DESIGN OF HEXAGONAL FRACTAL ANTENNA FOR WLAN/ WiMAX & BLUETOOTH APPLICATIONS

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Abstract

In this paper, hexagonal fractal antenna is investigated for wide band applications. The proposed antenna is made by removing the equilateral triangles of required dimensions. Modified line feed is used for designing the antenna to achieve wide bandwidth ranging from 1.751Ghz to 2.856Ghz with a bandwidth 47.97%.In the present work size reduction has been achieved. It offers gain of 2.88dBi, directivity of 3.12dBi and antenna efficiency of 94.57% at 1.95Ghz resonant frequency. This antenna is suitable for WLAN, WiMAX and Bluetooth applications. The proposed antenna is simulated by IE3D Zeland simulation software based on method of moments.

Keywords: *microstrip antenna, fractal, hexagonal bandwidth, line feed, WLAN, IE3D, miniaturization.*

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1. INTRODUCTION

In todays era, requirement of antennas demand high performance, high gain, wide bandwidth, multiband support, low cost and minituraziation. Microstrip antennas possess these advantages along with compatibility with monolithic microwave integrated circuits(MMICs) [1-3]. Microstrip antenna possess disadvantages as well like narrow bandwidth and lower gain. There are many approaches to reduce the size of the antenna and increase the bandwidth without much affecting the antenna performance. One of these techniques is fractal antenna.

The origin of word ‘fractal’ is from the Latin word fractus which is related to the verb fangere means to break [4-5]. Fractal antenna uses self similar structure to maximize the length or increase the perimeter on inside sections or the outer structure of the material that can receive or transmit electromagnetic radiations within a given total surface area or volume[6]. Certain fractals represent multiband behavior and space-filling properties as reduction in antenna size[7-11]. In the present work, the bandwidth of microstrip antenna is enhanced to 47.97% .The fourth iterated antenna is shown in Figure 1.The frequency band of this antenna is between 1.751Ghz to 2.856Ghz which is suitable for WLAN, WiMAX and Bluetooth applications[9-12]. This antenna has been designed on glass epoxy substrate (ε_r=4.4) [13].The substrate material has large effect in determining the size and bandwidth of an antenna. If the dielectric constant is increased, size of the antenna decreases but it lowers the bandwidth and efficiency of the antenna. If dielectric constant is decreased, bandwidth increases with an increase in size.

2. ANTENNA DESIGN SPECIFICATIONS

The design of fourth iterated antenna is shown in figure1. The antenna is designed by using glass epoxy substrate having the dielectric constant 4.4. The ground plane length and width are taken as 44 mm and 45 mm respectively. A regular hexagon of side 16mm is taken and six equilateral triangles of side 8mm are taken out so that we obtain first iteration. Then from first iterated antenna, six equilateral triangles of side 4mm are taken out so that we obtain second iterated antenna. Then again six equilateral triangles of side 2mm are taken so that we obtain third iterated antenna. Then again six equilateral triangles of side 1 mm are taken out so that we obtain fourth iterated antenna. Height of the dielectric substrate is 1.6 mm and loss tangent tan δ is 0.0013.Microstrip line feed is applied. Antenna is fed through 0.3 mm probe. Simulation work is done by using IE3D simulation software. All the specifications are given in table 1(all lengths in mm and frequency in GHz).

3. ANTENNA DESIGN PROCEDURE

The primary hexagonal shaped patch is having side length of 16mm.From that patch, six equilateral triangles of side length ‘a’ 8mm has been taken out to obtain first iteration. Then six equilateral triangles of side length ‘b’ 4mm has been taken out which results in second iteration. Then again six equilateral triangles of side ‘c’ 2mm are taken out to obtain third iteration. Then again six equilateral triangles of side ‘d’ 1mm are taken out to obtain fourth iteration. Figure 2 shows the design procedure of the proposed Fractal structure geometry, depicting 0^{th} iteration, 1^{st} iteration, 2^{nd} iteration,3^{rd} iteration and 4^{th} iteration. The proposed antenna can also be called as hexagonal fractal antenna, as it is obtained after four iterations of structure. Line feed is used. The probe feed is placed at point (X =21.8125, Y =2.5). During the designing of proposed antenna on IE3D ground plane is starting from (0,0) at lower left corner. The geometry of proposed antenna is shown in figure1.A slot of size (10X10mm) is introduced in order to enhance the bandwidth.

