"Design of Micro Strip Patch Antennas Using Knowledge Based Soft Computing Techniques"

E. Kusuma Kumari[1] Dr. D. C. Panda[2]

[1]Associate Professor, ECE Dept. Gayatri Institute of Engineering & Technology

[2]Berhampur University, Orissa

Abstract – This paper explains different computing techniques for the design of Micro strip patch antenna. The performance of antenna is significantly influenced by the selection of technique used to design antenna. In this paper three dissimilar soft computing techniques are presented and compared. The mainly lately used techniques Artificial Neural Networks (ANNs), Fuzzy Logic (FL) and Adaptive Neuro-Fuzzy Inference System (ANFIS) are explained. Antenna design is simulated for all three techniques and result is compared with every additional. ANFIS is the most efficient technique to use. As far as number of training data set is concern ANFIS necessitate small data set and hence ANFIS provides optimization too. Micro strip antenna design using a soft computing tool Artificial Neural Network the planned patch antenna is designed and replicated on the Zeland IE3D software and the outcomes are trained and verified using Artificial Neural networks.

Keywords: Artificial Neural Network, Micro Strip Patch Antennas, Soft Computing Techniques

---♦---

INTRODUCTION

Artificial neural networks are information processing systems with their design motivated by the studies of the capability of the human mind to study from comments and to generalize by generalization. As greatly nonlinear structures, ANNs are able to truthfully model any arbitrary nonlinear input–output relations among dissimilar data sets giving an efficient alternative to conservative technique such as arithmetical modeling techniques, which could be computationally exclusive, or analytical methods, which could be complex to achieve for new devices or empirical models, whose range and truthfulness could be limited. ANN model can be learned from: full-wave electromagnetic simulators, physics-based models, or measurements.

In the last decade, the use of different soft computing techniques has improved for design and optimization of various antennas. Soft computing technique differs from hard computing in that, not like hard computing, it is tolerant of imprecision, improbability, approximation and on the basis of partial truth. The principle of soft computing is: develop the tolerance of imprecision, improbability, approximation and partial truth to achieve the tractability, robustness and low resolution price. The principal constituents of Soft Computing (SC) are:

- Artificial Neural Networks (ANNs)
- Fuzzy Logic (FL)
- Evolutionary Computation (EC)
- Machine Learning (ML)
- Probabilistic Reasoning (PR)
- Genetic Algorithm (GA)
- Adaptive Neuro-Fuzzy Inference System (ANFIS).

The main constituent methodologies in Soft Computing (SC) are complementary rather than competitive. Soft computing may be out looked as a foundation element of conceptual brainpower (Bharadwaj, Prasanna, 2010. Ray, *et al.,* 2008. Deschamps, 1953). In many cases a difficulty can be resolved most effectively by using FL, ANNs, GA and PR in combination rather than competitive. A good example of a particular effectual combination is what has come to be known as "Neuro-Fuzzy systems." Such a method is generally used in consumer foodstuffs choice from air conditioners and washing machine to photocopiers. This paper presents most extensively used three techniques.

1) Artificial Neural Networks,

2) Fuzzy Inference System and

3) Adaptive Neuro Fuzzy Inference System.

ARTIFICIAL NEURAL NETWORKS

Neural computing: Artificial Neural Networks (Ann's) is an important processing pattern that is motivated from the biological anxious method, such as mind. It is collected highly inter joined processing elements called as neurons. Artificial Neural Networks (Ann's), like humans learn from example. A neural network is an artificial representation of the human brain. It tries to suggest its learning procedure. The term artificial resources that neural networks are executed in computer programs that are able to handle the large number of required calculations during the knowledge method. An ANN is configured for a definite application, such as pattern recognition or data categorization, through a education method. Learning in biological systems involves adjustments to the synaptic connections that survive among the neurons. This is also true for Ann's (Balanis, 2008).

