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Experimental Study on Cantor Shaped Fractal Patch Antenna for Wireless Applications

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ABSTRACT

Microstrip patch antenna is low profile, conformable to planner and non-planner surfaces, inexpensive and easy to manufacture by using modern printed circuit technology. For multi- band applications design antenna using fractal geometry. One promising approach in this regard is to use the fractal geometry, to find the best distribution of current in an area meet at a particular design. In this design we use cantor fractal geometry. The dimension of this patch is L*W (27*27) mm and height is 2mm. Dimension of ground is L*W (43*43) mm. FR-4 dielectric substrate is use in this design antenna. Four iterations used in this design, which is improve the performance of antenna. This proposed antenna is Omni- direction, good gain, compact size, easy to fabricate and used for GPS system, Wi-Fi and WLAN Network. This design antenna is multiband performance and simulated by IE3D simulator.

Keywords: *Fractal geometry, Patch antenna, IE3D Simulator*

I. INTRODUCTION

In the study of antennas, fractal antenna theory is relatively new area. The emergence of antenna is with fractal geometry has s given an answer to main limitation single band performance of antenna. The word 'fractal' means broken or irregular fragments. The development of fractal geometry has came largely from an in depth study of pattern of nature. For Multi-band applications and reduction of size there are Increasing, the demand in both of military and commercial applications.[7] Self similar properties of a certain fractal result in a multiband behavior of antenna and highly convoluted shape, of these fractal geometry makes possible the reduction size of patch. This reduction can make possible to combine multimedia, communication applications and It also can provide GPS services. Microstrip patch antenna (MPA) has wide interest due to its important characteristics, like light weight, low cost, mechanically robust, easy to integrated etc. Fractal antenna could be designed using self-similarity structure [2].The concept of fractal fundamental geometry construction principle in nature [1]. Microstrip patch antenna has resonant element [3]. In design of microstrip patch antenna main factors depends on dimensions of antenna. The self similarity is a property of log-periodic antenna that makes them frequency independent [4]. It has been demonstrated that the fractal properties based on space filling and self similarity which helpful for improving performance of antenna. The different feeding methodologies applied on fractal antenna without degrading their performance [5], if antenna size less than $\lambda/4$, it becomes inefficient because its parameters ruined [6].

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II. FRACTAL CONCEPT

Benoit Mandelbolt (1983) first defined the fractal geometry. This fractal geometry has been used previously to characterize unique occurrence in the nature. The fractal geometry has self-similar structures. Fractals can nature very well. Fractal can divide into many types. There have a number of theories and innovation applications developed by fractal. Fractal has been applied on compression of image and analyzed of high altitude of lighting process.[7]

III. ELEMENTS OF FRACTAL

The general concept of fractal geometry can be applied to develop many antenna elements. The self similarity concept used in designing of antenna. Which is develop the multiband applications.[7]

IV. SOFTWARE USED

In this design IE3D simulator used. It is a zeland program manager, which is used for simulate The design of patch.IE3D is an integral equation and moment based EM simulator.IE3D model model patch antenna with finite substrate and dielectric structure. It is mainly focused on general planner and 3D metallic structure. The main content of IE3D simulator is layout editor and editing modes and S parameters display, pattern handling, electromagnetic optimization and tuning. It increase accuracy and efficiency. IE3D is a very capable EM simulator and optimization package for both 2.5D and 3D antenna modeling. [8]

V. ALGORITHM USED

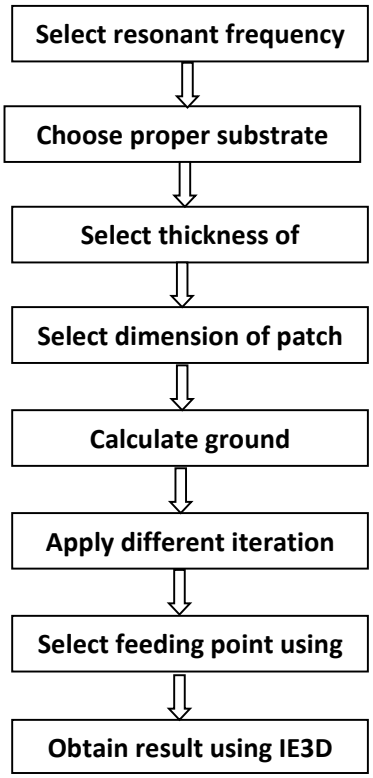

Figure 1: Flow chart of design antenna

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VI. ANTENNA DESIGN

It has been implemented that, a conventional microstrip square shaped patch antenna square has chose with proper dielectric substrate. There are number of dielectric substrates such as Roger, Taconic etc. Here we choose FR-4 substrate, which has dielectric constant $\varepsilon_r = 4.4$ and tangent loss is 0.02 which shown in below table.

