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RESEARCH ARTICLE

Square Spiral Curve Fractal Antenna for Multiband Wireless Communication

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Abstract

The design of spiral curve fractal antenna for multi frequency application is proposed in this paper. Designed shape is based on the principle of fractal geometry. The given antenna fallows both the properties of fractal i.e. self-similar and space filling in order to miniature the antenna size and use one antenna for more than one frequency band respectively. The proposed antenna used up to three iterations. It has been observed from the result that as we increase the number of iteration the antenna show multiband characteristics. Also the return loss, VSWR, current distribution, gain and direction pattern shows that this antenna is more applicable for multi frequency applications, especially in the range of 6 GHz to 9 GHz. The Ansoft HFSS software is used for the simulation purpose.

INTRODUCTION

The fractal antennas are the most useful antenna to fit in small size. Fractal antennas have the growing demand in modern wireless telecommunication system because of its small size and multi frequency behavior [1 - 3]. As the antenna size decreases the frequency goes on increases, based on the same principle as the number of iteration increases by using self similar property the antenna size goes on decreasing but at the same time the effective electrical length of the antenna goes on increasing [4]. The fractal antennas also show their importance in UHF and VHF applications [5]. The hexagonal type fractal antenna provides good characteristics in multiband applications [6]. Traditionally, a wideband antenna in the low frequency wireless bands can only be achieved with heavily loaded wire antennas; it means that different antennas are needed for different frequency of applications. Recent development in the study of fractal antennas shows mixed solutions for using a single small antenna operating over many frequency applications.

The term fractal means linguistically broken, "the fractal is the geometric shapes, which are self-similar, each of which is reduced size copy of whole". The term fractal was first coined by Mandelbrot in 1970, after that many researchers found that use of fractal in various area of wireless communication. Many sizes and shapes are used for the designing of the fractal antenna, like G. Cantor (1872), G. Peano (1890), D. Hilbert (1891), Helge von Koch (1904), W. Sierpinski (1916) Gaston Julia (1918) [7]. When the system requires operation at two or more frequencies, multi frequency antenna may avoid the use of different antennas. Applying fractal to antennas allow for miniaturization of antenna with multi-band and broad-band operation. Fractal geometries have two common properties, space filling and self similarity. It has been shown that 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 [8]. The use of fractal antennas in LTE mobile telecommunication system increases its demand because of its multi behavior property [9]. The ability of this type of antenna is to be fit longer curve in relatively smaller area. Fractal antennas are low profile, moderate gain, highly directive and multi resonant make them to be a good candidate to use in antenna design.

PROPOSED FRACTAL ANTENNA DESIGN

The designed antenna is inspired from the geometric shape spiral curve, which is simple to construct and easy design [3]. The aim of producing this design is to make small antenna size which will fit in given area. This antenna from the first iteration show multiband behavior. At the second and third iteration it gives increasing multiband behavior in frequency and bandwidth. The given antenna resonates in between 3 to 9 GHz frequency band.

Simulation is done by using Ansoft HFSS software. The dielectric material used is FR4 substrate having relative permittivity 4.4, and the thickness of 1.6 mm. The Fig. A.1, A.2, A.3 and A.4 shows the original curve of square spiral curve fractal antenna with first second and third iteration.

Fig. A.1, Original curve

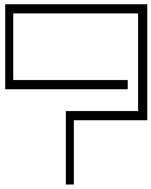

Fig. A.2, First iteration

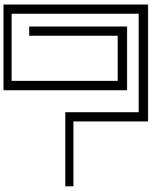

Fig. A.3, Second iteration

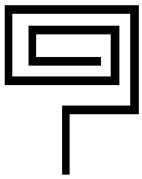

Fig. A.4, Third iteration

The curve is made by connecting line of width 2mm and length of 17 mm to another line of width 2mm and length of 31mm, which is further connected to line of width 2mm and width 29mm. by keeping the width same the line is made to produce a spiral shape up to third iterations. From the simulation result it shows that as we going to increase number of iteration the antenna resonate at more and more frequency bands. For excitation of antenna, microstrip feed point method is used because of its matching characteristics [5].

