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DESIGNING AND CHARACTERISTICS OF RECTANGULAR MICROSTRIP ANTENNA USING ARTIFICIAL NEURAL NETWORK

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Abstract :-

This Paper presents the design of rectangular microstrip antennas using artificial neural networks and its characteristics. Designing consist of synthesis in the forward side and analyzed as the revers side of the problem. The basic geometry of the microstrip antenna to obtain the various antenna dimensions to calculate the resonant frequency and furtheruse it in training the ANN model. In this work it is required to make a proper selection of the dielectric substrate and resonant frequency for which the antenna is to be designed. The neural network training algorithms are used in simulation of results for training the samples to minimize the error and obtain high accuracy. The results obtained from IE3D and those obtained using ANN and found to be good agreement almost 99% accuracy.

Key Words:- Microstrip antenna , Artificial Neural Network, Dielectric Sustrate, Metallic Surface.

1. INTRODUCTION

In any electrical circuit, antennas are the basic components that provide a linkage between transmitter and free space and between free space and receiver by converting the electrical energy into electromagnetic energy in the form of electromagnetic waves. Microstrip Antenna (MSA) technology that has evolved from academic novelty to the commercial reality with applications in a wide variety of microwave systems. Developed after revolution in electronic circuit miniaturization and LSI in 1970, the concept of MSA was first proposed in 1953 in the USA by Deschamps[1]and in France by Guttonand Bassinot [2]. The practical antennas were however developed by Munson [3] and Howell [4] in the 1970s. In the last two decades, it has become the most developing area in the field of antennas, receiving creative and overwhelming attention of academic, industrial, government engineers and researchers throughout the world. Infact, the rapidly developing markets in mobile satellite communications, Direct Broadcast Televisions (DBT), Personal Communication Systems (PCS), Wireless Local Area Network WLAN) suggest that the demand of microstrip antennas and arrays is to increase further. The extensive studies have been devoted to enhance the performance of MPAs resulting in their numerous applications in industrial and commercial

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sector. The area of microstrip antennas has emerged as one of the premium vigorous field of antenna theory where an increasingly creative effort is getting added day by day. Although the designing of MSA is not an easy task to achieve, inspite of this, the microstrip antennas due to their attractive features of being light weighted, low profile, less expensive and having ease of installation have gained immense popularity in various wireless applications viz. the high performance spacecraft, aircraft, missile and satellite applications. Microstrip antennas being low profile, conformal to both planar and non-planar surfaces, simple and inexpensive to fabricate using modern circuit printing technology exhibit compatibility with MMIC designs and when a particular shape and mode is selected, they are very versatile in terms of resonant frequency, radiation pattern, impedance and polarisation.

In this Paper, rectangular microstrip patch antenna is designed using artificial neural network modelling structure. The most important aspect of antenna designing is the selection of appropriate substrate material. The feed line and the radiating patch are usually photoetched on the dielectric substrate. For a rectangular patch, the length L of the patch is usually selected as to lie between 0.333ʎo and 0.5ʎo, where, ʎo= free space wavelength. The height of the dielectric substrate is selected to lie between 0.003 ʎo and 0.05ʎo. A thick substrate of low dielectric constant is usually preferred such that **εr** lies between 2.2-12 for good antenna performance, since it provides better radiation, larger bandwidth and better efficiency [5].The standard rectangular MSA suffers the drawbacks of narrow bandwidth and low gain. However, the bandwidth of microstrip antenna may be improved using several techniques such as use of a thick substrate, cutting slots like C-slot, E-shaped, H-shaped, U-slot patch antenna, introducing the parasitic elements in coplanar or stack configuration. In the present work an Artificial Neural Network (ANN) model is developed to analyze the bandwidth of the microstrip antenna. The Method of Moments (MOM) based IE3D software has been used to generate training and test data for the ANN.

