Study, Analysis and Design of Rectangular Microstrip Patch Antenna based Algorithms used in Artificial Neural Networks

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Abstract

In this paper, the analysis and design of rectangular microstrip patch antenna by using various algorithms used in Artificial neural Network (ANN) is presented. The feed forward back propogation algorithm, Levenburg-Marquardt Algorithm (LMA) and Radial Basis functions(RBF) of ANN is used to design the parameter of Rectangular Microstrip Patch Antenna(RMPA). The results obtained from training and testing of data are very close to each other and shows good agreement with the results available and obtained from formulae. Here models of ANN have been used in the field of electromagnetics of microstrip patch antenna as the most powerful optimizing tools. With the help of this analysis model, we get the accurate value of resonant frequency with width and length of RMPA.

Key words: *RMPA, ANN, FFBPA (Feed-Forword Back-propagation Algorithm), LMA, RBF.*

1. Introduction

The Rectangular Microstrip Patch Antenna can be developed in different shapes like, Rectangular, square, circular etc. Microstrip antennas due to their many attractive features have drawn attention of industries and researchers over the past decades [2] for an ultimate solution for wireless antenna. The existing era of wireless communication has led to the design of an efficient, wide band, low cost and small volume antennas which can readily be incorporated into a broad spectrum of systems. Since Neural networks also have recently gained attention as a fast and flexible vehicle to EM modeling, simulations and optimization. This paper is an attempt to exploit the capability of various algorithm used in artificial neural networks to calculate the resonating frequency of RMPA. With given parameters like width length height of dielectric substrate and dielectric constant.

2. Design of RMPA

Rectangular Microstrip Patch Antennas because of the radiating elements (patches) photoetched on the dielectric substrate. This radiating patch may be square, rectangular, circular, elliptical, triangular, and any other configuration. In this paper, rectangular microstrip patch antennas are taken under consideration. The patch dimensions of rectangular microstrip antennas are usually designed so its pattern maximum is normal to the patch. Because of their narrow bandwidths and effectively operation in the vicinity of resonant frequency, the choice of the patch dimensions giving the specified resonant frequency is very important .The rectangular microstrip antennas are made of a rectangular patch with dimensions of width (W), length (L) over a ground plane with a substrate thickness h and dielectric constants ε_r . Dielectric constants are generally used in the range $2.2 \leq \varepsilon_r \leq 12$. But, the most desirable are the dielectric constants at the lower end of this range together with the thick substrates, because they give better efficiency and larger bandwidth. For an effective radiator, a practical width that leads to good radiation efficiencies is given by [1]:

$$W = \frac{c}{2fo\sqrt{\frac{\varepsilon r+1}{2}}} \quad (1)$$

Where c is the free space velocity of light, the effectife dielectric constant of microstrip antenna

$$\varepsilon_{eff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}[1+12\frac{h}{W}]^{\wedge-(1/2)} \quad (2)$$

Where εeff = Effective dielectric constant
εr = Dielectric constant of substrate
h = Height of dielectric substrate
W = Width of the patch
The actual length of the patch

$$L = \left[c/2fr\sqrt{\varepsilon eff}\right] - 2\Delta L \quad (3)$$

Where ΔL is the extension of the length due to the fringing effects and is given by [3,4]

$$\Delta L = 0.412h\frac{(\varepsilon eff+0.3)(\frac{w}{h}+0.264)}{(\varepsilon eff-0.258)(\frac{w}{h}+0.8)} \quad (4)$$

$$f_r = \frac{c}{2\sqrt{\varepsilon eff}(L+2\Delta L)} \quad (5)$$

The design model, In this model, the accurate value of resonant frequency has been calculated with input parameters permittivity ε_r, the height of substrate h and patch dimensions width and length. The analysis model is as given in figure1. FFBPA and RBF algorithm is developed in MATLAB 7.11. The 201 data samples are used to design RMPA.

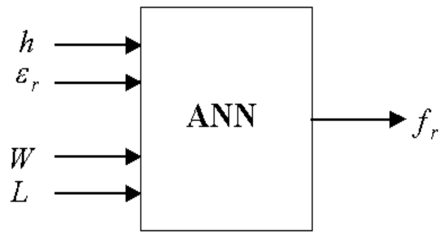

Figure 1 Analysis Model of ANN

The data samples generated is used for training and testing of ANN data is obtained from formula given in equation5, and after training 41 samples are tested the details of 21 data samples have been shown in table1.

