

# Design and Analysis of Sierpinski Pentagonal Fractal Antenna for Tri-Band Applications

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**ABSTRACT:** Now a days Smart vehicles has been developed due to the rapid evolution of technology and it consists several parameters such as low cost, low reliability with best performance and low delay traffic safety application. The low profile pentagonal sierpenski fractal geometry for the patch is incorporated as fractal geometry help in reduction of antenna size with simultaneous access of multiband operation. This modified design allows triple band by keeping the aperture coupled feed location constant. The use of the proposed multilayered structure with electromagnetic feeding technique helps the antenna to achieve high gains at all the three of its operating frequencies in the desired directions with increased bandwidth which is actually rendered superior to the performance than other fractal designs by the integration of modified sierpinski fractal. The proposed antenna can operate at 1.3GHz of the GPS L1, 4.5GHz of WiMax and 8 GHz bands. The performance of the present antenna element will be estimated by both Ansoft HFSS simulation software and experimental measurements. The analysis will also include comparison between the proposed antenna and existing compact multiband patch solutions.

**KEYWORDS:** Sierpinski, Fractal antenna ,Ansoft HFSS

## I. INTRODUCTION

In modern wireless communication systems wider bandwidth, multiband and low profile antennas are in great demand for both commercial and military applications. This has initiated antenna research in various directions; one of them is using fractal shaped antenna elements. Traditionally, each antenna operates at a single or dual frequency bands, where different antenna is needed for different applications. Fractals are space filling contours, meaning electrically large features can be efficiently packed into small areas. Since the electrical lengths play such an important role in antenna design, this efficient packing can be used as a viable miniaturization technique. Fractals are structures of infinite complexity with a self-similar nature. A fractal can fill the space occupied by the antenna in a more effective manner than the traditional Euclidean antenna. This can lead to more effective coupling of energy from feeding transmission lines to free space in less volume. Therefore, Fractals can be used in two ways to enhance antenna designs. The first method is in the design of miniaturized antenna elements. These can lead to antenna elements which are more discrete for the end user. The second method is to use the self-similarity in the geometry to blueprint antennas which are multiband or resonant over several frequency bands.

## II. ANTENNA DESIGN

The formulation of the resonance frequency of a pentagonal microstrip patch antenna is obtained from the resonance frequency equation

$$f_r = \frac{\chi_{mn}c}{5.7138s\sqrt{\epsilon_{reff}}}$$

$\epsilon_{reff}$  is the effective dielectric constant of the substrate material.

The substrate material choice depends on the application. Conformal antennas require flexible substrates; low frequency antennas require high dielectric constant substrates to reduce the size of the antenna. The first design step is to choose a suitable dielectric substrate of appropriate thickness  $h$  and loss tangent

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch

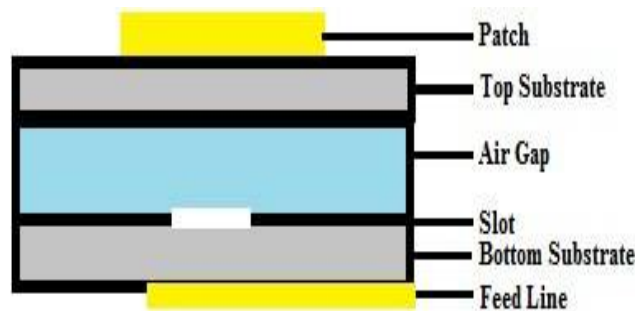


Fig2.1 basic structure of proposed antenna

The single patch is designed for one particular frequency and the aperture coupled Figure 3.2 Aperture Coupled Microstrip Patch Antenna patch is designed for another frequency. The radiating microstrip patch element is printed on the top of the substrate and the microstrip feed line is printed on the bottom of the feed substrate. The first thing to design of the patch is choosing a suitable substrate of suitable thickness. A microstrip antenna in its simplest form consists of a radiating patch on one side of dielectric substrate and a ground plane on the other side.

Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields.

### III. PROPOSED STRUCTURE OF HEXAGONAL ETCH TRIBAND APERTURE COUPLED FRACTAL ANTENNA

The proposed fractal antenna uses a combination of aperture coupled technique and fractal geometric approach. The proposed antenna consists of two layers. The top layer contains fractal patch as radiating element. The radiating patch is depicted with complementary minkowski fractal geometry with third order iteration. The 50 ohm micro strip feed-line is excited with a SMA connector. The proposed antenna consists of the Arlon AD320A(tm) substrate as a substrate that have a dielectric constant,  $\epsilon_r$  3.2 and  $\epsilon_{eff}$  3.3 with thickness of  $h_1=0.76$ mm.

