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Design and Analysis of Fractal Tree and Fractal Koch curve Antennas

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Abstract

In this paper we design and analysis the result of the 4th iteration of Fractal Koch curve and Fractal Tree antennas. The entire dimensions of the fractal Koch and tree antennas are 16mm * 18mm. In our paper there is comparison between fractal tree and Koch curve antennas. Antenna is simulated using high frequency structure simulator (HFSS) V.13 which is based on finite element modeling (FEM).The antenna characteristics such as return loss, radiation pattern and VSWR of the antenna are analyzed and presented.. The simulated result of Koch curve fractal antenna is much better than the fractal tree antenna.

Keywords: *Koch, fractal, space filling, self-similarity, octagonal.*

I. Introduction

With the tremendous advancements in wireless communications, there is an increasing demand for miniature, low-cost, easy-to-fabricate, multiband and wideband antennas for use in commercial communications systems.The size of antenna is extremely important for most wireless communication systems. But it is desired that the reduced size antenna have equivalent operation in comparison with ordinary developed antennas. There are limits to how small an antenna can be, however the most important of them are bandwidth and gain. Fortunately a lot of communication systems don't require large bandwidths; therefore, it is not an important problem. Many techniques have been used to reduce the size of antenna, such as using dielectric substrates with high permittivity [1], applying resistive or reactive loading [2], increasing the electrical length of antenna by optimizing its shape [3], Utilization of strategically positioned notches on the patch antenna [4]. Various shapes of slots and slits have been embedded on patch antennas to reduce their size.

The concepts of fractal were first introduced by Mandelbrot. The fractal antennas are different from traditional antennas because it is capable of operating at many different frequencies at a time. The radiation characteristics and bandwidth of the antenna are increased due to convoluted and jagged shapes of fractals. The key advantages of fractal antennas are reduced antenna size, support multiband and wideband operation with improved antenna performance. These can be achieved using fractal geometry. Hilbert, Sierpinski, Koch and Minkowski are the various types of fractal geometries. All these fractal geometries are used to design a small size multiband and wideband antennas.

Recently, fractal tree antennas have been studied with particular attention, as they provide miniaturization and multiband operation. Several papers have reported the use of fractal tree structures as end loads to achieve a resonant frequency lower than a standard dipole of comparable length have been recently studied.

In this paper we have designed only 4th iteration of the fractal tree antenna is given in fig of the fractal tree antenna.

II. Antenna Design

The geometry of proposed Koch loop fractal antenna is shown in Fig. 1. The different stages of iteration are shown in Fig 2(a), (b), (c) and (d). The proposed fractal antenna consists of octagonal shaped substrate with Koch fractal and fed with microstrip feed lines. The fractals are the main radiating element. The characteristics of the antenna parameter depend on the fractal geometry. The fractal geometries are generated from triangle slot using generation method. The antenna is printed on FR4 substrate with relative permittivity of $\varepsilon r = 4.4$ and loss tangent of 0.02.

The antenna dimensions are calculated using transmission line model [10]. The various dimensions of the antennas are calculated and the values are optimized. The length and width of the ground plane are $Lg = 16mm$ and $Wg = 18mm$ respectively. The substrate width $Ws = 18mm$, substrate length $Ls = 16mm$, feed width $Wf = 0.5mm$, feed length $Lf = 7mm$, the patch width and height of the substrate $h = 1.6mm$. The length of each side of octagon is 13.033mm. The ground plane and the patch are made of copper

Table 1: Antennas dimensions

Type	Length(mm)	Width(mm)	Height(mm)
Koch Fractal	16	18	1.6
Fractal Tree	16	18	1.6

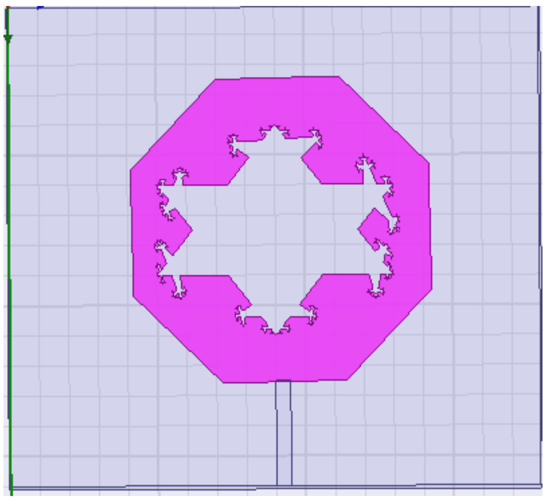


Figure 1(a)

