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Design Of Compact And Broadband Koch Fractal Antenna For Multiband Application

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Abstract— This paper presents the design of suspended fractal antenna using Koch Snowflake fractal geometry up to second iteration. 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. Due to Self Similar property of Fractal Antenna it takes less area and is thus low profile. Further they can obtain radiation pattern and input impedance similar to a larger multiband antennas. Koch Snowflake helps in fitting large electrical lengths into small volume. The proposed antenna is designed on FR4 substrate with dielectric constant of 4.4 and 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.

Keywords- CAD FEKO suit, Co-axial feed, Fractal antenna, Koch Curve

I. 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 many applications Micro strip 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.

In modern wireless communication systems and increase in different wireless applications, there is great demand for wide bandwidth and low profile antennas. We know that traditionally, each antenna operates at single or dual frequency bands so different antenna is needed for different applications. This led to the design of multiband antenna. One of them is using fractal shaped antenna elements. Traditionally, each antenna operates at a single or dual frequency bands, where different antenna is needed for different applications. In Order to overcome this problem there is need to design multiband antenna which can operate at many frequency bands. One technique to construct a multiband antenna is by applying fractal shape into antenna geometry.

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 and in past many have been presented the same. One of them is the use of substrate material with high dielectric constant but due to surface wave excitation it gives narrow bandwidth and poor efficiency. The cost of low loss, high dielectric constant material is high. This is another problem. 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.

In this work we have design Fractal antenna for multiple frequency bands as 1.41-1.65 GHz for GPS (Global Position Systems) applications, 3.41-3.81GHz & 5.41-5.80GHz for Wi - Max applications and 7.75-8.13GHz for applications is presented. To design antenna we have use suspended technique to get multiband frequency with broad bandwidth.

II. KOCH CURVE

The good example of self-similar space-filling property of fractals is the Koch Curve which can used to develop wideband/multiband and small size antennas. Koch geometry can overcome some of the limitation of small antennas. It minimizes the total height of the antennas at resonance. Koch geometry does not have piecewise continuous derivative. It is nowhere differentiable. Its shape is highly rough and uneven. So works as a very efficient radiator.

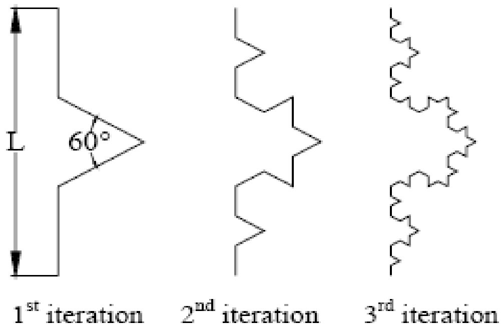


Figure 1. Fractal generation based upon Koch curve

III. KOCH SNOWFLAKE TECHNIQUE

The Koch curve or Koch snowflake is a mathematical curve and one of the initial fractal curves. Construction of The Koch fractal begins with a straight segment of length L (Initiator), then this is subdivided into three parts of equal length i.e. L/3 each, and middle segment is replaced with two other segments of same length, with intersection angle of 60 . This is called Generator, the first iterated version of geometry. Higher iterations are generated by reusing the process.

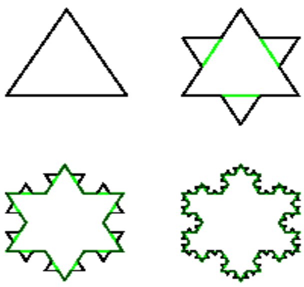
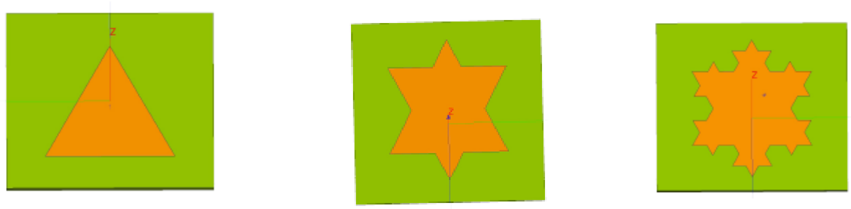


