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CPW-fed Sierpinski Fractal Monopole Antenna with Varying Scale Factor

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Abstract: A novel compact CPW-fed Sierpinski fractal antenna is presented. A Fractal radiating of the Sierpinski Gasket with Varying scale factor $\delta = 1.5$ (for first and second iteration) and $\delta = 2$ (for third iteration). The antenna was designed by changing various triangular widths to accommodate various bands of interest A quasi log periodic performance is achieved for the operating bands of varying scale factor. The antenna is printed on a single layer dielectric substrate and fed by 50 Ω CPW transmission line. Experimental results *i.e.*, Measured & Simulated Antenna Performance and radiation patterns show that there is strong similarity between patterns through four bands. It was specifically stated that these similarities are specifically remarkable at 2.9, 4.5, 6.9 and 13.8 GHz.

Keywords: Sierpinski fractal antenna, Varying scale factor, 50 Ω CPW transmission line

1. INTRODUCTION

The enhanced developments of a various wireless applications have remarkably increases the demand of multiband/wideband antennas with smaller dimensions than conventional ones. This has initiated antenna research in various directions, one of which is by using fractal shaped antenna element [1–2]. The relation between antenna dimensions and wavelength states if antenna size less than $\lambda/2$ then antenna is not efficient radiator due to reduction in radiation resistance, bandwidth and gain. Fractal geometry is a very good solution to this problem. In the recent times, self-similarity and space filling geometrical properties of fractal antennas proved very crucial to meet the requirement of multi-band, wideband and miniaturization in the field of fractals [3–5]. Hence a novel compact and unipolar CPW-fed Sierpinski fractal antenna is designed with varying scale factor.

2. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed CPW-fed monopole antenna. This antenna was printed on a 'GML' substrate with 0.762 mm thickness and relative permittivity $\varepsilon_r = 3.2$. The basis of antenna layout is third iteration of the Sierpinski gasket with scale factor $\delta = 1.5$ (for first and second iteration) and $\delta = 2$ (for third iteration). The 50 Ω CPW transmission line has been designed with metal strip width $w = 1.159$ mm and gap dimension of 0.0967 mm.The length and width of the CPW feeding structure are similar (Fig. 1) to the length and width of the main body of the Sierpinski gasket. The Ring Width s of the Sierpinski Gasket is varied from 0.05 mm to 0.30 mm to get the better result.

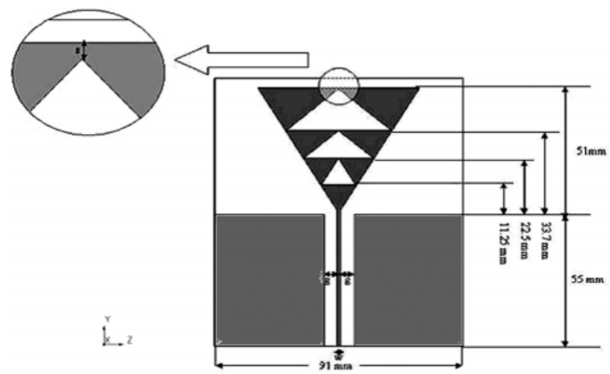


Fig. 1: Geometry of Proposed CPW-fed Third Iteration Sierpinski Monopole with Varying Scale Factor $\delta = 1.5, 1.5, 2$ and Flare Angle $\alpha = 60$ (total size 106 * 91 mm^2).

One of the most interesting properties of the fractal antenna based on the Sierpinski gasket is the opportunity to allocate operating bands by perturbing the shape of the antenna gasket. For example changing the scale factor *d* (perturbing the gasket of the antenna) one can influence the frequency ratio of the multiple bands. This type of structure and many other variations of the Sierpinski gasket were discussed in [3, 4]. All proposed structures [1–4] were mounted over a square conductor ground plane (Fig. 1), the dimensions of which significantly exceeded the dimensions of the radiating structure. Such configuration is heavy 'oversized', one can say uncomfortably so from the point of view of co-operation with a receiver-transmitter output. Recently Song et al. [5] proposed an improved feeding technique based on microstripline structure. As a result the whole antenna structure is planar as well as certain possibilities of input impedance matching appearing.

