International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:2682
Vol.4, No.5, May 2015 DOI:10.15693/ijaist/2015.v4i2.356-361

Investigation and Design of a Novel Multiband Fractal Antenna for ISM and Wireless Communication

Mr. P. Manikandan
Assistant Professor,
Department of ECE,
Kalasalingam Unversity.

Dr. P. Sivakumar
Associate Professor,
Department of ECE,
Kalasalingam Unversity.

***Abstract*— Wider bandwidth and multiple bandwidths are required in modern wireless communication. Traditionally we use antennas that operate on a single frequency band or dual frequency bands. This causes increase in size of the communication devices. Our project presents the idea of using fractals to design a multiband antenna. Fractals have self similar shapes and space filling properties. These properties of the fractal help in achieving multiband characteristics and occupy low space. In our project we are going to investigate different fractal structures present and design a novel fractal antenna more suitable for ISM and wireless communication (GSM; Bluetooth; Wi-Fi; etc) with a improved gain using ADS simulation software.**

Index terms - Multiband, fractal, gain, centre feeding.

I. INTRODUCTION

Fractal antennas can be utilized in a variety of applications, especially where space is limited. An example of exploiting the benefits of fractal in antenna systems is the phased arrays, where fractals can reduce mutual coupling and allow for lower scan angles, mobile phone handsets and satellite communications [1]. Since the first fractal antenna was introduced, fractal geometries have been applied to the design of antennas especially for multiband antennas because of its self-similarity. If an antenna is much smaller than the operating wavelength, its efficiency deteriorates drastically, since its radiation resistance decreases and the reactive energy stored in its near field increases [2]. Antenna geometries and dimensions are the main factors determining their operating frequencies [3]. Fractal antennas [4], have very good features like small size and multiband characteristics. Most fractal objects have self similar shape, with different scale [5, 6]. Fractal antennas have shown the possibility to miniaturize antenna structures and to improve the input matching. Certain classes of fractal antennas can be configured to operate effectively at various frequency bands [7]. As a part of an effort to further improve modern communication system technology, researchers are now studying many different approaches for creating new and innovative antennas. One technique that has a received much recent attention involves combining aspects of the modern theory of fractal geometry with antenna design [8].

In this paper we have proposed a novel multiband fractal antenna which is suitable for many wireless applications and which could achieve reconfigurability.

A.Multiband Antenna

A multiband antenna is an antenna designed to operate in multiple bands of frequencies. Multiband antennas use a design in which one part of the antenna is active for one band, while another part is active for a different band. Multiband antennas may have lower-than-average gains or be physically small in comparison to single-band antennas.

B.Fractal Antenna

A fractal antenna is an antenna that uses a fractal, self-similar design to maximize the length, or increase the perimeter (on inside sections or the outer structure), of material that can receive or transmit electromagnetic radiation within a given total surface area or volume. Such fractal antennas are also referred to as multilevel and space filling curves, but the key aspect lies in their repetition of a motif over two or more scale sizes, or "iterations". For this reason, fractal antennas are very compact, multiband or wideband, and have useful applications in cellular telephone and microwave communications. The two main properties of fractal antenna are

i. Property of Self Similarity
ii. Property of Space filling

i. Property of Self Similarity: The property of self similarity of fractals helps in achieving multiband characteristics. In fractals the base shape with a different scale is repeated for a number of times. At a particular iteration the multiband characteristic will be attained after which there will be no changes in the characteristics of the antenna.

ii. Property of Space filling: The property of space filling of fractals help in increasing the perimeter of the fractal structure or it increases the length of the radiating element without increasing the physical length of the antenna.

C.Center Feeding

The process of feeding takes place in antennas both on the transmitter and receiver sides of a communication system. The process by which the radio frequency current from the transmitter is radiated as radio waves (on the transmitting end) and collecting the incoming radio waves and converting them into electric current and transmitting them to the receiver (on the receiving end) is known as Feeding. Some of the main types of feeding are

i. Inset feeding
ii. Indirect or Coupled feeding
iii. Centre feeding
iv. Aperture feeding
v. Co-axial or probe feeding
vi. Transmission line feeding, etc.

Among the various types of feeding the centre feeding was found to be more effective for the antenna design proposed by us. In centre feed the ports are placed at the centre of the antenna design so that we could achieve more efficiency.

