Design and Analysis of Fractal Antenna with circular slot for satellite communication

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ABSTRACT

*A novel fractal antenna has been developed for multiband application. The proposed antenna consists of FR4 substrate with Robert Koch fractal and microstrip feed lines. The whole dimension of the antenna is 17mm * 17mm. Fractal antennas are additional economical than standard antenna. Self-similarity property makes fractal antenna appropriate for multiband operation. Miniaturization of the antenna is achieved by space filling property of fractals. The resonant frequency of the planned antenna will increase, because the range of iteration of Robert Koch fractal will increase. The antenna structure was simulated by Advanced Design System (ADS) software system. The radiation characteristics like return loss, radiation pattern of the antenna are analyzed. The proposed fractal antenna can be used in the frequency range from 3-8GHz. This makes the fractal antenna a wonderful alternative for broadband and multiband applications and military applications. Additionally the fractal nature of the antenna shrinks its size, without the employment of any components, like inductors or capacitors.*

Keywords: *Fractal antenna, Antenna gain, Return loss, Efficiency*

1. INTRODUCTION

A fractal could be a rough or fragmented geometric form which will be divided in elements, every of that is (at least approximately) a reduced-size copy of the whole. Fractals are typically self-similar and independent of scale. The terms fractal and fractal dimension are due to Mandelbrot, United Nations agency is that the person most frequently related to the arithmetic of fractals [Mandelbrot, 1983]. Mandelbrot enclosed a definition of fractal dimension (of a geometrical object) when he first talked concerning the thought of fractal in 1977 [Lauwerier, 1991].

The combination of geometries is that the one thought of geometry to boost the electrical property. Electrical property suggests that reduced antenna size and increased resonant frequency band. Due to these valuable attribute, it will take prevalence in multi -function and multi-standard wireless instrumentation.

In 1975, B.Madelbrot outlined geometry that supported iteration method. Sierpinski seal, Koch curve, Hilbert curve etc. are different types of geometry. Fractal geometry has two distinctive properties, first one is self-similarity and second is space filling property. In this paper, the combination of triangular and circle geometries is employed and iteration method applied. To boost the return loss and gain, circle shape slot is cut on the patch and infinite ground plane is employed.

2. FRACTAL STRUCTURE

There are several mathematical structures that are fractals; e.g. Sierpinski's seal, Cantor's comb, von Koch's snowflake, the Mandelbrot set, the Lorenz three attractor, etc. Fractals conjointly describe several real-world objects, like clouds, mountains, turbulence, and coastlines that do not correspond to simple geometric shapes. Fractal shape provides the mandatory continuity to provide the meant form by combining itself. Fractal shapes have totally different dimension ideas, in contrast to the conventional shapes. The dimensions of fractal structure can be calculated as follows:

$$D = \frac{\log(N)}{\log(r)} \quad l = h\left(\frac{N}{r}\right)^{n}$$

where D is dimension, l is length, N is the number of parts of shape, r is the number of division in every iteration, h is height, and n is the number of iterations.

3. PROPOSED SYSTEM

The proposed design used combination of geometries like triangular and circle. To design the fractal geometry, we have a tendency to use the iteration method. In the initiator part, design created by combination of triangular and circle, in the meantime a circle is bring to a halt from the Triangle. This can be the initiator part of the proposed design. Next stage i.e.1st iteration is obtained by repetition of the previous method which means combine geometry is applied within the initiator part. In the 2nd iteration same method is repeated as previous stage. This was repeated upto five iteration Fig. 1 shows the stage of iteration method for the proposed design.

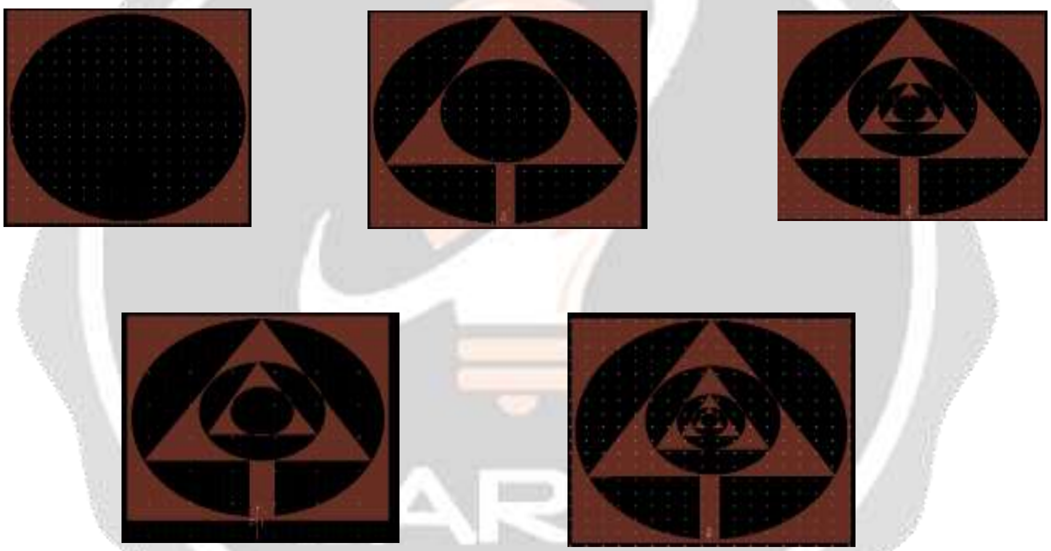

Fig -1: Stages of iteration

Iterated Function System:

