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Analysis Of The Patch Antenna Based On The Sierpinski Fractal

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ABSTRACT

There has been an ever growing demand for antenna designs that possesses compact size, low profile and multiband features. Recently the possibility of developing antenna designs that exploit in some way the properties of fractals to achieve these goals, at least in part, has attracted a lot of attention. Fractal antennas have useful applications in cellular telephone and microwave communications. Video conferencing, streaming video are main applications that require high data rates to have high bandwidth. But as size of antenna reduces bandwidth support also reduces. So it is required to have small size with high bandwidth. Fractal antennas are proposed in literature for different applications as it is compact and also has good bandwidth. Fractals found widespread use in many branches of science and engineering in a relatively short time. Recent progress in the study of fractal antennas suggests some attractive solutions for using a single small antenna operating in several frequency bands. The term fractal, which means broken or irregular fragments, was originally given by Mandelbrot to describe a family of complex shapes that possess an inherent self-similarity in their geometrical structure. In this paper various types of fractal antennas like sierpinski gasket, Koch and hexagonal are studied and their capabilities in SHF and UHF band are discussed.

Keywords: fractal antenna, hexagonal, Koch, microstrip antenna, microwave, sierpinski gasket.

1. INTRODUCTION

One of the prevailing trends in modern wireless mobile devices is a continuing decrease in physical size. In addition, as integration of multiple wireless technologies becomes possible, the wireless device will operate at multiple frequency bands. A reduction in physical size and multi-band capability are thus important design requirements for antennas in future wireless devices. Fractal geometry antennas are being studied in order to answer those requirements. The term of the fractal geometries was originally coined by Mandelbrot to describe a family of complex shapes that have self - similarity or self - affinity in their geometrical structures [1]. Fractals represent a class of geometry with very unique proper- ties that can be enticing for antenna designers. Fractals are space-filling contours, meaning electrically large features can be efficiently packed into small areas [2]. Since the electrical lengths play such an important role in antenna design, this efficient packing can be used as a viable miniaturization technique. In other words Fractals are broken or irregular fragments, generally shaped composed of multiple copies of themselves at different scales [3]. This fractal geometry, which has been used to model complex objects found in nature such as clouds and coastlines, has space filling properties. This space filling properties is useful to minimize the size of antenna. The space-filling property of fractals tends to fill the area occupied by the antenna as order of iteration is increased.

In recent years, a lot of studies have done in the area of fractal techniques and fractal antenna structures like dipole [4], monopole [5], and patch [6]. Some of these techniques are useful in reducing the size of the antenna, while other used to design antenna having multiband characteristics. These are low profile antennas with moderate gain and can be made operative at multiple frequency bands and hence are multi-functional.

Some of the common fractal geometries that have been found to be useful in developing new multiband antennas are Sierpinski gasket [7-8], Minkowski square loop [9-10], hexagonal [11] and Koch [12]. Sierpinski gasket is one of the earliest structures of fractal geometry. A miniaturization of loop antenna using the fractal technique is known as Minkowski square loop antenna. A hexagonal antenna is suitable for design an antenna of superior characteristic and allows flexibility in matching multiband operations in which a large frequency separation is required [11].

2. SIERPINSKI GASKET ANTENNA

The construction procedure of this fractal begins with an equilateral triangle contained in the plane, as illustrated in Stage 0 of Figure 1. The next step in the construction process (Stage 1) is to remove the central triangle with vertices that are located at the midpoints of the sides of the original triangle [13]. This process is then repeated for the three remaining triangles, as illustrated in Stage 2 of Figure. The Sierpinski-gasket fractal is generated by carrying out this iterative process an infinite number of times.

