

# Design of Dual-band Minkowski Fractal Antenna by using Coupling for Wireless Communication System

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**ABSTRACT:** A dual -band minkowski fractal antenna is presented here. this proposed antenna has been designed by using coupling. The proposed antenna is suitable for wireless local area network applications. The proposed antenna successfully obtained the bandwidth about (52.9% fractional bandwidth). The material used for substrate is FR4 with relative permittivity of 4.4 and thickness is about 1.6mm, and loss tangent of 0.0013. The obtained bandwidth is, gain of 3.32072 dbi, antenna efficiency of 99.67% . The antenna is fed by 50Ω Micro strip line feed

**KEYWORDS:** Micro strip patch antenna, fractal, coupling, Ground plane, IE3D simulator, Micro strip line feed.

## I. INTRODUCTION

In recent years, the fractal shape antenna elements have drawn interests of many researchers. Because the fractal geometries are featuring two common properties, space- filling property and self-similarity property, fractal shaped antenna elements have a various advantages, such as wide-band, multi-band, and reduced antenna size. Fractal geometry is applied in many different areas of life such as art, medicine, biology, computer science, Fractals are abstract objects that cannot be physically implemented. Nevertheless some related, slightly modified geometries can be used to approach an ideal fractal that are useful in constructing antennas. Some properties of fractal geometry are useful in designing small size and multi-frequency antenna [2]. A number of techniques have been proposed in order to improve the characteristics of antennas such as to enhance gain or widen the impedance bandwidth. Gap coupling is one of the techniques being used by the researchers throughout the world. . Different types of gap-coupled antennas have been proposed by the contributors. In some applications, multi frequency operations are required; this can be achieved by gap coupling [3].

The FR4 substrate is used and micro strip line feed [4-5] is used for feeding. Details of the proposed antenna design and experimental results for antenna are presented.

## II. RELATED WORK

Sayantana Dhar, Sudipta Maity, Bhaskar Gupta, D.R. Poddar [13] has been obtained multiband characteristics with narrow bandwidth. The proposed antenna radiates with an omni directional pattern. Rupleen kaur, Sahil saini, Satbir singh, Naveen kumar[1] has been presented a multiband fractal square patch antenna. They observed that rise in each level of iteration, results in increase in number of resonating frequencies with improved bandwidth. They presented multiple band at 7.0,9.4,11.4,13.4,17,18.2,19.4 GHz with dimension 45x45x1.6mm. Abhishek kandwal, Suneel kumar khan[3] has been obtain wideband by using gap coupling between the elements. They analysed bandwidth of 1.2 GHz in X-band along with reduced side lobe level of -15.0 db and gain 12 dbi. After this literature survey in this paper the design of Dual band minkowski fractal antenna by using coupling with dimension 29.44mmx38.04mm is presented.

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### III. MATHEMETICAL FORMULAS TO CALCULATE THE DESIGN DIMENSIONS OF MICROSTRIP PATCH ANTENNA

The mathematical formula is used to calculate the dimensions of ground plane and micro strip patch in the form of length and width.

The formula of calculating the width of Patch antenna [8,9] is given as:

$$W = \left( \frac{c}{f_r} \right) \left( \frac{\epsilon_r + 1}{2} \right)^{-0.5}$$

Where:  $c = 3 \times 10^8 \text{ ms}^{-1}$ ,  $\epsilon_r = 4.4$ ,  $f_r = 2.4 \text{ GHz}$

Formula of effective dielectric constant [9,11] is given as:

$$\epsilon_{eff} = \left( \frac{\epsilon_r + 1}{2} \right) + \left( \frac{\epsilon_r - 1}{2} \right) \left( 1 + \frac{12W}{H} \right)^{-0.5}$$

Where:  $H = 1.6 \text{ mm}$

Formula of extension in length [10,11] is given as:

$$\Delta L = .412H \left( \frac{\epsilon_{eff} + 3}{\epsilon_{eff} - 2.58} \right) \left( \frac{\left( \frac{W}{H} \right) + .285}{\left( \frac{W}{H} \right) + .8} \right)$$

The formula of calculating the length of Patch antenna [8,12] is given as:

$$L = \left( \frac{c}{2f_r \sqrt{\epsilon_{eff}}} \right) - 2\Delta L$$

### IV. ANTENNA DESIGN SPECIFICATION

To calculate the dimensions of the patch, above formulas are used. The parameter required to calculate dimension are resonant frequency ( $f_r$ ), dielectric constant ( $\epsilon_r$ ), substrate thickness ( $H$ ) and loss tangent ( $\tan \delta$ ) and  $50\Omega$  Micro strip line is used as feed into patch. The antenna specifications that are required are given in table 1.

