# GROUNDED COPLANAR WAVEGUIDE FED ULTRA WIDEBAND FRACTAL MONOPOLE ANTENNA

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*Abstract*— in this paper a compact and super wideband grounded coplanar waveguide (GCPW) fed fractal monopole antenna is presented. Antenna size is significantly reduced as compared to the simple polygonal antenna and size of proposed antenna is 25×30×1.524 mm3. The octagonal fractal antenna is fabricated on Rogers RO4003C with εr=3.38. The base structure of antenna is consist of an octagonal that a circle is cut from it. Five iterations of base shape are performed. Overall fractal geometry appears as a central octagonal array surrounded by concentric scaled octagonal arrays. 50 GCPW structure is used for feeding. Antenna is analyzed over 2-12GHz frequency range. S11, gain plots and radiation patterns comparison is made in this work. The antenna shows better than 13 dB return loss and peak gain 5±2 dB over FCC UWB from 3.1 to 10.6 GHz.

*Key words —Grounded Coplanar waveguide, fractal, octagonal, monopole, UWB.*

## I. INTRODUCTION

Ultra wideband technology (UWB) [1] has posed new challenges in designing wideband antennas. Since the Federal Communications Commission (FCC) in 2002 approved the commercial use of frequency bands from 3.1 to 10.6 GHz for ultra-wideband systems, UWB antennas received more and more attention with the advancement of communication technology [2-4]. Ultra Wide Band is fast becoming a popular and widely used radio platform for commercial Wireless Personal Area Networks (WPAN) and other wireless technologies. There is a growing demand for UWB radio components, in-clouding the antenna, which has to be broadband (over 100 percent of its bandwidth), omnidirectional, compact, and easy to fabricate. On the other hand, fractal geometry allows the antenna to be low profile, compact and broadband. Fractal antennas have space filling and self-similarity characteristics [5-6] which offer miniaturization and ultra-wide bandwidth. Electrically long curves fit into a very small space owing to space filling nature

of fractals. Several fractal geometries have been discussed in the literature like Koch, Minkowski, Sierpinski, Hilbert and Fractal tree. The concept behind the jagged shapes of fractals is that the discontinuities increase band-width and effective radiation. Monopole antennas have a variety of wireless applications due to Omni directional radiation pattern and simple structure. The requirements of ultra-wideband applications include sufficiently high bandwidths of 100% or even more.

The use of grounded coplanar waveguide (GCPW) to feed printed antennas offers many advantages over conventional microstrip feed lines. GCPW has lower dispersion characteristics at higher frequencies and a broader impedance bandwidth than microstrip lines [6]. In this paper with combination of a fractal antenna and a GCPW provided an antenna for UWB applications. At follow the structure and result of proposed antenna will discussed.

## II. ANTENNA DESIGN AND FABRICATION

Antenna is designed and fabricated on substrate of Rogers RO4003 with εr =3.38 and thickness 1.524mm. The area of substrate is 25×30mm². In order to obtain optimum impedance bandwidth, a parametric analysis is done by some variations on the gap, port size, center conductor width and the size of ground planes width. Simple CPW is used for fractal antenna feeding which gives ultra-wideband behavior. To provide 50 impedance is used of the GCPW with the width is 2mm and the gap is 0.5mm. GCPW gap for feeding. The Length of GCPW structure is 10.5mm.

The proposed fractal geometry is obtained by reproduction of base shape in five steps (Five regular octagon and five circle nesting). The final structure is composed of concentric scaled heptagonal arrays. Integration of fractal monopole antenna with GCPW feed is expected to show wideband impedance matching and Omni directional radiation pattern. The final structure of antenna consists of five octagon monopoles and five circles nesting by stepped CPW line on one side of a substrate and

stepped the other side of substrate ground planes. Five iterative versions of fractal antennas with edge dimensions and inner radii are shown in Fig. 1. The length of ground planes are Lg1=9 mm, $L_{g2}$=5mm, width of $W_{g1}$=25mm and $W_{g2}$=11mm. The impedance characteristics of a GCPW is dependent on the feed line and gap widths and can be calculated through the design formula for GCPW feed line [7]. In our calculations the feed line width Wf is kept the same and the gap width g is changed to obtain the characteristic impedance of 50 . The default size values of this antenna are shown in Table. 1. Fig. 2. Shows the front and back sides of the actual fabricated antenna.

