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Design of inside cut von koch fractal UWB MIMO antenna

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Abstract. An Inside Cut Hexagonal Von Koch fractal MIMO antenna is designed for UWB applications and its characteristics behaviour are studied. Self-comparative and space filling properties of Koch fractal structure are utilized in the antenna design which leads to the desired miniaturization and wideband characteristics. The hexagonal shaped Von Koch Fractal antenna with Defected Ground Structure (DGS) is designed on FR4 substrate with a compact size of 30mm x 20mm x 1.6mm.the antenna achieves a maximum of -44dB and -51dB at 7.1GHz for 1-element and 2-element case respectively.

1. Introduction

The rapid growth of wireless communication system and increasing user demand for more bandwidth and data rate, inspired the evolution of Ultra Wide Band and Multi-Input Multi-Output (MIMO) technology [4-7]. Thus the need for designing a wideband or multiband antenna is becoming popular in order to achieve high data rate with less power consumed, wide operating bandwidth, etc. Thus, UWB antenna design using fractal geometry is structured to meet these demands. The UWB offer very high bandwidth within short range. Since there is no carrier signal it transmits data with extremely low transmission energy (less than 1mW) [9-10]. MIMO system has become an important breakthrough in wireless communication system. MIMO technology provides increased data rate by exploiting the multipath effect and also provide increased transmission range and reliability. The UWB system along with MIMO will improve the wireless communication systems with extended range and link reliability of communication along with the benefits of higher data rate with interference mitigation [11-12].

In literature of UWB MIMO antenna design, most of the work shows an antenna designed are having less return loss and less mutual coupling. In [1], the author designed a compact Octagonal shaped fractal Ultra Wide Band MIMO. But the achieved isolation is -17 dB which is a poor value and also the achieved return loss is -32 dB. In [2], the author designed a compact 2-element ultra-wideband MIMO antenna .A T-shaped reflecting stub is placed between the two antennas to reduce mutual coupling and hence to improve isolation. But the achieved return loss is -39dB. In [3], the author designed an antenna with Sierpinski carpet structure into the etched edge with less return loss.

Therefore, in this paper, we propose an antenna with two various feeding techniques, one with an insert fed and another with a normal fed. Antenna is designed by etching the edges inside the element according to Von Koch curve and also by modifying the ground plane structure so as to support multi band operation with improved return loss and wide bandwidth and also to provide better isolation. And also the antenna designed operates at 7.1GHz with a very wide bandwidth and also with the reduced size.

The rest of the paper is organized as follows: The design of the proposed Von Koch fractal UWB MIMO antenna system is presented in Section II. The simulation results for the various cases of the proposed antenna is analysed in Section III. The major finding of the paper is discussed in Section V.

2. Proposed antenna structure

The structure of the proposed Von Koch fractal UWB MIMO antenna (VKFUMA) using FR4 substrate is shown in Figure 1. The structure has a dimension of 30mm x 20mm x1.6mm, dielectric constant of 4.4. The upper layer has the antenna structure and the matching network, the bottom layer with defective ground structured is etched from the ground plane. Here three cases are designed. Case I is hexagonal fractal with normal feeding technique. Case II is insert fed technique. Case III is array of two element with insert fed.

