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DESIGN AND SIMULATION OF NOVEL L-SHAPE FRACTAL ANTENNA

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Abstract: This paper represents design of L-shaped rectangular fractal antenna and the excitation is provided by using the microstrip line feeding technique. Copper annealed is used as a substrate material with relative permittivity 4.3, thickness 1mm and the resonant frequency is taken as 3.2GHz for the designing of proposed antenna. This is designed and simulated by using CST simulation software of 2021 version. The designed antenna can be used for various wireless applications such as WLAN, long distance communications, space communication etc. The L- shapes slots are etched from the patch to improve the gain and return loss of the antenna. In the L-Shaped antenna design, firstly designed the antenna's shape and designed on FR4-epoxy substrate with dielectric constant 4.3 and thickness 1mm. The proposed antenna is designed to analyze the different antenna parameters such as Gain, Return loss, and VSWR. We perform different iterations by adding or removing the substrate material as L shape and analyze different antenna parameters.

Keywords: L-slots, rectangular patch, circular patch, return loss, gain.

1. Introduction

According to the IEEE standard an antenna can be defined as “a means for receiving or radiating electromagnetic waves”. The patch antenna has basically three layers: ground layer, substrate layer and conducting patch. An antenna is also called transducer that converts electric power into electromagnetic waves [1]. Patch antenna consists of ground on one side and patch on the other side of the substrate. Different types of feeding techniques are used in antenna technology to excite the patch. Patch antenna is most novel technology in antenna field. It is used in many recent technologies. In today's modern technology antennas are the basic and important elements which are used to make proper connections between transmitter and receiver. Antennas are used in different systems in different forms. In communication system low cost, small size, high gain and wide bandwidth antennas are required.

Different types of antennae have been used in the modern communication systems such as microstrip patch antenna (MPA) and fractal antenna (FA) [2] [3][12].MPA has many applications in communication field such as satellite, missile, aircraft and spacecraft due to various advantages like low cost, easy installation better performance [4][13]. These antennas can be mounted to metal bodies. Various types of feed techniques are used to excite the patch. These antennas work on above 100 MHz frequencies. Substrate, patch and ground are the basic component of patch antenna. Patch is present on the one side of substrate and ground is on the other side of substrate. To improve the performance of antenna various types of modifications are done in basic geometry like slots in the patch and defected ground plane etc. [5]. Fractal antennas are used to overcome limitations of patch antenna such as limited bandwidth, size and efficiency. Idea of fractal antenna came from fractals present in nature. Fractal antennas are considered using fractal geometries that have properties like space filling, self-similarity and difficulty in their formation [6].

Shapes that exist in nature shows space filling and self-similarity properties. These characteristics of fractal antenna are used for more bandwidth and high gain. According to dictionary definition fractal word derived from word „fructus" which means has broken into various sub parts. In fractal geometry, shapes and curves repeated itself [7]. The fractal assumption techniques have been used for range reduce technique for all antennas types such as loops, dipoles, patches for the growth of fractal antenna. Fractal antennas allow antennas having different frequencies to design tetra band and tri-band antennas with a same gain and a very small size factor as a conventional antenna [8].

2. Literature survey

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 behavior 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.

3. PROPOSED ANTENNA DESIGN

In this paper, the performance of space-filling L – shaped meandered fractal lines on coaxial fed patch antennas have 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 Fr4 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*16.5mm2 and figure2 shows the first order shape after cutting the “L” shaped meanders of dimension 9.375*12.375mm2 which is basically ¾ of the base shape dimensions

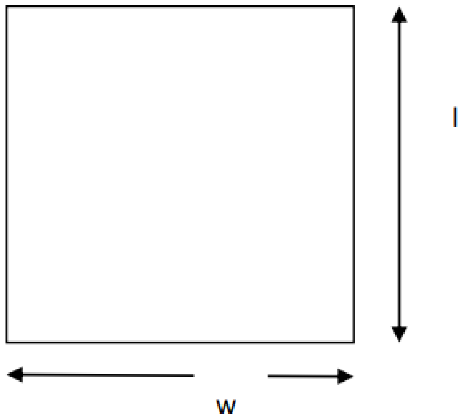

Fig. 1: - Base Shape of L-shaped Meandered Quasi fractal antenna (l=16.5mm, w=2.5mm)

