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Bandwidth and Gain Enhancement of Multiband Fractal Antenna using Suspended Technique

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ABSTRACT

This paper presents the design of triangular microstrip patch antenna at 1.6 GHz Further by applying fractal geometry to the star shaped antenna Koch Snowflake Fractal Antenna is designed. The Koch snowflake antenna is used for size reduction. To improve gain and bandwidth, suspended technique is used. The self similar and space-filling property of fractal geometry, antenna operates at lower resonant frequency. From the results we get it is observed that, as the iteration and the iteration factor increases, the resonant frequency of the patch antenna decreases. Broad band operation with size reduction is obtained. In this paper fractal antenna using Koch Snowflake fractal geometry up to second is presented Antenna design tool CAD-FEKO 6.3 is used to simulate and design. The simulated antenna has Koch Curve shape at the patch with suspended ground plane. Further the radiation pattern and input impedance they obtain are similar to the larger multiband antennas. Koch Snowflake helps in fitting large electrical lengths into small volume. FR4 substrate having dielectric constant -4.4 is used for designing the antenna and is fed with 50 ohms coaxial line. By optimizing the coaxial feed and its location the antenna has been optimized to operate in multiple bands of 1.41-1.65GHz, 3.41-3.81GHz, &7.75-8.13GHz.

Key words: CAD FEKO suit, Co-axial feed, Fractal antenna, Koch Curve

INTRODUCTION

Antenna makes wireless communication between two stations by directing signals towards the stations. Antenna is the key component of any wireless communication system. Thus a properly designed antenna enhances entire system performance. In modern wireless communication systems there is increasing range of wireless telecommunication services and related applications needs the design of multi frequency and compact antennas [1]. In different wireless applications, there is great demand for wide bandwidth and low profile antennas. Most of the antennas are operates at a single or dual frequency bands, therefore different antenna is needed for different applications. In order to overcome this problem there is need to antenna which can operate at many frequency bands that is multiband antenna [2]. By applying fractal shape to antenna geometry we can construct a multiband antenna [3].

In many applications microstrip patch antennas are widely used, as they exhibit great features viz. very light weight, low profile, shaping is conformal, cost effective, highly efficient, simple design and easy circuit integration. These antennas are not desirable as they provide inherently low impedance bandwidth. If fractal shape is applied to antenna geometry, multiband antenna can be constructed. For minimizing the size of the patch lot of techniques are available in literature [4]. To overcome microstrip antenna’s limitation of narrow bandwidth by generating more than one resonant frequency many techniques have been available e.g. different shaped slots/slits [5-6] , multilayer, stack [7], two folded parts to the main radiating patch and use of air gap have been proposed and investigated [8]. The antenna design presented in this paper used suspended techniques to get multiband frequency with broad bandwidth [9]. Due to the use of fractal configuration large electrical length is fitted into the small physical volume. Thus fractal technique helps to reduce the overall volume occupied by the resonating elements [10-13].

The objective of this paper is to design fractal antenna, which can operate in multiple frequency bands: 1.41-1.65 GHz for GPS (Global Position Systems) applications, 3.41-3.81GHz & 5.41-5.80GHz for WiMax applications and 7.75-8.13GHz for applications is presented.

FRACTAL GEOMETRY

A fractal is a shape made from parts similar to the whole in some way. So, the simplest way to define a fractal is as an object that appears self-similar under varying degrees of magnification, and in result, possessing symmetry across scale, with each small part of the object replicating the structure of the whole [3]. The fractals are self similar and independent of scale. A fractal antenna uses fractals or self similar design to maximize the length of antenna that is able to receive/transmit electromagnetic radiation within a total given surface area/volume. There are many mathematical structures that are fractals; e.g. Sierpinski's gasket, Cantor's comb, von Koch's snowflake Fractals also describe many real-world objects, such as clouds, mountains, turbulence, and coastlines that do not correspond to simple geometric shapes. Fractal geometry is a very good solution to reduce the size of antenna. The geometrical properties of fractal shaped antenna show some interesting features. The unique features of fractals such as the self-similarity and space filling properties are the unique features of fractals which enable the realization of antennas with interesting characteristics such as multi-band operation and miniaturization. In this paper we used Koch's snowflake fractal

Koch Snowflake Technique

The Koch curve is a mathematical curve and is initial fractal curve. The construction of the Koch fractal starts with a straight segment having length L (Initiator), then this line segment is divided into three parts of equal length i.e. L/3 each, and next the middle segment is replaced with other two segments of the same length, with 60degree as intersection angle. This is called as the Generator and is the first iterated version of geometry. By using this process further, higher iterations are generated.

