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Design of Plus Shape Fractal Antenna for Various Applications

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Abstract**—**This paper describes design of a tri-band antenna based on fractal concepts. Fractal antenna exhibits multiband behavior due to self-similarity in their structure. Plus shaped micro-strip antenna utilizes two substrates of same dielectric material mounted above the other having individual dielectric constant of 4.4 and each of thickness 1.6 mm. This antenna is radiating at multiple resonant frequencies. The resultant resonant frequencies obtained are of triple bands i.e. 2.9GHz, 3.2GHz and 3.6GHz for IMT 200 and GSM application. The proposed plus shaped fractal antenna is simulated using the CST Studio 2010 and was found to perform well in terms of Bandwidth. Radiation pattern simulated results are in good agreement with the experimental results.

Keywords*- Fractal antenna, Multiband antenna, Size reduction.*

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I. INTRODUCTION

As the demand for portable systems has enhanced, low profile systems have drawn much interest from researchers in the recent years. In making low profile communication systems, the size of the antenna is critical. Micro-strip antennas are popular due to their properties, such as low profile, low cost, conformability and ease of integration with active devices. To the growing demand of MMIC (monolithic microwave integrated circuits) compatible antennas, patch antennas offer a good solution. To integrate these antennas in MMIC circuits for wireless communication applications the size of these micro-strip antennas should be as small as possible without compromising on their performance. Therefore, many kinds of miniaturization techniques, such as utilizing high dielectric substrates [1], applying reactive or resistive loading [2], increasing the electrical length of the antenna by optimizing its shape [3], use of short circuits and notches on the patch antenna [4] and use of magnetic substrates [5] have been proposed and applied to the micro-strip patch antennas. Techniques to obtain dual band operation of micro-strip antennas are also available [6-9]. The application of fractal geometry to conventional patch antenna structures modifies the shape of the antennas in order to increase its effective electrical length at the same time reducing their overall geometrical size.

Because fractal geometries have two main features in common, self-similar and space-filling properties, fractal shape antenna elements present various advantages like multiband [10, 11], wide bandwidth and reduced antenna size. It provides a larger sufficient bandwidth by increasing the overall thickness of the antenna without the need to enlarge the planar size [12]. In the present work, a plus shape patch is taken as a base shape and iterations are placed touching the base shape. In the simulated results a Plus shape patch is taken as a base shape and in first iteration four other plus shape patches of the order of 1/3 of base shape are placed. Plus shaped geometry has been applied to micro-strip patch antennas to reduce their overall size. It is found that as the iteration number and iteration factors increase, the resonant frequencies become lower than that of zero iteration, which depicts a conventional plus shape patch.

II. ANTENNA DESIGN

Plus shaped micro-strip antenna is a configuration that uses plus shaped defect in patch by using proximity coupling feeding technique in which two substrates are used which are electromagnetically coupled to each other. Figure 1 shows the cross sectional view of the plus shaped micro-strip antenna with two layer of dielectric substrate. Such combination will results in high surface wave efficiency and low cross polarization. Both the substrate are of same material i.e. f_r 4 with dielectric constant $\varepsilon_r = 4.4$ and thickness 1.6mm for base shape a plus shaped patch is taken as shown in figure 2a. Further this base shape of plus shaped patch is modified by inserting horizontal slots on both the sides with respect to centre of patch. The length of slot Ls is varied on either side from edge so as to get lower possible resonant frequency for optimum length obtained is Ls = 22.15mm. The base antenna with slots is treated as antenna 1 and whose geometry as shown in fig.2b. Next iteration is obtained with four plus shapes of order (1/3) of base shape are placed touching the base shape as shown in fig 2c. For each iteration plus shapes of order (1/3)n of the base shape are taken. Where n is number of iteration. In our simulation the dimension of first iteration can be calculated as follows

$$e = (1/3)a \ \& \ g = (1/3)c \text{ also } f = (1/3)b \ \& \ h = (1/3)d \quad (1)$$
$$i = (1/3)b \ \& \ k = (1/3)g \quad (2)$$

So with optimized design the dimension obtained are a= 45.3mm, b= 15.1mm, c= 35.4mm and d= 11.8mm

Parameters	Values
Length of Substrate	85mm
Width of Substrate	55mm
Length of Patch	45.3mm
Width of Patch	35.4mm
Length of Slot	22.15mm
Width of Slot (r)	2mm

Table I. Parameters of plus shaped antenna

A 50 ohms SMA connector is used to feed the antenna by proximity coupling technique in which feed line is in between two substrates having dimensions from centre to edge and thickness of 3.05mm. Fig 3a and Fig 3b shows photographic view of top and bottom of base antenna.

