Modified Koch Fractal Antenna for Ku and K-Band Applications

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Abstract

In this article, a modified Koch fractal Antenna for Ku and K-band utilizing satellite application is proposed. The design is based on the conventional microstrip antenna (MSA) and the advantage of fractal concepts. The proposed antenna is the combination of triangular shape of radiating patch and two iterations Koch snowflake is applied on each side. Modified Koch Antenna used Von Koch's snowflake concept with an additional notch generation in second iteration. Commercially available High Frequency Structure Simulator (HFSS) is used here for simulation purpose. The suggested antenna is assembled on FR4 substrate with dielectric constant (εr) 4.4. The antenna covers 12.31 GHz, 13.18 GHz, 15.21 GHz and 19.7 GHz which is useful in uplinking and downlinking of satellite applications.

Keywords – Fractal, Snowflake, Koch antenna, Radiation, Iteration.

Introduction

The combined geometry fractal with conventional microstrip antenna structure led to the development of fractal antennas. The low bandwidth and gain of MSA evolved the researchers to design an antenna with improved bandwidth and multiband. Fractal antenna can also be used to achieve these characteristics. Fractal antenna application in engineering is firstly discussed by Cohen *et al.,* (1997). The fractal geometries are uneven shapes which can be separated into sub-parts and every sub-part is the small copy of overall shape. The fractal geometry acts as the radiating element of copper or gold metal which is fabricated on dielectric substrate. This type of antenna geometry is useful for military, satellite and wireless applications.

The numbers of papers have been published on this topic such as Von Koch's snowflake, Sierpinski's gasket, Koch- Sierpinksi shapes and Sierpinski- Koch etc. Baliarda *et al.*, (2000) has discussed the behavior of small fractal Koch monopole antenna numerically and experimentally. Diotie Li *et al.*, (2012) designed a Koch-like fractal bow-tie UWB antenna. The main advantage of using fractal geometry as the radiating element is due to its more electrical length fitting into small areas. The application of the new theory of self-similar fractal radiators or fractal antennas was discussed by Werner *et al.,* (1996). Usually, fractal antenna using fractal geometries are used for miniaturization (Gianvittorrio *et al.,* 2002), space-filling and multiband application (Viani *et al.,* 2012; Puente *et al.*, 1998). The design of a Pythagorean tree fractal patch antenna is done by Silva *et al.*, (2017), where the squares made on the base of the radiating patch. The antenna is designed to achieve multiband characteristics. Also, Pythagorean shaped iterated fractal antenna is realized by Kumar *et al.*, (2013) The multiband fractal antenna design of Pythagoras tree shapes is previously done by Kumar *et al.,* (2014).

In this paper, a new Modified Koch fractal Antenna is designed and analyzed. The method of generating Koch curve concept can be regarded as a length of 'L' Euclidian segment which is divided into three segments. Figure 1 shows the method of dividing single line segment and the number of iterations. The antenna covers frequency range useful for satellite applications which are 12.31 GHz, 13.18 GHz, 15.21 GHz and 19.7 GHz. The design of antenna is done using FEM based simulator Ansoft designer HFSS. The antenna configuration, fractal techniques, implementation, results and discussion are discussed in the following sections.

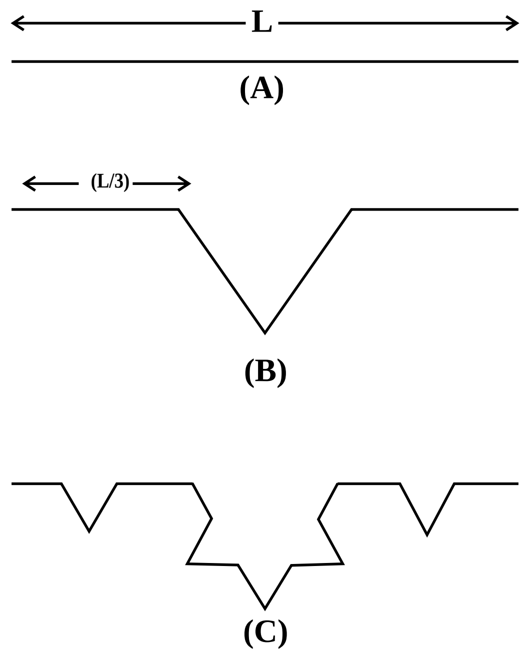

Figure 1: Number of iterations on each side of Isosceles triangle: (A) Zeroth Iteration, (B) First Iteration and, (C) Second Iteration

Antenna Configuration

The proposed antenna consists of an Isosceles triangle with two equal sides as 60 mm and other larger side as 70 mm. The dimension of the substrate used is 80x90x1.6 mm3. The location of the feed point is an important parameter on which all the other constraint depends. After various iterations, the feeding of proposed antenna is located at the co-ordinate (0, 9.35) mm. The substrate material used is FR4 whose dielectric constant is 4.4 and height is 1.6 mm from the ground plane. The dimensions are shown in table 1.

