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MULTIBAND MINIATURISED FRACTAL ANTENNA FOR MOBILE COMMUNICATIONS

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ABSTRACT

Fractal antennas are found to be advantageous because of their small size and multiband functionality. This paper proposes a composite miniaturized fractal antenna as a combination of Minkowski and Koch curves. The structure of the proposed antenna is the result of the modifications made with the basic fractal square and triangular curves. The design and simulation have been performed using a full-wave 3-dimensional electromagnetic simulator. The antenna can be used for most handheld devices and thus finds wide applications in the field of wireless and mobile communication.

KEYWORDS: Antenna, Fractal, Microstrip Feed, Miniaturization, Multiband

INTRODUCTION

In view of the progress in the field of modern communication systems and increase in the number of application areas with vital requirements such as small size, light weight and better performance, the miniaturized multiband antennas are in great demand. Microstrip patch antennas are a class of miniaturized antennas with many advantages like light weight, conformability, low cost etc. For simple radiating patch shapes, the design can be carried out easily. However, being a high Q electromagnetic structure, a microstrip antenna exhibits a narrow bandwidth. Many times it is considered as one of the major limitations. On the other hand, fractal antennas have attracted the attention of the researchers because of the features like small size and multiband characteristics.

The fractal geometry was first defined by B. Mandelbrot to describe complex geometries and it was generated with an iterative procedure. Followed by his concept, there had been many reports proposed by researchers with different fractal structures in the recent years. Sierpinski fractal antenna is based on the triangular (gasket) filled shape, Koch snow-flake fractal antenna is developed using triangular curve and the Hilbert or Minkowski fractal antenna design is based on the square curve. Fractals have plane or space filling and the self-similarity properties.

The use of fractal geometries in antenna design has shown to be a good strategy in order to attain the following benefits: broadband and/or multiband frequency response, compact size compared to conventional designs while maintaining good efficiencies and gain, mechanical simplicity and robustness and flexibility of designing for particular multi-frequency characteristics. Fractal antennas are mainly categorized into four types such as fractal line antennas, fractal three-dimensional antennas, fractal planar antennas and fractal antenna arrays. In this project, the design of fractal planar antenna as a combination of Minkowski and Koch curves is considered.

LITERATURE SURVEY

The term fractal, which means broken or irregular fragments, was originally coined by Mandelbrot to describe a family of complex shapes that possess an inherent self similarity in their geometrical structure. A new miniaturized fractal antenna as a combination of Minkowski and Koch curves can be developed. The structure of the proposed antenna is the result of the modifications made with the basic fractal square and triangular curves. The design and simulation have been performed using IE3D; a full-wave electromagnetic simulator.

The simulation with microstrip feed and coplanar waveguide feed systems and the results reveal that both the designs are extremely good in terms of multiband operations. The final design is a radiating fractal antenna separated from the ground plane by the substrate with a thickness of 1.6mm. In this case, both the radiating structure and the CPW are in the same plane on the substrate. Copper is used for designing the radiating structure.

The thickness of the copper layer is 0.016mm [1]. The substrate is FR4 with relative epsilon 4.4 and board size 52mm x 20mm. This is preferred because of ease of fabrication and availability. Another simulation is also performed for the same antenna with CPW feed system. The results of simulation show that the new Minkowski-Koch fractal antennae perform satisfactorily and yield good results. They provide good radiation pattern, appreciable gain, directivity and efficiency at resonant frequencies. Moreover, these antenna structures provide resonant frequencies at 2.29, 4, 4.17, 4.24, 5.71, 6.18, and 9.13GHz with good bandwidths.

