ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 3, September 2012

Small Sized L- Shaped Meandered Quad Band Quasi Fractal Patch Antenna

Kirti Vyas, Devendra Soni J.P Mishra, P. K. Singhal

Abstract-In this paper, a novel design of Quasi Fractal Patch Antenna is presented. It is a compact design of 12.5×16.5 mm^2 area on FR$_4$ substrate with dielectric constant of 4.4, thickness of 1.6 mm and fed by a coaxial feed technique. Microstrip patch antenna consists of a quasi fractal patch with L- shaped meandered lines to provide multiband operations. The proposed antenna resonates at four different frequencies 5.78GHz, 9.13GHz, 9.72GHz and 11.3GHz with high return loss of -17.01dB, -17 dB ,-14.45dB and -32.49dB respectively with satisfactory radiation properties. The antenna operated in quad band, viz. 5.7-5.9 GHz with percentage bandwidth of 3.633% at 9-9.3 GHz with percentage bandwidth of 2.12%, at 9.6-9.9 GHz with percentage bandwidth of 4%, and 11-11.5 GHz with percentage bandwidth of 7.2% .The parameters that affect the performance of the antenna in terms of its frequency domain characteristics are investigated. The antenna design has been simulated on IE3D, an electromagnetic (EM) simulation software tool. This antenna is good for mobile and wireless applications.

Keywords—Fractal Antenna, Quad Band, IE3D Return Loss.

I. INTRODUCTION

Fractal shaped antennas exhibit some interesting features that stem from their inherent geometrical properties. The self-similarity of certain fractal structures results in a multiband behaviour of self-similar fractal antennas and frequency-selective surfaces (FSS) [1-3].The interaction of electromagnetic waves with fractal bodies has been the study of many researchers in the recent years [4]. The word “Fractal” is outcome of Latin word “fractus” which means linguistically “broken” or “fractured”. Benoit Mandelbrot, a French mathematician, introduced the term about 20 years ago in his book “The fractal geometry of Nature” [5].The term fractal was coined by Mandelbrot in 1975, but many types of fractal shapes have been proposed long before. Fractals are generally self-similar and independent of scale [6]. Micro strip patch Antennas are very popular in many fields as they are low-profile, low weight, robust and cheap. In last year’s new techniques employing fractal geometries are studied and developed [7].One of them is the fractalizing of antennas boundary where new qualitative effect as the higher mode localization appears that result in directive radiation patterns [7].

In this paper, we propose a novel space filling quasi fractal L- shaped meandered patch antenna to reduce the size of micro strip patch antenna. The original meander is constructed by removing a strip of constant width and length from central main rectangle. The proposed antenna is designed and simulated using IE3D Software. The fractal Antenna is advantageous in generating multiple resonances.

II.PROPOSED ANTENNA DESIGN

In this paper, the performance of space-filling L – shaped meandered fractal lines on coaxial fed patch antennas has been investigated till third order. It may be contended that the bends and corners of these geometries would add to the radiation efficiency of the antenna, thereby improving its gain.[7] Advantage of these configurations is that they lead to multiband conformal antennas[6].The proposed antenna is designed on Fr$_4$ epoxy substrate having the dielectric constant of 4.4 and 0.02 loss tangent. In the design of this type of antennas, the width ‘W’ and length ‘L’ of base shape (zero order) patch play a crucial role in determining the resonant frequency. Here for the zero order or base shape the length of rectangular patch is taken as l=12.5 mm and width as w=16.5 mm. The designed value of the antenna is optimized with IE3D tool. The first order design is created from first iteration by removal of two “L” shaped slots placed as shown in the figure 2. In next second iteration to create order shape we will repeat this process and increase one “L” shaped strip inside first and in second order increase one more than first order. A ground plane of copper is printed on the back of the substrate as a ground plane for the probe feed line technique .Figure 1 shows the base shape of proposed antenna of dimension 12.5*16.5mm^2 and figure2 shows the first order shape after cutting the “L” shaped meanders of dimension 9.375*12.375mm^2 which is basically ¾ of the base shape dimensions.

