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Hybrid Fractal Antenna for UWB Applications

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Abstract-This paper describes the design of a hybrid fractal antenna with combination of sierpinski, Koch and Minkowski fractals. The antenna operates in upper UWB frequency range. The base of the antenna is a square patch with the second iteration of sierpinski. Along the boundary of the patch a third iteration of Koch curve and a combination of Koch and minkowski is given at top and bottom respectively. The antenna element is fed through a 50 ohm microstrip line (MTL). It is printed on the substrate FR4-epoxy. The antenna is designed for a frequency range of 3GHz to 15GHz. The simulated output shows that, the designed antenna gives multiband resonant frequencies and wide bandwidth. The resonance frequencies are 4.26GHZ, 7.04GHz, 10.1GHz, 12.82GHz and 13.79GHZ. The antenna is simulated on Ansoft HFSS (High Frequency Structure Simulator). The Parameters like return loss and VSWR are discussed.

Index Terms-Sierpinski Carpet, Koch curve, Minkowski, Hybrid fractal, ultra wideband, return loss, VSWR, HFSS.

1. INTRODUCTION

Future wireless communication systems demands for antenna with wider bandwidth, higher performance, low cost, conventionally small dimension and that have multiband characteristics. Generally all antennas operate at single or dual frequency bands which are applicable for particular applications. This will cause antenna to operate in the limited frequency bands. In order to solve this problem multiband antennas are introduced, where a single antenna can operate at many frequency bands. The multiband antennas that operate over wide band of frequency range are commonly called as ultra-wideband (UWB) antennas. UWB communication systems get attention in wireless world because of its advantages. Some of the advantages are high data rate, low spectral power density, high precision ranging, low cost, large channel capacity, high immune to multipath interference [1]. Federal Communication Commission (FCC) in 2002 has permitted the use of frequency band from 3.1 to 10.6 GHz for UWB communication.

Introduction of fractal geometry to antenna structure has proved to give multiband frequencies. The word fractal is taken from the Latin word ‘fractus’ meaning broken into parts or fragments. Fractals have different geometries like Hilbert curve, Sierpinski carpet, Sierpinski gasket, Giusepe-piano, Koch snowflake and Minkowski loop. Fractal geometry was first proposed by Mandelbrot. These fractal geometries have two main properties in general which are self similarity and space filling. The former allow wider band and multiband operations while the latter leads to reduction in size, which allows antenna to be fabricated in a smaller space. Thus in antenna design fractals become more attractive because of the early mentioned properties. A sierpinski fractal antenna is designed in [3] and it results with 6 resonance frequencies having a return loss of -17dB. Combination of two or more different fractal structure is called as hybrid fractal. Were those different fractals are fabricated on the same the substrate. Advantages of hybrid fractals include it offers wider bandwidth, planar structure, increase surface area to volume ratio, compact size and more number of resonant frequencies. These characteristics make it more popular and widely demanding one. Hybrid combination with sierpinski carpet fractal and minkowski loop is presented to increase the number of resonance frequencies and enhance the bandwidth in [6], [15], [19]. Were [12] and [14] investigates an ultra wideband monopole along with hybrid structure. Antenna operating in ultra wideband frequency range with wide bandwidth and good characteristics is discussed in [10]-[12], [16], [18]. A new triple band hybrid fractal boundary antenna is proposed in [17].

This paper discuss about a hybrid fractal antenna. The fractal antenna consists of geometrical shapes that are repeated. Each one has a unique attributes. The self similarity that distributed on this antenna is expected to cause its multiband characteristics. Combination of 2 or more different fractal geometries gives hybrid structure. Here the proposed antenna is a combination of sierpinski carpet, Koch and minkowski fractals. The proposed antenna is applicable for WLAN, WiMAX, C-band and X-band applications.

2. ANTENNA DESIGN

The proposed work is a hybrid fractal antenna. The foundation of antenna starts with a basic microstrip square patch antenna. For the proposed structure any one of the available fractal geometry must choose to integrate into the patch. Among them sierpinski carpet fractal geometry is one of the most widely used fractal. So sierpinski carpet fractal geometry having iterations up to level two is chosen. In which circular slots are introduced in second iteration. Other popularly used fractal is Koch curve. The third iterated Koch curve is inserted along the boundary of patch at top. At bottom along the boundary an affine structure which is the combination of Koch and minkowski curve is inserted. Thus the proposed hybrid fractal antenna is formed by combining sierpinski carpet, Koch and minkowski curve.

The step taken for design is as follow. Figure 1 shows the construction of sierpinski carpet. Figure 1 (a) the initiator, is a square patch of dimension 36x36mm^2. The first iteration is done by dividing the base square into nine smaller congruent squares which is one by third of the side of base shape, i.e., 12x12 mm^2 and the open central square is dropped as in figure 1(b). As shown in figure 1(c) for second iteration, the remaining eight squares are divided into nine smaller congruent squares. Instead of squares circle of diameter one by nine of base square is removed.

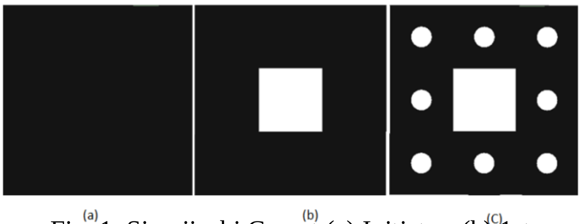

Fig. 1. Sierpiinski Carpet (a) Initiator, (b) 1st iteration, (c) 2nd iteration.

Figure 2 shows the construction of Koch curve. It starts with a straight line i.e., initiator in figure 2(a). This is partitioned into three equal parts, and the segment at the middle is replaced with two others of the same length which is the first iteration figure 2(b). The process is repeated in all remaining segments to generate higher order iterations figure (c) and (d). The third iteration of Koch curve is inserted at top of the square patch along the boundary.

