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Design and Analysis of a Multiband Rectangular Fractal Antenna

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Abstract- This review presents the design and investigation the multiband rectangular fractal antenna. It is designed with the combinations of fractal geometries. Fractal technology has great potential in antenna miniaturization; multi-frequency, ultra-wideband application, and this paper are about fractal technology in the application of multi-frequency microstrip antenna. We studied the multirate characteristics of multiband rectangular fractal antenna, using high frequency structural simulator. The current communication system has been developed to the broadband and integration; meanwhile people's needs for portable mobile communication are higher. Future communications will put more serious technology challenges for antenna, demanding a miniaturized structure to complete antenna miscellaneous tasks. Fractal antenna can meet the need antenna requirements of modern communication thin section, small size, being easy to manufacture and low price.

Keywords:- antennas, multi-band antennas, fractal antennas, monopole antenna, antenna miniaturization.

I. INTRODUCTION

Fractal technology has great potential in antenna miniaturization, multi-frequency, ultra-wideband application, and this paper are about fractal technology in the application of multi-frequency microstrip antenna. Based on the fractal structure design of Sierpinski, we studied the multirate characteristics of multiband rectangular fractal antenna, using high frequency structural simulator. The current communication system has been developed to the broadband and integration; meanwhile people's needs for portable mobile communication are higher. This requires antenna development conesponding broadband technology, multifrequency technology and miniaturization. Multifrequency antenna has been taken more and more attention, with its small volume, light weight, easy and active circuitry integration advantages, especially along with the rapid development of wireless communications. Antenna of multifrequency, miniaturization, wideband and circular polarization such technology will be the domestic and foreign research hotspot. Future communications will put more serious technology challenges for antenna, demanding a miniaturized structure to complete antenna miscellaneous tasks. Fractal antenna can meet the need ntenna requirements of modern communication thin section, small size, being easy to manufacture and low price. Fractal is produced with the self-similarity of fractal dimension structure through iterative, not only realized the antenna of miniaturization, but also strengthened the directional antenna. The antennas produce low frequency resonant modes. Fractal antenna solved two limitations of the traditional antenna:

l) Commonly used antenna performance is highly dependent upon the antenna electricity size. This means that main antenna parameters (gain, input impedance, and orientation graph and side lobe electricity equality) will changes as working frequency for fixed antenna size. Fractal self-similarity make fractal antenna how frequency and broadband characteristics.

2) Fractal complex shapes make some antenna's size get reduced. The research of fractal antenna in military and civilian have a widely application prospect.

Fractal shaped antennas have already been proven to have some unique characteristics that are linked to the geometrical properties of fractal. Self-similarity of fractal makes them especially suitable for multi-frequency applications. When the size of an antenna is made much smaller than the operating Wavelength, theoretically, it becomes highly inefficient. Its radiation resistance decreases proportionally, along with the rapid increase of stored reactive energy.

Fractal Antennas Elements:-

There are many benefits when we applied these fractals to develop various antenna elements. By applying fractals to antenna elements:

• We can create smaller antenna size.
• Achieve resonance frequencies that are multiband.
• May be optimized for gain.
• Achieve wideband frequency band.

Most fractals have infinite complexity and detail that can be used to reduce antenna size and develop low profile antennas. For most fractals, self-similarity concept can achieve multiple frequency bands because of different parts of the antenna are similar to each other at different scales. The combination of infinite complexity and self similarity makes it possible to design antennas with various wideband performances.

We need fractal antenna due to the following facts:

- Very broadband and multiband frequency response that derives from the inherent properties of the fractal geometry of the antenna.
- Compact size compared to antennas of conventional designs, while maintaining good to excellent efficiencies and gains.
- Mechanical simplicity and robustness; the characteristics of the fractal antenna are obtained due to its geometry and not by the addition of discrete components.
- Design to particular multi frequency characteristics containing specified stop bands as well as specific multiple pass bands.

FRACTAL GEOMETRY

There are many fractal geometries that have been found to be useful in developing new and innovative design for antennas. Figure [1] below shows some of these unique geometries.

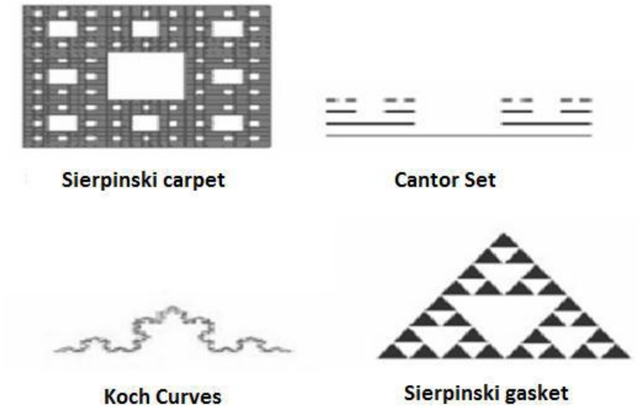

Figure 1:- Types of fractal geometries.