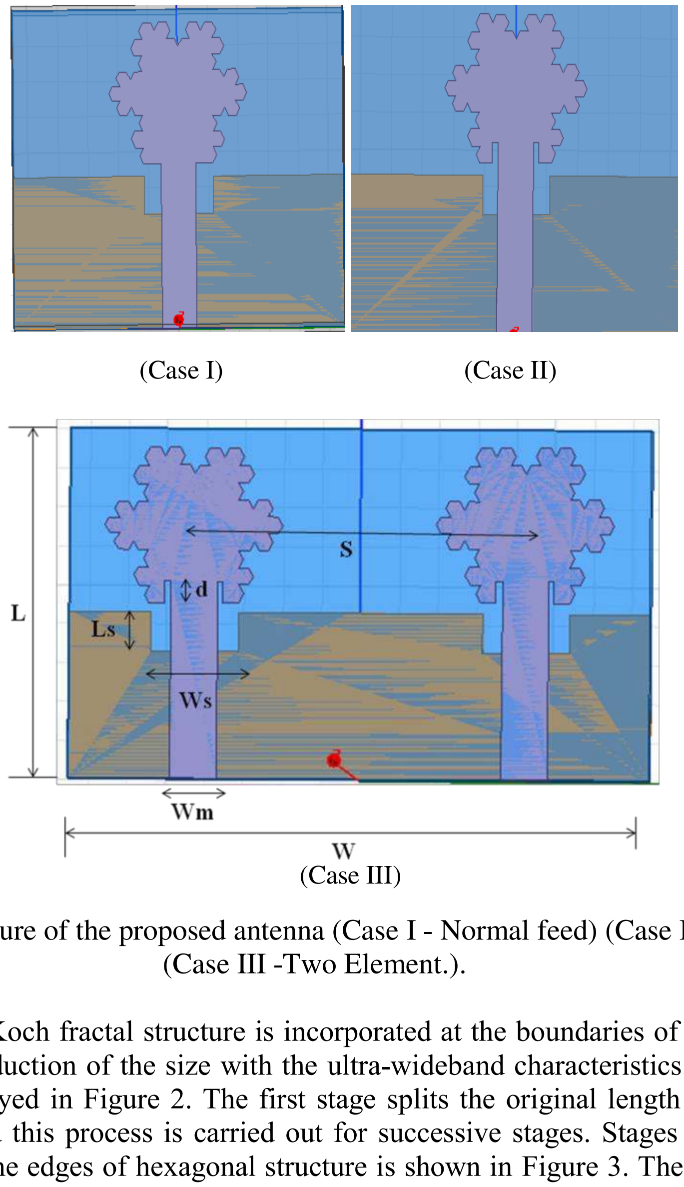
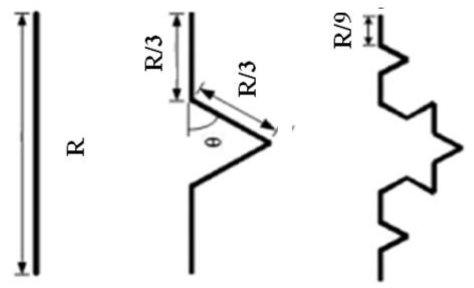


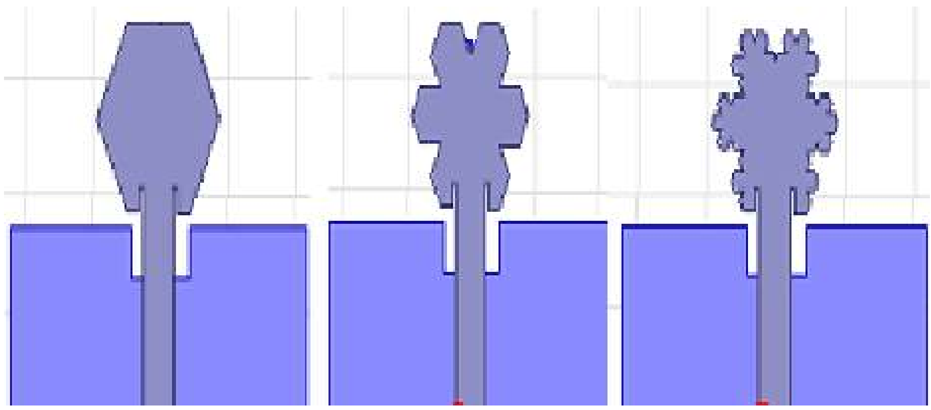
Figure 1. Structure of the proposed antenna (Case I - Normal feed) (Case II - Insert feed) (Case III -Two Element.).