Fig1. Shows our proposed structure designed using centre feed (via feed)

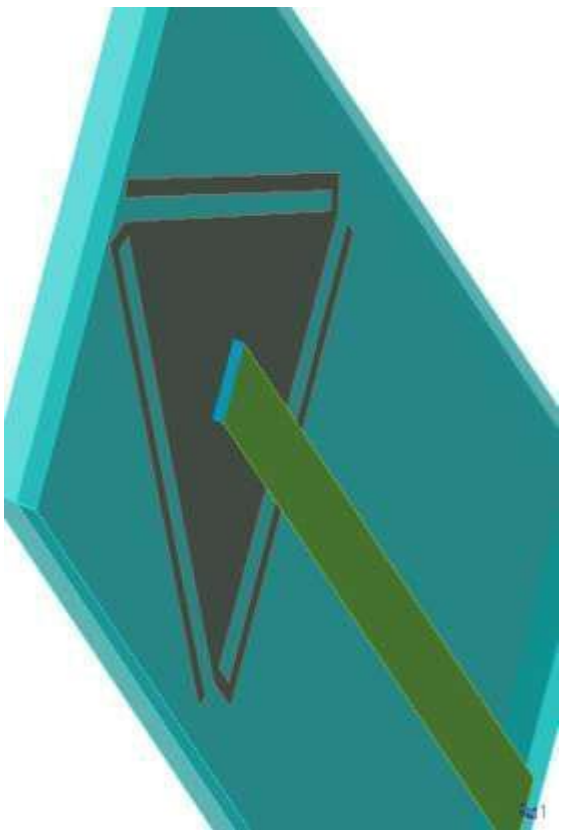


Figure 1. Centre Feeding in the proposed antenna structure.

II. Related Work

A. Proposed Structure to Achieve Multiband

The antenna design proposed by us is a patch antenna. The substrate material chosen is FR4. The thickness of this layer is 1.6 mm. The permittivity (ε_r) of the FR4 material is 4.6 and the loss tangent of the material is 0.0001. To achieve multiband we proposed the triangular antenna design as shown in figure-2. The triangle is equilateral triangle and each side of the triangle measures 30 mm. A rectangular conducting material of length 30 mm and width 1mm is drawn parallel to each side of the triangle. These rectangular structures are connected to the triangle by means of a connector of height 2 mm and width 1 mm. This design is fed by means of via feed (Centre feeding). For which we use the feed of height50 mm and width 5 mm. The Material used for the feed line is FR4. The length of the hole in the via feeding technique is 5 mm.

The design proposed by us is shown in figure-2.

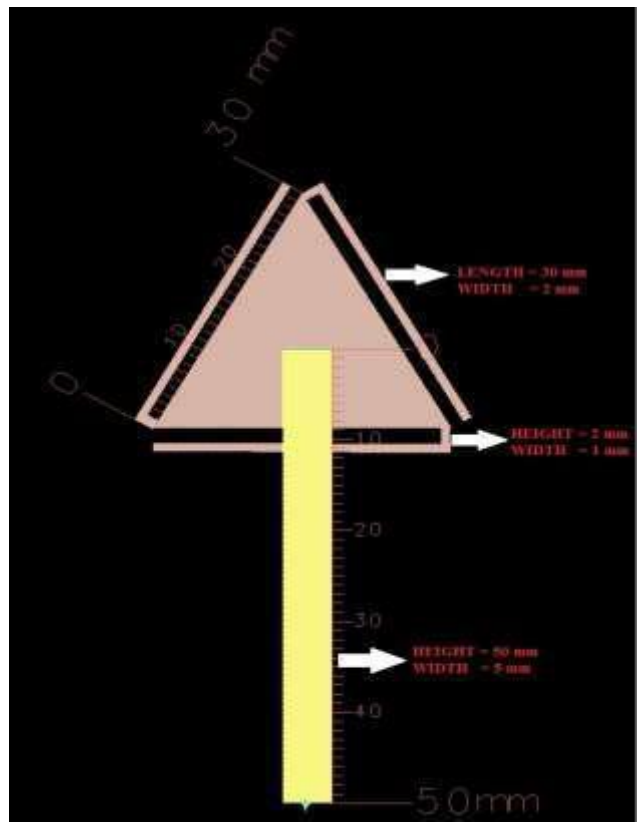


Figure 2. Proposed Antenna Design and its Dimensions.