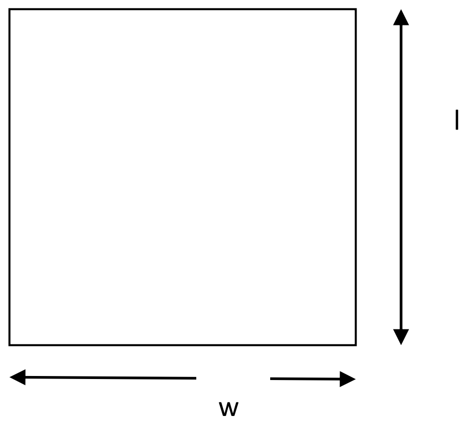

Fig. 1:- Base Shape of L-shaped Meandered Quasi fractal antenna (l=16.5mm, w=2.5mm)

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 3, September 2012

The main advantages of the proposed antenna are: (1) compact size, (2) multiband characteristics (3) size reduction.

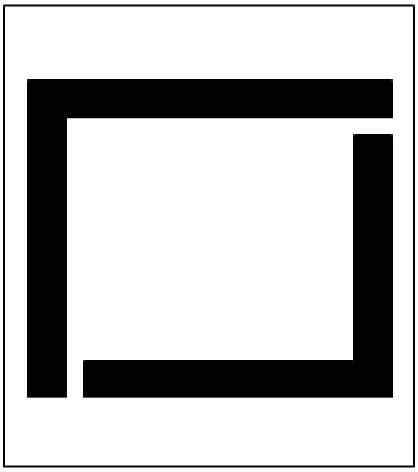

Fig. 2:- First Order Shape of L- Shaped Meandered Quasi Fractal Antenna

Here the size of the antenna will be depending on the resonant frequency which will be reducing as we keep on iterating the first order design. The correct resonant frequencies and impedance matching of the proposed antenna can be established by adjusting the location of feed point and the distance between the L- shaped meandered portions. Figure 3 and 4 show the second and third order shape of L-shaped meandered quasi fractal antenna with dimension of inner L- shaped lines chosen as ¾ of higher order l- shaped dimensions.

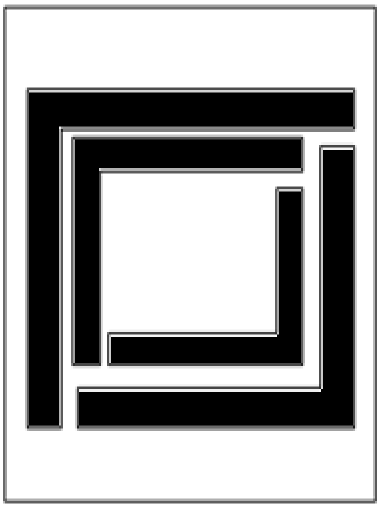

Fig. 3:- Second Order Shape of L- Shaped Meandered Quasi Fractal Antenna

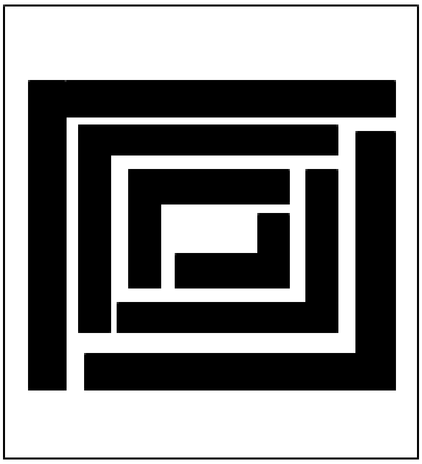

Fig. 4:- Third Order Shape of L- Shaped Meandered Quasi Fractal Antenna

III RESULTS AND DISCUSSION

The results for the three iterations performed on the rectangular patch to get the desired L- shaped meandered quasi fractal antenna are as follows:

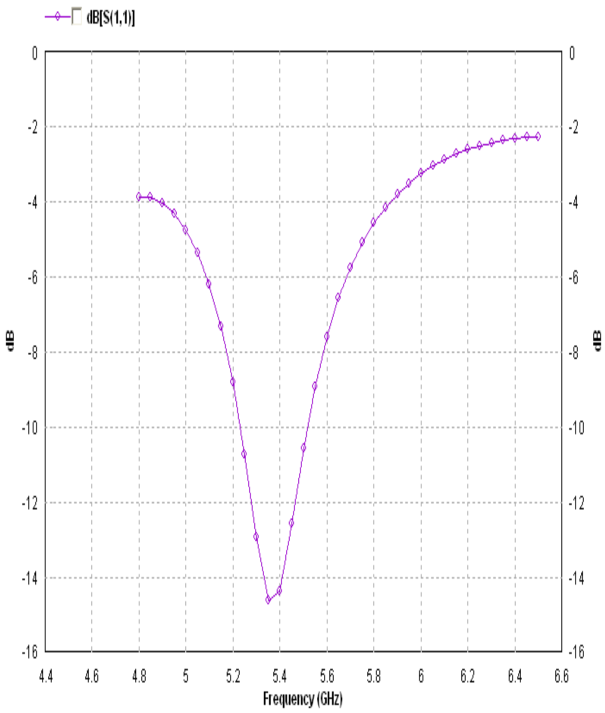

Fig. 5:- Return Loss for Base Shape

Fig.5 shows that the antenna resonates at 5.4 GHz with return loss of -14.38 dB. This design can be used in IEEE 802.11a Wireless LAN application and in C band applications.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 3, September 2012

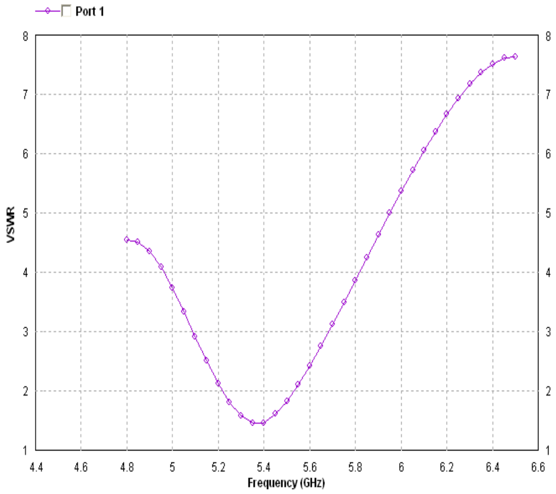

Fig. 6:- VSWR of Base Shape

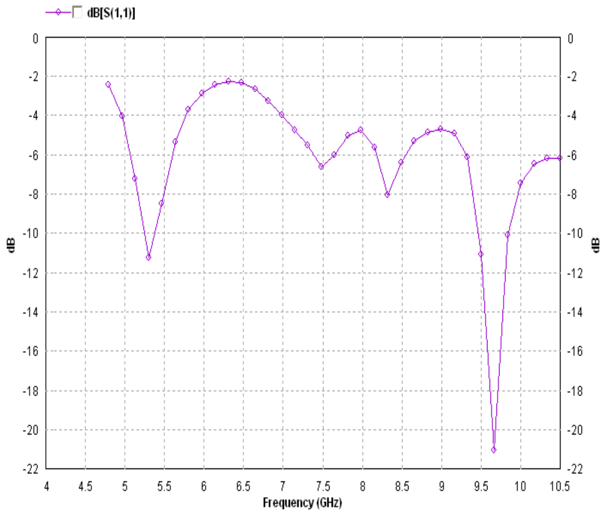

Fig. 7:- Return Loss of First Order

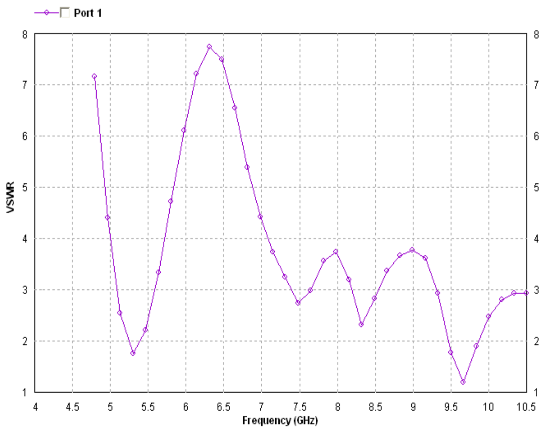

Fig. 8:- VSWR Of First Order

For First Order There Are Two Bands Occurring With Resonance Frequencies At 5.303 Ghz And 9.662 Ghz

