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Dual band Omni-Directional Fractal Boundary Micro-Strip Antenna

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Abstract- **Compact fractal boundary dual band Omni-directional antenna is proposed for circular polarization (CP). Total four antennas were proposed by taking different fractal curves as the sides of a square patch. Optimization of indentation parameter is done to design the compact dual band antennas. The proposed antenna works at dual band of operating frequencies at 5.4 GHz and 8 GHz. Results show that an excellent CP is attained with dual band characteristics utilising a single probe feed, besides diminution in the antenna size by applying fractal boundary concept.**

Index Terms— **Fractal, single-probe feed, dual-band, circular polarization.**

I. INTRODUCTION

Micro strip Patch antennas become the core of investigation for wireless applications as it provides less complexity, light weight and occupies less space on the wireless boards. Also they can exhibit both linear and circular polarization with different feed techniques. Despite these advantages it works only for narrow band of desired frequency. Hence in order to enable the patch antenna to work for multiband or dual band, Fractal geometry would be the better solution. Fractal geometry on the antenna miniaturizes the size of the antenna and also it makes the antenna to resonate for multiband. Hence we can use one antenna instead of many for most applications.

In 1996 Iwasaki proposed an antenna which is a circular patch embedded with a cross shaped slot at the centre of it [1]. Asymmetrical U-slot is made for CP operation [2]. In 2002 Gianvittorio have studied the result of increase in the number of iterations on the number of resonance frequencies [3]. In 2004, Vinoy expounded that the dimension of the fractal geometry changes the resonance frequencies [4]. Based on the slot loaded techniques, several single layer single feed asymmetrical structures are advised for CP operation [5]. Using fractal geometries several antennas were proposed for multi band applications [6]. Fractal antennas have many desired characteristics such as compact size, broad band, less prone to breakage. Fractals are classified into different types based upon their geometry. If iterations are taken as parameter then they are classified as linear, non-linear and random fractals. If indentation factor is taken as parameter they are classified into mass and boundary fractals. In order to eliminate the misalignment between the transmitter and receiver circularly polarized antennas became the core area for recent developments. The traditional approach to achieve the CP is to feed two orthogonal signals of equal amplitude and which are orthogonal to each other to the radiating and non-radiating edges of the patch antenna. Even though it offers high bandwidth and good axial ratio, the dual feed technique requires lot of board space. Hence single-probe feed is paid much attention in recent years. In this paper, a novel compact circularly polarized dual-band antenna for military applications is proposed by making fractal curves on the boundaries of a square patch.

II. PROPOSED ANTENNA GEOMETRY DESIGN

Fractal curves are made by taking two parameters: Iteration Order (IO) and Indentation Factor (IF). Here, Indentation Radius (IR) is taken as IF for the proposed design. The geometry of proposed antenna is shown in the Fig. 1. The specifications of the antenna are as follows: The length of patch (L) is 36mm; The thickness (h) of the substrate is 3.2 mm; Relative permittivity (ε_r) is 2.2; Loss tangent is 0.0019; and R_x , R_y are the IRs along x-axis and y-axis respectively and R_z is the IR at the corners of the patch. P_x and P_y are the radii of the hexagons at the centre and corners of the patch respectively.

The pre fractal hexa-circles are deployed to achieve circular polarization. The sides of the patch are replaced with eight fractal curves of which four are at the corners of

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the patch and four are at the middle of the patch for CP realization. With the use of these fractals as edges of the square patch, we can achieve two orthogonal signals with phase shift as 90^0 for CP. The IFs of fractals are used to minimize the antenna size and to enhance the impedance bandwidth. The proposed antenna design is shown in the Fig.1 (a). The four antennas proposed are dual band antennas which are circularly polarized and Omni-directional antennas. Dimensions of Antenna are defined in the Table-1. F indicates the position of the feed along the diagonal of the square patch.

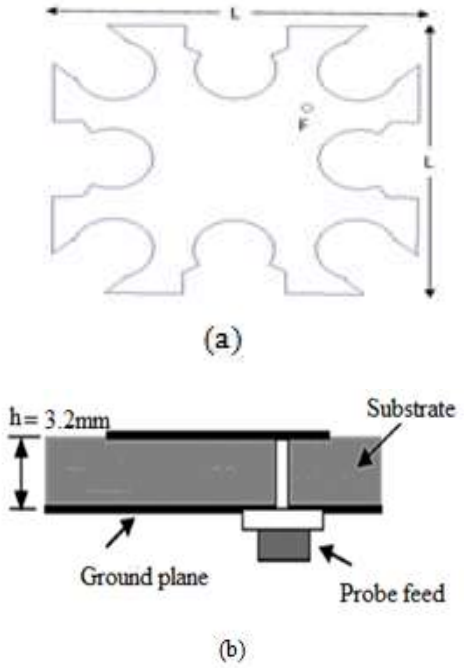


Fig.1. (a) Proposed Antenna (b) Feed Position.