3. Neural Network Model and Training

The relation between Target value and predicted is accurate and efficient models for antenna designing and are essential for cost effective design. In this design patch dimensions length L and width W supplied with dielectric constant ε_r and substrate thickness h to the ANN model as in fig.1 and then frequency is calculated as an output of ANN.The network is trained using back propagation algorithm [5] Levenburg-Marquardt Algorithm[8] and Radial Basis Function [6] in the network. There are three layers, input layer, hidden layer and output layer. There are four input Parameter, and one output parameter and number of hidden neurons 20 depending on network accuracy. The training algorithm used is trainlm [8] .The error goal is 0 and learning rate kept is 0.4.

4. Network Testing

The performance of the network is tested by a second set of sample vector pairs in the relevant range. These samples are were included in the training data set

5. Results

The neural network developed models the response of the Microstrip patch antenna shown in Figure 2, Figure 3 and Figure 4 the RBF network the LMA network and the feed forward back propagation network giving the best approximation to the target values. The Table 2 shows the comparison of results between RBF, LMA and FFBPA. The values obtained from ANN are very close to simulation readings. The error between the outputs of Artificial Neural Network against Target is measured in terms of Mean Square Error (MSE) which is very small or one can say it is almost zero in case of the networks used in this paper, hence ANN can be used in obtaining resonant frequency of RMPA efficiently.

6. Conclusions

The paper utilizes a new approach of using an ANN for fast and accurate solving of Microstrip Patch Antenna design problem. Neural Network offers the advantage of superior computational ability due to high degree of interconnectivity .This ability makes a Neural Network very attractive in many applications. In future these models can be developed with the help of self Organization Map.

7. References

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Table 1 Frequency for different values of W and L with ε_r=4.7, h=2mm

S.No	Length	Width	Frequency	FFBPN	LMA	RBF
	Mm	Mm	GHz	GHz	GHz	GHz
1	4.60	7.60	12.3064	12.3064	12.3064	12.3064
2	4.62	7.62	12.2651	12.2651	12.2651	12.2651
3	4.63	7.63	12.2446	12.2445	12.2446	12.2446
4	4.65	7.65	12.2037	12.2037	12.2037	12.2037
5	4.66	7.66	12.1833	12.1833	12.1833	12.1833
6	4.67	7.67	12.1630	12.1631	12.163	12.163
7	4.68	7.68	12.1428	12.1429	12.1428	12.1428
8	4.70	7.70	12.1026	12.1026	12.1026	12.1026
9	4.71	7.71	12.0826	12.0826	12.0826	12.0826
10	4.73	7.73	12.0427	12.0428	12.0427	12.0427
11	4.77	7.77	11.9638	11.9638	11.9638	11.9638
12	4.80	7.80	11.9053	11.9053	11.9053	11.9053
13	4.84	7.84	11.8282	11.8281	11.8281	11.8282
14	4.86	7.86	11.7900	11.7899	11.7899	11.79
15	4.91	7.91	11.6955	11.6955	11.6955	11.6955
16	4.92	7.92	11.6768	11.6769	11.6768	11.6768
17	4.93	7.93	11.6582	11.6582	11.6581	11.6582
18	4.94	7.94	11.6396	11.6397	11.6396	11.6396
19	4.95	7.95	11.6210	11.6211	11.621	11.621
20	4.96	7.96	11.6026	11.6027	11.6026	11.6026
21	5.00	8.00	11.5293	11.5291	11.5293	11.5293

Table 2 Performance Comparison

ANN	MSE	Performance
RBF	1.28E-14	1.46836e-014
LMA	2.58E-10	1.266e-009
FFBPA	2.84E-09	2.1773e-009