Figure 2 shows the top and side view geometry of proposed antenna. Here, all the dimensions are marked such as length of sides of Isosceles triangle, height of substrate, dielectric constant, feed point location and both the axis of 2-D plane. The geometry is excited by co-axial probe of 50 ohm input impedance at the feed point location of (0, 9.35) mm. After performing the simulations, the results are analyzed and saved. The current distribution i.e. E-field or V/m is shown in figure 3.

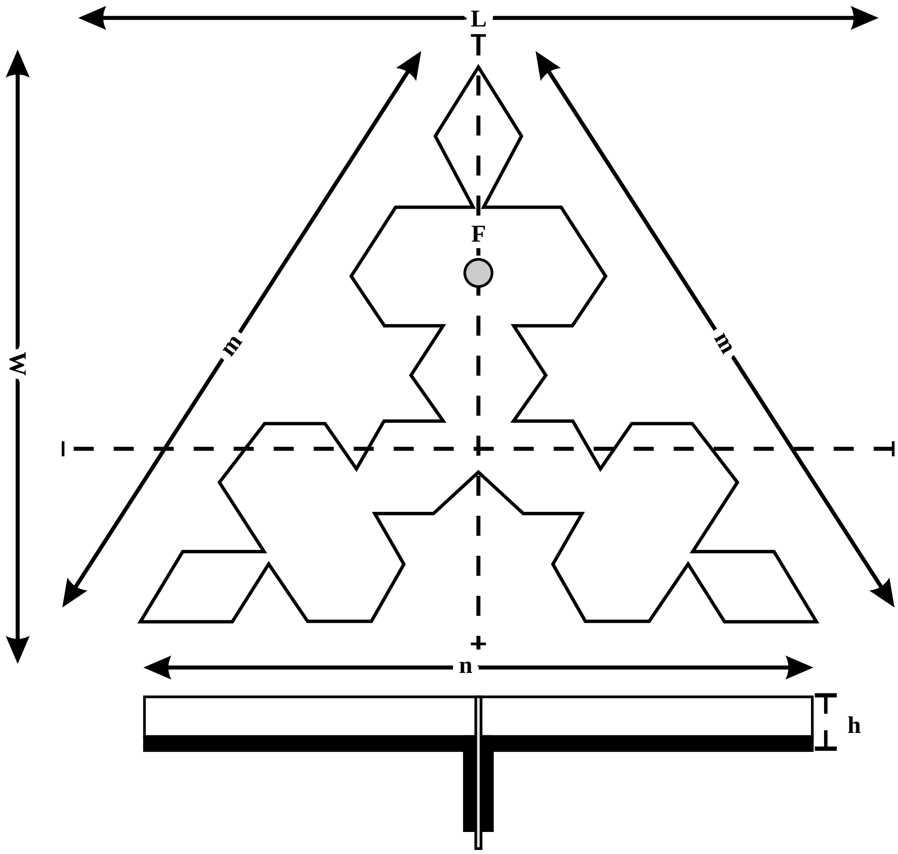

Figure 2: Geometry of proposed Antenna, Top and Side view

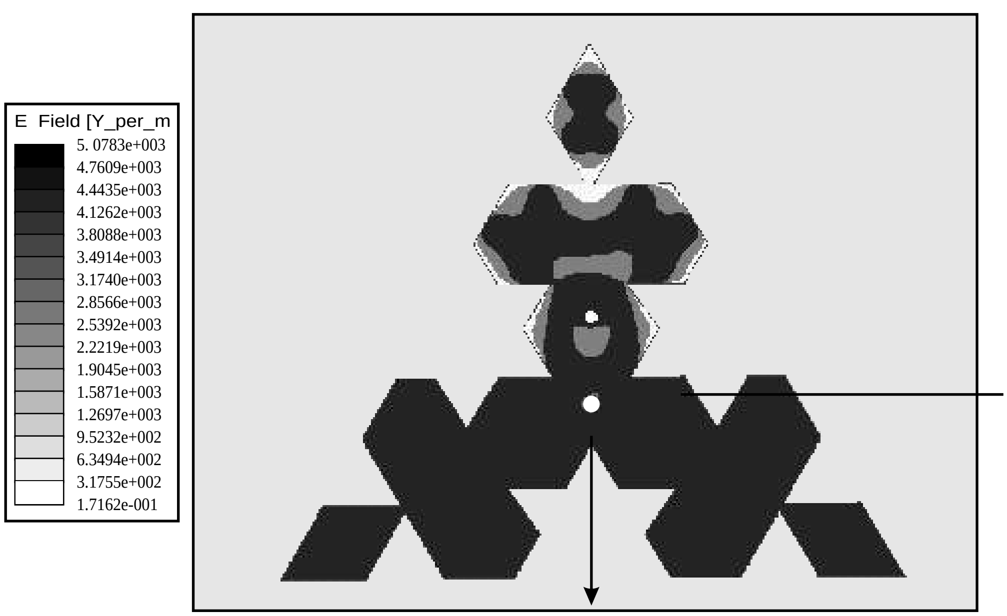

Figure 3: Current distribution of proposed Modified Koch Antenna

Table 1: Dimensions of Proposed Antenna

Length of equal side of triangle **(m)**	60 mm
Length of other side of triangle **(n)**	70 mm
Length of substrate **(L)**	80 mm
Width of substrate **(W)**	90 mm
Feed point location **(F)**	(0, 9.35)mm
Dielectric constant **(ε_r)**	4.4
Thickness of Substrate **(h)**	1.6 mm

Koch Fractal Concept

The proposed Modified Koch Antenna is based on the Von Koch's snowflake. The design of fractal geometry is done using Koch curve concept. Koch curve concept is based on generating L Euclidian segment which is divided into three segments. The method of iteration Koch curve is applied on the proposed Modified Koch Antenna at each side of Isosceles triangle. In this method, a line segment L is divided into three subsequent parts and middle portion is replaced by an equilateral triangle whose base line is removed.

After each iteration, the length of each line increased to 4/3rd to the original. The new length becomes Ln as in equation (1).

$$L_n = L\,(4/3)^{n} \tag{1}$$

Here L is the length of the original line and Ln is the length of new line after (n) iteration, (n) is the number of iterations. In proposed Modified Koch Antenna, number of iteration is n=2.

Result and Discussion

The simulation of proposed Modified Koch Antenna is done by Ansoft HFSS software. The multiband response is recorded after performing the simulation. The fractal antenna generally gives multiband characteristics. The results show that the proposed also exhibits multiband behavior, and discussed in this section.

Figure 4 shows the return loss versus frequency of proposed antenna. From the fig, it is found that antenna resonates at 12.31 GHz, 13.18 GHz, 15.21 GHz and 19.7 GHz with return loss of covering the operating frequency band of Ku-band [12- 18 GHz] and K-band [18- 27 GHz].

Figure 5 shows the plot of VSWR versus frequency that verifies that frequency bands are reasonable. The limit of VSWR is easily satisfied at each of the frequency bands under consideration i.e. 12.31 GHz, 13.18 GHz, 15.21 GHz and 19.7 GHz.

