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Neural Network Analysis of Rectangular slot Loaded Patch Antenna for UMTS Application

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***Abstract-** In the present work first a rectangular slot loaded patch antenna is designed and then it is analyzed through artificial neural network. For this purpose the rectangular slot of antenna varying sequentially and its bandwidth is observed through IE3D simulation software. After it an artificial neural network is designed that directly gives the bandwidth of antenna for different length of the slot. For making a proposed neural network feed forward back propagation with levenberg marquardt training function is used. The proposed neural network gives highly accurate result after training. The proposed antenna is feeding through coaxial probe which gives 31.34% bandwidth and maximum antenna efficiency of about 98%.The proposed antenna is designed to operate in the frequency range of 1.824-2.502 GHz which is suitable for ultra mobile telecommunication system. The antenna is analyzed through IE3D simulation software for maximum bandwidth.*

***Keywords:** Coaxial probe, Slotted patch, UMTS, neural network.*

I. INTRODUCTION

Microstrip patch antenna is a type of microwave antenna and attracted widespread interest due to their small section plane, light weight and low profile. They are simple to manufacture and are easily integrated with circuits [1-2]. It is used for GPS/DCS/PCS/UMTS/WLAN and WiMax Applications [3-5]. It consists of a radiating patch on one side of a dielectric Substrate and a ground plane on the other side. Radiation from MSA can occur from the fringing fields between the periphery of the patch and the ground plane. By increasing the width W of the patch, substrate thickness and decreasing the ε_r the fringing fields from the patch can be enhanced which accounts for radiation. Therefore unlike the microwave integrated circuits (MIC) applications MSA uses microstrip patches with longer width and substrate with lower ε_r [6-8]. The conducting patch and the ground plane are separated by a low loss dielectric material called a substrate. The shape of the patch can be arbitrary. It may be square, rectangular, dipole, circular, elliptical, triangular, disc sector, circular ring; ring sector. The most popular shapes however, are the rectangle and circle. A coaxial line or strip line can be used to carry electromagnetic energy to the patch. Regardless of which feed line is used, the energy is first carried to the region under the patch. This region acts like a resonant cavity with open circuits on all sides. At this point the energy is either reflected back along the same feed line or it leaks out and radiates into free space resulting in an antenna [9-11]. The dimensions such as size, shape, as well as the thickness and dielectric constant (ε_r) of the substrate used to separate the patch and the ground plane of the patch, is determined on the basis of operating frequency of the patch antenna. If the operating frequency is lowered then the area of the patch is increased (whenever the substrate is not changed). The design of Microstrip antenna is vital study for today's Wireless communication system to achieve higher radiation pattern, highly directional beam and also to counteract the effect of fading while signal propagates through various corrupted environments.

Now the basic problem of antenna analysis is that it is very time consuming process through IE3D or any other software so in order to reduce the analysis time we used neural network approach [12-18]. The proposed network is based on feed forward back propagation model. The network has two layers with 4 neurons in hidden layer. Sigmoid transfer is used for making the proposed network.

II. ANTENNA DESIGN

In this paper the basic structure is as shown in fig1 is a rectangular patch of dimension 27.16 mm x 35.2 mm and ground plane length and width is 36.76 mm x 44.8 mm and the rectangular slot of length and width size is 25mm x 3.2mm.The dual triangle slotted microstrip patch antenna is designed. Glass epoxy substrate having εr=4.4 is used for making the proposed antenna. The operating frequency considered here is 2.6 GHz. The characteristics of proposed antenna such as return loss (RL), VSWR, and bandwidth (BW) of the proposed antenna have been investigated. The numerical study has been done by using Zeland IE3D electromagnetic simulator.

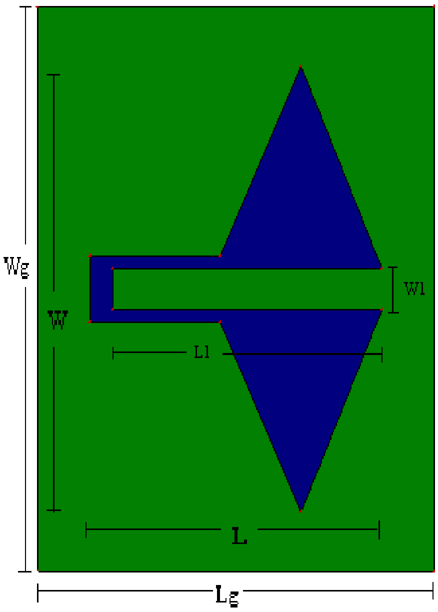

Fig.1. Geometry of proposed microstrip antenna for optimum bandwidth

TABLE 1 ANTENNA DESIGN PARAMETERS

Parameter	Value
h	1.6mm
ε_r	4.4
Wg	44.8mm
Lg	36.76mm
W	35.2mm
L	27.16mm
W_1	3.2mm
L_1	25.0mm

The calculations are based on transmission line model. The width and length of the microstrip patch have been calculated by using following equations (1)-(4).

