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Microstrip Sierpinski Fractal Antenna for Wireless Application

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Abstract: As in the present scenario antenna miniaturization is necessary task with the multiband characteristics. Various techniques have been employed to fulfil these requirements. Fractal antenna is one of them particularly for multiband characteristics with miniaturization. A square fractal microstrip antenna is described in this paper. The use of fractal pattern in this paper provides a simple and efficient method for obtaining the compactness. A Sierpinski based fractal antenna is designed for 5.10 GHz, 6.82 GHz, 7.28 GHz, 10.08 GHz and 10.37 GHz. The FR-4 epoxy/glass material is used as substrate. The radiation pattern shows the gain of the antenna which is 2.80 dBi, 8.97 dBi, 3.66 dBi, 4.32 dBi and 2.37 dBi for 5.10 GHz, 6.82 GHz, 7.28 GHz, 10.08 GHz and 10.37 GHz respectively. The directivity of the antenna satisfies present need and the VSWR is minimum. The bandwidth of the antenna is 20 MHz, 185 MHz, 70 MHz, 50 MHz and 360 MHz respectively.

Keywords-Fractal, Multiband patch antenna, Sierpinski.

I. INTRODUCTION

Due to growing of wireless communication market, future system is expected to provide multimedia, high data rate as well as communication services. Many application such as imaging, radar communication measurement system required integrated antenna of small size, low cost, low profile with very broadband performance. The advancement of wireless communication has led to the development of several wireless communication applications. To integrate more than one communication services in a wireless device, multiband antenna should be used because the radiation way of using different antennas for different frequency bands cause a limited space problem. It has been discovered that fractal shapes radiate electromagnetic energy well and also demonstrate that fractal antennas.

Fractal represents a class of geometry with very unique properties. Fractals are space-filling contours, meaning electrically large features can be efficiently packed into small area so that space filling property is used for size reduction of the antenna.

Fractal geometry is self similar in that some portion of the geometry that has the same shape as the overall geometry, only at the reduce scale. The self similarity property of fractals results in a multiband behaviour. Using self similar properties a fractal antenna can transmit and receive over a wide range of frequencies.

M. Comsso described the theoretical and numerical analysis of the resonant behaviour of the Minkowski fractal dipole antenna. In this paper the resonant behaviour and size reduction capabilities of the Minkowski fractal dipole antenna are investigated.

In this paper we have used Sierpinski based square patch fractal antenna. The advantage of Sierpinski square patch fractal antenna is that a Sierpinski square patch fractal antenna manifests a useful resonance at a lower frequency in comparison to a non-fractal square antenna of the same physical area.

II. ANTENNA DESIGN

The square patch fractal antenna is based on sierpinski square shaped. For designing this fractal antenna IE3D software is used which is based on method of moment (MoM). The FR-4 epoxy material is used as substrate. The thickness of the substrate is 1.575 mm. The dielectric constant (ε_r) of the antenna is 4.3. The sierpinski fractal shape is used in this paper with single iteration. In decomposition algorithm for square shape is cut down from the centre of the square patch antenna which shows the 1st iteration. and finally 2nd iteration has been done with five resonance frequencies. To design the fractal antenna a square shape structure is designed on the simulator. Square indentation is cut down from the each side of the square. Fig. 1 shows the square patch antenna without iteration and fig. 2 shows the fractal with 1st iteration of the square patch antenna with 1st iteration. Fig 3 shows the fractal with 2nd iteration. The side length of square patch fractal antenna is 30 mm (without iteration). This square patch fractal antenna has scale factor

$$\delta = \frac{h_n}{h_{n+1}} \qquad (1)$$

Where h represents the side length of the square patch fractal antenna and n is a natural number represents the number of iteration.

The side length of the square shape antenna is 30 mm.

