# Comparison of Multi-Fractal Antenna with Star Shaped Fractal Antenna for Wireless Applications

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## ABSTRACT
This paper presents the comparison of two different fractal antennas. Both the antennas are designed by using FR4 glass epoxy substrate with relative permittivity of 4.4 and 1.6mm thickness. The different parameters such as return loss, VSWR, gain and bandwidth of existing antenna (multi-fractal antenna) are compared with designed antenna (star shaped fractal antenna) which shows that the designed antenna have more better results as compared with the existing antenna. The designed antenna was simulated by using HFSS V13 software and the antenna can be used for different wireless applications such as WLAN, satellite communication, long distance radar telecommunication etc.

## Keywords
HFSS, VSWR, Multi-fractal.

## 1. INTRODUCTION
In 1995 the concept of fractal antenna geometries was put forwarded by Nathen Cohen [1]. The self-similarity and space-filling properties of fractal antenna are used to design the antenna for multiband and wideband characteristics. Fractal antennas repeat their geometries by a particular scale in different iterations to get better results [3]. In wireless communication the multiband and wideband characteristics is desirable to design more effective antennas. These characteristics can be achieved by designing the fractal antenna or by making the defective ground plane structure [4]. The main advantages of the fractal antennas are that these antennas have circular and linear polarization, low profile, light weight, low fabrication cost and mechanically robust when mounted on stiff surfaces [5]. In this paper comparison of two different shapes of fractal antennas are discussed. The different parameters and designing procedure of existing antenna (multi-fractal antenna) [1] and the designed star shaped fractal antenna are discussed and compared in this work

## 2. ANTENNA DESIGN
The different iterations of existing multi-fractal antenna [1] and the designed star shaped fractal antenna are shown in Figure 1 and Figure 2 respectively. The FR4 epoxy substrate with dielectric constant 4.4, thickness 1.6mm and resonant frequency of 5GHz are used for the designing of multi-fractal antenna and star shaped fractal antenna. The side lengths of the triangular antennas are calculated by using equation 1 and are found to be 19.04mm.

$$W_t\,(mm) = \frac{2\ X\ c}{3\ X\ f_r\ X\sqrt{\varepsilon_r}} \qquad (1)$$

Where,

C = velocity of light in free space.

$f_r$ = resonant frequency.

$\varepsilon_r$ = dielectric constant of substrate.

$W_t$ = side length of triangular patch.

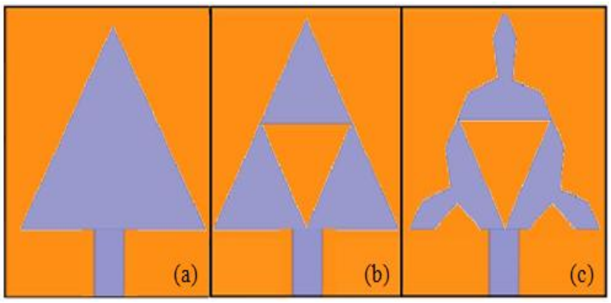


**Figure 1: (a) 0th iteration, (b) 1st iteration and (c) 2nd iteration of multi-fractal antenna [1]**

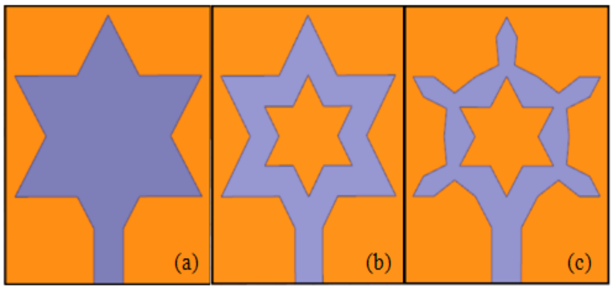


**Figure 2: (a) 0th iteration, (b) 1st iteration and (c) 2nd iteration of star shaped fractal antenna**

The dimensions of the multi-fractal antenna [1] are as follows in which the length *(Lf)* and width *(Wf)* of feed line is 8mm and 3mm respectively. Dimension of partial ground plane *Lg*=5mm and *Wg*= 21.06 mm. Dimension of the substrate *Wsub*, Lsub and *Hsub are* 25.5mm, 21.06mm and 1.6mm respectively. Figure 3 shows the geometry of multi-fractal antenna in which the sierpinksi triangle cut out from the equilateral patch is having dimension, Hst = Ht/2 = 8.25 mm and side length of 9.53 mm. The Koch curve cut out from the sides of the Sierpinski iterated structure are congruent to each other and have dimensions Lk = Ls× 2 = 4.76 mm, Hk = 2mm and Ls=Wt/8 = 2.38 mm.