## III. RESULTS AND DISCUSSION

Fig. 3. Shows port characteristic impedance in the 2-12GHz frequency range. From figure, as expected for a GCPW structure, the impedance characteristics stays nearly constant in the wide frequency range. Analysis of antenna is performed over 2-12GHz frequency range. High bandwidth can be seen in return loss plots using S11 < -10dB criteria. In order to show how the fractal geometry improves the performance of antenna, we study the $S_{11}$ and gain characteristics for the structures of Fig. 1. Fig. 3. Shows the return loss plots of four monopole antennas in dB The criteria for high bandwidth is the range of $S_{11}$ < -10dB. From the figure, as the fractal grows up, the $S_{11}$ considerably improves. The reason arises from the fact however all the four antennas are ultra-wideband as shown in Fig. 4.

The measured and simulated return loss characteristic of the proposed antenna are shown in Fig. 4. The experimental results confirm wideband operation of the antenna in the range of 3-15 GHz. Detailed measurement results are also shown in Fig. 4 for return loss of antenna in the 3-15GHz frequency range.

Fig. 5 shows peak gain characteristics for fractal antennas of Fig.1. However the peak gain is approximately constant with 5±2 dB variations within 3-15 GHz range. The E-plane and H-plane radiation patterns for this antenna are presented in Fig. 5.
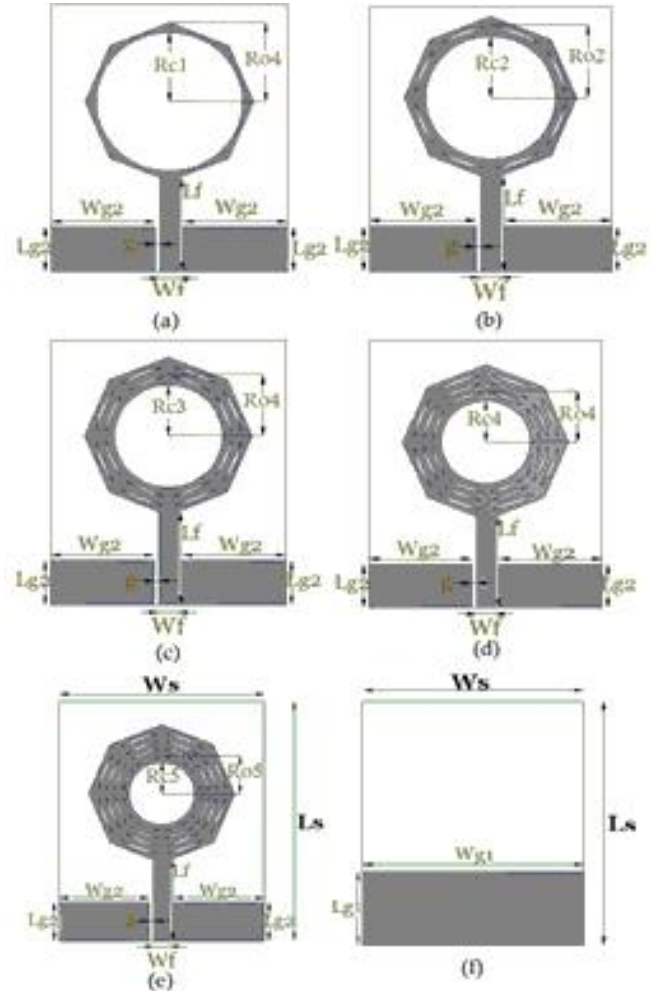


**Fig. 1**. Structure of the fabricated antenna and Geometries of the GCPW-fed ultra-wideband fractal antennas (black: copper; white: substrate): (a) the original structure, (b) the first order iteration, (c) the Third order iteration, (d) the Fourth order iteration, (e) the Fifth order iteration, (f) Behind substrate ground planes.
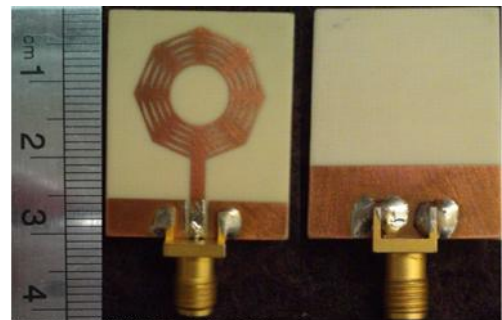


Fig. 2. Prototype of the fabricated antenna.

