International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 3, Issue 1, January 2014

DESIGN AND ANALYSIS OF MULTIBAND SLOTTED OCTAGONAL FRACTAL ANTENNA

NEHYA CHAUDHARY, SONIKA SINDHIYA, K.K TIRPHATI (A.K.G.E.C)

Department of Electronics and Communication

U.P. Technical University,Lucknow,India

Abstract- Slotted Octagonal Fractal Antennal designing frequency 2.5 GHz, The small physical size and multi-band capability are very important in the design of multiband antennas. Fractals have unique properties such as self-similarity and space-filling. The use of fractal geometry in antenna design provides a good method for achieving the desired miniaturization and multi-band properties. In this communication, a multi-band antenna based on a new fractal geometry is presented. The proposed design is an Octagonal shape fractal antenna. The simulated through IE3D software. It is worth noticeable that proposed shapes suits for 2.5 GHz WLAN and Bluetooth (IEEE-802.11b/g std.),3.5 GHz WIMAX(IEEE-802.11y std.) std. The results show that the proposed Crown shaped Fractal Antenna can be used for 2 GHz –5 GHz frequency range.

I. INTRODUCTION

Modern communication systems require antennas with more bandwidth and smaller dimension. One of the main components of ultrawideband (UWB) communication systems is an UWB antenna. Customarily, wideband antennas need different antenna elements for different frequency bands. If antenna size is less than a quarter of wavelength, antenna will not be efficient. Fractal geometry is a very good solution to fabricate multi-band and low profile antennas. Applying fractals to antenna elements allows for smaller size, multi-band and broad-band properties. Thus, this is the cause of spread research on fractal antennas in recent years [1]–[4]. Fractals have self-similar shapes and can be subdivided in parts such that each part is a reduced size copy of the whole. The self-similarity of fractals is the cause of multi-band and broad-band properties and their complicated shapes provides design of antennas with smaller size. Fractals have convoluted and jagged shapes such that these discontinuities increase bandwidth and the effective radiation of antennas. The space-filling property of fractals leads to curves which have long electrical length but fit into a compact physical volume. [5]–[9]. Several UWB antenna configurations based on fractal geometries have been investigated includingKoch, Sierpinski, Minkowski, Hilbert, Cantor, and fractal tree antennas in recent years. The numerical simulation and experimental results of these antennas are available in literature to date. In this communication, a fractal microstrip antenna is presented. This new fractal geometry is based on an iterative octagon. The huge bandwidth is the main advantage of this fractal antenna over conventional fractal antennas. The commercially available simulation software IE3D Microwave Studio has been used for the design and simulation of the proposed microstrip antenna. According to the results, this new fractal antenna is applicable in 2 GHz–5 GHz frequency range and the gain of this fractal microstrip antenna is reasonable in entire bandwidth.

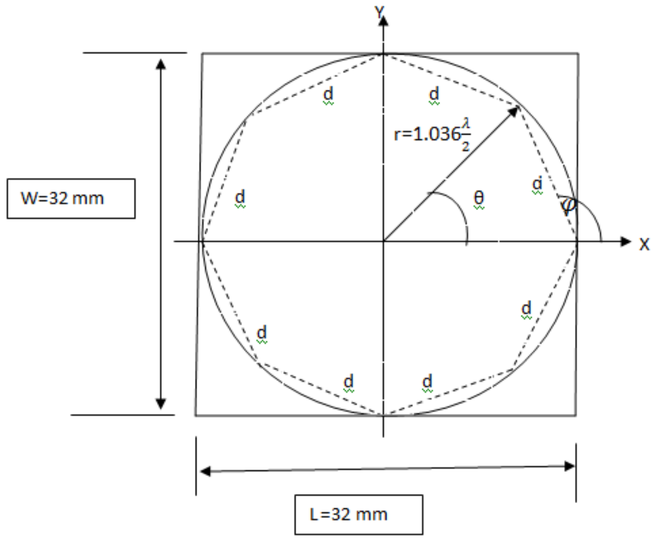

Fig. 1. geometry of Slotted octagonal subarray generator

This communication is arranged in four sections. Design of proposed antenna is discussed in Section II. Simulated and measured results are presented in Section III,IV .

