Size Reduction of plus shape fractal antenna

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Abstract: In this paper a concept of probe feed multiband plus shape fractal antenna is presented. Fractal antenna are characterized by space filling and self-similarity properties which results in size reduction and having characteristic of generation of multiband due to self-similarity. Plus shaped antenna has been designed on a substrate of dielectric constant εr=4.4 and thickness 1.6mm. The proposed antenna is characterized by a compact size and it is probe feed fractal patch of order 1/3.Design antenna gives good size reduction of about 33.8%. This antenna having ability to generate multiband frequency over the range from 1- 4Ghz .The prototype antenna is simulated using the method of moments based commercial software (IE3D) and it is found that simulated results are in good agreement with experimental results.

Keywords: probe feed fractal antenna, size reduction, fractal antenna, multiband, self similarity

1. Introduction

Rapid Fractals represent a class of geometry with very unique properties that can be enticing for antenna designers. Fractals are space-filling contours, meaning electrically large features can be efficiently packed into small areas. Since electrical lengths play such an important role in antenna design, this efficient packing can be used as a viable miniaturization technique [1].fractal is "a rough or fragmented geometric shape that can be split into parts, each of which is a reduced size copy of the whole. Roots of mathematical interest in fractal can be traced back to the late 19th century; however mathematical fractal is based on equation that undergo iterations, a form of feed based on recursion. Fractals are a class of shapes of shapes which have not characteristic size. Each fractal is composed of multiple iterations of single elementary shape. The iteration can continue infinitely, thus forming a shape within a finite boundary but of infinite length or area. Fractal has the following features a) It has a fine structure at arbitrarily small scales. b) It is too irregular to be easily described in traditional Euclidean geometric c) it is self-similar d) simple and recursive [2]. The advantages of microstrip antennas such as the low profile, the ease of fabrication and the low cost have made this element very popular and attracted the scientific research for many years. Although the above-mentioned merits would be expected to project the patch as a good candidate for many applications, its large physical size renders it improper where the antenna space availability is a limitation. For this several methods have been considered to reduce the antenna size such as the use of shorting pins [3], material loading and geometry optimization [4]. Although it is interesting to notice that attempts to increase the conductive patch of the antenna have been endeavored by introducing slots and notches [4.5]. it was not until recently with the introduction of fractals in antenna engineering that this could be done in a most efficient and sophisticated way[6]. Fractal shapes have proved to possess higher dimensionally than the Euclidean ones, in other words they can exploit more efficiently a finitely a finite area or volume. Modern telecommunication systems require antenna with wider bandwidth and smaller dimension than conventionally possible. This has initiated antenna research in various directions, are of which is by using fractal shaped antenna elements. In recent years several fractal geometries have been introduced for antenna application with varying degree of success in improving antenna characteristics. Some of these geometries have been particularly useful in reducing the size of the antenna, while other designs aim at incorporating multiband characteristics. These are low profile antennas with moderate gain and can be made operative at multiple frequency bands and hence are multifunctional [7].In our present work we are focused size reduction of antenna. 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 touching the base shape. It is found that as the iteration number and iteration factor increases, the resonance frequencies become lower than those of the zero iteration, which represents a conventional plus shape patch. Simulation is being utilized by using the method of moment (MoM) software package i.e Zeland IE3D ver14 [8].

2. Design Consideration

For base shape a plus shaped patch as shown in figure 1(a). For the first iteration four plus shapes of the order 1/3 of base shape are placed touching the base shape is shown in fig1 (b). Same procedure is repeated for the third iterations which as shown in fig 1(c). For each iteration plus shapes of the order of $(1/3)^n$ of base shape are taken. Where n is the number of iterations. This geometry is fabricated antenna of dielectric substrate having a dielectric constant of εr=4.4 and height of substrate is 1.6mm.Geometry of design antenna of base, First and second Iteration as shown in fig1(a),1(b),1(c).Design fabricated antenna as shown in fig.2(a),2(b),2(c),2(d).In our simulation a=40mm, c=30mm, b=13.33mm, d=10mm dimension for first iteration can be calculated as e=g=(1/3)a=(1/3)c and f=h=(1/3)b=(1/3)d. which gives b=e=13.33mm,g=d=10mm f & h gives 4.443mm and 3.33mm respectively. Probe feed is used as a feed line with probe radius 0.6mm and length of the probe equal to the substrate thickness.

