Improve Characteristics of Patch Antenna with Fractal Geometry

Renu Kumari[1] Mrs. Vijeta[2]
[1]M Tech Student [2]Assistant Professor
[1,2]R.N College of Engineering, Madlauda, Panipat, Kurukshatra University Haryana, India

Abstract— A microstrip antennas include more than one patches in a two-dimensional array. The antenna is typically related to the transmitter or receiver via foil microstrip transmission lines. The radio frequency modern-day is applied (or in receiving antennas the obtained sign is produced) among the antenna and floor plane. Microstrip antennas have end up very famous in latest a long time because of their skinny planar profile which may be included into the surfaces of customer products, plane and missiles; their ease of fabrication the usage of revealed circuit techniques; the benefit of integrating the antenna at the equal board with the relaxation of the circuit, and the opportunity of including lively gadgets which includes microwave incorporated circuits to the antenna itself to make lively antennas. This paintings explores the overall performance enhancement of microstrip patch antenna via way of means of analyzing the numerous papers. The antennas are analyzed the usage of the exclusive antenna parameters like Radiation pattern, Gain, Return loss, Directivity and Radiation pattern.
Keywords: Patch Antenna, FRACTAL GEOMETRY

I. Introduction

Microstrip antennas (additionally referred to as the patch antenna) are the maximum simple form of antenna that is used now days, specifically withinside the variety from 1 to six GHz. The microstrip antenna first got here into life withinside the early 1955 whilst G.A. Deschamps first proposed the idea of microstrip idea via way of means of the usage of microstrip feed line to feed an array of revealed antenna elements. The flat profile and decreased weight of those antennas in comparison to the parabolic reflector antennas and different antennas, made it appealing for airborne and spacecraft applications. With extra length discount and the usage of excessive dielectric energy substances have brought about using such antennas in handsets and GPS systems. Microstrip patch antenna is one of the maximum beneficial antennas at microwave frequency variety.

II. Basic Patch Antenna Design

There are a number of configurations in which a patch antenna can be designed, the basic one is shown in figure 1.1.

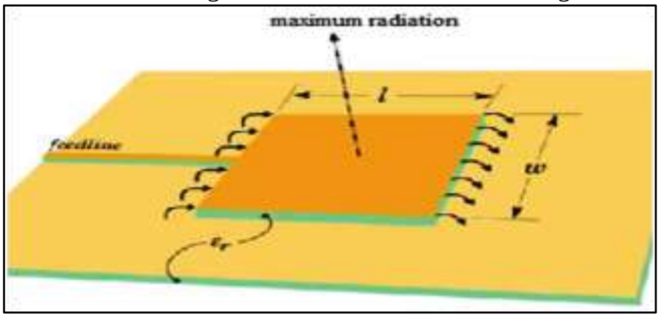

Fig. 1.1: Basic configuration of microstrip patch antenna

Here, *l* is the length and *w* is the width of the patch. In simplest configuration $l = w = \lambda_{eff}/2$ or an electrical one half wavelength, including the shortening effect of the dielectric constant (ε_r) of the material between the patch and the conducting surface. The width w of the microstrip antenna controls the enter impedance. Larger width can also growth the bandwidth. By growing the width, the impedance may be reduced. Several strategies have developed to lessen the antenna length which include the usage of shorting posts, fabric loading and geometry optimization. The use of slots with distinctive shapes in microstrip patch antenna has proved to be the maximum nice strategies of all the stated strategies.

III. Fractal Geometry

Fractal geometry is a very popular method which has unique properties to improve the characteristics of the patch antennas. Fractal was first defined by Benoit Madelbrot in 1975 and snowflake curve was the first example of fractal given by him. We can define a fractal as an object with nonlinear self-similar properties. Fractal geometry has unique features occurring in nature. The self-similar property of fractal can be explained with the help of an example of a fern leaf. If we observe a fern leaf carefully then we will notice that each small leaf which is a part of the big leaf has the same shape as that of the whole fern leaf. Hence we can say that the fern leaf is self-similar [29]. The iteration of one or more affine transformations can generate fractals reproducing real shapes, such as clouds, mountains etc. An affine transformation is a recursive transformation of the form given below.

$$\begin{pmatrix} x_{n+1} \\ y_{n+1} \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} x_n \\ y_n \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix} \quad (1.1)$$

To run this system an initial point have to be chosen and one transformation is chosen randomly according to the assigned probabilities on each iteration, the resulting point (x_{n+1}, x_{y+1}) are drawn on a page. The fundamental iterative process involves replacing rectangles with a series of rectangles called generator.

