# Design of Koch Fractal Antenna for Wireless Applications

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***Abstract* - This paper presents the design of Koch fractal antenna for wireless applications. The idea behind the use of Koch fractal antenna is to achieve multiband, wideband and size miniaturization.The resonant frequency used for designing the antenna is 2.45 GHz frequency. Four iterations of the antenna is designed and simulated using HFSS simulation tool. Radiation characteristics of Koch based fractal antenna is compared with existing model by the performance of antenna in terms of return loss, gain, VSWR and radiation pattern.**

***Keywords: Fractal antenna, Koch curve, HFSS, return loss.***

## I. INTRODUCTION

According to Webster's dictionary, a fractal is defined as being "derived from the latin word fractus which means broken, irrespective of various extremely irregular curves or shapes that repeat themselves at any scale on which they are examined. The formal mathematical definition of fractal is defined by Benoit Mandelbrot[1]. The fractals are generally self similar and independent of scale. There are various shapes of fractal antenna such as Koch curve, Sierpinski carpet, sierpinski gasket, Minkowski,Hilbert curve etc.Koch curve is generated by a simple geometric procedure which can be iterated an infinite number of times by dividing a straight line segment into three equal parts and substituting the intermediate part with two segments of the same length[2].

At present, compact and portable communication systems have increased demand in wireless communications[4]. In order to achieve multiband /wideband performance, Koch fractal antenna was chosen.Fractal antenna can be operated at 2.45 GHz in different wireless applications such as WLAN, Wi-MAX, Bluetooth, etc[3].

## II EXISTING DESIGN

In this model 3 iterations of star shaped Koch fractal antenna were designed using HFSS V13 Simulation tool, 0th Iterations Koch fractal antenna is labeled as I-0 with the length of 30 mm.

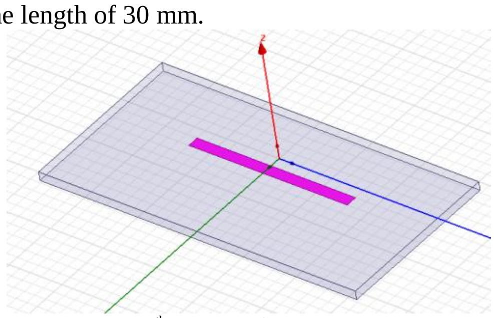


Fig. 1. 0th iteration of existing antenna

1st iteration is designed by the straight line transformation is scaled to one third of its original length, with the center line bent at θ= 60°

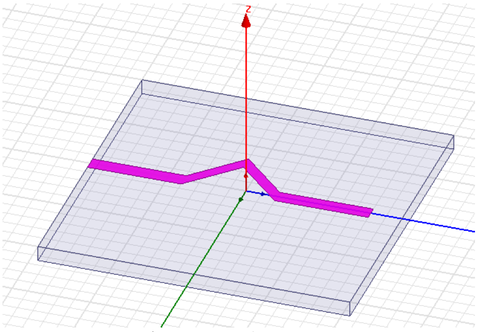


Fig. 2. 1st iteration of existing antenna

2nd iteration is designed by translating their previous iteration, which each side of the line with the same length.

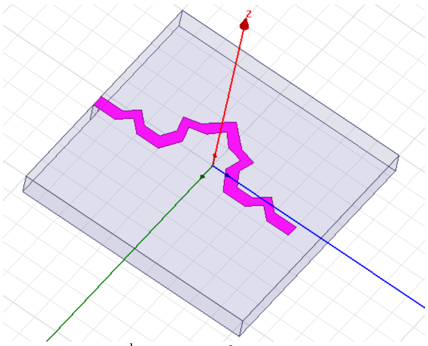
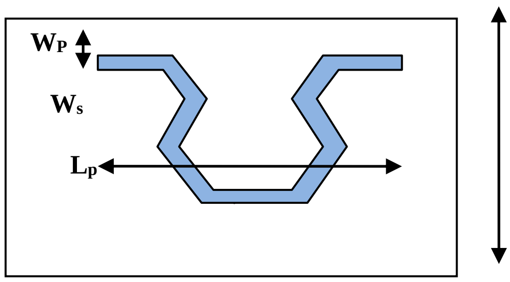


Fig. 3. 2nd iteration of existing antenna

## III PROPOSED ANTENNA DESIGN




The parametric values of the proposed model is shown in the above table.