The inside cut Von Koch fractal structure is incorporated at the boundaries of hexagonal structure in order to attain the reduction of the size with the ultra-wideband characteristics. The stages of Von Koch structure is displayed in Figure 2. The first stage splits the original length of the antenna into three equal portions and this process is carried out for successive stages. Stages based utilization of Von Koch structure at the edges of hexagonal structure is shown in Figure 3. The current distribution of the proposed antenna is showed in Figure 4 and the return loss variation of the proposed antenna is displayed in Figure 5. These changes in the structure enhance the qualities in the UWB range spectrum. The fractal structure produces various resonances. Furthermore, by consolidating these resonances the wideband bandwidth can be attained. In, order to improve the current distribution and to attain the UWB nature, a rectangular space of measurements length and width is presented in the ground plane beneath the feed line. The HFSS is used to optimize the dimension of the proposed antenna and the dimension in case 3 correspond to the following: R = 4.6mm, L = 30mm, W=20mm,W_m=,2.3mm W_s=4.3mm, L_s=2.1mm ,d = 0.8mm,S = 15mm.



(a) (b) (c)

Figure 2. Stages of inside cut Von Koch arrangement (a) Stage - 0 (b) Stage -1 (c) Stage -2



(a) (b) (c)

Figure 3. Stages of the Von Koch fractal structure at the edges of Hexagonal structure (a) Initial stage (b) First stage(c) Second stage

3. Result and discussion

The current distribution of the proposed MIMO antenna is displayed in Figure 4. From the display it could be inferred that most of the current is centered around the hexagonal part of the antenna. The display in Figure 5 shows that case 1 having a return loss of – 40 db at 7.1 GHz .Case 2 having a return loss of – 44 dB at 6.5 GHz. Case 3 the antenna resonate at – 51 dB frequency at 7.1GHz. These high return losses at the above mentioned frequencies is the resultant of the novel inside cut Von Koch fractal structure. Among the three cases, the frequency center around 7 GHz, is used in defense applications and hence the proposed antenna can provide a better communication link as it provide very less return loss characteristics. The impedance bandwidth at these frequency provide high bandwidth with improved gain of 8.3 dBi as seen in Figure 6. The radiation pattern for 0^0 and 90^0 characteristics of all the three cases is shown in Figure 6, which display a gain of 6.4 dBi for case 1, 4.9 dBi for case 2 and 8.3 dBi for case 3.

