Design of Circular Fractal Antenna for Dual band and UWB Applications

S. Alekhya[1] B. Rama Rao[2] Dr. P. V. Sridevi[3]

Abstract—In this paper, the design of Crown circular shaped Fractal Microstrip patch antenna is presented. The two iterative Circular fractal antenna have been designed and simulated with Ansoft HFSS and fabricated on FR4 substrate with dielectric constant of (ε_r) 4.4) with different configurations of ground planes at the bottom of the substrate. The proposed antenna (without ground) offers excellent ultra wideband performance ranging from 3.80 GHz to 12.8 GHz. The antenna

exhibits bandwidth of 9 GHz. The experimental radiation pattern of Crown fractal antenna has been observed nearly Omni-directional. This antenna can be used for dual band and UWB applications

Index Terms- Microstrip patch antenna, Crown fractal antenna, Ultra-wideband,HFSS.

I.INTRODUCTION

Microstrip patch fractal antennas have been rapidly developed for multi-band and broad band in high data rate systems known as wideband communication systems. The use of microstrip fractal geometry antennas in electromagnetic radiations has been a recent topic of interest in the world. It has been shown that fractal shaped antennas exhibit features that are directly associated with the geometric properties of fractals.In modern communication world microstrip patch antenna is basic and widely used antenna in mobile, avionics, radar applications as it is low profile antenna and can be integrated easily with other RF front-end circuits. However low bandwidth is major drawback of microstrip patch antenna. To overcome this, dual band, multi band and ultra wide band (UWB) are being designed by changing parameters (shapes) of basic antenna.

As the performances of microstrip patch antenna with basic geometric shapes have been studied during 19th century, fractal antennas have drawn special interest in microwave engineering since a century. “A fractal is a rough or fragmented geometric shape that can be split into parts, each of which is a reduced-size copy of the whole." The term is coined by B.B. Mandelbrot in 1975 and was derived from the Latin word fractus, meaning "broken" or "fractured."[1] There various types of fractal antennas includes (1) the von Koch curve, (2) the Sierpinski (gasket and carpet) and (3) the fractal tree. The proposed antenna structure comes under Sierpinski Gasket as its structure is repeated again and again [7][6]. In 2002 bandwidth of ultra-wideband (UWB) radio system approved by Federal Communications Commission is 3-10.8 GHz [2].Fractal geometries have two common properties, space-filling and self-similarity [5][1]. It is self similar in a way that structure of antenna is repeated indefinite form so as to produce similar surface current distributions for different frequencies, i.e. to produce multiband response. The space filling property leads to an increase of the electrical length and hence the physical size of the whole structure can be reduced. In the present work, a simple structure of printed Triangular crown fractal antennas has been simulated and also fabricated and tested .

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II. GEOMETRY OF CROWN FRACTAL ANTENNA

Figure 1 shows the geometry of the proposed antenna. The exact dimensions for the proposed antenna are also given in Table 1.The antenna is built over a 100x106 mm FR4 substrate with dielectric constant (ε_r) 4.4, thickness 1.6 mm. The upper plane (radiating element) is an equilateral triangular slot of side 71.016 mm on solid circle of 82 mm diameter, by repeated stages of subtracting triangles with sides half the size of the former triangles from corresponding circles with diameter half of their former retaining their centre of geometry the proposed antenna is generated at the fourth stage. The feed of antenna is 2.2 mm wide and 15 mm long. The space between ground and feed is 0.25 mm. A Coplanar Waveguide fed technique is used in this design The advantage of CPW fed is that both radiating element and ground plane is on the same side of path[3][1]. However to achieve dual band response through this design ground plane is also placed on the bottom of the patch of size 50x53 mm (half the size of substrate).

As the shape antenna is fractal triangular slot over circle it is named as crown circular microstrip fractal antenna in the literature [6]. Basically it is designed for UWB applications, but the analysis of the proposed antenna reports the performance of this UWB antenna into dual band antenna by placing a shorted half ground plane on the bottom of the substrate which was absent on actual crown circular microstrip fractal antenna design[7].

