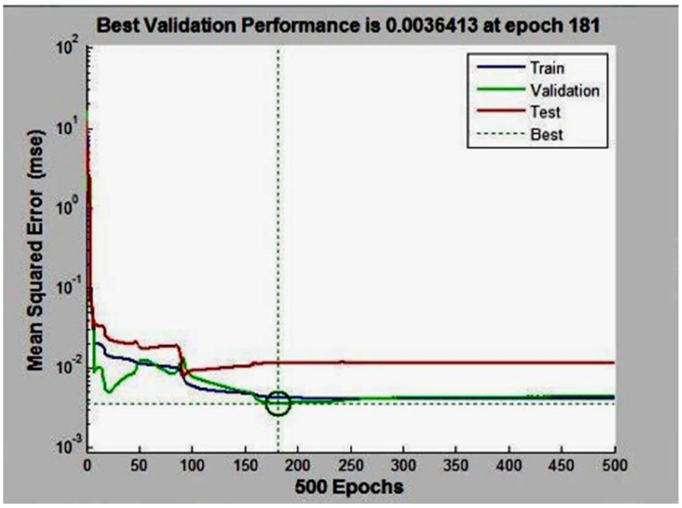

Fig 4. Training performance of ANN model

In this antenna the resonance frequency and Return loss are affected by the following parameters as L_1 W_1 .It is observed that the resonance frequency (f)and bandwidth are increased with increase the value of L_1shown in Figure5.

Table 3. Comparison results of IE3D and ANN outputs

SL No	Input Test Data		% BW (IE3D)	% BW (ANN)
	L_1	W_1		
1	14.2	10.5	26.22	25.7621
2	14.8	10.5	24.19	27.0284
3	15.6	14.5	23.82	23.9582
4	16	12.5	21.28	28.2882
5	16.4	14.2	23.07	26.7021
6	12.3	10.8	24.28	23.2035

This Table 3 shows the comparison results of IE3Dand ANN .Most of data are very closed each others.

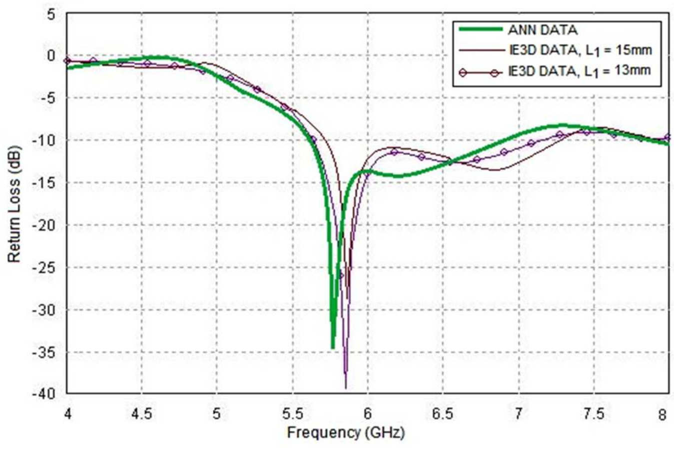

Figure 5. Comparison results of Return loss with variation L_1

Also it is observed that the resonance frequency and bandwidth are decreased with increased the value of W_1 but at same time the return loss is increased when all other parameters in Table 1 are fixed shown in Fig. 6.

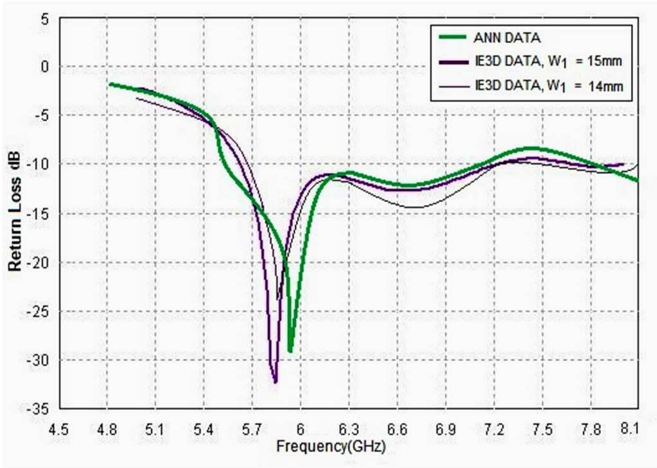

Figure 6. Comparison results of Return loss with variation W

The VSWR of proposed antenna is 1.64 shown in Fig 7.