3. EXPERIMENTAL RESULTS

3.1 Antenna Performance

The $|S_{11}|$ performance (Fig. 3) was measured in 1 to 14 GHz. Frequency range on VNA Network Analyser.The structure was earlier simulated using Micro stripes 7 (Flomerics group PLC). Both results are shown in Fig. 3. The first frequency at 2.9 GHz and second Frequency at 4.5 GHz are giving the 1.55 ratio, for second band it is 1.53 and thereafter we are getting exact ratio 2 (Table 1). The scale factor of first two bands is around 1.5 and of third band are 2, which is in accordance with the conclusions in [6]. More accurate results are obtained by changing the adequate Ring widths of the structure from 0.05 mm to 0.3 mm and it was found that at 0.15 mm, results are better matched with scale factors.

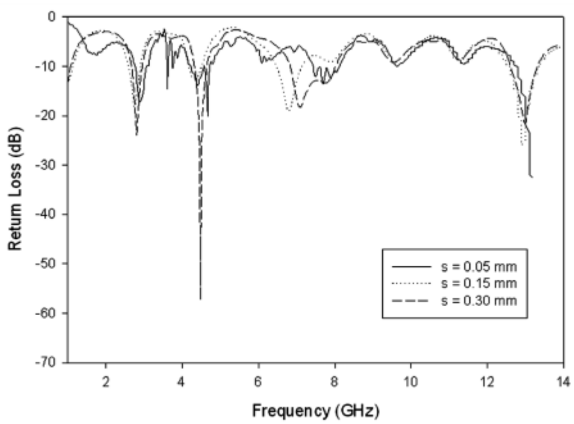


Fig. 2: Simulated $|S_{11}|$ Performance of Proposed Varying Scale-Factor Monopole Structure with Change in Ring Widths

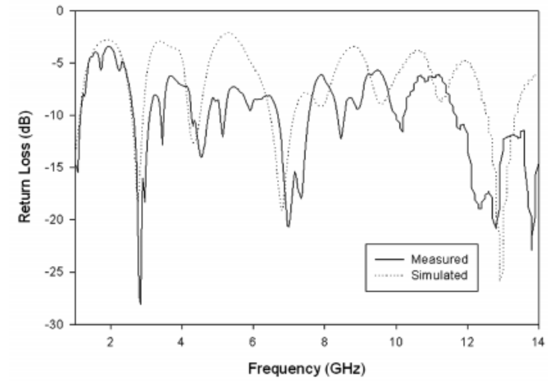


Fig. 3 : Measured $|S_{11}|$ Performance of Proposed Varying Scale-Factor Monopole Structure.

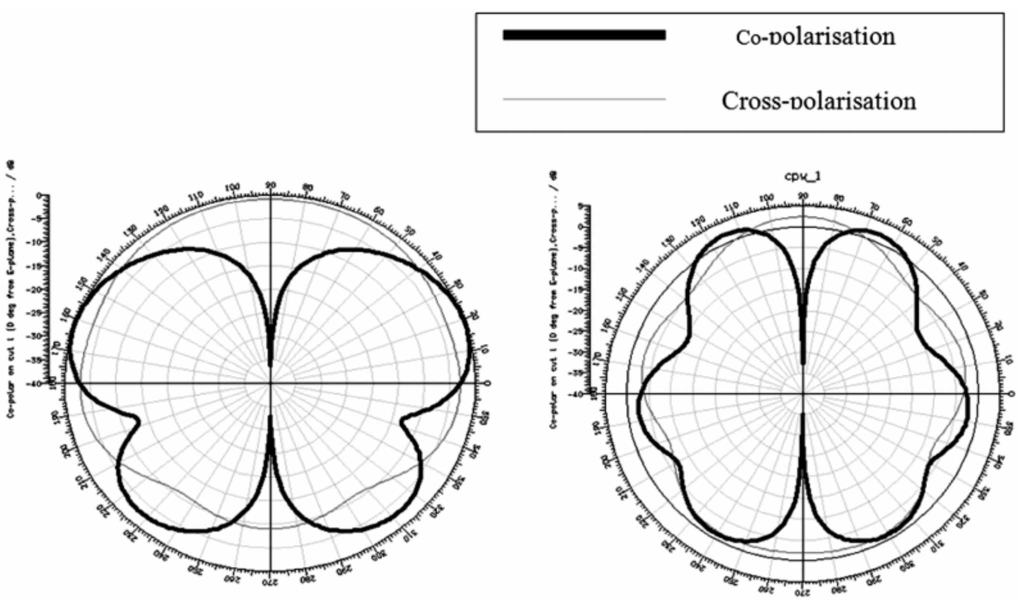
Table 1
Measured Parameters of Proposed Monopole Structure

