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Design of Multiband Antennas Using Sierpinski Gasket Geometry

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Abstract- In this paper fractal geometry have been used for antenna designs. In patch antenna Fractal is a concept which is being employed to have better characteristics than the other conventional microstrip antenna. For multiband wireless applications a Sierpinski Carpet fractal antenna is proposed. It consists of two-stage. Sierpinski Carpet fractal geometry used as a radiating element. This proposed antenna has compact dimension of 59.06×47.16×1.6 mm^3. The multiband characteristic for a return loss less than 10dB is achieved. The major advantage of Sierpinski Carpet antenna is, it exhibits high self-similarity and symmetry.

Index Terms- MSA, WLAN, EBG,

1. INTRODUCTION

Today's small handheld devices challenge antenna designers for ultrathin, convenient and high performance devices that have the capability to meet the multi standards [1]. This feature emerged antenna examination in different ways, one of the method is the use of fractal shaped geometry [2] [3]. Fractal is a concept extension to the microstrip antenna. In modern years many geometrical structures have been proposed with different degree of achievement in enhancing antenna characteristics.

Fractals can be found from natural surroundings or produced using mathematical formulae. Fractal was first invented by Benoit Mandelbrot, and he is known as the predecessor of fractal geometry. He stated, "I devised fractal from the Latin adjective". As compared with the Euclidean geometry antenna fractal are known for their ability to fill the space available more effectively. Fractals are geometrical structures, which are self-similar, repeating at regular intervals of time. One of the most distinctive characteristics of fractal is self-similarity [4]-[6]. Five important characteristics of fractals are given by

- They have details on arbitrary scales
- Fractals contains complex geometries.
- Fractal shapes possess self-similarity
- Fractals are defined by iterative rule
- Fractals have fractal dimension

2. SYSTEM REQUIREMENT

Sierpinski gasket is the basic fractal geometry to get multiband behaviour in antenna applications. This was invented by Polish mathematician Sierpinski. Inverted triangle is taken as a generator for Sierpinski Gasket [5]. Then apply series of affine transformation using triangle to get the generator, repeat this procedure until the final geometry is obtained [7].

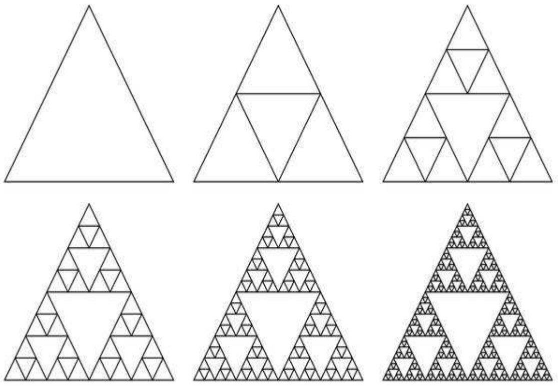

Figure 1 Recursive iteration levels of Sierpinski Gasket

Scaling factor used for Sierpinski gasket is 2, the number of copies obtained after first iteration is 3, then the fractal dimension is given by.

$$D= \frac{\log 3}{\log 2} = 1.585$$

The numerator term represents the number of pieces obtained after first iteration, and the dinaminator term represents the scaling factor.

The multiband behavior of planar monopole antennas [5] using Sierpinski Gasket. Through the use of the fractal geometry these designs are able to meet the multiband behaviour. The antenna performance is evaluated by creating iterated fractal diamonds to the planar microstrip antenna.

The microstrip patch antenna analysed using iterated Sierpinski Carpet geometry. FR4 substrate used as a dielectric for both of these designs with the relative dielectric constant value of 4.4. The thickness of substrate is taken as 1.6mm for these designs. Both of these designs are best matched with 50 ohm input impedance. Antennas are simulated using CST microwave studio 2012, simulated results shows that the antenna has a decent performance with 10dB return loss. Gain, radiation patterns are also presented in this paper.