Figure 2. Koch Snowflake Fractal generation based upon Koch curve

II. ANTENNA DESIGN

The geometry of designed antenna is as shown in Fig. 3. In first step a conventional triangular patch of side length 60mm is design on a dielectric substrate FR-4with $r\varepsilon$ = 4.4 of thickness1.6 mm, with resonating frequency 1.4 GHz is designed as shown in fig. 3



(A) Basic TMSA (B) **Iteration 1** **(C) Iteration 2**

Figure 3. Koch Snowflake Fractal Geometry

In second step the structure is modified by copying and rotating the original triangle by 180 degree to get the star shape patch as shown in fig .(B). The basic structure is a triangle patch. Each straight segment of the triangle is divided in to three equal parts. The middle part is replaced by two straight lines meeting at 60^0 angles (a bent) and they fit into the original gap in an equilateral triangular fashion as shown in the Fig. (B). Thus the dimension of each newly generated straight line is now one third of the original straight line and each side of the triangle when stretched out, increases by one third of the original length. This iteration process of dividing a straight line into three equal segments and replacing the middle part by a bent curve is continued. In the true fractal, this process is repeated for infinite number of times. But in this project only two iterations are considered and the fractal patch obtained is shown in the Fig.(C). This figure shows the proportionate reduction in patch area by keeping the total perimeter of the triangle constant after each fractal iteration. Thus with each iteration, the total perimeter of the triangle increases by 4/3 times the original perimeter of the triangle. It is observed that although the length of the radiating patch with proportionate reduction is kept constant at 60 mm but the resonant frequency does not remain constant at 1.4 GHz. After each iteration, the dimension of the fractal patch and feed position are optimized to obtain multiband. The CAD FEKO -6.3 simulation tools is used to modeled and simulate the designed antenna.

IV. RESULTS AND DISCUSSIONS

The simulation tool used for evaluating the performance of the fractal antenna is CAD-FEKO 6.3 software, which is based on the method of moment's technique. Fig. 2 shows the reflection coefficients for all the three iterations of proposed fractal antenna that is first, second and third iteration. As expected, it was demonstrated that with increase in the iterations, resonant frequency shifts towards lower side. The simulated resonant performance characteristics of the designed antenna are reported in Table. 1. It can be noticed that there is an increase in the impedance bandwidth of the designed antenna when the iterations of the fractal antenna increases, with considerable improvement in gain and the impedance matching.

4.1. Simulation results

The designed fractal antenna is modeled in the CAD FEKO -6.3 and simulated for each iteration. The Fig.(4) shows the simulation results of zero iteration. The triangle patch resonates at the frequency band 1.57 GHz having bandwidth25.25 MHz with a return loss of -15 dB.

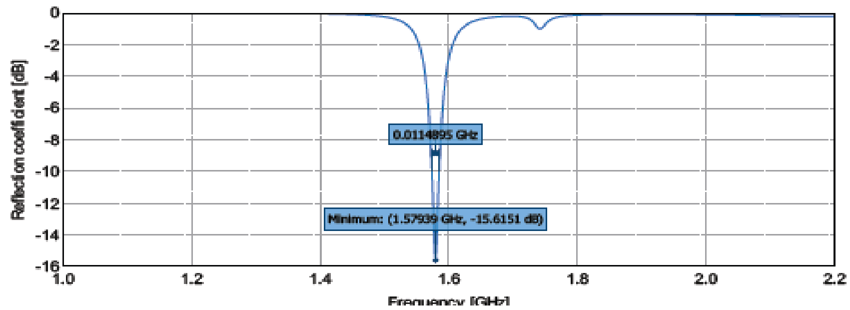


Figure 4 . Reflection coefficient Magnitude [dB]-Fractal TMSA Iteration 0

The Fig. (5) shows the simulation results of the first iteration. The Koch Snowflake patch resonates at the frequency band at 1.4 GHz having bandwidth 20.04 MHz with a return loss of -20.20 dB these are covered GPS (Global Positioning System) application.