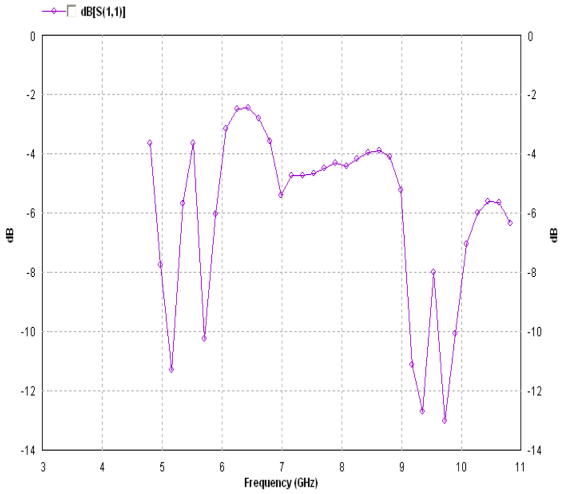

Fig. 9:- Return Loss of Second Order

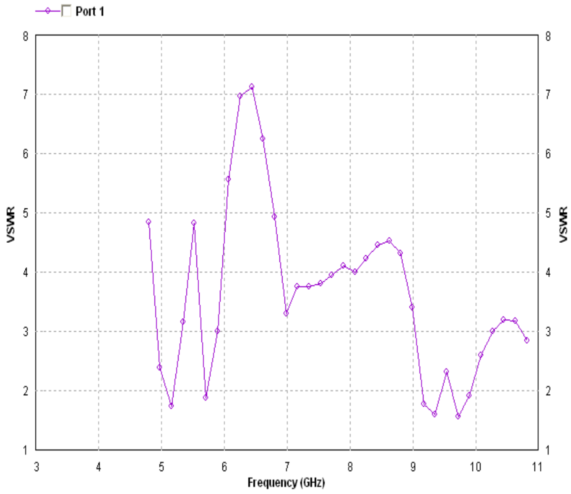

Fig. 10:- VSWR of Second Order

For second iteration three bands are occurs at resonance frequency of 5.165 GHz, 9.395 GHz and 9.724 GHz.

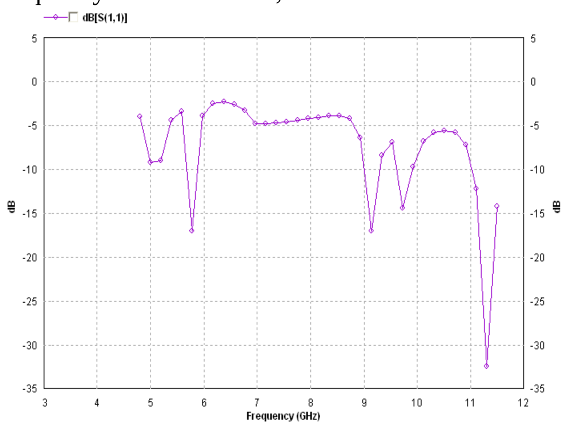

Fig. 11:- Return Loss for Third Order

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 3, September 2012

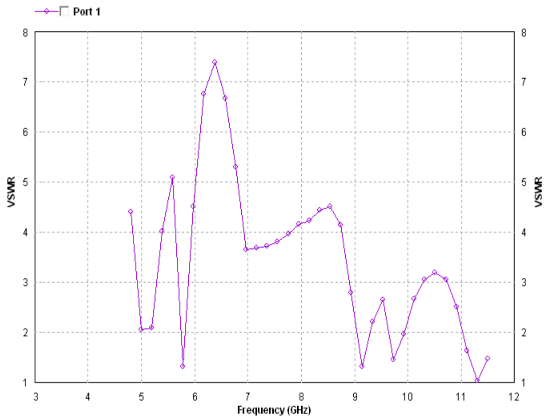

Fig. 12:- VSWR of third order

The proposed antenna resonates at four different frequencies 5.78GHz,9.13GHz,9.72GHz and 11.3GHz with high return loss of -17.01dB,-17 dB ,-14.45dB and -32.49dB respectively with satisfactory radiation properties. The antenna operated in quad band at 5.7-5.9 GHz with percentage bandwidth of 3.633%, at 9-9.3 GHz and with percentage bandwidth of 2.12%, at 9.6-9.9 GHz with percentage bandwidth of 4%, and 11-11.5 GHz with percentage bandwidth of 7.2%.The table 1 below shows the frequency detail of the third order of the l-shaped quasi fractal antenna. Frequency detail table we see that the antenna gives the gain of 3.23dBi with directivity of 7.202dBi. A Comparative table for all the iterations is given in appendix-I for detailed performance evaluation of the proposed design.

