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A Novel Fractal Antenna in Planar Configuration for Wireless Devices

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Abstract**—***In today's wireless communication, there has been an increasing need for more compact, portable and wideband radiators. There is a need to evolve antenna designs to minimum size which can be used in many practical applications in modern 2G, 3G, LTW, WiFi and WiMax wireless communications systems. Fractal antenna is one such antenna which is irregular in shape and it is mainly used for wireless applications. Thus, the objective is to design a novel fractal geometry which exhibits self similarity property and can be confined to space. The new proposed fractal antenna is designed in such a way that it can be operating at a frequency of 2.4GHz. This structure is built up through replication of a base shape, improving antenna performance. The purpose of this project is to explore fractal elements antennas through simulation and design experimentation. In the proposed approach, simulators are carried out using FEKO simulator 6.1 and the results are compared with the existing structures of monopole and Koch fractal. The design is implemented in planar structure also to improve its characteristics when compared to the wire monopole.*

Keywords—Fractal antenna, Koch fractal, Antenna radiation pattern, Theta gain and Phi gain.

I. INTRODUCTION

An antenna is the basic elemental components of the communication system. An antenna or aerial is an electrical device that converts electric currents into radio waves and vice versa and therefore antenna performs as a transducer. Antennas operate as a link between the source to free space or free space to recipient. The uniqueness of the communication system is mainly dependent on the characteristics of the antenna used in the system. The antenna is used in wide varieties of applications. Radio waves are the electromagnetic waves that carry signals via air or through free space at the speed of light with almost no transmission loss. Radio source as well as recipient are mainly used to convey signals or information in systems including broadcast/audio or radio, television and mobile communication, Wireless Fidelity/Wireless local area network (Wi-Fi /WLAN) data and communication networks, peer-to-peer communications links such as phone, data networks, satellite links, many other remote controlled devices such as garage door openers, and wireless remote sensors etc. This paper presents the objective to design a novel fractal antenna in planar configuration which exhibits stable gain and wider bandwidth. The fractals are a geometrical shape, which exhibits self similar, repeating themselves at different scales. Fractal antenna are widely used in applications across many industries, military, public safety applications.

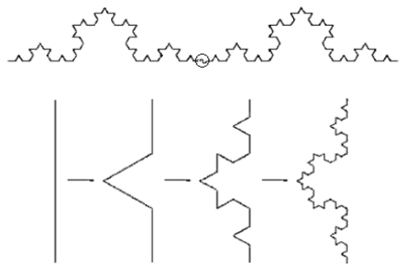

Fig.1: Iterated Fractal antenna

II. DESIGN OF MONOPOLE IN PLANAR CONFIGURATION

The monopole antenna is designed for the frequency of 2.4GHz. The height of the antenna is quarter of its wavelength and the wavelength is obtained by using the formula c0/f, where 'c0' represents the velocity of wave in free space and 'f' represents the designed frequency. As the model unit is set as centimeters the lambda value is multiplied by 100. The calculated height of our antenna is 3.125cm for the corresponding frequency. The feed point acts both as the transmitter and the receiver. A cuboid surface is created as a planar surface and its outer boundary is dielectric and the bottom surface of the cuboid will be perfect conductor. A rectangle surface is created which acts as the ground plane for the monopole. The monopole antenna is placed on the planar surface. The feed is given in between the inner and outer boundary. We have considered the parameters of reflection coefficients, VSWR measurement, impedance magnitude and gain of the antenna. The radiation pattern for monopole antenna is Omni-directional and is represented in 3-D view and the above mentioned parameters are analyzed for various frequencies.

III. DESIGN OF KOCH FRACTAL IN PLANAR CONFIGURATIONS

The first iteration of the Koch monopole fractal antenna was designed for the frequency 2.4GHz. The fractal structure is formed by dividing the total length into three equal segments and each segment length is 1.0416cm. Remove the center part and add an equilateral triangle pointing outwards. The first and the last segment should not be changed. The total wire length obtained is 4.166cm. A cuboid surface is created as a planar surface and its outer boundary is dielectric and the bottom surface of the cuboid will be perfect conductor. The second and third iteration of Koch fractal is designed using 2.4GHz. The length of the Koch fractal for the second and third iteration is 4.166cm and 5.566cm.

