ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 5, Issue 1, January 2018

Modified Sierpinski Carpet Fractal Antenna with Circular Slots

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***Abstract*— This paper describes the design of a modified sierpinski fractal antenna with circular slots. The antenna is designed in such a way that make it is suitable for upper UWB frequency applications. The antenna size is 30x30 mm2 and iterations performed till second iteration. 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 2.5GHz to 15GHz. The simulated output shows that, the designed antenna operates in multiband frequencies. The resonance frequencies appeared at 5.2GHz, 9.4GHz and 10.1GHz for second iteration. The output is simulated on Ansoft HFSS (High Frequency Structure Simulator).**

***Keywords* — Sierpinski carpet, Ultra Wide Band, FR4-epoxy, Return loss, VWSR, HFSS**
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1. INTRODUCTION

Modern wireless communication systems demands for antenna with higher performance, wider bandwidth, multiband support, low cost and conventionally small dimension. Generally all antennas operate at single or dual frequency bands, depending upon different applications. This will cause a limited space problem. In order to solve this problem multiband antennas are used where a single antenna can operate at many frequency bands. These multiband antennas are operating over wide band of frequencies, which are called as ultra-wideband (UWB). UWB communication systems get attention in wireless world because of its advantages. Some of the advantages of UWB systems 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) has approved the use of frequency range of 3.1 to 10.6 GHz for UWB communication systems.

To construct a multiband antenna which operates over UWB frequency range on possible technique is to apply fractal into the antenna geometry. 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 geometries have two properties in general which are self similarity and space filling. These geometries were first proposed by Mandelbrot. Due to the self similarity and space filling properties of fractals, it comes out as an attractive way to design an antenna. These properties allow the wider band and multiband operations and the space filling property leads to a reduction in size, which allows antenna to be fabricated in a smaller space. A sierpinski fractal antenna is designed in [3]

and it results with 6 resonance frequencies having a return loss of -17dB. For a Wireless Power Transmission (WPT) system with low profile and light weight, a fractal based microstrip patch antenna is proposed for multiband operations [5]. Hybrid combination with sierpinski carpet fractal and minkowski loop is presented to increase the number of resonance frequencies and enhance the bandwidth [4], [10], [12]. [6] investigates a ultra wideband monopole along with hybrid structure. Antenna operating in ultra wideband frequency range with wide bandwidth and good characteristics is discussed in [6]-[9], [11].

This paper discuss about a sierpinski carpet fractal antenna with circular slots. Sierpinski carpet fractal antenna is the most widely studied fractal geometry for antenna application [3]. 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. The proposed antenna is applicable for WLAN, WiMAX, C-band and X-band applications.

II. ANTENNA DESIGN

The design of antenna starts with a basic square patch microstrip antenna. Further iterations are performed in the basic structure to form the proposed antenna structure. Sierpinski carpet fractal geometry is used here for designing of the antenna.. In which circular slots are introduced in its second iteration. The steps taken for each iterations is as shown in figure 1.

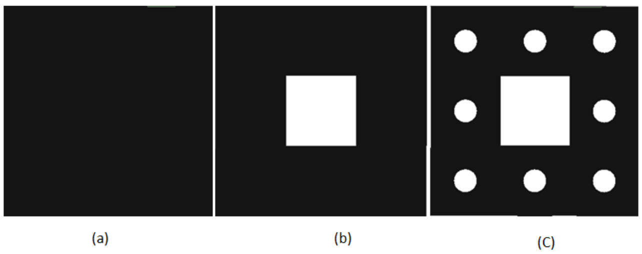

Figure 1. Sierpiinski Carpet (a) initiator, (b) 1st iteration, (c) 2nd iteration.

Figure 2 shows the proposed antenna geometry. The operating frequency of antenna is set at 2.5GHz. The antenna is designed in FR4- epoxy substrate of 70x60 mm2 and thickness of 1.6mm. FR4- epoxy has a relative permittivity of 4.4. The dimensions of the proposed antenna are given in the table I. The square patch has the dimension of 30x30mm2 and it is fed through 50 ohm microstrip line (MTL) of width 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.