Table 1: Property of material

Material Properties	Value
Dielectric constant	4.4
Loss tangent	0.02

After selection of substrate FR-4, select the thickness of patch. Then we select dimension of patch L=W=27 mm and Height of antenna is 1.5 mm. after that calculate the dimensions of ground, length and width.

$$Lg = 6h + L$$

$$Wg = 6h + w$$

It has been implemented that, after this process apply iterations on the square-shaped patch. In this antenna cantor fractal geometry has used and number of three iterations applied on the square-shaped patch. First apply 0^{th} iteration on the patch and obtained results. The length and width of cut in 1^{st} iteration is 13.5 mm and 9 mm, after that 2^{nd} iteration applied, cuts are made (L*W) 6.75 mm and 3mm, 3^{rd} iteration applied with dimensions 3.375 mm and 1mm. In this design $\theta=90^{\bullet}$ is used in every step. These three iterated design shown in figures 2.

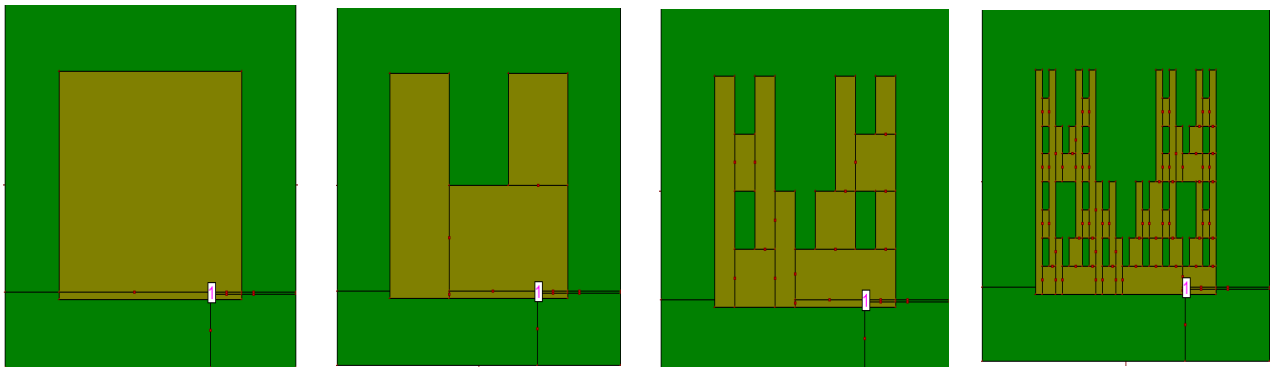

Figure 2 (a) 0^{th} iteration (b) 1^{st} iteration (c) 2^{nd} iteration (d) 3^{rd} iteration

It is observed that, values of all parameters are varied, when apply on patch iteration algorithm. All parameters are improve, when increases the number of iterations. It has been concluded that, after this step select the feeding technique, which is used to give the input to antenna. It has been experimented that select probe fed method, to apply the input to designed antenna, These values of fed point has on the X-axis and Y-axis are (9,-12.7) on the patch. In this design of square shape patch antenna, By applying iterative algorithm all three steps fed point and height is always same. After all this process we modeled our designed square shape patch antenna, each fractal patch configuration same dielectric substrate and same thickness modeled in IE3D and simulated for each iterative step. In this design $\theta=90^{\bullet}$ used in each iteration step. It is observed that frequency does not constant in every step of iteration.. The design of square-shaped patch is complex when all iterations applied on this patch antenna. But this design antenna give multiband characteristics.