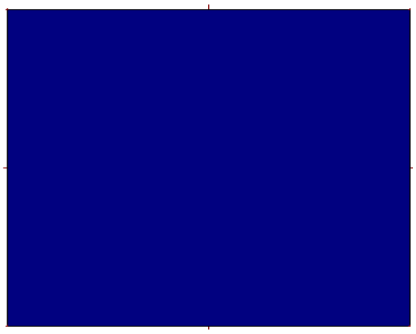

Fig. 1 Proposed antenna with zero iteration

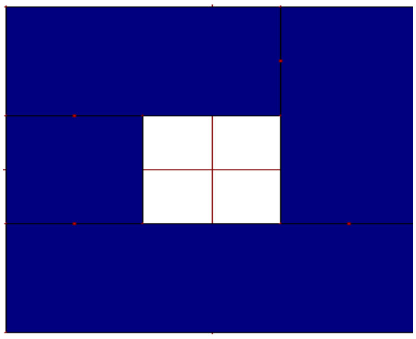

Fig.2 Proposed antenna after 1st iteration

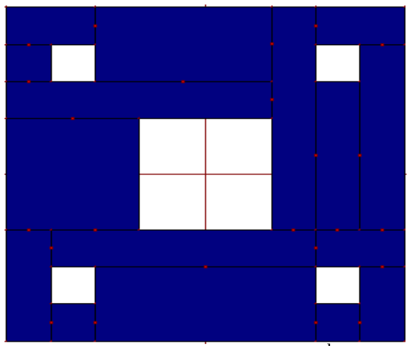

Fig.3 Proposed antenna after 2nd iteration

After iteration the fractal antenna has four square of same size. Each square has side length 3.33 mm.

III. RESULT AND DISCUSSION

The simulated results of input return loss are shown in fig. 3. The return losses are -11.76 dBi, -14.68 dBi, -16.58 dBi, -11.46 dBi and –24.90 dBi for the resonance frequencies 5.10 GHz, 6.82 GHz, 7.28 GHz, 10.08 GHz, and 10.37 GHz respectively. The bandwidth of the antenna is 20 MHz, 185 MHz, 70 MHz, 50 MHz, and 360 MHz for five band respectively.

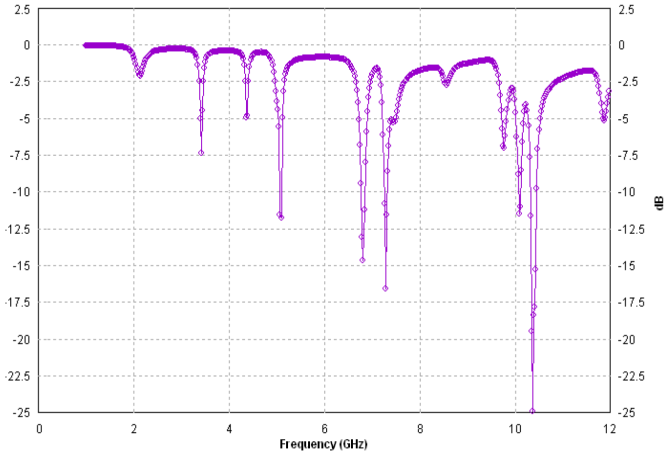

Fig.4 Return loss (S_{11}) Characteristics of the antenna

The gain of the antenna should be positive.In this paper the gain of the antenna is 2.80 dBi, 8.97 dBi, 3.66 dBi, 4.32 dBi, and 2.37 dBi for the resonance frequencies 5.10 GHz 6.82 GHz, 7.28 GHz, 10.08 GHz and 10.37 GHz respectively. The characteristics of the gain are shown in fig.5.

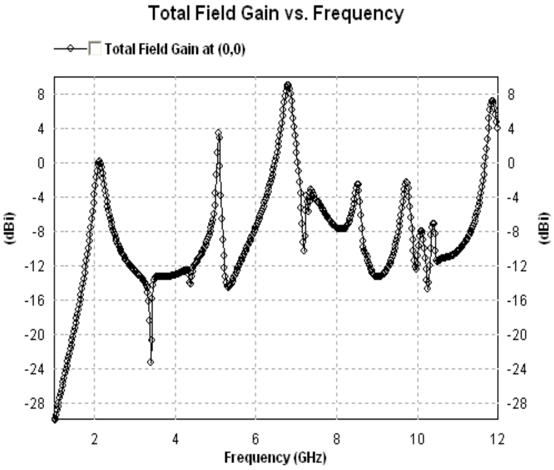

Fig.5 Gain characteristic of the antenna

The radiation pattern shows the gain of the antenna which should be positive. Fig .5 and fig. 6 show the gain of the antenna which is 2.80 dBi, 8.97 dBi, 3.66 dBi, 4.32 dBi, 2.37 dBi and 2.37 dBi, which is suitable for radiation for resonant frequency 5.10 GHz, 6.82 GHz, 7.28 GHz, 10.08 GHz, and 10.37 GHz respectively.