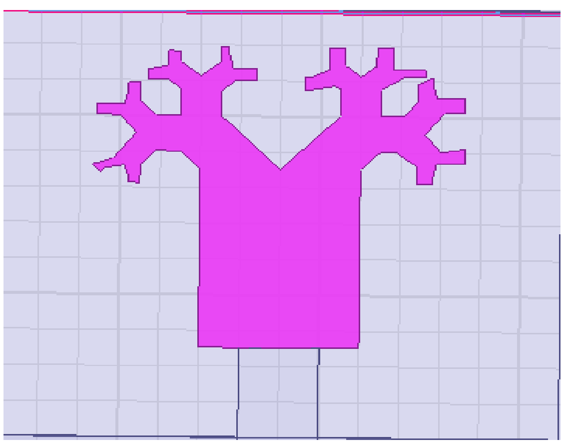
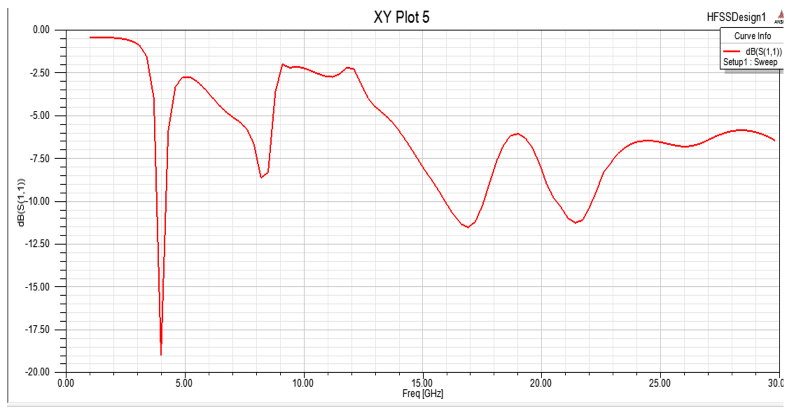


Figure 1(b)

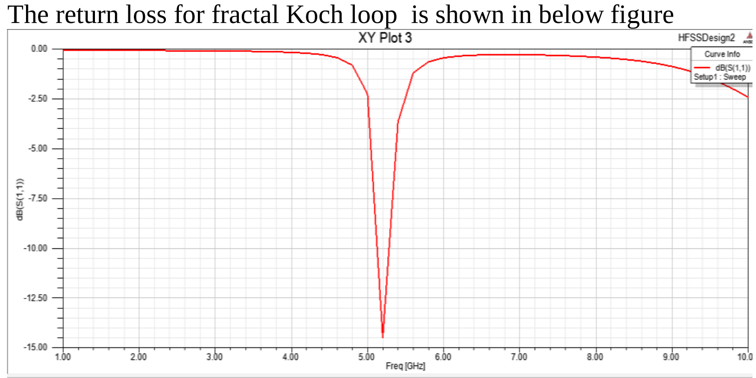
An octagonal shaped substrate is selected in order to enhance the radiation characteristics of the antenna. Initially a triangle shape Koch loop patch is generated. In the first iteration, Koch loop fractal is generated by dividing the side of triangle by 3. To improve the antenna performance and to increase operating range, second iteration is performed. In the second iteration, the Koch loop fractal is generated by dividing the sides of the triangle in first iteration by 9. In the third iteration, the Koch loop fractal is generated by dividing the sides of the triangle in second iteration by 27 In the four iteration, the Koch loop fractal is generated by dividing the sides of the triangle in third iteration by 81. Multiband operation can be achieved by increasing the iteration order. As the number of iteration increases, bandwidth is also increases.

