Design of Koch Square Fractal Antenna with Micro strip Feed for Multiband or UWB Application

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Abstract: **This paper presents the design of a Koch square fractal antenna. The proposed antenna is designed on FR4 substrate with dielectric constant and is fed by micro strip line. The provide contribution in the design and evaluation of multiband fractal antenna suitable for GPS, Wi-Max and Wi-Fi applications. The antenna array uses the advantages of the fractal geometry. The inverted Koch square patch fractal antenna has been modified in order to gain more control over the efficiency degradation originating from production difficulties. This antenna is designed to operate at four resonance frequencies are 1.57, 2.7, 3.4 and 5.3 GHz. The Simulation of the proposed antenna design has done by advanced design system (ADS) and measurement results show the applicability of fractal geometry in antenna arrays.**

Keywords: FR4, Koch Square Shape, Micro strip patch antenna, Return Loss, Gain, VSWR.

I. INTRODUCTION

Micro strip patch fractal antennas have been rapidly developed for multiband and broadband in high data rate system known as wide band communication systems. [1] Micro strip patch antennas are light in weight because of absence of machined parts and are simpler, compact and easy to manufacture with printed circuit technology. One property associated with fractal geometry that is used in the design of super special antennas is self similarity which means that some of the parts have the same shape as the whole object but at a different scale. When it comes to designing antenna systems, it is essential to properly set the spacing between antenna elements. The interelement spacing should not exceed one wavelength to avoid grating lobes (multiple main beams) [2].

However, the physical size of single elements is commensurable with half wavelength or quarter wavelength in general. Therefore, the realization of the antenna system could easily come up against problem [3].One of the possible solutions to size reduction is the application of fractal antennas. A fractal antenna can be designed to receive and transmit over a wide range of frequencies using the self similarity properties associated with fractal geometry structures. We are using the FR4 as the substrate. FR4 is a composite material composed of woven fiberglass cloth with an epoxy resin binder that is flame resistance (self existing)[4].

Use of fractal geometry is to improve the several feature and performance of antennas .Several slot geometry are as :Square ,Rectangle ,triangle ,trapezoidal ,circular ,elliptical in combination with either a rectangular, fork like or circular turning stub ,optimized for wide band operation[5].The goal of this paper is to present the design and evaluation of an antenna system that takes advantage of fractal antennas. The design considerations and the characterization of single element are discussed in detail. [6] In this paper we describe our fractal geometry which is a modification of the inverted Koch square fractal. The simulation analysis of the presented antenna is carried out by applying a commercial software package called Advanced Design system (ADS) Software.

