ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 4, Issue 5, May 2015**

# Design of Sierpinski Carpet Fractal Antenna for Multiband Applications

Ashish Dhankhar[1], Dr.Jaswinder Kaur[2]

PG Student [WC], Dept. of ECE, Thapar University, Patiala, India [1]

Lecturer, Dept. of ECE, Thapar University, Patiala, India [2]

**ABSTRACT**: In this paper, the design of Sierpinski Carpet fractal antenna for multiband application is presented. The return loss of designed structures is simulated using 3D electromagnetic simulator CST MWS 14.0.The proposed antenna is designed on (FR-4) Lossy Substrate with thickness 1.58 mm and relativity permittivity 4.44. It is the combination of initial, first and second iterations. Simulated results show that from initial, first and second iteration, it starts showing different frequency which cover the multiband applications. It also covers the C Band communication satellite for their uplink and downlink frequency application. The Broadband and multiple frequency features of fractal antenna will be presented and discussed.

**KEYWORDS:** Sierpinski Carpet, Frequency, CST MWS V14.0, Return Loss, and Fractal antenna.

## I.INTRODUCTION

The necessity for wireless application and its abstruse nature is large during past few decades. Nowadays, wireless technology requires antenna with wider bandwidth and smaller dimensions and therefore it is concentrating more on the fractal structures [1]. The word fractal comes from Latin 'fractus' means broken lines. Benoit Mandelbort describes the relationship between fractal and nature using discovery made by Gaston Julia and Pierre Fataou. Fractal geometry formed using iterative process that leads to self-similarity and self-affinity structure [2]. The Sierpinski Carpet was introduced by Waclaw Sierpinski in 1916 and it is an important part of fractal set.The construction of Sierpinski Carpet begin with square. The square is cut in to 9 congurrent sub square in a 3 by 3 grid and central sub square is removed[3]. Fractal antenna is used for multiband applications because they are small in size, low cost and easy to fabricate . Fractal concept has been applied to many branches of science and engineering including fractal electrodynamics for radiation and propagation [4]. In this paper, design of Sierpinski Carpet fractal antenna starts with an square patch with operational frequency 1 GHz to 9 GHz for various iterations. There are various type of fractal antenna included [5]:

- The Von Koch curve
- The Sierpinski (Gasket and Carpet)
- Minkowski fractal island

Most of the fractal geometry antennas have two common properties which are multi-banding and space filling [7]. Microstrip line using PCB Connector feeding technique has been used in this paper because it is simple and easy to fabricate which reduced the spurious radiation and coupling . Because of these remarkable properties, fractal is an attractive way in designing antenna[6]. The disadvantage of fractal is gain loss, numerical limitation and complexity. Fractal structure is used to represent structure in nature such as cloud, mountain, flower and star [8] .The application of fractal geometry to conventional antenna structures in order to obtain a compact size antenna has been introduced recently in antenna design. Figure 1 shows the initial, first and second iteration of Sierpinski Carpet antenna. Further, the detailed of proposed antenna design are discussed in this paper.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

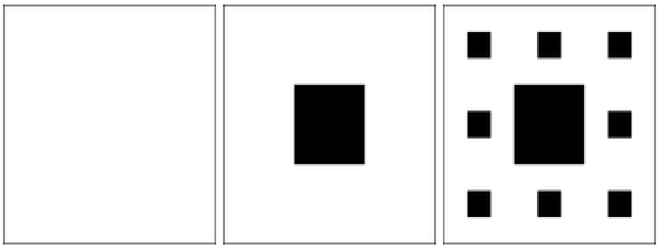

Fig. 1: Sierpinski Carpet for initial, First and Second Iteration [3]

## II. ANTENNA DESIGN AND SPECIFICATIONS

The procedure of Sierpinski Carpet fractal antenna is shown in figure 2, figure 3 and figure 4. The proposed antenna design is shown in figure 4, where the parameter value of final structure shown in Table I. The proposed Sierpinski Carpet antenna is design on FR-4 Lossy Substrate (dielectric constant 4.4) with substrate thickness of 1.60mm. There are three important parameter for design of proposed antenna: height of substrate, dielectric material of substrate and resonant frequency. First a simple square patch is taken as shown in figure 2. For first iteration, remove central inverted square from main square and process is repeated for further iteration [9]. This antenna is fed through 50ohm microstrip line using PCB Connnector technique which is easy to fabricate and simple to match by controlling the inset position.

