OPEN ACCESS
International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-5, March 2020

Different Fractal Antenna Structure Analysis using ANN

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***Abstract:** In this paper various geometrical shapes, derived from fractal mathematics have been simulated for obtaining its multiband or wideband features. Design of fractal antennas involves a lot of calculations. In order to ease the calculation, the Artificial Neural Network (ANN) is implemented. The results obtained from ANN are in accordance with the measured results.*

Index Terms: **Artificial Neural Network, Fractal Antennas, Sierpinski Gasket, Sierpinski Carpet.**

I. INTRODUCTION

Microstrip antennas have many important characteristics such as low cost, low profile, lightweight, mechanically robust, simple to manufacture and easy to be integrated with RF devices for which it has always attracted the wide interest of people. Because of the multiband characteristics and capability to be used in various fields, fractal antennas gaining popularity day by day. In case of fractal antennas, with every iteration, the area of the fractal will be reduced that is the main structure will be divided into various parts with each iteration in order to get the multiband characteristics as desired. Hence, because of this fractal are called as self-similar structures, which are also independent of scale. In this case, keeping the volume or area of the fractal, one can increase its perimeter i.e. in the inside of the basic structure so as to receive and transmit electromagnetic signals [6]. There are various mathematical structures which can be called as fractals; e.g. Sierpinskigasket[1], Sierpinski Carpet[2], Cantor's comb, the Lorenz attractor, the Mandelbrot set, von Koch's snowflake. In this paper, the concept of fractal has been applied to triangular as well as rectangular shaped microstrip patch antenna to obtain multi-band frequency operation. Various features of fractals include its compact size, ability work in the wideband/multiband frequency range, being a frequency independent antenna, possessing fractal loading capability because of which inductance and capacitance are added. In order to solve various engineering problems without much hassle, Artificial Neural Network (ANN) techniques are always helpful. ANN is a system is comparable to the human brain. As in the case of the human brain, ANN consists of a nonlinear, simple functional blocks, which are called neurons. These neurons in case of ANN are organized into layers, which will be mutually connected by synaptic weights which are highly parallel. In the case of ANN, no formula requirement is needed so as to design a microstrip antenna. ANN can be used to calculate different parameters of rectangular and other shapes of microstrip antenna, some of the examples of those parameters being radiation efficiency, resonant frequency of triangular and rectangular microstrip antennas, resonant resistance calculation of electrically thin and thick rectangular microstrip antennas, input impedance of rectangular microstrip antennas [7]. Similarly, artificial neural networks have been used for the design of a Sierpinski Gasket, Sierpinski carpet, and a modified Gasket in order to calculate the length of the antenna. Here, the artificial neural network has been used to design Sierpinski Gasket, Sierpinski carpet, and modified Gasket fractal antennas. Fig 1. and Fig 2. shows the iteration process in the design of the Sierpinski Gasket and Sierpinski Carpet fractal antennas.

Revised Manuscript Received on March 30, 2020.
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II. DESIGN OF ANTENNA

A. Sierpinski Gasket

In order to design a Sierpinski Gasket Antenna the resonant frequency is taken as 2.5 GHz, the scale factor is considered as 2, flare angle as 60^0. The side length of the antenna and the height is calculated to be 38.6mm and 33.4mm respectively. Up to 2nd iteration is considered. The substrate is taken to be FR4 substrate with dielectric constant 4.3 and its height is taken as 1.6mm. The design using CST is shown in Fig. 4 and Fig. 5 for 1st and 2nd iteration respectively.

B. Sierpinski Carpet

In order to design a Sierpinski Gasket Antenna, the resonant frequency is taken as 2.5 GHz. The substrate is taken to be FR4 substrate with dielectric constant 4.3 and its height is taken as 1.6mm. For this, the side length of the antenna is found out to be 27.36mm and the width to be 36.85mmUp to 2nd iteration is considered. The design using CST is shown in Fig 6. and Fig 7.

