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Design and Analysis of Miniaturized Patch Microstrip Antenna Based on Sierpinski and Koch Fractal Shape

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Abstract :-*In this paper, a miniaturized fractal structure using Sierpinski fractal-shapes is proposed and investigated. By inserting the Sierpinski carpets into the single patch and etching the inner and outer patch edges according to Koch curves, the resonant frequency of the patch antenna can be lowered significantly.The higher of the iteration order of the fractal shapes, resonant frequency becomes lower. In this paper, a compact- size single patch microstrip antenna based on the proposed fractal-shapes is designed. It is found that the size reduction can reach 70.3%. as compared to the conventional square single patch antenna, the proposed antenna maintains comparable radiation patterns. Therefore, the small-size single patch microstrip antenna considered here can be applied to portable wireless communication systems requiring small devices.The Proposed antenna has been designed on FR4 substrate dielectric constant 4.4 and thickness h=1.53 mm & its dimension is 80.0 mm × 85.0 mm × 1.6 mm. The proposed antenna has been optimized to operate in multiple bands of 0.97GHz, 2.13GHz, & 3.68GHz and respectively with bandwidth of 20MHz, 60MHz & 100MHz at corresponding frequencies. The proposed antenna has a compact size and used for Mobile &WiMAX Applications .The radiation pattern, return loss, VSWR and gain of the proposed antenna are described and simulated using the HFSS software package.*

Keywords— Miniaturization, Minkowski Fractal Geometry, Multiband, Iteration, Koch and Sierpinski.

I. INTRODUCTION

Antenna miniaturization design is an important issue in integrated wireless communication systems. Significant research activities and interests have been aroused in academic field to reduce the microstrip patch antenna size [1, 11]. Lots of literatures on design of the single patch microstripantenna miniaturization have been presented, which can be mainly diviedinto three major styles of antenna structures.Thesimplest design is to adopt high dielectric constant substrate.

However, this method can not only raise product costs, but also obtain rather limited maximum size reduction. The most accepted method is tohot spot to reduce the microstrip patch antenna size, such as inserting slots into the patch to increase the electric length of the antenna [1],inductive element of the edges of the patch [2] and it etching periodical slow wave structures in the ground plane [3, 4], loading shorting technique [5]. Meanwhile, combination of these methodsis also applied to achieve size reduction of that [6]. Though this technology utilized in [6] can achieve maximum 75% size reduction, the radiation patterns have changed greatly as a result of the asymmetrical structure. Furthermore, the introduction of shorting posts raises the fabrication difficulties and product cost.

Recently, fractal technique has been commonly used for antenna design to reduce the antenna size [7,11]. Small-size antennas by etching fractal shapes into the patch edges have been introduced[8]. The maximum size reduction can only achieve 45%. In [7], the proposed edge-fed Sierpinski carpet microstrip patch antenna achieves a maximum 33.9% size reduction. By combining fractal shapes such as Koch and Sierpinski fractal shapes, antenna size can be reduced significantly [9, 10].

In this paper, a compact -size single patch microstrip antenna based on Koch and Sierpinskifractal-shapes is proposed. Inserting the Sierpinskitypecarpets into the single patch and etching the inner and outer patch edges as per Koch curves, a compact-size antenna is designed and

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simulated. The simulated results have demonstrated that the antenna can achieve 70.3% size reduction and maintains comparable radiation patterns compared to the normal square patch.

II. DESIGN OF PROPOSED FRACTAL ANTENNA

The fractal microstrip patch antenna using the fractal structure shown in Figure 1 is designed following the procedure below. TheSierpinski iteration factor is 1/3, the Koch iteration factor of the inner and the outer edges are set to 1/4 and 1/4, respectively. The antennais simulated on the FR4 substrate with thedielectric constant of 4.4 andthe thickness of 1.53 mm. The design procedure of the antenna whichutilizes the proposed fractal pattern can be summarized as follows:

1) Specify the operated frequency $f0$, and then obtain thetransformation frequency ft through the formula listed below.

$$ft = f0/\eta \quad (1)$$

2) Decide the initial dimensions of the patch antenna according to the transformation frequency *ft*. The following approximate equations are suggested.

$$W = \frac{c}{2ft\sqrt{\epsilon e}} - 2\Delta\omega \qquad (2)$$

$$L = \frac{c}{2ft}\left(\frac{\epsilon r+1}{2}\right)^{-1/2} \quad (3)$$

Where

$$\epsilon\, e = \frac{\epsilon r+1}{2} + \left(\frac{\epsilon r-1}{2}\right)\left(1+\frac{10h}{W}\right)^{-1/2} \quad (4)$$

$$\Delta\omega = 0.412h\,\frac{(\epsilon e+0.300)\left(\frac{L}{h}+0.264\right)}{(\epsilon e-0.258)\left(\frac{L}{h}+0.8\right)} \quad (5)$$

In this design, the proposed antenna is a square antenna.Therefore, the width and the length of the patch antenna are equal in size.