Property	**Value**
Frequency	9.135GHz
Incident power	0.01W
Input Power	0.00979943W
Radiated power	0.00090339W
Average Radiated power	7.18854e-005W/s
Radiation efficiency	9.21827%
Total Field Properties	
Gain	3.23362 dBi
Directivity	720788dBi
Maximum	At [59.3296,260]deg
3 dB Beam width	[48.6083,78.556]deg
Theta Field properties	
Gain	3.90902
Directivity	6.53248dbi
Maximum	At [58.324,270]deg
3dB Beam width	[45.4691,56.6656]deg

Table 1.Frequency Detail Table of Third Order

IV CONCLUSION

In this paper, the L- shaped meandered fractal antenna up to third order has been designed & simulated using the IE3D. It has been observed that with the increase in number of orders the band-width of the antenna, VSWR and return loss also increased. In third order, antenna is showing multiband results at higher bandwidth and maximum return loss. The self-similarity properties of the fractal shape are translated into its multiband behaviour. The simulation shows a size reduction is achieved by the proposed fractal antenna, without degrading the antenna performance, such as return loss and radiation pattern due to the meandered L shaped slots which have increased the length of the current path.

REFERERENCES

[1] C. Puente, J. Romeu, R. Pous, and A. Cardama, "On the behavior of the Sierpinski multiband antenna," IEEE Truns. Antennas Propagation. Vol. 46, pp. 5 17-524, Apr. 1998.

[2] J. Solcr and J. Romeu, "Generalized Sierpinski fractal antenna," IEEE Truw. Antennas Propagation. Vol. 49, pp. 1237-1234, Aug. 2001.

[3] J. Romeu and Y. Rahmat-Samii, "Fractal FSS: A novel multiband frequency selective surface,"lEEE Trans.Antennas Propagation., Vol. 48, pp. 7 13-7 19, July 2000.

[4] Carles Puente-Baliarda et al, "On the behaviour of the Sierpinski Multiband Fractal Antenna", IEEE Transactions on Antennas and Propagation, 1998, Vol.46, No.4, pp.517-523.

[5] Mandelbrot, B.B. (1983): The Fractal Geometry of Nature. W.H. Freeman and Company, New York.

[6] M. R Haji-Hashed , H. AbiriA ,"Comparative Study of some Space-Filling Micro strip Patch antennas" IEEE International Workshop on Antenna Technology 2005, pp.274-277.

[7] M. R. Haji-Hashemi, H. Mir-Mohammad Sadeghi, and V. M. Moghtadai "Space-filling Patch Antennas with CPW Feed" Progress In Electromagnetic Research Symposium 2006, Cambridge, USA, March 26-29, pp. 69-70.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 3, September 2012

APPENDIX

Comparative Table Of L- Shaped Meandered Quad Band Quasi Fractal Patch Antenna

S. No.	Shape	Resonant Freq. (GHz)	Return Loss	Bandwidth	Gain	VSWR
1.	Base Shape	F_{r1} =5.4 GHz	-14.38db	5.233%	3.231dbi	1.472
2.	1^{st} Iteration	Fr_1 =5.3 GHz	-11.25db	3.773%	2.82dbi	1.754
		F_{r2} = 9.66GHz	-21.06db	3.2%	0.577dbi	1.194
3.	2^{nd} Iteration	F_{r1} =5.16GHz	-11.29db	3.294%	2.203dbi	1.175
		F_{r2} =9.35GHz	-12.67db	2.45%	2.951dbi	1.606
		F_{r3} =9.72GHz	-13db	2.29%	2.252dbi	1.577
4.	3^{rd} Iteration	F_{r1} =5.78GHz	-17.01db	3.633%	3.02dbi	1.329
		F_{r2} =9.13GHz	-17db	2.19%	0.366dbi	1.329
		F_{r3} =9.72GHz	-14.45db	4%	1.391dbi	1.467
		F_{r4} =11.3GHz	-32.49db	7.2%	3.23dbi	1.043