Multiband Microstrip Fractal Antenna for Next Generation Networks

In today's era rapid increase in the need and demand for next generation wireless network application driven the antenna designers to design new antennas that simultaneously appear miniaturized and at the same time useful for many wireless standards. So the biggest requirements for an antenna are, to work for many [1]applications simultaneously and its small size [2]. For performing multi-application operations at a single time, multiband characteristic is required. These multiband characteristics can be achieved by using the concept of fractal antenna. A folded-slot fractal antenna can be designed by using Koch iteration technique. The proposed antenna is designed and simulated in HFSS. The designed antenna is showing less than -10 dB return loss for six frequency bands including 2.37 GHz, 4.00 GHz, 5.57 GHz, 6.11 GHz, 7.27 GHz and 8.95 GHz with return loss -22.28 dB, -18.43 dB, -14.85 dB, -25.05 dB, -18.43 dB and -11.88 dB respectively. These results show a good agreement with next generation mobile terminal applications.

Radiation patterns with return loss less than -10 dB are considered perfect because below -10dB return loss, reflections are negligible. Radiation pattern is also plotted. Radiation pattern explains that antenna is radiating in Omni-direction [3]. This is always desirable for the applications like mobile applications and multiband support make it multi-application compatible.

A new form of a hybrid design of a microstrip-fed parasitic coupled ring fractal monopole antenna with semi-ellipse ground plane is proposed for modern mobile devices having a wireless local area network (WLAN) module along with a Worldwide Interoperability for Microwave Access (WiMAX) function exists [3]. In comparison to the previous monopole structures, the miniaturized antenna dimension is only about 25 X 25 X 1 mm^3, which is 15 times smaller than the previous proposed design. By only increasing the fractal iterations, very good impedance characteristics are obtained [4].

The measured results illustrate that the proposed antenna offers a very good bandwidth and Omni directional -pattern up to 10 GHz. As a result, the proposed simple antenna can be very suitable for various applications of the future such as WiMAX/WLAN technologies for mobile and handheld devices. A fractal monopole antenna is proposed for the application in the UWB frequency range, which is designed by the combination of two fractal geometries. The first iterations of Giusepe Peano fractal are applied on the edges of a square patch, and a Sierpinski Carpet fractal is formed on its surface. [3]. The feed circuit is a microstrip line with a matching section over a semi-elliptical ground plane. The presented antenna has an Omni-directional radiation pattern, a good gain, and high efficiency. The fabrication and measurement data attest to the satisfaction of the design specifications. The selected substrate is FR4 with dielectric constant of 4.4, substrate thickness 1.6 mm, and loss tangent of 0.02. The metallic square patch has dimensions 20 X 13 mm^2. The feed line is designed for 50-Ω characteristic impedance, where its width is 3 mm. The feed line is tapered for impedance matching. The ground plane is a combination of rectangular and elliptical sheets. Its dimensions are optimized by the HFSS12 simulation software, which is also used for the analysis of the antenna. The comparison of antenna characteristics (namely gain, return loss, radiation efficiency, and SWR) of the first and second iterations of the Giusepe Peano fractal indicates that the first iteration has more desirable characteristics and also a simpler fabrication process.

Composite Fractal Antenna Structure

This paper proposes a composite hybrid structure which is a combination of the basic triangular and Hilbert curves. The characteristics of both these antennas are combined into one structure and hence this antenna is an enhancement over others. It is tested in three different frequency bands (S, C and X bands shows its multiband functionality. Its dimension is also kept small enough so that its miniaturized structure can easily be used for mobile devices. This antenna has been simulated using 3-D simulator software that provides near accurate results in minimal time. It offers advantages of allowing versatility in the design process and enables the designer to implement different types of feeding techniques as well. Two iterations have been done. The antenna is a radiating patch and it is been supplied with a micro strip feed line. A substrate separates the conducting ground plane and the radiating structure thus forming a micro strip antenna. The radiation patterns are also plotted that helps in understanding the operation and characteristics of the antenna better.

