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Microstrip Line-Fed Modified Sierpinki Fractal Monopole Antenna for Dual-Wideband Applications

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***Abstract*— A printed monopole antenna with microstrip-fed Sierpinski fractal geometry for dual wideband application is presented. The operating bands are adjusted with the design of modified Sierpinski triangle (radiating patch), ground plane and scale factor used to create a fractal shape. The simulated -10 dB (VSWR 2:1) reflection bandwidth for first resonant frequency is 60% (1.47 GHz- 2.7 GHz). It covers GPS, DCS-1800, PCS-1800, UMTS, IMT-2000, WiBRO (Wireless Broadband Internet Services) and WLAN bands. For second resonant frequency the band width is 8% (4.991HHz-5.4 GHz) and covers 5.2 GHz WLAN (802.11/ a). The radiation characteristics and gain of the modified Sierpinski fractal antenna are also presented and discussed.**

Keywords- Microstrip line Fed, Fractal antenna, Sierpinski Triangle, Dual wideband.

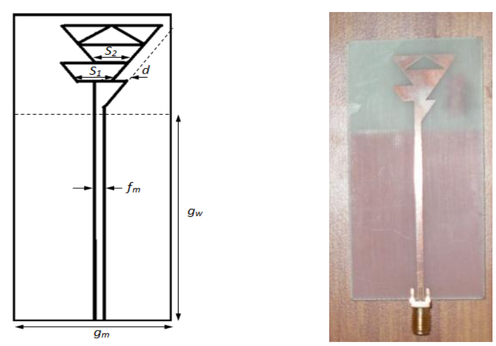
I. INTRODUCTION

Rapid progress in wireless communication promises for replacing wired communication in the near future in which antenna plays a more important role. Microstrip patch antennas are widely used due to their inherent advantages of low profile, light weight, low cost [1-4] etc. For high speed, broadband and high capacities of indoor and outdoor WLAN are more predominant today. The advantage of microstrip antenna has made them perfect candidate for use in the WLAN application. The major limitation of microstrip patch antenna is narrow bandwidth. For this, many promising dual- or multiband planar antenna designs such as the microstrip-line-fed antennas [5]–[8], the probe-fed antennas [9]–[11], the planar inverted-F antennas (PIFAs) [12]–[14], the dielectric resonator antennas [15], [16], and the coplanar waveguide (CPW)-fed antennas [17,18] have been reported. However, most of them have either a large overall size or a complicated structure to reduce the antenna's application.

Fractal antenna [19], have very good feature like small size and multiband characteristics. Most of the fractal structures are characterized by a series of built–in self similarities in which an object, the motive is being repeated on an ever-diminishing scale. The fractal shape is carried out by applying the infinite number of iteration using multiple reduction copy machine (MRCM) algorithm [20].

In this paper, a simple dual wide band design of a microstrip-fed monopole antenna consisting of a Sierpinski triangle patch and modified with half Sierpinski slot are discussed. This model is used to reduce the volume of the radiating patch and obtained dual frequency resonance. These modified proposed geometry based on the triangle shape with scale factor of $\xi_1=h_1/h_2$ and $\xi_2= h_2/h_3$ and the flare angle of α. The design of antenna is performed and optimized using CST Microwave studio (MWS) based on the three dimensional finite integration time domain (FITD) method.

II. ANTENNA DESIGN



(a) (b)

Fig. 1(a) Modified Sierpinski Fractal Antenna
(b) Fabricated Prototype of Proposed Antenna

The proposed dual wideband modified Sierpinski fractal antenna and its fabricated prototype is illustrated in Fig. 1(a) and (b). The classical sierpinski triangle has a scale factor, ξ of 0.5 [23].

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

Where *n* represents the iteration number and *h* represents the no. of iterated triangles.

Fig. 2 shows, the design procedure of modified sierpinski fractal antenna in three stages. For first stage, a perturbed, two-iterated sierpinski fractal antenna with flare angle of α and different scale factors ($\xi_1=h_1/h_2$ and $\xi_2= h_2/h_3$) is shown in Fig 2(a). In Fig 2(b), the half version of sierpinski triangle patch antenna. Here, it is possible to miniaturize the radiating patch size by utilizing the half Sierpinski triangle antenna. It