3. SET UP AND RESULTS

Sierpinski gasket is the basic fractal geometry to get multiband behaviour in antenna applications. Affine transformation is used to describe about IFS .Iterated function Systems is the general method to illustrate the fractal structure. The expression for affine transformation is given by

$$\begin{pmatrix} x_{n+1} \\ y_{n+1} \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} x_n \\ y_n \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix}$$

Scaling parameters a, b, c and d are always real integers. Parameters a, b, c and d are governs scaling and shearing. Whereas e and f are responsible for linear translation. Therefore, the linear affine transformation, W is defined by this constraints as given below.

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} e \\ f \end{pmatrix}$$

The basic structure or motif of Sierpinski Gasket is built from a normal microstrip antenna and goes through some iterations to generate multiband behaviour. A simple rectangular patch antenna is taken as a motif fed by CPW. The 0^{th} iteration represents a simple patch antenna, this is responsible for first resonant frequency of the antenna. In the first iteration, the rectangle or motif is divided into 9 equal rectangular portions then the middle portion of rectangle is eliminated to get the second resonant frequency.

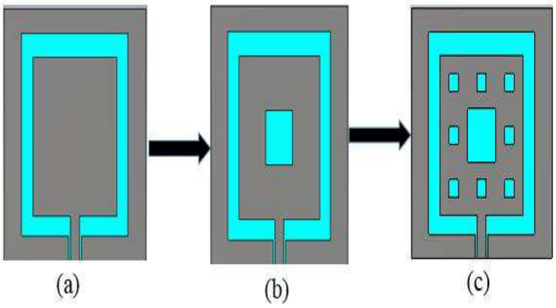

Figure 2 Recursive iteration levels of the proposed Sierpinski Carpet antenna (a) Initiator, (b) First iteration, (c) Second iteration.

The parameter return loss is a figure of merit that mathematically describes the impedance matching between transmission line and antenna. This transfers happens only when characteristic impedance is matched with input impedance of antenna otherwise reflected waves are generated which results in the degraded performance of an antenna. Ideally reflected waves must be zero. Reflected waves are responsible for VSWR.

The proposed antenna gives good impedance matching at 2.4 GHz for Bluetooth, 3.62 GHz for WiMAX, 5.24 GHz for WiFi. The return loss curve for proposed geometry is shown in figure

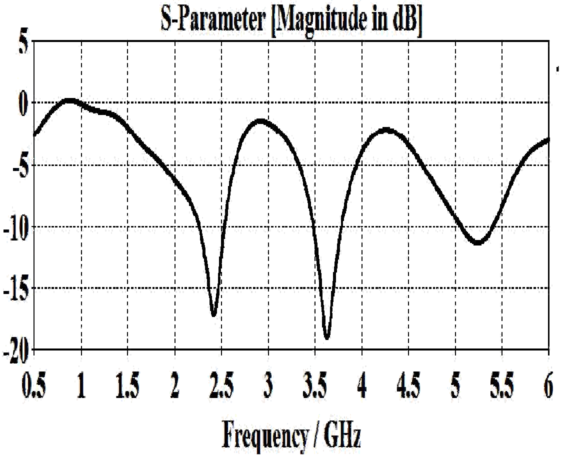

Figure 3 Simulated return loss curve for the proposed geometry

Table 1. Measured results from the return loss curve

Bands	Fr in GHz	Fractional BW (%)	S11 in dB	Gain in dB
1st band	2.4	12.08	-17.09	3.62
2nd band	3.62	8	-18.95	5.21
3rd band	5.24	7	-11.34	4.18

Antenna radiation is possible only when the order of separation approaches the order of wave length (λ) or more. Therefore the open end of the patch acts like a transmitting antenna. The current on the transmission line or wave guide stream out on the antenna and end there, on the other hand the fields accompanying with them keep on going. Radiation pattern defines the deviation of maximum power radiated by an antenna in the fraunhofer realm.

It is easier to analyse the radiation pattern in Cartesian coordinate system compared to spherical coordinate system. In order to represent radiation pattern in a Cartesian coordinate system usually we require two principle planes.