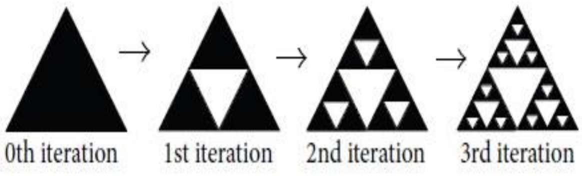

Fig. 1. The first three iteration of Sierpinski Gasket

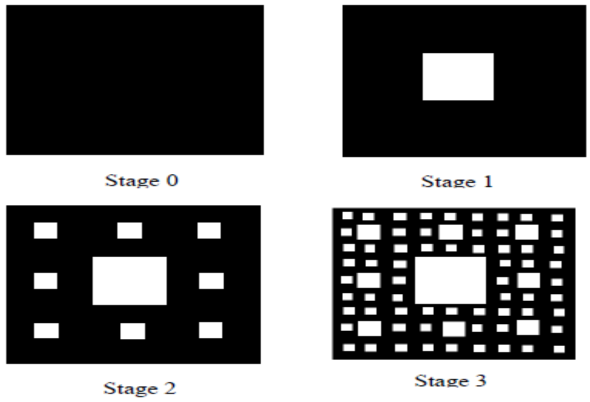

Fig. 2. The first three iteration of Sierpinski Carpet

C. Modified Sierpinski Carpet

It has been previously demonstrated that the full sub-gap structure introduced with each fractal iteration is not required to create the operating bands. The periodic multiband behavior of the Sierpinski Gasket is primarily a function of the four main gaps located along the central vertical axis of the structure [1]. And keeping that in mind the next design of Sierpinski Gasket has been designed. The design using CST is shown in Fig 8.

Fig. 3. Modified Sierpinski Gasket

The 1st iteration geometry for Sierpinski Gasket is designed by dropping a triangle of length 19.3mm and in order to get the 2nd iteration structure 3 triangles with side length 9.65mm is dropped from the 1st iteration structure.

The 1st iteration geometry for Sierpinski Carpet is designed by dropping a rectangle of dimension (9.12 X 12.28) mm. And in order to get the 2nd iteration structure 3 rectangles with dimension (3.04 X 4.09) mm is dropped from the 1st iteration structure.

The same approach is taken for designing Sierpinski Gasket modified structure but not all the triangles are removed with successive iterations, but only single ones for every iteration.

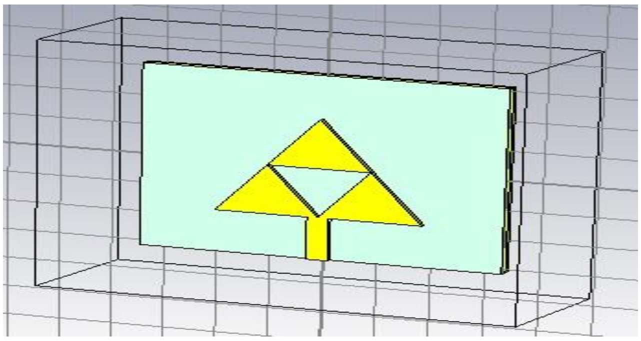

Fig. 4. Simulated structure of Sierpinski Gasket fractal antenna for 1st iteration using CST

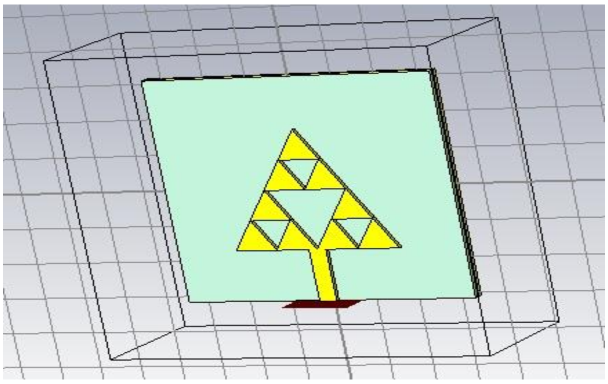

Fig. 5. Simulated structure of Sierpinski Gasket fractal antenna for 2nd iteration using CST

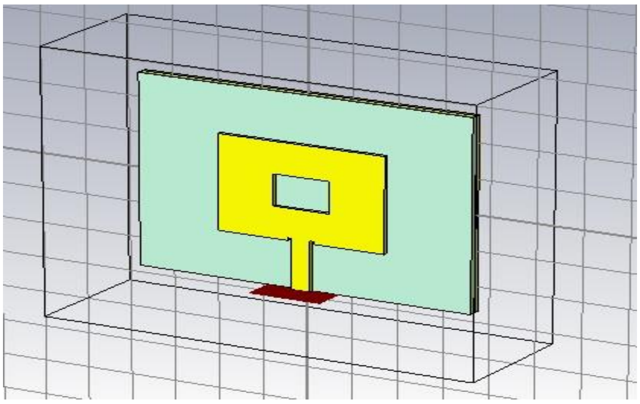

Fig. 6. Simulated structure of Sierpinski Carpet fractal antenna for 1st iteration using CST

