Rhombus Shaped Sierpinski Carpet Fractal Antenna between 2-6 GHz

Deepal Gupta[1], Prof. Umesh Barahadiya[2]

[1,2]Electronics and Communication Engineering, Nagaji Institute of Technology and Management Gwalior, India

Abstract— **This paper presents a rhombus shaped sierpinski carpet antenna based on fractal geometry. The antenna is designed to operate between 2-6 GHz frequencies for Wimax applications for three iterations. The given antenna consists of a rectangular patch antenna loaded with rhombus structures. The proposed antenna is simulated on CST version 10 and the results are in good agreement. The 50 ohm port is used to fed the proposed antenna.**

***Keywords*—Fractal, Wimax, Sierpinski Carpet Fractal Antenna, Micro-strip antenna.**

I. INTRODUCTION

Today world of wireless communications, there has been an increasing need for more compact and portable communications systems. A fractal element antenna, or FEA, is one that has been shaped in a fractal fashion, either through bending or shaping a volume, or introducing holes. They are based on fractal shapes such as the Sierpinski triangle. Mandelbrot tree, Koch curve, and Koch island. Size can be shrunk from two to four times with surprising good performance. In order for an antenna to work equally well at all frequencies, it must satisfy two criteria: it must be symmetrical about a point, and it must be self-similar, having the same basic appearance at every scale: that is, it has to be fractal. In many cases, the use of fractal element antennas can simplify circuit design, reduce construction costs and improve reliability. Because FEAs are self-loading, no antenna tuning coils or capacitors are necessary. Often they do not require any matching components to achieve multiband or broadband performance. The fractal antenna not only has a large effective length, but the contours of its shape can generate a capacitance or inductance that can help to match the antenna to the circuit. Fractal antennas can take on various shapes and forms. Concept of antenna has been around for a long time, millions of years, as the organ of touch or feeling of animal, birds and insects. But in the last 100 years they have acquired a new significance as the connection link between a radio system and the outside World. The first radio Antenna was built by Heinrich Hertz, a professor at the Technical Institute in Karlsruhe, Germany. The IEEE standard defines an antenna as a part of a transmitting or receiving system that is designed to radiate or to receive electromagnetic waves [1]. A patch antenna [2–3] is a low-profile antenna consisting of a metal layer over a FR-4 substrate made up of dielectric substrate and ground plane. Typically, a patch antenna is fed by a micro-strip transmission line, but other feed lines such as coaxial can be used. The advantages of patch antennas are that they radiate with moderately high gain in a direction perpendicular to the substrate and can be fabricated in a low cost FR-4 substrate. Micro-strip antennas have unique features and attractive properties such as low profile, light weight, compactness and Conformability in structure [4]. With those advantages, the antennas can be easily fabricated and integrated in solid-state devices. Micro-strip antennas are widely applied in radio frequency devices with single-ended signal operation. In modern wireless communication systems, the micro-strip patch antennas are commonly used in the wireless devices. Therefore, the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system [6]. Further the tremendous increase in wireless communication in the last few decades has led to the need of larger bandwidth and low profile antennas for both commercial and military applications. One technique to construct a multiband antenna is by applying fractal shape into antenna geometry that may provide the better performance in terms of bandwidth

II. ANTENNA DESIGN THEORY

The designing parameters [10, 11] of rectangular micro-strip patch antenna are L=28.50mm, W=36.00 mm, length of transmission line feed=35.82175 mm, with width of the feed=3.009 mm. The rectangular micro-strip patch antenna is designed on FR-4 (Loss free) substrate with permittivity of 4.3 and height from the ground plane is 1.6 mm. A novel printed fractal antenna is composed of a rectangular patch printed antenna over the FR4 substrate loaded with a rhombus shaped structure treated as a base fraction. The rhombic structure is positioned at the center of the micro-strip patch antenna for first iterations. For the second iteration, base fraction will be constantly positioned and sierpinski carpet is designed around this base fraction that will be considered as a second iteration. During third iteration, the sierpinski carpet will be again designed around the every sub structures of the second iteration. The RMPA parameters are calculated from the following formulas [11-12].

Calculation of Width (W):

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where C = free space velocity of light,

Ɛr =Dielectric constant of substrate.

The effective dielectric constant of the rectangular micro-strip patch antenna:

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

Actual length of the patch (L):

$L = L_{eff} - 2\Delta L$

Where, $\text{Leff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}}$

Calculation of length extension:

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

Fig.1, 2, 3 shows the structure of the first, second and third iteration of the proposed antenna respectively and the Table. I show the parameters of the 1st iteration of proposed antenna. The antenna is modeled and simulated using method of moment based electromagnetic simulation software CST, version 10, between 2 to 6GHz. The shape and size of the structures used in 2nd and 3rd iteration are of 1/3 of the basic fraction.

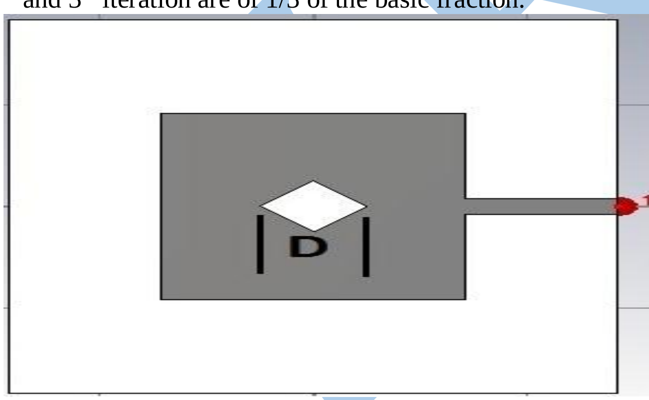

Figure 1: Structure of 1st iteration of proposed antenna.

