Compact Modified Sierpinski Fractal Monopole Antenna for Multiband Wireless Applications

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***Abstract*— A Sierpinski fractal antenna is proposed for multiband wireless applications. It consists of three-stage Sierpinski fractal geometry as the radiating element. The proposed antenna has compact dimension of 75×89.5×1.5 mm^3. The multiband characteristic for a return loss less than 10dB is achieved. The model is applied to predict the behavior of fractal antenna when the height of the antenna is changed. The proposed antenna is considered a good candidate for Multiband Wireless applications.**

Keywords—Sierpinski fractal antenna, multiband, wireless, monopole antenna.

I. Introduction

To meet the current trends in the field of communication systems, it is essential to design a compact antenna which suits for different wireless applications. Fractal antennas [2-3] are the best suitable radiating structures. Fractal is a new class of geometry that was proposed by "Mandelbrot". The physical construction of the fractal is not possible only objects with a limited number of iterations can be built. These objects are usually referred to as pre fractals. These fractals increase the electrical length of the antenna without affecting the radiation characteristic of conventional antenna [4]. Fractal antennas play a vital role in developing new types of antennas with notable characteristics such as multiband, miniature and high directive elements [5]. Another prominent benefit that has been derived from using fractal geometries has been to design antenna with multiple resonances [1].

Self similarity and Space filling properties of fractal antennas are utilized in the design of antennas with notable characteristics like multiband behavior and miniaturization.

Self similarity means that an object is build of sub units and sub units on multiple levels which tries to figure out the structure of entire object. Space filling means it uses long electrical length into small dimensions [6-8]. In this paper, we propose a microstrip patch antenna embedded with a Sierpinski fractal geometry, which exhibits a large size reduction. The size reduction is achieved by increasing the electrical length of the antennas. A three-stage Sierpinski fractal geometry is introduced as a radiating element. The patch is fed by a microstrip feed line, and this antenna has a good matching at 50 ohms at the frequency of multiband systems. The results show that the proposed design provides sufficient antenna performances such as wide impedance bandwidth and omnidirectional radiation pattern.

II. Antenna Geometry and Simulation Results

The Sierpinski is one of the mathematician who has proposed the Sierpinski triangle in 1961. The proposed Sierpinski diamond shape antenna for multi band application is shown in Fig.1. Classical Sierpinski triangle is having the scale factors as given in (1)

$$\delta = h_n / h_n + 1 \qquad (1)$$

Where n represents the iteration and h represents the height of the diamond. The proposed antenna having different scale factors ($\delta_1 = h_1/h_2$ and $\delta_2 = h_2/h_3$). It is printed on a 1.58 mm thick substrate, dielectric $\varepsilon_r = 4.4$, with the size 75×89.5 mm^2, the radiating element consists of a three-stage modified Sierpinski fractal geometry diagonal lengths of the diamonds d_1=28 mm, d_2 = 15 mm, d=38. 87 mm, L_1= 66.2 mm, L_2= 75 mm, h_1= 40 mm, h_2= 63.52 mm, h_3 = 76.74, H=21 mm, w=3 mm, g = 2.3 mm.

The recursive procedure of the proposed antenna is shown in Fig. 2 for different iterations. Fig. 3 shows the simulated return loss of the proposed antenna for different iteration levels. The proposed antenna provides reasonable impedance matching at 900 MHz for GSM, UHF-RFID, 2.4 GHz for Bluetooth, and at 5.8 GHz for WLAN. A fourth pass band can be added using the small diamond slots of diagonal length of 6 mm. Fig. 4 shows the parametric study for different height *H* of Sierpinski antenna. It is very critical parameter for obtaining the impedance bandwidth and resonances. It is observed that when, the height of the ground plane increased the impedance bandwidth of the proposed antenna well below -10dB. Omni directional radiation patterns are often required for multiband antennas. For the antenna two principal planes are selected to present the radiation patterns.