IFS= set of contractive affine transformations

$$W(A) = \bigcup_{n=1}^{N} w_n(A)$$

Affine transformation,

$$w\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix},$$

Iteration process:

$$A_1 = W(A_0),\ A_2 = W(A_1),\ \cdots,\ A_{k+1} = W(A_k).$$

Where A_0 represents initial geomentry

4. ANTENNA DESIGN

Fig.2 shows the design part of the proposed antenna design. Ground plane having dimension 17 x 17 mm2, is the bottom part of the combine geometry antenna design. The material of substrate is FR-4 epoxy with relative permittivity 4.4 and loss tangent 0.019 having dimension 17 x 17 x 1.6 mm3. The combined fractal geometry antenna is printed on upper side of substrate surface. Probe Feed is used as feed mechanism. Microstrip feed has a width of 1.2mm and height of 5mm

Fig -2: Fractal antenna views in front side with four iterations

5. SIMULATION RESULT

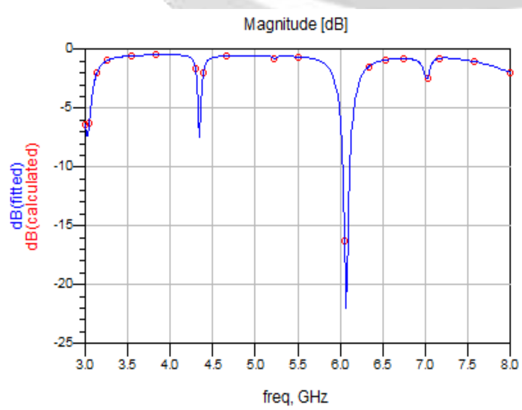

Fig -3: S_{11} of fractal antenna between 3 to 8GHz

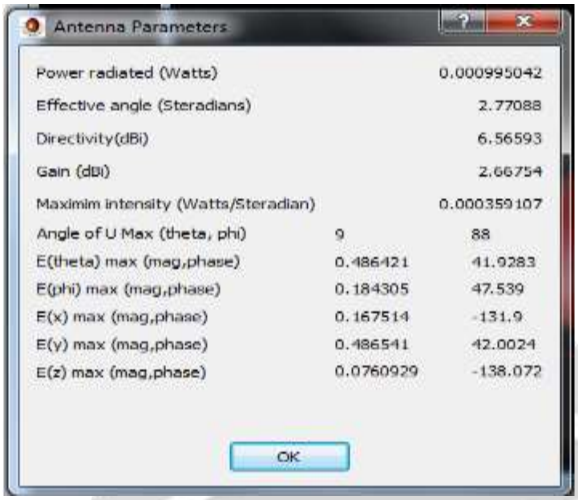

Fig -4: Gain of single fractal antenna

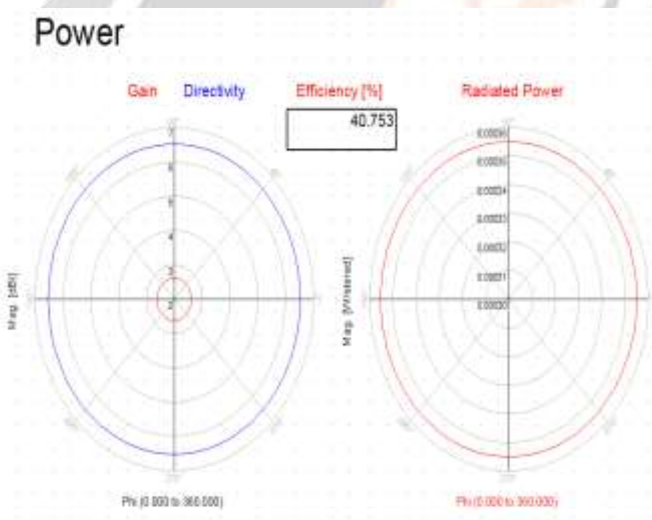

Fig -5: Efficiency of fractal antenna in percentage

6. RESULT AND DISCUSSION

Measured and simulated results for the fractal antenna are presented in this section. Antenna have been fabricated on an FR-4 board (with dielectric constant, ϵr = 4.7, and substrate thickness, t = 1.6 mm). Antenna operates well in 6.1 GHz frequency range. The antenna resonates at a single frequency, while five resonance frequencies are achieved by the fifth iteration fractal antenna. This shows that the number of resonant frequencies relates to the increase in the fractal iteration number. Antenna generates radiation patterns at both E- and H-planes. Gain produced by antenna is 2.6 dBi and return loss is about -24dB and efficiency is 40.75%.

7. CONCLUSION

In this paper combined geometry concept is used to get better result. Triangular and circle has used as a combined fractal geometry. To increase the return loss and gain, circular slots are cut on the patch. The proposed design is operate in the frequency range 3GHz – 8 GHz which satisfy the band specification of the ultra-wide band, So it can be used in C band (4-8GHz) and X Band (8-10 GHz). The proposed design has Omni directional radiation pattern in H-plane and symmetric in E-plane over the frequency range. This multiband fractal antenna can cover the frequency bands of satellite communication. Future work is foreseen to optimize the antenna by improving the return loss and pattern for satellite reception first by using another material like RT-Duroid.

8.REFERENCES

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