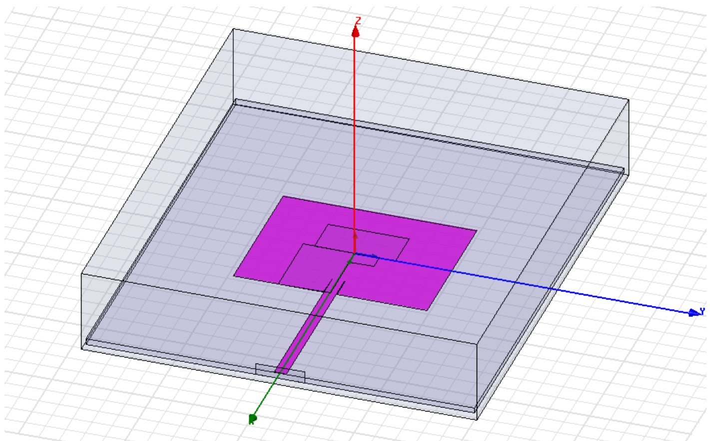

Figure 2 Structure of designed antenna.

II ANTENNA DESIGN

Microstrip antenna is a simple antenna that consists of radiated patch component, dielectric substrate, and ground plane. The radiated patch and ground plane is a thin layer of copper or gold which is a good conductor. Each dielectric substrate has their own dielectric permittivity values. This permittivity will influence the size of the Antenna. Microstrip antenna is a low profile antenna. They have several advantages like light weight, small dimension, cheap and easy to integrate with other circuits which make it chosen in many applications.

ANTENNA PROPERTIES: - The performance of the antenna is determined by several factors. Properties of those factors are as follows:

- **Input Impedance:-** Generally, input impedance is important to determine maximum power transfer between transmission line and the antenna. This transfer only happen when input impedance of antenna and input impedance of the transmission line matches. If they do not match, reflected wave will be generated at the antenna terminal and travel back towards the energy source. This reflection of energy results causes a reduction in the overall system efficiency.
- **Gain: -** The gain of an antenna is essentially a measure of the antenna's overall efficiency. If an antenna is 100% efficient, it would have a gain equal to its directivity. There are many factors that affect and reduce at the overall efficiency of an antenna. Some of the most significant factors that impact antenna gain include impedance matching, network losses, material losses and random losses. By considering all factors, it would appear that the antenna must overcome a lot of adversity in order to achieve acceptable gain performance.

- **Radiation Pattern: -** The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. All antennas if 100% efficient, will radiate the same total energy for equal input power regardless of the pattern shape. Radiation patterns are generally presented on a relative power dB scale.
- **Directivity:-** Directivity, D is important parameter that shows the ability of the antenna focusing radiated energy. Directivity is the ratio of maximum radiated to radiate reference antenna. Reference antenna usually is an isotropic radiator where the radiated energy is same in all direction and has directivity of 1. Directivity is defined as the following equation:

$$D = F_{max} / F_0$$

Where, F_{max} = Maximum radiated energy
F_0 = Isotropic radiator radiated energy

- **Polarization:-** The polarization of an antenna describes the orientation and sense of the radiated wave's electric field vector. There are three types of basic polarization:
  - Linear polarization
  - Elliptical polarization
  - Circular polarization
- Generally most antennas radiate with linear or circular polarization. Antennas with linear polarization radiate at the same plane with the direction of the wave propagate. For circular polarization the antenna radiate in circular form.
- **Bandwidth:-** The term bandwidth simply defines the frequency range over which an antenna meets a certain set of specification performance criteria. The important issue to consider regarding bandwidth is the performance tradeoffs between all of its performance properties described above. There are two methods for computing an antenna bandwidth. An antenna is considered broadband if $f_H/f_L \geq 2$.

Narrowband by % age
$BW_p = (f_h - f_l)/f_0 \times 100\%$
Broadband by ratio
$BW_b = f_h/f_l$
where f_0 = Operating frequency
f_h = Higher cut-off frequency

- f_l = Lower cut-off frequency
- **FEEDING TECHNIQUES:-** Feeding techniques [1-2-13] are important in designing the antenna to make antenna structure so that it can operate at full power of transmission. Designing the feeding techniques for high frequency, need more difficult process. This is because the input loss of feeding increases depending on frequency and finally give huge effect on overall design. There are a few techniques that can be used.