**TABLE I**
**PHYSICAL DIMENSION PARAMETER OF PROPOSED ANTENNA DESIGN**

| S.NO | Antenna Parameter | Design Value |
|---|---|---|
| 1 | Dielectrical Material | FR4_LOSSY |
| 2 | Substrate Height | 1.58 mm |
| 3 | Loss Tangent | 0.09 |
| 4 | Length of substrate(L) | 35.40 mm |
| 5 | Width of substrate(W) | 35.40 mm |
| 6 | Length of Patch ($L_P$) | 17.70 mm |
| 7 | Width of Patch ($W_p$) | 17.70 mm |
| 8 | Dielectric Constant | 4.40 |
| 9 | Length of feed($L_f$) | 11.6 mm |

### A.SCMPA's Iterations

Miniaturization techniques on fractal structure involves the process of removing some parts of basic structure. The schematic design of Sierpinski Carpet of initial iteration, first iteration and second iteration figures 2,3 and 4. In this paper, Modified Sierpinski Carpet antenna design procedure are as follows [10]:

- For the square patch antenna, the sierpinski carpet fractal concept is applied. CST MICROWAVE STUDIO 14.0 is used for designing this fracta antenna.
- Square shape is cut down from the centre of microstrip patch antenna which shows the first iteration.
- Again Square shape is cut down from some portion of first iteration, various resonant frequencies found at 2$^{nd}$ iteration.
- Following equations are used to find the iteration, capacity dimension and for fractional area are as:

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

$$N_n = 8^n$$

$$L_n = \left(\frac{1}{3}\right)^n$$

$$A_n = \left(\frac{8}{9}\right)^n$$

Where $N_n$ is number of rectangle covering the radiating material, $L_n$ is length ratio and $A_n$ is ratio for fractional area.

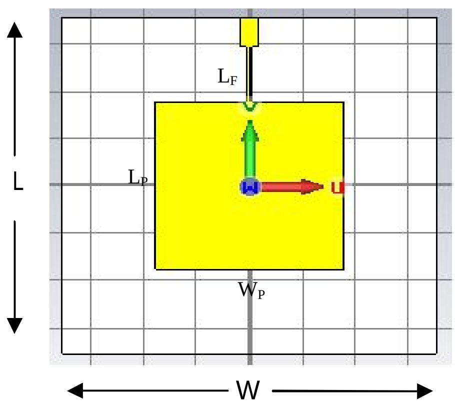


Fig. 2: Initial iteration of the designed antenna

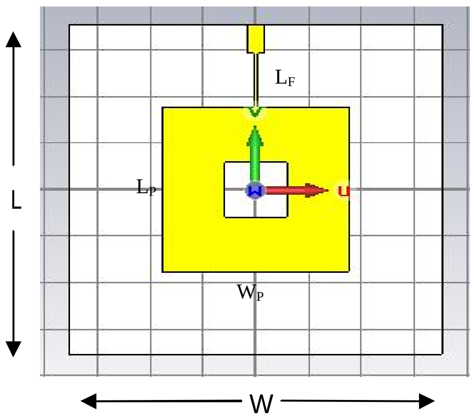


Fig. 3: First iteration of the designed antenna

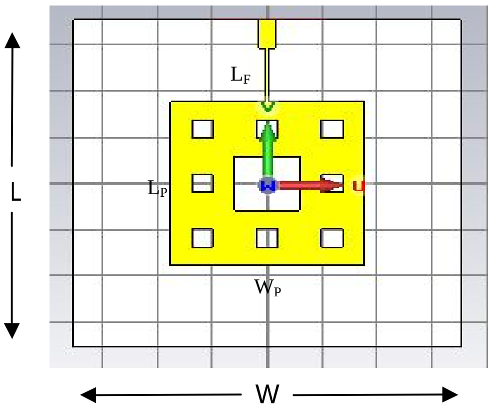


Fig. 4: Second iteration of designed antenna

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 4, Issue 5, May 2015**

## III. RESULTS AND DISCUSSION

Dimensions of the proposed antenna are optimized by CST MICROWAVE STUDIO 14.0 and final dimensions are listed in TABLE II. $S_{11}$ Parameter indicates Return Loss. It is defined as maximum reflection of power from the given antenna. The designed antenna is simulated and shows the different frequency which cover the multiband application. Simulated return loss is shown in the figures 4(a),4(b) and4(c).

