Review of Microstrip Patch Antenna using Fractal Techniques for Wireless Applications

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Abstract

In the modern world, there is different kind of antennas available for wireless communication. With the advancement in the antenna technology some system like military and commercial telecommunication system requires miniaturization, ultra wideband, multiband and cost effective antennas. Fractal antenna has attractive kind of properties that are distinct from other antennas. In order to achieve desired properties like miniaturization, multiband different shapes fractals are used. Microstrip antenna has limitation of narrow bandwidth that can be overcome using fractal slot. In this paper we will discuss various kinds of fractal geometries that make it more attractive for different type of applications.

Keywords: *Fractal, Sierpinski, Iteration, Koch, Hilbert, Co-axial probe, triangular fractal*

I. Introduction

Modern era of wireless technology demands wider band, low profile, low cost and multiband antenna having huge military and commercial applications. But the microstrip patch antenna has a problem of narrow bandwidth. So in the enormous change of the technology, the requirement of fractal antenna is increases because of its multiband operation. Thus, Fractals are used to improve the performance of microstrip patch antenna. The definition of fractal geometry is given by B.Mandelbort in 1975 and its meaning is irregular. Clouds, mountains, plant leaves and coastlines are the inspiration for fractal geometries [1]-[5]. It is essential to design antenna as compressed as achievable for some application. Fractal antenna has entered the view of many as a very promising solution. Fractal antenna [2] [4] is the best suitable radiating structure. In modern technology fractal antenna theory exist as a new area. Fractal geometry has self-similar and space filling property [3]. These pattern no doubt looks complex but because of their self-similarity are very simple geometry. Minkoski Island, Sierpinski gasket, Hilbert and Koch Snowflake, Sierpinski carpet, are the basic geometric pattern of fractal antennas. To provide feed to antenna there are different type of feeding techniques are used such as microstrip line [6], coaxial probe [7], coplanar waveguide [8] etc. Each feeding technique is used for different application purpose.

II. Fractal Geometry

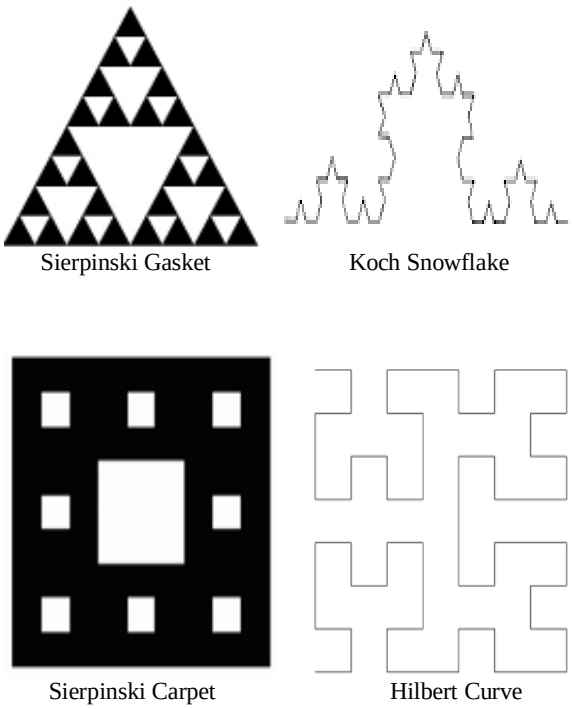

Fig. 1 different kind of shapes used in fractal antenna [9], [15]

1. **Sirepinski gasket:** it is also called Sierpinski sieve. It is a fractal that has attractive fixed set with overall shape of equilateral triangles and subdivided recursively into smaller equilateral triangles.
2. **Koch snowflake:** the initiator for the Koch snowflake is an equilateral triangle. Then divide the line segment into three segments

of equal length. After that draw the equilateral triangle by taking drawn line segment as its base and points outward. Remove the line segment that is the base of triangle made from the first line segment. The Koch curve originally described by Koch is constructed with only one of three sides of the original triangle. In other words, three Koch curves make a Koch snowflake.

