COMPACT SIZE FRACTAL ANTENNA DESIGN USING STRIPES TO INCREASES ANTENNA LENGTH FOR ISM AND HIGHER FREQUENCY APPLICATIONS.

Er. Jitin Verma\textsuperscript{1} and Dr. Nerru Malhotra\textsuperscript{2}.

\textsuperscript{1} St. Soldier Polytechnic College, Jalandhar.
\textsuperscript{2} HoD (DAVIET), Jalandhar.

\textbf{Introduction:-}

The antennas with multiple frequencies and smaller dimensions than conventional ones are preferred. Various methodologies have been studied in the antenna research to compress the size and to achieve multi-band characteristics in a single patch. Multiple bands with good gain & radiation in a single patch are not easily achievable in simple microstrip antenna. A review of various techniques to reduce the antenna size is given in Ref. [1]. In [2] simulation of the patch antenna is obtained by using and merging techniques, inserting slots as inductive loading and making some short point in the middle of the patch. In [3] a design is proposed to reduce the size of a microstrip patch antenna and another technique is employed to achieve antenna size reduction by increasing the electrical length of the antenna [4]. Many research papers have reported for achieving dual band operation of microstrip antennas. A novel design of a dual band planar monopole antenna, consisting of a rectangular strip ring with double meander-lines and a top loaded vertical strip, is presented in [5]. In [6] slot antennas were used to achieve multiband characteristics. In [8] multi-band probe fed stacked patch antenna for GPS is given which is intensively used both in civilian and military application.

\textbf{Fractal Antennas:-}

Recently fractal techniques have been widely used in antenna design so that the antenna size is reduced and to achieve multi-band behavior. Fractal antennas are physically small but electrically longer in lengths in small packages. Various geometries have been utilized to develop fractal antennas in order to have multi-band characteristics and miniaturization. Much intensive researches have been done in recent years to develop fractal antennas: long periodic fractal Koch antenna [9] and bow shaped fractal helix antenna [10]. A modified Minkowski fractal geometry for multiband operation is presented in [11]. Koch-like curve and Sierpinski Gasket are synchronized in a way, comprising so called Sierpinski Koch-like sided bow-tie (SKLB) multi-fractal to achieve size reduction and multi-frequency use [12]. A plus shaped slotted fractal antenna with first and second iteration is reported in [13] that gives a good size reduction and enhanced band width. Fractal geometry composed of multiple iterations of a single elementary shape. This compact & advance in property is highly attractive in mobile wireless applications. The advantages of fractal antenna compared with a standard microstrip antenna are their high gain and bandwidth.
Today there is rapid development of mobile communication systems and devices operating at multiple frequency bands have led to the requirement of antennas which support multi-band or wideband operation. Various wireless communication services have been available which may use frequency spectrum allocation like ISM band along with K band system. This leads to development of multi-band antennas, where lower as well as higher frequencies can be used simultaneously. Various research papers have reported about dual band antennas that are suitable for above mentioned application [19] [20]. The ISM standard has the advantage of allowing wireless connection between a base transceiver station and thousands of subscribers without requiring the subscriber to be in a direct line of sight with the station, called non line of sight communication [NLOS]. The advantage of multi-band antenna is the ability to integrate several frequency bands on one single antenna, making it useful for several frequency ranges. In this paper, stripes are used with finite dimensions as fractal microstrip antenna for multi-band applications. This concept is introduced into a square and plus shaped microstrip patch antenna to obtain multi-band behavior and miniaturization. This square shaped dual band fractal microstrip patch antenna resonates at 2.58 GHz to 6.24 GHz and 14.88 GHz to 16.73 GHz. The first frequency is used for ISM band and the second frequency is used for K & Ku band applications. In order to obtain antenna, with optimized parameters, simulation studies were carried out using high frequency structure simulator (HFSS).