III. Performance Evaluation

A. Comparison of Ordinary Triangle with the Proposed Design

The ordinary triangle without the rectangular conducting materials was found to be less efficient when compared to the design proposed by us. The ordinary triangle

design and the design proposed by us both were simulated using Advanced Design System (ADS 2009) simulation software and their results were compared and from the comparisons we concluded that our design is better than the ordinary triangular structure. The figure- 3 shows the ordinary triangle design and its dimensions.

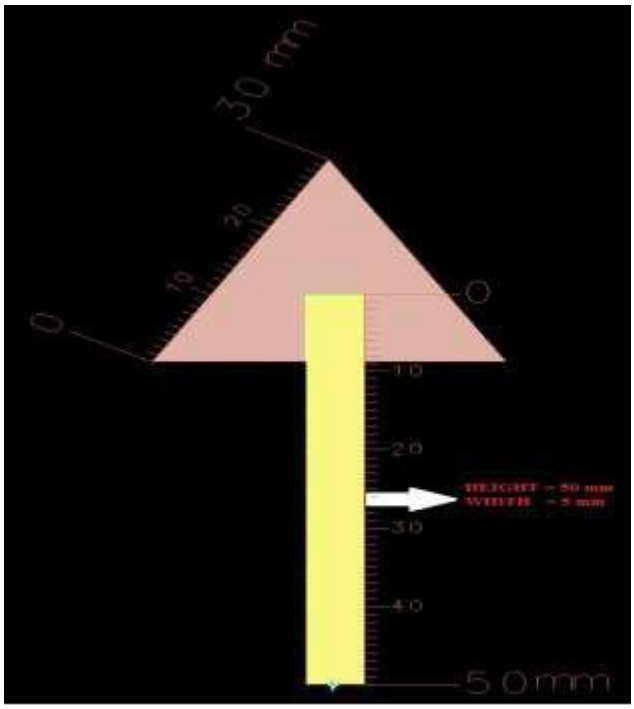
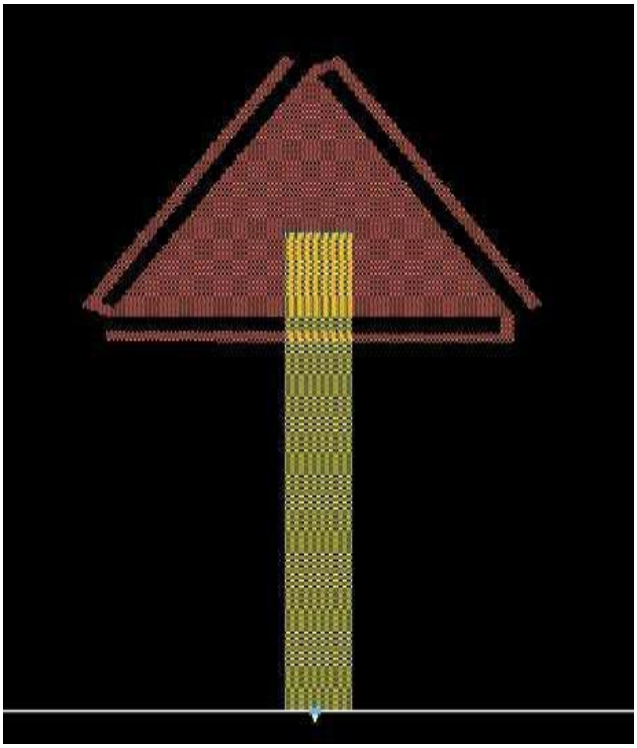


Figure 3. Ordinary Triangle Antenna Design.

The following figures show the different iterations of the antenna design proposed and their frequency responses.