ANNs Architecture: The basic structural design consists of three types of neuron layers: input, hidden, and output. ANN structure has two basic components, (1) the processing elements and (2) the interconnection among them. The processing elements are called neurons and the connections among the neurons are known as links or synapses, as shown in fig-1. Each link has the corresponding weight associated with it. Every neuron obtains incentive from other neurons joined to it, procedure the information and produces an output. Neurons that receive the stimuli or input from peripheral surroundings are known as input neurons, while neurons whose outputs are given to the external environment are known as output neurons. Neurons that obtain the stimuli or input from the other neurons and whose outputs are stimuli for other neurons in the networks are known as hidden neurons (Lamba, 2011).

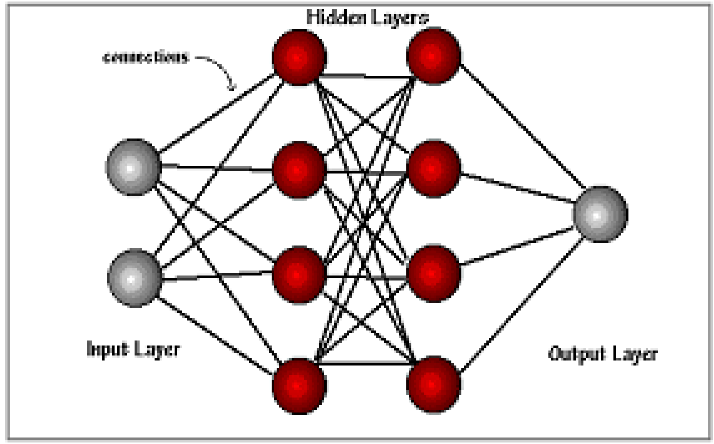

Fig-1 Neural Network Architecture

Network Size and Layer: The number of hidden neurons depends on the degree of non-linearity of function and dimensionality of inputs and outputs. Extremely nonlinear element requirements more neurons and smoother requirements fewer neurons. However, we do not specify the size of the networks. User can employ either experience or a trial and mistake procedure to judge the number of secreted neurons. Generally, one or two hidden layer is generally used for antenna applications. But there is presently no theoretical motive to use neural networks more than two hidden layer. With no secreted layer is capable of representing linear separable functions or decisions (Balanis, 2008). Rule-of-thumb techniques:

- The number of hidden neurons should be 2/3 the size of the input layer, plus the size of the output layer.
- The number of hidden neurons should be less than twice the size of the input layer.
- For a three layer network with n input and m output neurons, the hidden layer would have (n m) neurons.

FUZZY INFERENCE SYSTEM

Fuzzy inference is the technique of formulating the charting from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made, or models discerned. The technique of fuzzy inference involves membership functions, logical operations, and if-then Rules. You can implement two types of fuzzy inference systems in the toolbox: Mamdani-type and Sugeno-type. Fuzzy inference systems have been successfully applied in fields such as automatic control, data classification, decision analysis, expert systems, and computer vision. Fuzzy inference systems are associated with a number of names, such as fuzzy-rule-based systems, fuzzy expert systems, fuzzy modeling, fuzzy associative memory, fuzzy logic controllers, and basically (and ambiguously) fuzzy systems (Lamba, 2011).