2.1 BASIC CHARACTERISTICS OF MICROSTRIP ANTENNA

A microstrip patch antenna in its most basic form consists of a radiating patch embedded on one side of a dielectric substrate whose other side is grounded. The radiating patch is generally made of a metallic material such as copper or gold and it can assume any geometrical form among which rectangular and circular are the most common. Among different types of antennas available, the microstrip patch antenna is the most widely used antenna due to its low profile, ease of fabrication and low cost. Another significant feature of microstrip patch antenna is that it can be designed for any shape.MSAs come in various shapes such as square, triangular, rectangular, circular, elliptical, hexagonal, semicircular, trapezoidal, annular ring shapes etc. as shown in fig 1.

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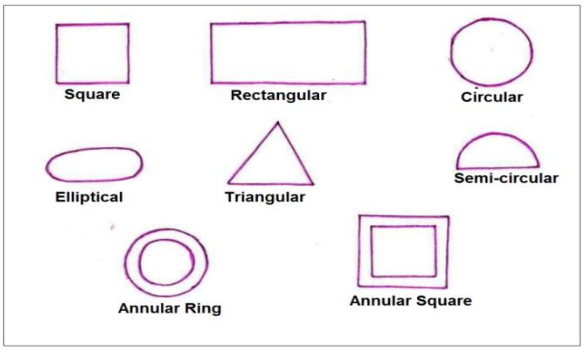

Fig 1.COMMON SHAPES OF MSA

2.2 ADVANTAGES AND DISADVANTAGES OF MICROSTRIP PATCH ANTENNA:

Some of the principal advantages of MPA as discussed by Balanis[5], Kumar and Ray[6] are given below:

- Low volume and light weighted
- Low fabrication cost, therefore can be manufactured in large quantities
- Low profile planar configuration that can be made conformal to the host surface
- Supports linear aswell as circular polarisation
- Can be easily integrated with microwave integrated circuits (MICs)
- Capable of both dual and triple frequency operations
- Mechanically robust when mounted on rigid surfaces.
- When compared to conventional antennas, the microstrip patch antennas suffer from a number of disadvantages [7], of which the major drawbacks are as mentioned below:
- Low gain
- Narrow bandwidth
- Low efficiency
- Extraneous radiations from feeds and junctions
- Surface wave excitation
- Poor end fire radiator except the tapered slot antennas
- Low power handling capacity
- Useful only at microwave frequencies and above (the substrate becomes too large at low frequencies).

2.3 PRINCIPLE OF OPERATION:

The microstrip patch acts as a resonant cavity i.e. it comprises of short circuit walls on top and bottom and open circuit walls on the sides. A resonant cavity has a limited number of modes that are allowed to exist at different resonant frequencies. When the antenna is excited at a certain resonant frequency, the waves generated within the dielectric undergo reflections and a small amount of energy gets radiated from the edges of the radiating patch. This results in a strong electric field setup inside the cavity and a strong current on the surface of the

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patch resulting in production of significant radiation which is a characteristic of good antenna.

2.4 DESIGNING OF RECTANGULAR MICROSTRIP ANTENNA AND DATA GENERATION:

The figure 2 below shows the basic geometry of the microstrip patch antenna, the designing and fabrication of which are defined so as to obtain the various antenna dimensions to calculate the resonant frequency and further use it in training the ANN model. For this purpose, it is required to make a proper selection of the dielectric substrate and the resonant frequency for which the antenna is to be designed. The commonly used substrate is FR-4 because of its ease of availability and cost effectiveness. In the proposed design also FR-4 is been used. The metallic ground surface results in the effect of fringing field. Feeds are used for carrying signal from the connector to the patch. The use of different kinds of feeds is also discussed in next section.
A simple rectangular patch of dimension W*L*h is considered as the base of the work. The four antenna input variables namely width(W), length(L), substrate height(h) and the dielectric constant(εr) are initially calculated using equations 1-5.