MODEL OF FABRICATED FRACTAL ANTENNA

For the fabrication of antenna PCB technique is used, because it offers excellent features such as low weight, profile and cost while, maintaining good performance characteristics. The eagle software is used for drawing of accurate PCB design and measurement of the antenna element. Actual fabricated antenna is shown in Fig. A.17.

Fig. A.17, The fabricated antenna

SIMULATION AND RESULTS

1. Original curve

The simulation result for the original curve shows that the antenna resonates at frequency range of 6.84 to 8.52 GHz having VSWR near about 2 in Fig. A.5. and Fig. A.6 shows the return loss ranges from -5 to -8 dB. The gain accepted is 1.94.

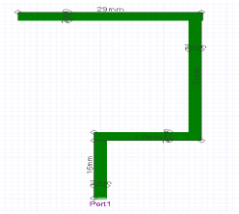

Fig. A.5, Original curve

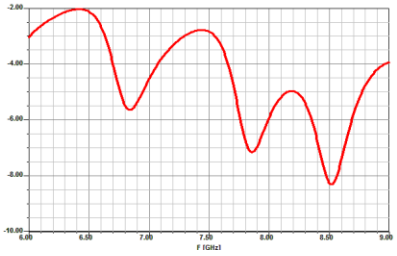

Fig. A.6, Return loss

2. First Iteration

The Fig. A.7 and Fig. A.8 shows the structre of fractal antenna at first iteration, and its return loss. The simulation result shows that at the first iteration the resonant curve become more sharper and result in multiband behavour, the gain also insresed. It cover 6GHz to 9GHz frequency which is useful for long distance radio telecommunication.

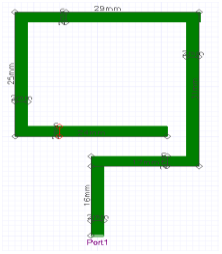

Fig. A.7, First iteration

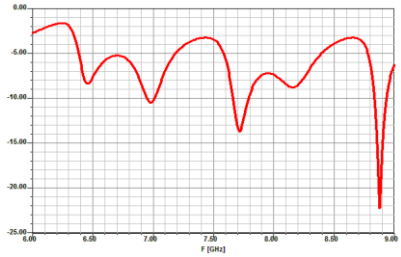

Fig. A.8, Return loss

3 Second Iteration

The Fig. A.9 and Fig. A.10 shows the second iteration of fractal antenna and its return loss. It clearly seen from results that the multiband property of antenna goes on increasing as we increase number of iteration.

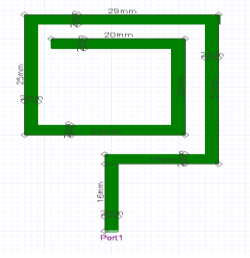

Fig. A.9, Second iteration

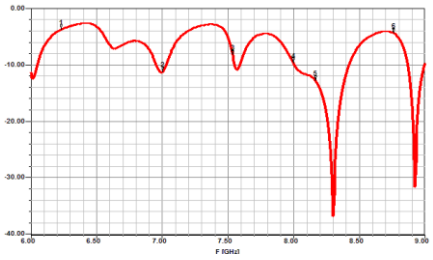

Fig. A.10, Return loss

4 Third Iteration

This Fig. A.11 and Fig. A.12 shows the antenna at third iteration and its return loss. At the third iteration, the antenna resonate at various frequencies starts from 6.22GHz to 8.79GHz with return loss of -9.29 to -24.79 having VSWR in between 1 to 2.

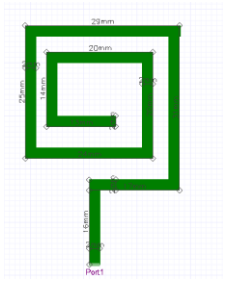

Fig. A.11, third iteration

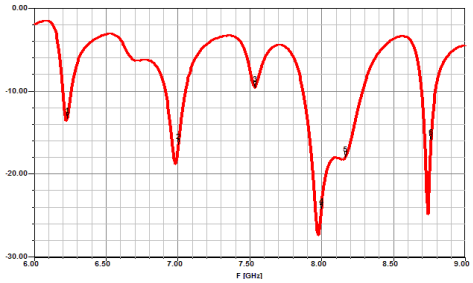

Fig. A.12, Return loss

5 Radiation pattern

The far field radiation patterns of praposed antenna are shown in Fig. A.13, A.14, A.15 and A.16.

