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Design and Analysis of Ultra Wide Band Antenna using Fractal Geometry

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ABSTRACT: This paper describes the design and simulation of a novel multiband fractal antenna based on Sierpinski structure. The fractal structure is advantageous in generating multiple resonances or enhancing bandwidth. This paper proposed the design and simulation of three stages of antennas and performance characteristics of these three antennas have been reported. The fractal antenna has been designed on substrate (FR4 epoxy) with ε_r = 4.4 and height = 3 mm. This antenna offers the operation at different frequencies such as 2.5 GHz, 3.7 GHz, 4.7 GHz, 7 GHz, 7.9 GHz and 9.5 GHz.

Keywords: Fractals, Fractal antenna, Sierpinski geometry, multi-frequency, return loss.

I. INTRODUCTION

Microstrip patch antennas have an advantage that they can adapt to fit in many fields due to their compact size, light weight and economic fabrications. As per the latest trend in antenna engineering, it focuses towards the designing of antennas which can realize significant size reduction in order to meet up the with space needs in many applications. With the advance of wireless communication systems and ever increasing importance of wireless application in recent years, the need for small size and miniaturized, broadband, multifrequency and multiband antenna was realized. In application such as Global Positioning System and Wi-Max, operation at two or more sub-bends are necessary; a valid alternative to the broadening of total bandwidth is the use of multifrequency antenna.. Fractal geometries have two common properties, space filling and self similarity. The self similarity property of fractal shapes can be applied to the design of multiband fractal antennas and the space filling property of fractals can be utilized to reduce antenna size.

Moreover, fractal antennas are reliable and lower cost than traditional antennas because of its fractal geometry. The better performance is obtained through the geometry of the conductor.

II. ANTENNA GEOMETRY

The proposed multifrequency patch antenna is designed upto three iteration. Initially antenna geometry looks like a simple patch designed on FR4 Epoxy substrate wih ε_r = 4.4 and substrate thickness of 3 mm. The rectangular patch is calculated from the basic equations and found to be 28.42 mm X 36.51 mm. Initially the the patch is scaled to 0.15 of the original size and antenna is simulated for results. Secondly , these scaled patches are further increased so as to analyze their effect over the result. Finally, the patches are further scaled to 0.5 size of modified versions (i.e.,0.15 of the initial patch with dimensions of 28.42mm X 36.51mm). Thus, the patches are filled all along to analyze the final outcome of the modified geometry.

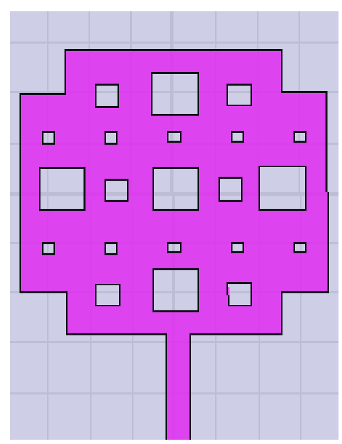

Fig. 1. Final iterative.

The antenna geometry is based on the Sierpinski carpet. Although the antenna is based on the structure but still with a difference in geometry, now scaled to a factor of 0.35 in order to get a newer scaled version (case-3).

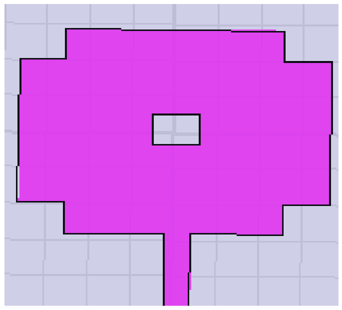

Fig. 2(a) 1st iteration.

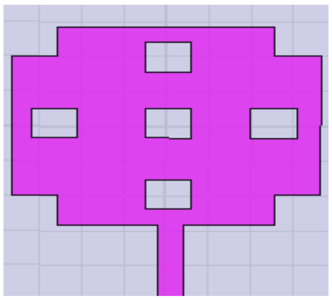

Fig. 2 (b) 2nd iteration.

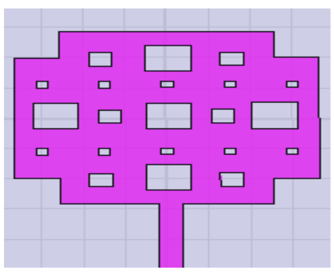

Fig. 2 (c) 3 rd iteration.

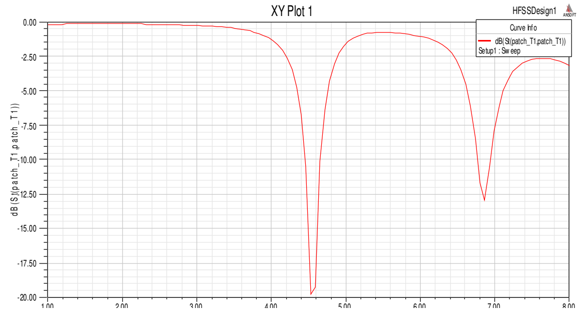

Fig. 3(a). Return loss for 1st iteration

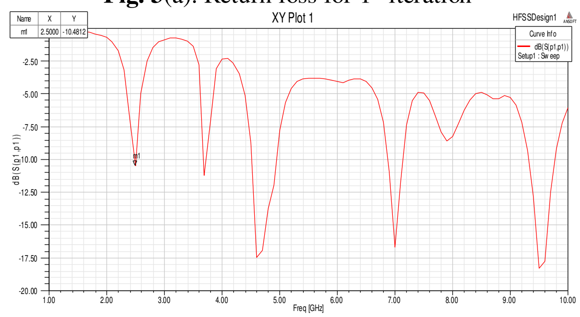

Fig. 3 (b) Return loss for 2nd iteration.