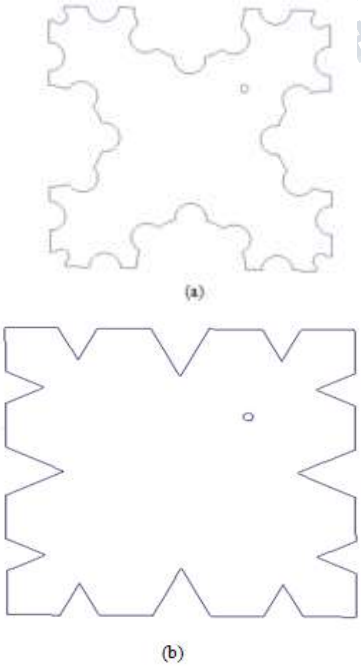
The coaxial line feed is given along the diagonal of the square patch. Both left-hand and right- hand CP can be achieved by shifting the feed point on the diagonal axis. Side length of the original patch is taken as 36mm and the feed position is taken along the diagonal of the patch for optimization. Co-axial feed is used so that it would occupy less board space. R_x, Ry, Rz are changed and parametric analysis is done and P_x, P_y are kept not equal for best results. By changing the dimensions of these Antenna parameters the properties are changed.

Table 1: The parameters of Designed Antenna

Parameter	Dimension
L	36 mm
P_x	5.8 mm
P_y	4.2 mm
R_x,R_y,R_z	4 mm
F	(7mm,7mm)

We have tried by making different fractal curves and obtained dual band characteristics. For different fractal curves we have taken different IFs such that the desired characteristics are obtained.

All the four antennas that are designed shown in Fig. 2. are circularly polarized. In Antenna 1 the fractal curves are made using circles at the centre along side of the patch a large circular curve is made and then the small circular curves are made on that curve.



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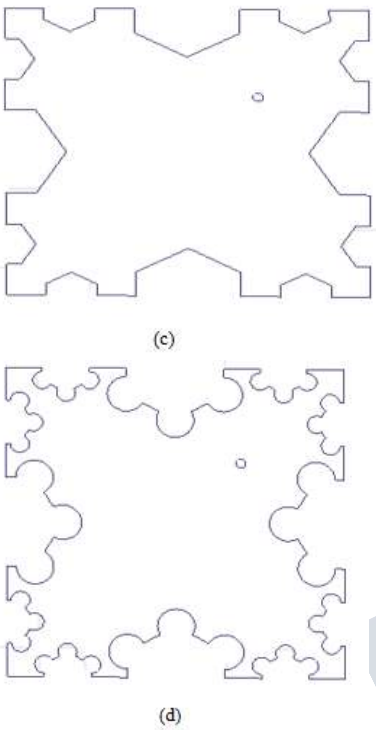

