FRACTAL DESIGN OF SIERPINSKI TRIANGLE WITH PROBE FED AND CAPACITIVE FED

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***Abstract*-The Sierpinski gasket monopole antenna has been shown to be an excellent candidate for multiband applications. The multiband behavior of the fractal Sierpinski antenna is described in this paper. An analysis is performed to examine the parameters of antenna with a frequency range in between 1 GHz to 6 GHz, at various operating frequency with a VSWR <2 and return loss<-10 dB of similar antenna structures. The single band behaviors of antenna are studied in this paper with an iterative method and try it to convert in multiband antenna. In this paper, proposed antenna is designed to satisfy all the system requirements for DCS1800 (1.71–1.88 GHz), DCS1900 (1.85–1.99 GHz), IMT-2000 (1.885–2.2 GHz), UMTS (1.92–2.17 GHz), WiBro (2.3–2.39 GHz), WLAN (2.4–2.483 GHz), and DMB (2.605–2.655 GHz), simultaneously. All the simulated results are mandatory and satisfactory using HFSS software.**

***Keywords*- Fractal antenna, multiband ,Sierpinski triangle Gasket, iterative method, probe feeding, capacitive feeding.**

I. INTRODUCTION

A multi-band fractal monopole antenna, based on the Sierpinski gasket[1,2], was first introduced by Puente et al. in 1996 has been widely studied for planar monopoles and dipoles [3,4]. The Sierpinski triangle (also with the original orthography Sierpinski), also called the Sierpinski gasket or the Sierpinski Sieve, is a fractal named after the Polish mathematician Wacław Sierpinski who described it in 1915. In modern wireless communication systems and increasing of other wireless applications, wider bandwidth, multiband and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions, one of them is using fractal shaped antenna elements. Fractal geometries have found an intricate place in science as a representation of some of unique geometrical features occurring in nature. For most fractals, self-similarity concept can achieve multiple frequency bands because of different parts of the antenna are similar to each other at different scales. The combination of infinite complexity and detail and self similarity makes it possible to design antennas with very wideband performances. The essential research objects are Sierpinski gasket monopole antenna which has multi-band characteristic. In the field of antenna, fractal antennas have many advantages such as size reduction, multiband and so on. Fractals have many properties and the main one is self-similarity. The term fractal, which means broken or irregular fragments, was originally coined by Mandelbrot [5] to describe a family of complex shapes that possess an inherent self-similarity in their geometrical structure. The first four stages in the construction of the Sierpinski gasket are shown in Figure 1.

Figure 1. Four Iterative stages of Sierpinski triangle

In the design 3D structure of fractals of triangle there is an error, for limiting this we construct the next iteration so that it remains a gap between the main patch and next iterative stages. As shown in Fig2. In Fig3 we also show the size of consecutive iterations that we are used for study.