IV. DESIGN OF NOVEL MEANDER ANTENNA IN PLANAR SURFACE

The new proposed fractal monopole design procedure is given in the following steps:

Step 1: A cuboid surface is created as a planar surface and its outer boundary is dielectric and the bottom surface of the cuboid will be perfect conductor.

Step 2:The total height of the monopole antenna is divided into five segments. All the segments should be of equal length of h/5.

Step 3: The second segment is removed and a square pulse is added pointing upwards.

Step 4: The fourth segment is removed and a square pulse is added pointing downwards. The other three segments (1, 3, 5) need not to be disturbed.

This proposed fractal monopole is designed for the frequency of 2.4GHz. The wavelength is obtained by l=c0/f*100 and the height h=l/4.

l = wavelength
c0 = velocity of light in free space ($3x10^8$m/s)
f = desired frequency in hertz
h = height of monopole antenna

Step 5: Repeat the step 2, 3, 4 for further iterations.

The increase in total wire length for Koch and Proposed fractal antenna is shown in table 1. The total wire length increases highly for novel meander fractal than for the Koch monopole. The design of Novel meander fractal antenna in planar configurations is shown in the Figure 2.

Table 1: Comparisons of wire lengths

Iterations	Monopole	Koch	Meander
1	3.125cm	3.125cm	3.125cm
2	3.125cm	4.166cm	5.625cm
3	3.125cm	5.556cm	10.125cm

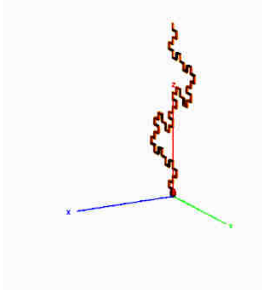

Fig.2: Iterated Novel meander fractal antenna

V. SIMULATION RESULTS

5.1. ANALYSIS OF ANTENNA PARAMETERS

Various parameters of proposed fractal antenna are analyzed and are compared with the results of both monopole antenna and Koch fractal monopole antenna with the substrate. The main considerations in our design are the antenna gain, VSWR, impedance and reflection coefficient.

5.2 RESULTS OBTAINED FOR THE KOCH MONOPOLE

The analysis results of Koch wire monopole without using any substrate is depicted in the Fig.3. and the voltage source is given at one end of the wire monopole.

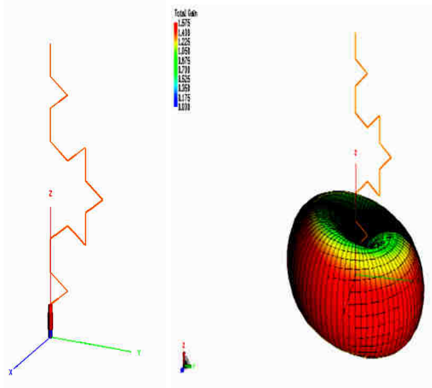

Fig.3: Koch fractal antenna and its radiation pattern

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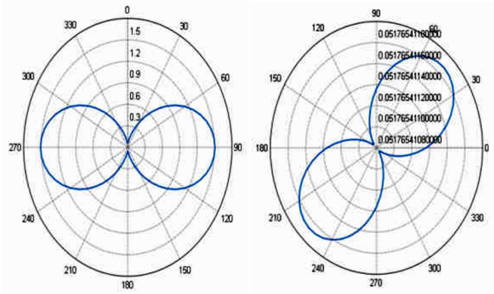