II.ANTENNA DESIGN

For microstrip antennas, the width (W) and length (L) of the radiating patch and the effective permittivity of the microstrip structure (ε_e) which support the operation at the required resonant frequency (or the free-space wavelength (λ_0) can be designed as follows, using the formulas give[14].

$$W = \frac{c}{2 f_0 \sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad \text{.........................(1)}$$

ISSN: 2278 – 909X

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}} ......(2)$$

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\xi_{eff}}} ....(3)$$

$$\Delta L = 0.412h \frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} ....(4)$$

$$L = L_{eff} - 2\Delta L ....(5)$$

A conventional microstrip antenna, having square radiating patch, with patch dimensions L=32mm W = 32 mm, designed to operate at 2.5 GHz, the standard frequency for wireless LAN. A printed circuit board (PCB) with the permittivity ε_r = 4.4 (compared to the commercial PCB, FR-4) is used as the dielectric substrate placed on top of the group plane to form the microstrip antenna. The thickness of the substrate is 1.6 mm.

There are several types of fractal microstrip patch antennas. The most well-known fractal patch antenna is Sierpinski patch antenna such that the various types of it are used greatly in telecommunication systems. The quadrilateral and hexagonal fractal microstrip antennas were discussed in some papers.

In initial process of this project, many designs and simulations areperformed over fractal patch antennas. The various types of quadrilat-eral, pentagonal and hexagonal fractal patch antennas are considered and finally the octagonal fractal shape is selected because of its good performances in bandwidth and gain.

The standard octagonal arrays are formed by placing elements in an equilateral triangular grid. These arrays can also be viewed as con-sisting of a single element at the center, surrounded by several con c-entric eight element circular arrays.

To investigate the designs for octagonal arrays via a recursive application, we consider the eight-element circular generating sub-array of $d = \lambda/2$ shown in Fig. 1. According to the octagonal pro-perties, the interior angle is 135^0 and the exterior angle is 45^0.Thus we can conclude

$$\cos\left(\frac{135^0}{2}\right) = \frac{\frac{d}{2}}{r} \rightarrow r = 1.306\left(d or \frac{\lambda}{2}\right) ......(6)$$

(1)

The array factor may be expressed in the form

$$A\wedge F_p(\theta,\varphi) = \frac{1}{8^P}\prod_{P=1}^{P}\sum_{n-1}^{8} e^{j\delta P-1[1.306\pi \sin\theta \cos(\varphi-\varphi_n)+\alpha_n]} ...(7)$$

Where

$$\varphi_n = (n-1)\frac{\pi}{4} ....(8)$$

$$\alpha_n = -1.306\pi \sin\theta_0 \cos(\varphi_0 - \varphi_n) ....(9)$$

The parameter δ is a scale factor that controls the largeness of the
array with each recursive generation application and P is the number
of concentric octagons in the array. Therefore, the total number of elements with P octagons is

$$N_P = 4P(P+1) + 1 ....(10)$$

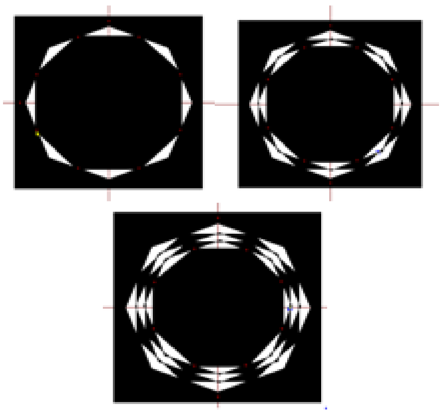

Fig. 2. Iterations of the proposed fractal geometry.

The array factor expression may also be written in the form

$$A\wedge F_P(\theta,\varphi) = \prod_{P=1}^{P}\sum_{n=1}^{8} e^{j\delta P-1\phi_n(\theta,\varphi)} ....(11)$$

Where

ISSN: 2278 – 909X

$$\varphi_n(\theta,\varphi)=1.306\pi[\sin\theta\cos(\varphi-\varphi_n)-\sin\theta_0\cos(\varphi_0-\varphi_n)]....(12)$$

If the expansion factor of the recursive octagonal array is assumed to be $\delta = 1$, the equation is expressed in form

$$A\wedge F_p(\theta,\varphi)=\left[\frac{1}{8}\sum_{n=1}^{8}e^{j\varphi_n(\theta,\varphi)}\right]......................(13)$$

The geometric construction of Fig 2 there are a three shape first fractal shape starts with an octagon, called the base shape, which is shown in Fig. 2 (Base Shape). By adding another octagon inside the base shape, the first version of the new fractal geometry, shown in Fig. 2 (First Iteration) is created. The process is repeated in the generation of the second iteration which is also shown in Fig. 2 (Second Iteration).