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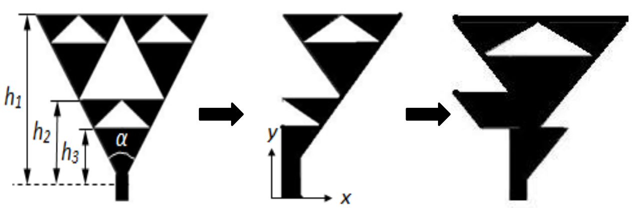
is shown that the multi resonance behavior of the half Sierpinski fractal antenna is similar to the perturbed Sierpinski fractal triangle antenna [24]. Finally, the half version of Sierpinski antenna is modified in three parts as shown in Fig. 2(c). This modification is for enhancement of the bandwidth of lower resonant antenna as well as enables the fine tuning of the higher resonant frequency. The proposed modified antenna is constructed through two iterations and printed on an FR4 substrate (thickness h=1.6 mm and relative dielectric constant ε_r=4.4). The 50 Ω microstrip-Fed ($f_m \times g_m$) is used for impedance matching. It is calculated using equation (2) and (3).

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + 12\frac{h}{w}}}\right) \qquad (2)$$

$$Z_0 = \frac{120\Pi}{\sqrt{\varepsilon_{eff}}\left[\frac{w}{h} + 1.393 + 0.667\ln\left(\frac{w}{h} + 1.444\right)\right]} \quad for \quad \frac{w}{h} \geq 1 \qquad (3)$$

On bottom side of the substrate a ground plane ($g_w \times g_m$) is present. The optimized geometry parameter are h_1=22.4 mm, h_2= 13.4mm, h_3=9 mm, α=60°, ξ_1=1.6, ξ_2=1.4, d=3.45 mm, S_1=6.9 mm, S_2=7 mm, f_m=2 mm, g_m=42 mm, g_w =50mm.



(a) (b) (c)

Fig. 2 Antenna Design Procedure
(a) Classical Sierpinski Fractal monopole antenna
(b) Half Modified Sierpinski Fractal Antenna
(c) Proposed Modified Sierpinski Fractal Antenna

III. RESULT AND DISCUSSION

A. Return Loss Characteristics

Fig. 3 shows the simulated input return loss performance (S_{11}) of modified Sierpinski fractal antenna with different scale factors at desired dual wide-band frequency ranges. The antenna is simulated using commercial software package CST MWS. It is also observed that the -10dB simulated operating bandwidth for band 1 is 60% (1.47 GHz-2.7 GHz), covering the WLAN band and other important frequencies like GPS (1.56 GHz-1.58GHz), DCS-1800 (1.71 GHz-1.88 GHz), PCS-1800 (1.85 GHz-1.99 GHz), UMTS (1.92 GHz-2.1 GHz), IMT-2000 (1.9 GHz-2.2 GHz), WiBRO (2.3 GHz-2.4 GHz), Bluetooth (2.4 GHz-2.48 GHz), Satellite DMB (2.6 GHz- 2.65 GHz) and WLAN 802.11 b/g bands. For band 2, it covers the WLAN frequency of 802.11/a standard band.

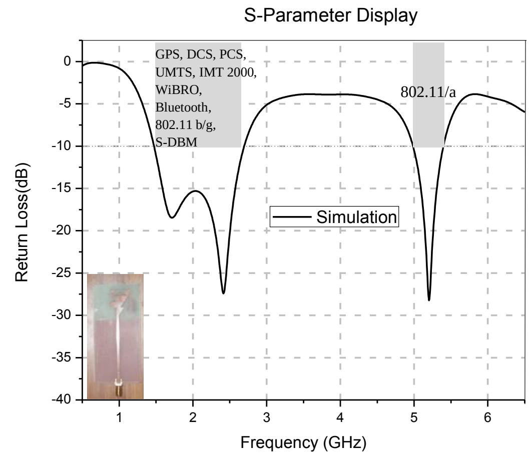
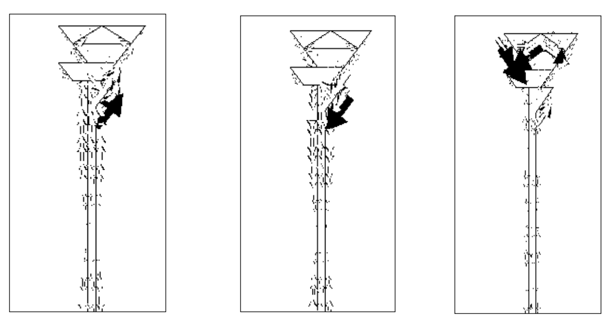


Fig. 3 Simulated Return Loss Vs Frequency

B. Current Distribution

The total surface current distribution of proposed modified Sierpinski antenna at frequencies 1.725 GHz, 2.415 GHz and 5.2 GHz are shown in Fig. 4. The surface current density spreads over the whole patch (up to end of antenna). It radiates strongly at desired WLAN and other important frequencies bands.