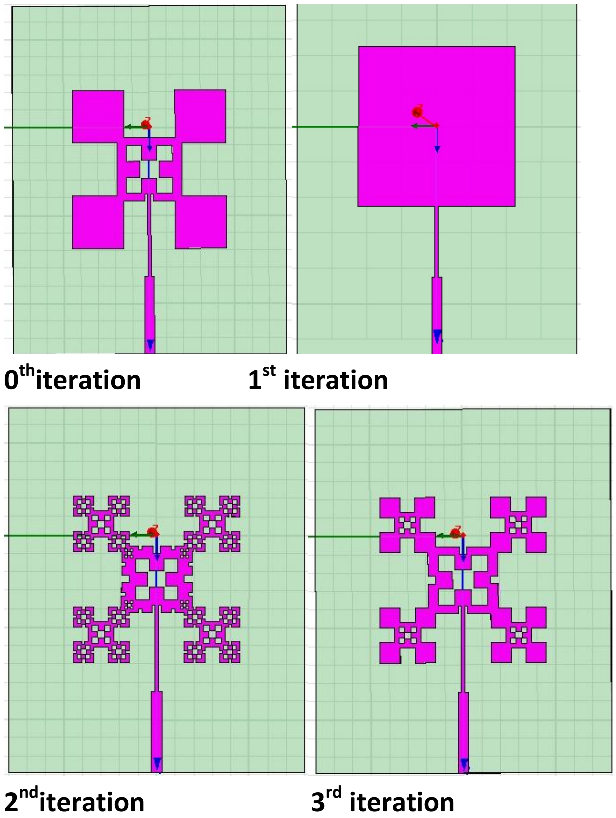

Figure 1: Generation Process of the proposed fractal

3) Match the patch by one quarter wavelength impedance trans- former, and implement the optimization function of the Ansoft Designer software. Then, properly adjust the dimensions of the patch and impedance transformer to make it resonate at the frequency point *ft*.

4) Design the fractal-shaped microstrip antenna according to the fractal structure proposed here. Insert the Sierpinski carpets into the patch devised in step 3) whose iteration factor is set to 1/3and etch the inner and outer edges according to the Koch curves whose iteration factor is 1/4.

IV.RESULTS AND DISCUSSIONS

The configuration of the proposed a compact-size antenna is shown in Figure 2. In this design, the proposed fractal-shaped small size antenna is specified to operate at 1.5GHz (GHZ Band). According to the design procedure in Section 3, the structure dimensions of the proposed antenna are listed as followed: *Lsub*= 80 mm, *Wsub*= 85 mm*Lp*= 45mm, *Wp*= 45 mm, *Lt* = 22 mm, *Wt*= 23 mm.

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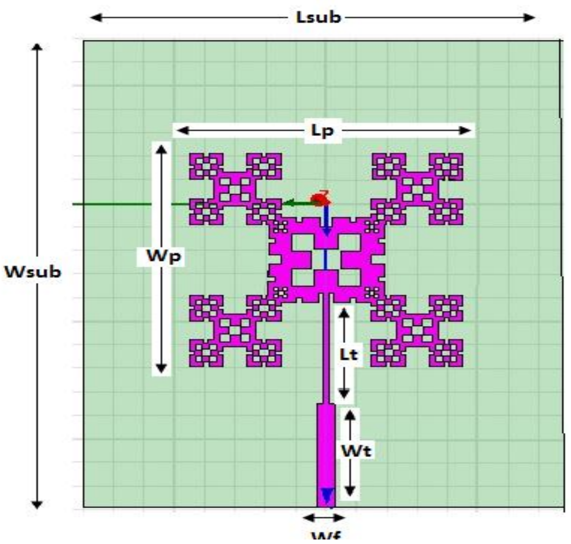

Figure 2:Schematics diagram of the proposed Fractal antenna

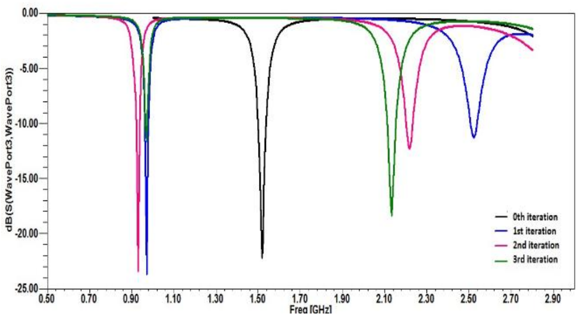

Figure 3: Iteration wise Return loss of proposed antenna

As seen from fig.3, the number of iteration increases then resonant freq shift to lower side and higher freq will added. The 0th iteration patch antenna resonate freq is 1.5GHz.When 1st iteration we introduce in same patchy then the freq is shift to lower side at 0.97GHz. This is almost 70.3% size reduction compared to conventional patch antenna.