Fig 3.a: Theta gain and Phi gain at the frequency of 1.0GHz

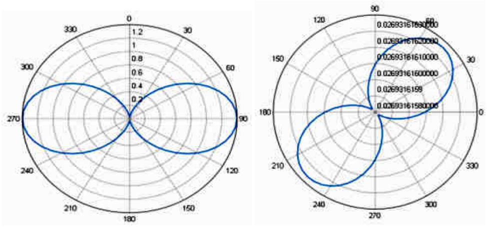

Fig.3.b Theta gain and Phi gain at the frequency of 2.4GHz

5.3 RESULTS OBTAINED FOR NOVEL MEANDER ANTENNA

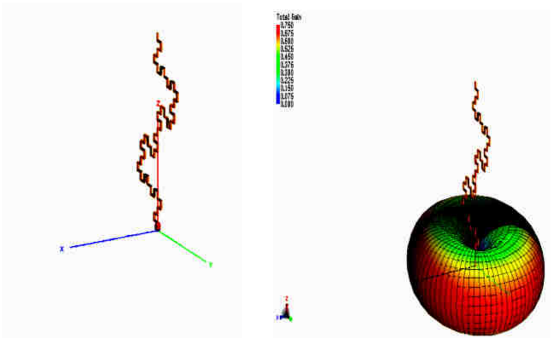

Fig.4: Novel Meander antenna and its radiation pattern

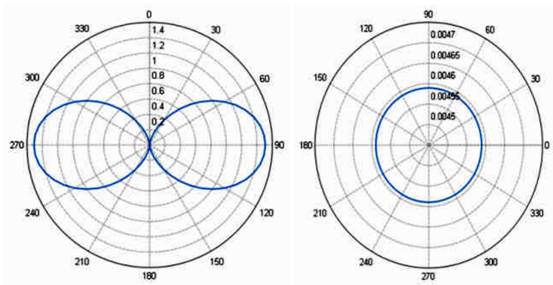

Fig.4.a Theta and Phi gain at the frequency of 1.0GHz

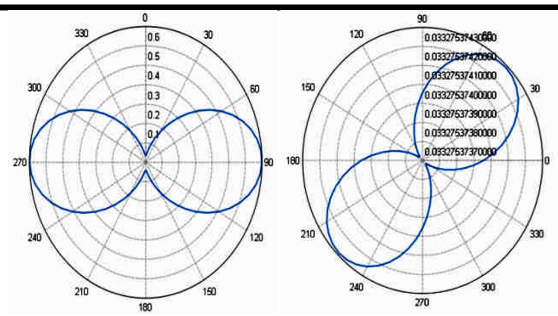

Fig.4.b Theta and Phi gain at the frequency of 2.4GHz

5.3 RESULTS OBTAINED FOR MONOPOLE WITH SUBSTRATE

A monopole rod is placed on the substrate to make it as a planar structure. A wire monopole of radius 0.02 centimeter is converted into an rectangular strip of width 0.08 centimeter. The outer surface boundary is dielectric, whereas the bottom surface is perfect electric conductor which acts as a ground for the voltage source excited on the port. The simulation results are shown in the Fig.5 below.

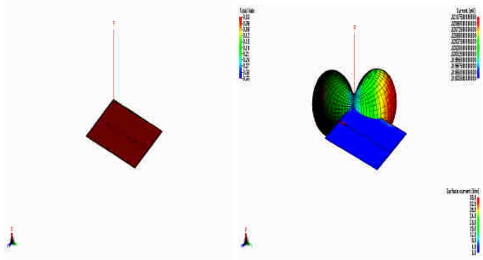

Fig.5: Monopole antenna with substrate and its radiation pattern

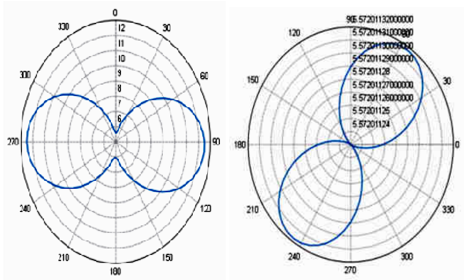

Fig.5.a: Theta and phi gain at the frequency of 1.0GHz

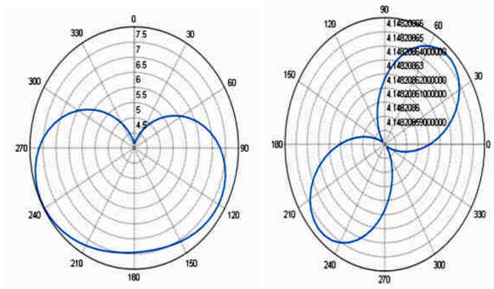

Fig.5.b: Theta and phi gain at the frequency of 2.4GHz

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5.4. RESULTS OBTAINED FOR THE NOVEL PLANAR FRACTAL 2ND ITERATION WITH SUBSTRATE

A novel meander line fractal antenna, which is placed on the FR4 substrate of thickness 0.02 centimeter and its radiation pattern which has been designed in planar configuration including theta and phi gain pattern is shown in the Fig.6.