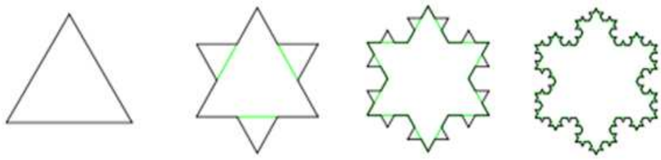


Fig. 1 Koch Snowflake Fractal generation based upon Koch curve

ANTENNA DESIGN

Here CAD FEKO-6.3 software is used to design the Suspended Koch antenna. The Koch snowflake is constructed first by starting with a basic equilateral triangular patch, and then further each line segment is repeatedly altered as follows:

- The line segment is divided into 3 equal parts.
- Then an equilateral triangle is drawn having the mid segment taken from step 1 as its base and points outwards.
- At last the line segment of the triangle taken as its base is removed.

After first iteration of the above mentioned process, the resulting shape is a star. The Koch Snowflake is the limit reached when the above process is repeated over and over again. The Koch curve is constructed using only one of the three sides of the original triangle as given by Koch. In other words we can say that three Koch curves make a Koch snowflake. First 3 iterations of Koch curve are shown in the Figures –2(a), (b), (c). For the design of patch antenna there are three vital parameters i.e. resonant frequency (Fr), dielectric material of the substrate (ϵ_r), and the thickness of the substrate (D).The resonant frequency chosen here is 1.6 GHz. FR-4 is the dielectric material selected for this design having a dielectric constant (ϵ_r) of 4.4.

The fundamental mode resonant frequency of such antenna is given as follows:

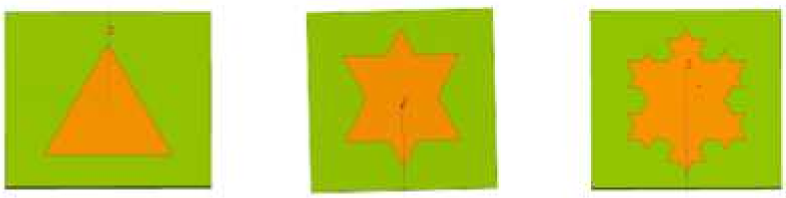
$$f_r = \frac{2c}{3a\sqrt{\epsilon_r}} \qquad (1)$$

Where, c = Speed of light, ϵ_r= Relative permittivity of substrate

The patch side length id of triangle is given as follows,

$$w = \frac{2c}{3f_r\sqrt{\epsilon_r}} \qquad (2)$$

where, f_r = 1.6 GHz, ϵ_r = 4.4 and Ground length = λ/2



(a) (b) (c)

Fig. 2 (a), (b) & (c) Illustrates the Basic TMSA, Koch fractal Iteration-1and Koch fractal Iteration-2

In order to improve bandwidth air gap is introduced between patch and ground plane. This means suspended technique is used. This configuration improved bandwidth of the antenna with four frequency bands. The Suspended Koch Snowflake Fractal Antenna Configuration is shown in fig. 3.

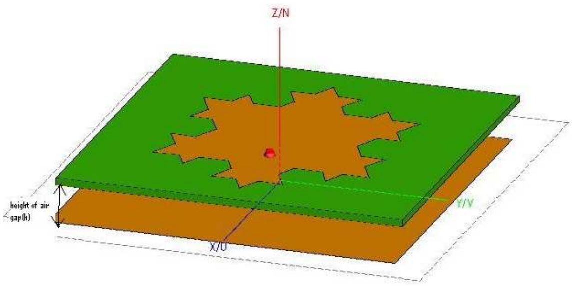


Fig. 3 Final Suspended Koch Fractal Antenna Configuration

SIMULATION RESULT AND DISCUSSION

The simulation tool used for evaluating the performance of the fractal antenna is CAD-FEKO 6.3 software [14], which is based on the method of moment's technique and used for computing VSWR, Return Loss and Gain of proposed antenna. Return loss indicates the amount of power that is lost to load and does not return as reflection. The simulated return loss for basic TMSA, Koch Fractal Iteration-1and Koch Fractal Iteration - 2 and Final Suspended Koch Fractal antenna shown in fig. 4 (a), (b), (c) and (d) respectively.