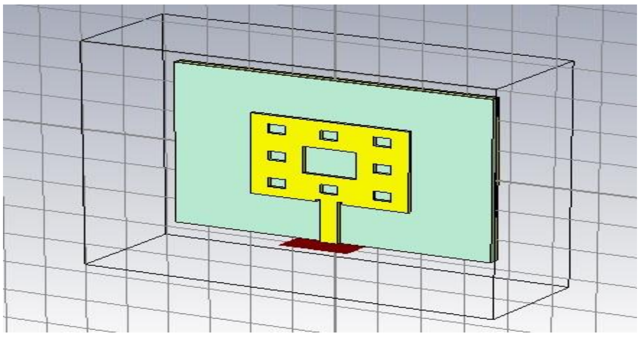

Fig. 7. Simulated structure of Sierpinski Carpet fractal antenna for 2nd iteration using CST

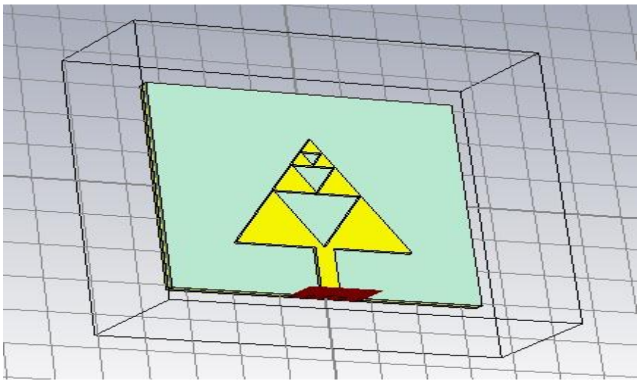

Fig. 8. Simulated structure of Modified Sierpinski Gasket fractal antenna for 3rditeration using CST

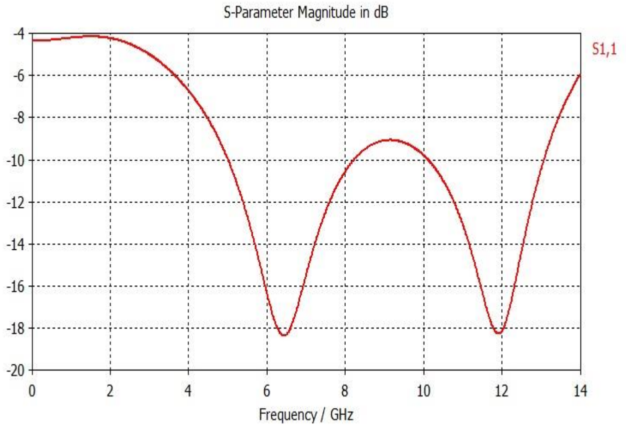

Fig. 9. Return loss curve of Sierpinski Gasket fractal antenna for 1st iteration as simulated using CST

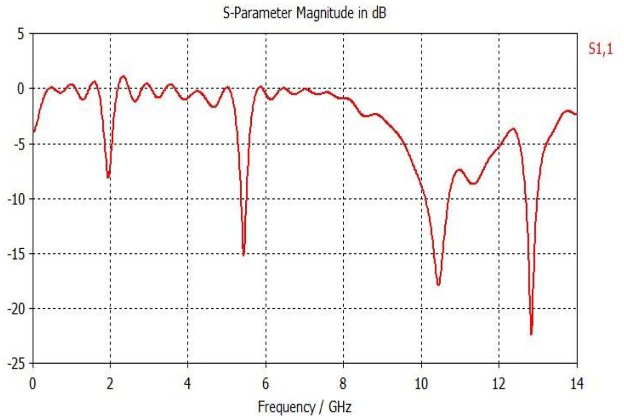

Fig. 10. Return loss curve of Sierpinski Gasket fractal antenna for 2nd iteration as simulated using CST

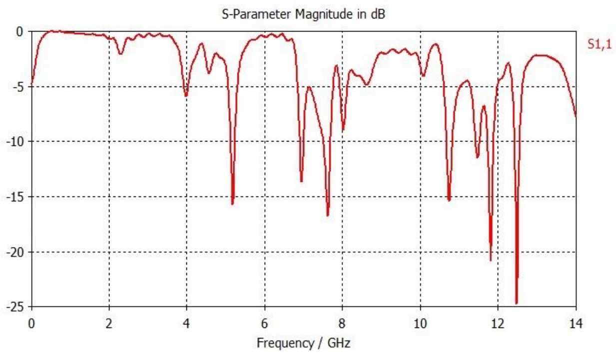

Fig 11. Return loss curve of Sierpinski Carpet fractal antenna for 1st iteration as simulated using CST