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

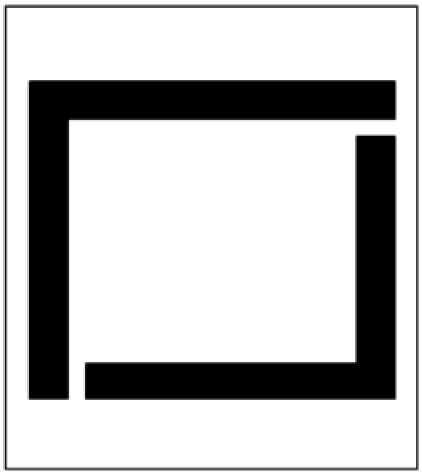

Fig. 2: - First Order Shape of L- Shaped Meandered Quasi Fractal Antenna

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.

IV RESULTS AND DISCUSSION

The results for the three iterations performed on the rectangular patch to get the desired L-shaped meandered quasi fractal antenna. In this section, the details regarding the antenna's design are provided followed by the results of the simulations that were carried out.

Design Parameters: The 3rd iteration of the proposed antenna has been designed by taking the 2nd iteration as a base geometry and extracting the design is modified by adding all the L

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Shaped slots of the rectangular patch except 2 large L shape slots. The small L shapes are filled with patch and all L shapes in 3rd iteration are removed. The simulated structure of 4th iteration of the proposed antenna is shown in Figure 3. In figure 4, the return loss of -54dB occurred around at 11.2 GHz frequency.

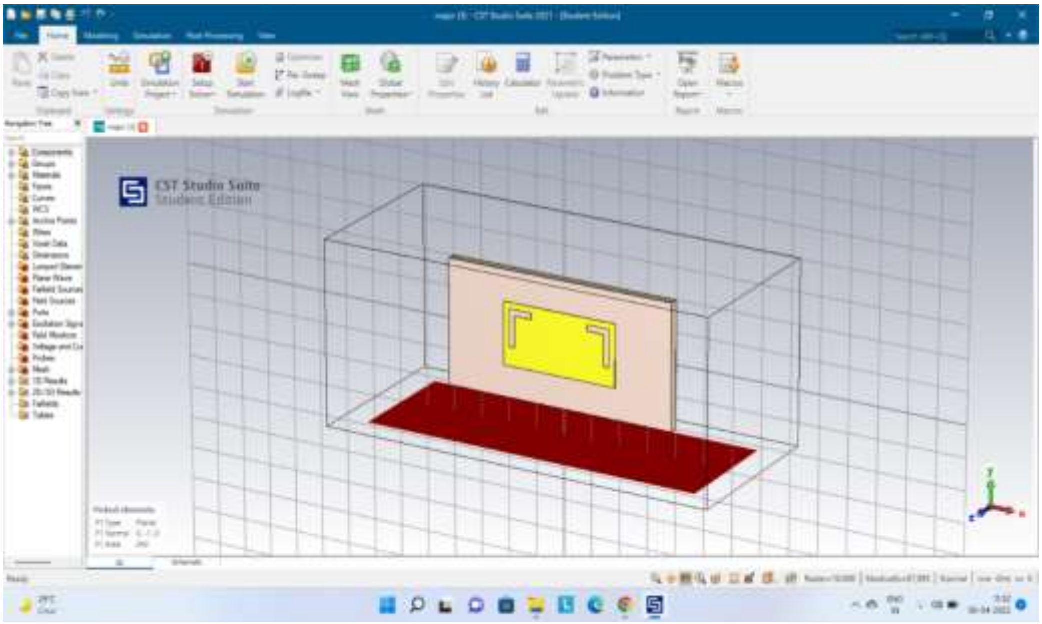

Figure 3. simulated structure of 4th iteration of the proposed antenna

Table 1. Dimensions of the design

s.no	Parameters	Description	Values
1.	LS	Length of substrate	80mm
2.	WS	Width of substrate	40mm
3.	LP	Total Length of L patch	100mm
4.	WP	Width of L patch	2mm
5.	LF	Length of the feed line	80mm
6.	WF	Width of the feed line	1mm