In this communication, the second iteration of the octagonal fractal geometry is considered since higher order iterations do not make significant affect on antenna properties.

III. SIMULATED RESULT

For this antenna, the length of each side of octagon is 2 cm. with patch dimensions L=32mm W = 32 mm, designed to operate at 2.5 GHz, the standard frequency for wireless LAN. A printed circuit board (PCB) with the relative permittivity ε_r = 4.4 (compared to the commercial PCB, FR-4) is used as the dielectric substrate placed on top of the group plane form the microstrip antenna. The thickness of the substrate is 1.6 mm.

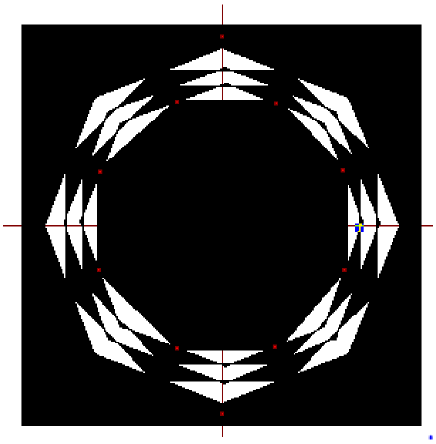

Fig. 3. Antenna structure second iteration

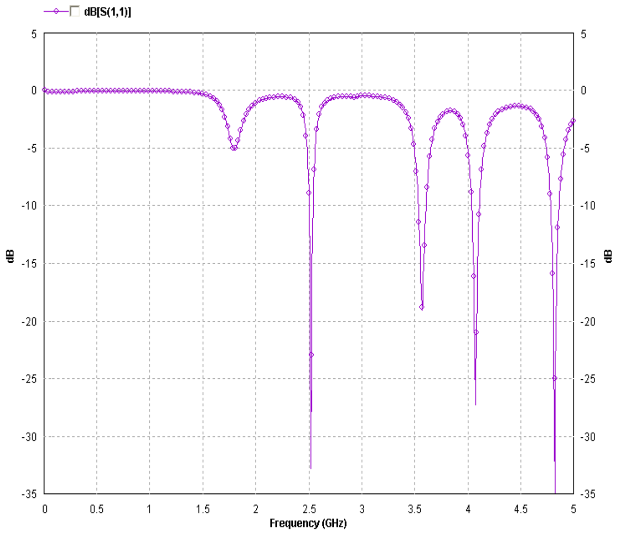

Fig.4. The simulated S_{11} for the second iteration

After completion of simulation setup IE3D provides various antenna parameters through its easily accessible in user graphics format for analysis point of view. The fig 4 represents the simulated curve of Return Loss parameter (in dB). As far a freq. to be resonant freq, it must follow the rule of $S_{11} \leq$ -10 dB. On this rule our proposed Slotted Octagonal geometry antenna provides multiple frequency sample point where $S_{11} \leq$ -10 .The same is also verified by VSWR curve in VSWR $\leq$ 2).

ISSN: 2278 – 909X

International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 3, Issue 1, January 2014