An important property of fractal geometry is the possibility of obtaining an arbitrarily long curve confined to a given apace. This property can be exploited properly in the process of antenna miniaturization. Another property is the self similar property. The self similar properties can take different forms depending on the choice of fractal representation. There are a lot of advantages. Some of these advantages include the reduction in size, decrease in the resonant frequency and multiband generation. The different fractal geometries are discussed below.

A. Koch Fractal:

The advantages of using a fractal as a dipole antenna are to miniaturize the total height of the antenna at resonance. The curve of Koch is generated by a geometric method which can be iterated an infinite number of times by dividing a straight line segment into three equal parts and substituting the intermediate part with two segment of the same length. With each new iteration a length is added to the total curve which results in 4/3 the original geometry.

$$Length_{koch} = h\left(\frac{4}{3}\right)^n \quad (1.2)$$

Above equation (1.2) gives the length of n^{th} iteration.

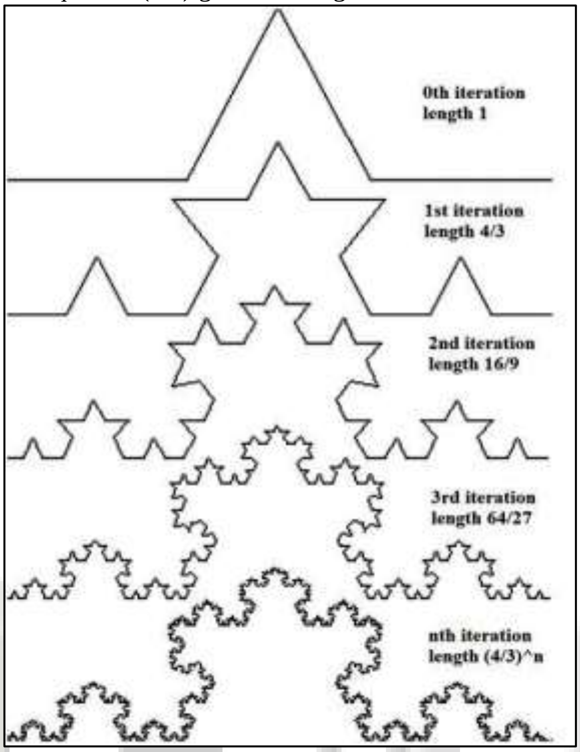

Fig. 1.2: Koch Fractal Geometry

The self-similar property of the fractal geometry can be observed from the above figure (1.1).the amount of scaling that is necessary for each iteration gradually reduces as the number of iterations increase. Hence we can say that resonant length increases with increase of iterations but the area reduces.

B. Minkowski Fractal:

Hermann Minkowski introduced the Minkowski fractals in the year 1885. This geometry can be used to reduce the size of the antenna by increasing the efficiency with which it fills up its occupied volume with electrical length. In case of this geometry the fractal is formed by displacing the middle one-third of each straight segment by some fraction called the indentation factor

Indentation factor = indentation width / indentation length

Changing the indentation factor causes a change in the resonant frequency, hence proper tuning should be there to obtain the required frequencies.

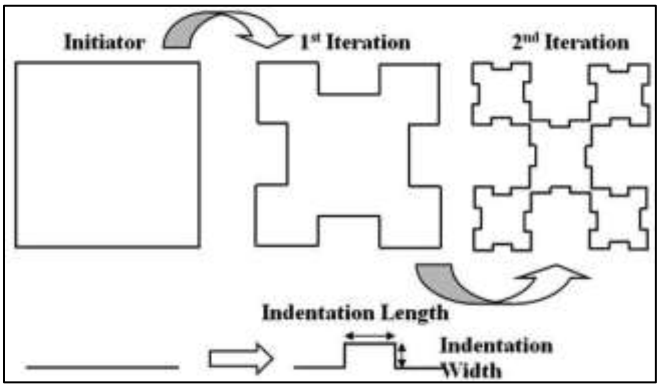

Fig. 1.3: Minkowski Fractal Geometry

The starting geometry in this case is a square patch. The first iteration is obtained by replacing each of the four sides of the square by an indentation. The dimensions of the indentation vary with each iteration.