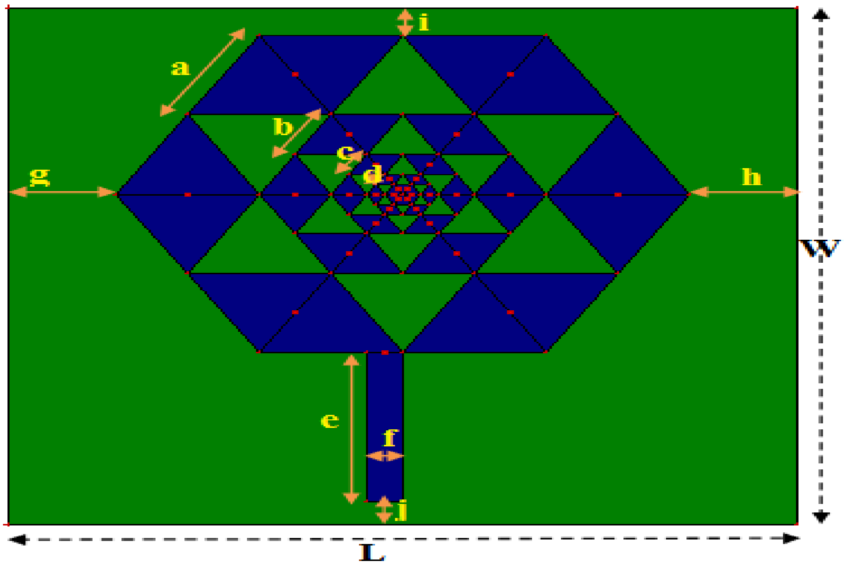
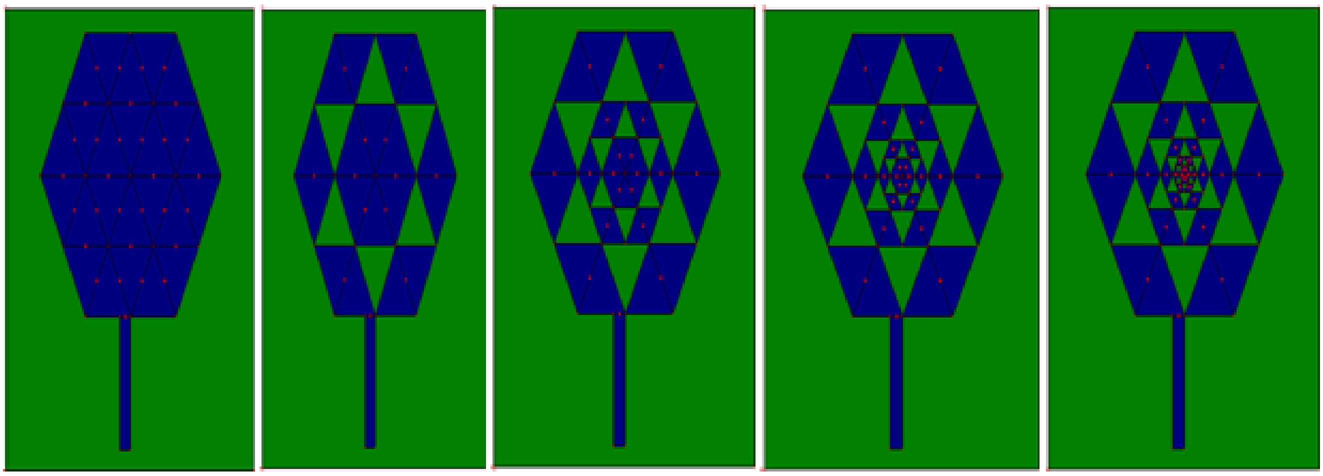


Fig.1. Geometry of proposed Microstrip antenna

Table1: Antenna design specifications

S.No.	Parameters	Values
1.	dielectric constant ε_r	4.4
2.	Substrate height	1.6mm
3.	Ground plane width,W	45mm
4.	Ground plane length,L	44mm
5.	a	8mm
6.	b	4mm
7.	c	2mm
8.	d	1mm
9.	e	13mm
10.	f	2mm
11.	g	6mm
12.	h	6mm
13.	i	2.32mm
14.	j	2mm