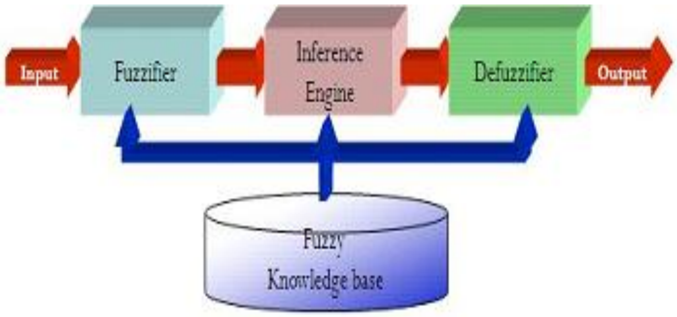

Fig-2 Fuzzy Inference System

ADAPTIVE NEURO-FUZZY INFERENCE SYSTEMS

The basic idea after these Neuro-Adaptive learning techniques is very simple. These techniques provide a technique for the fuzzy modeling process to learn information about a data set, in order to compute the relationship purpose parameters that best allow the associated fuzzy inference method to pathway the given input/output data. This learning technique works likewise to that of neural networks (Heidari, Dadgarnia, 2011. Singh, *et. al.,* 1993. Zadeh, *et. al.,* 1994). The word ANFIS derives its name from adaptive Neuro-Fuzzy inference system. Using a given input/output data set, the toolbox function ANFIS constructs a fuzzy inference system (FIS) whose relationship function parameters are tuned (adjusted) using either a back propagation algorithm only, or in grouping with a slightest squares type of technique. This allows your fuzzy systems to learn from the data they are modeling. Fuzzy systems are more constructive in that their behaviour can be clarified based on fuzzy rules and thus their presentation can be accustomed by tuning the system. But since, in common, fuzzy systems are classified to the fields where the specialist knowledge is obtainable and the number of input variable is small. To overcome the difficulty of knowledge acquisition, neural network are extensive to mechanically extract fuzzy rules from numerical data. ANFIS use the neural network to optimize certain parameters of an ordinary fuzzy system, or to pre-process data and extract fuzzy rules from the data (Jang, *et. al.,* 2004).

ANTENNA DESIGN AND LAYOUT

To design a rectangular micro strip patch antenna following parameters such as dielectric constant of substrate (ε_r), the resonant frequency (f_r) and height of the substrate (h) should be measured for calculating the length and the width of the rectangular micro strip patch.

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

Where c is the velocity of light, ε_r is the dielectric constant of substrate, f is the antenna functioning regularity, W is the patch width; the effectual dielectric constant and the length extension are given as,

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

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

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

Figure 3 shows the layout of a coaxial probe-fed slotted patch antenna. The slots on the scrap are shown in Figure 3, where, L and W are the length and width of the scrap. The scrap is fed by a coaxial probe. The resonant frequency for the planned antenna is 5.61GHz. The substrate used for the production of planned antenna is RT Duroid 5880 substrate with dielectric. For the design of Micro strip antenna IE3D electromagnetic simulator is used. The dimension of Antenna is as follows:

Table 1 Antenna design parameters

Parameters	Value (mm)
W	20
L	17
L_1	9.8
W_1	7.6
W_2	6.2

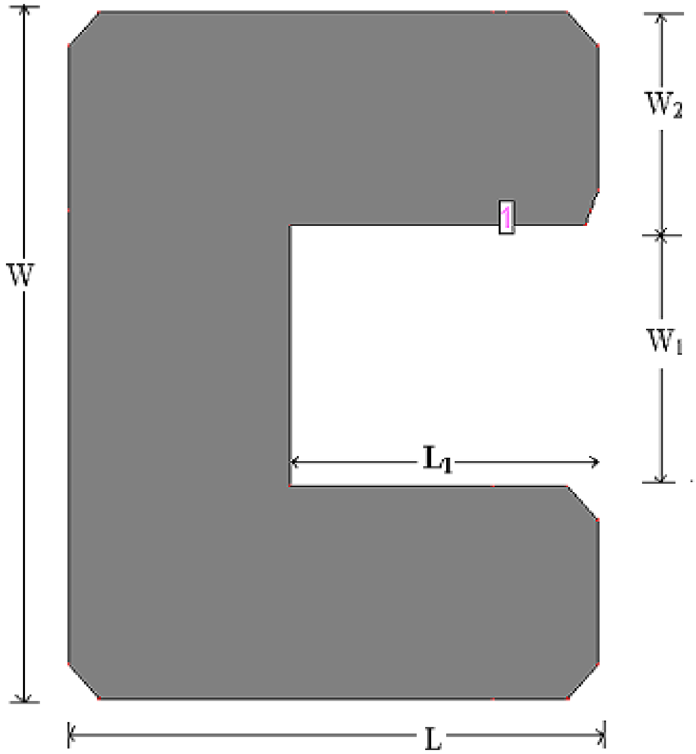

Figure 3 Geometry of C shaped micro strip antenna

TRAINING DATA AND GENERATION WITH EM AND ANN

The data has been obtained from the Zeland IE3D simulator based on techniques of moments. The width and length of the patch is kept constant and position of the feed is varied to obtain the resonant regularity and concurrently bandwidth of the micro strip antenna is calculated. MLP networks are feed forward networks qualified with the standard back circulation algorithm. The working out purpose used is TRANLM and the adaption learning function used is TRAINGDM they are supervised networks and also they necessaries a preferred response to be trained. With one or two hidden layers they can approximate practically any input output map (Singh, Ali, 2010). The weights of the network are usually computed by training the network.

Table 2 Comparison of results of IE3D and ANN

SLOT LENGTH (L_1)	SLOT WIDTH (W_1)	PROBE (X_1,Y_1)	BW IE3D (GHz)	BW FFBPN (GHz)	BW WITHOUT SLOT(GHz)
10	7.6	16,17.5	0.591, 0.850	0.591 0.852	0.536, 0. 531
10	7.6	16,18	0.592, 0.891	0591 0.892	0.536, 0. 531
10	7.6	16,18.5	0.592, 0.899	0.593 0.896	0.536, 0. 531
10	7.6	16,19	0.566, 0.799	0.565 0.799	0.536, 0. 531
10	7.6	16,19.5	0.563, 0.763	0.561 0.762	0.536, 0. 531
10	7.6	16,20	0.523, 0.633	0.522 0.631	0.536, 0. 531

NEURAL NETWORK ARCHITECTURE AND TRAINING

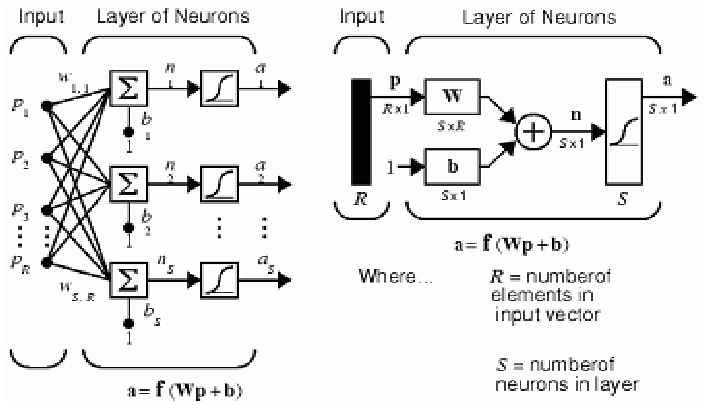

Figure 4 Feed Forward Network

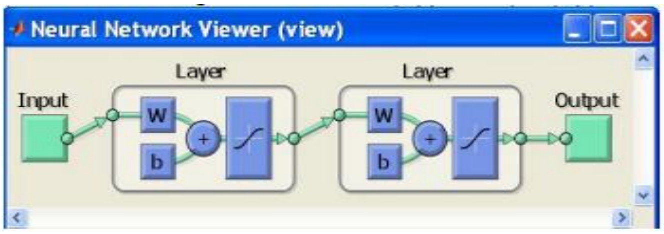

Figure 5 Neural Network Viewer as obtained from MATLAB

RESULTS AND DISCUSSIONS

Figure 6 shows the return loss diagram of micro strip antenna. The slotted antenna resonanates at 5.61 GHz and 6.84 GHz frequency giving double bandwidths of 8.08% and 8.15% hence it is suitable for dual band operations. Results obtained from the electromagnetic simulator IE3D has been used as an input to the soft computing tool Artificial Neural Network is calculate from the ANN as well as IE3D simulator and it is observed that in both cases the outcome are satisfactory as represented in table 2. Figure 7 shows the smith chart; figure 8 shows the emission model and figure 9 shows the VSWR curve which are of c shaped micro strip antenna achieved from IE3D.The planned micro strip antenna have improved gain and good radiation efficiency.