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

The effective length (L_{eff}) of the patch can be calculated with the help of equations (3) and (4).

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

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

By using above equations we can find the value of actual length of the patch as,

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

III. DESIGNING & ARCHITECTURE OF PROPOSED NEURAL NETWORK:

GENERATION OF INPUT DATA SET:

Input data set for proposed neural network is nothing but the variation in slot of length L1 as shown in figure 1. Different value of slot length is taken as input to the neural network.

GENERATION OF TARGET DATA SET:

Target data set is nothing but the bandwidth of the proposed antenna for different value of the slot length which is obtained through IE3D simulation software. The input and target data set is given in table 2.

The architecture and training of proposed neural network is shown in figures 2 to 6. The other specifications of the proposed neural network are given as:[11]

Network type → Feed Forward Back Propagation
Number of layers → 2
Number of neurons in hidden layer → 4
Transfer function → TANSIG.
Training function → TRAINLM (Levenberg-Marquardt)
Adaption learning function → LEARNGDM
Performance → MSE (mean square error)
Error goal → 0
Number of epoch's → 151
Iterations → 151
Gradient → 1.78e-015

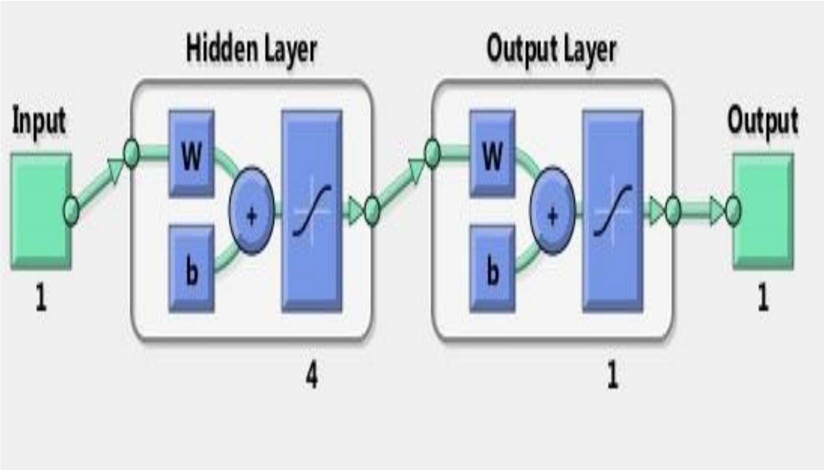

Fig.2. Proposed Neural Network

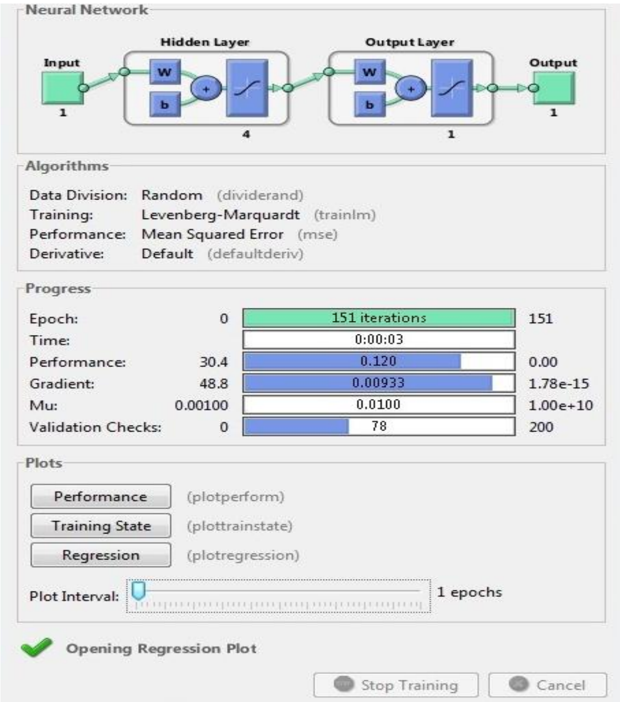

Fig.3 Training of Neural Network

IV. NEURAL NETWORK RESULT

Table 3 shows the result and accuracy of proposed neural network. The data that is used for comparison of neural network results with IE3D results is not included in training of neural network. Figure 4 shows the training performances of training and test results which are very close to each other.