0th iteration 1st iteration 2nd iteration 3rd iteration 4th iteration

Fig 2 Various iterations of hexagonal-shaped fractal antenna

4. SIMULATION RESULT AND DISCUSSION

The simulated return losses of 0th iteration, 1st iteration 2nd iteration, 3rd iteration and 4th iteration are shown in figure 3. It is clearly observed that size reduction has been achieved in 1st, 2nd, 3rd and 4th iteration. It is due to the fact that as the order of iteration increases, electrical path length increases which leads to the lowering of resonance frequency. Thus, this property can be utilized for size reduction.

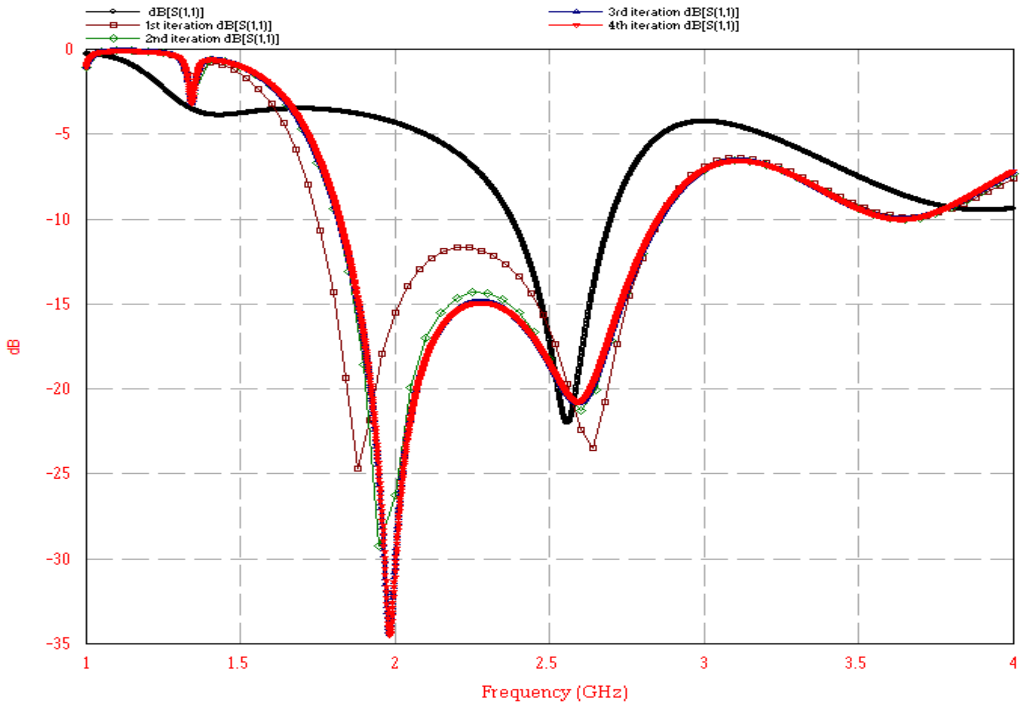


Fig.3. Return loss graph for 0th,1st,2nd ,3rd & 4th iteration

Table 2, summarizes the simulated results of zeroth, first, second, third and fourth iterated antenna. The first iterated antenna is the proposed antenna which shows quiet a good return loss, bandwidth, VSWR and size reduction.

The fractional bandwidth of proposed antenna is 47.97%. The efficiency of proposed antenna is found to be 94.56%.The gain of antenna is 2.88dBi and the directivity is found to be 3.12dBi. VSWR of the antenna is in between 1 to 2 over the entire frequency band.

