Fault Finding in Antenna array using Adaptive Neuro Fuzzy Inference System

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ABSTRACT

In this paper, Adaptive Neuro-Fuzzy Inference model is developed to diagnose the location of a faulty elements and estimate the corresponding error in magnitude and phase of excitation current for a 4x4 planar array antenna. The array has an inter-element spacing of 0.84λ, and a uniform excitation. Radiation pattern is calculated by considering different combinations of location of faulty elements, error in the magnitude and the phase of excitation current. The results obtained through the proposed model are compared with the simulated values.

Keyword : - *ANFIS, Fuzzy Logic, Phase excitation , Magnitude excitation*

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1. INTRODUCTION

An Antenna is a device which is used to radiate and receive electromagnetic waves. It is a transducer which converts the electrical energy into electromagnetic energy. The antennas can be classified on the basis of operating frequency, polarization, bandwidth, aperture and radiation pattern. Microstrip antenna is of aperture type antennas. It has various advantages such as low cost, compact structure, easy to fabricate, light weight, etc. So, it is preferred for applications such as RADAR, spacecrafts, satellites etc. However, Microstrip antenna has some limitations like low gain, poor power handling capability and narrow bandwidth. To achieve better gain and directivity array is preferred. As there are hundreds of radiating elements in arrays, there is always a possibility of failure of some of the elements. It is well known that the effect of such failures is usually expressed in terms of corresponding degradation of radiation pattern.

1.1 Various Optimization Techniques

The problem of fault diagnosis has been addressed by using algorithms like ANN(Artificial Neural Network), GA (Genetic Algorithm), FL (Fuzzy Logic) etc. In thepresent study, ANFIS (Adaptive Neuro Fuzzy Inference System) is not only usedfor diagnosing the location of faulty element but also estimating the magnitude andphase error in the excitation current.

1.2 Computing Techniques

There are two basic types of computing techniques: Hard Computing and soft computing. Hard computing also known as traditional computing requires a specially stated analytical model and usually a large amount of processing time. While Soft computing is bearable to imprecision, uncertainty, partial truth and relevant approximation.[1]

Hard Computing	Soft Computing
Uses two value logic	Uses multi-valued logic
Produces precise answers	Produces approximate answers
Imprecision ,uncertainty are not desirable properties	Tolerance to uncertainty

2. PROBLEM FORMULATION

To diagnose the faulty element in array, phase of radiation pattern is taken as an input. In the present case, error in magnitude and phase of excitation current is taken as the error in the faulty elements. The deviation pattern is calculated for different combinations of fault locations and errors in excitation current. The main aim is to develop a mapping between the distorted deviation patterns with the corresponding location of faulty elements and estimating the corresponding magnitude and phase of error in the excitation current.A single element is first designed to operate at 2.4 GHz. It is then utilized to design 1x2, 2x2 and Finally 4x4 array without feeder network. Here an ANFIS based model is proposed to diagnose faulty element as shown in Figure1.

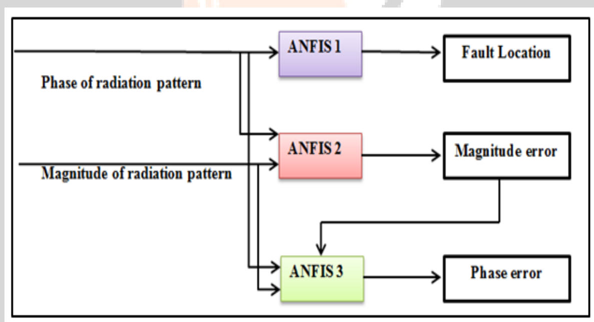

Fig -1: Proposed ANFIS Model

2.1 Diagnosis Method

First model diagnose location of faulty element. For Φ=0˚ the radiation pattern remains sameirrespective of the location of the faulty elements in the particular column. Similarly, for Φ=90˚, the radiation pattern remains same irrespective of the location of the faulty elements in the particular row. Hence, Φ=0˚determines the column of thefaulty element and Φ=90˚ determines the row of the faulty element .For fault location diagnosis, two data sets of Φ=0˚ and Φ=90˚ are developed. Value of θ=-90˚ to 90˚ with step size of 1˚except for three fault location diagnosis. In case of three fault diagnosis step size of 5˚ is taken. A similar approach is considered for two and three faulty element in array.