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Table 2: Design parameters of Proposed Antenna

Variable	Value
Length of patch	27 mm
Width of patch	27 mm
Length of ground	43 mm
Width of ground	43 mm
Substrate thickness	1.5 mm
Feeding technique	Probe Feed
Substrate	FR-4
Feed point	(9,-12.7)
Length of 1st iteration	13.5 mm
Length of 2nd iteration	6.75 mm
Length of 3rd iteration	3.375 mm

VII. RESULTS OF SQUARE SHAPE PATCH ANTENNA

Table 3: Comparisons of height

Number of iteration	Resonant frequency (GHz)	Return loss (dB)	Gain (dBi)	Directivity (dBi)	Bandwidth (MHz)
1st	5.1	-19.6	4.8	7.1	195
	7.6	-16	8.2	11.6	210
	8.2	-12.9	5.8	11	165
2nd	5.2	-17.1	4.5	7.1	280
	10.7	-25.9	3.2	8.04	320
3rd	5.3	-14.7	3.7	7.8	200
4th	**4.6**	**-25.9**	**2.5**	**6.1**	**195**
	5.2	**-15**	**4.1**	**7.8**	**210**

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It has been observed that from the comparison table when number of iterations increased, then the directivity and bandwidth has also increased. At the final iteration results has improved. This designed antenna operated in two bands, C and S Band.

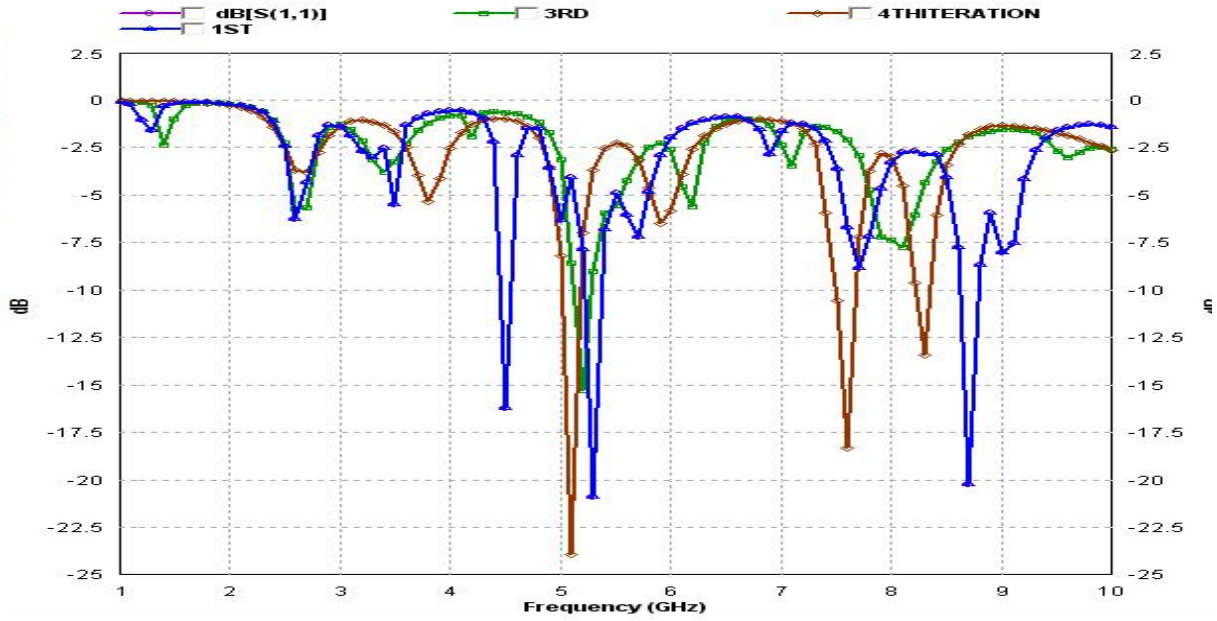

Figure 2: Frequency vs return loss graph

VIII. CONCLUSION

In this design it has been concluded that cantor fractal geometry used. The dimension of this patch has L*W (27*27) mm and height is 1.5 mm. Dimension of ground is L*W (43*43) mm. FR-4 substrate has been used in this design of square shaped patch antenna. Four iterations used in this design of square shaped patch antenna, which has improved the performance. This proposed antenna has Omni-direction, good gain, compact size and easy to fabricate and used for GPS system, Wi-Fi and WLAN Network. This antenna has been resonated with multiband performance.

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