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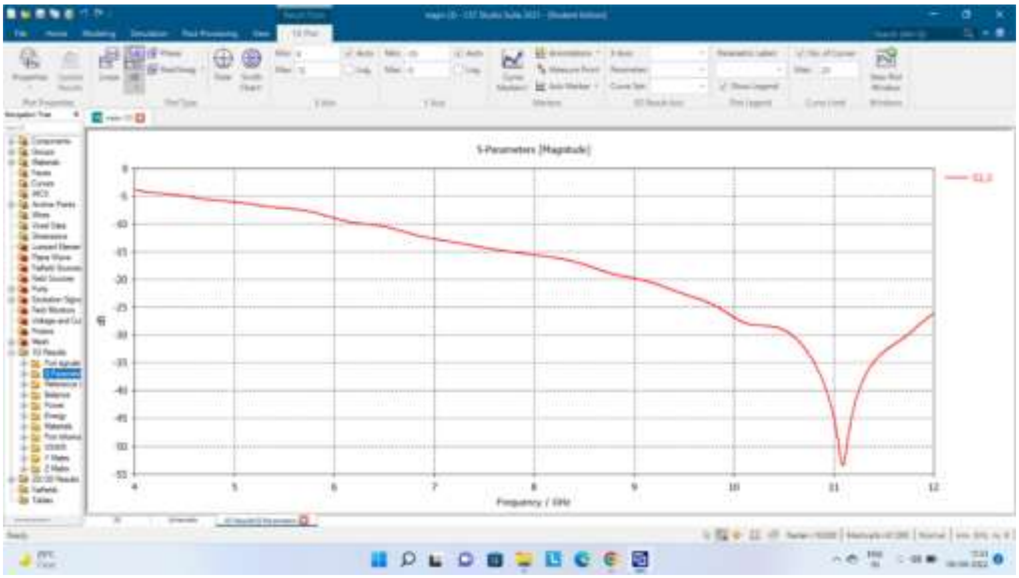

Figure 4. The S parameter plot (Return Loss).