3. **Sirepinski carpet:** in this technique a shape is subdividing into smaller copies of itself, removing one or more copies and continuing recursively can be extended to other shapes.
4. **Hilbert curve:** it is a continuous fractal space filling curve that fills the square. The beginning state is on the left. Hilbert designed his curve as connecting the centers of four sub squares, which made up a larger square. To begin three segments connect the four centers in an upside down U shape.

III. Different types of Fractal Antennas

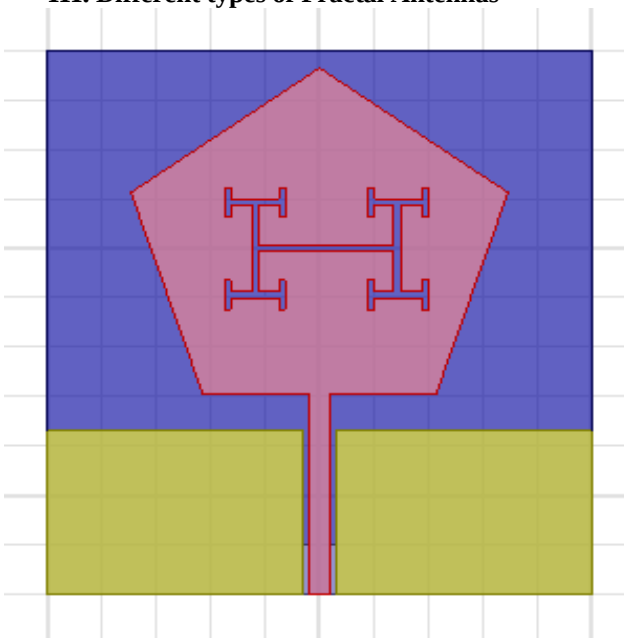

Fig.2 microstrip pentagonal patch antenna with H-Tree with fractal slot [10]

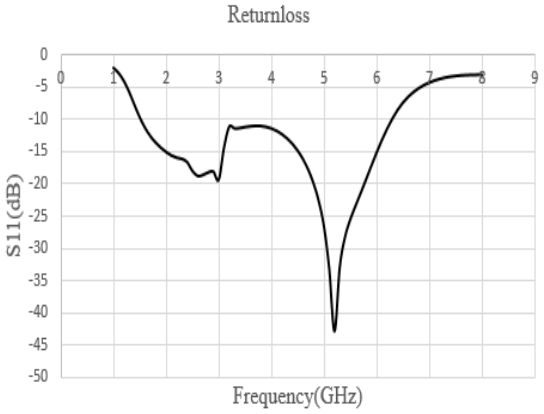

Fig. 3 Return loss of the optimized antenna [10]

In this paper [10] A Coplanar Waveguide (CPW) fed patch antenna is designed for S-band and WiMAX applications with H-Tree fractal geometry. The HFSS (High Frequency Structure Simulator) is used for simulation of proposed antenna. The idea behind design patch is to decrease the Return loss and wider band width by changing the shapes of patch. The two resonant frequencies which are obtained after simulation are at 2.5GHz (WLAN), 5GHz with the return loss better than 10dB, the impedance bandwidth of 4.82GHz and better gain of 5.18dBi.

The use of a pentagonal patch antenna with H-Tree fractal slots enhances the characteristics and performance of the antenna. The bandwidth is useful in the S-band range of frequencies. The present patch antenna which is presented in this paper has better features when compared with other patch antennas. The antenna is used for s-band, dual band and WI-MAX Application.

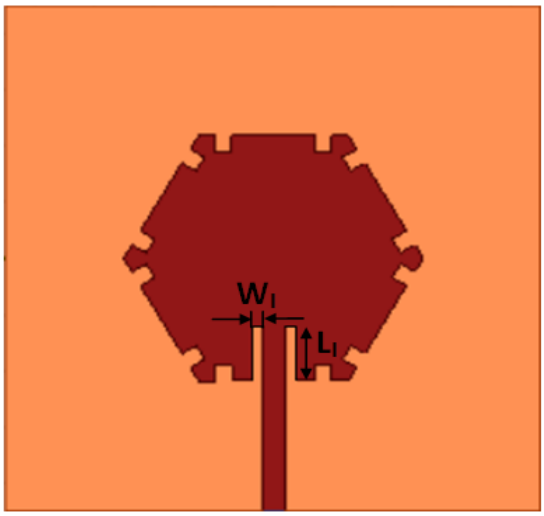

Fig.4 Design of proposed antenna with inset feed [11]