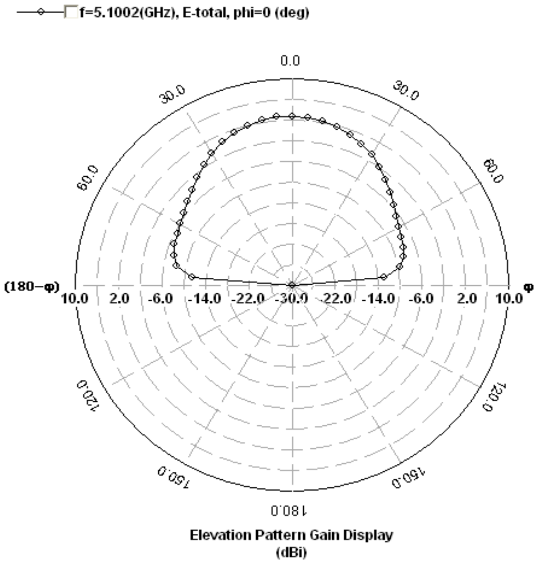

Fig.6 Elevation radiation pattern for 5.10 GHz

The elevation radiation pattern are shown in fig. 7 and fig. 8 for resonant frequencies 4.9 GHz and 9.5 GHz respectively.

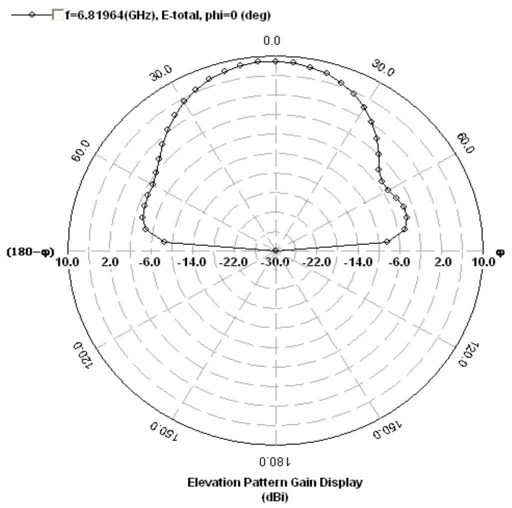

Fig.7 Elevation radiation pattern for 6.82 GHz

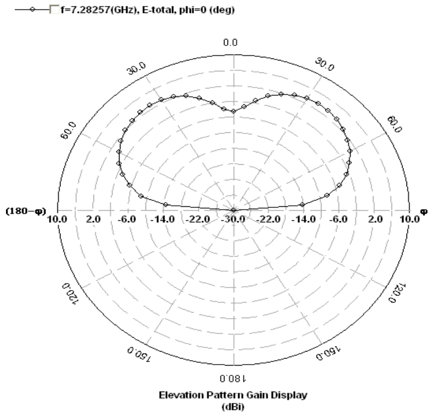

Fig.8 Elevation radiation pattern for 7.28 GHz

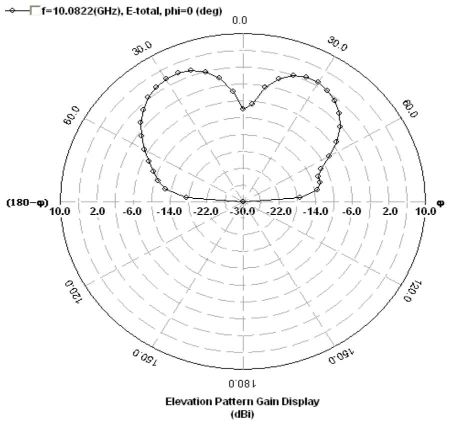

Fig.9 Elevation radiation pattern for 10.08 GHz

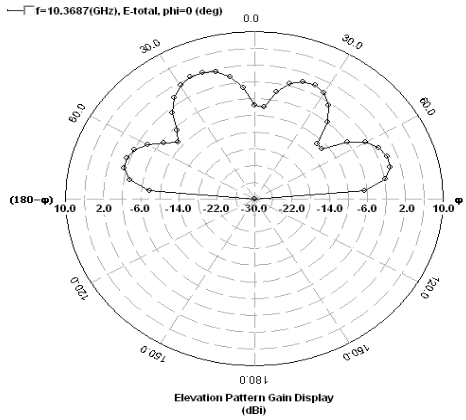

Fig.10 Elevation radiation pattern for 10.37 GHz

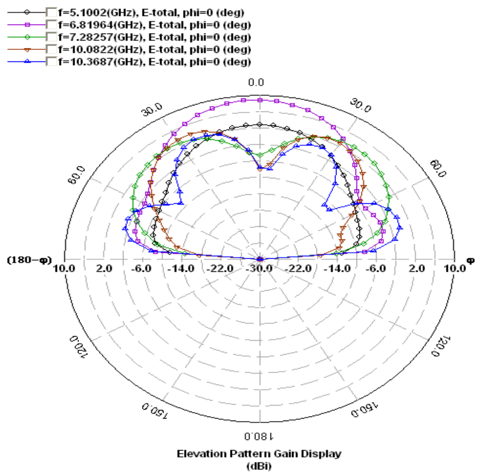

Fig.10 Comman Elevation radiation pattern

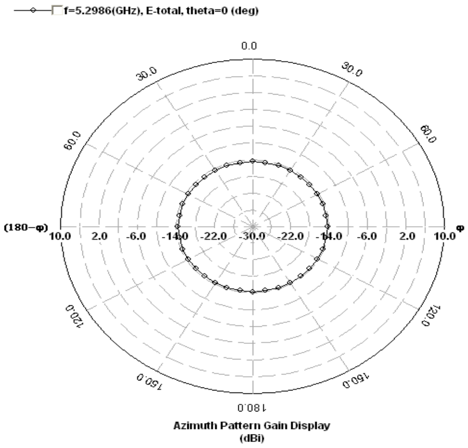

Fig.11 Azimuth Radiation pattern for 5.10 GHz

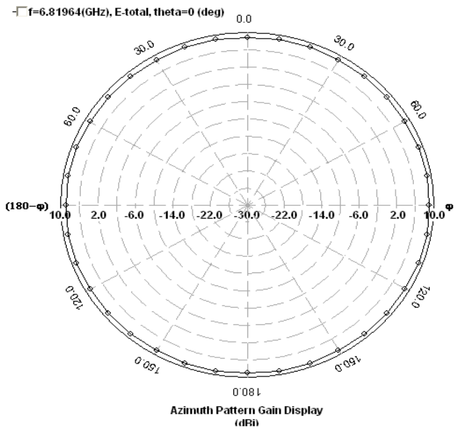

