# ANALYSIS AND DESIGN OF CIRCULAR MICROSTRIP FRACTAL ANTENNA

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*Abstract*—**A circular multiband fractal antenna is presented here.The fractal antenna has the multiband operation due to the self-similar property in fractal geometry. Sierpinski Gasket approach is used to make the circular fractals. The antenna consists of a circular patch with a line feed that is designed to radiate at 3.5 GHz. Antenna is designed on FR4 glass epoxy substrate with parameters like thickness 1.6mm, dielectric constant 4.4. Fractal geometry helps to improved bandwidth, radiation efficiency and reduced size. The proposed antenna resonant frequencies are centred at 3.8 GHz, 4.8 GHz, 5.6 GHz, 6.3 GHz. Circular patch antenna is used as the basic geometry and 3 stages of iterations produced the proposed design. Radius of the base antenna is 25 mm. The simulated results for various parameters like return loss, radiation pattern etc have been presented . Designed antenna can be used for several wireless communication applications like WiMAX (5.2-5.5 GHz), C-band (6.95-7.4 GHz). The designed model is simulated using HFSS 13.0**

**Keywords—*Circular Microstrip Patch Antenna, HFSS, radiation pattern,* Return loss; VSWR**

## I. INTRODUCTION

Antenna is the foremost part of wireless communication system used for transmitting and receiving the electromagnetic signal .Recent development in the field of wireless communication systems to realize high speed data transfer between PCs, laptops, cell phones etc, lead to antenna with improved gain and bandwidth. The microstrip antenna is the backbone for these applications. Microstrip patch antennas is most widely used in recent wireless communications devices because of some advantageous features such as small size,low profile, light weight, low cost, compact and planner structure[7]. Due to these characteristics, it has been widely used for specific applications in satellite communications, mobile communication for GSM, mobile radio and remote sensing[3]. The Micro-strip patch antenna consists of radiating patch on one side of dielectric substrate, where as a ground plane on other side. The patch consists of conducting material for example gold, copper etc. A 'Fractal' is a repeated generated structure having a fractional dimension which provides wide flexibility in antenna design & analysis[5].The word fractal is derived from the Latin word "fractus" meaning broken that repeat themselves at any scale on which they are examined.The fractal geometries have two unique features such as self similarity and space filling properties which plays important role in designing the antenna for multiband and wideband applications. The self similarity is when an object is precisely similar to a part of itself and space filling is the property when the size become larger with exactly the same area when the number of iterations are increased. Iterations lead to large effective size keeping the area same[5]. Fractal antennas can be designed in many shapes using fractal geometries such as Sierpinski Carpet, Sierpinski Gasket, Minkowaski Loop, Koch Island.[4].

## II. ANTENNA DESIGN

Antenna design for wireless applications requires low cost, compact size, simple radiating element, good performance, easy and simple fabrication and suitable feeding technique. The circular Fractal Antenna with line feed is designed in this paper. The detail for the same is briefly discussed in the following sub-sections.

### *A. circular microstrip fractal antenna*

To design circular fractal antenna firstly circular microstrip patch antenna is designed at 3.5GHz operating frequency using High Frequency Structure

Simulater (HFSS). performance of antenna depends upon the feeding technique and its suitable position. Basic feeding technique are, Microstrip Line Feeding, Coaxial Probe Feeding, Proximity Coupled Feeding and Aperture Coupled Feeding. In this work microstrip line feed is used used.and its conducting strip is connected directly to the edge of the Microstrip patch. Fractal antenna geometries are inspired by nature i.e. they possess features of fractals that exists in nature.