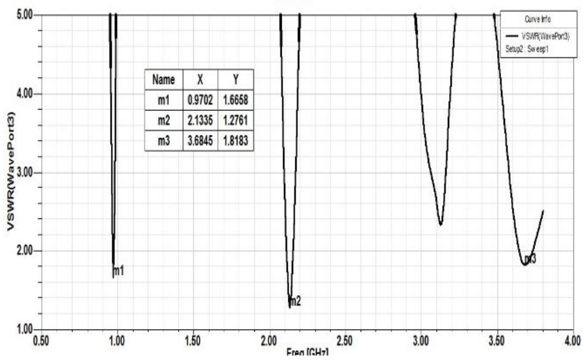

Figure 4: VSWR

From the Fig.4 we can be seen that the VSWR of Proposed fractal antenna lies below the value 2. The proposed antenna has been operate in multiple bands of 0.97GHz, 2.13GHz, & 3.68GHz and respectively with bandwidth of 20MHz, 60MHz & 100MHz at corresponding frequencies.

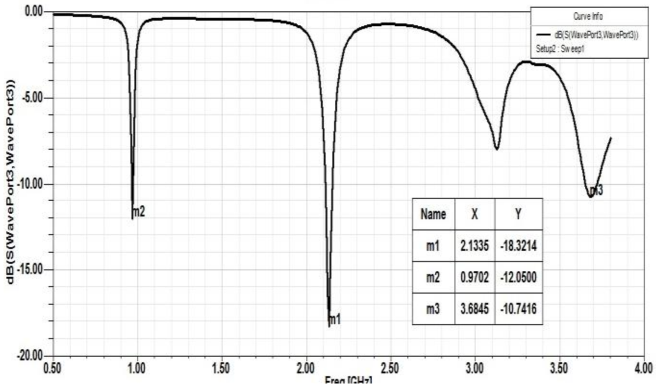

Figure 5: Return loss

As shown in figure: 5 the value of Return loss is -12.05 dB at 0.97GHz,-18.32 at 2.13GHz and -10.74 at 3.68GHz respectively.

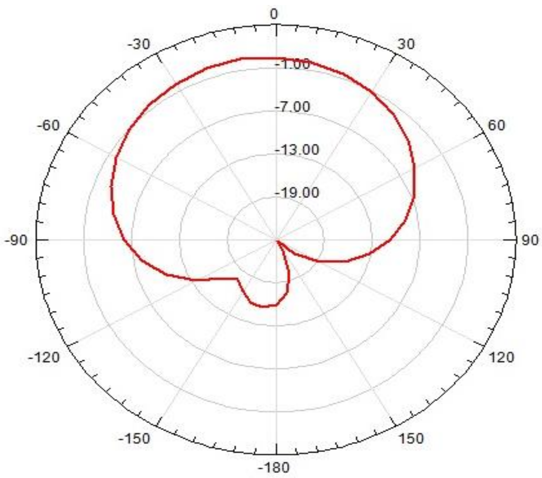

Figure 6: Radiation pattern

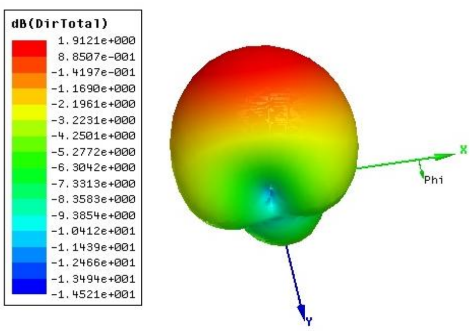

Figure 7: Directivity

The simulated gain of the antenna at resonant frequencyat 1.5GHz is presented in Figure 7 and it is perceived that the stable directivity across the operating Freq. The maximum directivity is 2.0 dBi.

V.COMPARISON TABLE

To reduce the size of of this antenna, Minkowski fractal structure techniques are introduced. As seen from the table, the number of iteration increases then resonant freq shift to lower side and higher freq will added. The proposed antenna has realized 70.3% size reduction, thus the antenna effective radiation area is reduced significantly with the size reduction.

VI.CONCLUSION

In this paper, a fractal structure using Koch curves and Sierpinski carpets is introduced. A small-size microstrip antenna based on the proposed fractal structure is proposed. Compared with the conventional microstrip patch antennas without fractal shapes, the proposed antenna achieves 70.3% size reduction and maintains comparable radiation patterns. The proposed a compact-size antenna can be applied to portable wireless communication systems successfully.

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