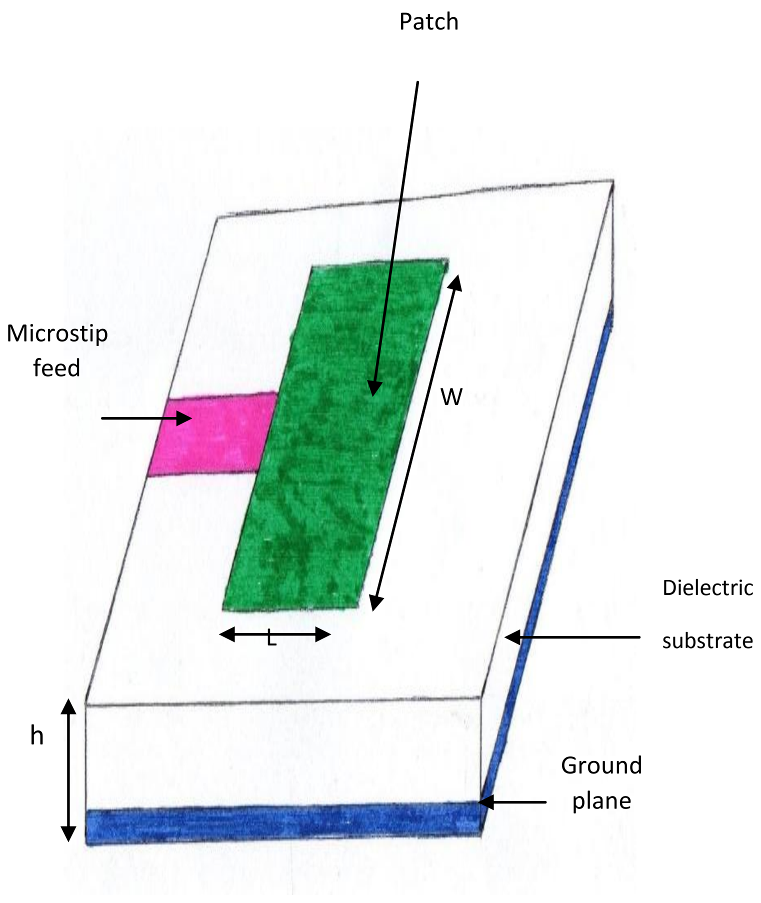

Fig 2. RECTANGULAR PATCH ANTENNA

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The various parameters involved are calculated [8] as follows:

Width (W):

The width of the patch is computed using the following equation:

$$w = c/2f\ (Er+1)/2 \text{ ----------(1)}$$

where, W= width of the patch,

f_r=antenna resonance frequency,

ε_r =relative permittivity of the dielectric substrate

c=speed of light= 3*10^8 m/sec

Effective dielectric constant($\varepsilon_{r\ eff}$):

The effective dielectric constant of a patch is one of the most prominent parameter in designing of microstrip patch antenna. When the radiations travel from the patch towards the ground, some of them pass through air & some through the substrate, this phenomenon termed as fringing. Now, since both air and the substrate have different dielectric values therefore, in order to account this, we need to find the value of effective dielectric constant. The value of effective dielectric constant (εr_{eff})is computed using the following equation:

$$Eeff=(\varepsilon_r+1)/2+(\varepsilon_r-1)/2[1+10h/w]^{\wedge}-1/2 \text{ -------(2)}$$

Length (L) :

Fringing results in increasing the length of the antenna by an amount ΔL. The actual increase in the length of the antenna patch can therefore the calculated using the following equation:

$$\Delta l/h=0.412[\ eff+0.300\ [w/h+0.262]/\ (Eeff-0.258\ )[w/h+0813] \text{ - ---------(3)}$$

$$l=c/2f\sqrt{Eeff}-2\Delta l \text{ --------(4)}$$

Thus, the dimensions of the patch are known.

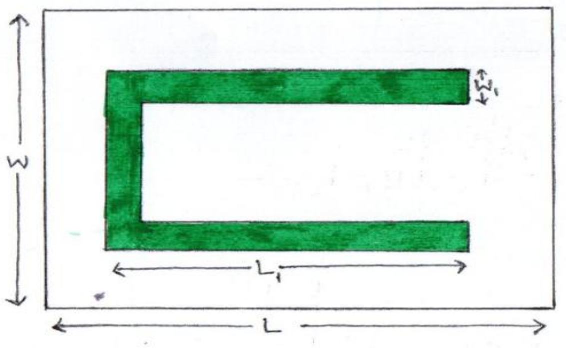

Fig 3. GEOMETRY OF PROPOSED C- SHAPED MSA

The figure 3 above shows the geometry of the designed microstrip antenna. The length and width of the patch are selected as 7.5 mm and 4.5 mm and the dielectric substrate used here is FR-4 of height 1.2 mm. In order to improve the bandwidth of the antenna, a C slot is digged in this rectangular patch. The C slot dimensions are taken as 4.1 mm*2 mm.