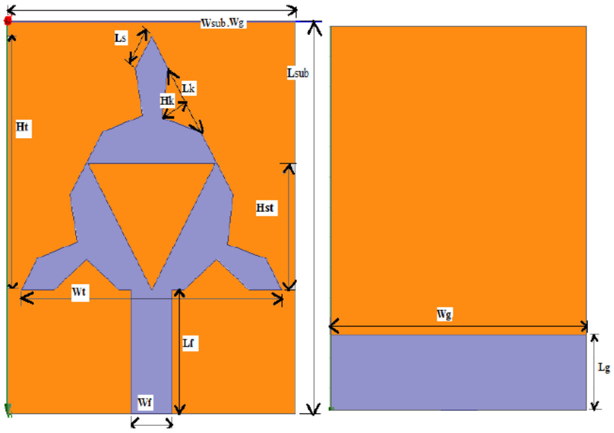


**Figure 3: Geometry of multi-fractal antenna [1]**

The length *Ls*, width *Ws* and height of the substrate of star shaped fractal antenna is 25.5mm, 21.06mm and 1.6mm respectively. Dimension of defected ground plane length *Lg* and width *Wg* are 4.8mm and 21.06mm respectively. The length *(Lf)* and width *(Wf)* of feed line is 5.09mm and 3mm respectively. The star shaped sierpinski iterated structure having the dimensions $Y_t = Y_k/2 = 11$mm is cut out from the star shaped patch with a side length $C_1 = 3.17$ mm. The Koch curves cut out from each side of the star shaped patch having dimension $X_k = X_t/2 = 1.58$ mm, $X_p = 1.5$ mm and $W_k = 2.58$ mm. The geometry of star shaped fractal antenna is shown in Figure 4.

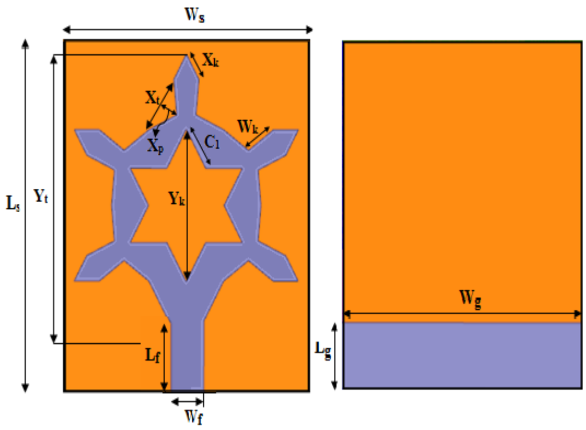


**Figure 4: Geometry of star shaped fractal antenna**

## 3. RESULT AND DISCUSSIONS

### 3.1 Return loss and VSWR

Return loss and VSWR are important parameters of antenna and the value of return loss is less than -10dB and the value of VSWR is less than 2 for the antenna to work effectively. The return loss curves of $0^{th}$, $1^{st}$ and $2^{nd}$ iteration of multi-fractal antenna [1] and star shaped fractal antenna are shown in Figure 5 and Figure 6 respectively. The VSWR of multi-fractal antenna is not calculated but in this work the VSWR of existing antenna is also calculated and for the designed star shaped fractal antenna the VSWR curve is shown in Figure 7 and the comparisons of their values are shown in Table 1.