Fig.12 Azimuth Radiation pattern for 6.82 GHz

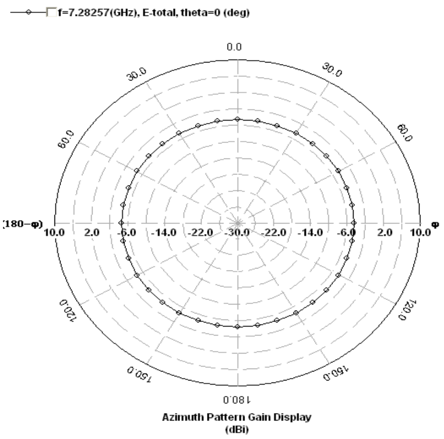

Fig.13 Azimuth Radiation pattern 7.28 GHz

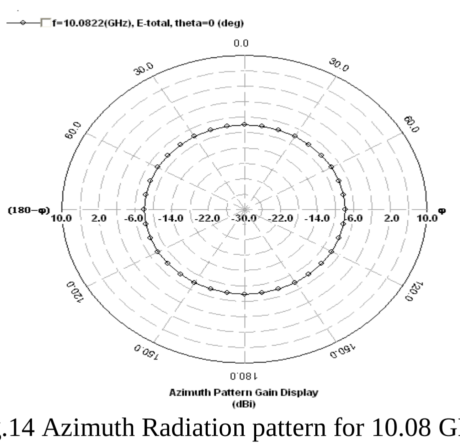

Fig.14 Azimuth Radiation pattern for 10.08 GHz

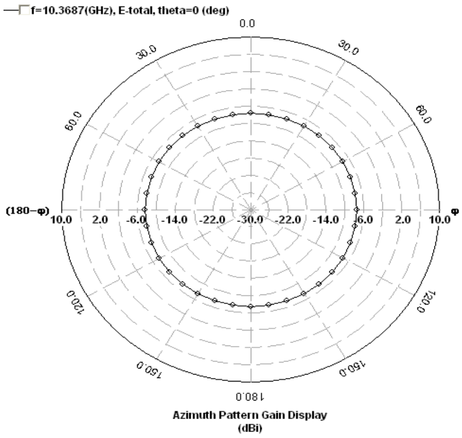

Fig.15 Azimuth Radiation pattern for 10.37 GHz

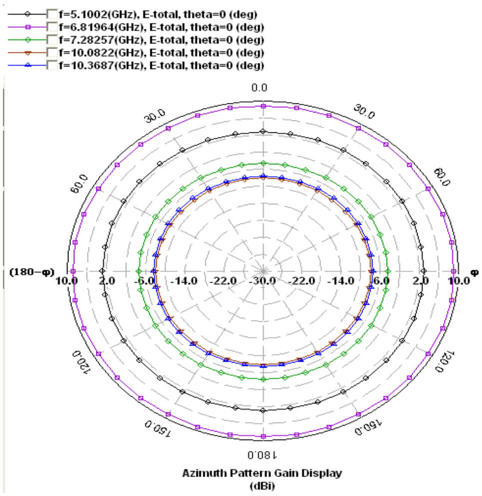

Fig.16 Comman Azimuth Radiation pattern

The directivity of the antenna is related to gain as

$$G = kD \quad (5)$$

Where G is the gain of antenna, k is efficiency coefficient and D is the Directivity of the antenna. The value of k is always less than 1 so that D is always greater than G.

The VSWR is the voltage standing wave ratio should be leis between 1.2 to 2.
The VSWR is between 1 & 2 for both resonance frequencies.

$$VSWR = \frac{1+S_{11}}{1-S_{11}} \quad (6)$$