In order to increase the performance of antenna such as gain and efficiency, an air gap substrate of  $h_2=1$  mm thickness with Dielectric constant,  $\epsilon_r$  1 is inserted between top layer and bottom layer. The air gap is used to avoid coupling problems between the aperture slot on ground plane and the fractal patch on the top layer due to improper alignment between them. The top layer and bottom layer substrate dimensions are

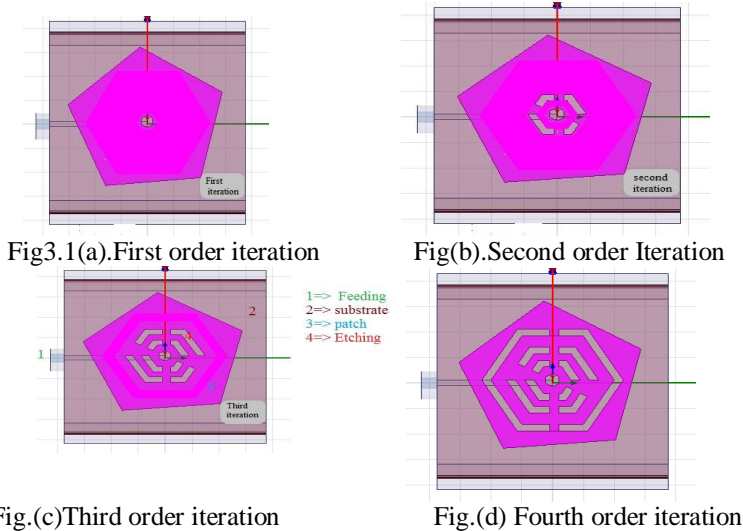


Figure 3.1.a shows top view of the proposed aperture coupled fractal antenna for first order iteration to fourth order iteration. Here, radiating patch is designed using fractal approach. The figure 3 shows various iteration of fractal antenna based Serpinski approach. This antenna is operated at Tri band frequencies 1.3, 4.5GHz and 8GHz. This Tri band frequency response depends on iterations, islands-spaces and perturbation dimensions. The figure 4.a shows first iteration of MIB based fractal antenna this gives reduction in patch area is 49.39%. The figure 4.b shows second iteration of MIB based fractal antenna. This gives reduction in patch area is 61.737%. The figure 4.c shows third iteration of MIB based fractal antenna. This gives reduction in patch area is 64.556%. Fig 4.d. shows fourth order iteration of MIB. This gives reduction in patch area is 65.33%. If iteration order increases, the resonance frequency, return loss, VSWR, directivity and gain are improved. Also bandwidth improved in higher frequency and reduced in lower frequency. This proposed fourth order iteration of MIB aperture coupled fractal antenna used in WLAN and Wi-Fi applications.

#### IV. SIMULATION RESULTS

The designed antenna is simulated by Ansoft HFSS DESIGNSTUDIO™ antenna design software. The proposed Tri band aperture coupled fractal antenna(fourth iteration) is operating at 1.3 GHz with return loss -19.181 and 4.5GHz with return loss -21.932, and 8 GHz with return loss -16.5. This is shows in fig.4.2

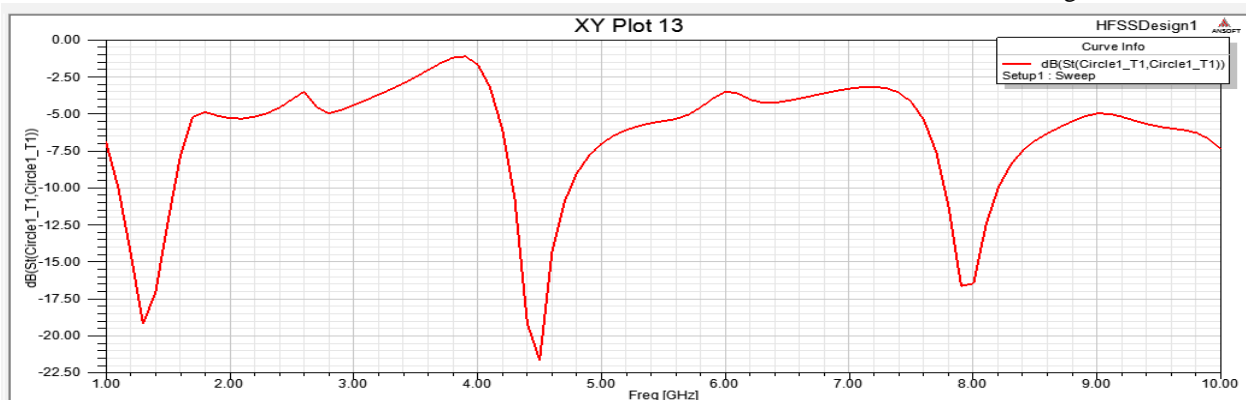


Fig.4.2. Simulated return loss of various iteration order MIB

The proposed dual band aperture coupled fractal antenna (fifth iteration) is operating at 1.3 GHz with VSWR 1.2617 and 4.5GHz with VSWR 1.3615 and 8 GHz with VSWR 1.2115. This shows in fig.4.3.