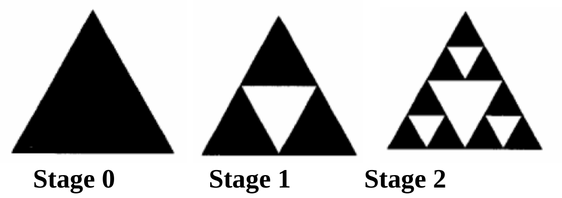


Figure 1: Example of Sierpinski-gasket fractal antenna

It is interesting to note that the band number, n, and the iteration, k, are interchangeable. In other words, band zero and the 0th iteration correspond to the fundamental resonance of the antenna. The first band and the first fractal iteration correspond to the log-periodic resonant frequency. Therefore, after the first iteration, two resonant frequencies are available. This is valid for higher fractal iterations. In general, the antenna radiates in two distinct bands for single fractal iteration, three bands for double fractal iteration, and so on.

3. RESULT ANALYSIS OF SIERPINSKI GASKET FRACTAL ANTENNA

The sierpinski gasket patch fractal antenna with 2nd iteration is shown in figure 2. The antenna is designed and simulated using simulation tool Ansoft HFSS.

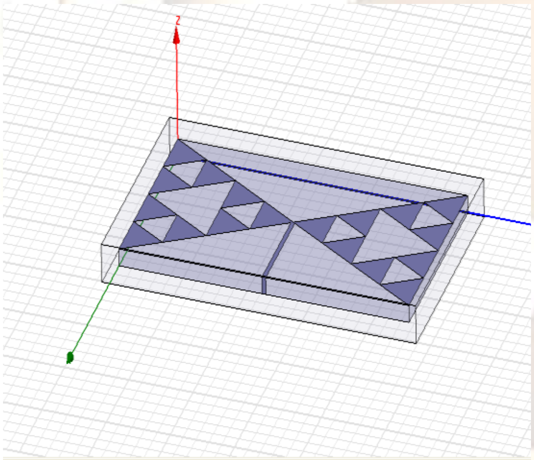
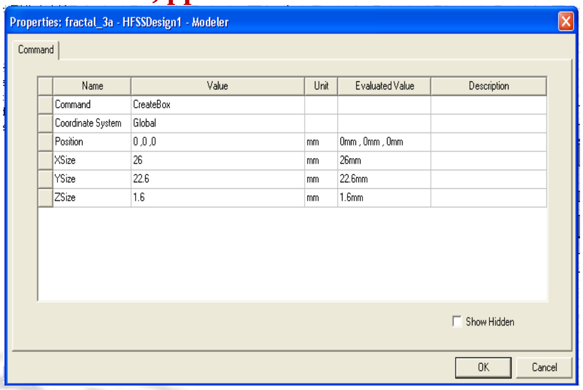


Figure 2: Sierpinski Fractal Antenna with second iteration

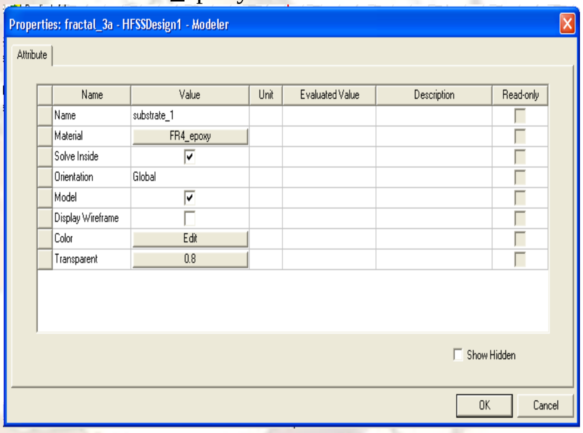
The dimensions of substrate used in proposed antenna are shown in figure 3. The side length and height of the largest triangle of the sierpinski gasket fractal antenna is taken as 26mm and 22.6mm respectively.



Name	Value	Unit	Evaluated Value	Description
Command	CreateBox			
Coordinate System	Global			
Position	0 ,0 ,0	mm	0mm , 0mm , 0mm	
XSize	26	mm	26mm	
YSize	22.6	mm	22.6mm	
ZSize	1.6	mm	1.6mm	

Figure 3: Dimensions used for designing Sierpinski Gasket Fractal Antenna

Substrate dielectric constants use to be in range $2.2 \leq \varepsilon_r \leq 12$. We always prefer substrate whose dielectric constant is in the lower end of the range because they provide better efficiency. In case of sierpinski gasket fractal antenna the material used for substrate is FR4_epoxy.