III. Result and Discussion

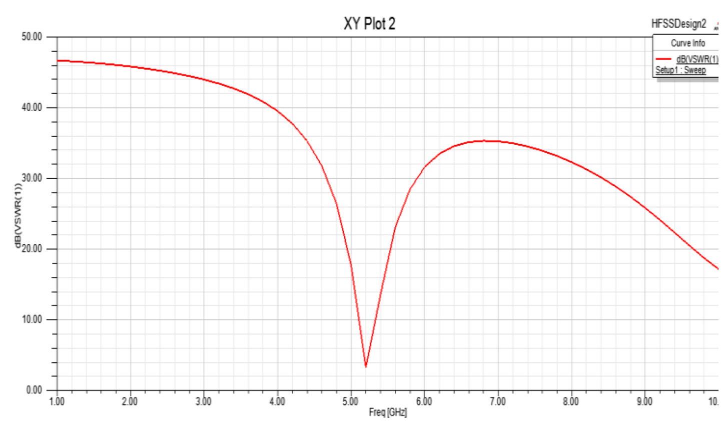
The return loss for fractal tree is shown in below figures:



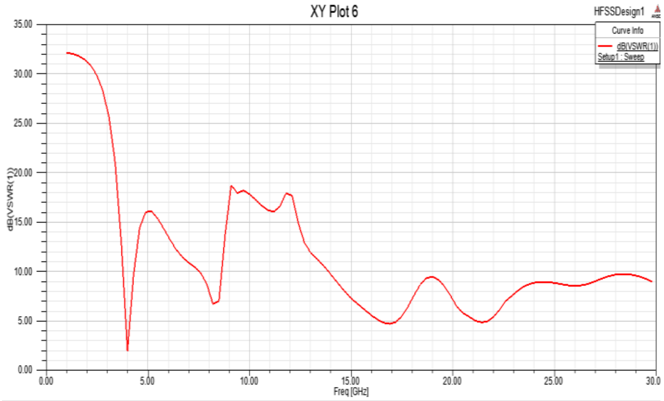
The return loss for fractal Koch loop is shown in below figure



The VSWR for Koch loop fractal is shown below



The VSWR for fractal tree is shown below:



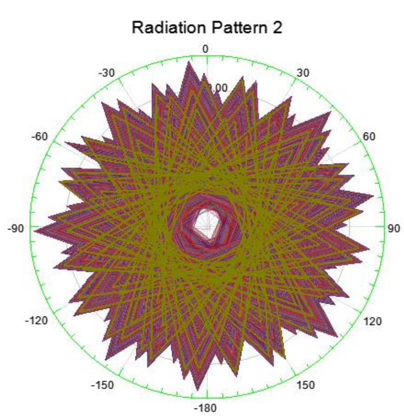
The table for the measured values of the designed antennas is given below:-
For Koch fractal antenna

Ref. No	Resonating Frequency (GHz)	Return Loss(db)	VSWR(db)	Bandwidth(%)
1	5.2	-16	3.4	-
2	16.5	-17	1.8	-
3	17	-25	1	5.5
4	17.2	-22	1.8	-
5	17.5	-19	2.1	-

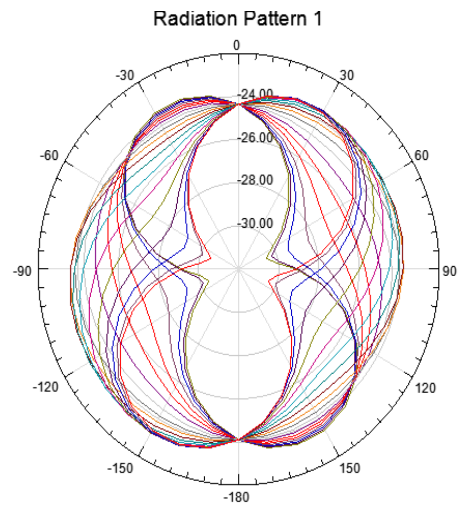
For fractal tree antenna

Ref. No	Resonating Frequency (GHz)	Return Loss(db)	VSWR(db)	Bandwidth(%)
1	4	-21.25	1.5	12.5
2	16	-10	5.5	-
3	16.3	-10.8	5	-
4	16.6	-11.3	4.8	-
5	16.9	-11.5	4.7	-

Radiation Pattern for Koch curve is given below:



Radiation Pattern for Fractal tree is given below:



IV. Conclusion

The fractal Koch and fractal tree antennas are designed and its performance characterstics are analysed. The measured results of designed model also exhibit wide bandwidth to support WLAN, WIMAX and Bluetooth bands. Therefore this 4th iteration of Koch fractal antenna model is useful for cellular telephone and multiband applications. This antenna can be used in applications where the overall volume of the structure is an important factor, such as mobile terminals, etc.

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