International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-2 Issue-5, April 2013

# Miniaturized Compact Patch Antenna for Multiband Applications using Combination of Sierpinski Carpet & Giuseppe Peano Fractral Geometries

**Pradip P.Patel, Sameena Zafar, Syed Uvaid**

***Abstract—Modern telecommunication system require antenna with wider bandwidth and smaller dimensions. Various antennas for wide band operation have been studied for communication and radar system. A fractal monopole antenna is proposed for the application in the UWB frequency range, which is designed by the combination of two fractal geometries. The first iterations of Giusepe Peano fractal are applied on the edges of a square patch, and a Sierpinski Carpet fractal is formed on its surface. The fractal antenna is preferred due to small size, light weight and easy installation. A fractal micro strip antenna is used for multiband application in this project provides a simple and efficient method for obtaining the compactness. A sierpinski carpet based fractal antenna is designed for multiband applications. It should be in compactness and less weight is the major point for designing an antenna. This antenna is providing better efficiency.***

***Keywords— component; Sierpinski gasket, fractal, multiband antenna, miniaturization.***

## I. INTRODUCTION

The term fractal was coined by the French mathematician B.B.Mandelbrot during 1970's after his pioneering research on several naturally occurring irregular of conventional geometrics not contained within the realms of conventional Antenna using some of these geometries for various telecommunication application are already available commercially .The use of fractal geometrics has been shown to improve several antenna features to varying extents. Microstrip patch antenna (MPA) has attracted wide interest due to its important features .Such as light weight, low cost, simple to manufacture and easy to integrate with RF devices. For reducing the size of antenna, fractal geometries have been introduced. The main objectives are to design a square shaped fractal antenna which will be small in size and multiband performance. A fractal is "a rough of fragmented geometric shape that can be split into parts, each of which is reduced size copy of the whole .Roots of the mathematical interest in fractals can be traced back to the late 19th century. However mathematical fractal is based on an equation that undergoes iteration, a form of feed based on recursion.

Fractals have the following features.
1. It has a fine structure at arbitrarily small scales.
2. It is too irregular to be easily described in traditional
3. Euclidean geometric.
4. It is self-similar.
5. Simple and recursive.

A fractal is "A rough of fragmented geometric shape" that is generated by starting with a very simple pattern that grows through the application of rules. In many cases the rules to make the figure grow from one stage to next involve taking the original figure and modifying it or adding to it. The process can be repeated recursively an infinite number of times.

The first application of fractals to the field of antenna theory was reported by Kim and jaggared. They introduced a methodology for designing low side lobe arrays that is based on the theory of random fractals. The fact that self-scaling array can produce fractal radiation pattern was first established in 1992.This is accomplished by studying the properties of a special type of non uniform linear array, called aweiertrass array, which has self-scaling element spacing and current distribution. For reducing the size of antenna, fractals geometries have been introduced in the design of antenna fractal geometries have two antennas. Fractal geometries have two common properties: self-similar property, space filling property. The self-similarity property of certain fractals results in multiband behavior. Using the self-similarity properties a fractal antenna can be designed to receive and transmit over a wide range of frequencies. While using space filling properties, fractal makes reduce antenna size.

Fractal antenna engineering is the field, which utilize fractal geometries for antenna design. It has become one of the growing fields of antenna engineering due to its advantage over conventional antenna design.

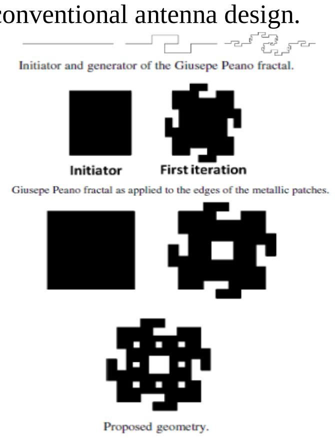



**Figure.1. Proposed Geometry**

**Manuscript received April, 2013.**
**Pradip P. Patel ,** Electronics & Communication, PIES, Bhopal, India.
**Sameena Zafar,** Electronics& Communication, PCST, Bhopal, India.
**Syed Uvaid,** Electrical & Electronics, PIT, Bhopal, India.