TABLE I
Optimized Dimensions of the Antenna

| Parameter | | Label | Dimension(mm) |
|---|---|---|---|
| Patch | Radius octagon 1 | Ro1 | 8.9 |
| | Radius Circle1 | Rc1 | 7.75 |
| | Radius octagon 2 | Ro2 | 8 |
| | Radius Circle2 | Rc2 | 6.9 |
| | Radius octagon 3 | Ro3 | 7.1 |
| | Radius Circle3 | Rc3 | 5.9 |
| | Radius octagon 4 | Ro4 | 6.05 |
| | Radius Circle4 | Rc4 | 5 |
| | Radius octagon 5 | Ro5 | 5.1 |
| | Radius Circle5 | Rc5 | 3.9 |
| Feedline | Width | Wf | 2 |
| | Length | Lf | 10.5 |
| Gap | Width | g | 0.5 |
| Ground | Width 1 | Wg1 | 25 |
| | Length 1 | Lg1 | 9 |
| | Width 2 | Wg2 | 5 |
| | Length 2 | Lg2 | 11 |
| Substrate Roger RO4003c (tm) | Width | Ws | 25 |
| | Length | Ls | 30 |
| | Thickness | h | 1.524 |
| | Dielectric constant | $\varepsilon_r$ | 3.38 |
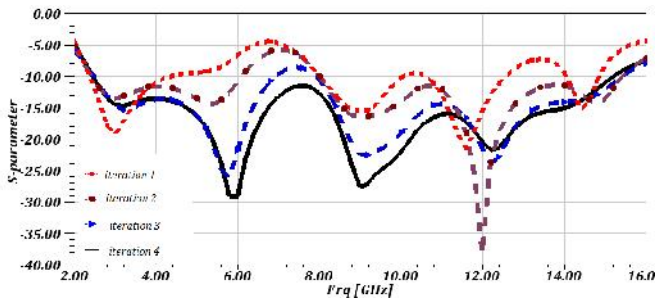


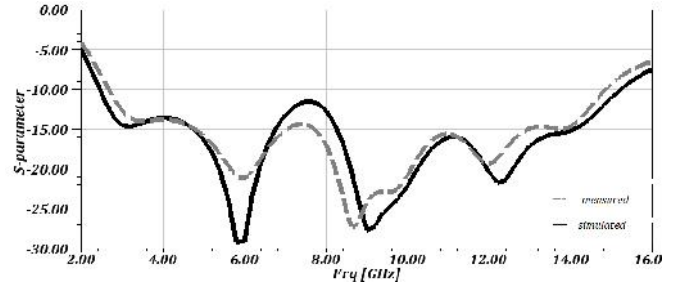Fig. 3. Comparison $S_{11}$ of fractal antennas at 4 step



Fig. 4. Comparison between simulated and measured return loss
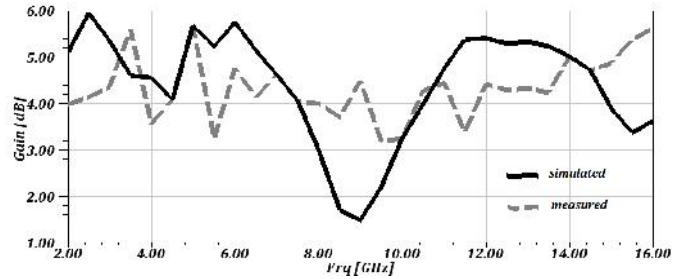


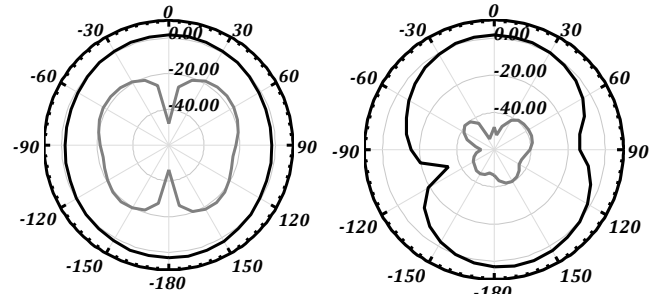Fig. 5. Comparison between simulated and measured gain



Fig. 6 measured pattern of antenna at 9 GHz

## IV. CONCLUSION

A fractal monopole antenna of concentric octagonal arrays is designed. Five iterations of base shape antenna are made. Fractal antennas are ultra wideband due to their self-similarity and space filling nature. GCPW structure is used for feeding. It provides optimum impedance matching over entire frequency range of 2-15GHz. Comparison of gain plots show that five arrays fractal antenna has highest peak gain of 5±2 dB within 3-15 GHz.

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