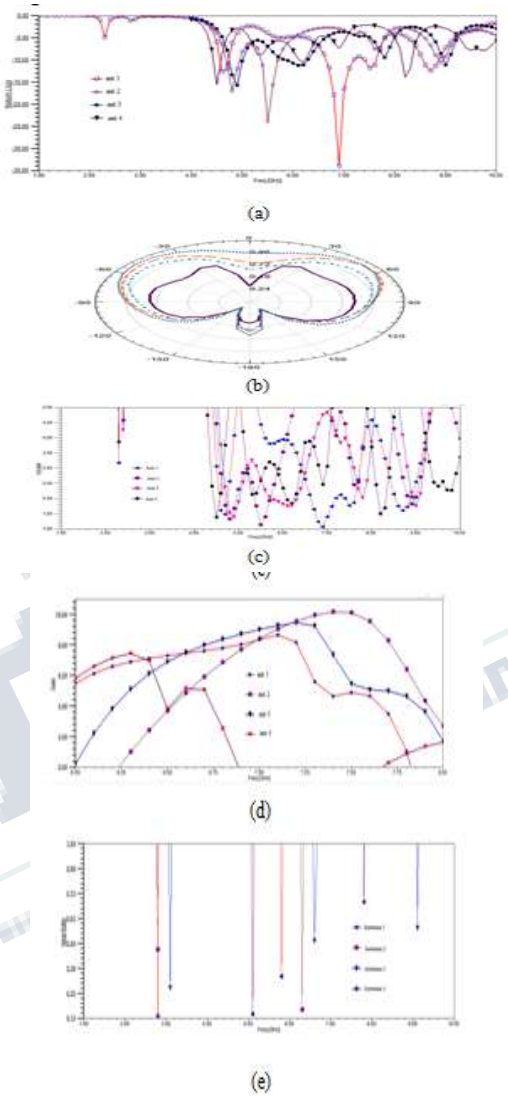

Fig.2.Design patterns (a) Antenna 1 (b) Antenna 2 (c) Antenna 3 (d) Antenna 4

The second iteration of Koch curve fractal geometry is made on the Antenna 2. The hexagonal curves are made along the sides of the patch on Antenna 3. By taking the corners of the hexagon as the centre circular curves are made in the Antenna 4. The radiation and gain characteristics of the antenna depend mainly on the fractal geometry of the antenna. Antenna 1 and Antenna 3 showed the better features than the other antennas. Hence we have combined the geometry of these two antennas and designed a novel shape antenna. It is showing better characteristics in two bands of frequencies.

III. SIMULATION RESULTS

To know the performance of the antennas the antenna parameters such as Return Loss, Radiation Pattern, VSWR, Gain of the four designed antennas are simulated using HFSS software. The simulated results of the Antennas are shown in Fig.3.

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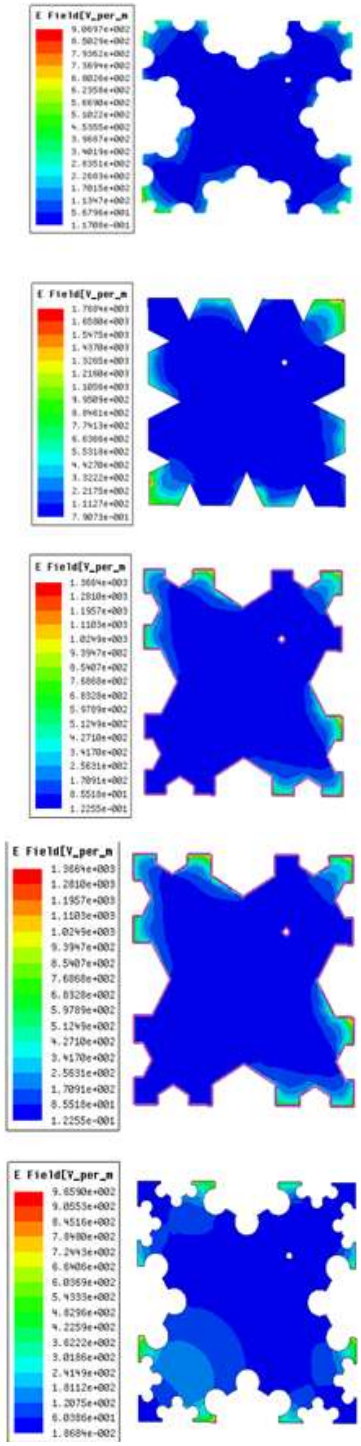

Fig.4. E Field Distribution of the Four Designed Antennas

To know the H Field distribution of the four designed antennas, the H field is plotted on the surface of the antennas using HFSS software. Fig.5 shows the H Field distribution of the four designed Antennas.

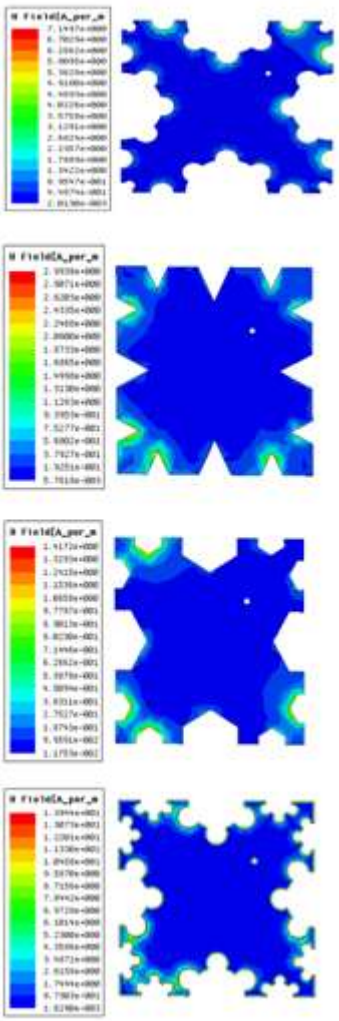

Fig.5. H Field Distribution of the Four Designed Antennas

To know the current distribution of the four designed antennas the J field is plotted on the surface of the antennas using HFSS software. Fig. 6 shows the current distribution of the four designed Antennas.

