CPW-Fed Compact Multiband Sierpinski Triangle Antenna

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***Abstract*—A small size and multiband behavior in the shape of Sierpinski triangle fractal is presented in this paper. The model is applied to predict the behavior of the fractal antenna when the flare angle and height of the antenna is changed. The simulated at $\geq$ -10 dB reflection bandwidth of the multiband frequencies for band 1, band 2, and band 3 are presented in this paper. The radiation characteristics, E M characteristics, gain and directivity are also presented and discussed.**

***Index Terms*–Fractal Antenna; Sierpinski Triangle; Multi Band;**

I. Introduction

Rapid progress in wireless communication promises to replace wired communication in the near future in which antenna plays a more important role. Recent years have witnessed great interest in wideband antenna and multiband antenna designs primarily to realise high data rate wireless transmission demanded by the continuously expanding range of wireless communication services. Microstrip patch antennas are widely used due to their inherent advantages of low profile, light weight, low cost [1-4] etc. The major limitation of microstrip antenna is narrow bandwidth. To overcome this limitation the patches are etched with slot like E-Shape [5], U-Shape [6], and Stack patch [7]. But using this type of shape the boundary condition and the cavity model are invalid for design or analysis.

Fractal antennas [8], have very good features like small size and multiband characteristics. Most fractal objects have self similar shape, with different scale [9-10]. The fractal shape carried out by applying the infinite number of iteration using multiple reduction copy machine (MRCM) algorithm [11]. The most common sierpinski fractal in the category of fractal antenna and empirical formula [12-13] are used for determining the resonant frequency if the planar monopole and dipole antenna based on fractal antenna geometry. Using the perturbed sierpinski fractal antenna with ground plane the antenna is designed to allocate the frequency band and enhance the bandwidth [15].

In this paper, we proposed the fractal antenna with Sierpinski triangle shape for multiband application. This is a simple model with CPW-Fed and reduces the volume of the radiating patch and obtains multi frequency operation. The proposed antenna design based on the triangle shape with the scale factor of δ_1=h_1/h_2 and δ_2=h_2/h_3 and different flare angle α_1=30°, α_2=45°, α_3=60°, α_4=75°, α_5=90°. This antenna is simulated using the CST microwave Studio based on the finite integration time domain (FITD) method and return loss and radiation pattern are presented.

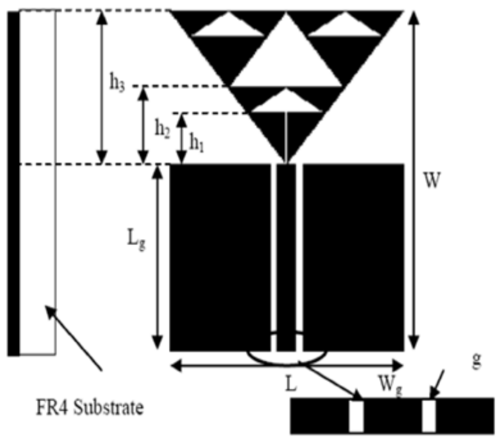


Fig. 1. Geometry of Proposed Antenna

II. Antenna Design

The sierpinski is the one of the mathematician who has proposed the sierpinski triangle at 1961 [9].The proposed sierpinski triangle multiband antenna is shown in Fig.1 with different scale factor (δ_1=h_1/h_2 and δ_2=h_2/h_3). Classical sierpinski triangle is having the scale factor of 2. This is [14] given by

$$\delta = \frac{h_n}{h_{n+1}} \tag{1}$$

Where the n represent the iteration number and the h represent the height of the triangle. It is shown in Fig. 1. The proposed antenna constructed through two iterations to reduce the volume of the radiating patch. The substrate 80×40 mm (W×L) is chosen for implementing the antenna with thickness of 1.6 mm. and ϵ_r=4.4. The antenna is fed by CPW, the centre microstrip line ($L_g \times W_g$) is having 50Ω impedance. It is calculated using the equation (2) and (3).

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r + 1}{2}\left[\frac{1}{\sqrt{1+12\frac{h}{w}}}\right] \tag{2}$$

$$Z_0 = \frac{120\pi}{\sqrt{\epsilon_{eff}}\left[\frac{w}{h} + 1.393_0.667ln\left(\frac{w}{h} + 1.444\right)\right]} for \frac{w}{h} \geq 1 \tag{3}$$

The optimized radiating parameters are h_1=8mm, h_2=12 mm and h_3=24 mm. α_3=60°, δ_1=2, δ_2=1.5, L_g=50 mm and W_g=2 mm.