C. Sierpinski Carpet Fractal Geometry:

The Sierpinski carpet fractal geometry is applied on square patches. It is made by taking a square and dividing the square into nine smaller squares and removing the central square. The process is then repeated for the eight small squares. As the number of iterations increase, the size of the square becomes smaller. Hence it can be said that as the iterations approach infinity, the area approaches to zero. A figure (1 3) illustrating the Sierpinski carpet fractal geometry is shown below. Three iterations have been shown in various stages (A), (B), (C) and (D).

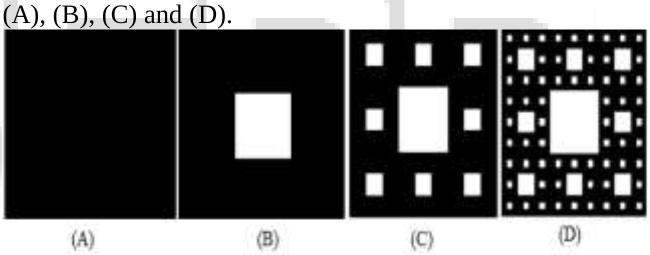

Fig. 1.4: Sierpinski Fractal Geometry

D. Cantor Fractal Geometry:

Cantor fractal is another form of multiband fractal structure. It is an iterated function system (IFS). This array can be formed by the repetitive application of a generating sub-array. The main advantage of this geometry is the reduction in the area. This geometry is applied to a straight line. In cantor set fractal structures, the segments generated at different iterations are of same dimension. The cantor set is constructed by taking a line segment of length, let us say 1. Then we divide the line into three equal parts and then remove a piece of length 1/3 from the middle. Next, these two pieces are also divided into three parts and then the middle part is removed. Repeating the process n times results in 2n line segments of total length (2/3)n.

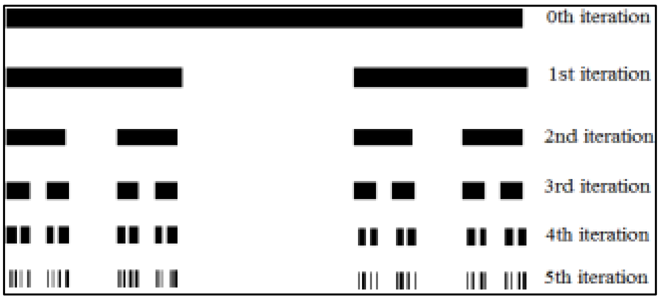

Fig. 1.5: Cantor Fractal Geometry

Above figure shows the different iterations applied to the line segment. With each iteration the area tends to reduce.

IV. Design and Methodology

For designing any antenna, its frequency of operation must be known. The antenna dimensions rely upon this frequency of operation. Single-band antenna helps simplest one or frequencies of wi-fi service. Nowadays, wi-fi gadgets help an increasing number of wi-fi requirements. And every widespread calls for a special antenna, so this makes the tool cumbersome therefore fractal geometry is used to offer multiband behavior. This makes the wi-fi tool to help numerous requirements with a unmarried antenna constructed inside it. If antenna is to be designed for cell use, then it's miles required to layout antenna for GPS, Wi-max, Bluetooth, PCS and lots of different applications

V. Results and Discussions

In this dissertation work, a mushroom shaped fractal antenna has been designed using Sierpinski Carpet fractal geometry. Initially a square patch has been analyzed. Then 1st iteration is made on it. And to get much better results, one more iteration has been done. As the number of fractal iterations increases, the antenna characteristics are improved and the size of antenna reduces. But this is valid till some limit and beyond that limit the antenna characteristics starts degrading.

VI. Conclusion

The basic understandings of the microstrip patch antenna and the fractals have been illustrated. Various fractal geometries have been discussed. By using these geometries we can improve the characteristics of the microstrip antennas. The various advantages and disadvantages of the fractal antennas have also been mentioned. Further the various fields of applications of fractal antenna are illustrated.

Reference

[1] Yogesh Kumar Choukiker, Satish K. Sharma and Santanu K. Behera, 2014. “Hybrid Fractal Planer Monopole Antenna Covering multiple Wireless Communication With (MIMO) Implementation For Handheld Devices,” IEEE transactions on antenna and propagation, Vol 62, No. 3, March 2014.

[2] V.V. Reddy and R.S.V.N. Sarma, 2014. “Compact Circularly Polarized Asymmetrical Fractal Boundary Microstrip Antenna for Wireless Applications,” IEEE antenna and wireless communication letters, Vol 13.

[3] Wei-Chung Weng and Chia Liang Hung, 2014. “An H-Fractal Antenna for Multiband Operations,”IEEE antenna and wireless communication letters, Vol 13.