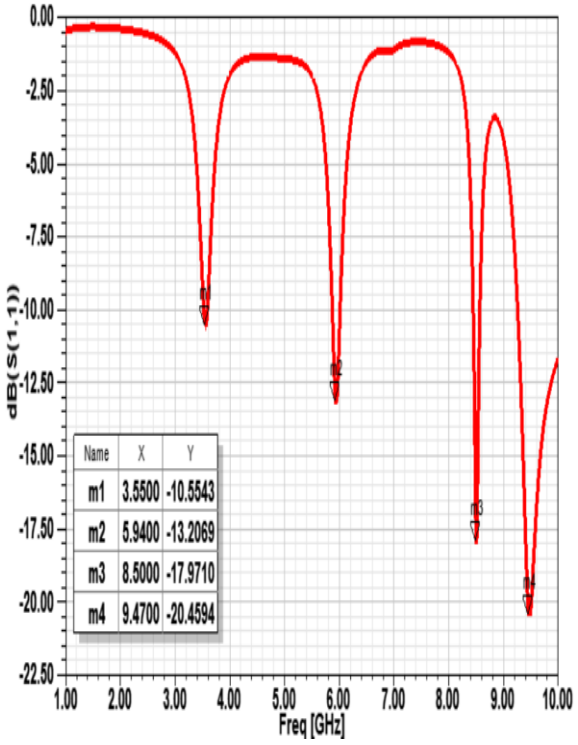

Fig. 5 Return loss curve of proposed antenna with inset feed [11]

In this paper [11], a Hexagonal patch antenna is presented for wireless applications. The resonant frequencies of the operating bands are 3.55GHz, 5.94GHz, 8.50GHz and 9.47GHz. Antenna parameters like bandwidth, radiation pattern and gain are also observed and analyzed. The Values of return loss and VSWR are at the acceptable level for each frequency bands of operation. Using High Frequency Structure Simulator, simulation is carried out to analyze the antenna's characteristics and performance.

Proposed antenna has been designed on low cost FR4 glass epoxy substrate with relative permittivity of 4.4 and thickness 1.6mm.

Inset feeding technique is applied to achieve the quad-band behavior of proposed antenna. The frequency is also shifted towards the lower side without affecting the antenna dimensions. The Value of maximum gain and bandwidth is 6.40dB and 750MHz respectively at 9.47GHz frequency band. The antenna can be used for different applications such as wireless point to point communication, WLAN and X-band.

Fig. 6 Geometry of proposed antenna design [12]

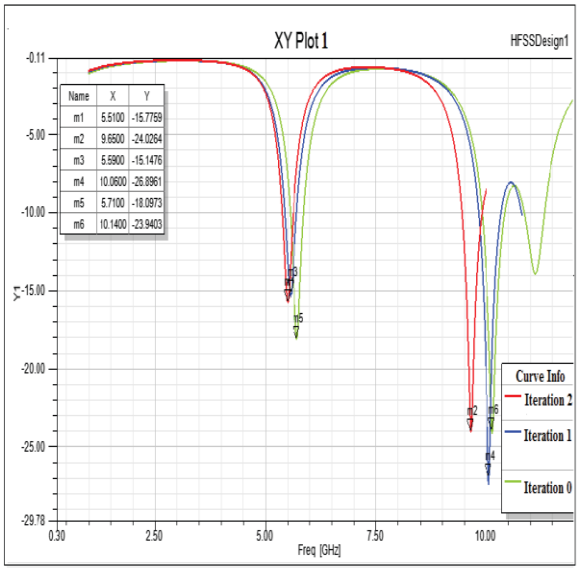

Fig.7 Return loss versus frequency plot of 0^{th}, 1th and 2^{nd} iterations [12]