The design is started with triangle, angle 30° and height h_1=8 mm and iterate with the scale factor of 1.5 which is having the height h_2=12 mm. For second iteration the scale factor is taken as 2, the height of the antenna is (h_3) =24 mm. Here, we have taken five different flare angles of the proposed antenna. Figure 2 shows the different angle of Sierpinski triangle antenna having the multiband characteristics.

For first band, the resonant frequency can be computed [16] by.

$$f_r = 0.152\left(\frac{c}{h}\right) cos\left(\alpha/2\right)\left(\delta\right)^n \tag{4}$$

Where c is the speed of light, h height of the antenna, α flare angle δ scales factor and n band number. The increase of flare angle implies longer edges of the triangle and resonant frequencies moves towards the lower frequencies. The height is kept same for all five cases.

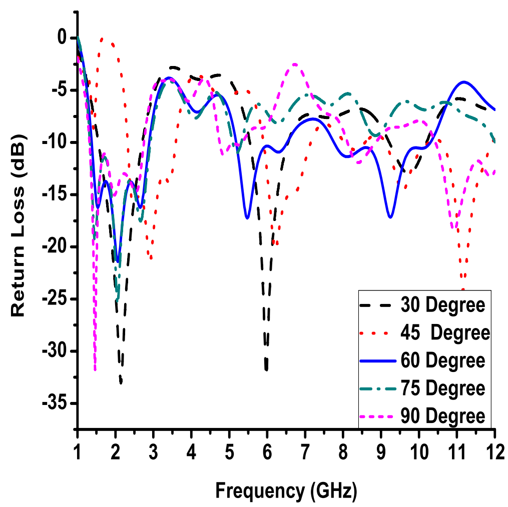


Fig. 2. Comparison of simulated Return Loss characteristics among the different Flare angle (α) geometry of proposed antennas

III. Result and Discussion

A. Return Loss Characteristics

The intermediate design steps and the corresponding simulated return loss obtained by the Sierpinski triangle geometry are shown in Fig. 2. Comparing the return loss plots for designs different flare angle α_1 to α_5, it is seen that only α_3 =60° achieves the desired resonant frequency for all three bands which is $\geq$ -10 dB and others fail at the higher band and they are $\leq$ -10 dB.

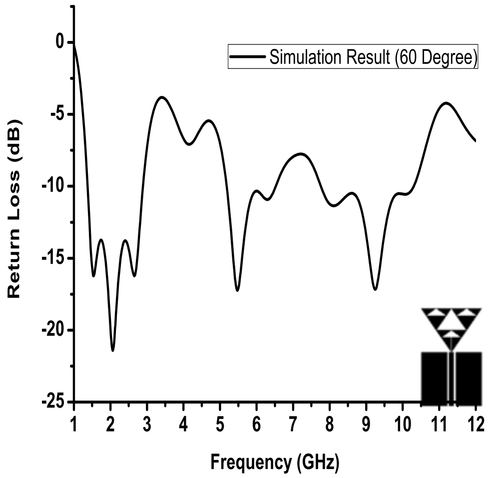


Fig. 3. Return Loss plot of proposed Sierpinski triangle shape antenna

The first band central frequency of the proposed antenna is 2.04 GHz; the second band is 5.46 GHz and the last band at 9.23 GHz. The simulated result is shown in Fig. 3.

B. Surface Current Distribution

The surface current distribution of the five antennas has been simulated using CST Microwave Studio 2008. The total current distribution is shown in Fig. 4. In case of α=60° and α=90° patterns are similar from band to band. For flare angle of α=90°, current distribution is not confined to an active region but it is distributed along the whole geometry of the proposed antenna. From the above explanation, it is clear that the geometry at flare angle α=90° provides poor radiator but the current distribution is found up to end of the antenna. In case of α=60° the surface current density of the antenna flows in whole patch and is stronger compare to other geometry.