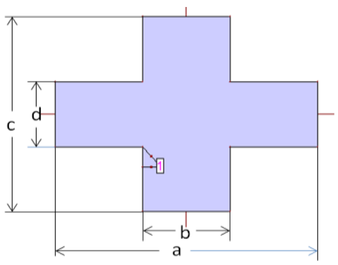


Fig 1(a)

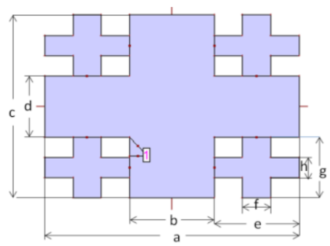


Fig 1(b)

Fig: 1(a) Geometry of base antenna
1(b) Geometry for First iteration

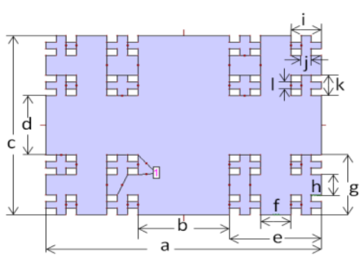
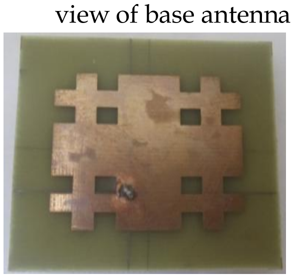


Fig1(c): Geometry for Third iteration

Fig2 (a) Photographic top view of base antenna

Fig2 (b) Photographic bottom view of base antenna



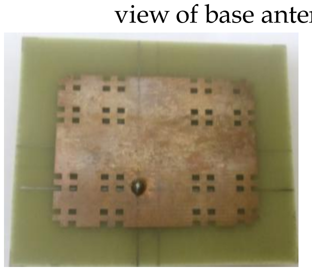


Fig2(c) Photograph with First iteration

Fig2(d) Photograph with second iteration

3. Results and Discussions

The proposed design has been simulated using Zeland's simulation package whose characteristic of the pus shaped antenna base with first and second iteration is studied using simulated software. Also the result have been verified practically with by using vector network make Agilent Technology E5062A (300kHz-3GHz) analyzer as shown in fig3. Practical results are in good agreement with simulated results. Fig. 4(a) & 4(b) shows the variation of return loss with frequency for the base shape. Result for first iteration is shown in fig 4(c) & 4(d). It is observed that for first iteration three bands occurs in the frequency range1-4 GHz. Similarly variation of return loss characteristic of of third iteration as shown in fig.4 (e) & 4(f) here also observed triple band for the frequency ranges from 1-4Ghz.While for the base shape only one band is achieved. Optimized base antenna with I & II iteration is summarized in Table1.Designed plus shaped antenna with base and of second iteration gives broad side radiation pattern which is shown in fig.5 (a) and 5(b).

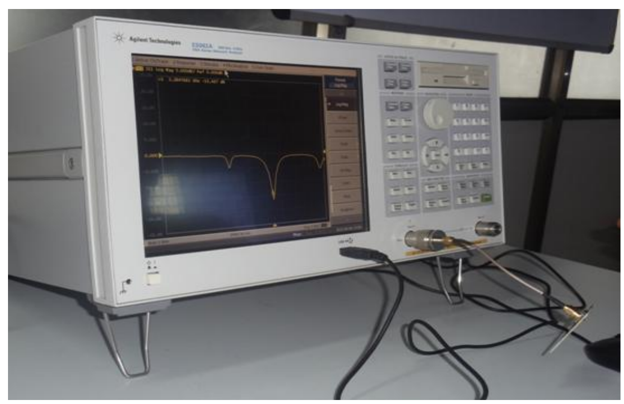


Fig3 Photograph of Network analyzer

Geometry	Resonant Frequency in GHz		Return loss in db	
	Simulated	Practical	Simulated	Practical
Base shape	2.79	2.76	-16	-15.37
First interaction	2.3	2.31	-19.7	-12.5
Second interaction	2.2	2.2	-13	-15.8