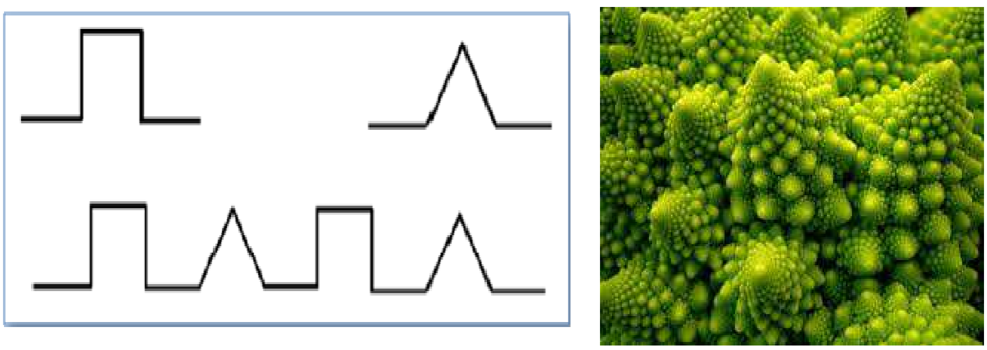


Figure 1: Fractal Antennas

METHOD

This paper aims at constructing a composite miniaturized fractal antenna that is a combination of the basic Koch and Minkowski fractal curves. The antenna is tested over three frequency bands, namely, the S band (2-4) GHz, C band (4-6) GHz and the X band (8-12) GHz. The performance of the antenna is compared in the three bands based on certain parameters like Directivity, Gain, Radiation Intensity and Radiation Efficiency.

The following steps are involved in the construction process:

- Creation of ground plane that is of PEC material and is (52x20x0.016) mm in dimension
- Creation of substrate which is assigned FR4 EPOXY material and is of dimension (52x20x1.6) mm
- Creation of patch fractal antenna structure that is of PEC material and dimension is (44x12x0.016) mm
- Providing the micro strip feed line with lumped port that is PEC material and dimension is (2x1.6) mm
- Specifying the radiation box that is perfect vacuum and of dimension (82x50x37) mm

The ground plane needs to be conductive as also the radiating patch antenna hence they are assigned with the PEC material. PEC is nothing but perfect electric conductor that has relative permeability and relative permittivity as equal to 1. On the other hand, the substrate needs to possess good dielectric properties so it is assigned with FR4 EPOXY material. This has a relative permittivity of 4.4 and relative permeability of 1. It is a glass fiber reinforced with epoxide base. Two iterations of the basic shapes have been done to obtain the fractal structure.

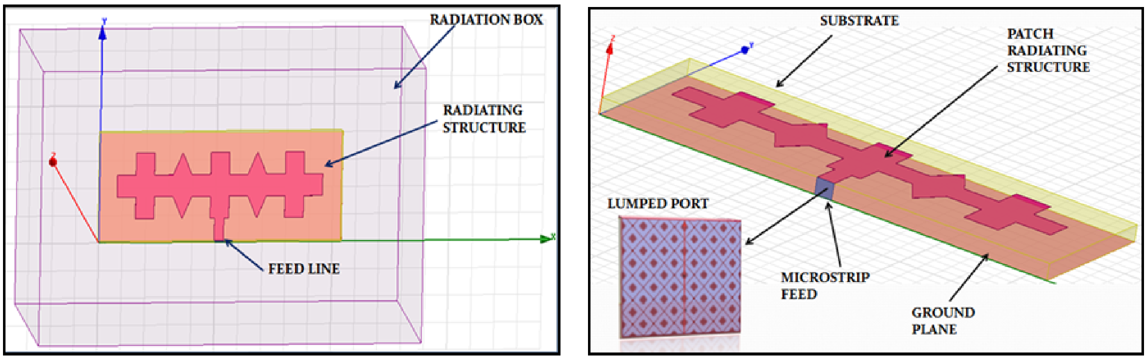


Figure 2: Multiband Composite Fractal Structure

RESULTS AND DISCUSSIONS

The simulated antenna is tested for multiband operation in three different bands, that is, the S band (2-4) GHz, C band (4-6) GHz and the X band (8-12) GHz. For all the three specific cases the directivity and gain polar plot is obtained which is a 2D polar plot and a 3D polar plot of the total electric field with the power levels also indicated. The plots are shown below. Apart from these plots, the Return Loss (S_{11} (in dB)) is plotted averaged over the three frequencies and also the VSWR (Voltage Standing Wave Ratio) is plot is obtained. Finally, a table is presented that compares some antenna parameter values in all the three bands.