*B. Fractal design*

The radius of the base antenna is 26mm. The FR4 glass epoxy substrate is used with dielectric constant 4.4 and thickness 1.6mm for designing an antenna. High value of dielectric constant of the substrate can reduce the dimensions of antenna. The antenna design depends upon dielectric constant of substrate material ($\mathcal{E}_r$), resonant frequency (fc ) and height of substrate (h). The radius of the patch is designed based on on the resonant frequency and radius of circular patch can be determined using following relation:

$$a=\frac{F}{\left\{\sqrt{1+\left\{\frac{2h}{\pi\varepsilon_r a}\left[ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}}\right.}$$

Where

$$F=\frac{8.791*10^9}{f_r\sqrt{\varepsilon_r}}$$

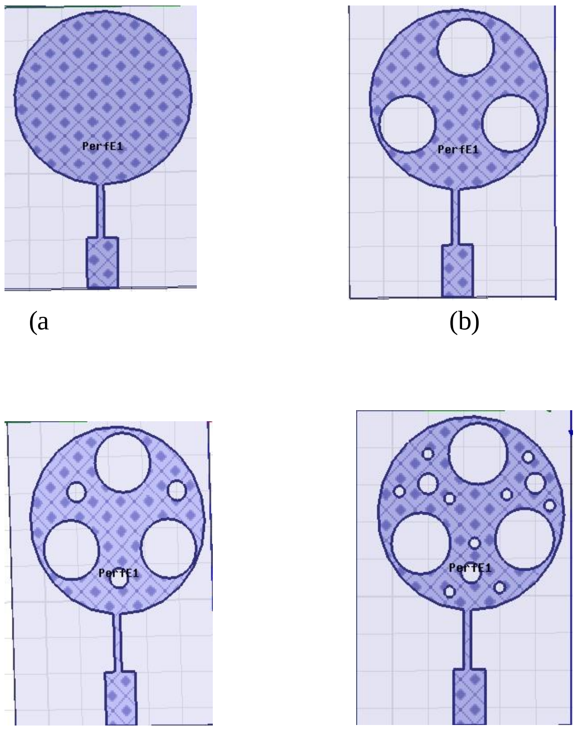
Effective radius is given by

$$a_e=a\sqrt{1+\left\{\frac{2h}{\pi\varepsilon_r a}\left[ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}}$$

ε = dielectric constant of substrate
h = height of substrate
a= radius of patch
$a_e$ =effective radius of patch

$fr$ = resonant frequency of substrate

The basic geometry of antenna consist of circular patch having diameter 52mm.In the first iteration three circles of radius 8.25mm are cut from the basic structure .In the second iteration three more circles of radius 2.75mm are subtracted from the base shape. In the third iteration nine circles of radius 1mm is cut along the subtracted circles. The figure shows the various iteration structures.



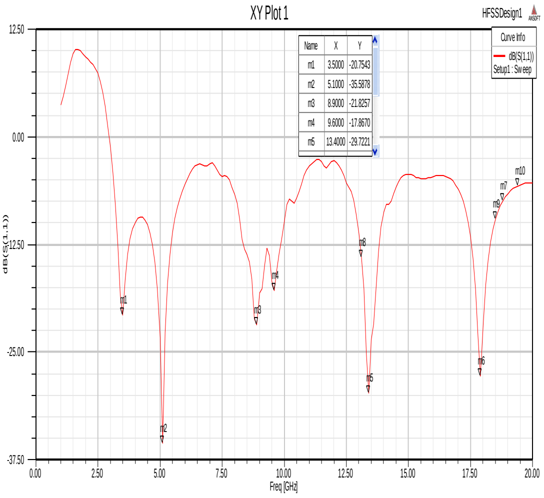

(a (b)

(c) (d)

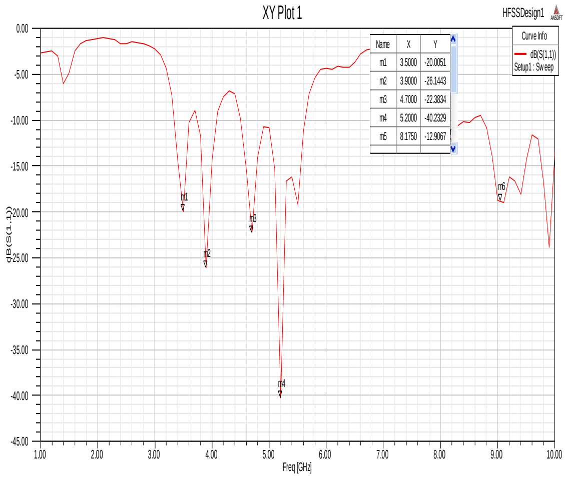
Fig1:(a)Iteration (b)Iteration1 (c)Iteration2 (d)Iteration(3)