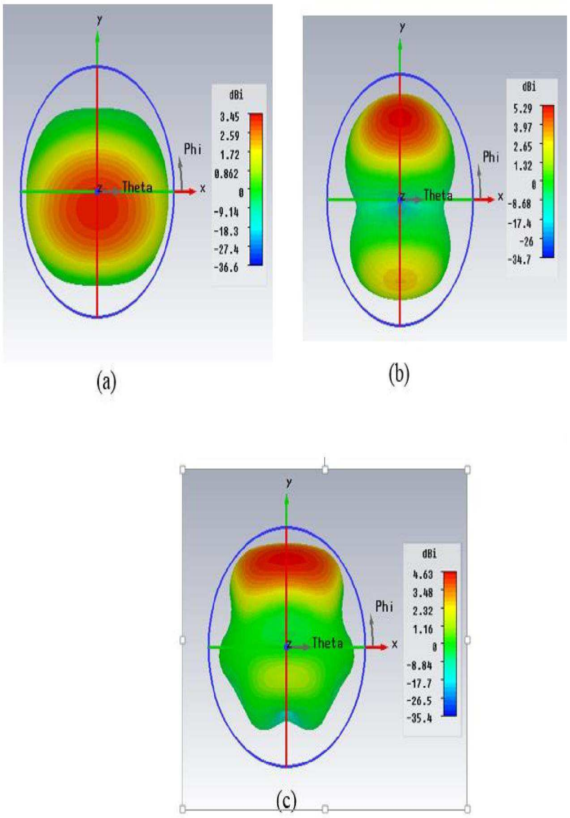

Figure 3 Simulated radiation patterns at (a) 2.4 GHz, (b) 3.62 GHz, (c) 5.24 GHz

The figure 4 shows the simulated gain vs frequency characteristics of the compact fractal antenna using Sierpinski Gasket Carpet geometry. It is observed that the proposed antenna gain lies between 1 to 5dB with the maximum gain of 5.2dBi.

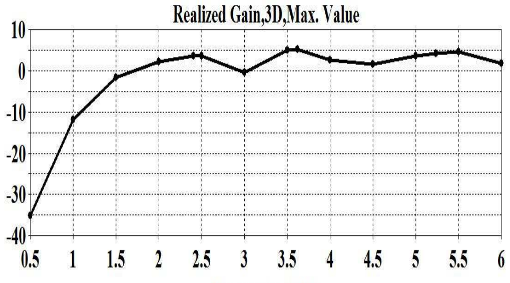

Figure 4 Simulated gain vs Frequency curve of the proposed antenna

Surface current distribution is an essential parameter to control the radiation pattern of an antenna. By introducing slots we can control the distribution of surface current. Surface current distribution at, 2.4 GHz, 3.62GHz and 5.24 GHz is shown in figure 5.

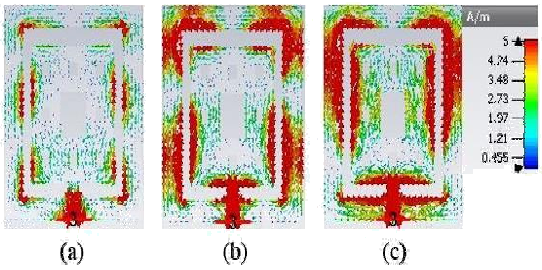

Figure 5. Surface current distribution at (a) 2.4 GHz, (b) 3.62 GHz, (c) 5.24 GHz

4. CONCLUSION

The multiband Sierpinski Carpet with fractal geometry has been investigated. From the measured results, the antenna is appropriate to apply for some wireless applications, such as 2.4 GHz for Bluetooth, 3.62 GHz for WiMAX and 5.24 GHz for WiFi. The model is a suitable candidate on the conduct of the Sierpinski Carpet antenna, with two iterations levels. The proposed antenna is having approximates omnidirectional radiation pattern.

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