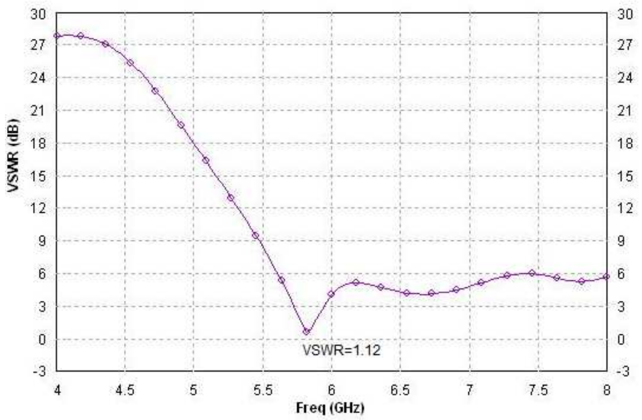

Figure 7. VSWR of proposed antenna (Simulated).

7 CONCLUSION

In this paper analysis for bandwidth of Ч – slotted microstrip patch antenna are achieved with the help of ANN model trained with Levenberg-Marquzdt algorithm. The bandwidth of proposed antenna is 28.17 %. The ANN results are closed to the IE3D results. Comparing results of simulated and Levenberg-Marquardt Neural Network outputs are satisfactory for microstrip broad banding, antenna size reduction, stable radiation pattern. These results shows that the ANN is studied successfully for analysis of bandwidth values of Ч – slotted microstrip patch antenna.

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REFERENCES

[1] Md. Mahabub Alam, Md. Suaibur Rahman, “A connected E-shape and U-shape Dual band patch Antenna for different wireless applications”, International Journal of Scientific & Engineering Research, ISSN 2229-5518, January 2013.

[2] Karim A. Hamad, “Design and Enhancement Bandwidth Rectangular Patch Antenna using Single Trapezoidal Slot Technique”.

[3] ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608, VOL. 7, NO. 3, p.p.292-297, March 2012.

[4] Elangovan, G. and J. Rajapaul Perinbam, "Wideband E-Shaped Microstrip Antenna for Wireless Sensor Networks," American

[5] E. Nishiyama, M. Aikawa and S. Egashira, "*Stacked microstrip antenna for wideband and high gain,"* IEE Proc.-Microw. Antennas Propag., Vol. 151, No. 2, p.p.143-148, April 2004.

[6] Amit Kumar Gupta, R.K. Prasad and Dr. D.K. Srivastava, "Design and Development of Dual E-shaped Microstrip patch antenna for *bandwidth and gain enhancement*," IJECET, ISSN: 0976-6464, Volume3, Issue3, Oct-Dec 2012.

[7] B-K Ang and B-K chung, " A Wideband E-shaped Microstrip Patch Antenna for 5-6 GHz Wireless communication, "Progress in Electromagnetics Research, Vol.75, p.p.397-407, 2007.

[8] Haykin, S., "Neural Networks: A Comprehensive Foundation". Printice-Hall Inc., USA, 1999.

[9] Chritstodoulou, C. G.; Georgiopoulous, M., "Applications of Neural Networks in Electromagnetics". Artech House, USA,2001.

[10] Krose , Ben; van der Smagt, P., "An Introduction to Neural Networks". University of Amsterdam, Netherlands, Noverber 1996.

[11] Patnaik, A.; Mishra, R,K., "ANN Techniques in Microwave Engineering" *IEEE Microwave Magazine*, Vol. 1,No. 1, March 2000, p 55-60.

[12] Vegni, L.; Toscano, A., "Analysis of Microstrip Antennas Using Neural Networks", *IEEE Transactions on Magnetics*, Vol. 33, No. 2, March 1997, p. 1414- 1419.