## II. ANTENNA DESIGN

### *A. Equation*

The transmission line model represents the Microstrip Antenna by two slots each of width 'W' and height 'h' separated by two impedance ZC transmission line of length L. the essential parameters for the design an antenna according the transmission line method are dielectric constant of the substrate (ε ),resonant frequency (fr) and the height of substrate h. The conventional Microstrip rectangular antenna is designed by following the standard procedures:

1. Calculation of the width W of antenna, which is given by:

$$W = \frac{C}{2\,fo\sqrt{\frac{(\mathcal{E}r+1)}{2}}}$$

2. Calculation of effective dielectric constant, $\varepsilon_{reff,}$ which is given by:

$$\varepsilon\text{reff} = \frac{\mathcal{E}r+1}{2} + \frac{\mathcal{E}r-1}{2}\left[\left[1/\sqrt{(1+12(h/W))}\right]\right]$$

3. Calculation of the effective length, $L_{eff}$ which is given by:

$$\text{Leff} = \frac{\lambda 0}{2\text{fr}\sqrt{\varepsilon\text{eff.}}}$$

4. Calculation of the length extension, ΔL, which is given by:

$$\Delta\text{L} = 0.412\text{h}\frac{(\mathcal{E}r + 0.3)(\frac{\text{W}}{\text{h}} + 0.264)}{(\varepsilon\text{eff} + 0.258)(\frac{\text{W}}{\text{h}} + 8)}$$

5. Calculation of the effective length extension of patch L which is given by:

$$\text{L} = \text{L}_{\text{eff}} - 2\Delta\text{L}$$

6. Ground plane dimension *LS* and *WS* which are given by:

$$\text{Ls} = 6\text{h} + \text{L}$$
$$\text{Ws} = 6\text{h} + \text{L}$$

### *B. Design*

The parameter taken into account for the design are the resonant frequency (*fr*=2.4GHz),dielectric constant ($\varepsilon_r$=4.4) and thickness of the substrate (*h*=1.6mm). the conventional patch antenna is shown in figure-1with dimensions. The rectangular Microstrip patch antenna is based on sieperinski carpet. For designing this fractal antenna IE3D software is used. The FR-4 epoxy material is used as substrate. The thickness of the substrate is 1.575mm. The dielectric constant $\varepsilon_r$ of the antenna is 4.3. The sierpinski carpet fractal shapes is used in this paper with single iteration. In decomposing algorithm for rectangular shapes is cut down from the center of the rectangular patch antenna which is shown the first iteration, again rectangular shape is cut down from the some portion of 1st iteration. Finally resonant frequency found at 2nd iteration.fig.1 shows the rectangular patch antenna without iteration and fig.2 shows the fractal with 1$^{st}$ iteration of the rectangular patch antenna. Fig.3 shows the rectangular patch antenna with 2nd iteration. The size of the rectangular patch antenna is 24mm × 33mm (without iteration) and after 1st iteration 'indetation' 8mm×11mm. This rectangular patch fractal antenna has scale factor equal to 1/3.