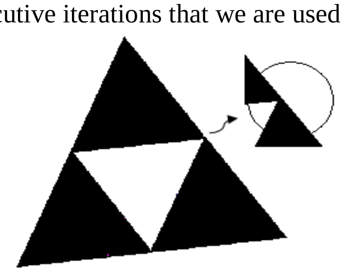

Figure 2. Gap between main and next iteration patch

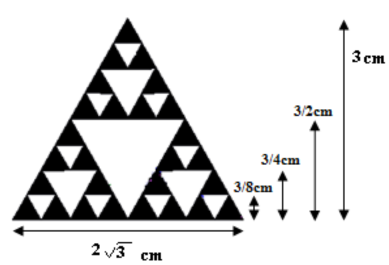

Figure 3. Sierpinski triangle

II. FEEDING SCHEME

In this paper, we proposed two feeding designs such as probe fed and capacitive fed. We have seen various types of feeding arrangements above such as microstrip line feed and proximity coupled feed, aperture coupled feed, coplanar waveguide feed. In case of microstrip line feed, the entire geometry remains symmetrical, but because of line feed it creates cross-polar radiation. Proximity coupled feed and aperture coupled feed can be better feeding arrangement than other but alignment issues are very serious in these feeding because it generates impedance mismatch [6, 7]. Similarly several innovative feeding techniques have also been suggested to improve the bandwidth which included modification to a meandered probe feed [8]. Such three-dimensional feed arrangements are usually difficult to realize in a consistent manner. It may be pointed out that the primary advantage of MSAs [9] lies in their ease of fabrication by standard lithography techniques. So in all these general feed arrangements probe feed arrangement is most famously used for electrically thick substrates as shown in fig 4. As seen from Fig. 4, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. But as the width of substrate increases, increases probe length which makes the input impedance more inductive, leading to impedance matching problems. This problem of impedance mismatch can be compensated by cutting slots on the patch, modifying the probe shape, or by introducing a capacitive feed strip as shown in fig 5. In capacitive feeding the radiator patch and a smaller feed patch (triangular) are located on the same plane and the antenna substrate was located above the ground plane with an air-gap separation [10]. In this paper, we present a simple design of triangular patch antenna consisting of a triangular patch fed with a small coplanar rectangular capacitive feed placed very close to the radiator on a substrate [11]. First, an equilateral triangular microstrip antenna fed with a small rectangular patch placed symmetrically and parallel to an edge has been studied. Capacitive feeding can be used to avoid spurious radiations, provides an impedance bandwidth of nearly 50%, and has stable radiation patterns for almost all frequencies in the operational band [12, 13].

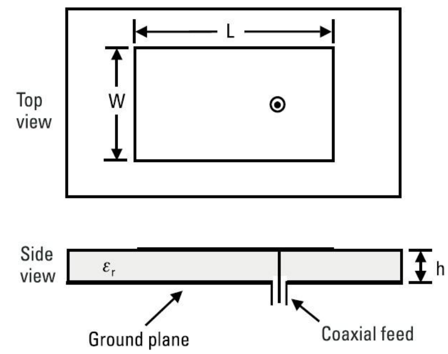

Figure 4. Probe feeding structure

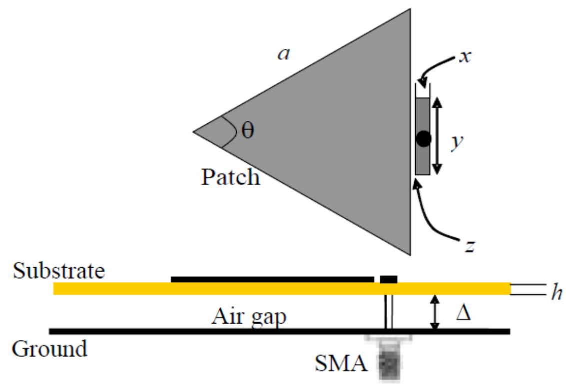

Figure 5. Capacitive feeding structure

III. EXPERIMENTAL RESULTS

A. *Probe Fed*

The design of Sierpinski triangle with probe fed starts with an equilateral triangle with operating frequency in between 3 GHz to 6 GHz at various iteration

By comparing the iterations of triangle patch with changing the material of substrate, Єr, changing the probe position and height, diameter. The frequency of operation only in between 1 GHz to 6 GHz with a VSWR < 2.