TABLE 1: ANTENNA DESIGN SPECIFICATIONS

S. NO	Antenna Parameter	Data
1.	Resonant frequency ( $f_r$ )	2.4GHz
2.	Substrate thickness ( $H$ )	1.6mm
3.	Dielectric constant ( $\epsilon_r$ )	4.4
4.	Loss Tangent ( $\tan \delta$ )	.0013

### V. ANTENNA DESIGN PROCEDURE

Using the above equations and geometrical parameters, the dimensions of the antenna is calculated. A  $50\Omega$  Micro strip line feed is used at mid of length of the patch antenna. The position of feed is  $(Lg/2)$  on the positive X axis from the origin. Different dimensional parameters of proposed antenna are given in table2.

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TABLE 2: CALCULATED ANTENNA DIMENSIONS

S. NO	Antenna Dimension	Data(mm)
1.	Strip length	5
2.	Strip width	3
3.	Ls	29.44
4.	Ws	.5

In the design of antennas first calculate the dimensions patch. The iterative procedure is continued to get the successive stages of Minkowski fractal patch antenna is shown in Figure. The starting geometry of the Minkowski fractal antenna is the initiator square slot at the centre, and the length and width of the square slot is 3 mm. the overlapped same dimension square slot made to each corner of the centre slot and remove it. and repeat this process four times , The design of calculated minkowski fractal antenna is shown in figure 1. In micro strip patch antenna to enhance the bandwidth coupling is used. For coupling , made a vertical and horizontal rectangular strip between the patch and remove it. In this design the bandwidth is increase by using coupling between patch as shown in figure 3.

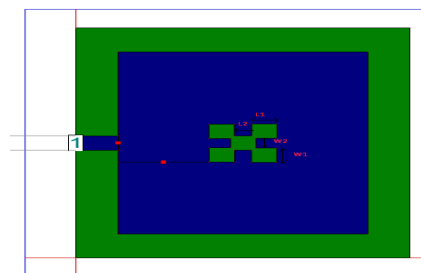


Figure:1 initial design of minkowski fractal design

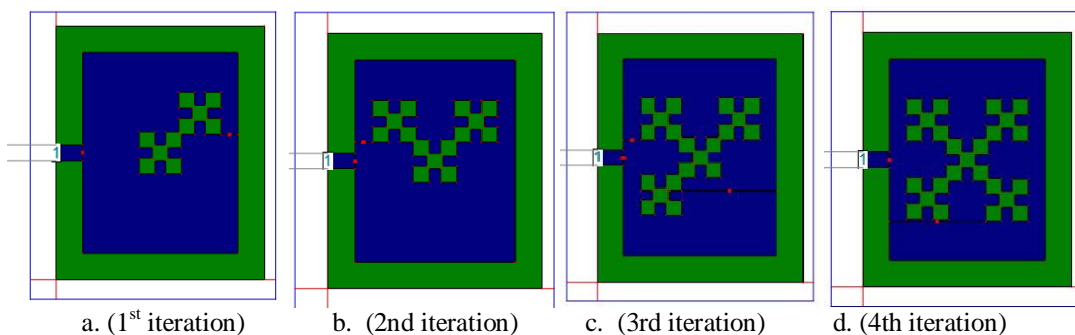


Figure 2: After performing successive iteration, minkowski fractal antenna is obtained (Geometry of design antenna and all dimensions in mm)

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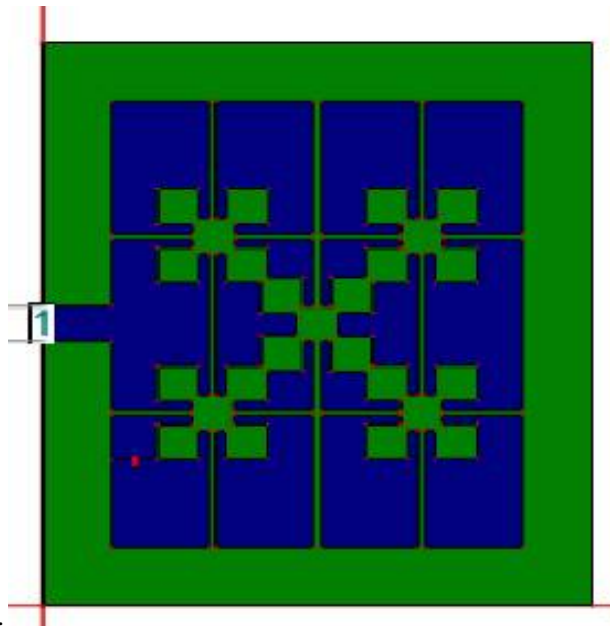