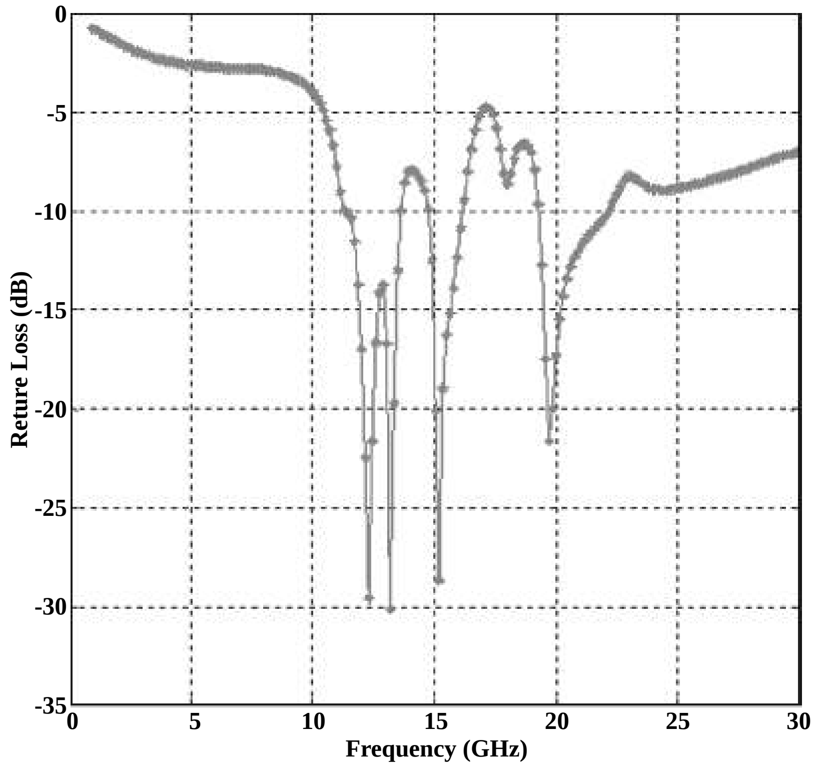

Figure 4: Plot of return loss versus frequency of proposed antenna

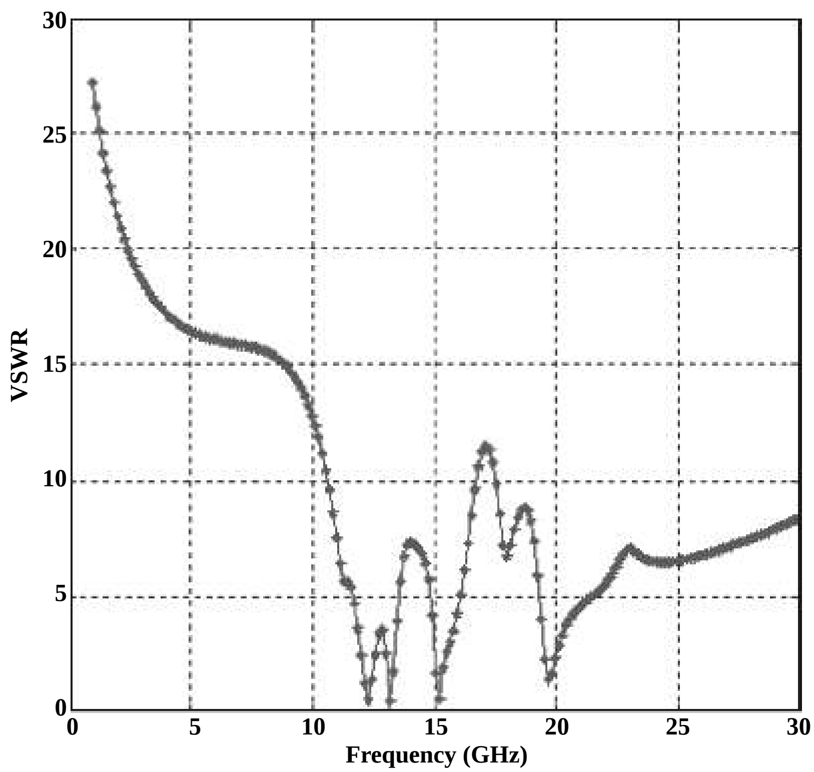

Figure 5: Plot of VSWR versus frequency of Modified Koch Antenna

Conclusion

It is now concluded that the proposed modified Koch Antenna is designed using Koch snowflake concept. The unique generation and iterations phenomenon applied on isosceles triangle is used as the radiating patch. The modified Koch Antenna shows multiband characteristics which resonates at 12.31 GHz, 13.18 GHz, 15.21 GHz and 19.7 GHz. Hence the frequency band of Ku-band [12- 18 GHz] and K-band [18- 27 GHz] is achieved.

Reference

Baliarda, C. P., Romeu, J., and Cardama, A. 2000. The Koch Monopole: A Small Fractal Antenna. *IEEE Transactions On Antennas And Propagation,* (48).

Cohen, N. 1997. Fractal Antenna Application in wireless telecommunication. *Proceeding of Electronics Industries Forum of New England,* 43-49.

Gianvittorrio, J.P. and Samii Y. R. 2002. Fractal antennas: A novel antenna miniaturization technique and applications. *IEEE Antennas Propag. Mag.,* (44), 20-36.

Kumar, A., Dutta, B. R. and Budhauliya S. 2013. Iterated Pythagorean fractal tree multiband antenna. *Int. Journal Scientific Res. Pub.,* (3), 1-3.

Kumar, D., Kumar, A. and Singh, A. K. 2014. Design analysis of Pythagoras tree shaped multiband fractal antenna. *Int. Conf. Comput. Intelligence Communication Networks (CICN), Bhopal,* 41-45.

Li, D., and Mao, J. 2012. A Koch-Like Sided Fractal Bow-Tie Dipole Antenna. *IEEE Transactions On Antennas And Propagation,* (60).

Puente, C., Romeu, J., Pous, R. and Cardama, A. 1998. On the behavior of the sierpinski multiband fractal antenna. *IEEE Trans. Antennas Propag,* (46), 517–524.

Silva, H. A. M., D'Assunção A. G. and Silva, J. P. 2017. Design of modified pythagorean fractal antenna for multiband application. *International Applied Computational Electromagnetics Society Symposium - Italy (ACES), Florence,* 1-2.

Viani, F., Salucci, M., Robol, F. and Massa, A. 2012. Multiband fractal ZigBee/WLAN antenna for ubiquitous wireless environments. *Journal of Electromagnetic Waves and Applications,* (26),1554-1562.

Werner, D. H., Werner, P. L. and Ferraro, A. J. 1996. Frequency independent features of self-similar fractal antennas. *In Antennas Propag. Soc. Int. Symp.,* (3), 2050–2053.