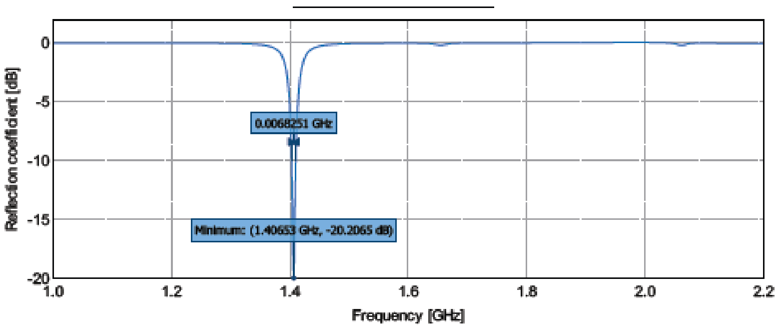


Figure 5. Reflection coefficient Magnitude [dB] – Fractal TMSA Iteration 1

The below Fig.(6) shows the simulation results of the second iteration. This Koch Snowflake patch resonates at three different frequency bands i.e. 1.24GHz has bandwidth 7.88MHz with a return loss of –11.91dB, 1.423GHz has bandwidth 10.43MHz with return loss -19.17dB and 2.91GHz has a bandwidth 41.22MHz with return loss -11.90dB.

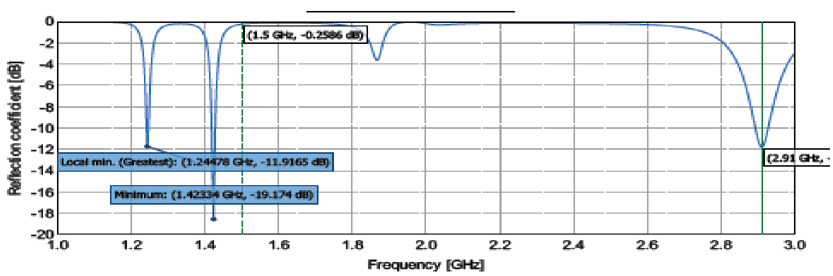


Figure 6. Reflection coefficient Magnitude [dB] – Fractal TMSA Iteration 2

Fig.(7) shows the simulation result of the final suspended fractal antenna. This antenna resonates at four different frequency bands i.e. 1.54GHz has bandwidth 249MHz with a return loss of –36.86dB, 3.63GHz has bandwidth 398.2MHz with return loss -28.30dB, 5.67GHz has a bandwidth 386.1MHz with return loss -14.80dB and 7.95GHz has bandwidth of 389.3MHzwith return loss -34.94 db.