## III SIMULATION RESULTS

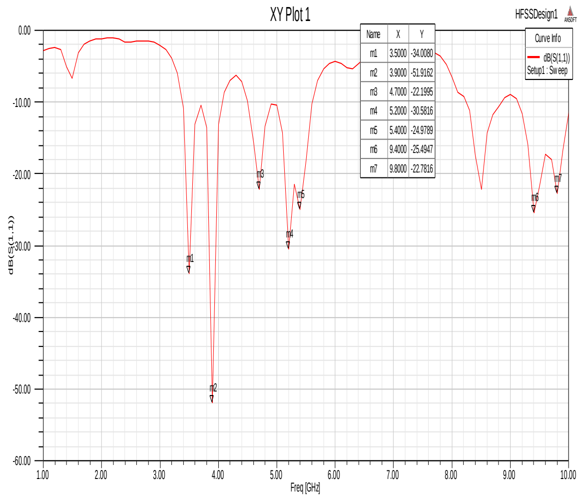
### A. Return loss



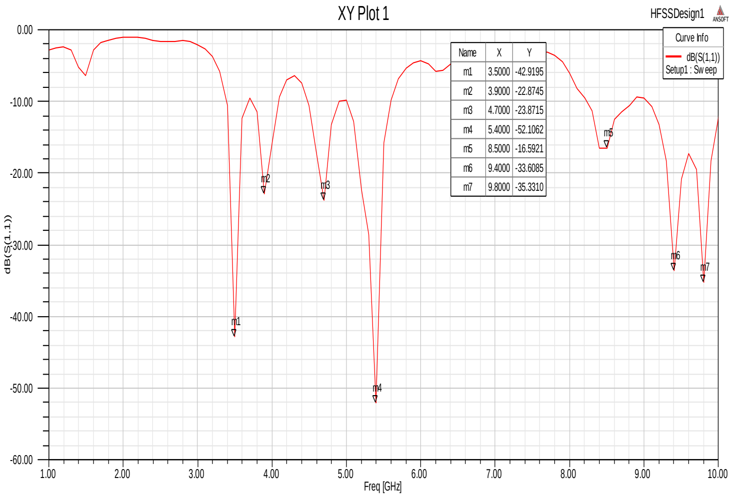

*(a)*




*(b)*




*(c)*

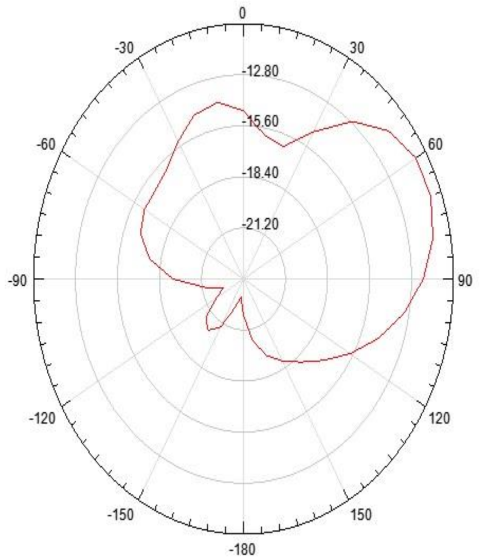



*(d)*

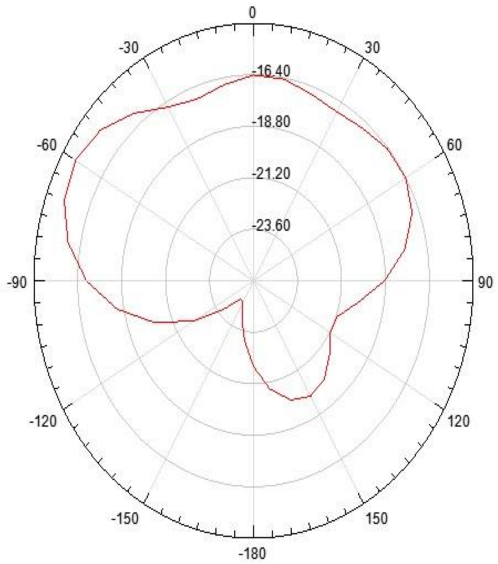
Fig 2: HFSS design for Return loss (a )iteration (b)iteration 1

(c) iteration 2 (d) iteration 3

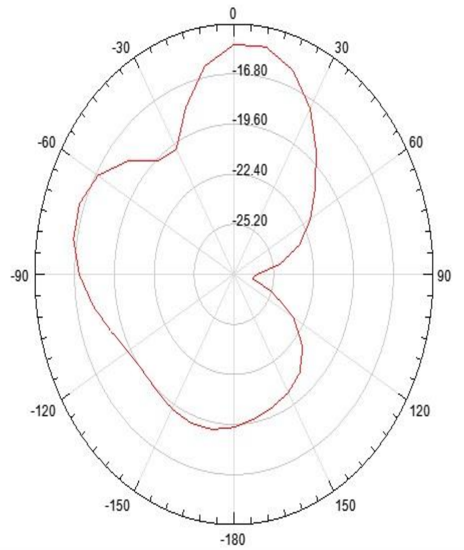
**B Radiation pattern**



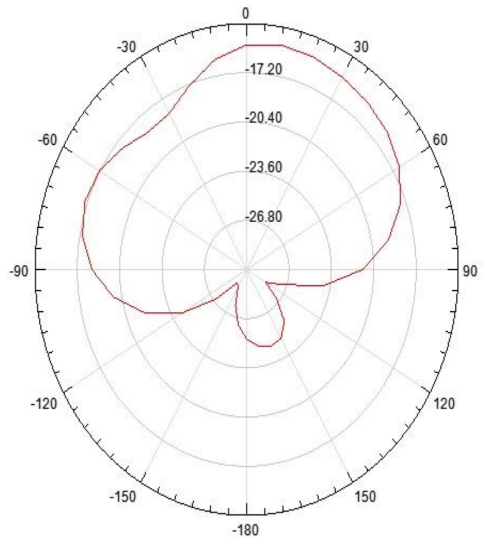

*(a)*




*(b)*




*(c)*




(d)

Fig 3:HFSS design for Radiation pattern (a )iteration 0 (b)iteration1 (c) iteration 2 (d) iteration 3

| parameter | Iteration 0 | Iteration 1 | Iteration 2 | Iteration 3 |
|---|---|---|---|---|
| Return loss | -35.5 (2-5.2GHZ) | -40.23 (4.5-6 GHZ) | -51.9 (3-5GHZ) | -52.10 (4-8GHZ) |
| VSWR | 0.2 | 0.1 | 0.04 | 0.04 |
| Directivity | 0.32 | 0.18 | 0.14 | 0.12 |
| Gain | 0.22 | 0.12 | 0.09 | 0.08 |
| Radiation efficiency | 0.713 | 0.67 | 0.69 | 0.69 |

Fig 4: Comparison table

## IV. CONCLUSION

Circular microstrip Fractal Antenna at 3.5GHz frequency has been designed upto 3rd iteration in this paper using High Frequency Simulation Software (HFSS). It has been analyzed for parameters such as return loss, VSWR, peak gain, peak directivity and radiation efficiency. It can be concluded from above simulation results (Iteration 0 to Iteration 3) that circular microstrip fractal antenna can be used as multiband antenna in this range ranging from 1 GHz to 10 GHz. It is also observed that circular Fractal Antenna possesses wide band characteristics that can be usedfor ultra wide band frequency applications.

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