Design and Analysis of Triangular-Circular Fractal Antenna for UWB Applications

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ABSTRACT - In this paper, microstrip patch antenna is fabricated on a low cost FR-4 epoxy substrate with relative permittivity 4.4 and having dimensions 17.89 x 21.45 x 1.6 mm^3. The antenna is a combination of Triangular and Circular shape Microstrip Antenna. For the proposed design return loss is -24.83 db has achieved at 5.50GHz. And also VSWR<2 for UWB frequency range. In this fractal antenna probe feed has used to feed the proposed antenna. The proposed design exhibits gain up to 2.91dB over frequency range. The simulation of proposed antenna design has done by High Frequency Structure Simulator.

Keywords - Combined fractal geometry, Fractal antenna, Triangular Shape, Triangular slot.

INTRODUCTION

A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally self-similar and independent of scale. There are many mathematical structures that are fractals; e.g. Sierpinski's gasket, Cantor's comb, von Koch's snowflake, the Mandelbrot set, the Lorenz 3 attractor, etc [1]. Fractals also describe many real-world objects, such as clouds, mountains, turbulence, and coastlines that do not correspond to simple geometric shapes. The terms fractal and fractal dimension are due to Mandelbrot, who is the person most often associated with the mathematics of fractals [Mandelbrot, 1983]. Mandelbrot included a definition of fractal dimension (of a geometric object)when he first talked about the concept of fractal in 1977 [Lauwerier, 1991]

The combination of geometries is the one concept of fractal geometry to improve the electrical property. Electrical property means reduced antenna size and increased resonant frequency band. Due to these valuable features, it can take advantages in multi -function and multi-standard wireless equipment [8].

In 1975, B.Madelbrot defined fractal geometry which based on iteration process [2]. Sierpinski gasket, Koch curve, Hilbert curve etc are different types of fractal geometry [3] .Fractal geometry has two unique properties, first one is self-similarity and second is space filling property [4].A self-similar set is one that consists of scaled down copies of itself. Self-similar property of fractal geometry aids to design of multiband antenna such as Sierpinski gasket [5] [6], Koch curve [7] while space filling property of antenna can be used to reduce the size of antenna.

In this paper, the combination of triangular and circle geometries is used and iteration process applied. To improve the return loss and gain, triangular shape slot is cut on the patch and infinite ground plane is used.

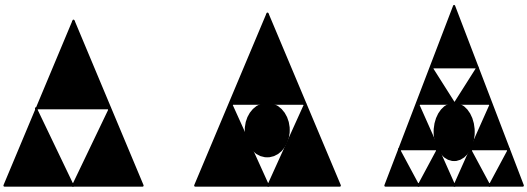
The proposed antenna is designed at 6 GHz frequency. The resonant frequency of proposed design is obtained by [9]:

$$f_r = \frac{2c}{3s_e\sqrt{\epsilon_r}}$$

Where c= velocity of light and s_e = effective value of side's' due to fringing field.

THEORY

The proposed design used combination of geometries such as equilateral triangular and circle. To design the fractal geometry, we used the iteration process. In the initiator part, design made by combination of equilateral triangular and circle, meanwhile a circle is cut off from the triangle. This is the initiator part of the proposed design. Next stage i.e.1st iteration is obtained by repeating the previous process that means combine geometry is applied in the initiator part. In the2nd iteration same process is repeat as done in previous stage. Fig. 1 shows the stage of iteration process for the proposed design.



(a) (b) (c)

Fig.1 Stage of iteration process of design (a) Initiator (b) 1st iteration (c) 2nd iteration.

When we apply the fractal geometry on the patch, discontinuity is generated and more current is flow on the discontinuity part. To improve the result, triangles are introduced on corner of triangular in 3rd iterations.

ANTENNA DESIGN

Fig. 2 and Fig. 3 shows the design part of the proposed antenna design. Ground plane having dimension 17.89 x 21.45 mm^2, is the bottom part of the combine geometry antenna design. The material of substrate is FR-4 epoxy with relative permittivity 4.4 and loss tangent 0.019, having dimension 17.89 x 21.45 x 1.6 mm^3. The combined fractal geometry antenna is printed on upper side of substrate surface .The height of the equilateral triangular is 13.76mm and radius of circle is 2.29mm. Probe Feed is used as feed mechanism. To improve the return loss and gain, Triangular shape slot is cut at the corner of the triangular patch. These triangular slots have side length 3.3mm.