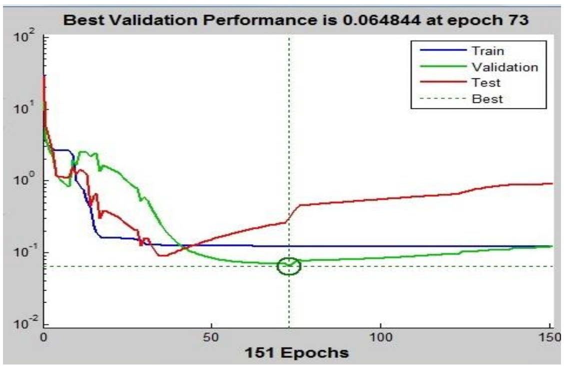

Fig.4.Training performances showing minimum MSE

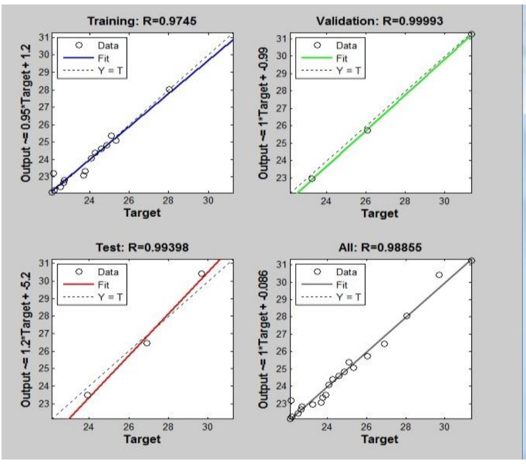

Fig.5.Regression states

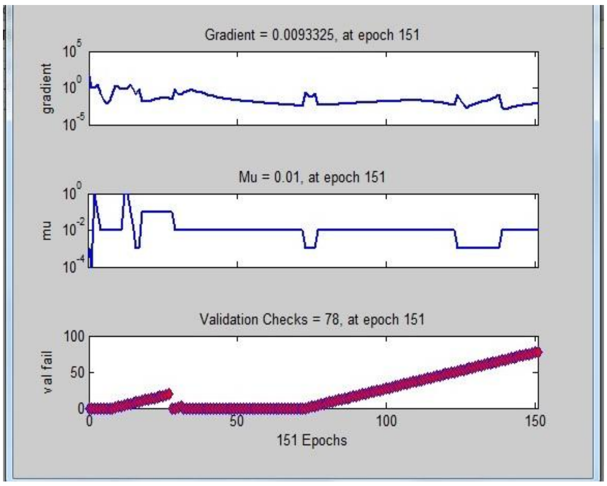

Fig.6.Neural network training result

TABLE 2: INPUT AND TARGET DATA SET.

S.No	Slot length (L_1) (input)	Band Width (%) (target)	S.No	Slot length (L_1) (input)	Band Width (%) (target)
1	25.0	31.34	**11**	20.0	24.07
2	24.5	29.69	**12**	19.5	23.91
3	24.0	28.04	**13**	19.0	23.78
4	23.5	26.91	**14**	18.5	22.16

5	23.0	26.06	**15**	18.0	23.70
6	22.5	25.11	**16**	17.5	23.26
7	22.0	25.34	**17**	17.0	22.7
8	21.5	24.87	**18**	16.5	22.66
9	21.0	24.58	**19**	16.0	22.50
10	20.5	24.28	**20**	15.5	22.18
11	20.0	24.07	**21**	15.0	22.10

IV. IE3D SIMULATION RESULTS OF PROPOSED ANTENNA

The bandwidth of proposed antenna for different value of slot length L_1 is determined through IE3D simulation software. The performance specifications like bandwidth, efficiency and directivity of proposed antenna is shown in the figures 7, 8 & 9. Figures7 shows the simulated Return loss Vs frequency of proposed microstrip antenna giving bandwidth is about 31.34% which is best suitable for UMTS applications. Figure 8 shows the maximum antenna efficiency of about 98%. Figure 9 shows the Directivity Vs Frequency of proposed microstrip antenna for optimum bandwidth.