n band	F_n*(GHz)*	F_{n+1}/F_n
1	2.9	1.55
2	4.5	1.53
3	6.9	2
4	13.825	

3.2 Radiation Pattern

To illustrate the significance of the Sierpinski Gasket's self-similar gap structure on its radiation pattern characteristics, radiation pattern is presented here. It is noted that there is strong similarity between patterns through four bands. It was specifically stated that these similarities are specifically remarkable at 2.9, 4.5, 6.9 and 13.8 GHz. It is very significant to note that these specified frequencies do not correspond to the four operating bands of the Sierpinski Gasket.

0° From E-Plane



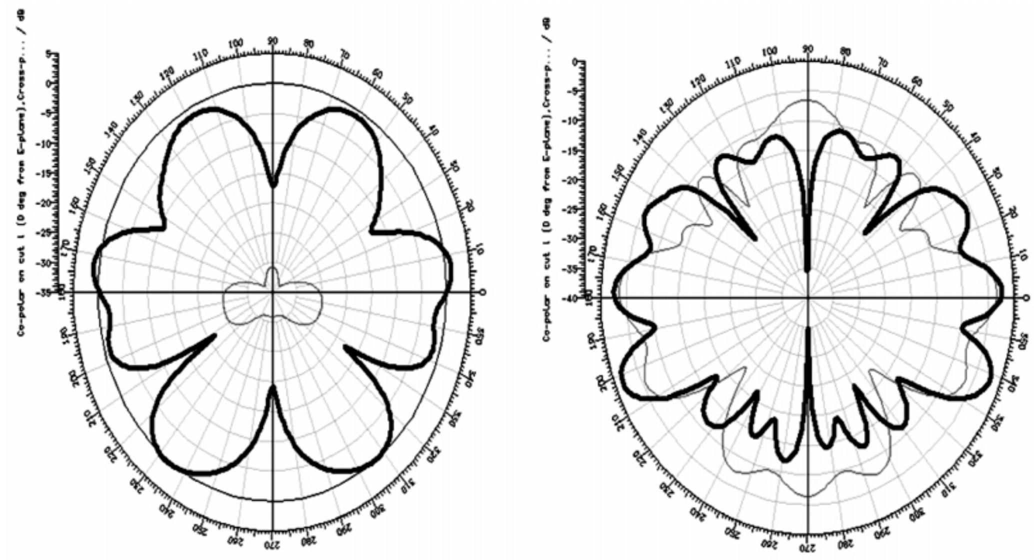


Fig.4: Radiation Pattern of the Sierpinski Monopole Antenna 0° From E-Plane
(From Left to Right f = 2.9 GHz, f = 4.5 GHz, f = 6.9 GHz, f = 13.825 GHz

