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Compact Fractal Antenna for Wireless Applications

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***Abstract*— The design of a simple fractal antenna for wireless communication is presented in this paper. The basic design consists of a rectangular patch antenna with a square shaped centre slot fed by a coplanar wave guide transmission line. The impedance bandwidth and gain has been further enhanced by introducing fractal structures in the patch. Here the features of the microstrip patch and fractal has been combined to design the required antenna. The antenna works at a frequency of 2.4GHz. The size of the proposed antenna is 65mmx60mmx1.6mm. The details of proposed antenna are described. The various antenna parameters like S parameters, current distribution and radiation pattern are studied. The proposed antenna is used in WI-MAX and GSM applications. All the proposed analysis has been carried out using HFSSV16.**

Keywords— Patch, Fractals, Return loss, gain, VSWR.

I. INTRODUCTION

Antenna has become an important component in everyday life. The present revolution has seen various models of mobile phones and other devices that require compact antennas with advanced features. The recent years have witnessed increase in demands on communication systems. In today's world of wireless communications, compact and low profile microstrip patch antennas are more on demand. Microstrip antennas are used widely due to their properties, such as lowprofile, lowcost, conformability and ease of integration with active devices. The size of antenna is extremely important for most wireless communication systems. Many techniques have been used to reduce the size of antenna, such as using dielectric substrates with high permittivity [1], applying resistive or reactive loading [2], increasing the electrical length of antenna by optimizing its shape, Utilization of strategically positioned notches on the patch antenna [4]. Various shapes of slots and slits have been embedded on patch antennas to reduce their size. Fractal antennas provide a solution for minimising the size along with maintaining the radiation efficiency.

Fractal is a concept that is implemented in microstrip antenna to have better characteristics than ordinary microstrip antenna. According to the latest technology fractal antennas play a vital role. The utilization of micro strip patch antenna with fractal structure has grown rapidly . Self-similarity and self-filling are the important properties of fractal geometry. Fractal antennas can take any shape. There are number of fractal shapes like Minkowski, Hilbert curve, Koch curve, Sierpinski and fractal arrays. Two examples of naturally occurring fractal geometries are snow-flakes and boundary of geographic continents. Some naturally occurring examples of fractals are given in Fig. . Most of these geometries are infinitely sub-divisible. Because of this special feature by applying fractal geometry on patch, area of patch decreases, resonant length increases and number of frequency bands of antenna increases. The main idea of this paper is to design patch antenna integrated with fractals.

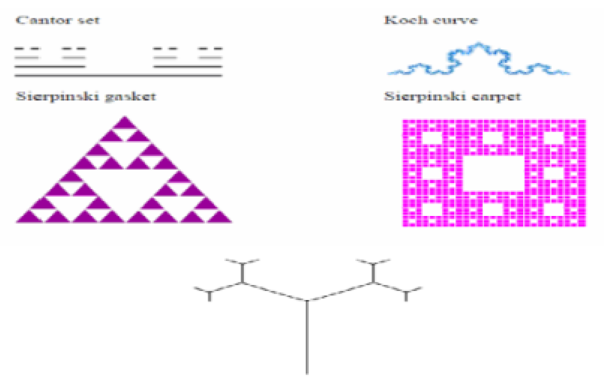

Fig 1: Various fractal structures

II. ANTENNA DESIGN

A. Basic Patch Antenna Design

The basic structure of the antenna is shown in fig. The proposed antenna in placed over FR4 substrate and has dimensions 65mmx60mm. The various dimensions of the antenna are shown in table.

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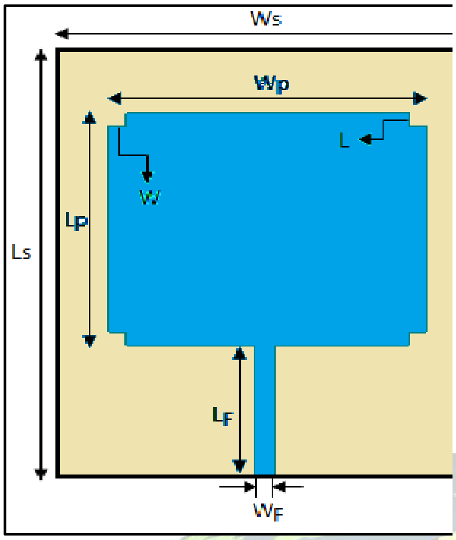

Fig 2: Basic design

Table 1: Antenna parameters

Parameter	Description	Value(mm)
Ls	length of substrate	65
Ws	Width of substrate	60
Lp	Length of patch	35.54
Wp	Width of patch	45.64
Lf	Length of feed	19.78
Wf	Width of feed	3
L	Length of slots	2
W	Width of Slots	2.5

A patch antenna also known as rectangular microstrip antenna is a type of antenna with a low profile that can be mounted a flat surface. .[3] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles.