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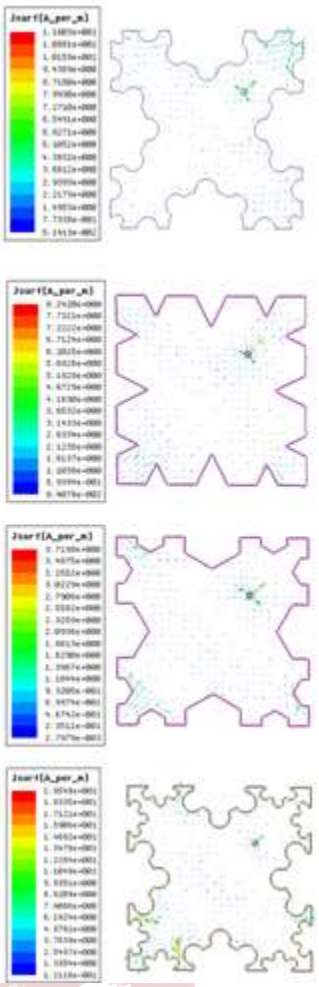
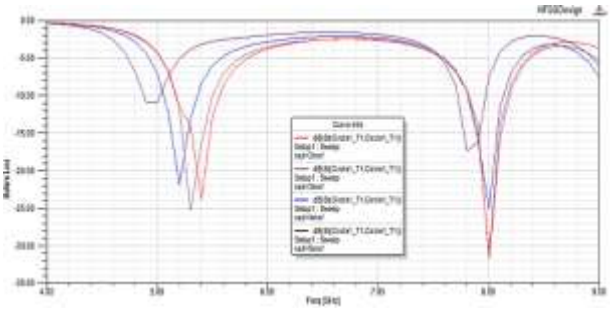
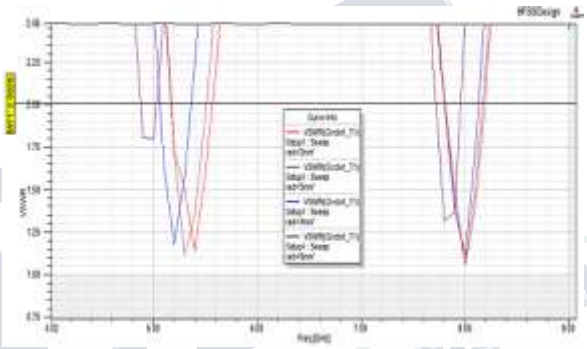




(a)



(b)

Fig.6. J Field Distribution of the Four Designed Antennas

Table 2: Summarized Results of the Four Designed Antennas

By observing the simulated results of the antennas it is clear that the antenna characteristics are better for Antenna 1 and Antenna 3. Hence the two fractal curves are combined and a new design is proposed. The antenna parameters of the new antenna are presented in Fig.7.

Antenna	Operating Frequency (GHz) F1	F2	Return Loss R1	R2	VSWR V1	V2
1	4.6	6.9	-12.66	-33.9	1.6	1.2
2	5.5	4.8	-19.12	-15.6	1.2	1.4
3	4.8	8.9	-13.77	-10.1	1.5	1.9
4	8.3	4.6	-15.08	-12.5	1.4	1.6

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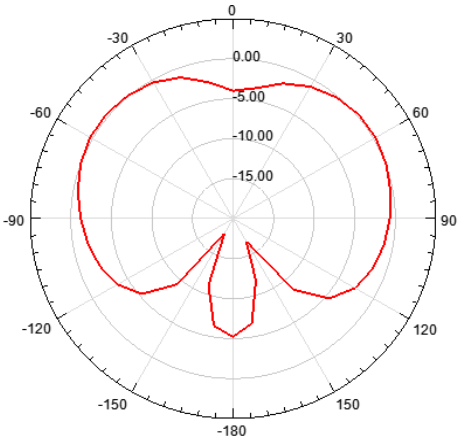
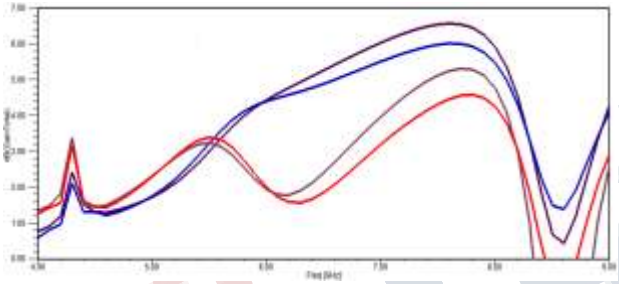