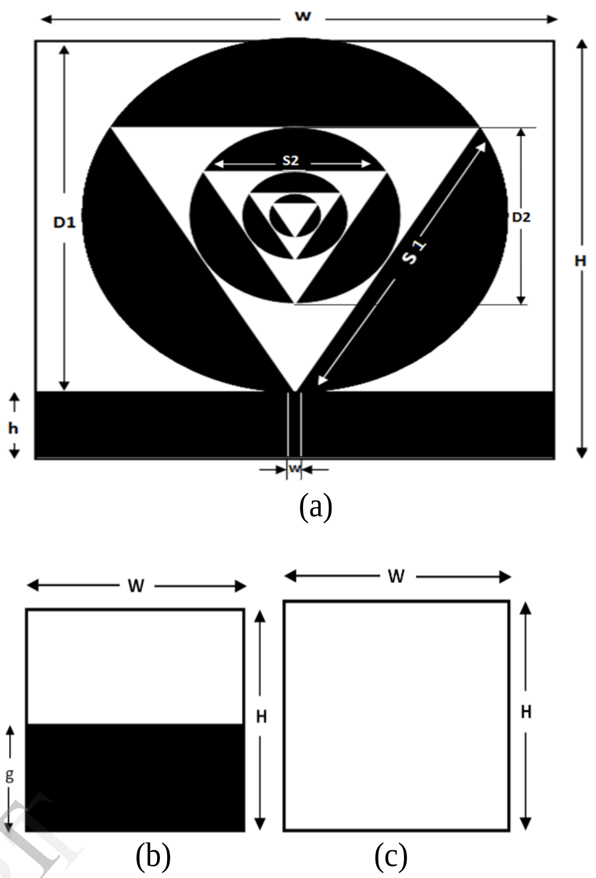


Figure 1. (a) Front view of dual band and UWB Antenna.
(b)back view of dual band antenna.
(c) Back view of UWB antenna (no ground)

Sl.No	Parameter	Length (mm)
1.	H	106
2.	W	100
3.	h	15
4.	w	2.2
5.	D1	82
6.	D2	41
7.	D3	20.5
8.	D4	10.25
9.	S1	71.016
10.	S2	35.508
11.	S3	17.754
12.	S4	8.877
13.	g	53

Table 1: Values of various Parameters used for the design.

III. DUAL BAND ANTENNA DESIGN

The design expression of simple circular microstrip antenna for calculating the resonant frequency is given as [4]

$$f_r = \frac{1.841 v_o}{2\Pi r_{eff}\sqrt{\epsilon_{eff}}} \qquad (1)$$

Where v_o is the velocity of light. The effective radius r_{eff} can be calculated by following expression [4]

$$r_{eff} = r_o\left[1 + \frac{2h}{\Pi r_o \epsilon_{eff}}\left\{\ln\left(\frac{r_o}{2h}\right) + (1.41\epsilon_r + 1.77) + \frac{h}{r_o}(0.268\epsilon_{eff} + 1.65)\right\}\right]^{1/2} \qquad (2)$$

IV. SIMULATION

Simulation of both the designs is done over High Frequency Structure Simulator (HFSS) version 13. The simulated results for various parameters like return loss, radiation pattern, gain etc., have been obtained from this software. Table 5.2 shows the various parameters used in the designing of dual band fractal circular patch antenna.

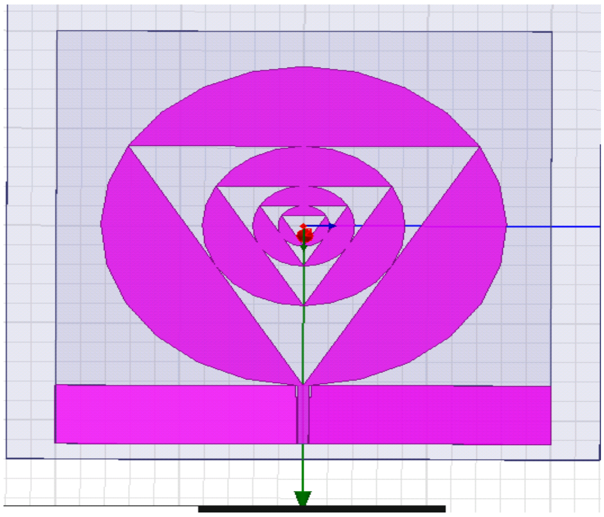


Figure 2. HFSS model of the proposed Crown fractal antenna

The most serious problem for UWB application is interference. Rejection of interference is necessary for UWB applications with existing wireless technologies such as IEEE 802.11a in USA (5.15-5.35 GHz, 5.725-5.825 GHz) [4]. A band stop filter can be used but the use of filter would make the system complex. Many UWB antennas have been designed to overcome this interference problem. However for better selectivity of frequency of operation, antennas with narrow bandwidth are used. Here comes the importance of antenna radiating only for certain frequencies like dual band and triple band antenna. Both the antennas, UWB and dual band antennas are fabricated using etching process and 50Ω ports are soldered at the end of the feed point.

V. RESULTS AND COMPARISONS

The performance of fabricated antenna is tested using 2-port vector network analyzer, Agilent E507C1. The figure 4 shows the experimental setup used to measure return loss, VSWR and smith chart etc through network analyzer.

Figure 3. Fabricated UWB crown fractal antenna

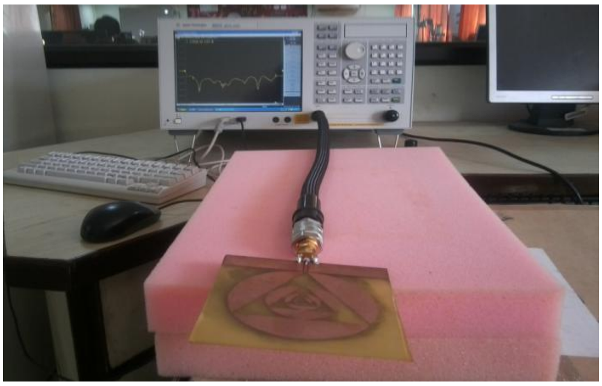


Figure.4 Experimental setup for measuring the various parameters of Crown fractal antenna

The simulated and practically tested results of crown antenna with no ground plane at the bottom are compared in figure 7. The antenna resonates for the entire band of 3.8-12.5 GHz covering entire commercial UWB band approved by FCC.