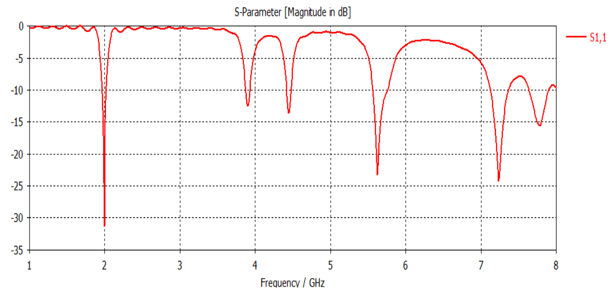


Fig. 4 (a): Return loss of initial iteration of designed antenna

In the Fig. 4 (a), it shows the different resonant frequencies at the frequency 1.91 GHz,3.91 GHz,4.43 GHz,5.62 GHz,7.23 GHz and 7.78 GHz which is used for multiband applications.

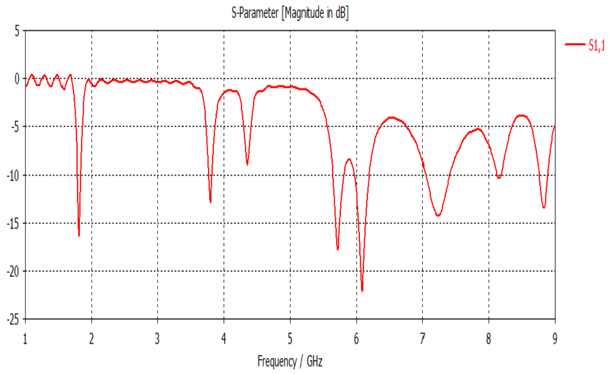


Fig. 4 (b): Return loss of first iteration of the designed antenna

In the Fig. 4 (b), it shows the different resonant frequencies at the frequency 1.80 GHz,3.80 GHz,5.72 GHz,6.09 GHz,7.22 GHz and 8.83 GHz which is used for multiband applications.

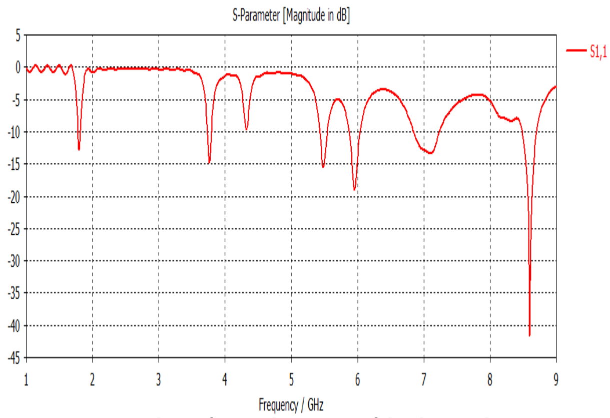


Fig. 4 (c): Return loss of second iteration of the designed antenna

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

**Vol. 4, Issue 5, May 2015**

In the Fig. 4 (c), it shows the different resonant frequencies at the frequency 1.79 GHz,3.79 GHz,5.48 GHz,5.96 GHz,7.11 GHz and 8.60 GHz which is used for multiband applications.

**TABLE II**
**COMPARISON OF RETURN LOSS AT VARIOUS RESONANT FREQUENCY FOR INITIAL, FIRST AND SECOND ITERATION**

| SI. NO. | Initial Iteration | | Iteration 1 | | Iteration 2 | |
|---|---|---|---|---|---|---|
| | Freq (GHz) | RL(dB) | Freq (GHz) | RL(dB) | Freq (GHz) | RL(dB) |
| 1 | 1.99 | -31.32 | 1.80 | -15.88 | 1.79 | -11.33 |
| 2 | 3.91 | -12.08 | 3.80 | -12.87 | 3.77 | -14.03 |
| 3 | 4.43 | -13.25 | 5.72 | -17.73 | 5.48 | -15.45 |
| 4 | 5.62 | -23.05 | 6.09 | -21.44 | 5.96 | -18.68 |
| 5 | 7.23 | -24.18 | 7.22 | -14.24 | 7.11 | -13.29 |
| 6 | 7.78 | -15.52 | 8.83 | -13.40 | 8.60 | -41.51 |

Simulated results for initial iteration, first iteration and second iteration shown in figure 4(a), 4(b) and 4(c). and the comparison of return loss at various resonant frequency for initial, first, and second iteration shown in above Table II.

