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Modified Sierpinski Gasket for Wi-Fi and WLAN Applications

Manoj Choudhary*, Manpreet Kaur**
*(M. Tech Student, Department of Electronics and Communication Engineering, YCOE, Punjabi University, Punjab)
**(Assistant Professor, Department of Electronics and Communication Engineering, YCOE, Punjabi University, Punjab)

ABSTRACT
The hasty growth of wireless technologies has drawn new demands for integrated components including antennas and antenna on chip is a new mantra in the area of antenna research. Various techniques have been suggested by researchers for the miniaturization of microstrip patch antennas with multiband characteristics. Numerous antennas for multiband operation have been studied and designed for communication and radar systems. One of the solutions for the multiband characteristics is the fractal antenna. The Fractal antennas are based on the concept of fractal geometries. They can be designed in a variety of shapes in order to obtain enhanced gain and bandwidth, dual band and circular polarization to even ultra-wideband operation. In this paper, the fractal antenna has been designed using the Arlon substrate with relative permittivity of 1.3 and a substrate of Sierpinski gasket shaped placed on it. Feed used is the line feed. The designed antenna is a low profile, small size and multiband antenna since it can be operated at different frequencies within the frequency range of (1.75 – 2.65) and (5.7 – 7.65) GHz. It includes the frequencies used for wireless WLAN application and used to receive and transmit a high-frequency signal.
***Keywords* -** Fractal Antenna, Multiband, Return Loss, Radiation Pattern, Wi-Fi, WLAN.

I. INTRODUCTION

An antenna plays a vital role in the field of integrated low profile wireless communication systems. The antenna miniaturization is also another egressing demand to meet the requirements of modern wireless standards and devices. The main problem of common antennas is that they only operate at one or two frequencies, restricting the number of bands that equipment is capable of supporting. Another issue is the size of a common antenna. Due to the very strict space that a handset has, setting up more than one antenna is very difficult. To help these problems, the use of fractal shaped antennas is being studied. Benoit Mandelbrot [9] defined fractal as a way of classifying structures whose dimensions are not whole numbers. These geometries have also been used previously to represent unique occurrences in nature that are difficult to define with the Euclidean geometries. Typical example includes defining the length of coastlines, density of clouds, branching of trees, snowflakes and human lungs. Most fractals have infinite density and detail that can be used to decrease antenna size and grow low profile antennas. For most fractals, self-similarity concept can attain multiple frequency bands because of dissimilar parts of the antenna are alike to each other at dissimilar scales [3]. Fractal geometries, to a certain level, can be found all around us, even though we are not aware of that, these are the natural fractals. Examples of
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natural fractals are: earthquakes, lightning, etc. as shown in figures below.

Fig 1: Earthquake Fractal Geometry

Fig 2: Lightning Fractal Geometry

Fractal antennas use a fractal, self-similar strategy to maximize the length and with this method we can attain multiple frequencies since dissimilar parts of the antenna are self-similar at dissimilar scale [4]. The relationship of the physical size of the antenna to its operating wavelength is a fundamental parameter in antenna design. The physical size of an antenna is generally half or quarter of its operating free space wavelength, and the range of frequencies over which the antenna operate satisfactorily is normally 10-40% of this center wavelength [6].

Types of Fractal Antennas: There are many fractal geometries that have been found to be useful in developing new and innovative design for antennas.

1) Koch Curve: Koch curve is constructed with a straight line, as shown in fig. 3. This line is divided into three equal segments and middle segment is replaced by two sides of an equilateral triangle of the same length, as the segment being removed. This makes four line segments. This process is repeated for each of these four segments as shown in Fig. 3. This procedure can be further applied repeatedly to the remaining lines.

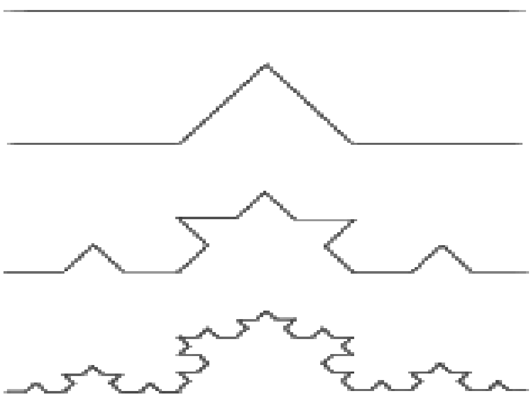

Fig 3: Koch curve

2) Sierpinski Gasket: Sierpinski Gasket triangle is a deterministic fractal. The deterministic construction algorithm for the Sierpinski Gasket is shown in fig. 4. It is evident from the fig. 4, that this geometry has self-similar properties like other fractals. It is because, whatever part of the triangle is taken; it replicates the same triangle on magnification. For example in Fig. 4, an equilateral triangle is used to start with. The midpoints of each side of this triangle are used as the vertices of a new triangle, which were then removed from the original one as shown in figure. This process can be continued further to produce smaller triangles or fractals.