II. DESIGN CONSIDERATION

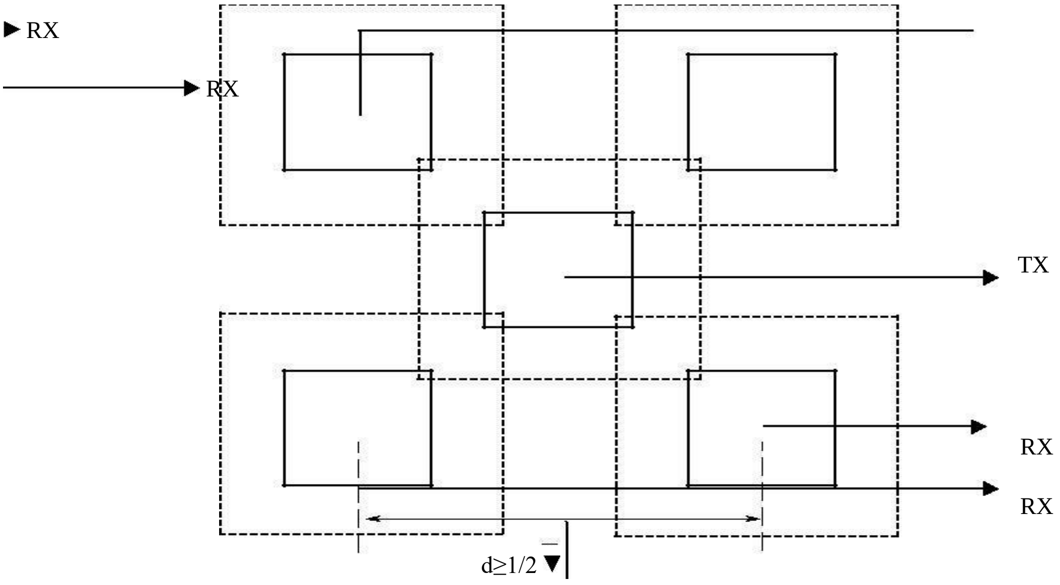


Figure 1: Schematic layout of the Multiband Structure

The collisions avoidance radar can use the multiband applications to detect nearby target and determine those position .UWB could execute the necessary maneuvers to avoid the collisions .The antenna system consist of four receiver and one transmitter antenna to produce two delta and some channel. The distance between receiver antenna elements should be kept around half a wavelength to evaluate wide enough beams. Receiver element should be placed maximum a wavelength away from each other .this separation of the transmitter and receiver antenna is impossible due to small space the layout present. Other benefit of this antenna layout is the nearly symmetrically electromagnetic field distribution on the different antenna element. The inter element spacing of the receiver antennas is half wavelength. The dashed line illustrates the previously calculated sizes of the antenna elements. As it can be seen from the layout the use of standard micro strip patch antennas is possible. Consequently the physical size of the antenna elements must be reduced. There are several methods to reduce the size of the micro strip patch antenna such as using substrate with high dielectric permittivity or applying slots. In order to increase the bandwidth of the antenna the FR4 substrate was extended with 10 mm height air gap (The height of the FR4 substrate is also decreased from 1:5 mm to 0:5 mm) the stack up of a single element. Our main goal was to design the above described antenna system using fractal geometry antennas thus the antenna system could meet the requirements.

FORMULA: Physical structure

$\lambda = C/f$ [C means speed of light, F means frequency of antenna]

Width= $(WL/2)*[\sqrt{2}\,(\epsilon_r+1)]$ [W means Width of an antenna]

$\epsilon_{reff} = \epsilon_r + (1/2)$ [€r means permeability resistance]

$\lambda_g = \lambda/\sqrt{\epsilon_r}$ [λg means Ground wave length, €r means relatives permeability] $L_f = \lambda_g/4$ [Lf means feed line length]

III. FRACTAL GEOMETRY

They are three types of fractal geometry are

1) Koch curve antenna.
2) Sirepinski fractal antenna.
3) Koch island fractal antenna.

These sirepinski fractal antenna and Koch island fractal antenna are better than the Koch curve antenna, so we choose the Koch curve antenna. The Koch curve fractal antenna means it has a two effective properties like space filling and self similarities.

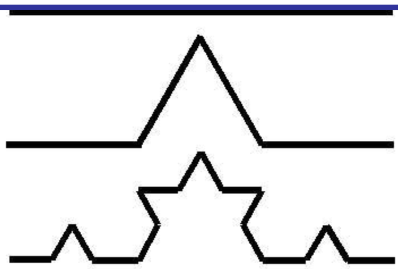


Figure 2: Koch curve fractal evolution.

These antenna are designed on the basic of Koch curve .In 1998 the VON KOCH monopole become the first reported ,the small fractal antenna the improved the feature of some classical antenna are bandwidth ,resonant frequency and radiation resistance. The Koch curve is a limiting curve obtained by applying the construction an infinite number of times. Taking a segment of straight line initiator, then these substitute of middle third of an equilateral triangle .This is called generator. Repeat the previous step for all they newly obtained segment again and again we get the Koch curve obtained.

IV. DESIGN METHODOLOGY

The structure of the proposed micro strip patch antenna with conventional Koch fractal geometry and in four iteration level is shown in figure .The proposed fractal antenna consist of radiating patch ,ground plane and micro strip feed by using fractal geometric the size of the antenna can be reduced while it still maintain its multiband behavior .