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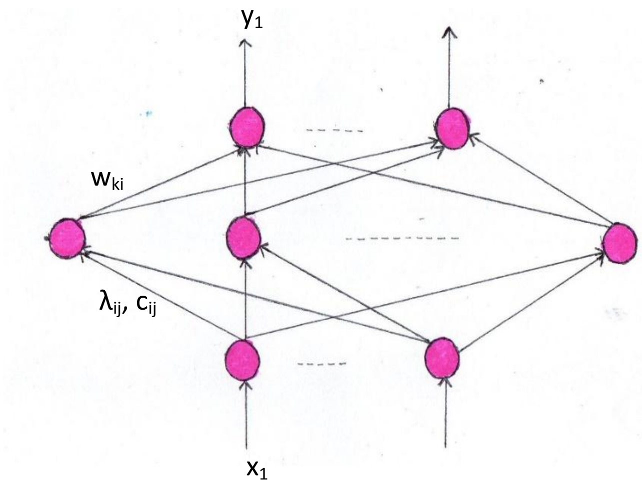
2.5 BASIS FUNCTION NETWORK ARCHITECTURE AND TRAINING:

The radial basis function (RBF) neural network is used to design and study the characteristics of the C-shaped rectangular microstrip patch antenna. The RBF network is a feedforward neural network consisting of a single hidden layer of neurons. RBF networks find several applications in various mathematical and microwave modelling purposes. The RBF neural network is composed of three layers of neurons: the input layer to feed the data or signal, the hidden layer where the actual processing occurs and the output layer where the result is output. The neurons in the hidden layer represent a series of centres in the input data space. Each of these centres has an activation functiontypically Gaussian [9]. The activation of these functions depends on the distance between the input vector and the centre. Now, because these functions are symmetric about the centre vector, hence they get the name radial basis function. Larger the distance of the vector from the centre, lower is the activation and vice versa. A supervised k-means clustering algorithm is been used for generation of the centres and their respective widths. The centres and their widths constitute the weights and the biases of the hidden layer and remain unchanged once the clustering has been performed.
A typical RBF network structure is shown in the figure 4 below:



Generally, the Gaussian and Multiquadratic functions are preferred as radial basis activation functions, of which Gaussian is been used here. The centres and the standard deviations of radial basis activation functions are denoted by parameters c_{ij} and λ_{ij}.
When the inputs x are given, the total input to the ith hidden neuron becomes$z_{ij} = \sigma(\gamma_i)$, where, (γ_i) is the radial basis function. The weights of the link between the ith neuron of the hidden layer and the k_{th} neuron of the output layer is denoted by w_{ki}. Finally, the outputs of the RBF network are computed using the hidden neurons. The training parameters of the RBF network include w_{ko}, w_{ki} and c_{ij}, λ_{ij} where, k=1, 2, ………., m, i= 1, 2, ………., N and j= 1, 2, ………., n.

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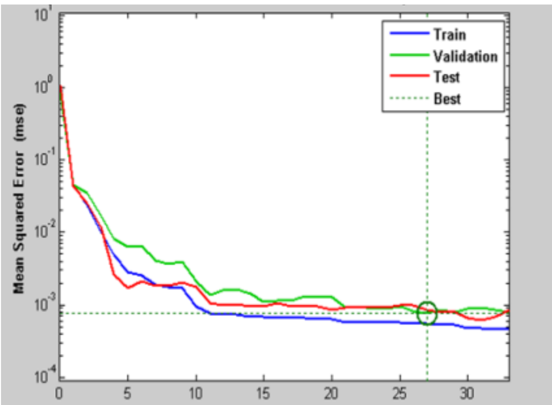