In the existing model, rectangular patch antenna was used for wireless applications. For the design of antenna resonant frequencies, substrate thickness ,length and width of patch, etc were considered. The substrate material used for the design is FR4 epoxy substrate with dielectric constant 4.4, thickness 1.6mm and resonant frequency taken as 2GHz[3].

| S.No | Parametres | Description | Values |
|---|---|---|---|
| 1. | $L_s$ | Length of substrate | 40 mm |
| 2. | $W_s$ | Width of substrate | 1.6 mm |
| 3. | $L_p$ | Length of patch | 30 mm |
| 4. | $W_p$ | Width of patch | 2 mm |
| 5. | $L_f$ | Length of feedline | 5 mm |
| 6. | $W_f$ | Width of feedline | 1.6mm |

Calculation of width ,(w)

$$w = \frac{c}{2fo\sqrt{\frac{\varepsilon r+1}{2}}} \ldots\ldots(1)$$

Calculation of Effective Dielectric constant($\varepsilon_{reff}$),

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12\frac{h}{w}]^{\frac{1}{2}}. \qquad \ldots..(2)$$

Calculation of effective length ($L_{eff}$),

$$L_{eff} = \frac{c}{2fo\sqrt{\varepsilon_{reff}}} \qquad \ldots\ldots(3)$$

Calculation of length extension ($\Delta L$),

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{w}{h}+0.8)} \qquad \ldots\ldots..(4)$$

The actual length (L) of patch,

$$L = h\left(\frac{4}{3}\right)^n \qquad \ldots\ldots\ldots.(5)$$

$$s = 2(1+\cos\theta) \qquad \ldots\ldots\ldots.(6)$$

Where,
c= velocity of light in free space
h= substrate height
$\varepsilon_r$=relative permittivity of the substrate

## V RESULTS AND DISCUSSIONS

The return loss measurement describes the ratio of the power in the reflected wave to the power in the incident wave in units of decibels.For an antenna to be efficient the acceptable value of return loss should be below -10dB.

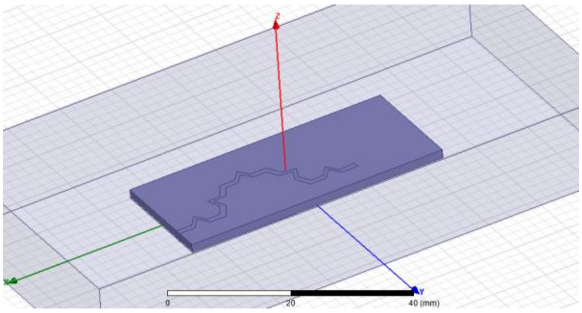


Fig. 5. design of existing antenna

The return loss versus frequency curve the existing antenna is shown below,

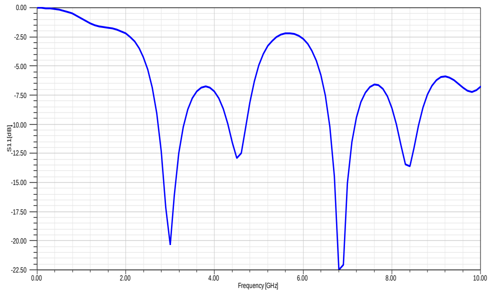


Fig.6. Simulated return loss result

The measured results of the above design goes well with the simulation and the wideband range of frequencies are between 2GHz and 8GHz.