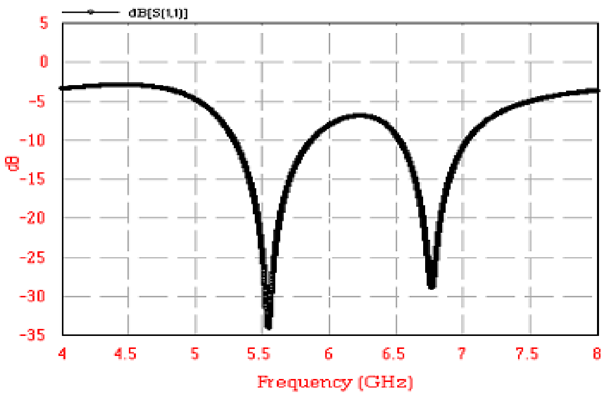

Figure 6 Return loss Vs frequency plot of C shaped micro strip antenna

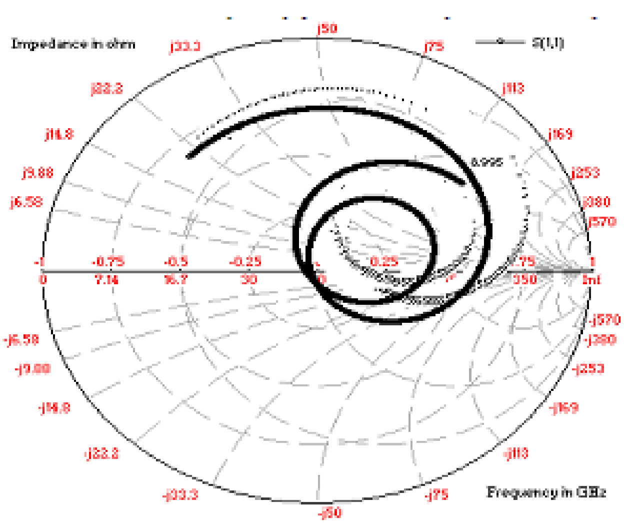

Figure 7 Smith Chart plot of C shaped micro strip antenna

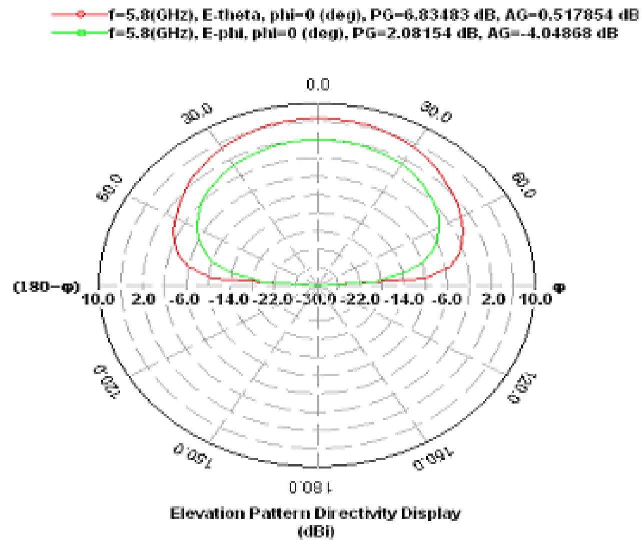

Figure 8 Radiation Pattern of the C shaped micro strip Antenna.

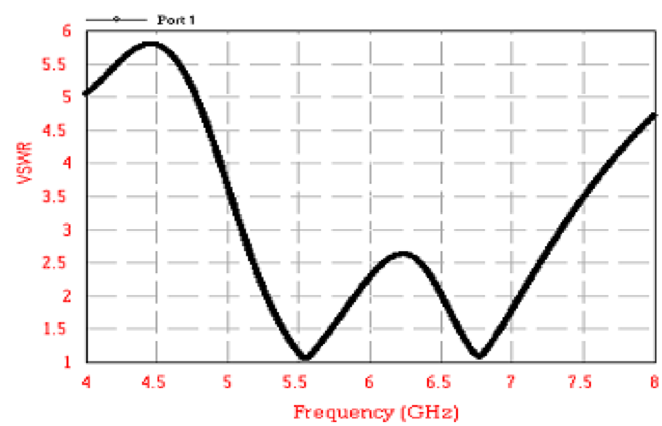

Figure 9 VSWR Vs frequency of C shaped micro strip antenna.