Fiure.4. Base Structure of the Design proposed

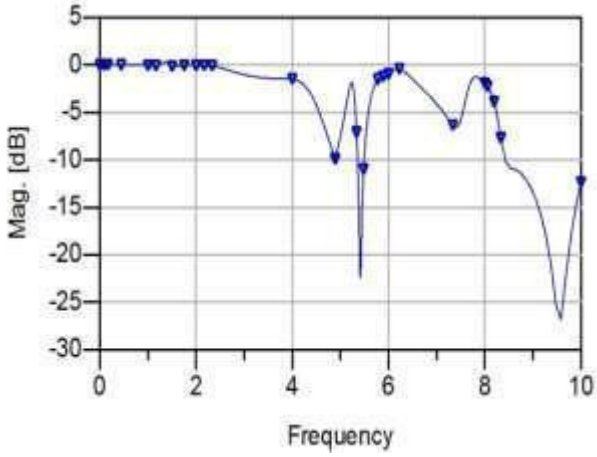


Figure 5. Frequency response of the base structure design proposed.

From the above graph we can see that the proposed base structure can achieve three resonant frequencies 5.531GHz; 7.469 GHz; 9.333GHz with return losses -20.335 dB; -10.288 dB;-20.710 dB respectively.

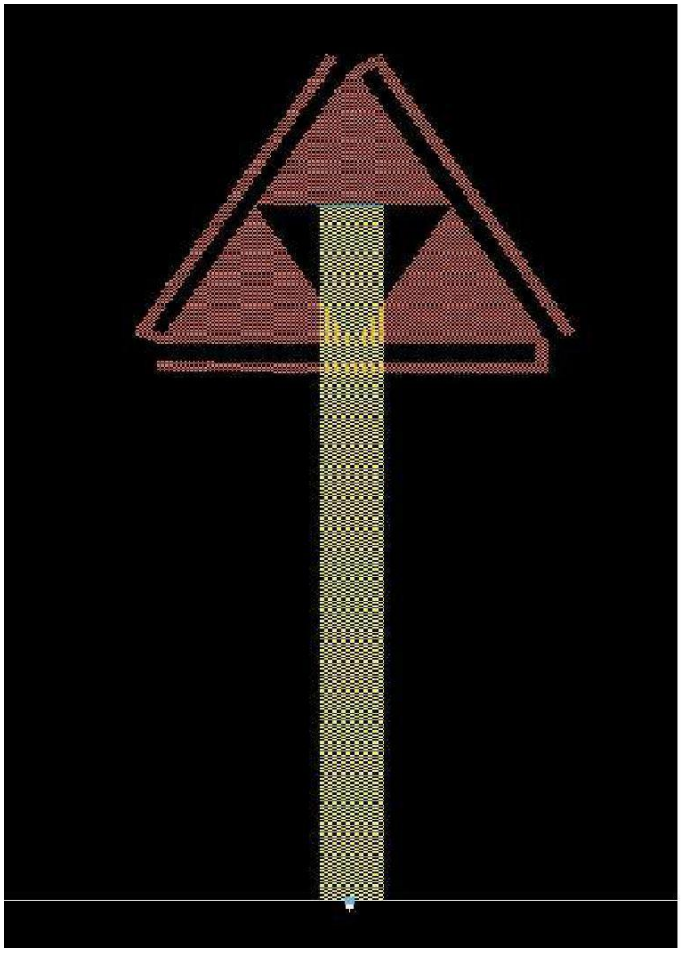


Figure 6. First Iteration of the Design proposed.

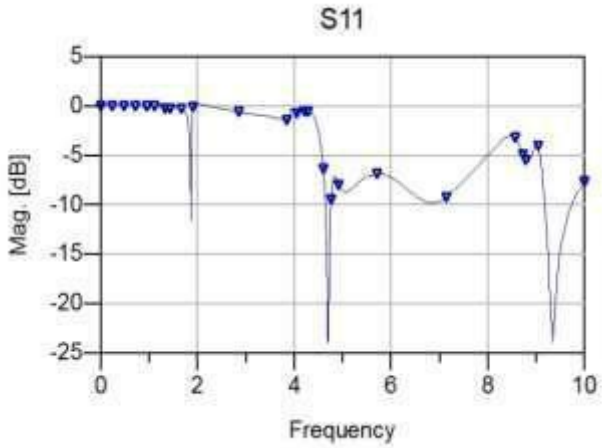


Figure 7. Frequency response of the first iteration of the design proposed.

From the above figure we can see that the first iteration of the proposed design can achieve four resonant frequencies 1.860 GHZ; 4.702 GHz; 6.875GHz; 9.345 GHz with return losses -11.646 dB; -24.005 dB; -9.805 dB; -23.891 dB respectively.