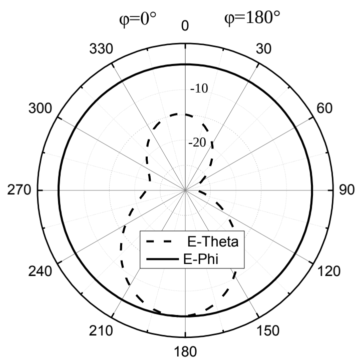


(a) (b) (c)

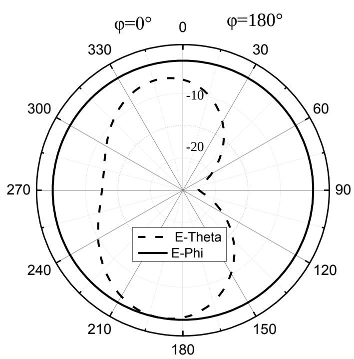
Fig. 4 Surface Current Distribution of proposed Antenna
(a) At 1.725 GHz
(b) At 2.415 GHz
(c) At 5.20 GHz

C. Radiation Pattern Characteristics

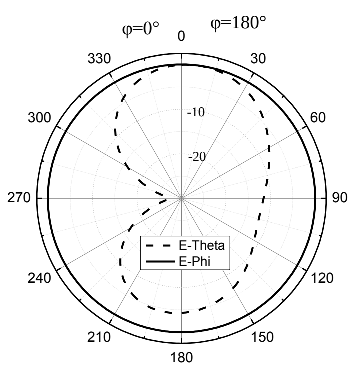
The radiation patterns of modified Sierpinski fractal antenna are shown in Fig. 5. The radiation pattern is Omni-directional characteristics. The main cuts E-theta and E-phi of modified Sierpinski fractal antenna are simulated at the frequencies 1.7 GHz, 2.45 GHz and 5.2 GHz.



(a)



(b)

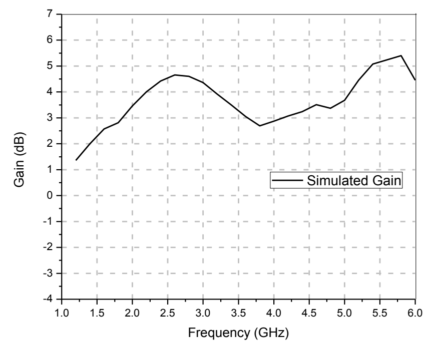


(c)

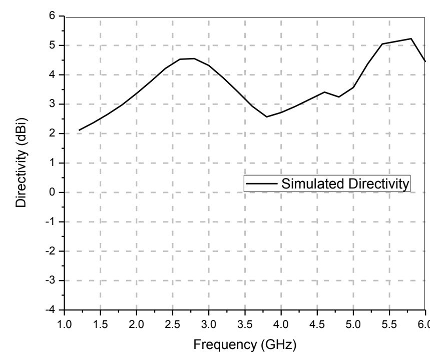
Fig. 5 Radiation Pattern Characteristics
(a) 1.7 GHz
(b) 2.45 GHz
(c) 5.2 GHz

D. Gain and Directivity

When the antenna is used for dual wideband characteristics, the impedance mismatch must be taken into account for defining its characteristics, especially gain of the antenna. For proposed modified Sierpinski fractal antenna, the gain from lower to higher frequencies is 3-5 dBi shown in Fig. 6(a). Directivity of the antenna is a good match with gain and it is also 3-5 dBi for both the bands. The directivity of the antenna is shown in fig 6(b).



(a)



(b)

Fig. 6 Antenna Performance
(a) Simulated Gain
(b) Simulated Directivity

IV. CONCLUSION

The proposed antenna gives a good prediction on the behavior of Sierpinski modified fractal antenna with different scale factors. This concept is for dual wide-band characteristics which cover the total WLAN band and other important bands. This patch is printed on a FR4 substrate and optimized with handheld terminals. The simulated results show the proposed antenna has sufficient bandwidth to cover dual bands. The radiation patterns are omni-directional in nature. Therefore, the proposed antenna is feasible for the use of a low profile and low-cost dual wide-band antenna for various wireless communications.

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