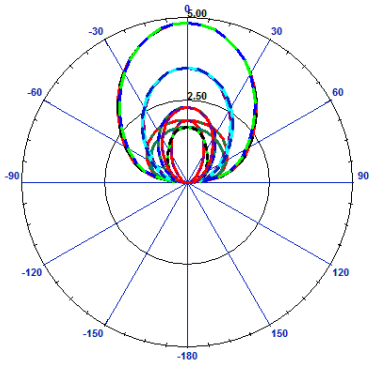

Fig. A.13, 0th iteration

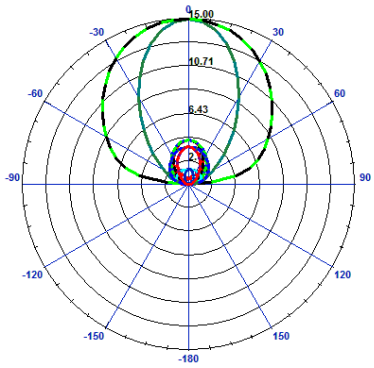

Fig. A.14, 1st iteration

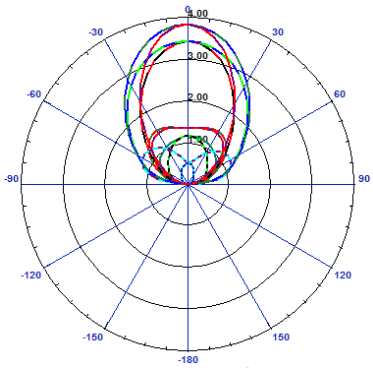

Fig. A.15, 2nd iteration

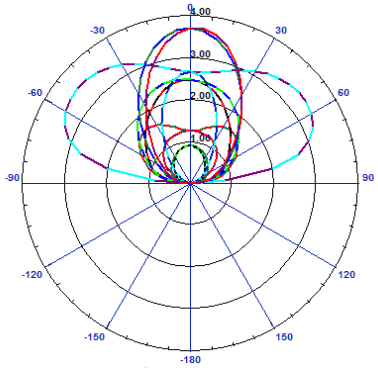

Fig. A.16, 3rd iteration

Simulated frequency, return loss, VSWR and gain is plotted in Table A.1

Iteration	Frequency GHz	Return loss dB	VSWR	Gain in dB
0th	6.84	-5.65	3.01	1.94
	7.76	-7.15	2.22	
	8.52	-8.29	1.97	
1st	7	-10.34	1.92	2.01
	7.73	-13.54	1.54	
	8	-7.36	2.43	
	8.17	-8.78	2.12	

	8.89	-22.21	1.20	2.42
2nd	7	-11.43	1.75	
	7.57	-10.59	1.80	
	8	-9.75	1.94	
	8.20	-13.83	1.48	
	8.93	-31.38	1.05	
3rd	7	-18.49	1.19	3.09
	7.54	-9.29	2.13	
	8	-26.87	1.04	
	8.10	-18.13	1.30	
	8.30	-9.84	1.83	
	8.79	-24.79	1.04	

Table A.1, Simulated frequency, return loss, VSWR and gain

CONCLUSION

The design of square spiral fractal antenna is presented in this paper. This antenna performs multiband characteristics from the frequency range of 6 GHz to 9 GHz. It has also been found from the simulation results that as we increase the number of iteration, the antenna shows multiband behavior and increasing order of gain. The return loss of the given antenna vary from -5dB to -31db. This antenna is very useful for C band applications such as long distance telecommunication, radar and satellite communication. The cost of fabrication of antenna is much cheaper because of PCB technique and the material used is FR4 substrate which is easily available. The overall simulation is done in Ansoft HFSS software.

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