Table 2: Comparison of various parameters of different iterations

ITERATION	BANDWIDTH	RETURN LOSS	GAIN	DIRECTIVITY	ANTENNA EFFICIENCY	AREA
	(%)	(dB)	(dBi)	(dBi)	(%)	(mm^2)
0th	12.64	-23.94	2.62	3.2	87.58	665.04
1st	47.97	-33.03	2.88	3.12	94.56	498.78
2nd	44.87	-33.43	2.87	3.07	95.64	457.26
3rd	44.28	-34.49	2.86	3.05	95.62	446.82
4th	44.23	-34.41	2.86	3.06	95.61	444.18

The simulation performance of proposed microstrip patch antenna is analyzed by using IE3D version 9.0software.The performance specifications like radiation pattern etc of proposed antenna is shown in the figures 4 to 8. Figure 9(a),(b) shows the front and back view of the fabricated antenna.

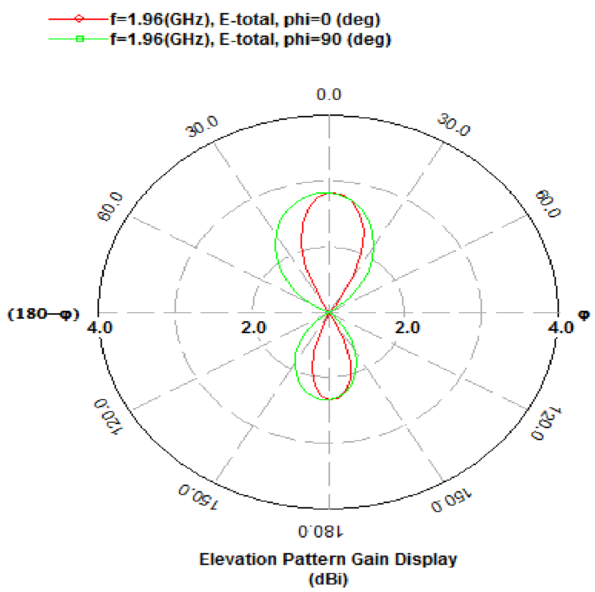


Fig.4. 2D Radiation pattern of proposed antenna

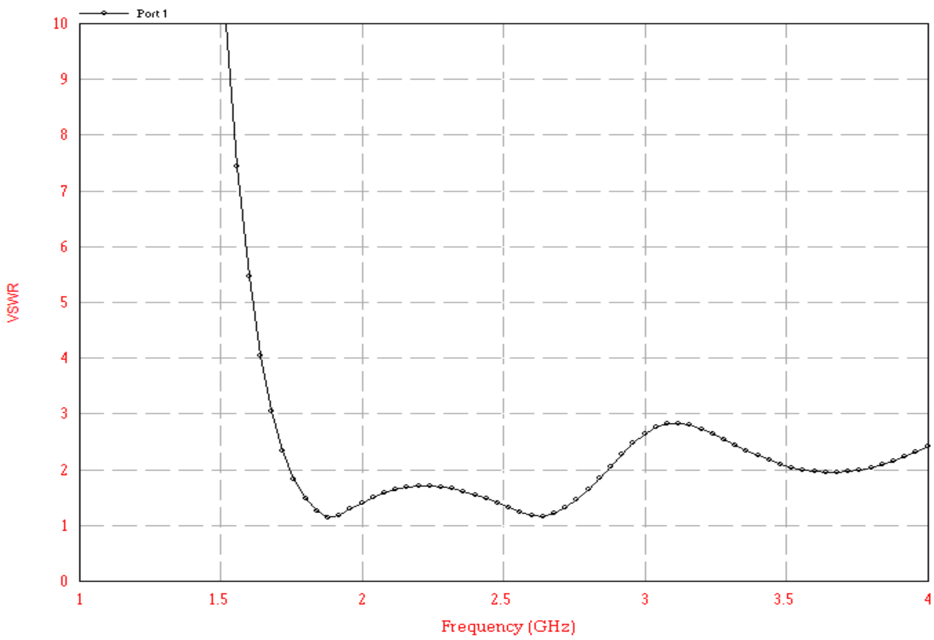


Fig 5 VSWR of proposed antenna

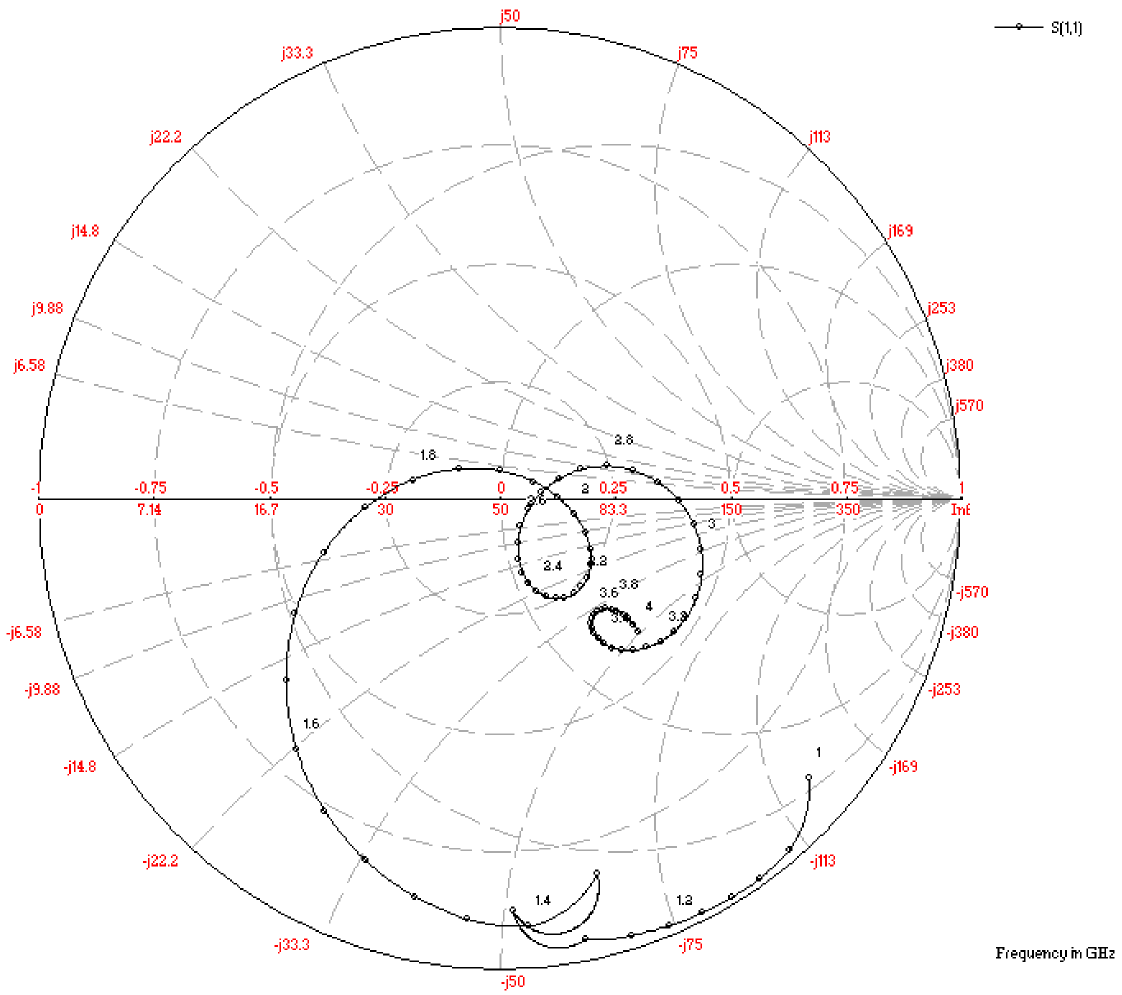


Fig 6 Smith chart of proposed antenna

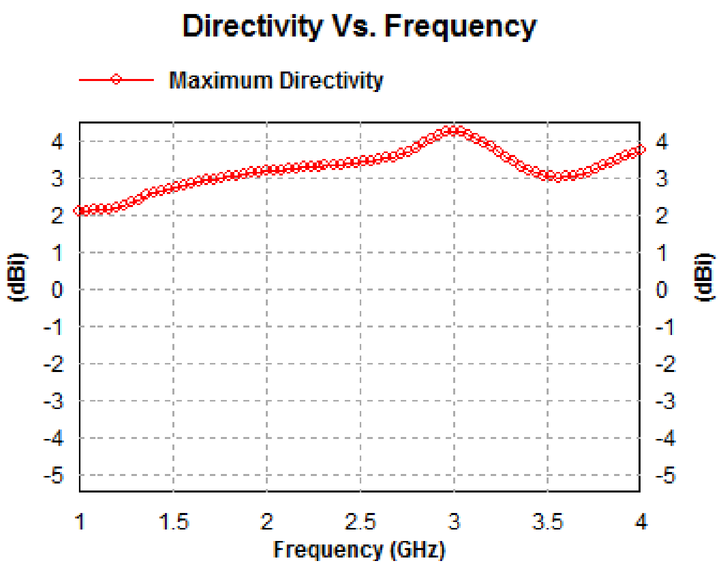


Fig 7 Directivity of proposed antenna

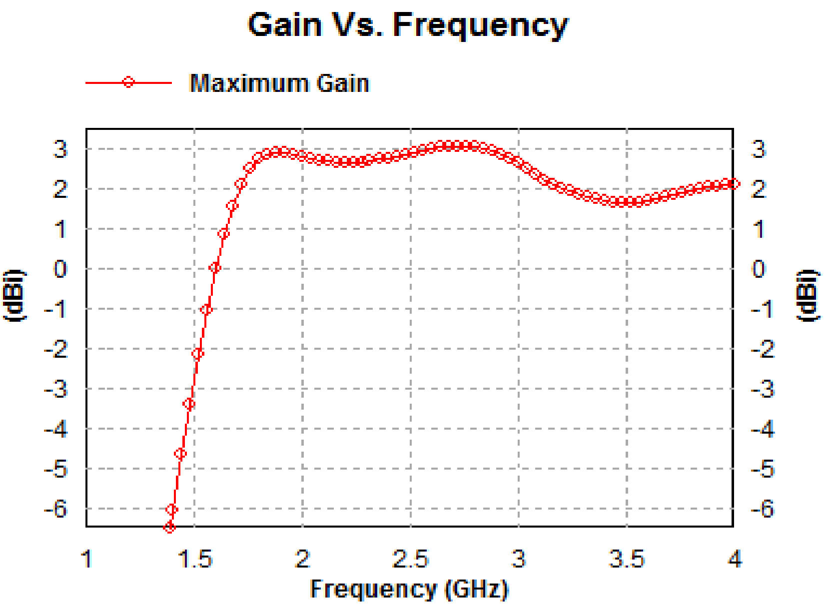
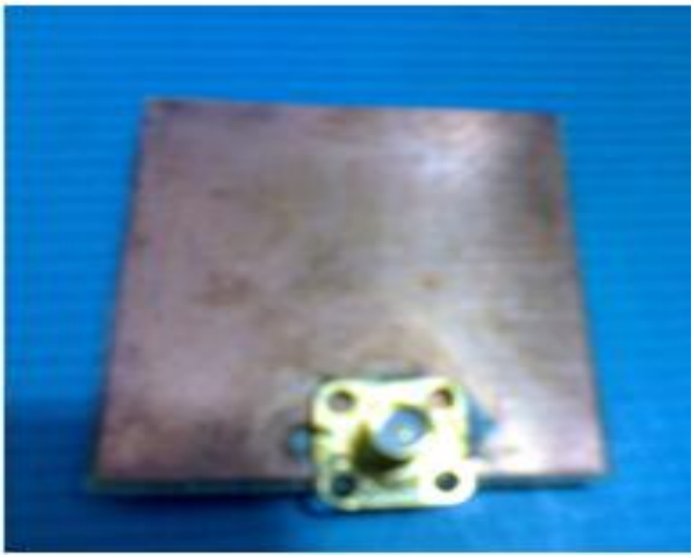


Fig.8. Gain of proposed antenna

(a) Top view of fabricated fractal antenna



(b) Bottom view of fabricated fractal antenna

Fig 9 Fabricated fractal antenna

5. CONCLUSION

Size reduction of the antenna is achieved. The characteristics of proposed antenna are studied. Proposed antenna improved the fractional bandwidth upto 47.97%. The proposed antenna has been designed on glass epoxy substrate to give a maximum radiation efficiency of about 94.98%, gain of about 2.88dBi and directivity of 3.12dBi.The proposed antenna is suitable for WLAN, WiMAX and Bluetooth applications.

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