This paper [12] presents a novel design of Modified Sierpinski Gasket fractal antenna. The proposed antenna is fed with the probe feed. Sierpinski Gasket is known by name of Sierpinski Triangle having triangular slots using mid-point geometry of triangle. It is fabricated on a low cost FR-4 epoxy substrate with relative permittivity of 4.4 and having dimensions 17.89 x 21.45 x 1.6 mm3. Sierpinski Gasket Geometry is modified using circular shape. The proposed antenna has return loss is -15.77 dB at 5.51GHz. Antenna has a gain 9.68dB at 9.65GHz. The simulation of proposed antenna is done using High Frequency Structure Simulator HFSS V13 Software. The proposed antenna has Omni-directional radiation pattern in H-plane and

symmetric in E-plane at the operating frequencies. In this paper, a novel Modified Siepinski Gasket Fractal Antenna (MSGFA) is designed with acceptable value of return loss and gain.

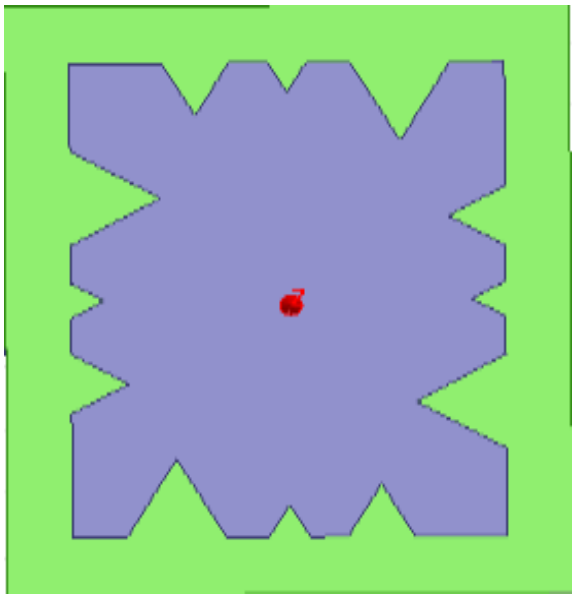

Fig.8 Geometry for proposed design antenna [13]

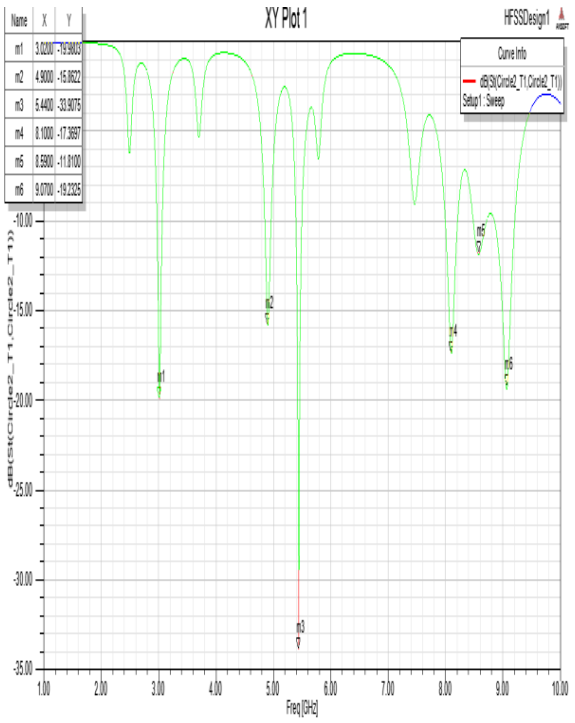

Fig.9 return loss for proposed antenna design [13]

Rectangular patch antenna with triangular fractal techniques is analyzed in this paper [13]. The proposed design operates at multi-bands of frequency. To get the proper impedance matching of 50Ω co-axial feed line is used. The proposed design can be used in weather forecasting, satellite communication, military, wireless communication, radar. The probe feed antenna is designed and simulated using High Frequency Structure Simulator (HFSS) v.13.0. The proposed antenna has been designed using the RT -duroid/5880 material with relative permittivity of 2.2.