**Antenna Configuration:**

The antenna is fabricated by using the FR-4 substrate which is having the thickness 1.6 mm, relative permittivity of 4.4 and dielectric constant 0.02. The multiple iterations have taken place to design the fractal antenna which is having the overall outer dimension of 34 mm each side whereas the smallest square which is subtracted from it of 2 mm each and other design specifications are given in table 1. The antenna is fed by co-axial feed at the edge of the outermost shell to have good radiation pattern and multiple bands. Multiple resonance frequencies are shown in table 3. Where return loss less than -10 dB at frequencies from 2.58 GHz – 16.73 GHz so as to obtain the maximum overall bandwidth. The design of an antenna was optimized using HFSS 13.2 simulator to get better results. The lower resonant frequency is suitable for ISM band, whereas upper/higher frequencies for K & Ku band or wireless access networks.
Table 1: Antenna dimensions

| Label | Dimensions (in mm) |
|-------|-------------------|
| A     | 34                |
| B     | 26                |
| C     | 18                |
| D     | 10                |
| E     | 2                 |

Results and Discussions:

Figure 3 shows the simulated results of the return loss variation with frequency and gain for the given fractal patch antenna. It can be seen that at −10 dB the bandwidth is measured from starting frequency 2.58 GHz to 16.73 GHz as shown in table 2 or below -10db multiple frequencies and bandwidth can be seen in frequency response curve, which can be used for many wireless communication systems or for different frequency bands. By using fractal geometry on behalf of simple square antenna the size is reduced and length for current distribution is increased.

![Return Loss Graph](image)

Table 2: Return Loss Graph Analysis

| Sr.no. | Start frequency (GHz) | Stop frequency (GHz) | Bandwidth (approximation) |
|--------|-----------------------|----------------------|---------------------------|
| B1     | 2.58                  | 6.24                 | 3.66 GHz                  |
| B2     | 6.62                  | 7.24                 | 620 MHz                   |
| B3     | 8.55                  | 8.77                 | 220 MHz                   |
| B4     | 9.56                  | 9.75                 | 200 MHz                   |
| B5     | 10.61                 | 11.23                | 620 MHz                   |
| B6     | 12.98                 | 14.12                | 1.4 GHz                   |
| B7     | 14.88                 | 16.73                | 1.85 GHz                  |

The radiation pattern is a graphical representation of the characteristics of an antenna radiation in a certain direction. These characteristics include radiation intensity, field intensity and polarization. It is normally represented with rectangular or polar plots and it is expressed in dB. Radiation pattern is a plane cut and represents one frequency and one polarization. The Radiation pattern of this antenna shows that the maximum energy is radiated towards theta = 0 and creates an equal power distribution in that particular direction and its values are given in table 3.

Table: Return Loss wrt Resonance Frequency

| SR.NO | RESONANCE FREQUENCY (GHz) | RETURN LOSS (dB) |
|-------|---------------------------|------------------|
| 1     | 3.50                      | -29.58           |
| 2     | 5.47                      | -26.43           |
| 3     | 7.00                      | -15.52           |
| 4     | 8.66                      | -30.35           |
| 5     | 9.65                      | -31.75           |
| 6     | 10.85                     | -33.98           |
| 7     | 13.37                     | -45.43           |
| 8     | 16.62                     | -36.77           |

435
Conclusion:-
The designed striped square shaped fractal microstrip patch antenna has established it’s prospective for all frequency bands for multi-functioning. The antenna generates many different frequencies for resonating modes, which are focused at the measured frequencies from 2.58 GHz to 16.73 GHz; the multiple bands antenna find its applications in mobile phone communication and in Wi-MAX or other wireless access. The designed multi-band multi-frequency antenna provides reasonable gain & the radiation patterns are also virtuous for all wireless applications.