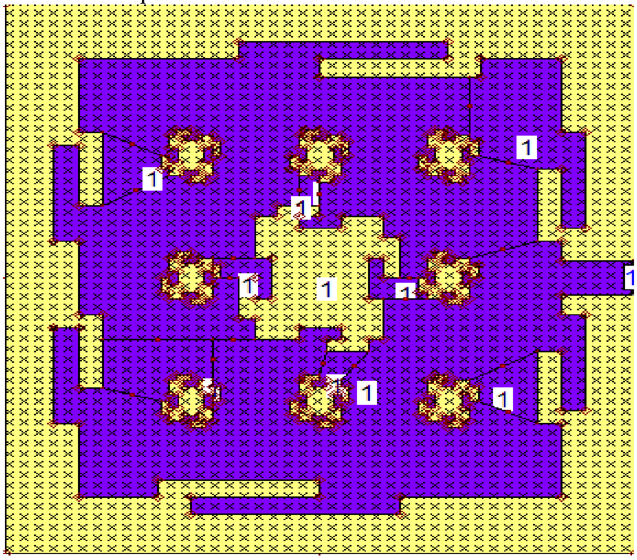


**Figure2.Design of proposed Sierpinski gasket antennas with Giusepe Peano fractal.**

## III. RESULT AND DISCUSSION

- The computer simulation results sown here.
- Observe that the bandwidth of the proposed antenna is from 1 to 20 GHz, which may cover the
- UWB(3.1GHZ-10.6GHz) **[Resonant Frequencies:3.545GHz,3.818GHz, 6GHz,10GHz)**
- ISM/WLAN/Bluetooth (2.3–2.49GHz) **[Resonant Frequencies:2.364GHz&2.455GHz]**
- WIFI(5.1-5.825GHz) **[ResonantFrequencies:5.8GHz]**
- WIMAX(3.4-3.69GHz)
- **[ResonantFrequencies:5.8GHz]**
- Hiper-Lan2(2.12-2.32GHz) **[ResonantFrequencies:2.182GHz]**
- Radar(1-20GHz).
- **[Resonant Frequencies:2.118GHz,2.365GHz, 2.455GHz,3.545GHz,3.818GHz,6GHz, 10GHz,14.55GHz,18.18GHz,20GHz]**

The center frequency is selected as the one at which the return loss is minimum. The bandwidth of the antenna is said to be those range of frequencies over which the return loss is greater than 7.3 dB, which is equivalent to 2.5:1 VSWR

| Sr. No. | Frequency (GHz) | Return loss(dB) | VSWR | Gain (dBi) | Anten-na Efficiency (%) | Radiation Efficiency(%) | Impedance(Ω) |
|---|---|---|---|---|---|---|---|
| 1 | 2.182 | -12.04 | 1.667 | 3.2 | 93.83 | 100 | 56.71 |
| 2 | 2.364 | -23.75 | 1.139 | 3.5 | 99.22 | 100 | 44.87 |
| 3 | 2.455 | -17.48 | 1.309 | 3.5 | 98.30 | 100 | 41.46 |
| 4 | 3.545 | -17.95 | 1.290 | 3.6 | 98.41 | 100 | 64.05 |
| 5 | 3.818 | -19.45 | 1.239 | 4.2 | 98.88 | 100 | 51.38 |
| 6 | 6.000 | -10.81 | 1.810 | 5.3 | 90.80 | 98.84 | 28.43 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7 | 10.00 | -8.125 | 2.292 | 4.6 | 84.65 | 99.95 | 79.20 |
| 8 | 14.55 | -6.950 | 2.631 | 5.8 | 75.49 | 94.49 | 43.18 |
| 9 | 18.18 | -8.624 | 2.177 | 5.5 | 86.25 | 100 | 28.85 |
| 10 | 20.00 | -17.09 | 1.325 | 6.2 | 97.73 | 100 | 37.84 |

**Table 1. Frequency Response**

### *A. Simulation Setup.*

The software used to model and simulate the Microstrip patch antenna is Zeland Inc's IE3D. 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.*Return Loss Characteristics*

The center frequency is selected as the one at which the return loss is minimum. The bandwidth can be calculated from the return loss (RL) plot. The bandwidth of the antenna is said to be those range of frequencies over which the return loss is greater than 7.3 dB, which is equivalent to 2.5:1 VSWR. Return loss graph is shown in figure 2.