Table -1: Fault Location Diagnosis

Simulated	Radii=4	Radii=3	Radii=2
(0,0)	(0,0)	(0,-1)	(0,0)
(2,1)	(2,2)	(2,1)	(2,1)
(3,3)	(3,3)	(1,3)	(3,3)

2.2 Parameters for developing proposed Model

- Number of elements in array: 16
- Excitation current: 1A
- Number of faulty pattern in single fault diagnosis:52
- Number of faulty pattern in two fault diagnosis:1450
- Number of faulty pattern in three fault diagnosis:580

3. ARRAY DESIGN AND DIAGNOSIS

Microstrip antennas can be used as a single element as well as an array. To enhance the performance of an antenna like to increase directivity, gain and to scan beam of antenna, arrays are used. Single lines or multiple lines can be used to fed an antenna. According to this arrays can be classified into two categories. [2-3]
1. Series Feed Network
2. Corporate or Parallel Feed Network

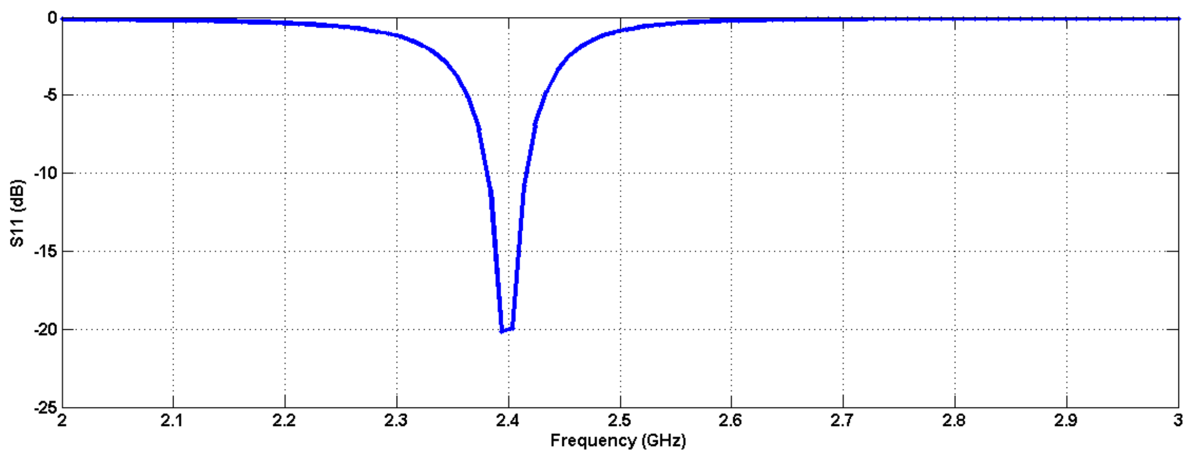

Chart -1: Simulated return loss

3.1 Magnitude and phase error diagnosis

For diagnosis for magnitude and phase of error in the excitation current, number of training data is 11 and 2 data is taken as testing data. For diagnosis of magnitude and phase error in excitation different types of membership functions like Gaussian, Generalized bell, Triangular and Trapezoidal are used [4]. Also different values of MF are taken. Also different values of MF are taken and number of epochs can also be changed for better results. In case of single fault magnitude error generalized bell type MF gives better results. Results of single fault, two fault and three fault can be localized. Effect of change in radii for single faulty element Phase of radiation pattern with step size of 1˚ is taken as an input.

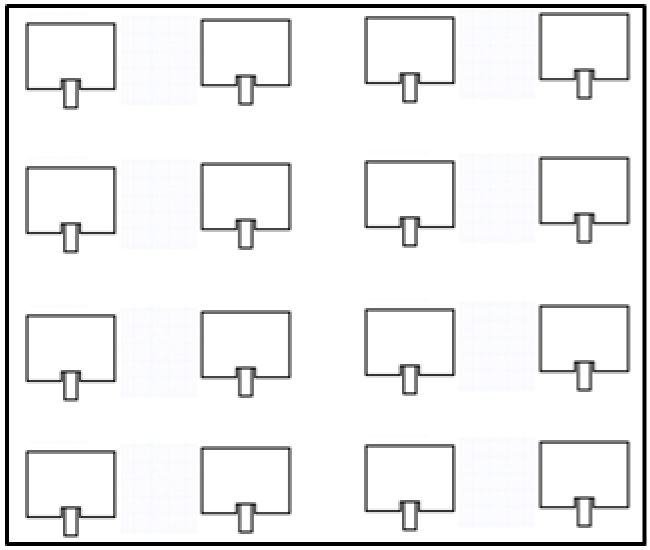

Fig -2: 4x4 array design

For three fault diagnosis 20 possible combinations of fault location are taken. For three Fault location diagnosis with all the possible combinations of faults, normalized value phase of faulty element with step size of 5 degree is taken as an input. It is tested that for any one row all the elements of that row have similar radiation patterns for phi=90. Similarly for any one column all the elements have similar radiation patterns for phi=0.

4. CONCLUSIONS

In the present work, ANFIS models are developed to diagnose the fault location(s) and the corresponding error in magnitude and phase of excitation current for 4 x 4 planar array antenna. The proposed model is tested for three fault locations but can be extended to more number of faults. It was observed that the results obtained through the proposed models resembles the simulated results

5. REFERENCES

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