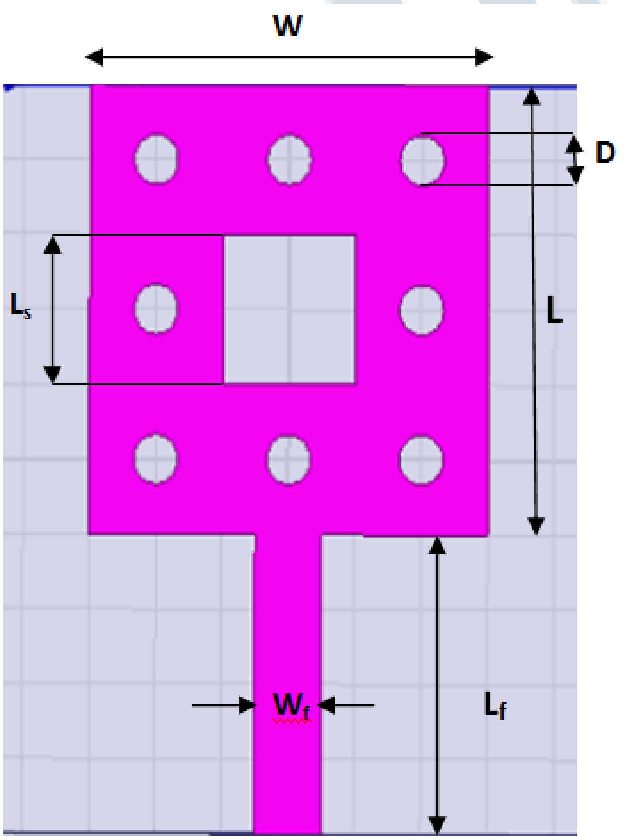

Figure 2. Geometry of the proposed antenna.

The first iteration is done by the removal of a square slot from the center of proposed base shape of antenna. The dimension of this square slot is one by third of the side of base shape, i.e., 10x10 mm2. In second iteration, 8 circular slots are provided on the remaining space of base square shape. 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 inorder to enhance the bandwidth.

TABLE I. DIMENSIONS OF PROPOSED ANTENNA

Parameter	Value (mm)
L	30
W	30
L_s	10
D	1.67
L_f	20
W_f	5

III. RESULTS AND DISCUSSION

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

A. Return Loss

Result shows that, antenna provides a return loss (s11 parameter) of -26.5dB at 5.2GHz.

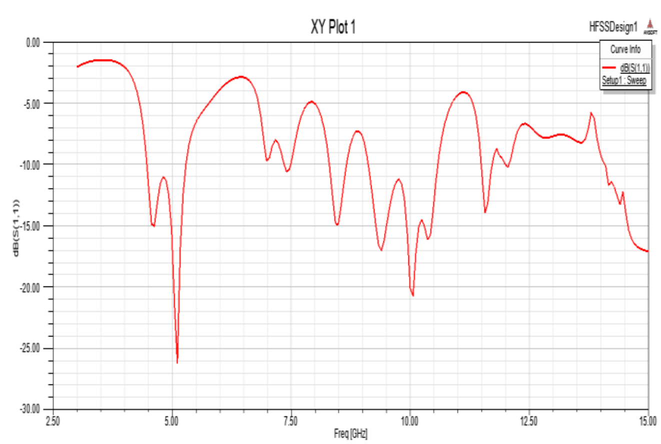

Figure 3. Stimulated return loss S11 versus frequency

B. VSWR

The VSWR graph shows that antenna satisfies the VWSR criterion.

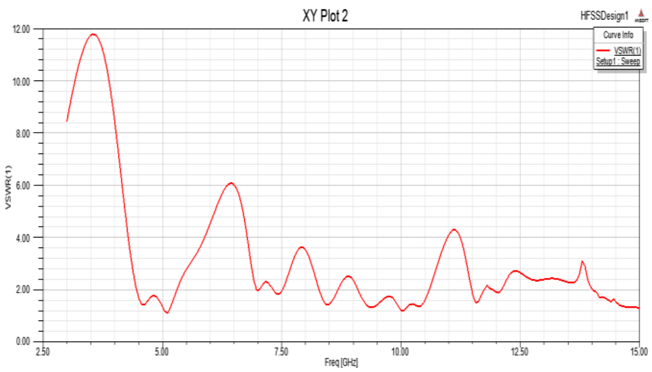

Figure 4. VSWR versus frequency

From this its seen that antenna operates in upper UWB frequency range. Multiple bands are obtained at frequencies of 5.2GHz, 9.4GHz and 10.1GHz.

CONCLUSION

A square microstrip Sierpinski Carpet antenna with circular slots was constructed using fractal geometry for multiband operation. 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 applications.

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