Figure:3 Minkowski fractal patch antenna by using coupling

## VI. SIMULATION RESULT AND DISCUSSION

The simulation performance of designed dual-band Minkowski fractal antenna is analyzed by using IE3D software (version 9.0) at select resonant frequency of 2.4GHz. The graph of return loss Vs frequency is plotted for the range of frequency 1GHz to 3GHz, because within this range the curve crosses the -10dB.

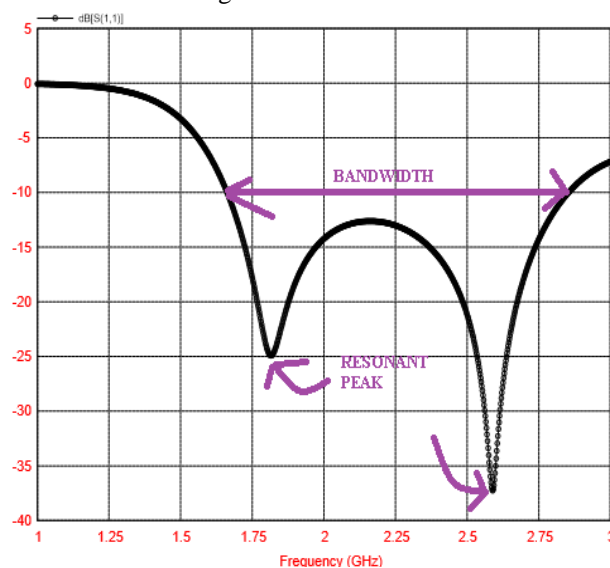


Figure:5.1 return loss vs. frequency graph

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figure 5.1 return loss vs. frequency graph of proposed antenna Thus an enhanced bandwidth 785 MHz (52.91 % fractional bandwidth) of designed antenna is obtained. And curve shows resonance at 2.59GHz very near to desired resonant frequency 2.4GHz.

In figure 5.2 the graph of Gain Vs Frequency is shown.

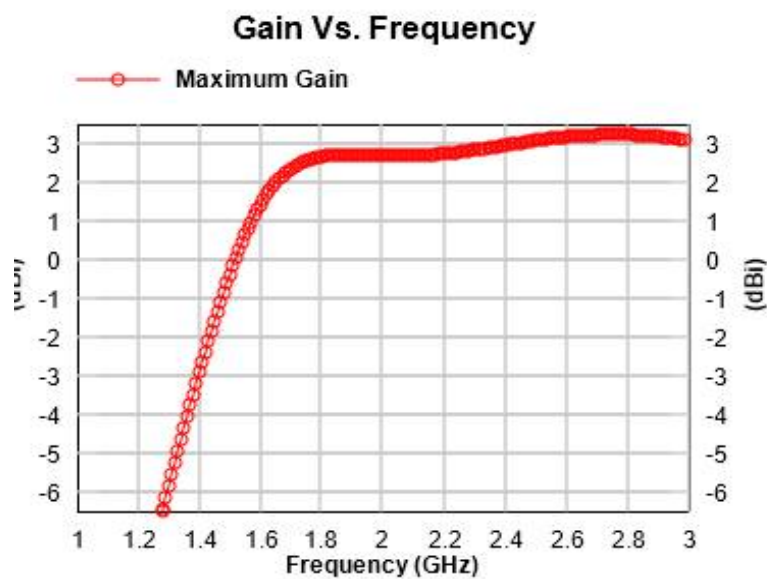


Figure :5.2 Gain Vs .Frequency graph of proposed antenna

In figure 5.3, the graph between efficiency Vs frequency is shown.