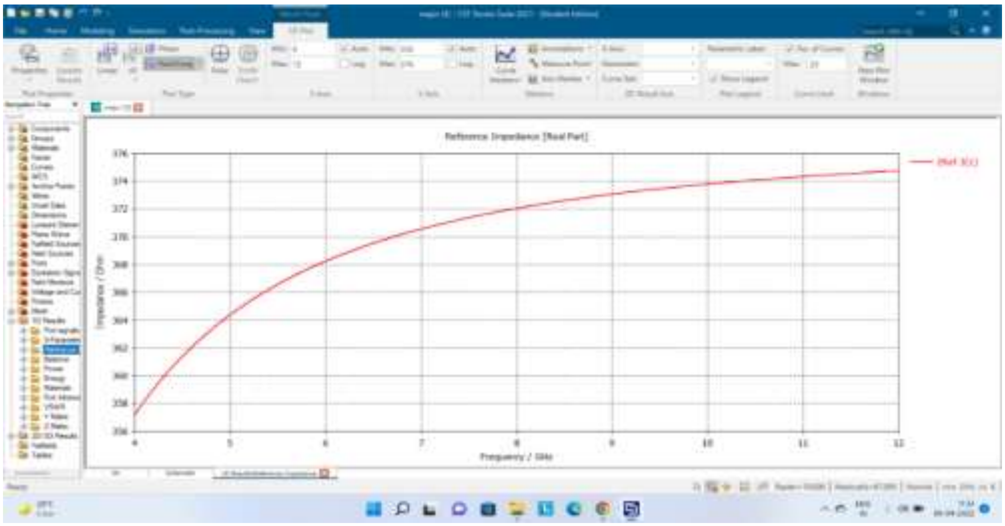

Figure 5. Reference impedance vs frequency

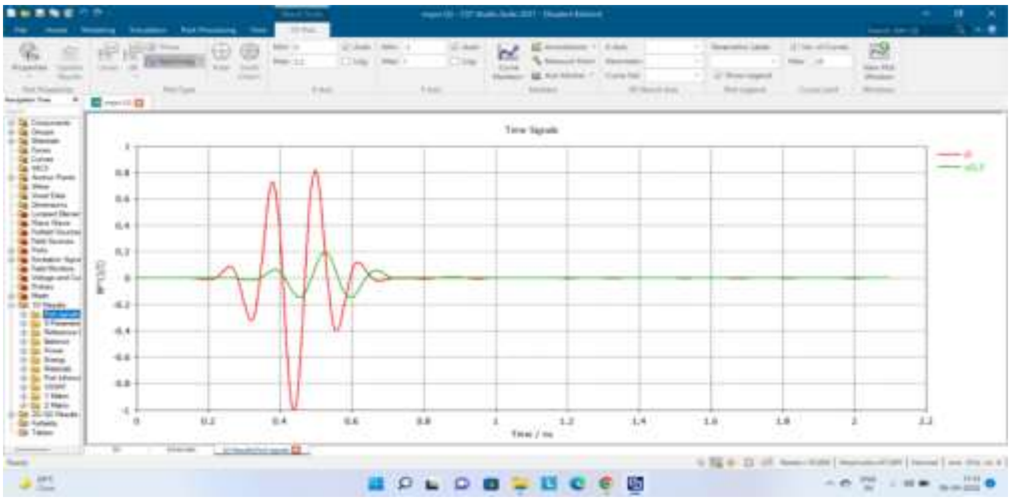

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Figure 6. Time signals graph