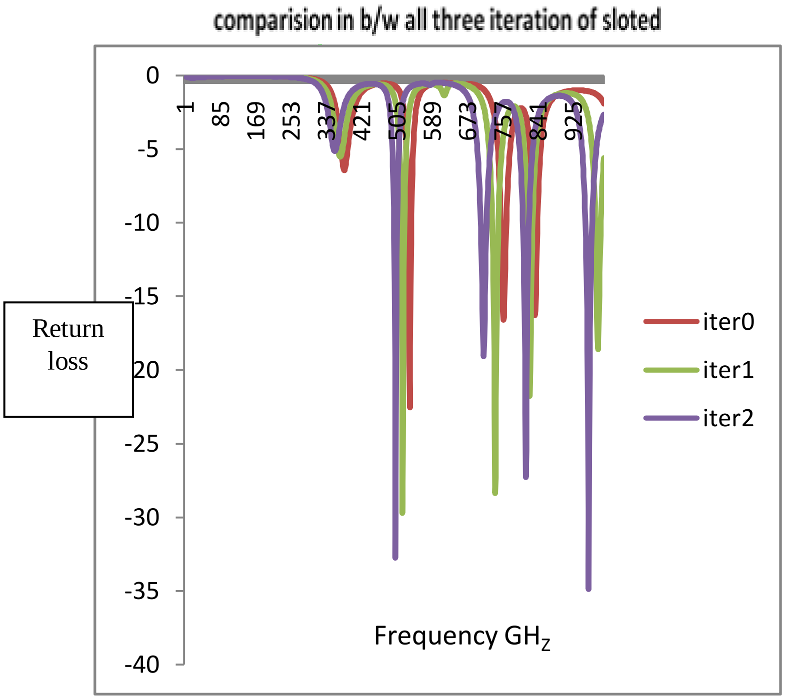

Fig.5. The Return loss curve for all iteration

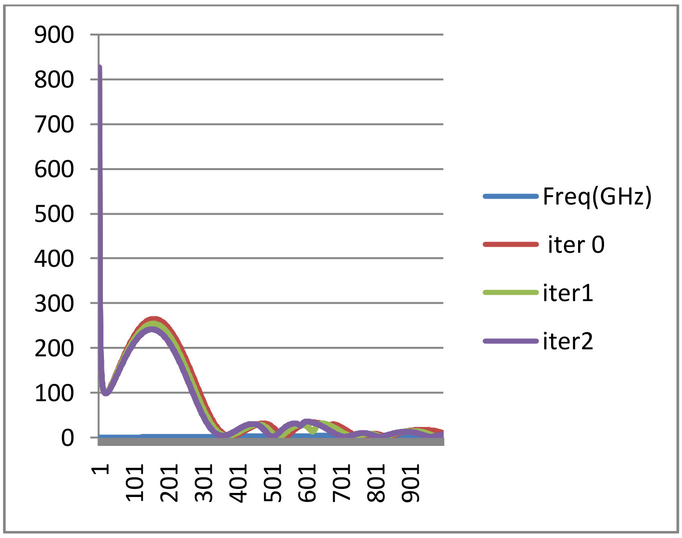

Fig.6. The VSWR curve for all iteration

TABLE 1 return loss curve for all iteration

Freq.	S_{11}-2nd-Iter.	Freq.	S_{11}-1st-Iter.	Freq.	Basic shape
2.5	-13	2.6	-30	2.7	-22-17
3.6	-27	3.7	-28	3.7	-17
4.1	-19	4.1	-22	4.2	
4.8	-35	4.9	-12		

IV. MEASURED RESULT

Antenna characteristics are measured using the network analyzer. It is very convenient and easy to obtain antenna input characteristics using a network analyzer. The return loss (S11) measurement can be obtained from this equipment using single port calibration. The experimental set up is shown in Fig. 7.

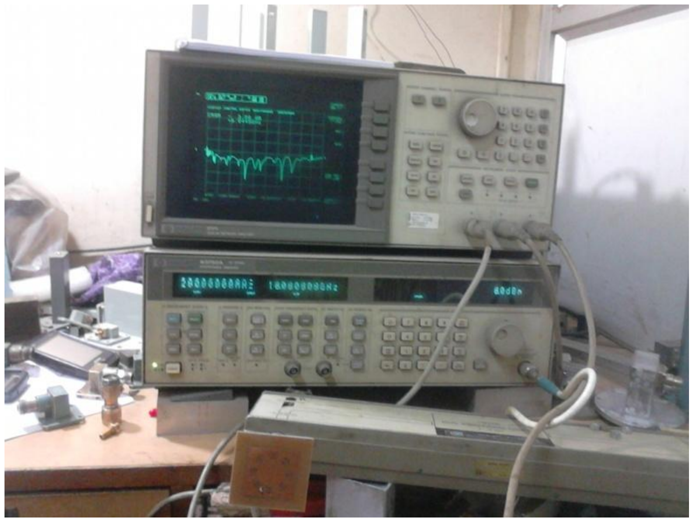

Fig.7. Testing of Complementary slotted octagonal antenna with Network analyzer (VNA) screen showing the Return Loss plot

TABLE:2 Difference B/W Return loss curve for Second iteration measured and simulated

Freq.	Measured RL	Freq.	Simulated RL
2.8	-14.8	2.5	-13
3.4	-12.12	3.6	-27
4.19	-10.8	4.1	-19
4.7	-17.25	4.8	-35

ISSN: 2278 – 909X

Fig. 7. shows the structure of antenna on the substrate.