It is an efficient radiator and can be used for both circular and linear polarization. Patch antenna is widely used because of its low cost and is easy to fabricate. The dimensions that is used for designing the basic patch antenna are calculated using the below given formulas.

The width of the patch element can be given by,

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

Calculation of effective dielectric constant

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right) \qquad (2)$$

Calculation of length extension

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)} \qquad (3)$$

Calculation of effective length

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \qquad (4)$$

The actual length can be calculated by

$$L = L_{eff} + 2\Delta L \qquad (5)$$

Where,

c = Velocity of light in free space.

h = Substrate height.

εr = Relative permittivity of the substrate.

The length and width of rectangular patch antenna comes to be 35.44mm and 45.64mm respectively. The return loss and the gain is simulated for this basic structure. It is clear from the fig. That a return loss of less than -10dB and a gain of 5 dB is obtained for the basic design.

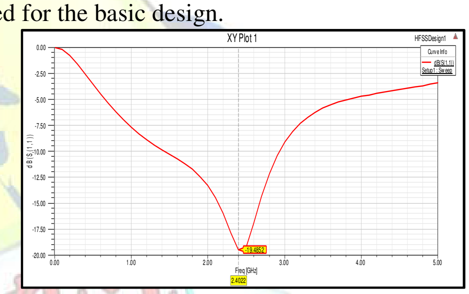

Fig 3: Return loss for basic design

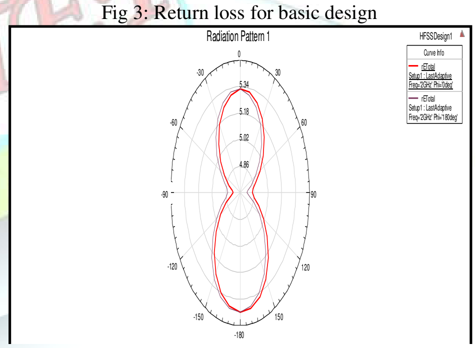

Fig 4:Radiation pattern

B. Antenna with Fractals

Fractal is a geometry shape that is sub divided into different parts and the each part is a copy of complete antenna shape at varying dimensions. It exhibits multiband behavior at reduced size. It provides increased bandwidth, improves VSWR and return loss. The most important advantage is that it helps in miniaturization of the antenna. The figure shows the evolution of the antenna with fractal structures . The basic structure has four small slots cut at the corners of the patch. In the succeeding structures, rectangular slots are inside the patch which is further subdivided using the self dividing property of the fractals. The dimensions of the centre slot is 5mmx5mm.

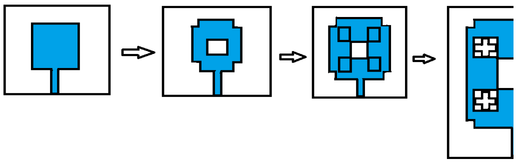

Fig 5:Evolution of antenna

III. SIMULATION AND RESULT

The return loss for the 0th, 1st , 2nd and 3rd iteration are shown below. The 0th iteration of the antenna is taken by designing at the length of 35.54mm and width of 45.64mm. The structure is further modified by cutting rectangular slots at four corners of the patch. The rectangular slot has length of 2mm and width of 2.5mm. The return loss obtained for 0th iteration is -19.40dB.