Fig. 4 (a) shows the return loss for basic TMSA, it operates at single frequency 1.57GHz. In second case Fig. 4 (b) Shows return loss for Koch Fractal Iteration-1 in which antenna operates at resonant frequency 1.40 GHz. In third case Fig. 4 (c) shows return loss for Koch Fractal Iteration-2 in which antenna operates at three resonant frequencies 1.24 GHz, 1.40 GHz and 2.91GHz. This concludes that, as number of iterations increases the first resonance frequency get shifted to lower side and higher frequency will be added. In last case Fig. 4 (d) shows return loss for Suspended Koch Fractal in which antenna operates at multiple frequencies 1.54 GHz, 3.63 GHz, 5.67 GHz & 7.95 GHz with four frequency bands. From above simulation results we observed that, Suspended Koch Fractal shows good results in comparison to all three cases. The bandwidth of Suspended Koch Fractal get increased with improvement in return loss.

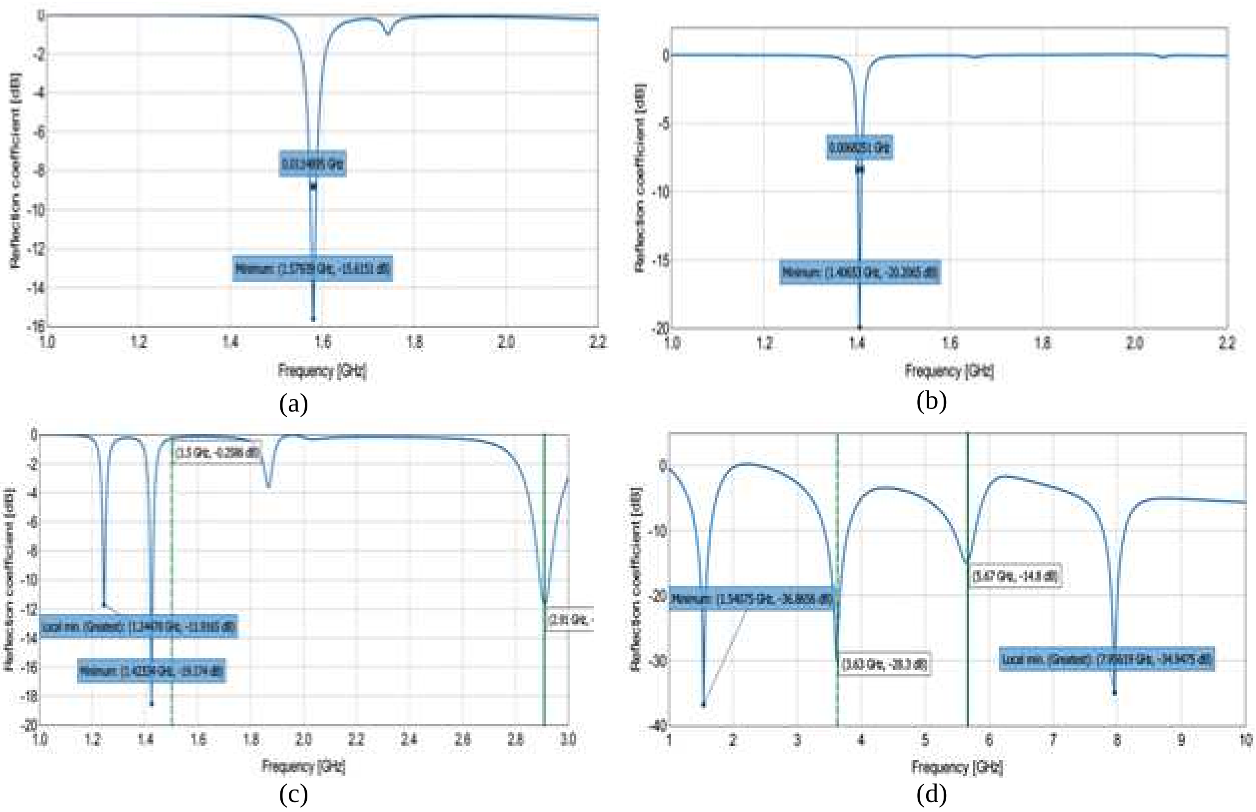


Fig. 4 (a)Return loss for basic TMSA, (b) Return loss for Koch Fractal Iteration-1, (c) Return loss for Koch Fractal Iteration-2 & (d) Final Suspended Koch Fractal antenna

The simulated E-plane Radiation pattern for simple TMSA, Koch Fractal Iteration-1, Koch Fractal Iteration-2 and final Suspended Koch Fractal antenna shown in fig.5 (a), (b), (c) and (d) respectively.