TABLE.I: STRUCTURAL PARAMETERS OF 1st ITERATION

Sr. No.	**Parameters of 1st iteration proposed antenna**		
	Parameters	***Dimension***	***Unit***
1.	D	05.00	mm

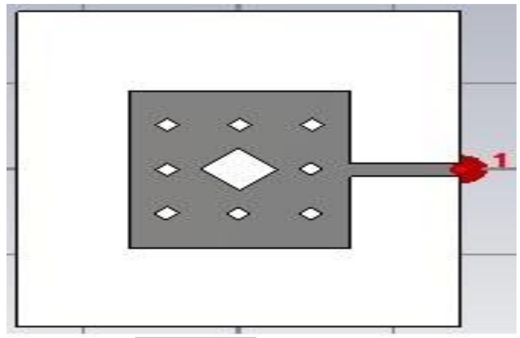

Figure 2: Structure of 2nd iteration of proposed antenna

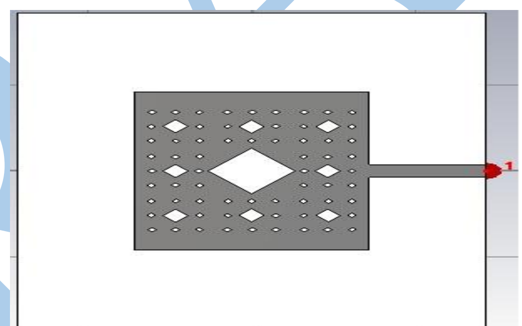

Figure 3: Structure of 3rd iteration of proposed antenna

SIMULATION RESULTS

Fig. 4, 5 and 6 shows the graph of return loss V/s frequency for 1st, 2nd and 3rd iteration respectively. The graph of return loss shows that antenna is resonating as a multiband between 2 to 6 GHz frequencies.

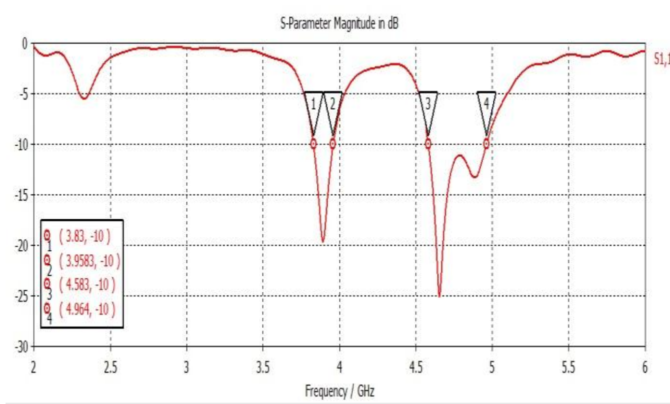

Figure 4: Return Loss V/s Frequency for 1st iteration.

In figure 4, the antenna is resonating at 3.8945 GHz with a bandwidth of 128.3 MHz and also shows an another band of 381 MHz

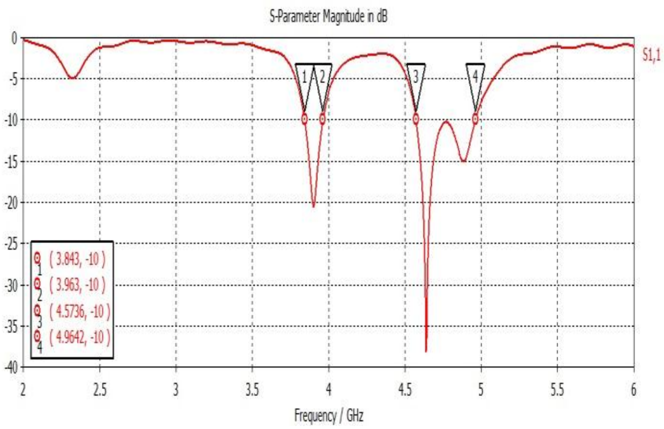

Figure 5: Return Loss V/s Frequency for 2nd iteration.

In figure 6, however the first band is reduced upto 120 MHz but second band has been extended upto 390.6 MHz

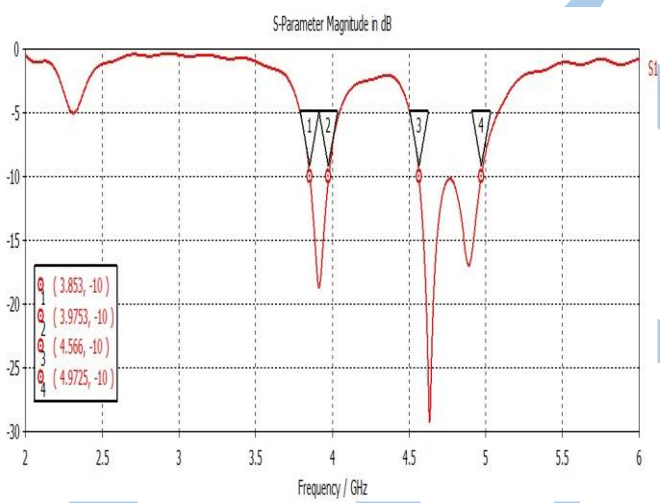

Figure 6: Return Loss V/s Frequency for 3rd iteration.

In figure 6, the first band is increased upto 122.3 MHz while second band has been again improved upto 406.5 MHz bandwidth.

III. CONCLUSION

A sierpinski carpet fractal antenna between 2 to 6 GHz frequencies is analyzed for Wimax applications. The antenna is modeled on low cost and easily available FR4 substrate. Each iteration is an improved version of the previous one. Bandwidth of the first band can be improved by using some different structures or techniques

IV. REFERENCES

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