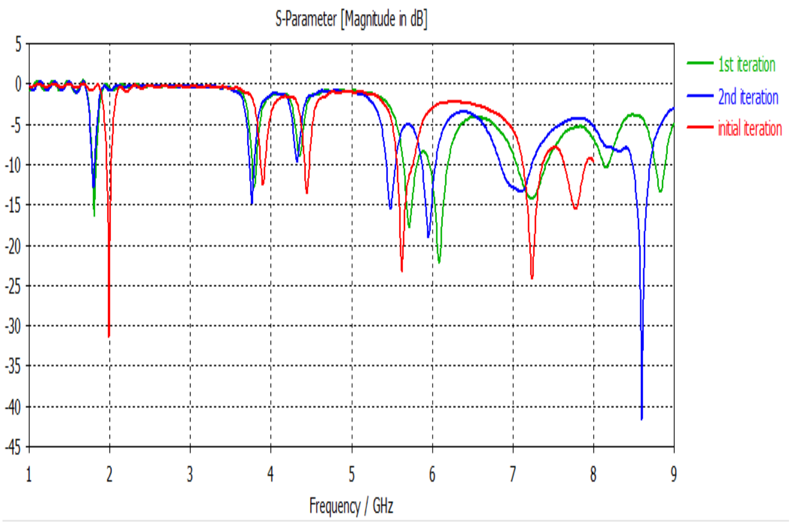


Fig.5: Comparison of initial, first and second iteration of Sierpinski Carpet fractal antenna

## IV. CONCLUSION

Sierpinski Carpet fractal antenna with microstrip line using PCB Connector feeding technique has been presented in this paper. This fractal antenna has been analysed using CST Microwave studio 14.0.It is observed that from initial, first and second iteration, it start showing multiple resonant frequency. As number of iteration increases, number of resonant frequencies gives multiband performance to the Sierpinski Carpet antenna structure. The result shows that antenna shows good return loss and with miniaturization size reduction techniques and this fractal antenna is best suited for 1.79/3.77/5.48/5.96/7.11/8.60 GHz multiband application.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

*(An ISO 3297: 2007 Certified Organization)*

Vol. 4, Issue 5, May 2015

## V. ACKNOWLEDGMENT

The authors greatly acknowledge the help provided by Electronics and Communication Engineering Department, T.U., Patiala by providing the necessary software for designing antenna, testing equipments and various infrastructural facilities for the successful completion of this paper.

## REFERENCES

[1] C. Balanis, “Antenna Theory: Analysis and Design” 2nd edition, New York, Wiley, 1997.
[2] Mandelbort, B.B. Petigen, “The Fractal geometry of Nature” W. H. Freeman and Company, 1982.
[3] A. Aggarwal, M.V. Kartikeyan, “Design of Sierpinski Carpet Antenna using two different feeding mechanism for WLAN applications,” 2010 IEEE.
[4] D.L. Jaggard, “On fractal electrodynamics” in recent advances in electromagnetic theory, H.N. Kritikos and D.L. Jaggard , edition, New York: Springer- Verlag, pp. 183-224, 1990.
[5] L. Lizzi and G. Oliveri, “Hybrid design of a fractal shaped GSM/UMTS Antenna” Microwave and optical technology Letters, vol. 50, no.3, pp. 825-829, 2010.
[6] G.F. Tsachtsiris, C.F. Soras, M.P. Karaboikis and V.T. Makois, “Analysis of Modified Sierpinski Gasket Monopole antenna Printed on Dual Band Wireless Devices” IEEE Transactions on Antennas and Propagation, vol. 52, no. 10, pp. 2571-2579, 2004.
[7] Carlos Puente Blairada, Jordi Romeu, Rafel Pous and Angle Cardama, “On the behavior of the Sierpinski Multiband Fractal Antenna”, IEEE Transactions on Antennas and Propagation, vol.46, no.4, pp. 517-524, 1998.
[8] Philip Felber, “Fractal Antennas”, Illinois institute of Technology, 2nd edition, 2001.
[9] W.L. Chen and G.M. Wang, “Small size edge-fed Sierpinski Carpet microstrip patch antenna” PIERS C, vol.3, pp. 195-202, 2008.
[10] T. Shanmuganantham and R. Mohanamurali, “Sierpinski Carpet Fractal antenna for multiband applications”, International Journal of Computer applications (0975-8887) vol. 39, no.14, pp. 19-23, 2012.