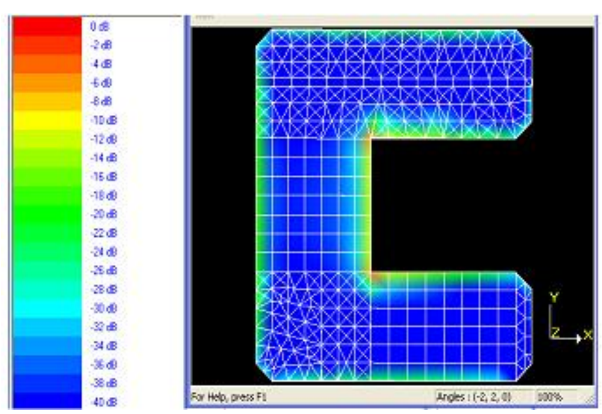

Figure 10 Current Distribution of C shaped micro strip antenna.

CONCLUSION

In this paper neural network systems are used as unconventional tools for square and rectangular patch antenna design Soft Computing Techniques. Our work is proposed to save the time of antenna designers as well as resolving the design problems with very good accuracy. This tool necessitates no prior knowledge of the antennas for implementation. ANFIS and Quasi Newton techniques can help in developing quicker and accurate techniques which can be used in computer aided micro strip antenna design. Thus ANFIS is the most efficient and effectual technique to use. Micro strip shaped antenna is computed truthfully by using the Artificial Neural Network model. The advantage of Artificial Neural Network model is simplicity and truthfulness. The Artificial Neural Network allows us to provide very fast, results of analysis.

REFERENCES

Abbas Ali Heidari, Abolfazl Dadgarnia, (2011). Design and Optimization of a Circularly Polarized Microstrip Antenna for GPS Applications Using ANFIS and GA, IEEE Transactions.

C. A. Balanis (2008). Modern Antenna Handbook, John Wiley and Sons, Chapter 33.

G. A. Deschamps, (1953). “Microstrip microwave antennas,” Presented at the Third USAF Symposium on Antennas, 1953.

Ganesh Bharadwaj, Prasanna Vadana D. (2010). “Resonant Frequency Computation of E- Plane Mutually Coupled Rectangular and Circular Patch Antennas Using Unconventional Tools”, IEEE conference.

I. Ray, M. Khan, D. Mondal, and A.K. Bhattacharjee, (2008). “Effect on resonant frequency for E-plane mutually coupled microstrip antennas”, progress in electromagnetics research letters, vol. 3, pp. 133-140.

J. S. R. Jang, C. T. Sun, E. Mizutani, (2004). Neuro-Fuzzy and Soft Computing, Pearson Education, 2004.

Jyh-Singh, Roger, Jang, (May/June 1993). Adaptive-Network-Based Fuzzy Inference System, IEEE Transactions on systems, man, and cybernetics, vol. 23, no. 3.

K. Guney, N. Sarikaya, (2008). Concurrent Neuro-fuzzy systems for resonant frequency computation of rectangular, circular, and triangular microstrip antennas, Progress In Electromagnetics Research, PIER 84, 253277.

V. K. Lamba (2011). Neuro-Fuzzy Systems, University Science Press.

Vinod K. Singh, Zakir Ali, (June 2010). “Dual Band U-shaped microstrip antenna for wireless Communication” International Journal of Engineering Science Technology, India, VOL 2 (6), pp 1623-1628.

Zadeh, Lofti A., Fuzzy Logic, (March 1994). Neural Networks, and Soft Computing, Communication of the ACM, vol. 37, no. 3.