Design and Analysis of a New Dual-Band Microstrip Fractal Antenna

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Abstract**—**This paper presents a novel design of a microstrip fractal antenna based on the use of Sierpinski triangle shape, it's designed and simulated by using FR4 substrate in the operating frequency bands (GPS, WiMAX), the design is a fractal antenna with a modified ground structure. The proposed antenna is simulated and validated by using CST Microwave Studio Software, the simulated results presents good performances in term of radiation pattern and matching input impedance.

Keywords**—**Dual-band antenna, Fractal antenna, GPS band, Modified ground structure, Sierpinski triangle, WiMAX band.

I. Introduction

WITH the development of the modern wireless communications, such as global system for mobile communication (GSM), global position system (GPS) and Worldwide Interoperability for Microwave Access (WiMAX), there is an increasing requirement for antennas having low profile, simple design, small size and multi-bands [1]–[6]. The antennas having small size are required for mobile phone applications and wireless integrated systems. Among the techniques used to design a multi band antenna, such as the combination of several radiating elements [7]–[11], the use of some common antennas like PIFA [12]–[15] and antennas using fractal techniques [16]–[19]. For this work we have used the fractal technique based on Sierpinski shape. This antenna is optimized and simulated by using CST-Microwave studio. The fractal shape is associated to a partial defected ground structure, which will permit to reach a multi band behavior. A fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is a reduced-size copy of the whole. Fractals are generally self-similar and independent of scale. There are many mathematics structures that are fractal:

- Sierpinski gasket
- Cantor's comb
- Von Koch's curve

The geometry of fractal is important because the effective length of the fractal antennas can be increased while keeping the same total area. The shape of the fractal antenna can be formed by an iterative mathematical process, called as iterative function systems IFS.

There are many fractal geometries that have been found to be useful in developing new and innovative design for antennas. For example we have the different shapes presented in Figs. 1-4:

- Sierpinski gasket

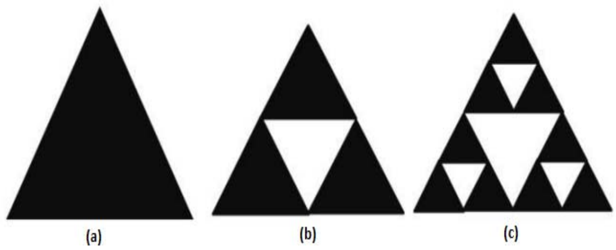
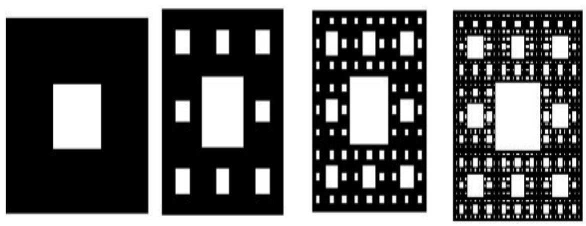


Fig. 1 Generation of Gasket geometry [20]

- Sierpinski carpet



(a) (b) (c) (d)

Fig. 2 Generation of Carpet geometry [21]

- Koch curves

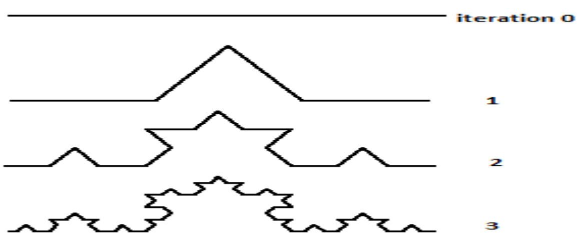


Fig. 3 Generation of Koch curve geometry [22]

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- The cantor set geometry

Fig. 4 Generation of Cantor Set geometry [23]

After studying the theory and different fractal shapes, we have developed and validated into simulation a new microstrip fractal multi band antenna. The proposed antenna is compact, easy to be fabricated and presents good performances concerning the radiation pattern and matching input impedance for all intended operating frequency bands.

II. Antenna Design and Simulation Results

The Sierpinski is the one of the mathematician who has proposed the Sierpinski triangle at 1961 [24]. Fig. 5 presents the proposed Sierpinski triangle multiband antenna with different scale factors (δ1=h1/h2, δ2=h2/h3and δ3=h3/h4) as mentioned in [25]:

$$d = h_n / h_{n+1} \quad (1)$$

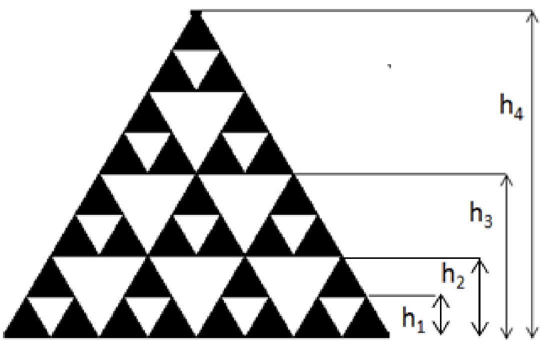


Fig. 5 Geometry of Sierpinski

where n is the iteration number and h is the height of the triangle.

The antenna design is based on the use of this Sierpinski configuration, for the substrate we have used FR4, with 1.6mm as a thickness, 4.4 for the relative dielectric constant and 0.025 for the loss tangent. The antenna is composed from the radiator associated to a modified ground. As we can see in Fig. 6, the different optimized slots permit to reach the desired frequency bands and to have multi band behavior. The antenna is fed by a 50 Ohm microstrip line, the total area of the whole circuit are 55X 50 mm^2.