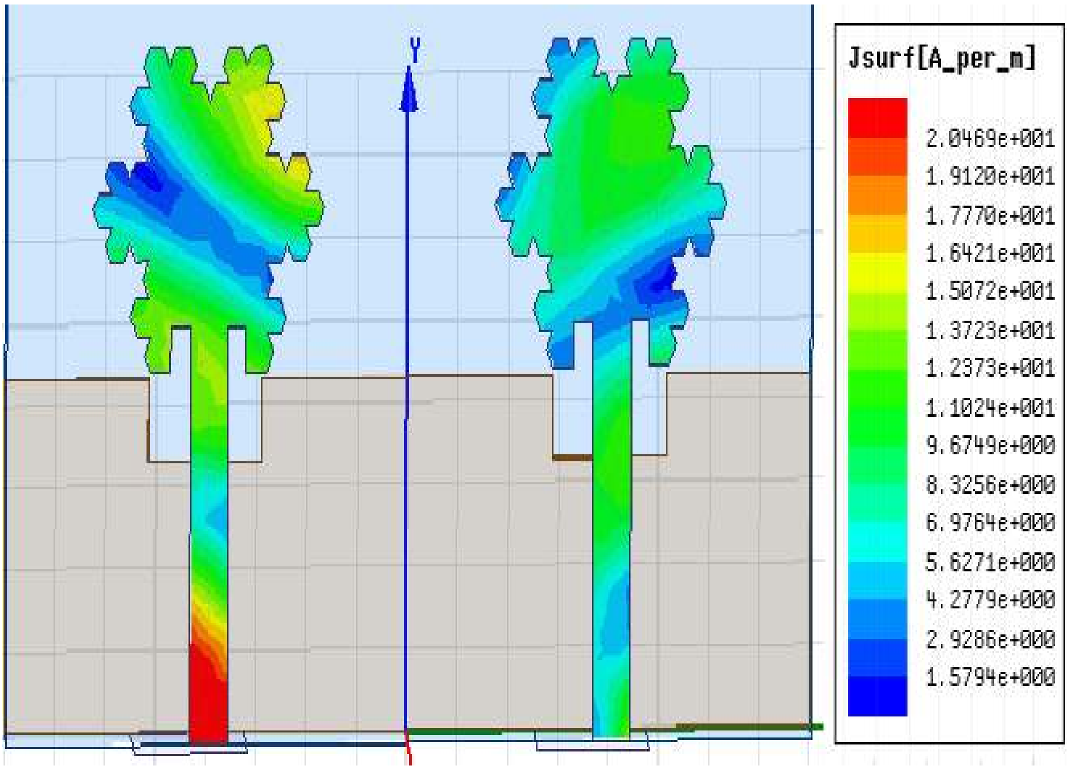


Figure 4. Current distribution of the proposed MIMO antenna.

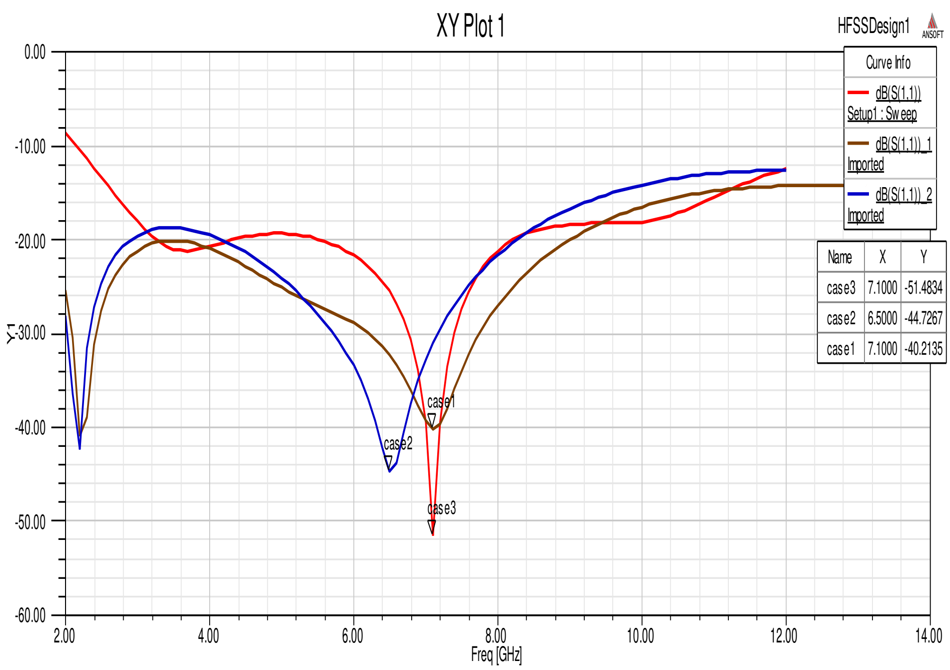
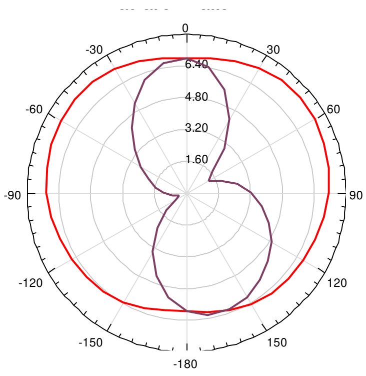
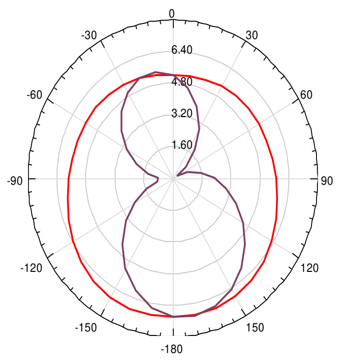
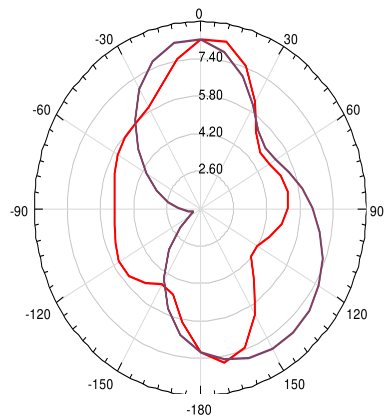


Figure 5. Return loss of the proposed antenna.