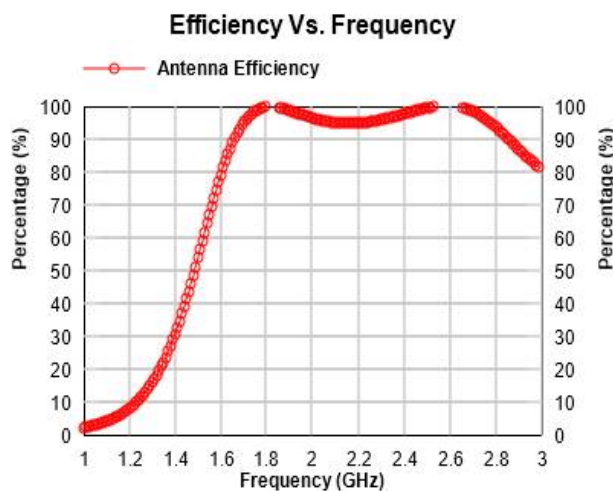


Figure :5.3 efficiency Vs Frequency graph of proposed antenna

In figure 5.4, the graph of 2D radiation pattern is shown.

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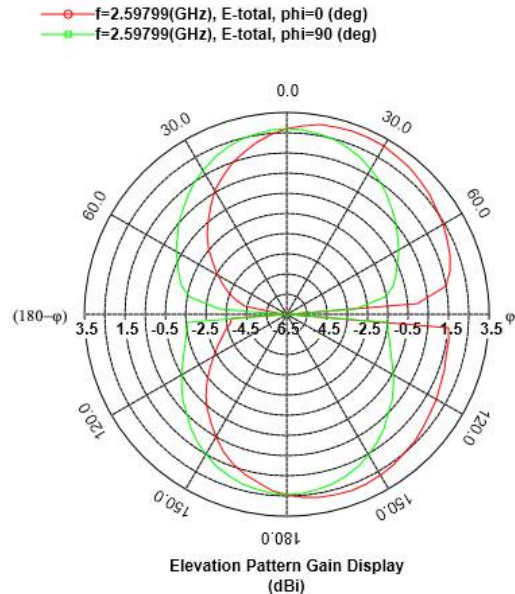


Figure: 5.4 2D radiation pattern of proposed antenna

In figure 5.5, the graph of total field Directivity Vs Frequency is shown.

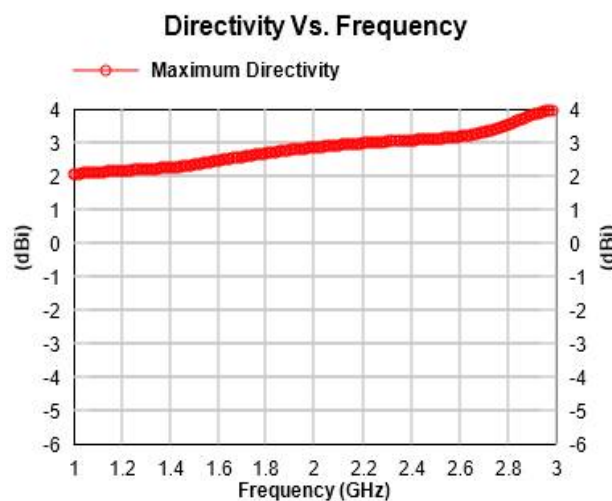


Figure: 5.5 directivity Vs frequency of proposed antenna

## VII. CONCLUSION

In this paper a dual band, Minkowski fractal antenna with coupling has been designed. 50Ω Micro strip line feed has been used in designed antenna . the minkowski fractal antenna with coupling has simulated for high speed wireless communication system and analysed using I3D software. The bandwidth 723 MHz (52.9% fractional bandwidth) of designed antenna is obtained. And curve shows resonance at 2.59GHz, 1.867GHz. 2.59GHz is very near to desired resonant frequency 2.4GHz, maximum gain of antenna is 3.3207 dBi at 2.77 GHz, radiation

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efficiency is 99.98% at 2.59 GHz, The radiation pattern represents radiation of all power in two direction therefore it shows that the designed antenna bidirectional, and directivity is maximums at 2.99GHz that is approx 3.94dBi. The bandwidth of antenna is depending on size of patch and coupling which used between patch. The antenna is thin and compact with the use of low dielectric constant substrate material. The proposed geometry is designed using glass epoxy (FR4) as a dielectric between the ground plane and patch. These features are very useful for portability of wireless communication equipment.

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