1. Microstrip Line feeding
2. Coaxial Probe feeding
3. Aperture Coupled feeding
4. Proximate Coupled feeding
5. CPW feeding

III. METHODOLOGY

We will use CST (Computer Simulation Technology), IE3D type's software for design and analysis. CST's high performance software is used for the design and electromagnetic analysis of all kinds of antenna systems. This software are given great flexibility in tackling a wide application range.Multi-frequency antenna has a low frequency operation also has a high frequency bandwidth and operating bandwidth. A fixed space often has many different communication systems, these wireless systems need to work on different operating frequency and pattern. If we can use one or very few antenna wireless systems that can meet these requirements, then no matter the cost size and weight of the system that are very meaningful. There are many methods of designing multi-frequency antenna. Resonant frequency of the antenna with the main unit placed near the resonant frequency of a parasitic element to another, you can get a dual-band antenna, which is to obtain dual-band antenna, the easiest method. The two works in different frequency antenna elements fed by a serial port work is also a way to achieve dual-band. Another way to obtain two resonant frequencies while the impedance matching.

The proposed model is designed using three iterative steps. Here the same radiating patch is used throughout the steps. But, the ground plane shape is modified in the consecutive steps. Starting from a triangle and superimposing another similar inverted triangle upon it and so on we have obtained the required geometry. The antenna is along XY plane. Along positive Y axis the antenna has rectangular geometry and that along negative Y axis has triangular geometry. The feed source point of this antenna is placed at origin (0,0,0) and this source set at 1 volt. The designed frequency has been chosen to be 900 MHz the corresponding wavelength is 0.33 m (33 cm).

Characteristics of fractalling:-

1) *Fractal set has any details of the proportion of small scale, that is, it has unlimited fine structure;*
2) *Fractal sets can not be described with traditional geometrical language, it is neither some simple equation' solution set, nor the locus of points which meet certain conditions;*

3) *Fractal sets have some form of self-similarity, including similar and statistically are self-similar;*
4) *In most interesting cases, fractal sets were defined by very simple method such as by transform iterations;*
5) *Defined by a certain dimension, fractal dimension of fractal sets is greater than the corresponding topological dimension.*

All Fractal have one important feature: by a feature number, that is the fractal dimension to measure the roughness, degree of complexity or convolution. For the characterization of fractal geometry is not limited within a certain plane figure or form of mathematics, fractal geometry can also be used to describe the characteristics and simulation of complex shape of certain entities in nature.

IFS fractal generation system:-
Iterated function system (IFS) is the general method to describe the fractal structure, it creates a series of self-affine [3, 5] on the basis of transformation *w*) Where the *a, b, c, d, e* and *f* are real numbers. The *a, b, c* and *d* control the rotation and scale transformation; the *e* and *f* control of linear shift. Assume *w1 w2…wn* are a series of linear affine transformation and the *A* represents the initial graph. By application transform of *A*.
Sierpinski Rectangular:-This process is continuously removed the small inverted triangle in the center of the original triangle. This process will produce 3*k* smaller triangle, and the area is (3/4)*k*, where *k* is the number of iterations. The side length of the triangle of each level is 1/2 of the side length of the top grade triangle .The final Sierpinski triangle contains numerous small triangular,and have maintained self-similarity at any scale.
The dipole antenna, based on the first and second iterations of square Koch antenna, has been modeled, analyzed, and its performance evaluated using the commercially available software 4NEC2. The Method of Moment (MoM) is used to calculate the current distribution along the square Koch curve, and hence the radiation characteristics of the antenna [9]. Typical geometry of square dipole antenna is based on the first and second iterations as shown in Figure 2 and 3, where the antenna is placed in the XY and YZ-plane. The feed source point of this antenna is placed at thve origin (0, 0, 0), and this source is set to 1 volt. The design frequency has been chosen to be 750 MHz for which the design wavelength λ is 0.4m (40 cm) then the length of the corresponding λ/2 dipole antenna length will be 20 cm, as shown in Figure 2.

IV. CONCLUSION

In modern wireless communication systems and increasing of other wireless applications, wider bandwidth, multiband and low profile antennas will be in great interest in both commercial and military applications. It has initiated antenna research in several directions; one of these is employing fractal shaped antenna elements. The intention of this project is usually to design and simulate the Koch and Gasket patch (microstrip) multiband fractal antenna. The behavior and properties of those antennas are investigated.

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