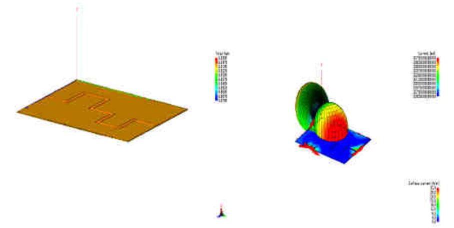

Fig.6: Novel fractal antenna of 2nd iteration with substrate and its radiation pattern

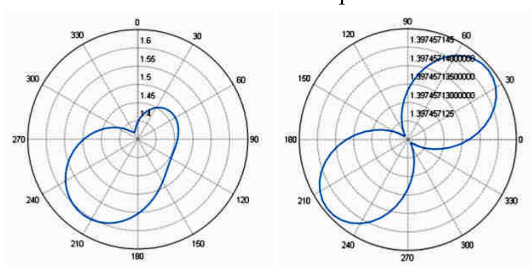

Fig.6.a: Theta and phi gain at the frequency of 1.0GHz

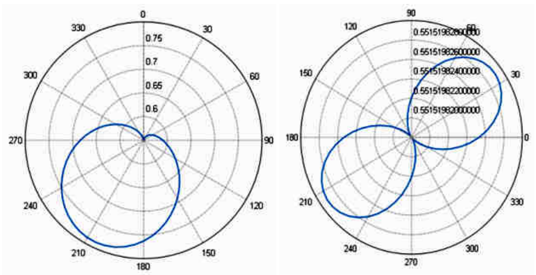

Fig.6.b: Theta and phi gain at the frequency of 2.4GHz

5.5. RESULTS OBTAINED FOR THE NOVEL PLANAR FRACTAL 3rd ITERATION WITH SUBSTRATE

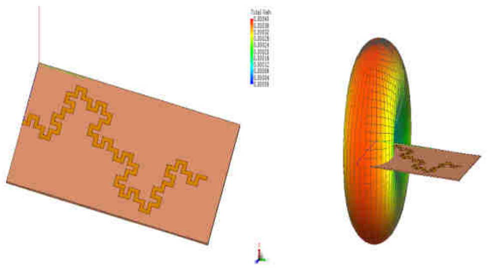

Fig.7: Novel planar fractal antenna 3rd iteration and its radiation pattern with substrate

The Fig.7 shows the design of novel planar fractal antenna, which is placed along xy-plane and its radiation pattern. The current distribution in the novel planar fractal antenna is shown in the Fig.8.in which the red color denotes the maximum distribution of current along the antenna surface.

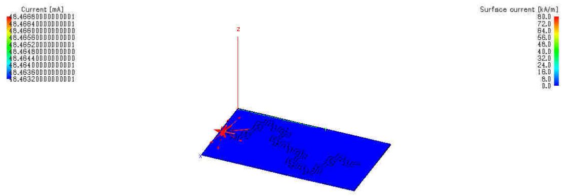

Fig.8: Current distribution in the novel planar fractal antenna.

VI. CONCLUSION

This new proposed fractal monopole is an efficient radiator with the ability to handle the frequency 2.4GHz without a matching network. Significant size reduction was achieved as compared to the traditional antennas. The characteristics of new fractal antenna were analyzed between the frequency ranges of 'f-2.2GHz' to 'f+2.2GHz'. It is observed that it exhibits good performance, reflection coefficient, VSWR and real impedance at all the analyzed frequencies. This proposed antenna features several controlling parameters making it very flexible in terms of band allocation and fine tuning. The design and development of a new fractal can be efficiently used in many handset devices. A Novel planar fractal antenna is also designed by implementing the meander line structure as a rectangular patches on the cuboidal surface. The parameters are analyzed for this design.

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