V. CONCLUSION

The Octagonal Fractal Antenna is observed to possess mulitiband behavior [1, 2,11], and it is practical to change the frequency separation as we want. It is easy to forecast the antenna's frequency; therefore, the Octagonal Fractal Antenna seems to be an interesting configuration for use in applications where multiband operation with a small and changed frequency separation is required.

When we need more than two resonant frequencies, we can use the more iterated ones. And use the same way to coordinate every square's circumcircle (R) to get the wanted frequencies.

V. REFERENCES

[1]. Falconer K. J., 1990, *Fractal Geometry: Mathematical Foundations and Applications*.New York: ,John Wiley& Sons,Inc. New York.

[2]. Gianvittorio J. P., 2003, Fractals, MEMS, and FSS electromagnetic devices miniaturization and multiple resonances," *Dissertation*, University of California, Los Angeles.

[3]. Gianvittorio J. P.,Rahmat-Sammi. Y, 2002, Fractal Antenna: A novel miniaturization Technique and Application, *IEEE Transactions on Antenna & Propagation*, vol.44, Issue: 1, pp20-36.

[4]. Kravchenko F. and A.A. Potapov, 2001 "New class of Atomic fractal functions & their applications", *Physics and Engineering of millimeter and Sub Millimeter Waves*, vol.1, pp.102-107.

[5]. Rager B.J. Baron, 1994, fractal landscape 280294 available at http://perso.club-internet.fu/regor/F-render/index.html.

[6]. Selvan, P.T. Raghavan, S. ,2011, A novel compact CPW-fed octagon shaped slot antenna for WLAN application,*WirelessCommunication,Vehicular Technology, Information Theory and Aerospace,& ElectronicSystem Technology*,pp.1-4

[7]. Wojciech J. Krzysztofik,MARCH 2009, "Modified Sierpinski Fractal Monopole for ISM-Bands Handset Applications" *IEEE Transactions on Antenna and Propagation*, Vol. 57, no. 3.

[8]. Aidin Mehdipour*, 2010,* Iosif D. Rosca, Abdel-Razik Sebak, *S*Full-Composite Fractal Antenna Using Carbon Nanotubes for Multiband Wireless Applications *IEEE Antennas and Wireless Propagation Vol.9.*

[9]. Mahdi Naghshvarian Jahromi, Abolfazl Falahati, 2011, Bandwidth and Impedance-Matching Enhancement of Fractal Monopole Antennas Using Compact Grounded Coplanar *Waveguide* , " *IEEE Transactions on Antenna and Propagation, Vol. 59, no.7.*

[10]. Amanpreet Kaur1, Nitin Saluja2,J S Ubhi3,july 2012 "Design Of Sierpinski Gasket Multiband Fractal Antenna For Wireless Applications" *IOSR Journal of Electronics and Communication Engineering (IOSRJECE)* ISSN : 2278-2834 Volume 2, Issue 3 , PP 05-06 www.iosrjournals.org

[11]. Abolfazl Azari,MAY 2011, SLOTTED OCTAGONAL FRACTAL ANTENNA *IEEE Transactions on Antenna and Propagation, Vol . 59, NO. 5,*

[12]. R. L. Yadava1, M. Ram1 and S. Das,2010 " Multiband Triangular Fractal Antenna for Mobile

Communications" R L Yadav et. al. / *International Journal of Engineering Science and Technology Vol. 2(11), 6335-6348*

[13]. Sachin chauhan,2012,a design of crown-shape fractal patch antenna" *International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 3.*

[14]. Constantine. A. Balanis, 1938 Antenna Theory, *Analysis and Design* (Second Edition) John Wiley & sons, Inc

[15]. Wang Yong, Liu. Shaobin ,2008 "A New Modified Crown Square Fractal Antenna" *IEEE Transactions on Antenna and Propagation.*

ISSN: 2278 – 909X