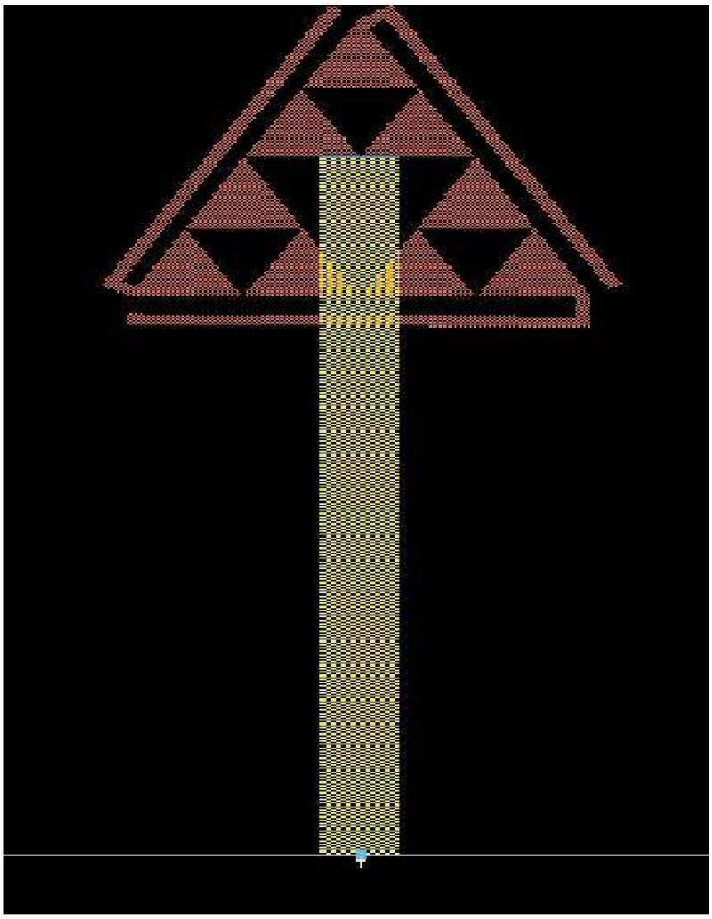


Figure 8. Second Iteration of the Design proposed

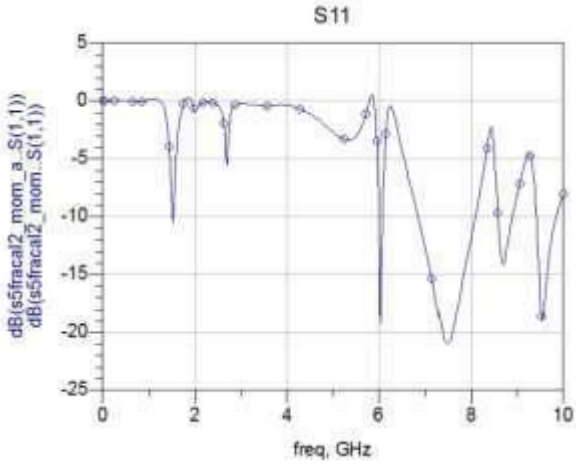


Figure 9. Frequency response of the second iteration of the design proposed.

From figure.9 we can see that the second iteration of the proposed antenna design can achieve five resonant frequencies 1.508 GHz; 6.039 GHz; 7.478 GHz; 8.661 GHz; 9.524 GHz with return losses -10.537 dB; -19.219 dB; -20.971 dB; -13.876 dB; -18.666 dB respectively. These frequencies can be matched with various applications.

ITERATION	RESONANT FREQUENCY (GHz)	RETURN LOSS (dB)
BASE STRUCTURE	5.531 7.469 9.333	-20.335 -10.288 -20.710
FIRST ITERATION	1.860 4.702 6.875 9.345	-11.646 -24.005 -9.805 -23.891
SECOND ITERATION	1.508 6.039 7.478 8.661 9.524	-10.537 -19.219 -20.971 -13.876 -18.666

Table.1. Frequency response and return loss of different iterations of proposed Antenna design

Table.1 shows the resonant frequencies achieved in different iterations of the proposed antenna design and their corresponding return losses.

The following figures show the second iteration of the ordinary triangular antenna design and its frequency response.