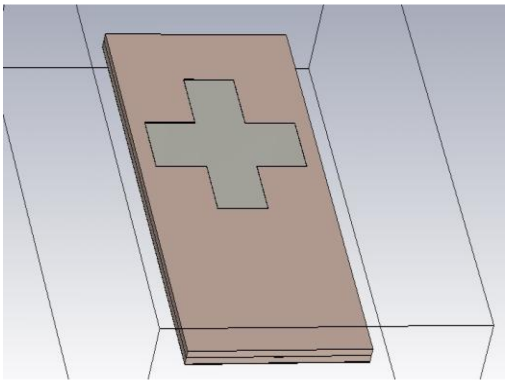

Fig. 1 Fractal Antenna

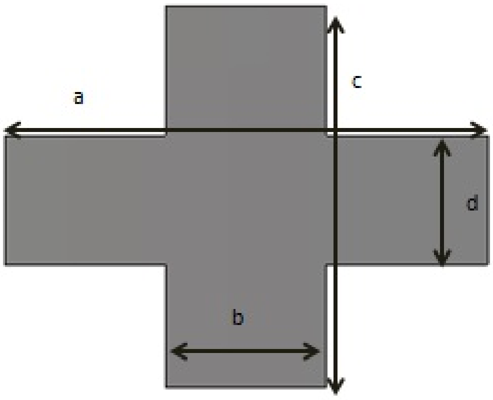

Fig. 2 a) Geometry of Base Antenna

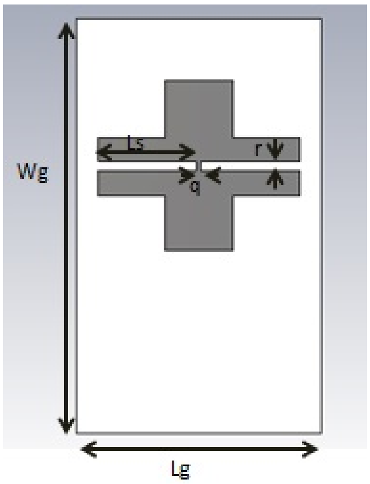

Fig. 2 b) Geometry for First Iteration

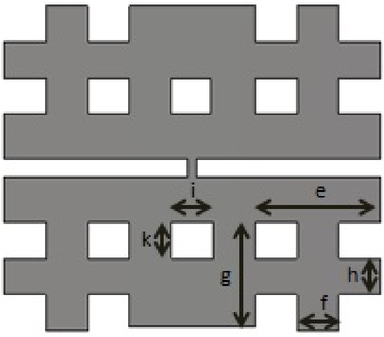

Fig. 2 c) Geometry for Second Iteration

Fig. 3 a) Photographic Top View of Antenna

Fig. 3 b) Photographic Bottom View of Antenna

III. RESULTS AND DISCUSSIONS

The proposed design antenna has been simulated using CST 2010 studio. Also the results have been verified practically. The practical results are in near agreement with simulated results. Resonant frequencies for which minimum return loss occurs for various bands for finalized antenna is given in table II. The table below shows the comparison of the simulated and the tested results of the designed antenna and the results are 90% matched.

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Parameters	Simulated Results	Tested Results
Return loss	-22dB	-25dB
Impedance	50 ohms	46.63 ohms
Resonant Frequency	3.2 GHz	3.4 GHz