Fig 5. THE TRAINING PERFORMANCE CHARACTERISTICS

2.6 OUTPUTS:

Slot length (L1)	Slot width (W1)	Probe (X1, Y1)	Bandwidth IE3D (GHz)	Bandwidth RBF (GHz)	Bandwidth without Slot (GHz)
42	6	10, 16	0.398 0.651	0.378 0.643	0.340 0.563
42	6	11, 16	0.235 0.619	0.358 0.623	0.328 0.489
42	6	12, 16	0.387 0.567	0.242 0.557	0.302 0.459
42	6	13, 16	0.358 0.501	0.359 0.506	0.320 0.475
42	6	14, 16	0.269 0.334	0.281 0.330	0.340 0.412

RETURN LOSS CHARACTERISTIC:

The return loss graph of the microstrip antenna for different positions of probe feed is plotted as below. It is evident from the results depicted in the table above that the results obtained from the ANN tool exhibits a very close approximation to that of IE3D, therefore giving accurate results after several trainings. Keeping the length and the width of the patch constant, the probe position is varied and the network is trained for the same adjustment. Further, it is observed that the ANN tool analyses almost the same bandwidth as is obtained using the IE3D software.

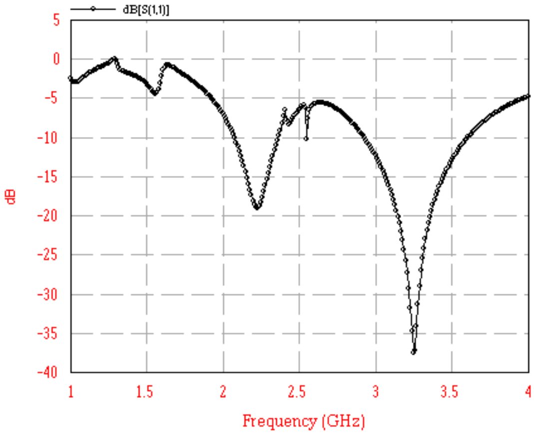

Fig 6. THE RETURN LOSS CHARACTERISTIC GRAPH

The figures (5) and (6) demonstrate the simulation characteristics of the microstrip antenna. The fig 6 depicts that the minimum return loss value for microstrip antenna is about -36 dB.The bandwidth of the antenna comes out to be 18.23% covering the range of 1.92 to 2.29 GHz and 16.76% covering the range of 3.452 to 3.890 GHz thus, making it suitable for broadband applications.

CONCLUSION:

In microstrip antennas, compactness and economical aspects are priority considerations.In this work, artificial neural network is used as a tool to study the bandwidth and return loss characteristics of microstrip antenna utilizing the IE3D software. The antenna designed here has reduced mutual coupling and improved bandwidth. The simulation of results for training the samples is achieved using neural network training algorithm to minimize the errors and obtain high accuracy results. The results obtained using IE3D software and those obtained using ANN are found to be in good agreement with almost 99%accuracy results.

REFERENCES:

1. G A Deschamps: ”Microstrip microwave antennas”, 3rd USAF Symposium on Antennas, 1953
2. H Gutton and G Bassinot: “Flat Aerial for Ultra high frequencies”, French Patent No. 703113, 1955
3. R E Munson: “Single slot cavity Antenna assembly”, US Patent NO. 3713162, Jan 23, 1973
4. J Q Howell: “Microstrip antennas in digital International Symposium”, Antenna Propagation Society, V A William Shurg, PP 177-180, Dec 1972
5.C A Balanis: “Antenna Theory- Analysis and Design”, John Wiley and Sons Inc. New York, 1982
6. G Kumar and K P Ray: “Broadband Microstrip Antennas”, Artech House Inc 2003
7. R Garg, P Bhatia, I Bahl, AIttipiboon: “A Microstrip Antenna Design Handbook”, Artech House Inc 2001
8. J L Narayana: ”Design of microstrip antennas using artificial neural networks”
9. K Guney, N Sarikaya: “ Comparison of adaptive network based fuzzy inference systems for bandwidth calculation of rectangular microstrip antennas”