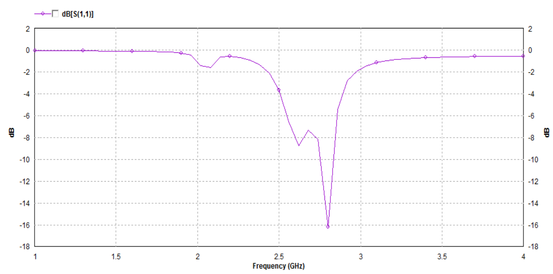


Table1 Table for frequencies at which minimum return loss occur

Figure4a. Simulated return loss characteristic for base antenna

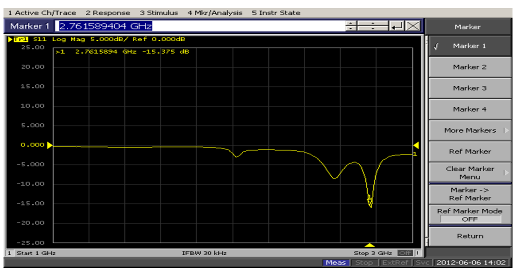


Figure4b. Practical return loss characteristic of base antenna (1-3 GHz)

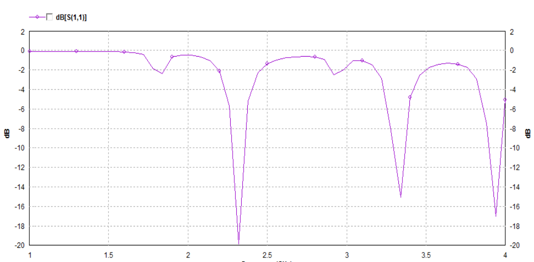


Fig.4 (c) Simulated return loss characteristic of plus shape antenna with First iteration

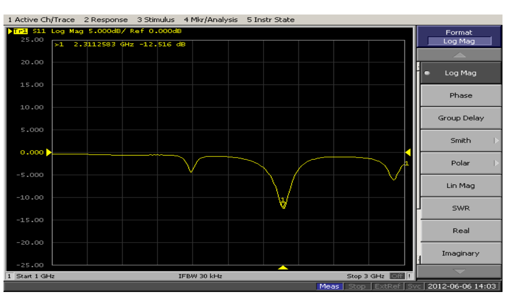


Figure.4(d) Practical return loss characteristic of Plus shape antenna with first iteration (1-3Ghz).

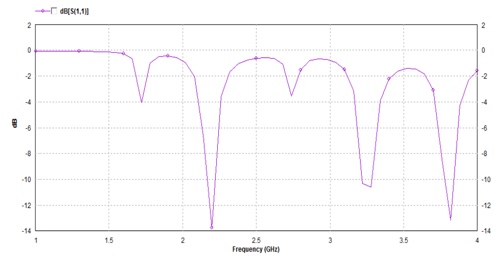


Fig.4 (e) Simulated return loss characteristic of plus shape antenna with second iteration

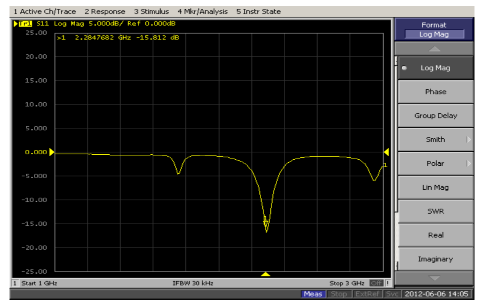


Figure.3 Practical return loss characteristic of plus shape antenna with first iteration (1-3Ghz).

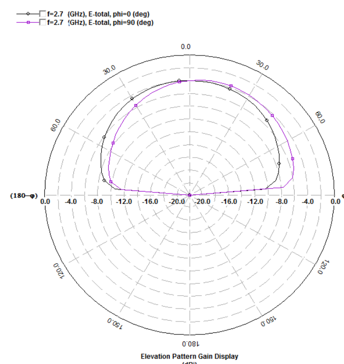


Figure: 5(a) Simulated radiation pattern of base antenna @ 2.76GHz

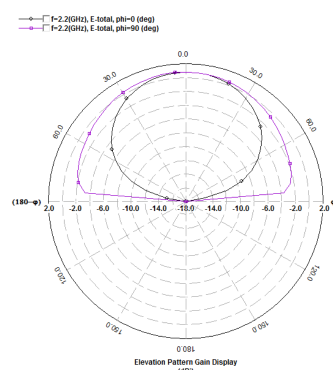


Fig: 5b Simulated radiation pattern of plus shape antenna@2.2Ghz with II iteration.

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4. Conclusion

A New design of fractal antenna has been proposed. This paper outlines plus shaped antenna has a lower resonant frequency compared to the base shaped patch of zeroth iteration, and this property contributes to the reduction in antenna size. This antenna having the capability of generating multi-frequency. For the first iteration patch, as the iteration factor increases, the resonant frequency of the patch also decreases with this result in size reduction of about 33.87 without degrading the radiation pattern.

Acknowledgement

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