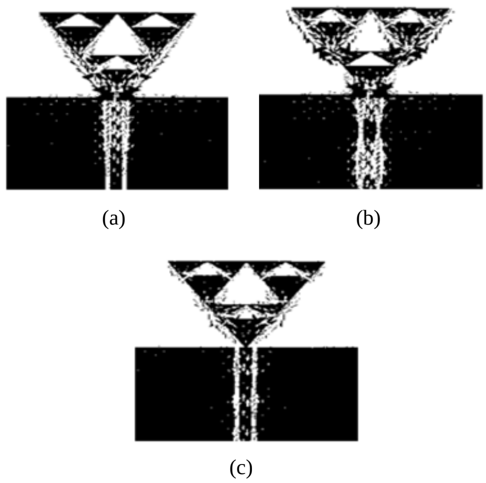
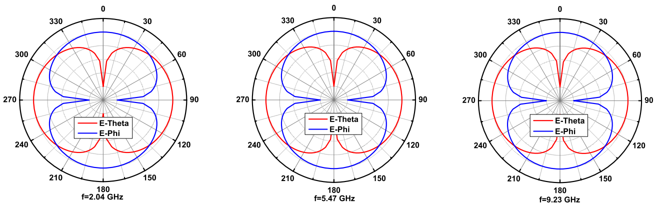


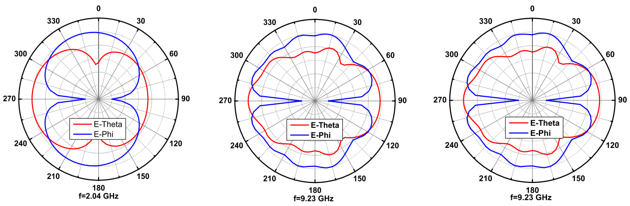
Fig. 4. Surface Current Distribution of proposed antenna at (a) Band 1 (2.04 GHz) (b) Band 2 (5.46 GHz) (c) Band 3 (9.23 GHz)

C. Radiation Pattern Characteristics

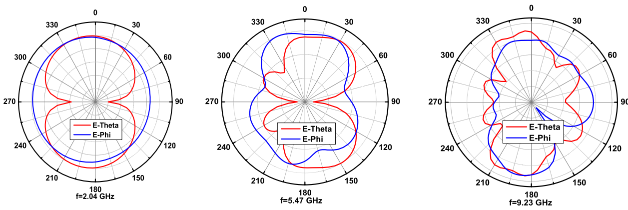
The radiation patterns of Sierpinski triangle antenna for flare angle α=30° with different scale factors shown in Fig. 5. Each plane has three patterns with each one having the three bands of proposed antenna. The main planes at ϕ=0°, ϕ=90° and θ=0° , θ=90° for proposed antenna, the pattern is like monopole pattern. With increase in frequency, the number of lobes is also increase. This type of behavior is seen in multiband fractal antenna [16].



(a) ϕ=0°



(b) ϕ=90°



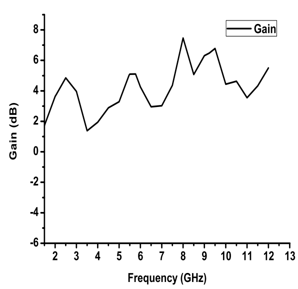
(c) θ=90°

Fig. 5. Radiation Pattern for α=60° of Sierpinski Triangle Antenna

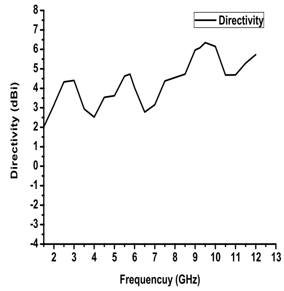
D. Gain and Directivity

When the antenna is used for multiband application, the impedance mismatch must be taken in to account for defining its characteristics especially when calculating antenna gain. CST MWS is used to compute the radiation characteristics of the proposed antenna. The simulated maximum realized antenna gain, over all the specified directions. The peak realized antenna gain for all bands is around 4-7 dB is shown in Fig. 6 (a).

For the proposed Sierpinski triangle fractal antenna the directivity is good match with gain and it is also 4-7 dBi for all bands. The directivity is shown in Fig. 6 (b).



(a)



(b)

Fig. 6. Antenna Performance (a) Gian (b) Directivity

IV. Conclusion

The model gives a good prediction on the behavior of the Sierpinski triangle antenna at flare angle α=60° with two iterations and different scale factors. Proposed antenna is working for multiband application. Here we use only two iterations and getting the multiband operation. This is very useful for reducing the volume of the antenna. The radiation pattern approximates an Omni directional pattern. Therefore, the proposed antenna is useful for low profile and low-cost and supporting multiband operation. The proposed antenna has a good return loss and good impedance matching, gain is $\geq$ 4 dB. It has good match with directivity of the antenna for all bands. The fabrication and experimental results will be carried out in future.

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