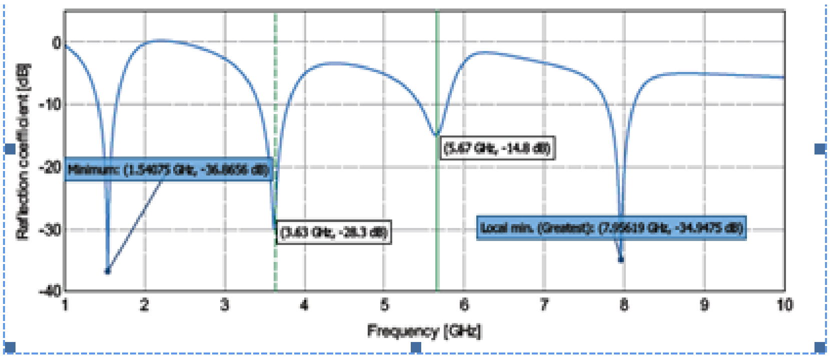


Figure 7. Reflection coefficient Magnitude [dB]- Final Suspended Fractal Antenna

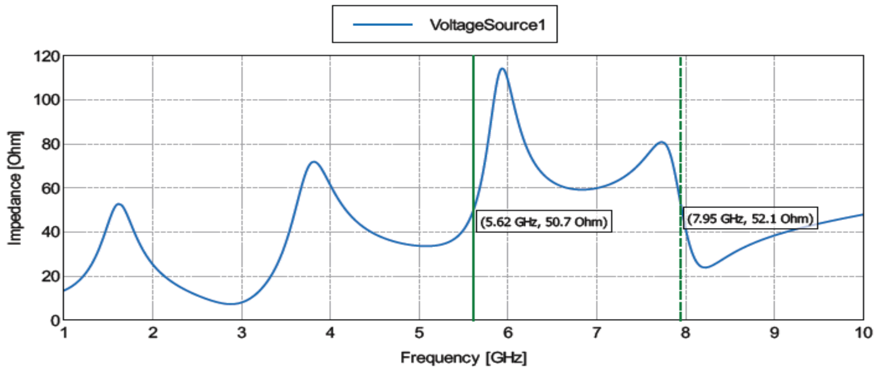


Figure 8. Impedance Magnitude [Ohm] – Final Suspended Fractal Antenna

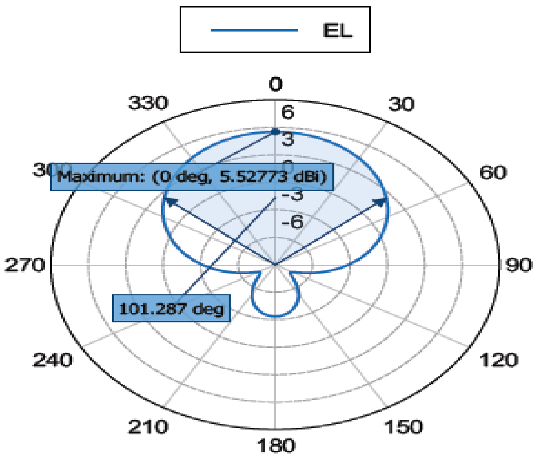


Figure 9. Total Directivity [dBi] (Frequency = 1 GHz; Phi = 90 deg) – Final Suspended fractal Antenna

Table 1. Comparison of fractal and Suspended fractal antenna

Sr.No.	Iterations of MSA	Freq (GHz)	Return Loss (dB)	VSWR	Gain (db)	BW (MHz)	Imp (Ohm)
1.	0	1.57	-15.61	1.39	3.42	25.25	47.12
2.	1	1.40	-20.20	1.27	4.95	20.04	42.54
3.	2	1.24	-11.91	1.67	3.36	7.88	53.90
		1.423	-19.17	1.24		10.43	47.83
		2.91	-11.90	1.68		41.22	53.12
4.	Final Suspended Fractal antenna	1.54	-36.86	1.11	5.527	249	50.82
		3.63	-28.30	1.11		398.2	50.1
		5.67	-14.80	1.45		386.1	50.7
		7.95	-34.94	1.05		389.3	52.1

V. CONCLUSION

The design of Koch Snowflake fractal antenna up to second iteration has presented. The resonance behavior and space filling capabilities of the Koch curve fractal antenna have been investigated. It is found that as the resonant frequencies decreased and after each iteration gain is increased. As the generating iteration is increased by introducing number of triangle and length of one antenna was reduced by bending the 2/3 pattern of the Koch fractal antenna counter clockwise. Then, again rotating whole antenna 90° counter clockwise with specific dimension improves the antenna gain as well as its bandwidth. The designed antenna have some favorable characteristics such as; compact size, almost symmetrical radiation pattern, multiband , higher gain, satisfactory return loss less than 10 db and acceptable bandwidth in desired frequency 1.41-1.65 GHz for GPS (Global Position Systems) applications, 3.41-3.81GHz & 5.41-5.80GHz for Wi -Max applications and 7.75-8.13GHz for applications . Due to suspended configuration we get multiband frequency with broad bandwidth.

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