Design and Analysis of a Modified Sierpinski Carpet Fractal Antenna for UWB Applications

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***Abstract*-This paper presents the design and analysis of a modified Sierpinski Carpet fractal antenna that contributes ultra wideband characteristics. The proposed antenna with coplanar waveguide-fed structure is compact, which has a total size of 40mm×50mm×1.8mm. An experimental prototype has been fabricated and tested .The measured results show the impedance bandwidth of the proposed fractal antenna that the return loss below -10dB is 8.1 GHz ranging from 2.2GHz to 10.3 GHz. Corresponding 129.6% impedance bandwidth. Analysis of antenna is done using Ansoft High Frequency Structure Simulator (HFSS v 10).Very good agreement obtained between simulation and experimental results.**

I INTRODUCTION

The ultra wideband (UWB) system have become emerging research topic in the field of modern wireless communications since Federal Communication Commission (FCC) band 3.1GHz-10.6GHz declared in Feb.2006 [1]. In recent years several printed planar micro-strip antennas are developed for UWB range due to their low profile, small volume, easy to integrate into the communication circuit [2-6]. In a UWB antenna system the construct is designed with the help of rectangular patch consisting of two steps and partial ground plane. This method can be used to achieve wideband characteristics.

The concept of fractal was first introduced by French mathematician B. B. Mandelbrot. Fractals have self similarity properties which are used in achieving multi band characteristics and hence can be optimized for UWB applications. Fractal shaped antennas have already been proven to have some unique characteristics that are linked to the geometrical properties of fractal. Self-similarity of fractal makes them especially suitable for Ultra Wide Band and multi-frequency applications [7-11]. Very recently, several antenna based on the fractal topology has been proposed and investigated. They have been applied to Loops, dipoles, monopoles, patches, slots, arrays and PIFA [12-13].

In this paper, a planar micro-strip antenna with modified Sierpinski Carpet Fractal is presented for UWB characteristics. This antenna exhibits the properties, such as miniature size, wideband phenomenon and Omni-directional radiation pattern. This antenna is developed which covers the UWB range of 2.2 GHz to 10.3 GHz achieving impedance bandwidth of 129.6%. The proposed antennas are simulated using Ansoft High Frequency Structure Simulator (HFSS v 10) to study the performance parameters related to size reduction.

II DESIGN OF FRACTAL PATCH ANTENNA

The initial design of the self similar Sierpinski Carpet Fractal is a rectangle patch. The dimensions of the fractals, which forms the basis of the antenna, are shown for first, second and third iterations. The zero element antenna is called Fractal 0. to form the first iteration Fractal 1, the rectangular in the center of the original patch is one third of its original size and remove the changed small unit from the original patch .The second Fractal 2 and third Fractal 3 iteration are formed by translating their previous iteration, which the dimension of each rectangular with the same size.

Figure 1 illustrates the geometry of the proposed ultra wideband patch antenna. As shown, the designed antenna which is printed on the FR-4 substrate with a thickness of 1.8 mm, relative dielectric constant of 4.4 and a dielectric loss tangent of 0.02, has a compact dimension of 40 mm× 50 mm. As in Figure 1, the proposed antenna consists of two asymmetrical part patches, one patch on the top called radiated element and the other patch on the bottom of the substrate called the limited ground plane. The feeding structure consists of a microstrip line, which is designed to have characteristic impedance of 50 Ohm. There also an impedance convertor for the microstrip structure. The convertor is determined according to optimization to implement 50 Ohm characteristic impedance, and a standard SMA connector is connected to facilitate its connection with other communication devices.

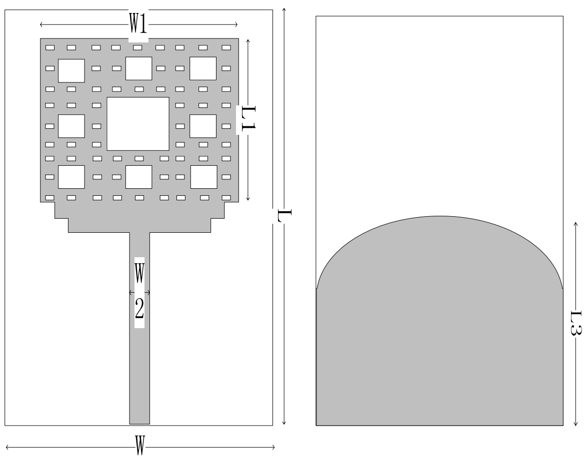


Figure 1 Geometry of the proposed antenna

The proposed antenna parameters are L=50mm, L1=18.9mm, L3=18mm, W=40mm, W1=27mm, W2=4mm. The parameters of a Sierpinski Carpet Fractal Antenna above has been optimized and simulated.