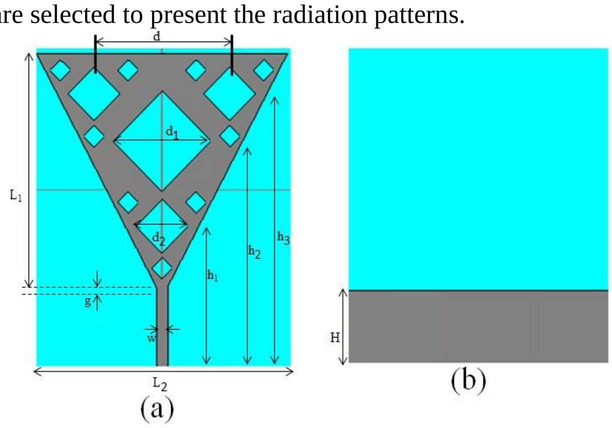

Fig. 1 Geometry of proposed Sierpinski fractal antenna.

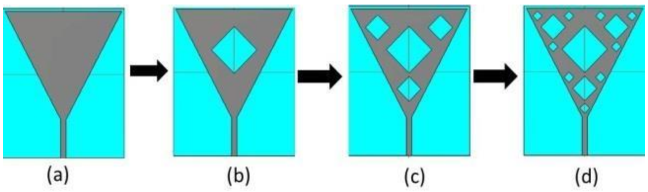

Fig.2. Recursive procedure of proposed antenna (a) Basic geometry, (b) First iteration, (c) Second iteration (d) Third iteration.

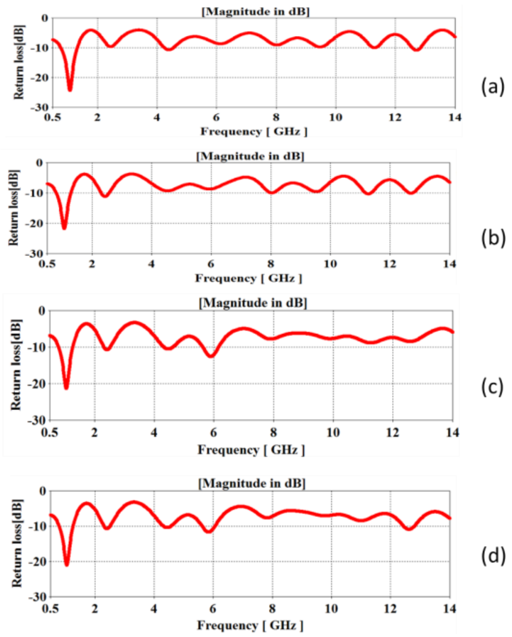

Fig.3. Simulated return loss curve for (a) Basic geometry,(b) First iteration,(c) Second iteration,(d) Third iteration

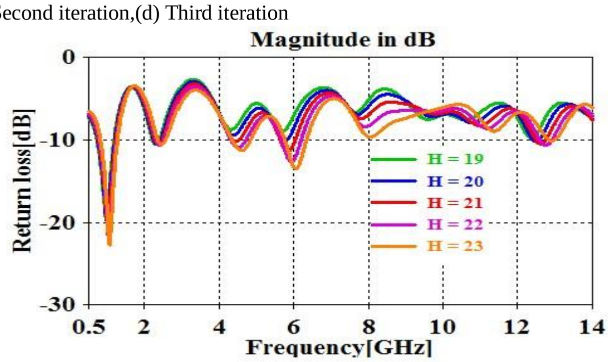

Fig.4. Simulated return loss curve for different heights of ground plane.

These are referred to as the x-y plane (E plane) and y-z plane (H plane). Fig.5 shows the plots of the simulated radiation patterns in the E-plane and H-plane at resonant frequencies. With increase in frequency, the number of lobes also increases. This type of behavior is seen in multiband fractal antenna. The antenna gain in broadside direction is plotted in Fig. 6. When the antenna is used for multiband application, the impedance mismatch must be taken in to account for defining its characteristics especially while calculating antenna gain. It is observed that the proposed antenna gain lies between 2dB to 7dB with maximum gain of 8 dBi .