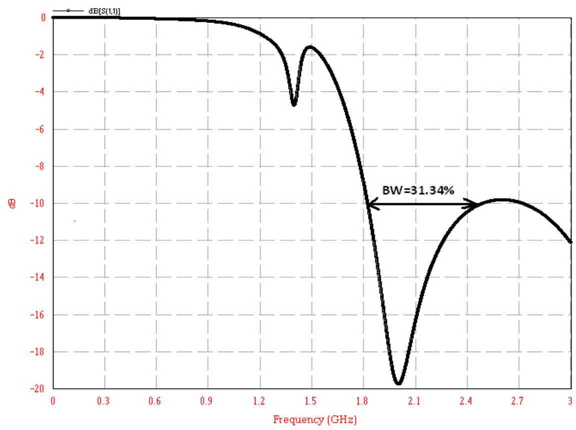

Fig.7.Simulated Return loss Vs frequency of proposed microstrip antenna for optimum bandwidth

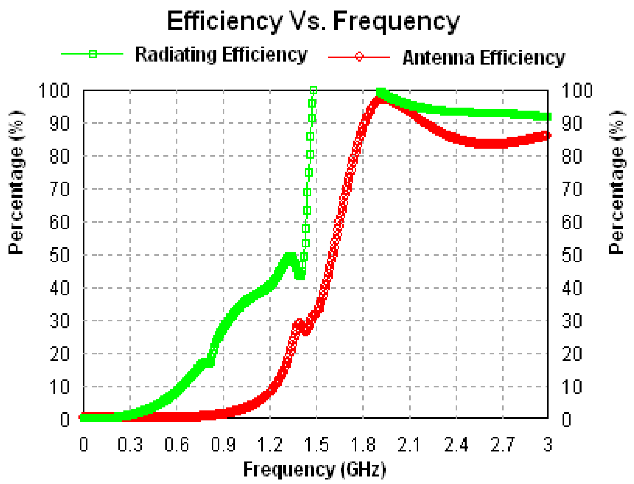

Fig.8.Efficiency Vs Frequency of proposed microstrip antenna for optimum bandwidth

TABLE 3: COMPARISON OF RESULTS OF IE3D AND PROPOSED ANN MODEL

S.No	Slot length (SL)	Band Width Through IE3D	Band Width Through ANN
1	24.46	29.53	30.27
2	22.7	25.19	25.50
3	20.76	24.45	24.49
4	19.61	23.91	23.60
5	17.75	23.26	23.01
6	15.46	22.24	22.22
7	14.5	21.97	22.10

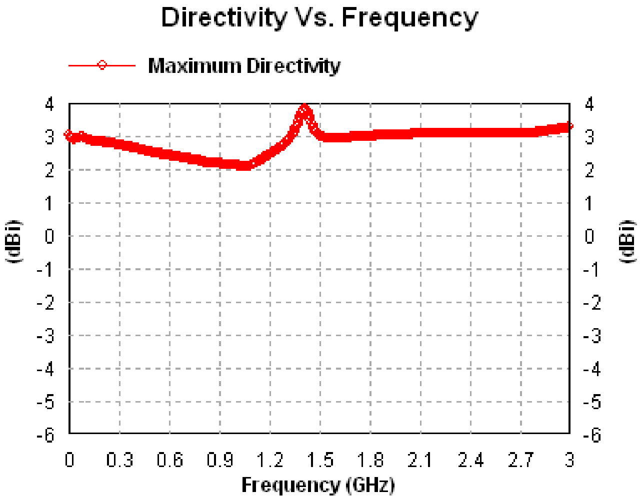

Fig.9.Directivity Vs Frequency of proposed microstrip antenna for optimum bandwidth

V. CONCLUSION

The characteristics of proposed antenna and its analysis through neural network are studied successfully. The bandwidth of proposed antenna for different value of slot length L_1 is determined through IE3D simulation software. Now the proposed neural network is trained for different value of slot length and target value is corresponding bandwidth for slot lengths. After training of neural network it gives highly accurate result. The proposed antenna is designed on glass epoxy (dielectric constant 4.4) substrate to give an optimum wide bandwidth 31.34% and maximum antenna efficiency of about 98% and the antenna is design to operate in the frequency range of 1.824-2.502 GHz which is best suitable for UMTS application.

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