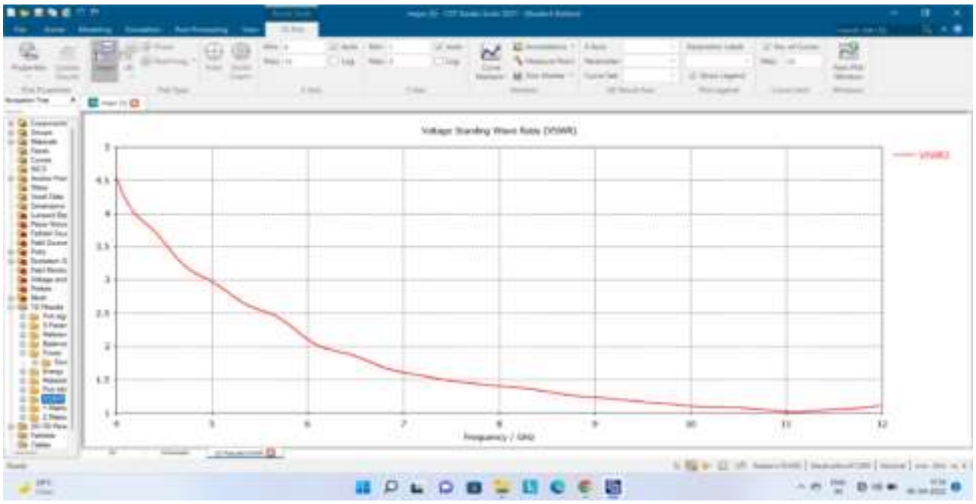

Figure 7. VSWR graph

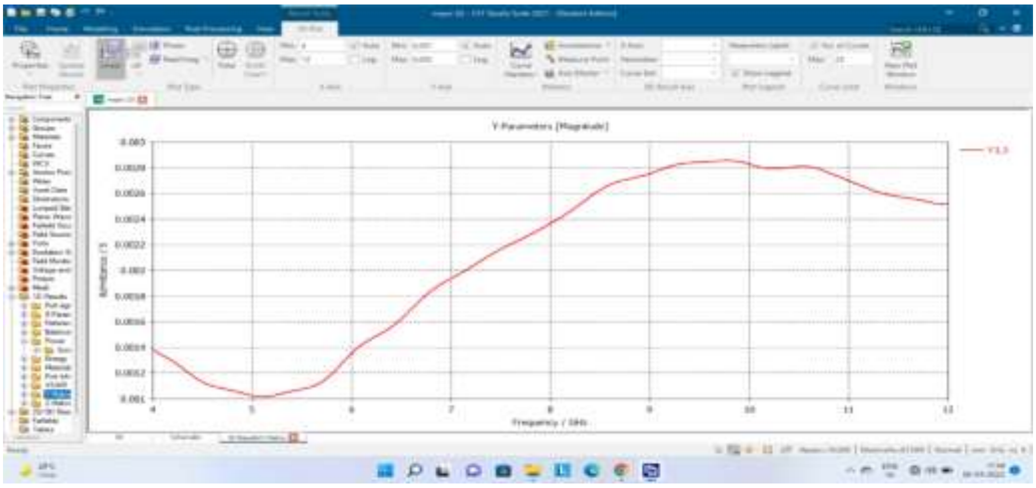

Figure 8. Y-parameters

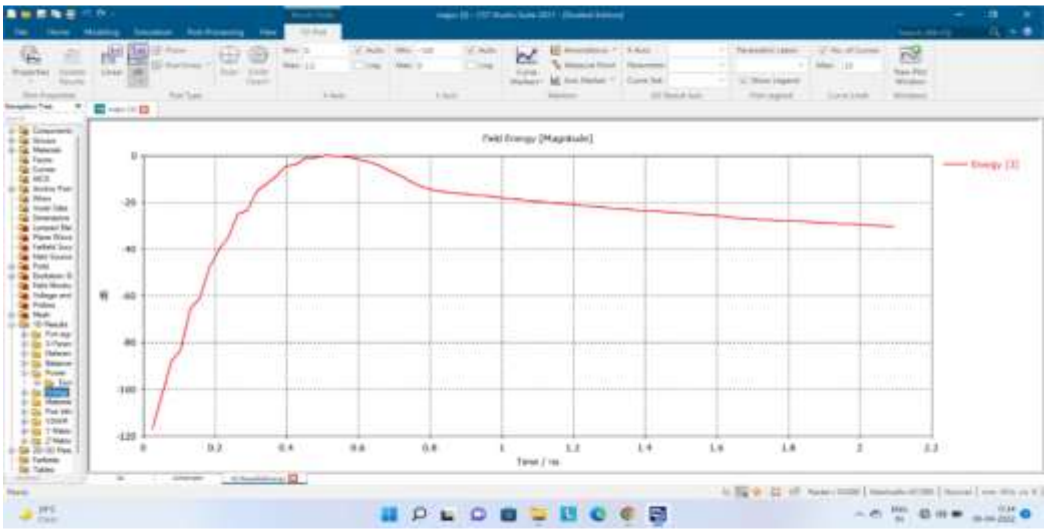

Figure 9. Field energy

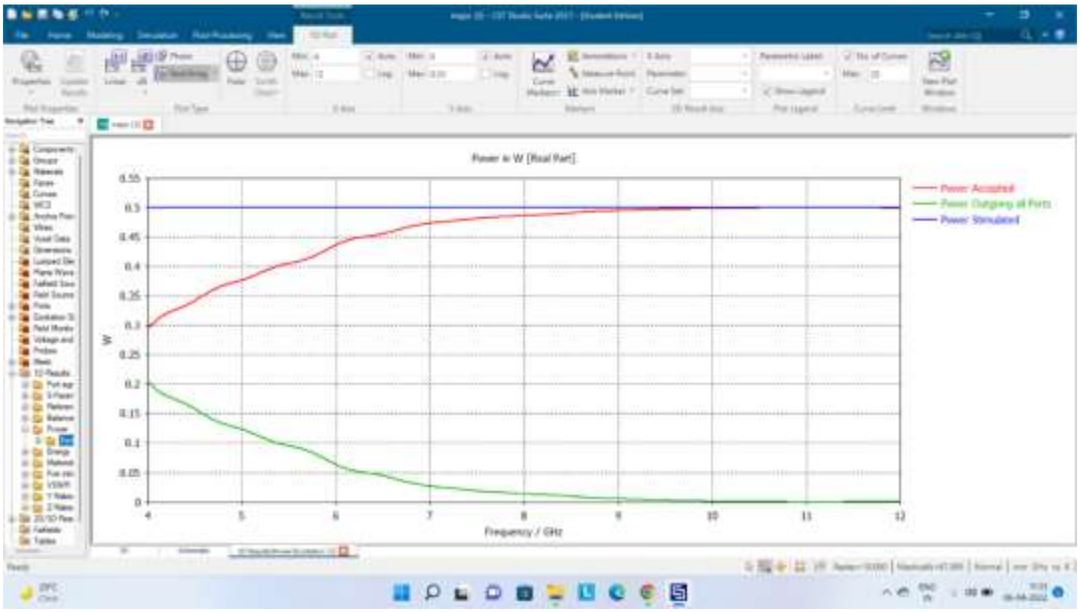

Figure 10. Power vs frequency

Table 2. Performance estimation

Iteration	**Occurred at frequency**	**Return loss**	**impedance vs frequency**	**VSWR graph**	**Y-parameters**
1st iteration	11.1GHz	-42dB	374.2ohms	1	0.0026.5
2nd iteration	10.9GHz	-45dB	374.2ohms	1	0.0027
3rd iteration	11.2GHz	-46dB	375ohms	1	0.0027
4th iteration	11.2GHz	-54dB	375ohms	1	0.0027

5. 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 behavior. 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.

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