Name	Value	Unit	Evaluated Value	Description	Read-only
Name	substrate_1				
Material	FR4_epoxy				
Solve Inside	✓				
Orientation	Global				
Model	✓				
Display Wireframe					
Color	Edit				
Transparent	0.8				

Figure 4: Properties of substrate used in designing Hexagonal Fractal antenna

Figure 5 shows the return loss as a function of frequency which shows the multiband behavior of the antenna having return loss less than -10dB because below -10dB return loss, reflections are negligible.

Figure 5: Frequency versus Return loss for Sierpinski Fractal antenna

Table I : Frequencies and their corresponding Return Losses

Name	X	Y
m1	21.9158	-10.2815
m2	22.7996	-10.0912
m3	22.5050	-11.2442
m4	26.8257	-10.2443
m5	28.6914	-10.3995
m6	27.7094	-16.4597
m7	32.3246	-10.2109
m8	34.3868	-10.3828
m9	33.5030	-15.5826
m10	37.6273	-10.3141
m11	39.3948	-10.2893
m12	38.5110	-13.4857
m13	43.7154	-15.7307
m14	44.4028	-7.9440

VSWR is standing wave ratio that tells about the impedance mismatch. . Increasing in VSWR indicates an increase in mismatch between the antenna and the transmission line. A decrease VSWR means good matching with minimum VSWR is one. It is always desirable for VSWR to be always less than 2. We can see in the figure that all the resonated frequency band have VSWR below 2. Figure 6 shows corresponding VSWR vs. frequency.

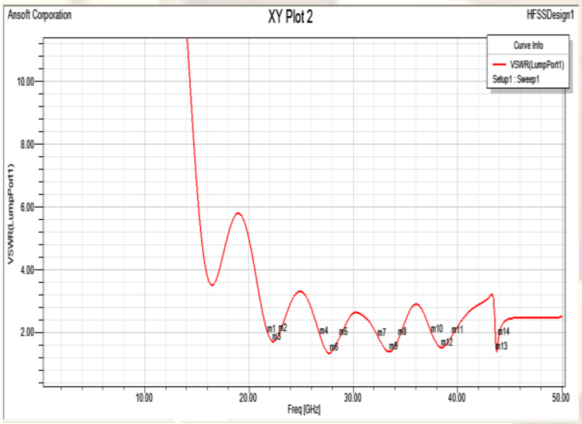


Figure 6: VSWR versus Frequency

The radiation pattern of an antenna provides the information that describes how the antenna directs the energy it radiates. Radiation pattern for proposed antenna is also depicted in the figure 7 given below. Radiation pattern explains that antenna is radiating in Omni-direction.

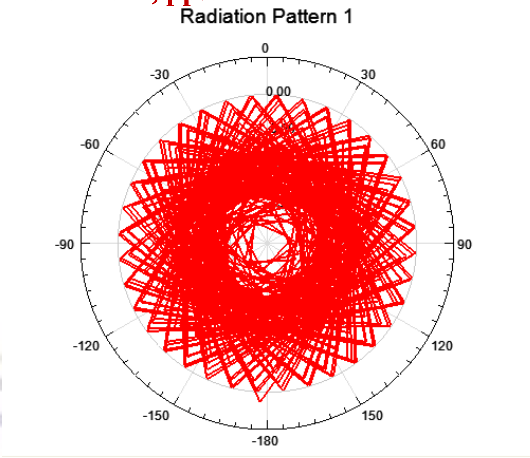


Fig 6: Radiation Pattern**.**

4. CONCLUSION

Sierpinski gasket patch antenna shows less than -10dB return loss which is required for efficient operation for frequency bands 22.5050GHz, 27.7094GHz, 33.5030GHz, 38.5110GHz, 43.7154GHz with return loss -11.2442dB, -16.4597dB, -15.5826dB, --13.4857dB and -15.7307 respectively. VSWR in these frequency bands are also in the required region i.e. below 2. These multibands are used by different technologies, so single antenna works for different technologies.

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