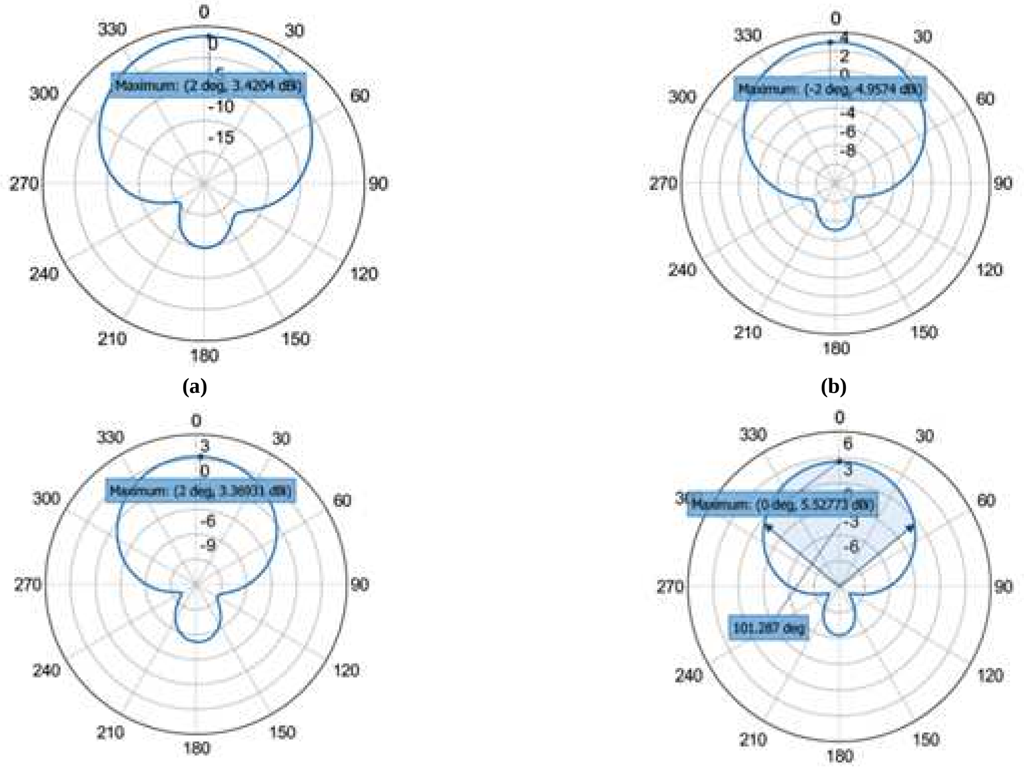


Fig. 5 (a) E-Plane radiation pattern for basic TMSA, (b) E-Plane radiation pattern for Koch fractal Iteration-1, (c) E-Plane radiation pattern for Koch fractal Iteration-2 (d) E-Plane radiation pattern for Final Suspended Koch Fractal antenna

Simulated results show that, Suspended Koch Fractal Antenna has maximum gain of 5.52 dB which is greater than gain of all three iterations. This concludes that, Suspended technique improves the gain of Koch fractal antenna with decreasing beamwidth.

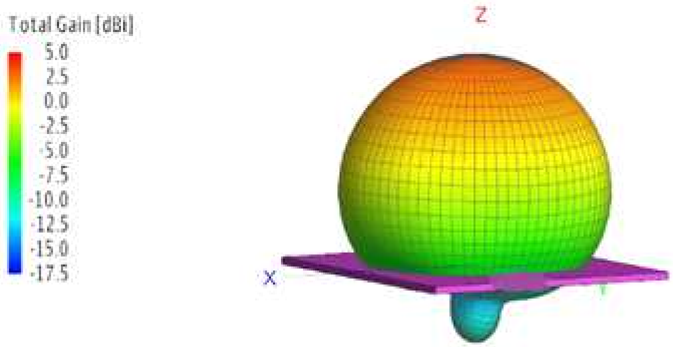


Fig. 6 (a) 3-D Total gain of the Final Suspended Koch Fractal Antenna

The Koch Fractal Antenna is designed for Iteration-0 (basic TMSA), Iteration – 1, Iteration – 2 and Suspended Koch Fractal Antenna and results are noted for the different parameters as shown in Table – 1.