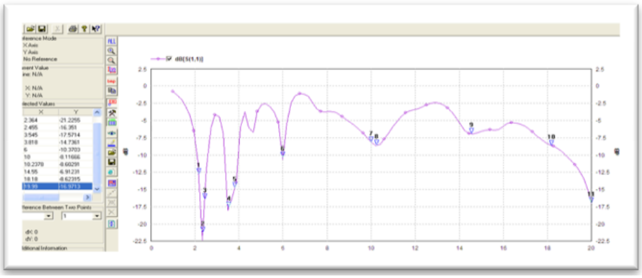


**Figure3. Return loss vs. frequency**

### *C. Gain vs. Frequency*

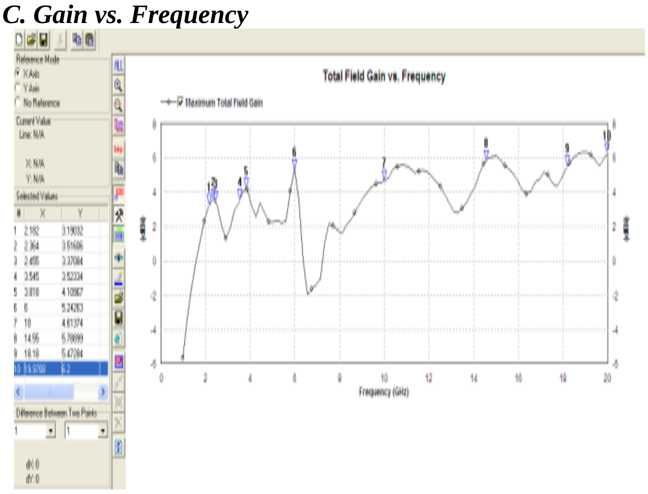



**Figure4.** ***Gain vs. Frequency***

### *D. Antenna efficiency and radiation efficiency*

Antenna efficiency and radiation efficiency graph is shown in figure 4 and figure 5 respectively.

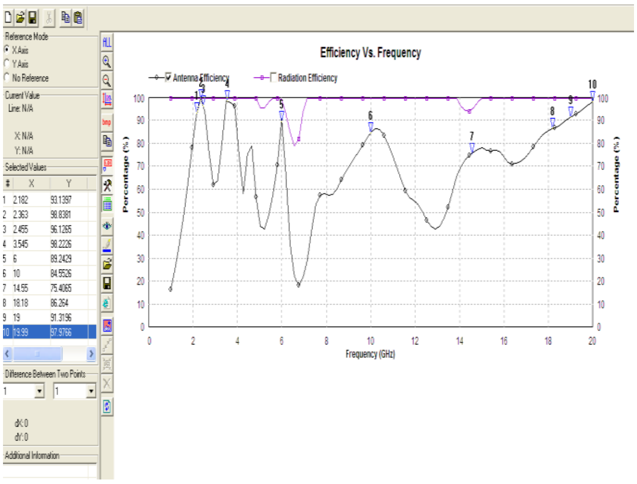



**Figure5.** ***Antenna efficiency plot.***

### *E. Input Impedance Plot.*

We expect pure impedance at frequencies where the patch resonates, and see table 1 and Figure 5.

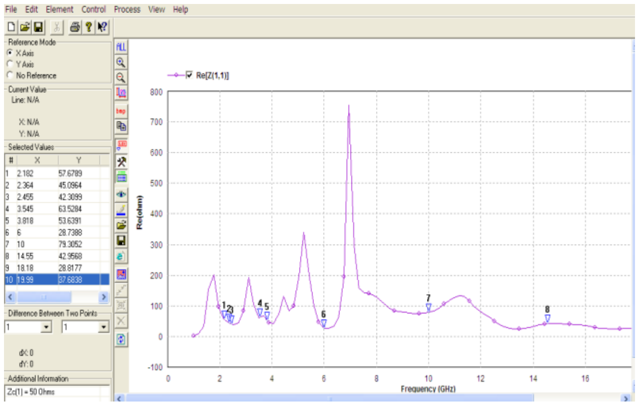
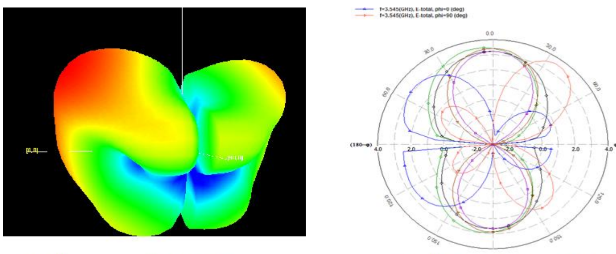



**Figure6. Graph between frequency and magnitude input impedance**

### *F. Radiation Pattern.*

The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. There are five bands we get at each resonant frequency we get different radiation patterns.