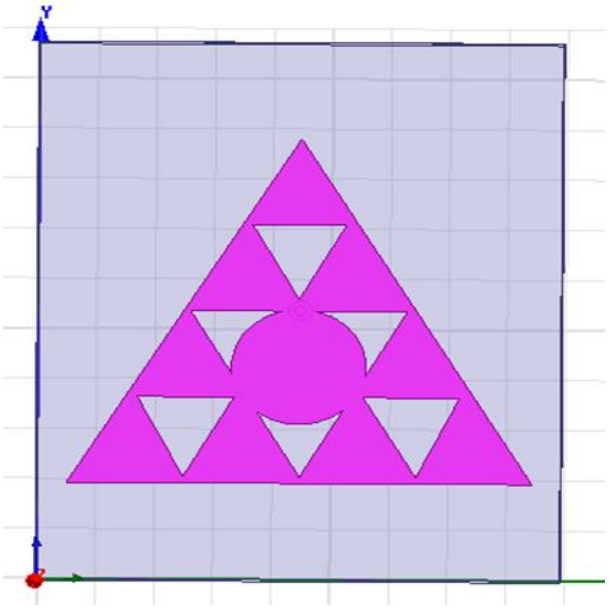


Fig. 2. Geometry of proposed antenna design.

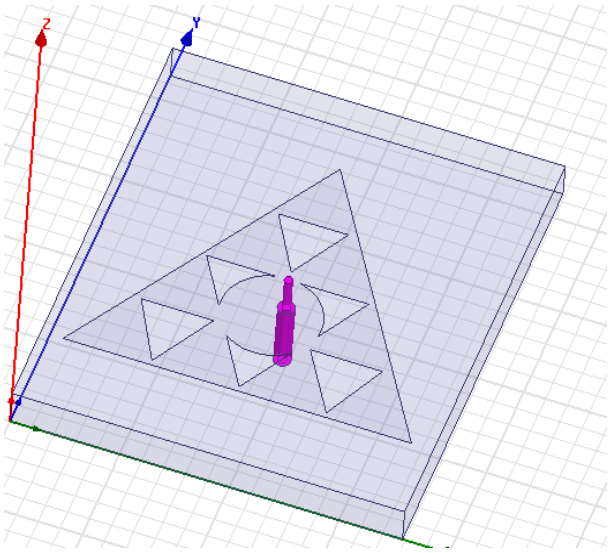


Fig. 3. Geometry of proposed antenna design with Probe.

Table 1. Antenna Parameters with Dimensions

Sr. No	Antenna Parameter	Design Value
1.	Outer Triangle Sides Length	15.88 mm
2.	Inner Larger Triangle Sides Length	7.33 mm
3.	Inner Small Triangles Sides Length	3.33 mm
4.	Inner Circle Radius	2.29 mm
5.	Substrate Height	1.6 mm
6.	Substrate Length	21.45 mm
7.	Substrate Width	17.89 mm
8.	Position of Probe Feed (x & y)	8.945 mm 10.75 mm

RESULT AND DISCUSSION

To understand the behavior of antenna structures and determine the parameters of antenna, the proposed design has simulated using high frequency structure simulator (HFSS vs-13).

Fig. 4 shows the comparative return loss characteristics of the proposed design (with and without triangles at the corners). Return loss of value -21.35 dBs obtained at resonant frequency 5.57 GHz in Antenna without triangles at the corners. It is shown in red color. Whereas in Antenna with Triangles at the corners has Return loss of value -24.83 dBs obtained at resonant frequency 5.51 GHz. It is shown in blue color.

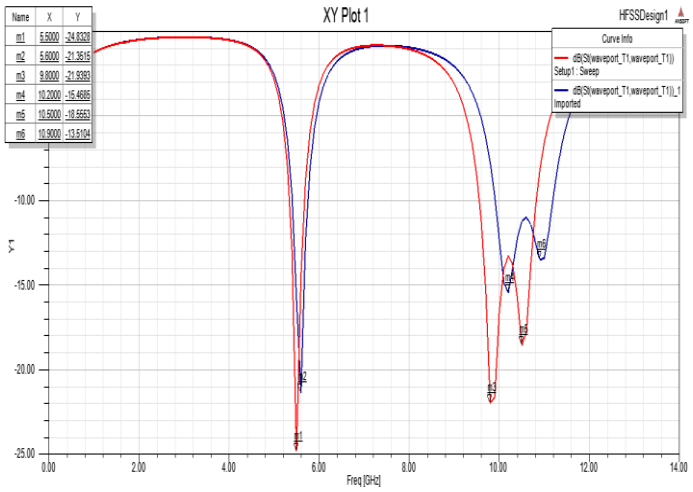


Fig. 4 Comparative Return loss characteristics of proposed design with and without Triangular slot in patch.