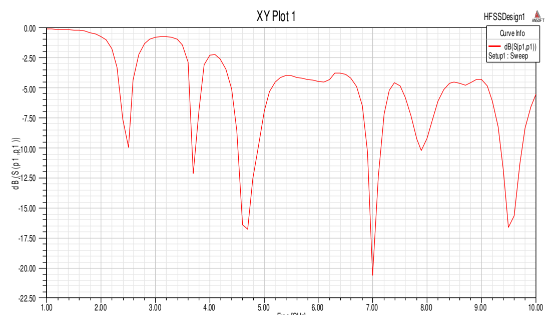

Fig. 3 (c) Return loss for 3rd iteration.

III. SIMULATION RESULTS

The antenna is simulated using Ansoft HFSS. All of the above mentioned designs showed specific results. Results were analyzed. Based on these analysis, inferences were made in order to form a better understanding of working of fractal patch antennas. Post simulation, it is noticed that each of the results(return loss, gain, radiation pattern etc.) is dependent on number of fractals along with the scaling factor and the relation between ground and patch. Each of the above cases provide us with a different result. Analysis is made on the basis of return loss and gain which is studied for each case. As we discover each of the cases; the frequencies and bandwidth over which the antenna radiates the energy is observed. S_{11} parameter provides us with valuable information of antenna characteristics and its relationship with various effecting factors.

IV. ANALYSIS OF RESULT

Case-I. In the first case, the cut off frequency is marked to be as 4.5 GHz. Also when we come across the rectangular plot depicting the gain found to be 5.1 dB. Also the same can be analysed over the radiation pattern. Though a good gain, but it is not a multiband system.

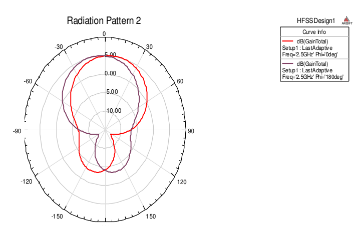

Fig. 4(a). Radiation pattern for 1st iteration (case-1).

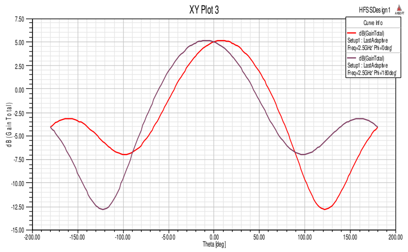

Fig. 5 (a). Gain for 1st iteration (case-1).

Case –II. Once the first case has been realized, the iteration comes into play. As we introduce the second iteration, a few behavioral changes are observed which are depicted by means of return loss plot and gain values.

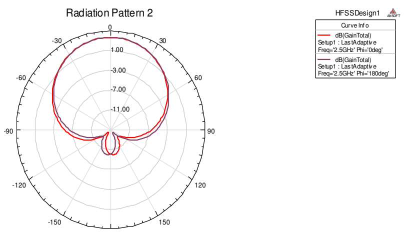

Fig. 4(b). Radiation pattern for 2nd iteration (case-2)

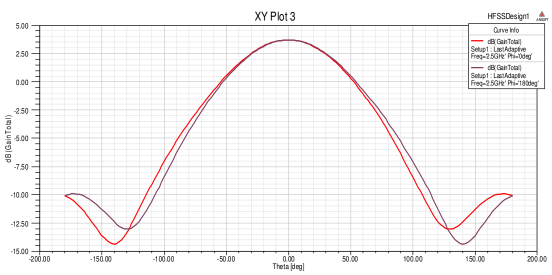

Fig. 5(b). Gain for 2nd iteration (case-2).

Now, when second iterations are made we find a multi frequency nature. Although a dip in gain of the system is observed found to be 3.69 dB. As well as radiation pattern is also altered accordingly.

Case-III. Now after the third iteration of the conducting structure, we witness a similar case as that of the first stage.

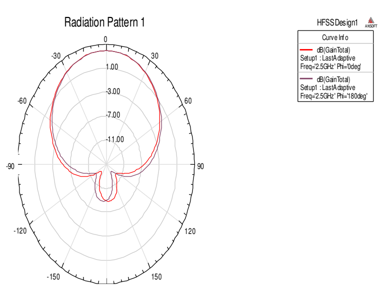

Fig. 4(c). Radiation pattern for 3rd iteration (case-3)

On final iteration, as depicted in the model, the multifrequency nature is further increased by another addition. Also an increase in gain was also observed which was found out to be 4 dB .This case is considered best for antenna applications since we get a good gain with multi-frequency output.

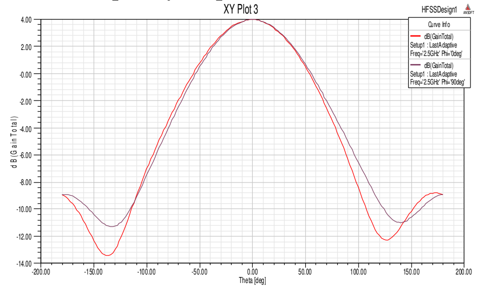

Fig. 5 (c). Gain for 3 rd iteration (case-3).

VI. CONCLUSION

The paper proposes a new form of fractal antenna system based on Sierpinski geometry designs which works on multiple band. The antenna has operational frequency ranging at 2.55 - 9.5 GHz normalized to 10 dB return loss value. The final iteration is found out to be more useful because of its better antenna performance. This is suitable for WiMax, UWB and WLAN applications. As gain is one of the performance parameter for different applications, further increase in Gain is possible by using antenna arrays. Stacked versions of substrate is also another feasible concept for increasing the gain.

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