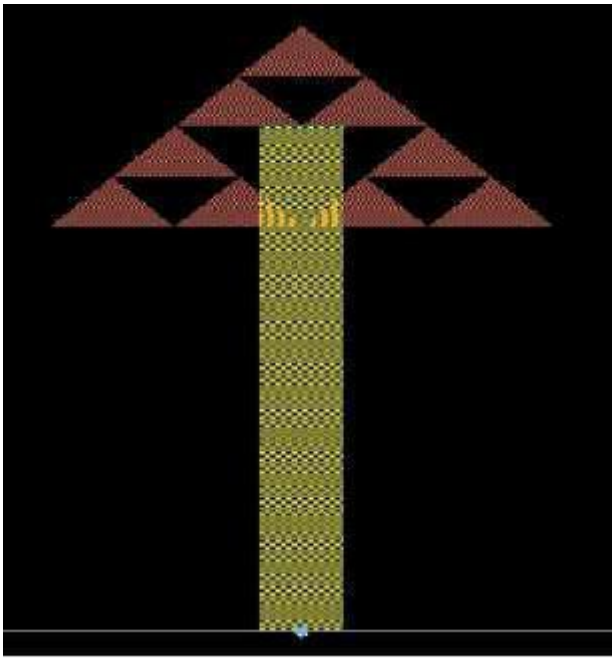


Figure 10. Second Iteration of the ordinary triangular antenna design.

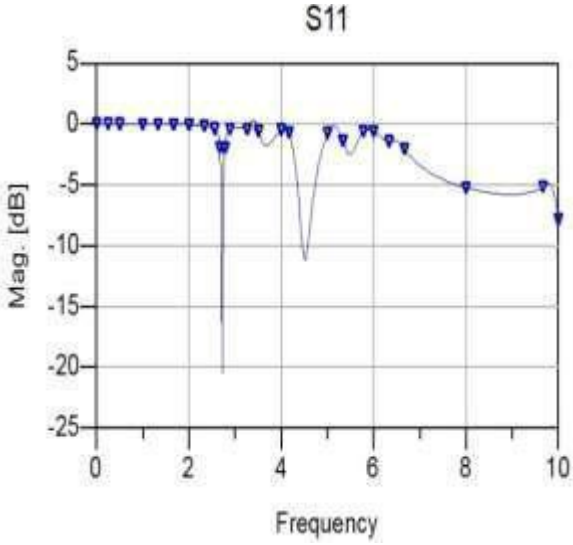


Figure 11. Frequency response of second iteration of Ordinary triangular Antenna design

ITERATION	RESONANT FREQUENCY (GHz)	RETURN LOSS (dB)
SECOND ITERATION	2.722 4.531	-20.466 -11.070

Table.2. Frequency response and return loss of second iteration of ordinary trianglular Antenna design

On simulating the various iterations of the ordinary triangular antenna design without the rectangular strips we found that it acts as an antenna only in its second iteration and in the second iteration two resonant frequencies are achieved so this design can act as a dual band antenna and not as a multi band antenna.

IV. CONCLUSION

Thus from this paper we conclude that the antenna design proposed by us is better than the ordinary triangular antenna and could achieve more bands than the ordinary triangular antenna. The second iteration of our antenna design could be used in applications such as GPS, PLL Synthesizer, Medical applications and Electronic counter Measure applications in militaries. We could also achieve reconfigurability in our antenna design by varying the connections between the triangle and the rectangular strips

ACKNOWLEDGEMENT

We thank the Department of Electronics and Communication Engineering of Kalasalingam University,(Kalasalingam Academy of Research and Education), Tamil Nadu, India for permitting to use the computational facilities available in Centre for Research in Signal Processing and VLSI Design which was setup with the support of the Department of Science and Technology (DST), New Delhi under FIST Program in 2014.

REFERENCES

[1]. J. Gianvittorio, "Fractal antennas: design, characterization and applications", Master's Thesis, University of California, Los Angeles, 2000.

[2]. John P. Gianvittori and Yahya Rahmat-Samii, "Fractal Antenna: A Novel Antenna Miniaturization Technique and Applications". IEEE Antenna and Propagation Mag. Vol.44, No.1, Feb. 2002.