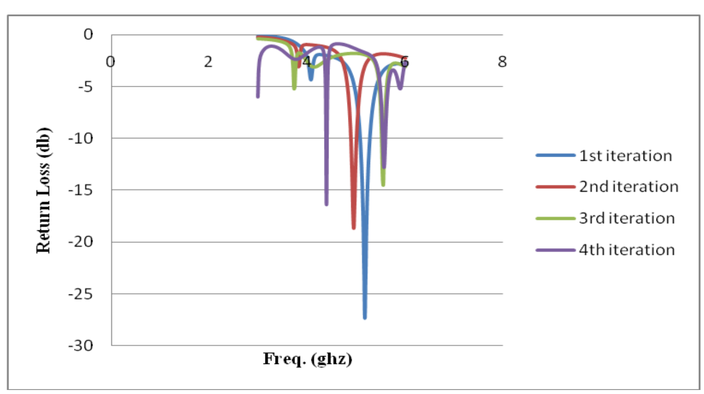

Figure 6. Return loss for I to IV iterations

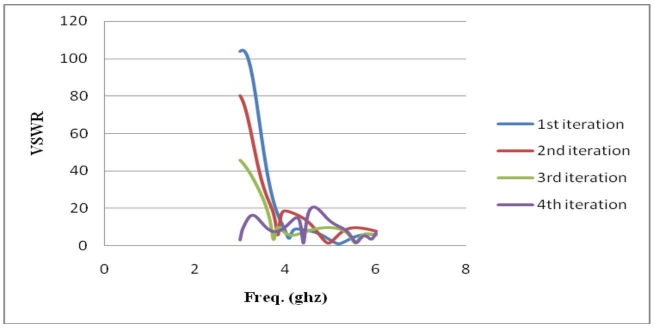

Figure 7. VSWR for I to IV iterations

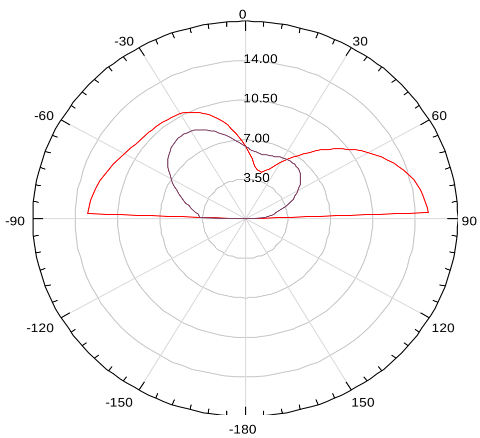

Figure 8. Radiation Pattern for IIIrd iteration

TABLE I
Comparison between iterations on different parameter

Iterations	VSWR	Bandwidth(MHz)	Return Loss(db)
Iteration 1	1.06	210 (4%)	-30
Iteration 2	1.28	110 (2.2%)	-18.2
Iteration 3	1.43	60 (1%)	-15

B. Capacitive Fed

The design of Sierpinski triangle with capacitive fed starts with an equilateral triangle with operating frequency in between 2 GHz to 5 GHz at various iteration.

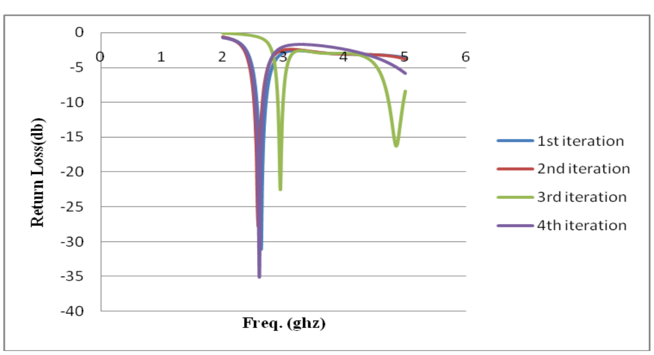

Figure 9. Return loss for I to IV iterations

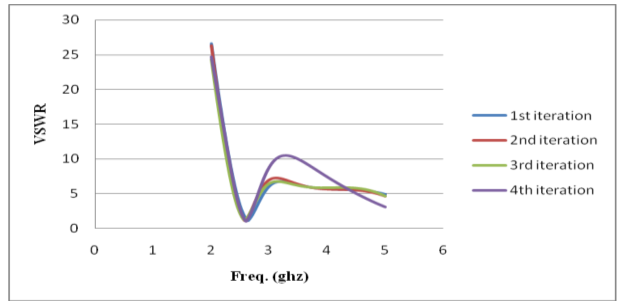

Figure 10. VSWR for I to IV iterations

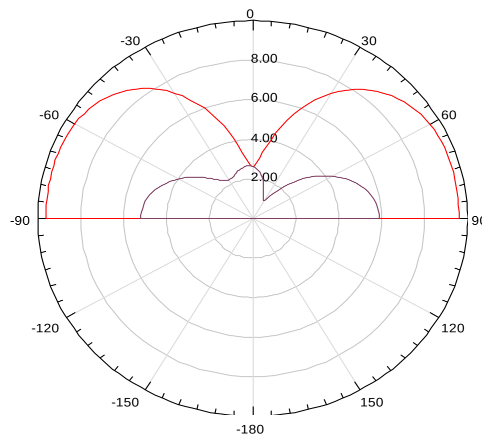

Figure 11. Radiation Pattern for IVth iteration

TABLE II
Comparison between iterations on different parameter

Iterations	*VSWR*	*Bandwidth(MHz)*	*Return Loss(dB)*
Iteration 1	1.1002	180 (6%)	-26
Iteration 2	1.29	425 (7.29%)	-30
Iteration 3	1.198	455 (7.5%)	-21
Iteration 4	1.04	140(5.4%)	-32