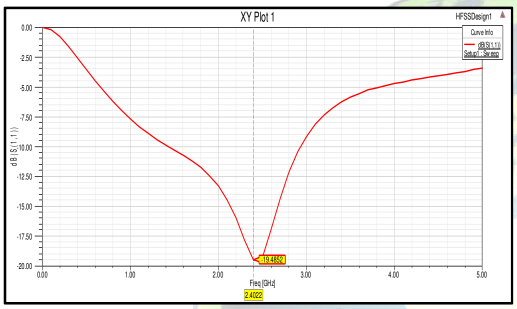

Fig 6:Return loss for zeroth iteration

The first iteration is done by keeping the 0th iteration as the base. The length and width remains the same except for the fact that the central part of the patch is removed. The length and width of the removed rectangular central slot is 10mm and 12mm respectively. The central part being extracted the antenna becomes more compact having a return loss of -20.10dB.

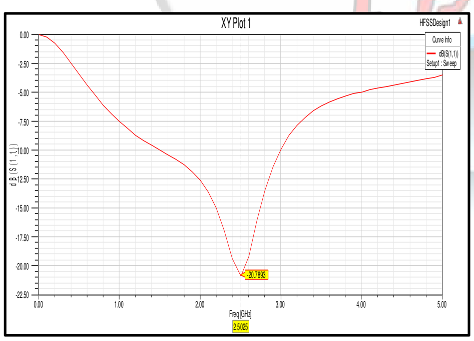

Fig 6:Return loss for first iteration

The first iteration acts as a base geometry for the second iteration. The length and width of the four slots are 1/3rd the length and width of the rectangular slot extracted from the previous iteration. In this Iteration the return loss obtained is -20.83dB. The gain obtained is comparatively greater than the previous iterations.

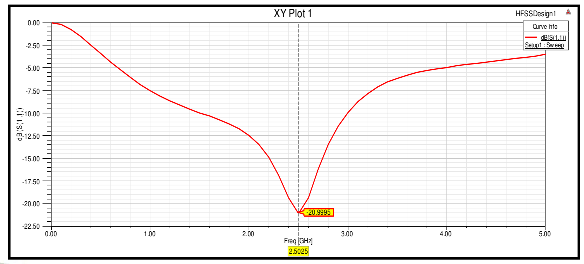

Fig 6:Return loss for second iteration

The 2nd iteration acts as a base geometry for the third iteration. In this iteration the length and width of the four rectangular slots are reduced to 1/9th of the length and width of the rectangular patch. The antenna becomes smaller in size with the return loss of -21.40dB. The gain obtained for the first three iterations is 5. Increased gain of 5.34 is obtained in third iteration.

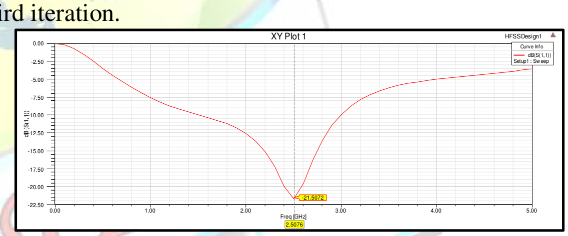

Fig 6:Return loss for third iteration

The rectangular patch fractal antenna exhibits a gain of 5.34dB after the final iteration. Also a stable radiation pattern which is omnidirectional is obtained. From the obtained radiation pattern its clear that the antenna can be used for various wireless applications.

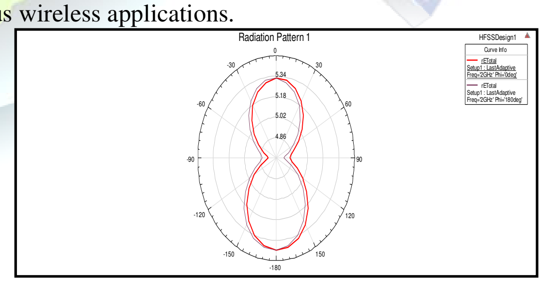

Fig 6:Gain of the final antenna

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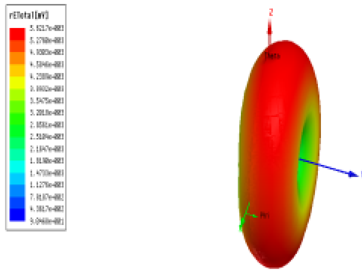

Fig 6: Radiation pattern

IV. CONCLUSION

A compact low profile microstrip patch fractal antenna has been designed. The proposed antenna works at a frequency of 2.4 GHz and produces an omni directional pattern. It gives an average gain of 5.38dB and a return loss of -21.03 dB. The antenna has been fabricated and the measured result agrees with the simulated results. The simulation has been carried out using HFSSV.16.

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