The VSWR values for resonant frequencies 5.10 GHz, 6.82 GHz, 7.28 GHz, 10.08 GHz, and for 10.37 GHZ is 1.69, 1.45, 1.40,1.76 and 1.18 respectively.

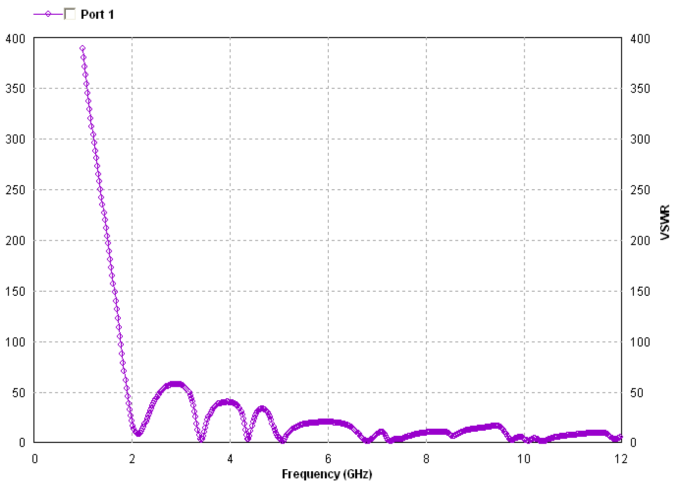

Fig. 17 VSWR characteristic of the antenna

V. CONCLUSION

To conclude, the resonance behaviour and space filling capabilities of the sierpinski based square patch fractal antenna have been investigated. It is found that this structure with an indentation in the border length offers considerable miniaturisation compared with a conventional square patch antenna (0 iteration). For this iteration the resonance frequencies decrease to lower side which indicates size reduction. The frequency bands of the antenna lies between 4-8 GHz (wi-max) and 8-12 Ghz (x-band) .

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