Table II. Tested Results of Antenna Design at 3.2 GHz Frequency

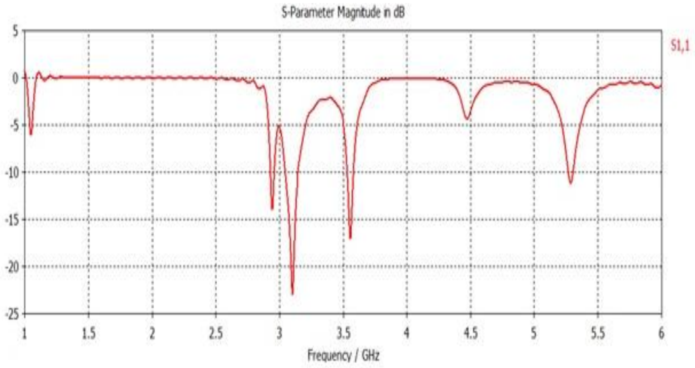

Fig. 4 a) Graph for Return Loss v/s Frequency of Base Antenna

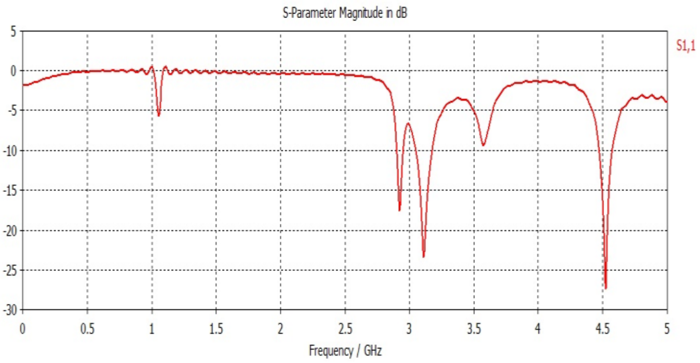

Fig. 4 b) Graph for Return Loss v/s Frequency for First Iteration

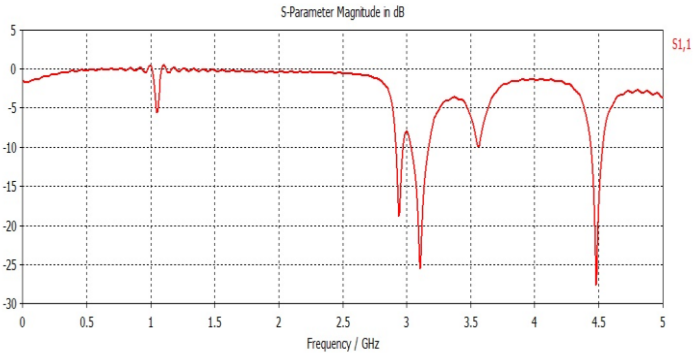

Fig. 4 c) Graph for Return Loss v/s Frequency for Second Iteration

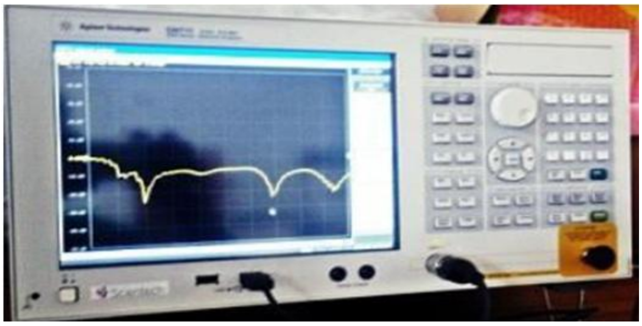

Fig. 5 Practical Results

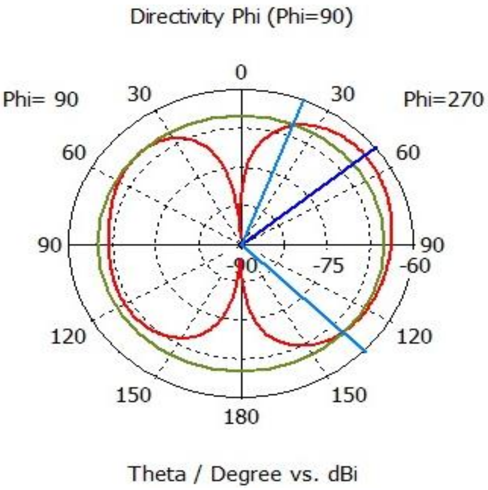

Fig. 6 a) Simulated 2D Radiation pattern at 2.5 GHz

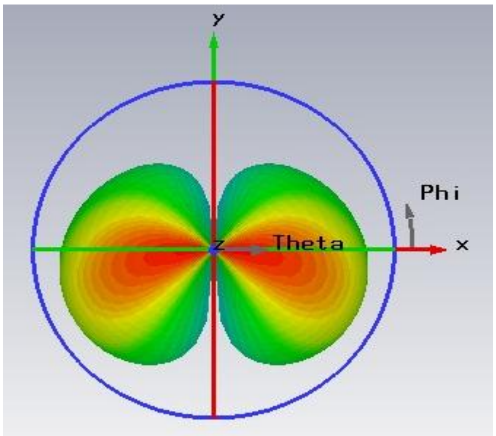

Fig. 6 b) Simulated 3D Radiation pattern at 2.5 GHz

IV. CONCLUSION

This paper proposes a plus shaped fractal antenna with first and second iterations. From the results discussed above, we conclude that the modified stacked antenna with iterations gives a good reduction in size and enhancement in bandwidth in comparison to the base fractal antenna.

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