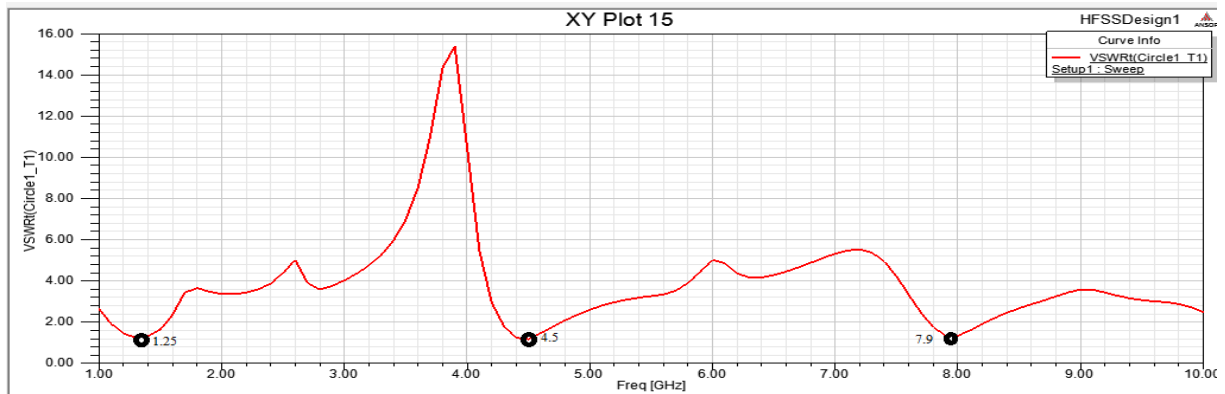


Fig.4.3. Simulated VSWR of proposed third order iteration MIB

The radiation pattern with resonant frequencies 1.3 GHz, 4.5GHz and 8 GHz are represented in figure. The antenna directional patterns are presented. The proposed aperture coupled fractal antenna achieved gain of 1.661dB at resonance frequency 3.529 GHz and 5.167dB at resonance frequency 5.176GHz. The 3D pattern of directivity is shown in fig.4. The directivity is 5.054dBi at 3.529GHz and 5.492dBi at 5.176GHz. The 3D pattern of gain is shown in fig.4. The table 2 shows antenna directivity and gain for various aperture iterations of fractal antenna. A maximum radiation in patch antenna size of 69.53% is achieved when using fourth order iteration of MIB fractal antenna.

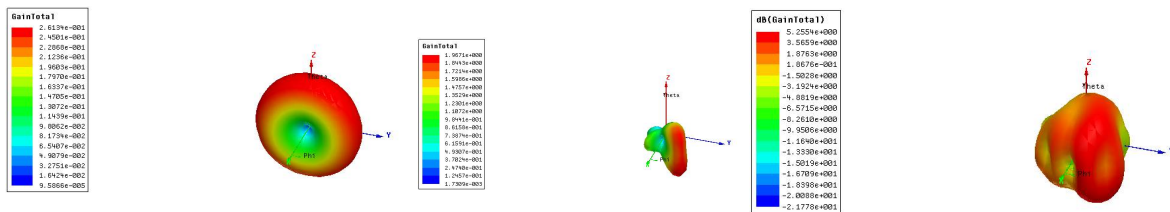


Fig.5.3 3D view of gain at 1.3 GHz , 4.5 and 8 GHz

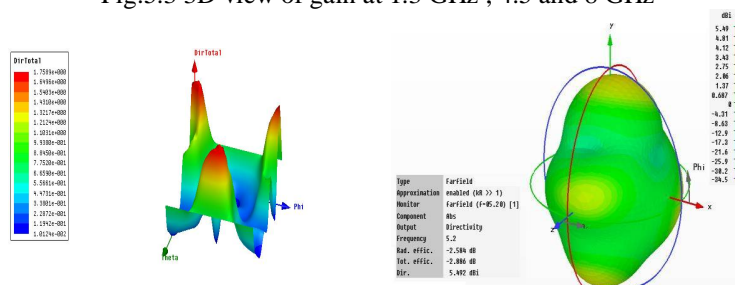


Fig.4.4 3D view of directivity at 3.5GHz and 5.2GHz

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