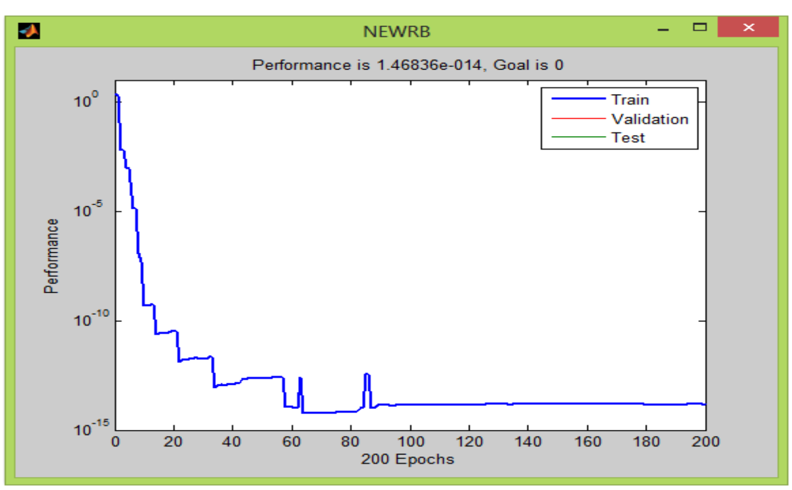

Figure 2 Performance Result for RBF Network

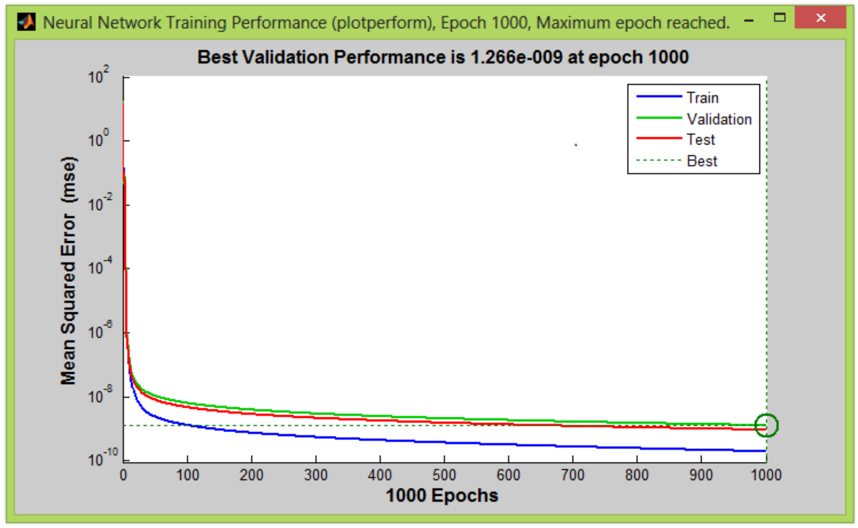

Figure 3 Performance Result for LMA Network

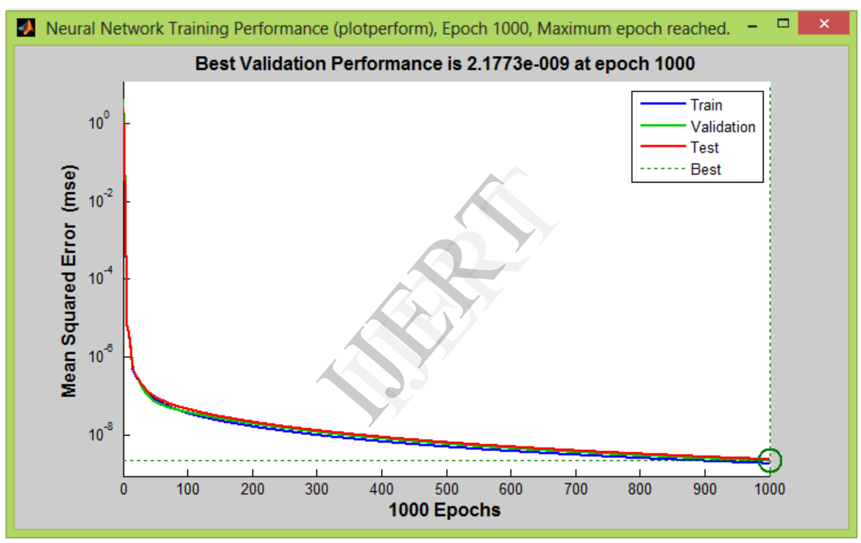

Figure 4 Performance Result for FFBPA Network