[3]. Douglas H. Werner and Suman Ganguly, "An Overview of Fractal Antenna Engineering Research". IEEE Antenna and Propagation Mag. Vol.45, No.1, Feb. 2003.

[4]. Werner D. H., Mittraa R:, "Frontier of Electromagnetic", (Wiley-IEEE Press), New York, 1999.

[5]. H. Jones, et al., "Fractals and chaos", A.J. Crilly, R.A. Earnsshaw, and H.Jones, Eds. New York: Springer – Verleg, 1990.

[6]. Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[7]. B.B.Mandelbort, "The Fractal Geometry of Nature" . San Francisci, CA: Freeman, 1983.

[8]. H.O.Peitgen, H. Jurgens, and D. Saupe, Chaos and Fractals, New Frontires in Science, New York: Springer-Verlag, 1992.

[9]. Ancy P V, Satya Bhushan Sukla, A K Prakash, K K Mukundan" Multiband Fractal Antenna for wireless communication" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol 3, Issue 2 , May 2014.

[10]. Sujeet Kumar Yadav, Kriti Vyas, Sudarshan Kumar " A Pythagorus Tree Shape Fractal Antenna for Multiband Applications" International Journal of Emerging Technology and Advanced Engineering, Vol 3, Issue 12, December 2013.

[11]. Amanpreet Kaur, Naveen Kumar, Dr. Basudeo Prasad " A Study of Various Fractal Antenna Design Techniques for wireless applications" IJECT, Vol 4, Issue spl 3 , April – June 2013.

[12]. Nikhar Trivedi, Sanjay Gurjar, Ashwanee Kumar Singh "Design and Simulation of Novel I shape Fractal Antenna" IJEST.

[13]. R.L. Yadava, M Ram, S Das "Multiband triangular fractal antenna for mobile communication" IJEST, Vol 2(11), 2010.

[14]. S Suganthi, D Kumar, S Raghavan "Design and simulation of miniaturized multiband fractal antennas for wireless applications" International Journal of Information and Electronics Engineering, Vol 2, ,No 3, September 2012.

[15]. A Azari, J Rowhani "Ultra Wideband Fractal Microstrip Antenna Design" Progress in electromagnetic research, Vol 2, 7-12-2008.

[16]. Manas Ranjan Jena, B B Mangaraj, Debasis Mishra " Bandwidth and Gain Enhancement of Multiband Fractal Antenna Based on the Sieroinski Carpet Geometry" ICTACT Journal on communication technology, Vol 4, Issue 1, March 2013.

[17]. W J Liao, S H Chang, L K Li " A Compact Planar Multiband Antenna for Integrated mobile devices" Progress in electromagnetic Research, Vol 109, 1-16, 2010.

[18]. Fuguo Zhu, Steven Gao, Jiadong Xu " A Low profile printed Tri Band antenna using multiband artificial

[19]. magnetic conductor ground plane" PIERS Proceedings, Suzhou

[20]. M R Zaman, Afaz Uddin Ahmed, Rezaul Azim, Huda Abdullah, Mohd Tarmizi Ali, M T Islam " Multiband Patch antenna for femto cell application" International Journal of Antennas and Propagation, Vol 2014 Article ID 352763.

[21]. Nehya Chaudhary, Sonika Sindhiya, K K Tirphathi : Design and analysis of multiband slotted Octagonal Fractal antenna" IJARECE, Vol 3, Issue 1, Jan 2014.

[22]. E Surducan, V Surducan, D Iancu, J Glossner "Multiband antenna for SDR applications" International journal of digital Multimedia Broadcasting, Vol 2009 , Article ID 460143.

Authors Profile

P.Manikandan received the **B.E.** degree in electronics and communication engineering from Krishnasamy college of Engineering, Cuddalore, India, in 2006. Also completed **M.E.** in Applied Electronics at Govt. college of technology, Coimbatore, India. Currently working as Assistant Professor, Department of electronics and communication engineering at Kalasalingam University.

P.Sivakumar received the **B.E.** degree in electronics and communication engineering from Madurai Kamaraj University, India, in 2001. Also completed **M.E.** in VLSI design at SASTRA University, Tanjore, India, in 2002. Received Ph.D degree from Anna University. Currently working as Associate Professor, Department of electronics and communication engineering at Kalasalingam University.