Table -1 Comparative Result for Basic TMSA, Iteration – 1, Iteration – 2 and Final Suspended Koch Fractal Antenna

Iteration	Frequency (GHz)	Return Loss(dB)	VSWR	Gain(dB)	Bandwidth (MHz)	Impedance
0	1.57	-15.61	1.39	3.42	25.25	47.12
1	1.4	-20.2	1.27	4.95	20.04	42.54
2	1.24	-11.91	1.67	3.36	7.88	53.9
	1.42	-19.17	1.24		10.43	47.83
	2.91	-11.9	1.68		41.22	53.12
Final Suspended Fractal Antenna	1.54	-36.86	1.11	5.52	249	50.82
	3.63	-28.3	1.11		398.2	50.1
	5.67	-14.8	1.45		386.1	50.7
	7.95	-34.94	1.05		389.3	52.1

The table -1 shows that as iteration increases the fundamental frequency is shifted to the lower side and which is used for multiband applications. The comparative table shows Final suspended Koch Fractal antenna, which gives good results in comparison to all iterations. It is also observed that final Suspended antenna has minimum VSWR, improvement in reflection coefficient, four frequency bands with broad bandwidth and high gain compared to first two iterations.

CONCLUSION

The design of suspended Koch snowflake antenna for bandwidth and gain improvement had been presented. We observed that, the final suspended designed antenna achieved some favourable characteristics such as, compact size, minimum VSWR, improved return loss, good impedance matching high gain and multiple frequency bands with broad bandwidth. These frequency band range has applications in different wireless systems like (1.41-1.65 GHz) for GPS application, (3.41-3.81GHz & 5.41-5.80 GHz) for Wi -Max application and (7.75 - 8.13GHz) for X-band application.

REFERENCES

[1] G Kumar and KP Ray, *Broadband Microstrip Antennas*, Artech House, London, **2003**.
[2] KL Wong, *Compact and Broadband Microstrip Antennas*, John Wiley & Sons, New York, **2003**.
[3] John Gianvittorio, *Fractal Antennas: Design, Characterization and Applications*, University of California, Los Angeles, **2000**.
[4] Kai Fong Lee and Kwai Man Luk, *Microstrip Patch Antennas*, World Scientific, **2011**.
[5] Vijay Sharma, VK Saxena, D Bhatnagar, JS Saini & KB Sharma, Compact Dual Frequency Wide Band Circular Patch Antenna with U-Slot, *IEEE International Symposium on Antennas and Propagation and USNC/URSI National Radio Science Meeting*, Charleston, SC USA, **2009**,1-5.
[6] BR Shrama, V Sharma, KB Sharma and D Bhatnagar, Broadband Semielliptical Patch Antenna with Semicircular Ring Slot for WiMax Application, *Chinese Journal of Engineering*, **2014**, Article ID 379073.
[7] Vijay Sharma, VK Saxena, JS Saini, D Bhatnagar, KB Sharma, D Pal and LM Joshi, Wideband Dual Frequency Right Triangular Microstrip Antenna with Parallel Narrow Slits, *International Journal of Microwave and Optical Technology Letters*, **2010**, 52 (5), 1082-1087.
[8] D Guha, Resonant Frequency of Circular Microstrip Antennas with and without Air Gaps, *IEEE Transaction on Antenna and Propagation*, **2001**, 49 (1), 55- 59.
[9] Vijay Sharma, VK Saxena, KB Sharma and D Bhatnagar, Multi-Band Elliptical Patch Antennas with Narrow Sector Slot for Wi-Max Applications, *International Journal of Microwave and Optical Technology*, **2012**, 7(2), 89-96.
[10] Prajakta B Jadhav and MM Pawar, Bandwidth and Gain improvement by using Suspended Fractal MSA at 2.4GHz, *IOSR Journal of Electronics and Communication Engineering*, **2014**, 9 (4), 2278-8735.
[11] SN Khan, J Hu, J Xiong and S He, Circular Fractal Monopole Antenna for Low VSWR UWB Applications, *Progress in Electromagnetics Research Letters*, **2008**, 1, 19–25.
[12] DH Werner and S Ganguly, An Overview of Fractal Antenna Engineering Research, *IEEE Antennas and Propagation Magazine*, **2003**, 45 (1), 38-57.
[13] Dipali Soren, Rowdra Ghatak, Rabindra Kishore Mishra and Dipak Ranjan Poddar, Wideband Sierpinski Carpet Fractal Shape Cylindrical Dielectric Resonator Antenna for X-Band Application, *Journal of Electromagnetics Analysis and Applications*, **2012**, 4, 9-14.
[14] CAD-FEKO 6.3 Software, **2013**.