[4] Shrivishal Tripathi, Akhilesh Mohan, SandeepYadav, 2015. “A Compact Kotch Fractal UWB MIMO Antenna with WLAN Band-Rejection,” IEEE antenna and wireless communication letters, Vol 14.

[5] T.Shanmuganantham, S.Raghavan, 2008. “Design Of a Compact Microstrip Patch Antenna With Probe Feeding for Wireless Applications,” International Journal for Electronics and Communication pp. 653-659.

[6] S. Chaimool, C. Chokchai and P. Akkeraekthalin, 2012. “Multiband Loaded Fractal Loop Monopole Antenna for USB Dongle Application,” Electronics letters, Vol 48, No. 23.

[7] Xue-Xea Yang, Bing-Cheng Shao, Fan Yang, Atef Z. Elsher beniamd Bo Gong, 2012. “A Polarization Reconfigurable Patch Antenna with Loop Slots on Ground Plane,” IEEE antenna and wireless communication letters, Vol 11.

[8] Christos G. Christodoulou, Youssef Tawk, Steven A. Lane, and Scott R. Erwin, 2012. “Reconfigurable Antennas for Wireless and Space Applications,” Proceedings of the IEEE, Vol 100, No. 7.

[9] V. Dinesh, Dr. G Karunakar, 2015. “Analysis of Microstrip rectangular carpet shaped fractal antenna”, SPACES-2015, Department of ECE, K.L.University.

[10] Raj Kumar, Dhananjay Magar, K. Kailas Sawant, 2012. “Design of Inscribed Triangle Circular Fractal Antenna for UWB Antenna.” International Journal for Electronics and Communications, pp 68-75.

[11] Zhangqi Liao, Rongzhou Gong, Yan Nie, Tao Wang, Xian Wang, 2011. “Absorption Enhancement Of Fractal Frequency Selective Surface Absorbs By Using Microwave Absorbing Material Based Substrates.” Photonics and Nanostructure –fundamental and application, pp.

[12] Ghanshyam Singh and Mithilesh Kumar, 2011. “Design of Frequency Reconfigurable Microstrip Patch Antenna,” 6th international conference on industrial and information system (ICIIS), pp. 16-19.

[13] ShufengZheng, Yingzeng Yin, Jun Fan, Xi Yang, Biao Li, Weixing Liu, 2012. “Analysis of Miniature Frequency Selective Surfaces Based on Fractal Antenna-Filter-Antenna Arrays,” IEEE antenna and wireless communication letters, Vol 11.

[14] Subhrakanta Behera and K. J. Vinoy, 2012. “Multi-Port Network Approach for Analysis of Dual Band Fractal Microstrip Antenna,” IEEE transactions on antenna and propagation, Vol 60, No. 11, November .

[15] Feng-Wei Yao, Xiao-Bo Xuan, Yuan-Yun Liu, Yuan-Bo Shang, 2012. “A Noval Compact Microstrip Slot Antenna with Spirals”. IEEE letters on antenna and wireless propagation, 2012.

[16] Nasser Ojaroudi, Mohammad Ojaroudi, Noradin Ghadimi, 2012. “Dual Band-Notched Small Monopole Antenna with Noval W-Shaped Conductor Backed-Plane and Novel T-Shaped slot for UWB Applications,” IET Microwave and Antenna Propagation, Vol. 7, Issue 1, pp. 8-14.

[17] Y. J. Sung M. Kim, and Y. S. Kim, 2003. "Harmonics Reduction With Defected Ground Structure for a Microstrip Patch Antenna," IEEE letters on Antennas and Wireless Propagations, Vol. 2.
[18] Victor Bernard, John Paul Izuchukwu Iloh, 2013. "Microstrip Antenna Design By Transmission Line Method", International journal of emerging technology and advanced engineering (IJETAE), Vol 3, issue 11, November 2013.
[19] Garg R., Bhartia P., Bahl I. and Ittipiboon A., 2001. "Microstrip Antenna Design Handbook", Edition 2nd, Artech House, Boston, London.
[20] Werner D.H. and Ganguly S., 2003. "An overview of Fractal Antenna Engineering Research", IEEE Antennas and Propagation Magazine, Vol.45, No.1, pp 38-57.
[21] Wong T.P., lau C.K.L., Luk Kwai-Man and Lee Kai-Fong, 2007. "Wideband Fractal Vertical Antenna", IEEE letters on Antenna and Wireless Propagation, Vol. 6, pp 5-6.