The parameters taken for performance analysis are Maximum Radiation Intensity, Peak Directivity, Peak Gain and Radiation Efficiency. As can be observed from the tabular column, the antenna performs well in the C band from point of view of the radiation efficiency and the radiation intensity but on the other hand, the antenna shows good results in the X band when the directivity and the gain are considered. The performance of the antenna is satisfactory in the S band.

Case 1: 4 GHz

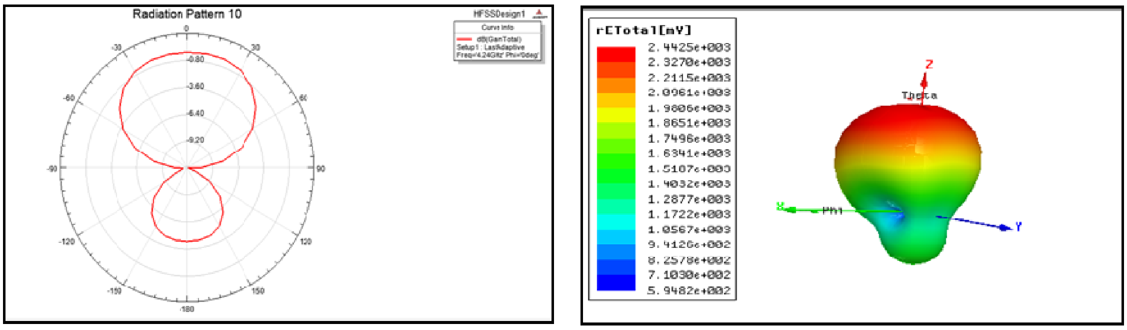


Figure 3: Radiation Pattern and Directivity Plot for 4GHz

Case 2: 6 GHz

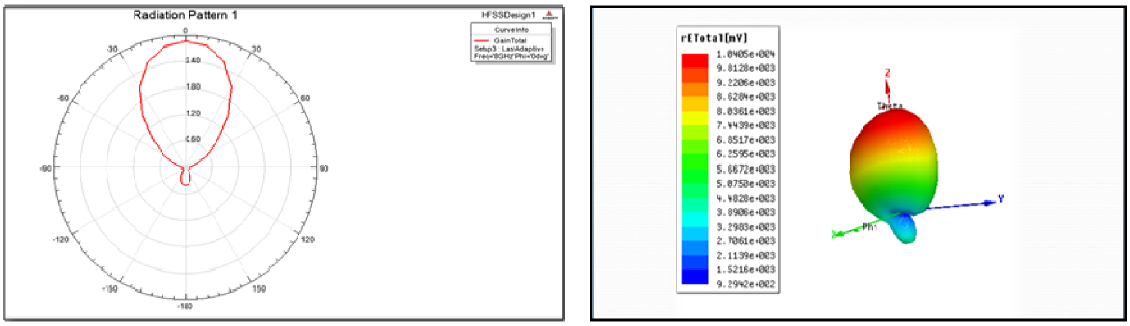


Figure 4: Radiation Pattern and Directivity Plot for 6GHz

Case 3: 12 GHz

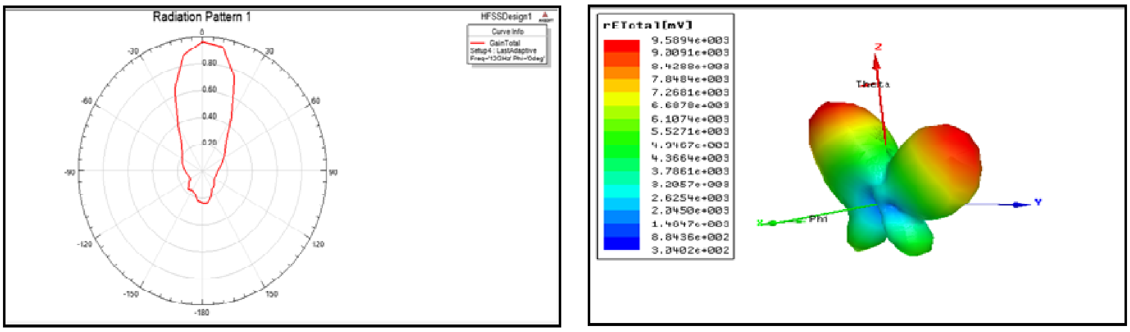


Figure 5: Radiation Pattern and Directivity Plot for 12GHz

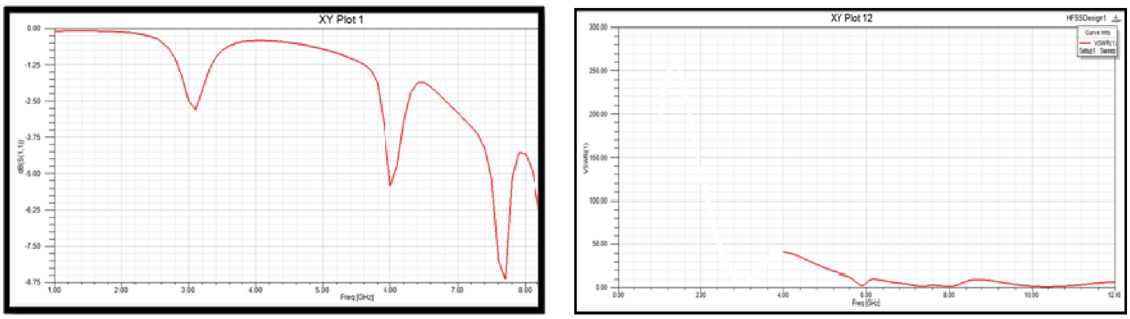
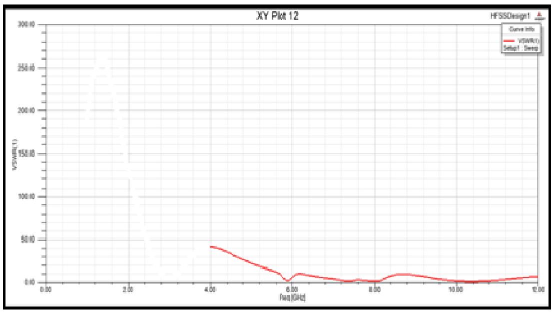


Figure 6: VSWR and Return Loss Plots across the Frequency Bands



FREQUENCY	MAX U (W/Sr)	PEAK DIRECTIVITY	PEAK GAIN	RADIAITON EFFICIENCY
4 GHZ (S band)	0.0079122	2.6579	1.0281	38.68 %
6 GHz (C band)	0.14359	4.5905	2.8597	62.29 %
12 GHz (X band)	0.12196	5.9718	3.6452	61.04 %

Figure 7: Tabulation of Comparison for Different Frequency Bands

CONCLUSIONS

Fractal antennas offer great advantage over the conventional structures because they are compact, mutual coupling is less and most importantly, for their multiband/wideband behaviour. The antenna that has been designed in this paper offers a new perspective because it is a combinational structure of two different fractal antennas. The performance analysis of this antenna has been done by carrying out a comparative study of the behaviour of the antenna in three frequency ranges. The radiation patterns that are plotted help to visualize the scenarios better while the tabulated parameter values provide a clear picture of actual statistics.

It has been observed from the tabulations that the antenna performs well in the C and the X band while it provides satisfactory operation in the S band. The antenna designed exhibits resonance at three different frequency bands and it finds application in the various wireless devices. The position of the feed is very important for getting good results. The future work of this project would include optimization of the design in terms of the exact position of the feed so that further accuracy is achieved in the results, incorporating other types of feeding techniques such as coplanar waveguide feed, inset feed and testing the antenna for these variations and fabricating and testing the fabricated antenna to measure the degree of closeness of the simulated and the actual values.

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