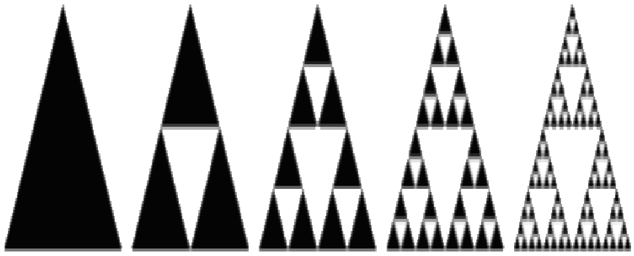

Fig 4: Sierpinski Gasket

3) Sierpinski Carpet: The Sierpinski Carpet is also a deterministic fractal which is a result of the generalization of Cantor set into two dimensions, as shown in fig. 5. In order to construct this fractal, the process is started with a square in a plane, which is further subdivided into nine smaller congruent squares. Among these nine squares, the opened central one is dropped out and the same process is repeated for each of the remaining eight squares.

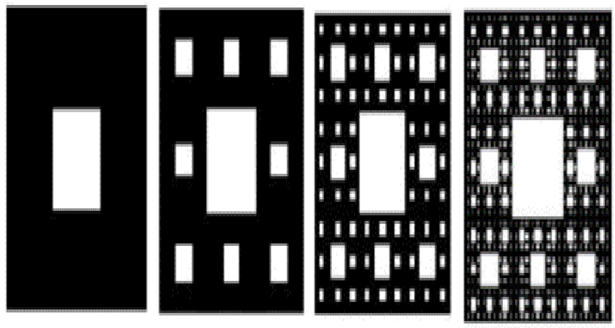

Fig 5: Sierpinski Carpet

Feeding Techniques:

1) Line Feed: In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure [12].

2) Co-axial Feed: The Coaxial feed or probe feed is a very common technique used for feeding Fractal antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane [12]. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation.

3) Aperture Coupled Feed: In this type of feed technique, the radiating patch and the fractal feed line are separated by the ground plane. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane [13]. The coupling

aperture is usually centred under the patch, leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture.

4) Proximity Coupled Feed: This type of feed technique is also called as the electromagnetic coupling scheme. Two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%), due to overall increase in the thickness of the fractal patch antenna.

II. Proposed Work:

We have proposed a new method to design a Sierpinski gasket Fractal Antenna. We use two triangles with overlapping from one side and edge feed is used for the best results. The designed fractal antenna used in Wi-MAX, Mobile Applications etc.

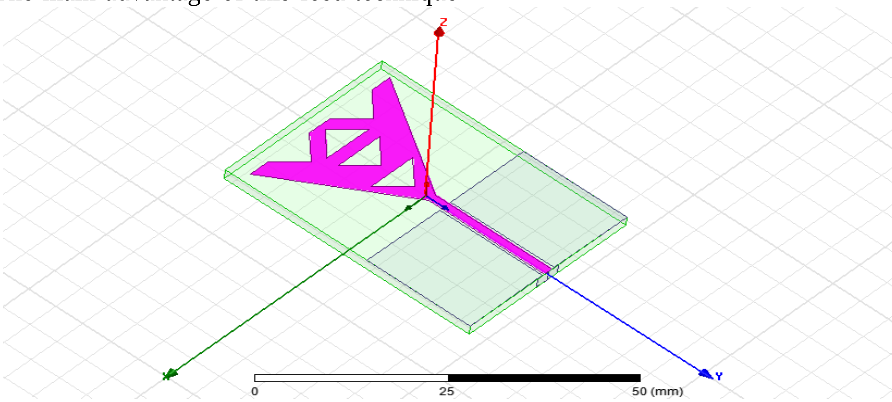

Fig 6: Geometry of the patch antenna

A scaling factor of 1/3 was chosen so as to maintain the perfect geometry symmetry of fractal structure.

III. Design Parameters

Substrate Dimensions		
Width of the dielectric substrate	W	30.2
Thickness of the dielectric substrate	T	0.8 mm
Length of the dielectric substrate	L	44 mm
Patch Dimension		
W_s	W_s	22.7mm
Port Dimensions		
Width	W_p	4mm
Height	W_h	0.8mm
Other	W_f	14.6mm
Feed Dimension		
Edge Feed	$L_g + d$	16.1mm, s-1

Table 1: Design parameters for proposed antenna

IV. Results:

Figures 7 - 11 shows various results from HFSS simulations, as may be noted that the antenna has a magnitude of return loss below-15 dB at the frequencies approximately 1.75 – 2.65 GHz, 5.7 GHz – 7.65 GHz, thus it is displaying multiband behavior, but there also a shift from the initial design frequency.