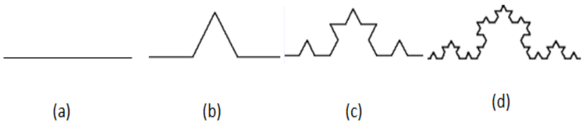

Fig. 2. Koch curve (a) initiator, (b) 1st iteration, (c) 2nd iteration, (d) 3rd iteration.

Figure 3 is Affine. It is a combination of Koch curve and minkowski curve. The generator is divided into four equal parts. Koch and Minkowski curve of equal length have inserted one upward and other downward respectively to generate hybrid fractal geometry. This hybrid fractal geometry affine is inserted on the bottom of the patch along the boundary.

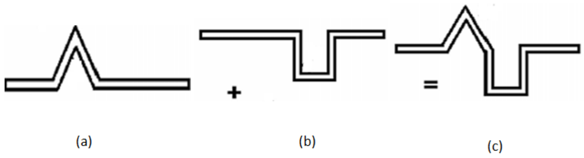

Fig. 3. Affine (a) Koch curve, (b) minkowski curve, (c) combined.

Figure 4 shows the proposed antenna geometry. The operating frequency of antenna is set at 5GHz. The antenna is designed in FR4- epoxy substrate of 70x70 mm^2 and thickness of 1.6mm. FR4- epoxy has a relative permittivity of 4.4.

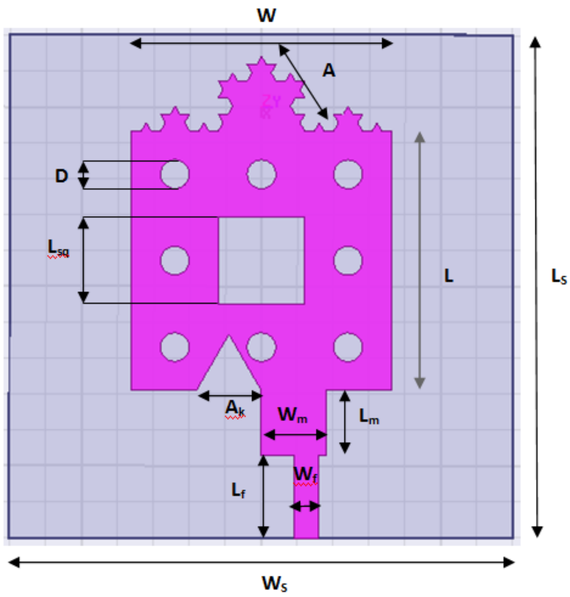

Fig. 4. Geometry of the proposed antenna.

The dimensions of the proposed antenna are given in the table I. The square patch has the dimension of 36x36mm^2 and it is fed through 50 ohm microstrip line (MTL) of width 3.5 mm. As the length and width of base shape (zero order) plays a salient role in determining the resonant frequency, we have specifically defined the geometry from zero to second order.

Table 1. Dimensions of Proposed Antenna

Parameter	Value (mm)
L	**36**
W	**36**
L_{sq}	**12**
D	**1.67**
A	**12**
A_k	**9**
L_m	**9**
W_m	**9**
L_s	**70**
W_s	**70**
L_f	**11.53**
W_f	**3.5**

Radius of the circle is defined by the one by ninth of the side of base square shape i.e., 1.67mm. These circular slots are provided in order to enhance the bandwidth. For multiple resonances hybrid fractal is introduced.

3. RESULT AND DISCUSSION

The proposed hybrid fractal antenna was simulated in an EM simulator, Ansoft HFSS (High Frequency Structure Simulator) to understand the behavior and determine the parameters.

3.1 Return Loss

Result shows that, antenna provides a return loss (S11 parameter) of -34.6dB at 10.29GHz.

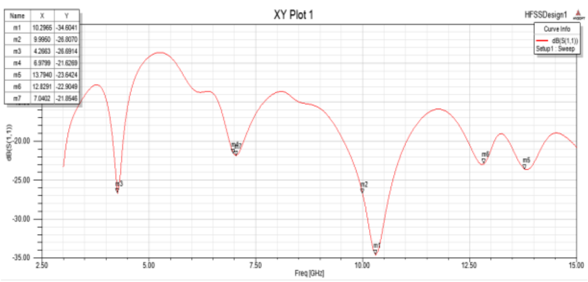

Fig. 5. Simulated return loss S11 versus frequency

3.2 VSWR

The VSWR graph shows that the antenna satisfies the VSWR criterion.

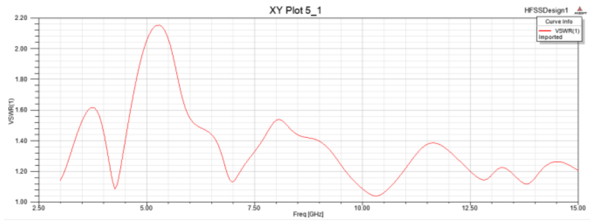

Fig. 6. VSWR versus frequency

From this it's seen that antenna operates in upper UWB frequency range. Multiple bands are obtained at frequencies of 4.26GHz, 7.04GHz, 10.29GHz, 12.82GHz and 13.79GHz.

4. CONCLUSION

A hybrid fractal antenna for multiband operation in UWB frequency range is designed. Sierpinski carpet, Koch and minkowski fractals form here the hybrid structure. Thus the proposed monopole satisfies all the requirements of an upper UWB antenna in perspective of return loss and VSWR. It is well applicable for WLAN, WiMAX, C-band, X-band, KU-band applications. The antenna will be fabricated and measured inorder to verify the simulated and measured results.

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