III. Conclusion

The proposed model is a good candidate on the behavior of the Sierpinski diamond antenna, with three iterations levels. It is very useful for reducing the volume of the antenna and for multiband operation. The proposed antenna is having approximates omnidirectional radiation pattern. Therefore the proposed antenna is useful for low profile, low-cost and supporting multiband operation such as GSM, Bluetooth, WLAN applications.

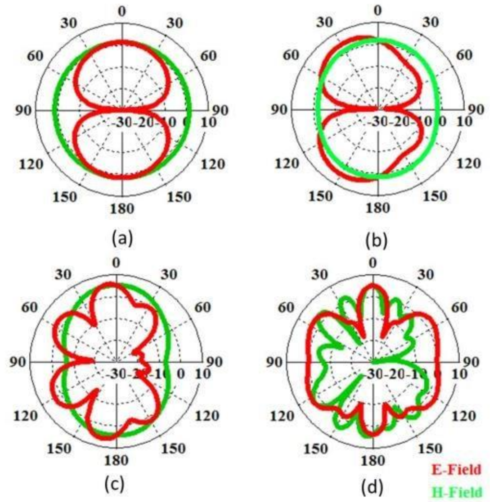

Fig. 5 Simulated radiation patterns of proposed multiband antenna at (a) 0.9 (b) 2.4 GHz (c) 5.8GHz (d) 12.6 GHz

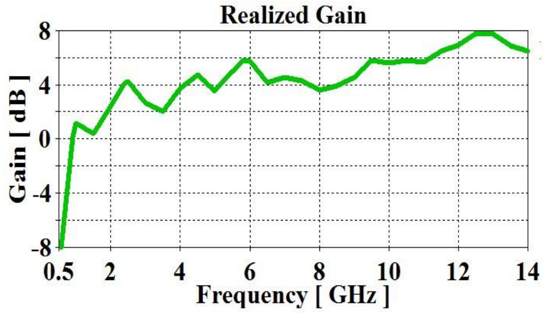

Fig. 6 Simulated gain vs. Frequency curve of the proposed multiband antenna

References

[1] Choukiker, Y.K.; Behera, S.K., "Microstrip line-fed modified Sierpinki fractal monopole antenna for dual-wideband applications," IEEE International Conference on Communication Control and Computing Technologies (ICCCCT), 2010,pp.17,20, 7-9 Oct. 2010.

[2] J. P. Gianvittorio and Y. Rahmat-Samii(2002), “Fractal antennas: A novel antenna miniaturization technique, and applications”, IEEE Antennas and Propagation. Mag., Vol. 44, no 1, pp 20-36.

[3] Y.J Sung, Bandwidth Enhancement of a Wide Slot Using Fractal Shaped Sierpinski, IEEE Transactions on Antenna and Wave Propagation, Vol .56, no. 12.

[4] http://www.fractenna.com

[5] J. L. Sanchez and L.de Haro, “experiences on multiband fractal antennas,” Antennas and Propagation Society International Symposium, IEEE Trans, Vol. 4,pp. 58-61,2001.

[6] J. L. Vehel, E.Lutton, and C.Tricot(editors), “Fractals in engineering”, Springe- Verlag, London,1997, pp.222-236.

[7] Chakkrit Kamtongdee and Nantakan Wongkasem(2009), “ A Novel Design of Compact 2.4 GHz Microstrip Antennas”. IEEE Trans.Antennas Propag, Vol.56, no. 12.

[8] Abd M.F, Ja’afar A.S. @ Abdul Aziz M.Z.A(2007), “ Sierpinski Carpet Fractal Antenna”, Proceedings of the 2007 Asia-Pacific conference on applied electromagnetic, Melaka.