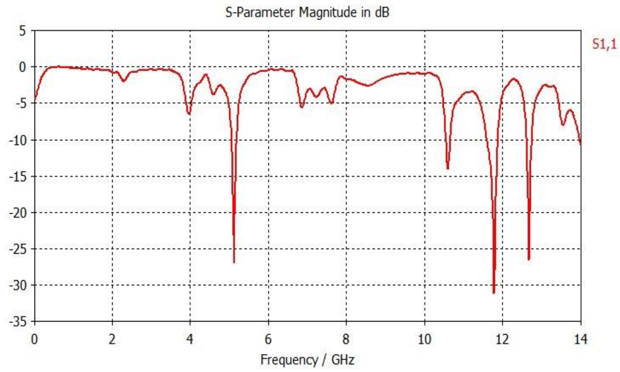

Fig. 12. Return loss curve of Sierpinski Carpet fractal antenna for 2nd iteration as simulated using CST

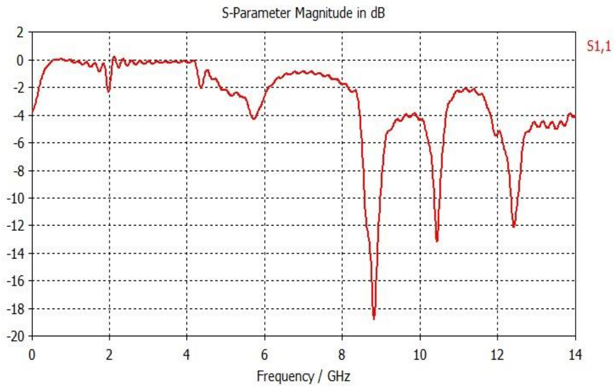

Fig. 13. Return loss curve of Modified Sierpinski Gasket fractal antenna for 3rditeration as simulated using CST

All the antennas are fed by microstrip line feed. In the 1st iteration itself the Sierpinski carpet fractal showed multiband nature as shown in Fig. 11, in the 2nd iteration it is working on 5.1 GHz, 10.6 GHz, 11.7 GHZ and 12.6 GHz frequency range, which can be viewed from Fig.12. Sierpinski Gasket in the first iteration is working at 6.3 GHz and 11.9 GHz frequency range which can be seen in Fig.9 and in the 2nd iteration at 5.45GHz, 10.465 GHz and 12.85 GHz frequency can be seen in Fig.10. The modified gasket also showed multiband features working at 8.8 GHz, 10.46 GHz, and 12.43 GHz which can be found out from Fig.13.

III. DESIGN & ANALYSIS USING ANN

For design of Sierpinski Carpet and Gasket Fractal antenna using ANN one should have information of resonant frequency (f_r) of microstrip antenna, dielectric constant of substrate (ε_r), height of substrate (h) and no. of iterations (n) of microstrip antenna. These all are fed as input to the ANN in order to calculate the length(L) value as output of ANN using MATLAB software. The ANN is trained with 250 input-output training patterns. This training data is used for training the proposed ANN structure with Levenberg Marquardt algorithm and gives results in terms of performance parameters such as number of epochs taken by each algorithm for training, performance plot and calculation is done.

The performance curve from ANN for Sierpinski Gasket and Sierpinski Carpet are shown in Fig. 14 and Fig. 15 respectively.