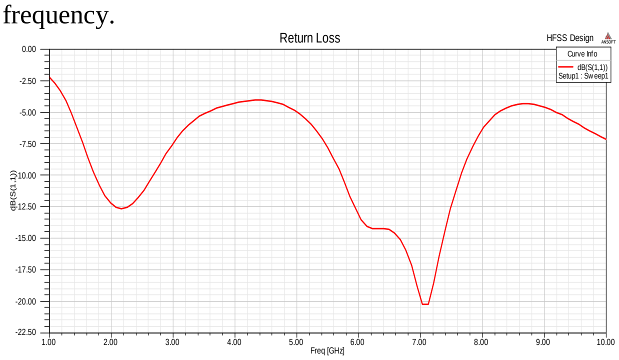

Fig 7: Return Loss parameter graph

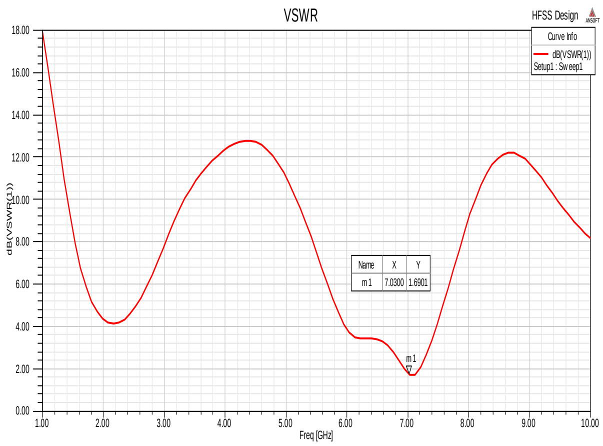

Fig 8: VSWR

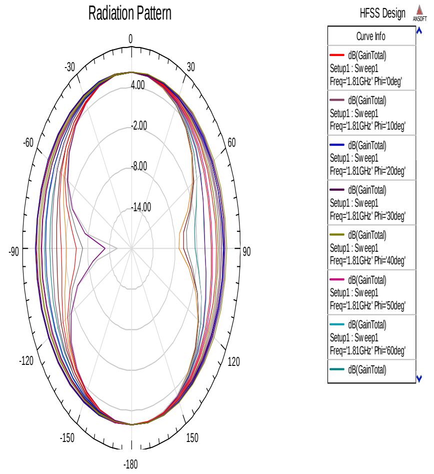

Fig 9: Radiation Pattern

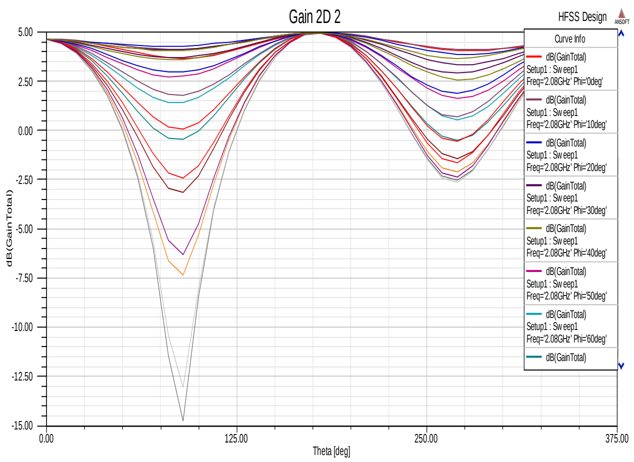

Fig 10: 2D gain plot for 2.08 GHz frequency

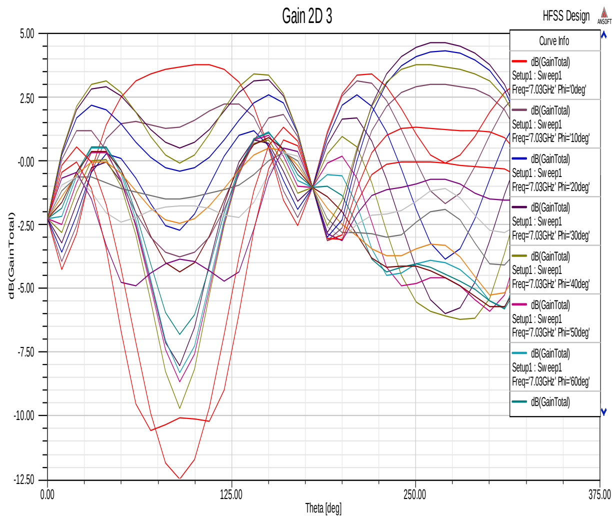

Fig 11: 2D gain plot for 7.03 GHz frequency

Conclusion: The main goal behind this thesis work was to design an antenna capable of working at different frequencies which categorized it under multiband antennas. The range of the operating frequencies is (1.75 – 2.65) and (5.7 – 7.65) GHz, therefore it can be used for wireless WLAN application and used to receive and transmit a high-frequency signal. Return loss is bellow -10dB which is our margin, consequently the VSWR is always under 1.8, the radiation patterns show that these antennas have good gain. From the results we can conclude that with the increase in iteration there is an increase in bandwidth and decrease in the return loss. In order to improve the performance of the optimization process, some recommendations and further improvements of the particular antenna model are provided for further study.

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