3D Radiation pattern for 3.545GHz 2D Radiation pattern for 3.545GHz

**Figure.7:Radiation Pattern for 3.545 GHz& 10GHz**

## IV. CONCLUSION

The aspects of Microstrip antenna have been studied in this paper. The aspect is the design of typical rectangular Microstrip antenna. A simple and efficient technique of design has been introduced for an impedance matching improvement of antenna in this paper.


*Published By:*
*Blue Eyes Intelligence Engineering*
*& Sciences Publication*

The Microstrip fractal antenna is proposed for the wireless various applications.

The antenna is designed for multiband frequencies (2.182,2.364,2.455,3.545,3.818,6.000,10.00,14.55,18.18,

20.00) GHz and the simulation result are obtained up to third iteration. The proposed antenna show a significant size reduction compared to the conventional Microstrip antenna. The designed antenna is compact enough to be placed in typical wireless devices.

## REFERENCES


1. Pramendra Tilanthe and P. C. Sharma, *"Design of a single layer multiband microstrip square ring antenna"* IEEE explore-www.ieee.org, Applied Electromagnetic Conference (AEMC), year: 2009, PP: 1– 4.
2. Duixian Liu and Brian Gaucher, "*A New multiband Antenna for WLAN/Cellular Applications"*, Vehicular Technology Conference, 2004;VTC2004-Fall; IEEE 60th, Year: 2004, Vol: 1, PP: 243 – 246.
3. C. Puente, J. Romeu, R. Pous, A. Cardama, *"On the behavior of the Sierpinski multiband antenna,"*IEEE Trans. Antennas Propagat., vol. 46, pp. 517-524, Apr. 1998
4. D. H. Werner, S. Ganguly, *"An overview of Fractal Antenna Engineering Research"*, IEEEAntennas and Propagation Magazine, vol. 45, pp.38-57, 2003.
5. Philip Tang and Parveen Wahid, *"Hexagonal Fractal Multiband Antenna," Antennas and Propagation Society International Symposium, IEEE*, vol. 4, pp. 554-557, June 2002.
6. Asit K.Panda, Manoj K.Panda, Sudhansu S.Patra *"A Compact Multiband Gasket Enable Rectangular Fractal Antenna"*IEEE2011 International Conference on Computational Intelligence and Communication Systems. Page(s):11-13
7. B.R.Franciscatto,T.P.Voung and G.Fontgalland *"High gain sierpinski gasket fractal shape antenna design for RFID"*IEEE2011.
8. J. Anguera; C. Borja; C. Puente, *"Microstrip Fractal-Shaped Antennas,"* A Review, Antennas and Propagation, 2007, EuCAP 2007, The second European Conference on 11-16 Nov. 2007 Page(s):1 – 7


## AUTHORS PROFILE


**Pradipkumar P. Patel** received the Engineering degree in Electronics & Telecommunication from North Maharashtra University, Jalgaon, in 2008 He is currently a Research for Microstrip patch antenna designing working toward the M.Tech degree in Digital Communication in the Institute PIES ,BHOPAL ,Rajiv Gandhi technological University, Bhopal,.

**Ms.Sameena Zafar**, Working in Electronics & Communication department as Professor and HOD In PCST, Bhopal. She received M.Tech degree in VLSI & Embedded System Design from Maulana Azad National Institute of Technology, Bhopal (MP)

**Mr.Syed Uvaid,** Working in Electrical & Electronics department as Professor and HOD In PIT, Bhopal. He received M.Tech degree from RGTU, Bhopal (MP)