III SIMULATRION AND MEASUREMENT RESULTS

A SIMULATRION RESULTS

Prior to fabrication of the final structure, a parametric study is carried out to pre-determine the cause-effects of fabrication inaccuracies. The study is carried out on proposed structures. Parameters investigated are critical parameters: (1) The times of Fractal on the patch is shown in Figure 2.With the time increasing its effects on the antenna's Return Loss (S11) and bandwidth , it is observed that the third iteration is better than the first and the second iteration in bandwidth: (2) It is seen from Figure 3 that a slight upwards shift and downward shift of the resonant frequency and *S*11 occurred with the increase in width: (3) As we see from Figure 4, with the length increasing, the matching of impedance is not very good in the high frequency range but match in the low range.

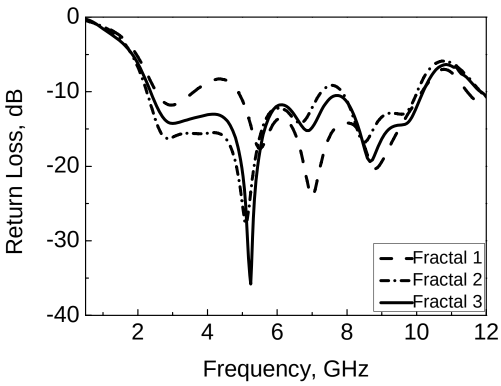


Figure 2

Return Loss for the proposed antenna with fractal

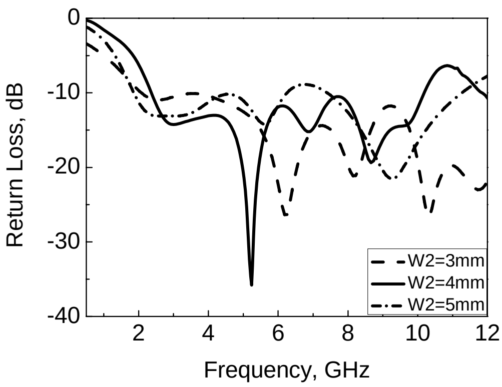


Figure 3 Return Loss for the proposed antenna with W2

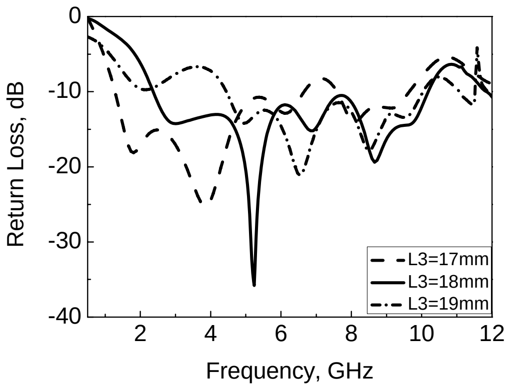


Figure 4 Return Loss for the proposed antenna with L3

B MEASUREMENT RESULTS

Base on the design dimensions shown in above parameters. An experimental prototype of the proposed antenna is fabricated as depicted in Figure 5, Figure 6 and Figure 7 show the measured and simulated the return loss (S11) and Voltage Standing Wave Ratio (VSWR) for the proposed antenna.