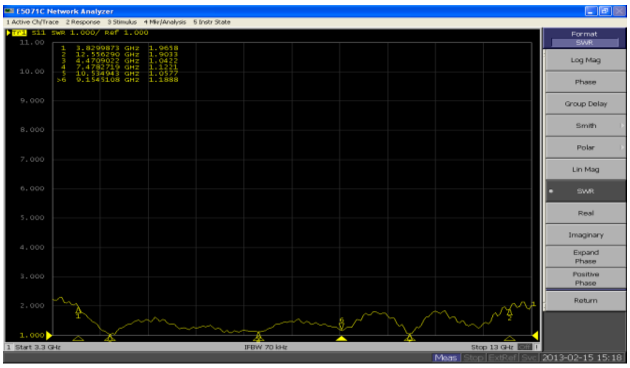


Figure 5. VSWR curve of antenna with half ground measured By Vector network Analyzer

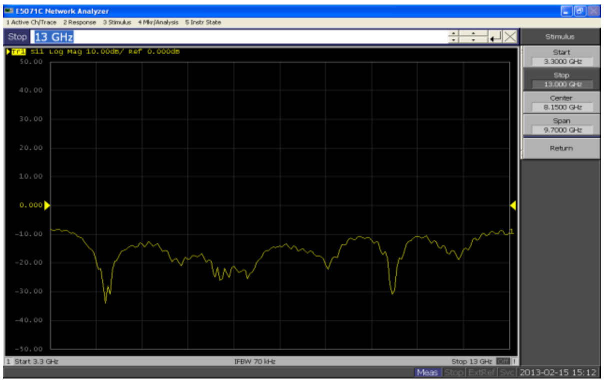
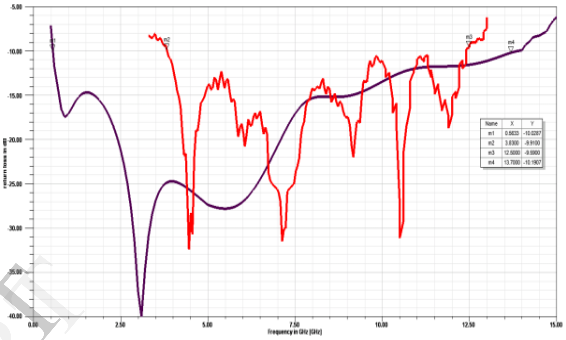


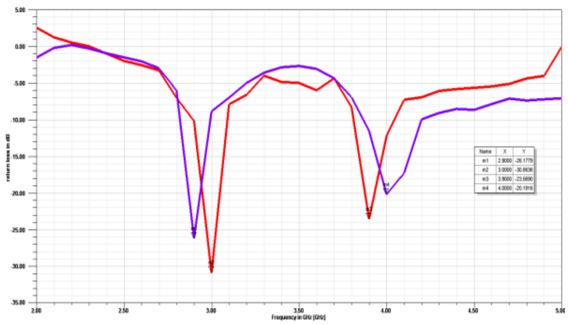
Figure 6. Measured Return loss curves of crown antenna by Vector network Analyzer



Measured result simulated result

Figure 7. Measured and simulated Rreturn loss curves of crown antenna without ground

The crown antenna with half ground at the bottom resonates at two frequencies 3, 3.9 GHz as shown in fig 7. Thus, it can be used for dual band applications.



Measured result simulated result

Figure 8.VSWR curve for UWB antenna Simulated measured By Vector network Analyzer

VI. CONCLUSION

A novel 3.8 GHz -12.8 GHz Crown fractal microstrip antenna with excellent very wide band performance has been successfully simulated fabricated and tested. The Crown Fractal antenna with CPW-fed offer larger bandwidth has been investigated. The simulated bandwidth of the proposed antenna is from 2.8 to 12.5GHz for VSWR <2 which covers the commercial UWB band approved by the FCC. Radiation patterns of these antennas are Omni-directional in the H-plane and bidirectional in E-plane. These properties of the antennas make it a suitable for modern UWB applications. The antenna is compact, simple to design and easy to fabricate and applicable in wide band communication systems

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Author Description:

S.Alekhaya completed her B.Tech in the year 2010 Now she is pursuing M.Tech ,AITAM , Tekkali

B.Rama Rao completed his B.E. and Master of Technology in the stream of Radar and microwave Engineering in the year of 1998,2004 respectively Now, he is working as Assoc. Professor in Aditya Institute of Technology And Management, Tekkali, India. He is pursuing his Ph. D in the area of Fractal Antenna. He is the Life member of IETE ,ISTE His area of interests are Antenna and propagation ,Microwave and Radars .

Dr. P. V. Sridevi completed her Master of Engineering in the stream of applied electronics from PSG college of Engineering in the year of 1988 and Ph.D in the area of Antennas and Microwave communications from Andhra University, Visakhapatnam Now, she is working as Professor in A U College of Engineering (A) Andhra University Visakhapatnam, India.