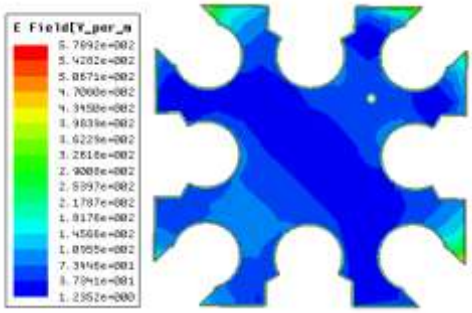
(c)



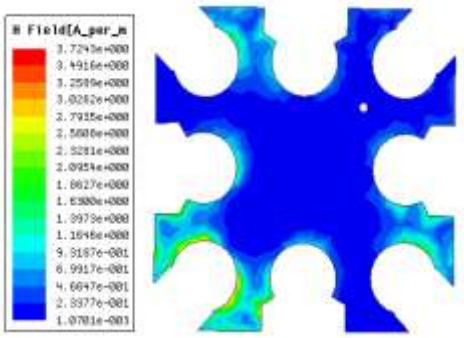
(d)

Fig.7. (a) Return loss (b) VSWR (c) Radiation Pattern (d) Gain of the proposed antenna

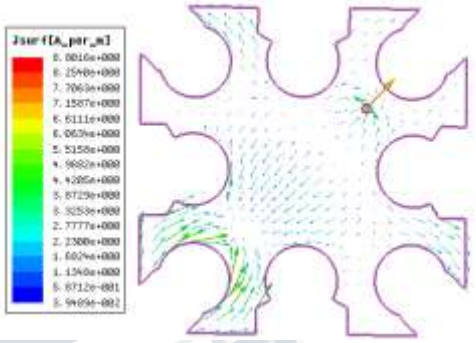
Table 2 shows the summarized results of the four designed antennas. To know the field patterns of the proposed design, the field distribution of the antenna is plotted with HFSS software. Fig.8 shows the E, H and J field distributions on the surface of the proposed antenna.



(a)



(b)



(c)

Fig.8. (a) E Field (b) H Field (c) J Field distributions of the Proposed Antenna

Table 3: Summarized Results of the Proposed Antenna

Radius (mm)	Operating Frequency (GHz)		Return Loss		VSWR	
	F1	F2	R1	R2	V1	V2
2	5.4	8	-23.7	-31.2	1.13	1.04
3	5.3	8	-25.2	-31.8	1.11	1.04
4	5.2	8	-21.8	-25.1	1.17	1.11
5	5	7.8	-10.8	-17.3	1.79	1.3

IV. MEASURED RESULTS AND DISCUSSIONS

The summarized results of the proposed antenna are mentioned in Table3.To validate the hypothesis made pertaining to the antenna proposed experimentally, the proposed antenna is fabricated and tested. The proposed antenna is printed on Rogers RT/Duroid 5880 substrate of

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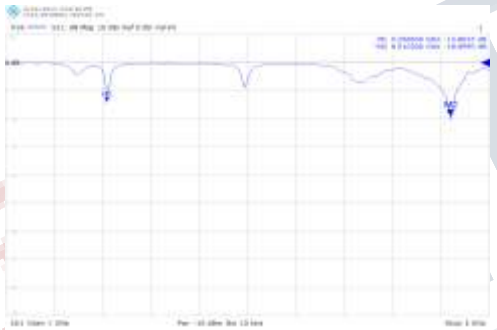
thickness 1.6 mm, and the size of the ground plane is 42 X 42 mm^2.

The evaluation between the simulated and the fabricated results is done and the deviation is due to tolerance levels during the fabrication process of the antenna. The designed antenna worked accurately in the two bands of frequency and shown high gain.

(a)



(b)

(c)

Fig.9. (a) Fabricated Design (b) Return Loss (c) VSWR of the Fabricated Design

V CONCLUSION

A novel design to generate circular polarization and having dual band characteristics is presented. By making fractal curves on the edges of the square patch, a compact dual-band Omni-directional antenna for CP operation is designed. By changing the IRs of the fractal curves we can change the operating frequency and antenna parameters.

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