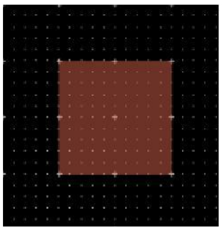
The fractal geometry can be changed mainly by two factors: the iteration number and iteration factor. The construction law of geometry is depicted by the iteration factor and the number of iteration process is represented by the number of iteration number .here ¼ factor are taken. Let us assume that the dimension of they are equal to the parameter, where A=40.various step of design fractal antenna are explained below.

0^{th} Iteration: The shape of the patch is square with an area A2 and perimeter 4A.

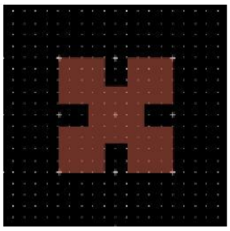
1^{st} Iteration: The four squares with dimension of ¼ are cut from the middle of the side of the main square as shown in figure .hence area equal to 0.75 A^2 and perimeter equal to 6A.

2^{ND} Iterations: The so far med four edges are taken as individual square and again four square with dimension 3A/32 are cut out of them as shown in figure .hence area=0.60A^2 and perimeter = 9A.

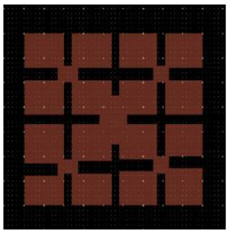
3^{RD} Iterations: The three small edges are taken as individual square and again the about steps are repeated and square of dimension 9A/256 are cut out from these edges. Hence area =0.36A^2 and perimeter =15.75 A.



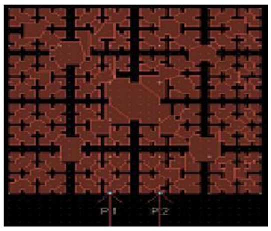
0^{TH} ITERATION



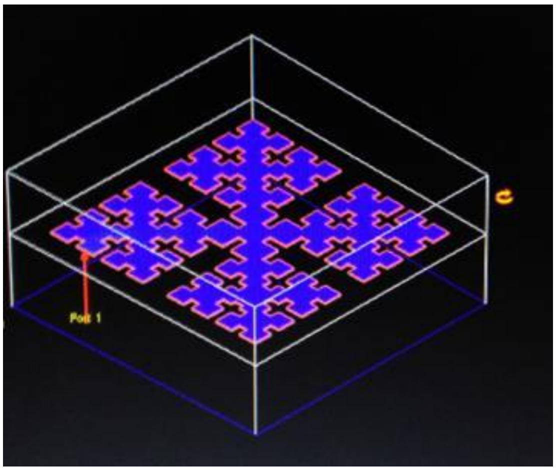
1^{ST} ITERATION



2^{ND} ITERATION



3^{RD} ITERATION



3D VIEW OF FRACTAL MICROSTRIP PATCH ANTENNA IN ADS

The main objective of the thesis work is to design a compact, robust and multiband antenna that covers maximum number of navigation frequencies and can be used in devices where less space is available. Therefore the dimension of the antenna is 45mm*45mm*1.6mm. With these dimensions the antennas resonate at 7.50GHz, 11.5GHz.

ADVANTAGES OF FRACTAL GEOMETRY:

1. Small in size.
2. Better input impedance.
3. Wideband and multiband support.
4. Easy fabrication and low cost.

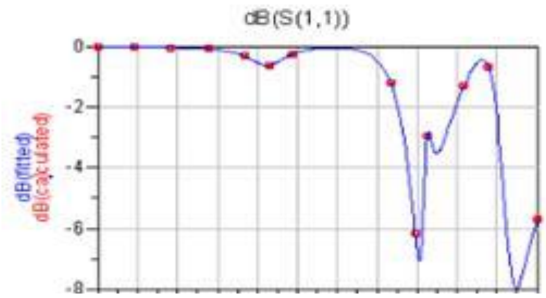
APPLICATIONS:

1. Leaves of the trees.
2. A DNA molecule.
3. Various veins in our hands.
4. Irregular patterns of clouds.

V. RESULT

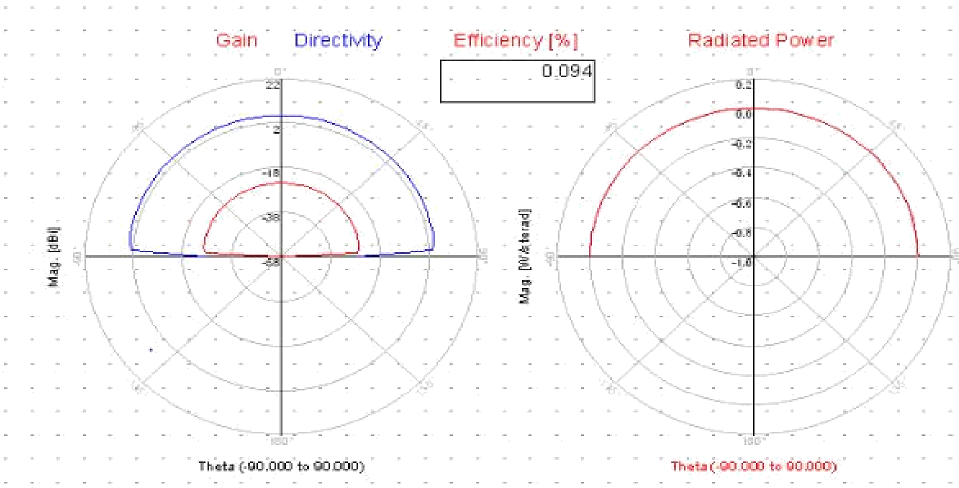
The proposed antenna geometry fulfills the self similarity property of fractal structure and exhibits multiband characteristics. The antenna is driven in resonant at the frequency band 2.12t-2.40 GHz, 4.0-4.83GHz, 7.40-7.60GHz and 8.82-10GHz.The first experimental prototype of the antenna has designed to opera it can be considered as a simultaneous multi and wideband opera of modified Koch fractal antenna for all four iteration have been detailed. Resonating characteristics at four resonant frequencies. In order to gain good enough size reduction and easy manufacturability we have designed the fractal geometry until the second iteration. The physical size of the designed fractal antenna element is 19 mm. Simulation results including the far field pattern, input reflection can be seen on figure 7, 8. After the simulations had made the antenna array was fabricated. Measured input reflection also can be seen on figure. The input reflection curve shows similarity between measured and simulated result.

During the course of optimization a trade-off must be made between the input reflection and the radiation pattern. The better the input reflection is the more the major beam splits into individual sections. To obtain better monopulse like characteristic, the splitting of the major beam cannot be accepted. Figure 8 and 9 shows the radiation pattern variation both in E-Plane and H-plane for different feed positions, while figure 10 shows the input reflection for different feeding offset. Thus to satisfy these conditions the radiation pattern of the antenna system has been optimized in the expense of input reflection.



(Measured and simulated input reflection)

The first investigated parameter for the planar monopole structure is its substrate length. Its effect on the antennas bandwidth in 0.5mm and1mm steps it can be observed that with an increasing length of L, The resonant frequency is shifting downwards.



Gain:

The gain of an antenna is the ratio of the maximum radiation intensity is given direction to the maximum radiation intensity from a referenced antenna in the same direction with same power input.

TABLE-1 [ANTENNA PARAMETER]

Iteration	Resonant frequency (GHz)	VSWR	Return loss (db)	Peak gain
1st	1.636	1.16	-22.63	2.26
	4.727	1.44	-14.75	4.52
2nd	2.727	1.16	-22.42	4.40
	4.455	1.15	-22.69	4.22
	8.182	1.0	-27.42	5.08
3rd	4.727	1.51	-13.78	3.63
	7.545	1.34	-16.62	4.30
	9.455	1.29	-17.95	5.14

VI. CONCLUSION

With the presented modifications on inverted Koch fractal geometry almost the same performance can be achieved as with the original one. The achieved 60 percent size reduction proves the applicability of the proposed geometry in antenna array where available space is an important factor. With careful design a reasonable trade-off can be made between the input reflection and the far field pattern of the antenna.

VII. ACKNOWLEDGMENT

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