(Case 1) -7.1GHz (Case 2)-6.5GHz



(Case 3)-7.1GHz

Figure 6. Radiation pattern of the proposed antenna

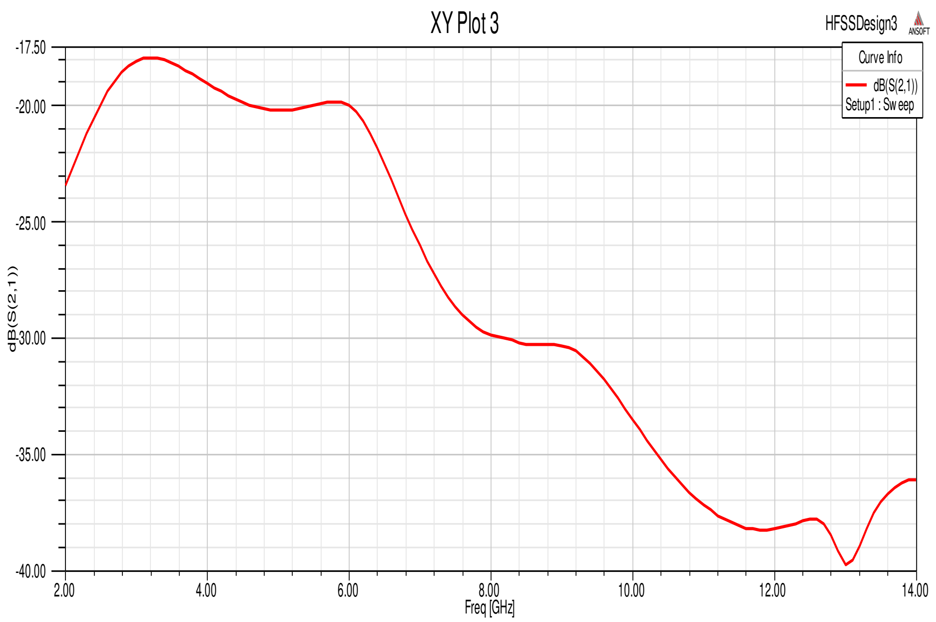


Figure 7. Mutual coupling (S21) of the proposed antenna

Table 1. Comparison of the prevailing and proposed inside cut Von Koch fractal MIMO antenna

Category	Reference[1]	Reference[2]	This work
Frequency Band (GHz)	7.45	4.1 8.4	7.1
Retrun loss(dB)	-39dB	-40dB	-51dB
Fractional Bandwidth(%)	59%	42%	73.5%
Total Size (mm)	32 x 20 x 1.6	45 x 45 x 1.6	30 x 20 x 1.6

Fig.7 shows the mutual coupling display for the proposed antenna. From the curve it is found that the mutual coupling of the antenna is – 21.3 dB near the operating frequency 6.5 GHz, -27.5 dB at 7.1 GH. As seen from the curves, the proposed antenna provide less mutual coupling for the entire band of UWB applications. The comparison between the proposed structure and the structures reported in literature is listed in Table 1. As seen from the table, the proposed inside cut Von Koch fractal structure perform better than the existing structures in terms of size, fractional bandwidth and return loss characteristics.

4. Conclusion

In this paper a compact hexagonal shaped inside etched Von Koch fractal antenna with DGS structure is designed with very much improved return loss and wider bandwidth. The return loss of the antenna is greater than -40 dB in all the cases. The gain of the antenna is also very much improved. And also the Fractional bandwidth is greater than 50% in all cases which show the wideband nature of the antenna .Thus the proposed antenna operates in very wide band it can be used to increase the data rate of the communication system.

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