The designed antenna has a high gain of 7.59, 6.11 and 5.24 at frequency of 9.07, 8.1 and 5.24 GHz with return loss of -19.23, -17.36,-33.90 dB respectively. Designed rectangular patch antenna with triangular fractal is covers several bands including C band, S band, X band.

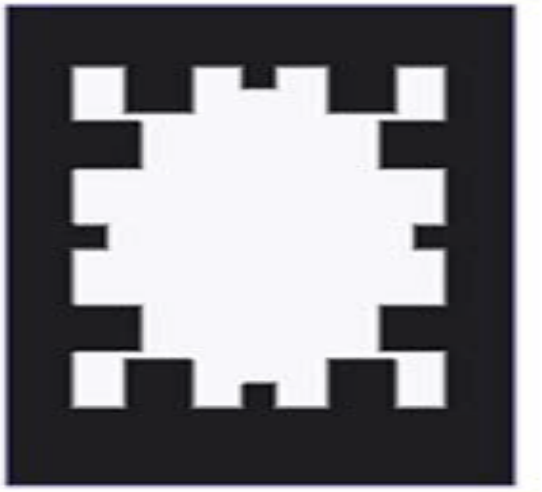

Fig .9 geometry of the proposed antenna [14]

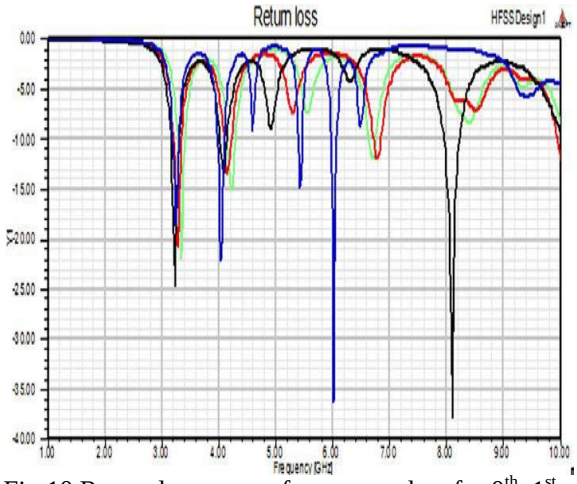

Fig.10 Return loss versus frequency plots for 0th, 1st, 2nd and 3rd iterations [14]

In this paper [14], rectangular patch with half rectangular fractal geometry is designed. To get the proper impedance matching of 50Ω co-axial feed line is used. The proposed design has return loss – 18.5061dB, -22.1394 dB, -4.7404 dB and -36.2199 dB in frequency bands 3.19-3.29 GHz, 3.98-4.09GHz, 5.4-5.46GHz and 5.97-6.06GHz. The proposed antenna is fabricated on RT/duroid 5880 with relative permittivity 2.2 and having dimensions 40mm x 30mm x 1.56mm. Using High Frequency Structure Simulator, simulation is carried out to analyze the antenna's characteristics and performance. The proposed antenna can be used in the military for meteorological purpose and satellite communications. The antenna parameters are improved by using half rectangular fractal geometry and coaxial feed line.

Literature Review Table I

Sr no	Antenna design	VSWR	Return loss	Gain
1	Design Patch antenna with H-tree fractal Geometry	1.52	-42dB	5.18dB
2	Design Patch antenna using modified Sierpinski Gasket Fractal	1.13	-26.89dB	9.68dB
3	Design Hexagonal patch antenna	1.20	-20.46dB	6.40dB
4	Design Patch antenna using triangular fractal techniques	1.04	-33.90dB	7.59dB
5	Design patch antenna using half rectangular fractal techniques	1.44	-36.21dB	7.79dB

IV. Conclusion

This review work provided an insight in determining the performance of microstrip patch antenna using different type fractal techniques. We conclude from the discussion, Fractal geometries enhanced the bandwidth of the antennas up to great extant. Fractal antennas have different properties which results in small size, high gain, and high efficiency antenna. With increasing the number of iterations of fractal geometry, resonant frequency increases that realized in lower return losses. Fractal antennas have various applications in radar, telecommunications, satellite communications, medical imaging, weather forecasting etc. Fractal plays vital role to reduce the size of conventional antenna which is prime requirement for the modern wireless system.

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