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# Design of Miniaturized Micro-Strip Triangular Patch Antenna with Hybrid Combination of Giuseppe and Sierpinski Carpet

KEYWORDS: Component, patch antenna, Sierpinski gasket, Giuseppe peano, Multiband antenna, iterations, and miniaturization

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**ABSTRACT** Globalization trend in Wireless or Cellular communication shows deep interest in Micro-strip antenna design. Development shows Micro-strip patch antenna design miniaturization using Sierpinski carpet with drawback of Gain and Giuseppe carpet fractal applied on Micro-strip patch antenna with improvement in various parameters like return loss, radiation pattern, smith chart, VSWR, and gain. The proposed technique is used for designing a Micro-strip patch antenna by hybrid combination considering the advantages of Sierpinski and Giuseppe Carpet. Micro-strip patch antenna will be designed and fabricated at 2.45 GHz. The stimulated results show significant improvement in the antenna parameters. Proposed antenna covers the operation bands of Wireless services including the UWB, ISM/WLAN/Bluetooth, WIFI, Hiper - Lan2 and Radar band.

## I. INTRODUCTION

Rapid development of modern communication technologies in recent years defines more and more requirements towards communication devices – to operate in several frequency bands and to be relatively small. These reasons bring new challenges to its antennas. Therefore in the last years there is a strong interest in fractal-shaped antennas usage in telecommunication devices. Their characteristics largely correspond to those challenges – multiband usage and relatively small sizes [1].

Many authors used the attempt to adjust the boundaries of the frequency bands using a modification of known fractal [2]. A fractal is a natural phenomenon or a mathematical set that exhibits a repeating pattern that displays at every scale. If the replication is exactly the same at every scale, it is called a self-similar pattern. Antennas or arrays with fractal geometry possess four desirable attributes which are compact size, low profile, conformal and multiband or broadband, which may benefit from inherent self-similarity or self-affinity in their geometrical structure. It attracts a number of researchers to the fractal engineering field where a variety of excellent results have been obtained. However, it is hard to improve the properties of an antenna greatly simply by a kind of technique. Combining several antenna techniques will be a tendency in designing modern antennas. In the paper, based on techniques of fractal shape and corner cutting, we propose an innovative design of a miniature and broadband antenna. Micro-strips patch antennas with several advantages such as conformal nature, light weight, and easy integration. Since compact antennas can achieve the same performance as large antennas do in a low price and ease with integration technology, reduction of antenna parameter is becoming an important design parameter. Several methods have been suggested to reduce the size of micro-strip patch antenna. Effective methods to scale down the size of the patch antennas are: use of high-permittivity substrates, loading the patch with shorting pins, and modifying the geometry of the patch or ground plane. The conventional patch antennas are modified in various ways to shrink the size of antennas. The application of fractal geometry to conventional antenna structures in order to obtain a compact size antenna has been introduced recently in antenna design. The presented work will be focused on patch antenna miniaturization by incorporating fractal geometry on patch antenna. In this work are proposed and analyzed a fractal antenna combination based on Sierpinski gasket and Giuseppe Peano [3]. The objective of this modification is to achieve the frequency bands, which are arranged close to each other and by combining these ranges to obtain a sufficient bandwidth.

## II. FRACTAL ANTENNA CONCEPTS

Fractal geometry involves nature inspired shapes, either random or deterministic. The latest are mathematically generated, self-similar structures, which can be infinitely multiplied and intricate. For antenna purposes only first few recursive iterations are of importance. Here it is proposed multiband fractal-like antennas based on triangle monopole antenna

Fig.1 Shows the Sierpinski carpet upto 3rd iterations applied on the triangular equilateral antenna.

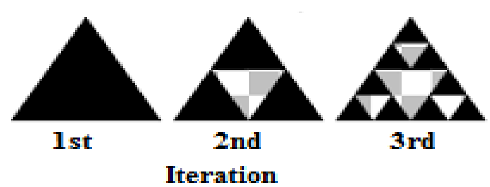


**Fig. 1. Sierpinski Carpet**

The geometrical construction of the popular Sierpinski gasket begins with an equilateral triangle which is considered as generator(1st). The next step in the construction process is to remove the central triangle, namely the one with vertices that are located at the midpoints of the sides of the original triangle. After the substruction, three equal triangles remain on the structure, each one being half of the size of the original one(2nd). This process is then repeated for the three remaining triangles etc(3rd). If the iteration is carried out an infinite number of times the ideal fractal Sierpinski gasket is obtained.

Fig.2 shows the Giuseppe fractal which is to be applied on the edges of the triangular antenna.

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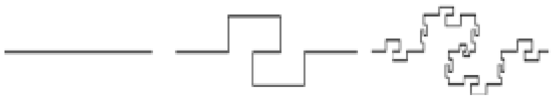

**Fig. 2. Giuseppe Peano**

Giuseppe employs "Cut and Grow" technique which is used to maintain the gain of the system.

As the iteration of fractal geometry increases, its resonance frequency decreases, this may lead to an effective antenna miniaturization [5].

However, for iterations higher than the second iteration, the reduction of operating frequency is not achievable since the antenna design becomes quite complicated and its fabrication becomes difficult.