Figure 5 shows the VSWR of proposed design. The proposed design has VSWR is .99 at resonant frequency 5.50 GHz . And 1.39 at resonant frequency 9.8 GHz.

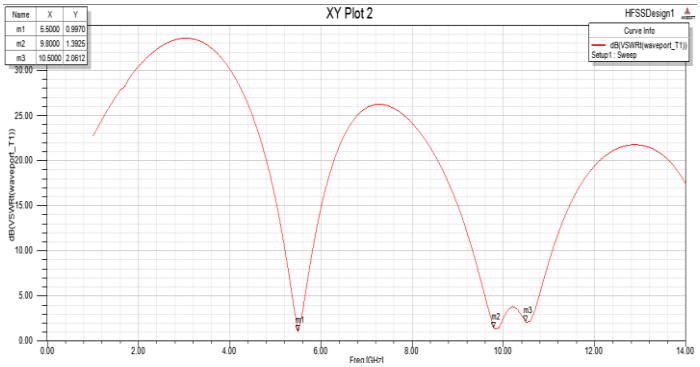


Fig. 5 Plot of VSWR of proposed design.

Figure 6 shows 3D Polar plot of Antenna with triangular slots. Gain is 2.912 dBs.

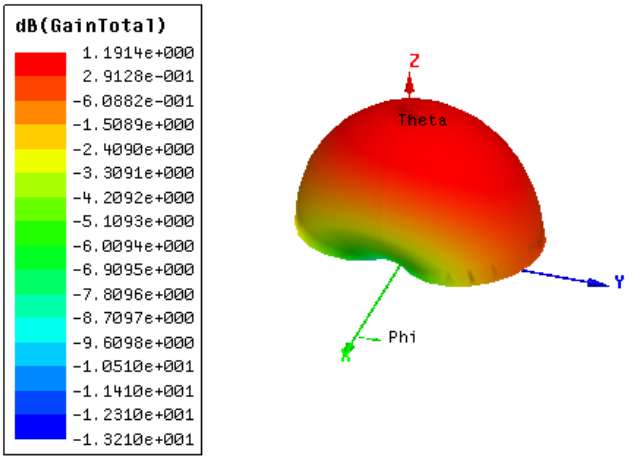


Fig. 6 shows 3D Polar plot of Antenna without slots

Figure 7 shows 3D Polar plot of Antenna with triangular slots.

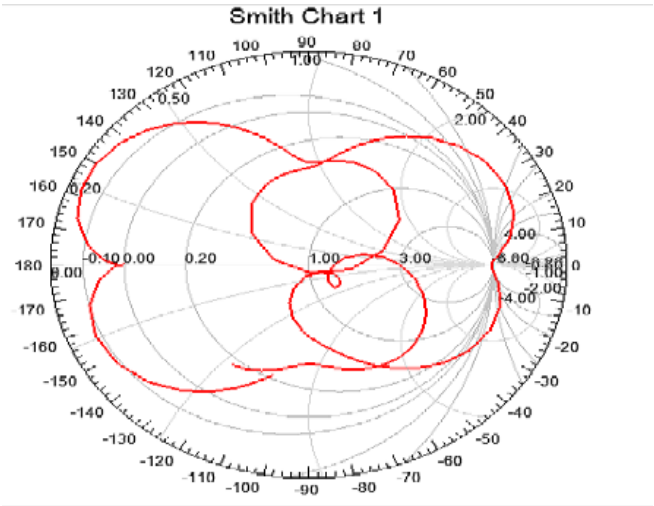


Fig. 7 shows Smith Chart of Designed Antenna.

CONCLUSION

In this paper combined geometry concept is used to get better result. Equilateral triangular and circle has used as a combined fractal geometry. To increase the return loss and gain, Triangular slots are cut on the patch. The proposed design is operate in the frequency range 3.1 GHz – 10.6 GHz which satisfy the band specification of the ultra wide band, So it can be used in C band (4-8Ghz) and X-Band (8-10 Ghz). The proposed design has Omni-directional radiation pattern in H-plane and symmetric in E-plane over the frequency range.

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