After many series of optimizations by using CST Microwave Studio, we have validated into simulation the proposed antenna structure depicted in Fig. 7. The different dimensions are presented in Table I. We can conclude that the first resonant mode occurs at the frequency of 1.58 GHz, that can match to the GPS band and the second resonant mode occurs at the frequency of 3.52 GHz with a bandwidth (3.5-3.55 GHz), and the third resonant occurs at 5.6GHz with bandwidth (5.45-5.70GHz), which tends to the WiMAX band.

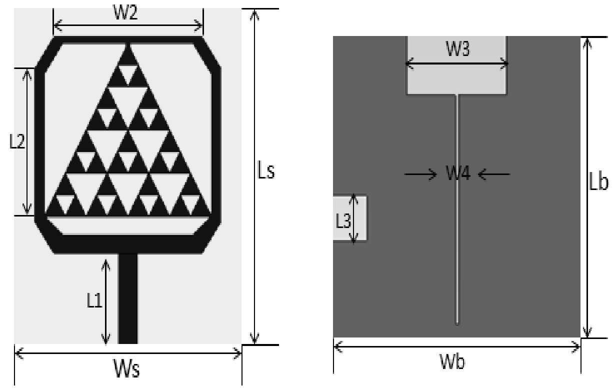


Fig. 6 Geometry of the proposed antenna with the modified GND

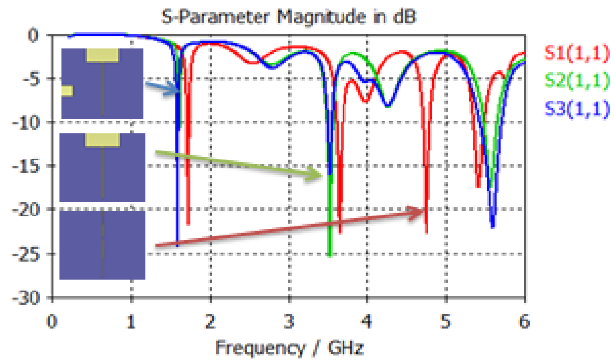
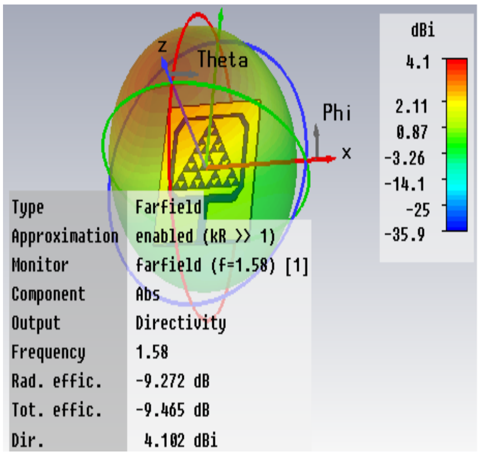


Fig. 7 Return loss versus frequency for different ground configurations

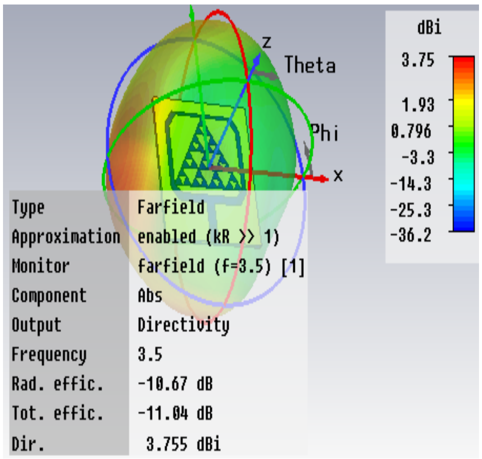
TABLE I
DIMENSION OF THE PROPOSED ANTENNA (UNIT: MM)

Parameter	Value
Ls	55
Ws	50
Lb	55
Wb	50
L1	15
L2	25
L3	8
W2	32
W3	20
W4	0.5

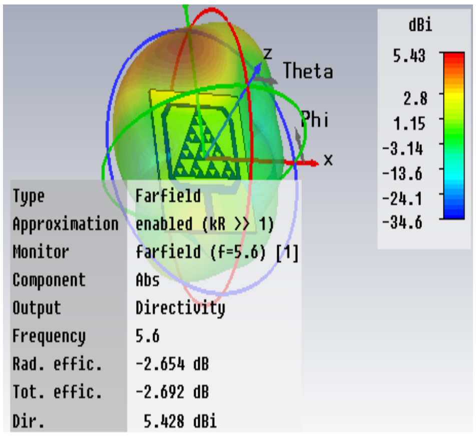
The simulated antenna radiation patterns for the three resonant frequencies are shown in Figs. 8 (a), (b) and (c) respectively.



(a)



(b)



(c)

Fig. 8 3D radiation pattern of the proposed antenna (a) @ 1.58 GHz (b) @ 3.5 GHz (c) @ 5.6 GHz

II. Conclusion

In this paper, a multiband microstrip antenna based on a fractal configuration with a modified ground integrating optimized slots, has been proposed and optimized for GPS and WiMAX applications. The antenna exhibits good performances and good matching input impedance at, 1.58, 3.5 and 5.6GHz. The antenna is low cost, compact, and exhibits moderate gain and stable radiation patterns which make it suitable for multiband wireless applications. This antenna has been validated into simulation by using CST Microwave studio, the entire area of this antenna is 50×55 mm^2. The different steps followed to design such antenna can be followed to match this structure to others operating frequency bands.

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