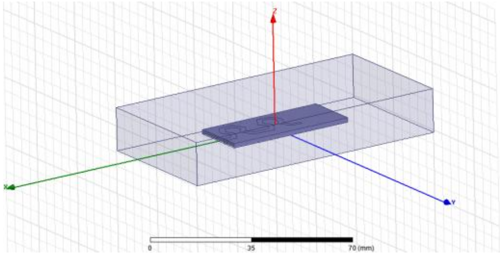


Fig.6. Design of proposed antenna

The return loss vs frequency curve of the proposed model is shown below,

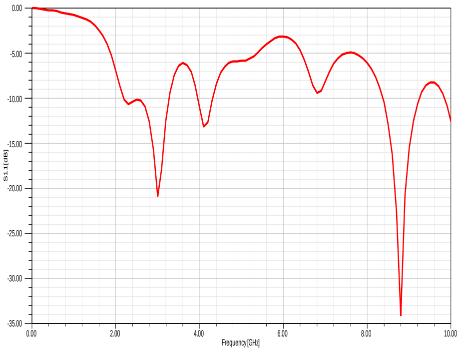


Fig.7. Simulated return loss results

The measured results of the above design goes well with the simulation and the wideband range frequencies are between 2GHz and 10GHz.. Comparing fig5 and fig7, the proposed antenna design has wider bandwidth compared to existing antenna design.

Radiation pattern shows the directivity nature in far field region for both azimuth and elevation plane.

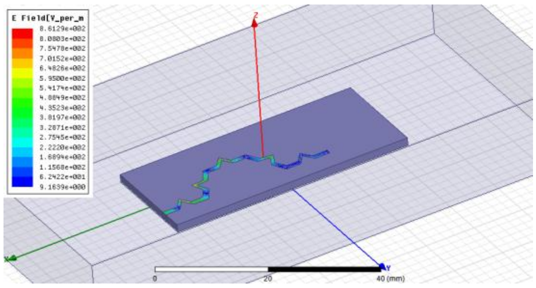


Fig.8. E field pattern of existing antenna

The measured radiation results of the existing antenna design I shown in the fig9.

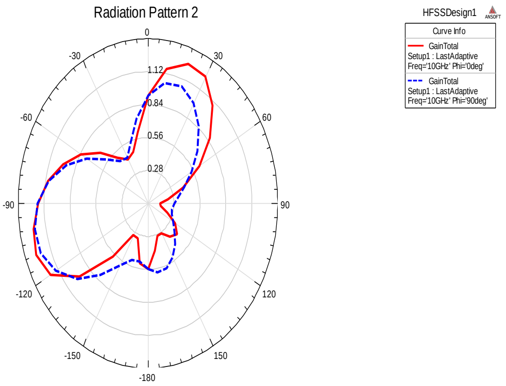



Fig. 9. Radiation pattern of existing antenna

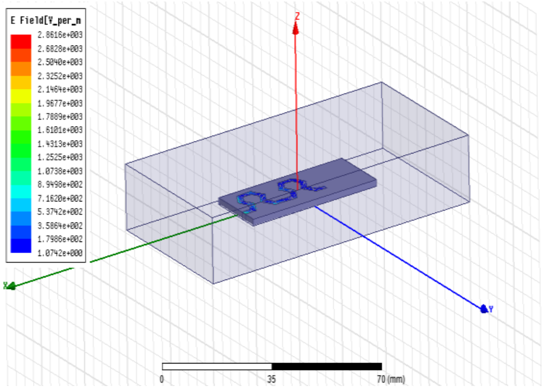



Fig.10. E field pattern of proposed antenna

The measured radiation results of the proposed antenna design I shown in the fig 10.

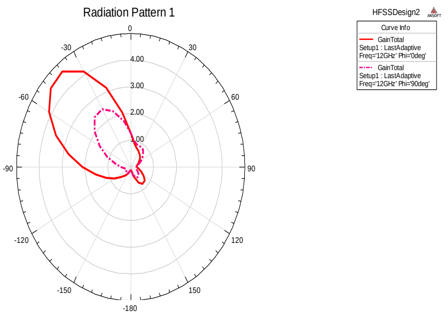



Fig 11: Radiation pattern of proposed antenna

By comparing fig 9 and fig 11, we infer that proposed antenna have better simulation results and bandwidth compared to the existing antenna.

## VI CONCLUSION

Koch fractal antenna with various iterations are designed and simulated in this paper for wireless applications. FR4 Epoxy substrate is chosen with thickness 1.6mm and relative permittivity of 4.4. The resonant frequency used for designing the antenna is 2.45 GHz.

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