90° From E-Plane

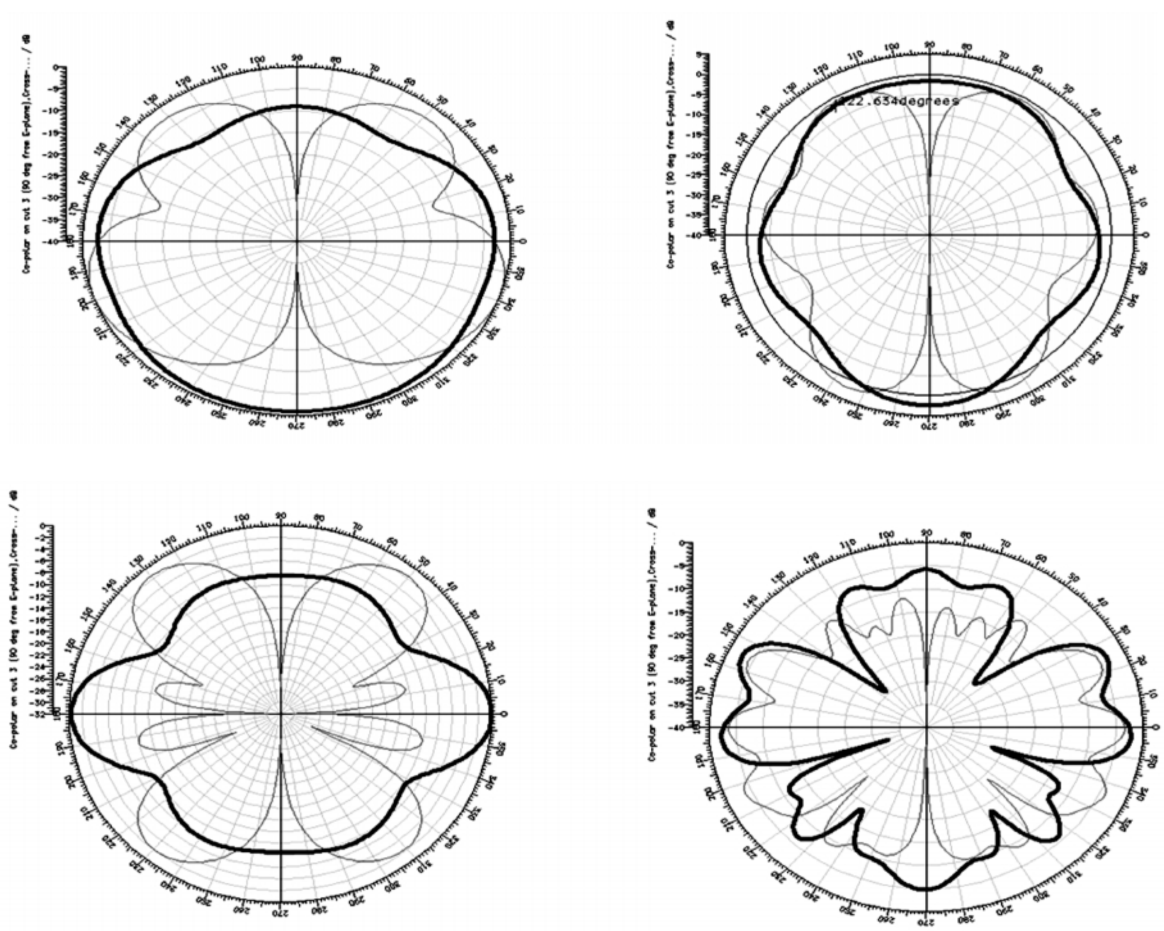


Fig. 5: Radiation Pattern of the Sierpinski Monopole Antenna 90° From E-Plane
(From Left to Right f = 2.9 GHz, f = 4.5 GHz, f = 6.9 GHz, f = 13.825 GHz).

4. CONCLUSION AND FUTURE WORK

A CPW-fed Sierpinski varying scale factor [3, 4, 7] monopole antenna is proposed. The antenna was designed by changing various triangular widths to accommodate various bands of interest. The proposed antenna possesses several controlling parameters making it very flexible in terms of band allocation and fine-tuning.

In the future, fractal antennas can be studied in several areas. One area of development is to implement fractal antennas in to current technologies in practical situations, such as the expanding wireless market. For this application, a rigorous analysis of the polarization of these antennas will be needed to be investigated. Another area of interest worth pursuing is to analyze the mathematical aspects of fractal to correlate their improved characteristics as antenna with their unique geometrical properties

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