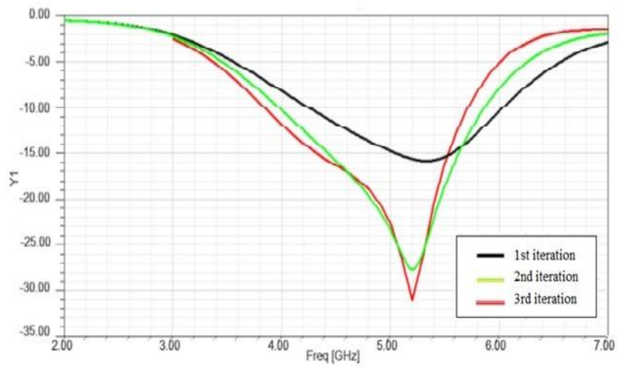


**Figure 5: Return loss v/s frequency plot of multi-fractal antenna [1]**

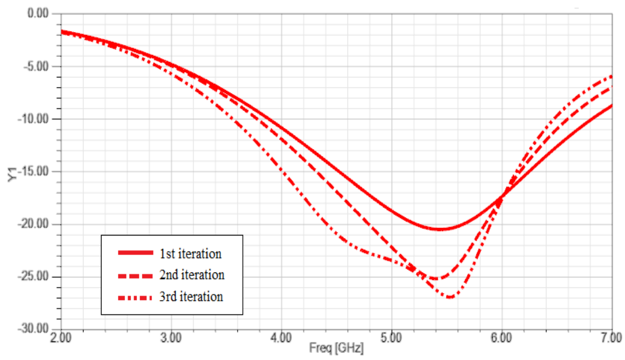


**Figure 6: Return loss v/s frequency plot of star shaped fractal antenna**

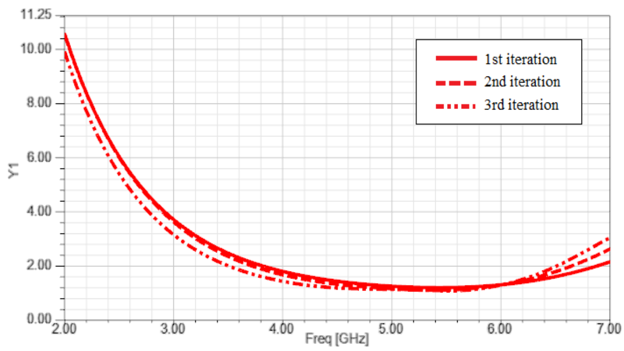


**Figure 7: VSWR v/s frequency plot of star shaped fractal antenna**

### 3.2 Gain And Bandwidth

The gain shows the directional capabilities and the efficiency of antenna. The desired value of the gain in greater than 3dB for the antenna to work efficiently. The bandwidth can be calculated by subtracting the lower frequency from the upper frequency and the bandwidth percentage can be calculated by using the formula given below. The gain and bandwidth of the multi-fractal is studied and the gain and bandwidth of the star shaped fractal antenna is calculated and there comparison is shown in Table 1.

$$Bandwidth\ \% = \frac{F_2 - F_1}{F_C}\ X\ 100$$

Where,

F2 = Upper Frequency

F1 = Lower Frequency

Fc = Centre Frequency

**Table 1. Comparison of different parameters of multi-fractal [1] with star shaped fractal antenna**

| Iteration No. | Parameters | Multi-Fractal Antenna [1] | Star Shaped Fractal Antenna |
|---|---|---|---|
| $0^{th}$ iteration | Return loss | -15.9 dB | -20.47 dB |
| | VSWR | 1.38 | 1.20 |
| | Gain | 2.95 dB | 5.45 dB |
| | Bandwidth % | 33.9 | 53.49 |
| $1^{st}$ iteration | Return loss | -27.7 dB | -25.14 dB |
| | VSWR | 1.08 | 1.11 |
| | Gain | 3.21 dB | 6.76 dB |
| | Bandwidth % | 36.22 | 52.04 |
| $2^{nd}$ iteration | Return loss | -31.3 dB | -26.91 dB |
| | VSWR | 1.05 | 1.09 |
| | Gain | 3.43 dB | 8.09 dB |
| | Bandwidth % | 35.77 | 52.44 |

## 4. CONCLUSIONS

The aim of this paper is to compare the existing multi-fractal antenna [1] design with the star shaped fractal antenna. The different parameters such as return loss, VSWR, Gain and bandwidth percentage of the designed antenna is compared with the existing fractal antenna which shows that the designed antenna shows the better results as compared to the existing antenna. The gain and bandwidth of the designed antenna increased on increasing the iteration number. Due to the better results of the designed antenna is more effective as compared to the existing antenna. Both the antennas can be used for different wireless applications but the designed antenna can be used more effectively for the practical applications.

## 5. REFERENCES

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