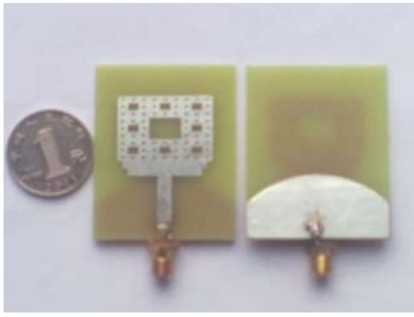


Figure 5 The manufactured of the proposed antenna

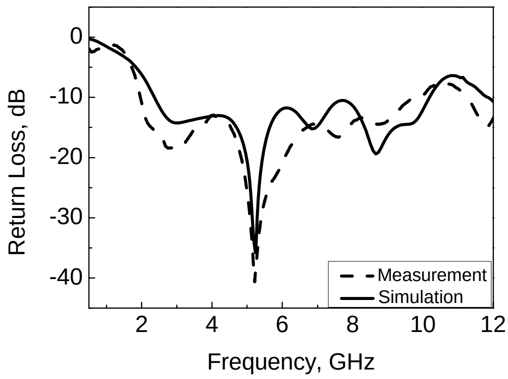


Figure 6 Measurement and simulation results of the antenna return loss

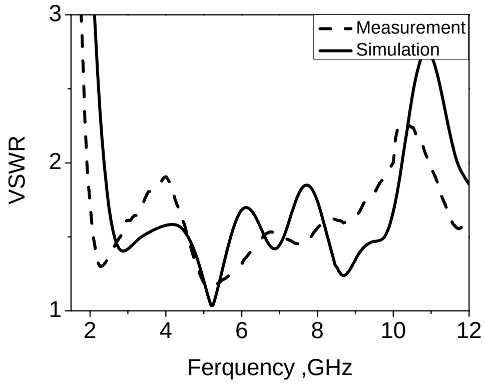
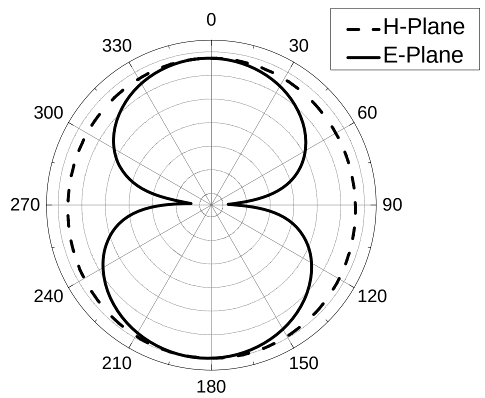


Figure 7 Measurement and simulation results of the antenna

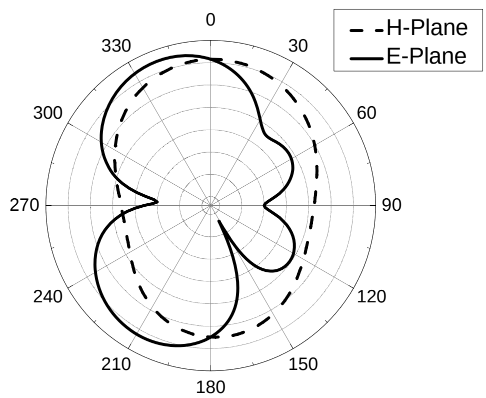
VSWR

The far-field radiation characteristics of the proposed ultra wideband antenna have also been studied. The normalized radiation patterns measured at 2.8 GHz, 5.2 GHz, 6.8 GHz and 8.7 GHz are plotted in Figure 8.



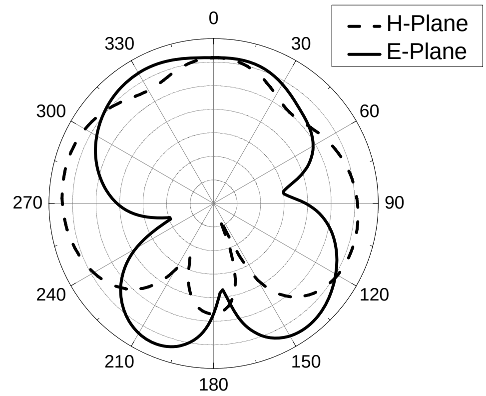
(a) F

=2.8GHz



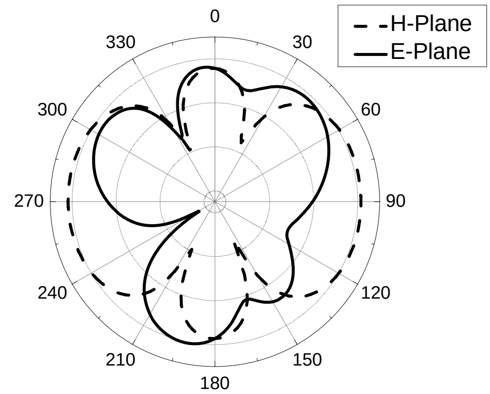
(b) F

=5.2GHz



(c) F

=6.8GHz



(d) F

=8.7GHz

Figure8 The far-field radiation patterns at resonant frequencies 2.8 GHz, 5.2 GHz, 6.8 GHz and 8.7GHz, respectively

IV CONCLUSION

A new compact ultra-wideband antenna has been proposed for UWB applications. The measured and simulated results conducted by the Ansoft High Frequency Structure Simulator (HFSS v 10) show a good performance. The frequency range obtained for return loss below -10 dB is 2.2 GHz -10.3 GHz. Corresponding 129.6% impedance bandwidth, the simulated radiation patterns at 2.8 GHz, 5.2 GHz, 6.8 GHz and 8.7 GHz is presented. The usage of the Sierpinski Carpet Fractal topology, in particular, has managed to enhance the antenna in terms of additional higher resonance frequencies and broad bandwidth. At the same time, it also contributed to space saving through electrical length shortening. These size compactness and multi-resonant antenna behaviors are particularly significant, in line with the miniaturization of today's electronic devices.

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