References:-
1. Constantine A. Balanis, Antenna theory analysis and design, 2nd edition, John Wiley &sons, Inc, 1997
2. Rachmansyah, Antonius Irianto, and A. Benny Mutiara, “Designing and Manufacturing Microstrip Antenna for Wireless Communication at 2.4 GHz,” International Journal of Computer and Electrical Engineering, Vol. 3, No. 5, October 2011.
3. D. Orban and G.J.K Moernaut, “The Basic of Patch Antenna.”
4. K. R Carver and J. W Mink. “Microstrip Antenna Technology” In: IEEE Trans. Antennas Propagate. Vol.AP-29.no.1 (1981), pp. 2–24.
5. Gurdeep Singh “ Comparative Analysis of Microstrip Patch Antenna With Different Feeding Techniques”
6. International Conference on Recent Advances and Future Trends in Information Technology (iRAFIT2012) Proceedings published in International Journal of Computer Applications® (IICA)
7. SubhrakantaBehera&DebaprasadBarad A Novel Design Of Micro Strip Fractal Antenna for Wireless Sensor Network” In International Conference On Computation Of Power, Energy, Information And Communication. 2015
8. Yabing Shi and Wenjun Zhang “High-Gain Stacked Minkowski Fractal Patch Antenna with Superstrate for 60GHz Communications” Institute of Microelectronics of Tsinghua University, 10084 Beijing, China
9. DethaliaAnkitkumarManjibhai, Prof. Jayeshkumar C. Prajapati, Dipakkumar J. Barasara “An Overview of Fractal Geometries and Antenna” International Journal of Engineering and Science ISSN: 2278-4721, Vol. 1, Issue 2(Sept 2012), PP 01-04 A. N. Bogolyubov “Analysis and Synthesis of Fractal Antenna Radiation Patterns” ISSN 0027-1349, Moscow University Physics Bulletin, 2009, Vol. 64, No. 6, pp. 561–568. © Allerton Press, Inc., 2009. Original Russian Text © A.N. Bogolyubov, A.A. Koblikov, N.E. Shapkina, 2009, published in VestnikMoskovskogoUniversiteta. Fizika, 2009, No. 6, pp. 3–10.
10. Jacob Abraham, Thomaskutty Mathew “Dual Band David Fractal Microstrip Patch Antenna for GSM and WiMAX Applications” Wireless Engineering and Technology, 2015, 6, 33-40
11. Jean-Francois, Zurcher Fred, E.Gardiol, “Broadband Patch Antennas,” Artech house, Boston, London
12. Jean-Francois, Zurcher Fred, E.Gardiol, “Broadband Patch Antennas,” Artech house, Boston, London
13. Douglas H. Werner and SumanGanguly, “An Overview of Fractal Antenna Engineering Research”,
14. IEEE Antenna and Propagation Magazine, Vol 45, No.1 February 2003
15. Peitgen, Jurgens, Saupe, “Chaos and Fractals New Frontiers of Science”, Second Edition, Springer, New York, 2004.
16. B.B.Mandelbort, “The Fractal Geometry of Nature,” New York, W. H. Freeman, 1983.
17. Constantine A. Balanis, “Antenna Theory and design,” Third edition, A John Wiley $ Sons, Inc. Publication
18. Rajshree, S. Sivasundarapandian and C.D. Suriyakala, ”A modified sierpinski gasket triangular multiband fractal antenna for cognitive radio,” Information Communication and Embedded Systems (ICICES), International Conference on, pp. 1–6, 2014.
19. D.S. Sagne, R.S. Batra and P.L. Zade, "Design of modified geometry Sierpinski carpet fractal antenna array for wireless communication," Advance Computing Conference (IACC), IEEE 3rd International, pp. 435-439, 2013
20. S. Tripathi, A. Mohan and S. Yadav, "Hexagonal fractal ultra-wideband antenna using Koch geometry with bandwidth enhancement," Microwaves, Antennas & Propagation, IET, vol. no. 8, iss. no. 15, pp. 1445-1450, 2014.
21. C. Ratnaratorn, N. Wongsin, C. Mahatthanajatuphat and P. Akkaraekthalin, "A multiband wide slotted antenna with Hilbert fractal slot on rectangular patch," Electrical Engineering/Electronics, Telecommunications and Information Technology (ECTICON), 10th International Conference on, pp. 1-4, 2013.
22. Sukhveer Singh” Design and Analysis of ESShapeSierpinski Fractal Antenna” International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 4, Issue 8, August 2015
23. Sandeep Singh Sran “design of c shape modified sierpinsi carpet fractal antenna for wireless applications”
24. International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) 2016