IV. CONCLUSION

In this paper we have been concluded multiband simulated bahaviours of iterative fractals with both probe and capacitive feeding schemes. It is demonstrated that the triangular patch antenna gives the best performance having bandwidth, and with a good broadside radiation patterns throughout this band. The basic configuration involving a Sierpinski triangular patch the effects of all key design parameters are studied for optimum design, return loss (below −10 dB), bandwidth. Fractals of such design can be used in 3G applications as like in 3G- IMT-2000 [14]. The relation between the parameters and the performance of the antenna will be further given to valuable design the antenna. The feed scheme is versatile and can be used for designing simple to fabricate wideband antenna.

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REFERENCES

[1] R. Friedberg and O. Martin, “Random walks on Sierpinski gasket”, IEEE, vol. 47, 1663-1669, 1986

[2] Brigita Kutnjak-Urbank, Stefano Zapperi, Sava Milosepic, and H. Eugene Stanley, “Sand pile Model on the Sierpinski gasket fractal,” IEEE, vol. 54, Number 1, 64.60.Ak, 02.60.Cb, July 1996.

[3] C. Puente, J. Romeu, R. Pous, X. Garcia, and F. Benitez, "Fractal multi-band antenna based on the Sierpinski gasket," Inst. Elect. Eng. Electron. Lett., vol. 32, no. 1, pp. 1-2, Jan. 1996.

[4] C. Puente, J. Romeu, R. Pous, and A. Cardama, "On the behavior of the Sierpinski multi-band fractal antenna," IEEE Trans. Antennas Propagat., vol. 46, pp. 517-524, 1998

[5] B.B. Madelbrot, “The Fractal geometry of nature,” New York: W.H. Freeman, 1983

[6] G.Kumar and K.P.Ray,“Broadband microstrip antennas,” Artect House, Norwood, Mass, USA 2003.

[7] C. A. Balanis, “Antenna Theory,” John Wiley & Sons, Hoboken,NJ, USA, 2nd edition, 2004.

[8] H. W. Lai and K. M. Luk, “Wideband stacked patch antenna fed by meandering probe,” Electronics Letters, vol. 41, no. 6,pp. 297–298, 200.

[9] R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook, Artech House, Norwood, MA, 2001.

[10] Veeresh G. Kasabegoudar, Dibyant S. Upadhyay, and K. J. Vinoy, “Design Studies of Ultra-Wideband Microstrip Antennas with a Small Capacitive Feed,” Received 29 May 2007; Accepted 10 October 2007

[11] Mukesh R. Solanki, Usha Kiran K., and K. J. Vinoy, “Broadband design of triangular mocrostrip antenna with a capacitive feed,” Journal of Microwaves, Optoelectronics and Electromagnetic Applications, Vol. 7, No.1, June 2008.

[12] G. Mayhew-Ridgers, J. W. Odendaal, and J. Joubert, “Single layer capacitive feed for wideband probe-fed microstrip antenna elements,” IEEE Transactions on Antennas and Propagation,vol. 51, no. 6, pp. 1405–1407, 2003.

[13] G. A. E. Vandenbosch and A. R. van de Capelle, “Study of the capacitively fed microstrip antenna element,” IEEE Transactions on Antennas and Propagation, vol. 42, no. 12, pp. 1648–1652, 1994.

[14] Y. J. Wang and C. K. Lee, “Compact and broadband microstrip patch antenna for the 3G- IMT-2000 handsets applying styrofoam and shorting-posts,” Progress In Electromagnetics Research, PIERS 47, pp. 75–85, 2004.