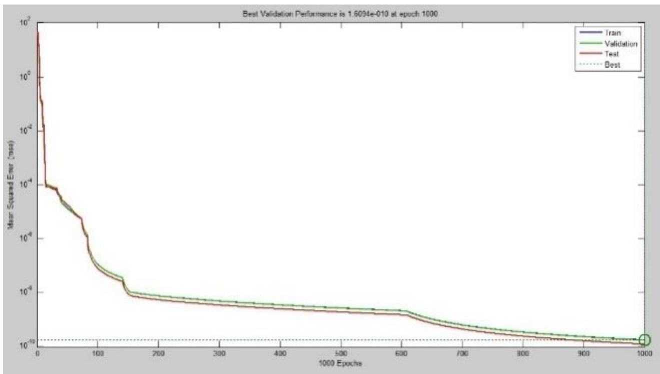

Fig. 14. Performance curve of Sierpinski Gasket fractal antenna

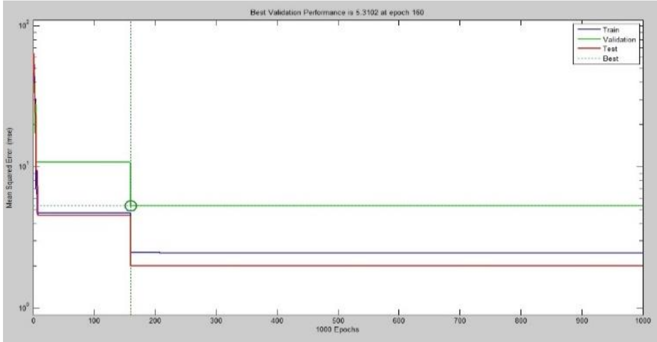

Fig. 15. Performance curve of Sierpinski Carpet fractal antenna

Table I. The values of length as measured experimentally and the results obtained from ANN for Sierpinski Gasket

Measured Values of Length (mm)	38.57	40.18	40.18	53.93	53.93	53.93	53.93	56.18
ANN Results of Length (mm)	38.57	40.18	40.18	53.93	53.93	53.93	53.93	56.18

Measured Values of Length (mm)	56.18	52.75	52.75	52.75	53.58	53.58	53.58
ANN Results of Length (mm)	56.18	52.75	52.75	52.75	53.58	53.58	53.58

Table II. The values of length as measured experimentally and the results obtained from ANN for Sierpinski Carpet

Measured Values of Length (mm)	27.4	28.6	28.6	38.8	37.9	38.7	27.5	28.6
ANN Results of Length (mm)	27.4	28.6689	28.4	39.1	37.9	38.7	27.4	28.6

Measured Values of Length (mm)	38.8	40.5	37.9	27.5	27.4	28.6	38.7
ANN Results of Length (mm)	38.9	40.5	37.89	27.5	27.4	27.4	40.5

IV. CONCLUSION

From the results it can be concluded that, fractal antenna are multi band or wide band antennas which is beneficial for instantaneous spectrum access and it lessens the number of antennas that need to be used to a single one as it shows multiband properties. The antennas are also compact and of small size which lowers the cost and increases desirability. Results have also shown that these are frequency independent antennas which performs consistently over a wide range of frequencies. The implementation of ANN eases the lengthy analysis and design cycles required to develop high performance system and states that it can be done in a very short product development time. The results of ANN for estimation of design and analysis parameters are in accordance with measured results for fractal antennas.

REFERENCES

1. Carles Puente Baliarda, Carmen Borja Borau, Mònica Navarro Rodero, and Jordi Romeu Robert, "An Iterative Model for Fractal Antennas: Application to the Sierpinski Gasket Antenna", IEEE Transactions on Antennas and Propagation, VOL. 48, NO. 5, MAY 2000.
2. Jagtar Singh Sivia, Amarpartap Singh, Tara Singh Kamal, "Design of Sierpinski Carpet Fractal Antenna using Artificial Neural Networks", International Journal of Computer Applications (0975 – 8887), Volume 68– No.8, April 2013.
3. Jagtar Singh Sivia1, Amar Partap Singh Pharwaha, and Tara Singh Kamal, "Analysis and design of circular fractal antenna using artificial neural networks, Progress In Electromagnetics Research B, Vol. 56, 251-267, 2013.
4. Steven R. Best, "On the Radiation Pattern Characteristics of the Sierpinski and Modified Parany Gasket Antennas", IEEE Antennas and Wireless Propagation Letters, VOL. 1, 2002.
5. Mahdi Naghshvarian Jahromi, Abolfazl Falahati, and Rob. M. Edwards, "Bandwidth and Impedance-Matching Enhancement of Fractal Monopole Antennas Using Compact Grounded Coplanar Waveguide", IEEE Transactions On Antennas And Propagation, Vol. 59, No. 7, July 2011.
6. Cohen, N., "Fractal antenna applications in wireless telecommunications," A Literature Study as Project for ECE 576, Illinois Institute of Technology, Dec. 2000.
7. Devi, S., D. C. Panda, and S. S. Patnaik, A novel method of using artificial neural networks to calculate input impedance of circular microstrip antenna," *International Symposium Antennas and Propagation Society*, Vol. 3, 462-465, Jun. 2002.

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