In the presented paper, a combination of both Sierpinski Carpet and Giuseppe fractal is applied on the triangular patch with Sierpinski at the center and Giuseppe at the edges of the triangular patch.

**III. ANTENNA DESIGN**

Equilateral Triangular Micro-strip Antenna Field solutions may be found using a cavity model, in which the triangle is surrounded by a magnetic wall.[7]

Consider a triangular resonator with magnetic sidewalls filled with a dielectric material of permittivity $\varepsilon = \varepsilon_0 \varepsilon_r$. Since h << , there is no variation in the electric field in the z – direction; therefore the structure supports TM modes.

The dominant mode is TM10 mode, and its resonant frequency is as follows:

$$f_r = 2c/[3a_e\sqrt{\varepsilon_{eff}}] \qquad (1)$$

where $a_e$ is the effective side length given by,

$$a_e = a + (h/\sqrt{\varepsilon_r}) \qquad (2)$$

and

$$\varepsilon_e = 0.5(\varepsilon_r+1) + 0.5(\varepsilon_r-1)(1+12h/a)^{-1/2} \qquad (3)$$

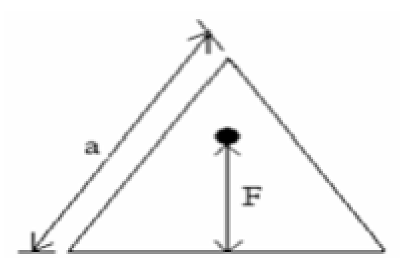

**Fig. 3. Equilateral triangular Patch**

Fig. 3 shows the equilateral triangular shape.
The design of single element equilateral triangular micro-strip antenna can be done using the above equations.
From (1),

$$a_e\sqrt{\varepsilon_e} = 2c/3f_r \qquad (4)$$

Substituting (2) & (3) in (4), we get the following design equation

$$(a + h/\sqrt{\varepsilon_r})(0.5(\varepsilon_r+1) + 0.5(\varepsilon_r-1)(1+12h/a) - 1/2)1/2 = 2C/3f_r$$
(5)

The dielectric material of the substrate selected for this design is FR-4 which has a dielectric constant of 4.4. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

The resonant frequency selected for my design is 2.4 GHz.
Height of dielectric substrate (h): For the Micro-strip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is to be selected between 0.4 to 1.6 mm.

**Steps required for calculating antenna parameters:[6]**

**1) Calculation of the width W of antenna**

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

Where, $f_r$ = resonant frequency,
r = Dielectric constant of the substrate

**2) Calculation of Effective dielectric constant *($\varepsilon_{reff}$)***

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}}$$

***3) Calculation of Effective Length ($L_{eff}$***

The effective length is calculated from the known frequency to which antenna is to be designed and dielectric constant of material

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}}$$

**4) Calculation of Length Extension ($\Delta L$**

The extension length due to fringing field effect [7] in the radiating patch is calculated given by [6]

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

**5) Calculation of Actual Length (L)**

From the fringing length the actual length of the patch is calculated given by [6]

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

**6) The feed point determination**

The matching impedance is 50Ω. In order to have a matching of the impedance the connector has to be placed at some distance from the edge which has a match of 50Ω. There is a trial and error method that has been adopted to check the minimum value of the Return loss. In this the Peano fractal is applied to the edges of a triangular patch. Sierpinski Carpet fractal is implemented by cutting slots on the patch area. Here we applied Giuseppe Peano fractal on inner and outer square patch of each Sierpinski carpet fractal by that we achieve more multiband frequency.

We get various resonance frequencies which cover UWB, WIMAX, WIFI, ISM/WLAN/Bluetooth, Hiper-Lan2 and Radar band [4].

**IV. SOFTWARE SIMULATORS**

There are a number of commonly available software packages which allow the simulation of antenna parameters. Some of the best known are: IE3D, HFSS, SONNET, CST, MAGUS.

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The software will use to model and simulate the Propose Micro-strip patch antenna is Zeland Inc's IE3D.

This antenna simulated for frequencies 1-20 GHz using IE3D Design of Combination of Sierpinski carpet and Giuseppe Peano Fractal Antenna (A novel Hybrid Antenna)

IE3D is a full-wave electromagnetic simulator based on the method of moments. It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF/wireless antennas. It can be used to calculate and Return loss plot, VSWR, current distributions, radiation patterns etc.

**V. CONCLUSION**

In this paper, a kind of new antenna, modified Sierpinski fractal based micro-strip triangular antenna, is proposed. It adopts three kinds of techniques to miniature the size and to broaden the band. What's more, the modified Sierpinski fractal antenna, a micro-strip antenna, can be produced easily and realize the batch production. It shows typical fractal antenna features with performance enhanced by departure of strict deterministic fractal generated geometry on order to become adapted to industry allocated spectrum bands.

Modified Fractal Antenna shows satisfactory electrical performance, compact size and easiness to manufacture, which makes it a strong candidate for practical applications. It can be used as standalone antenna and as feed for reflector antenna for point-to-point applications as well. The innovative approach chosen for antenna modification can lead to future developments in this still relatively undeveloped area of antenna design.

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