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Double Band Fractal Bow Tie Antenna Design for GPR Application

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Abstract - In this work, antenna is studied as an important part of Ground Penetration Radar (GPR). For obtaining information about materials in two different depths, a novel double band bow tie antenna is proposed. Fractal method is used for improving the antenna performance. The results of the antenna development is presented step by step. The low cost and light profile designed antenna has been fabricated and tested in microwave laboratory. The fabricated antenna results agree well with the simulation analysis.

Keywords - *Bow tie antenna, GPR*

1. Introduction

GPR application area can be classified in two main groups. In military field, GPR is used for underground warehouses, unexploded bombs, secret rooms and also bomb shelters. Besides, in civilian life, it is used for finding buried pipes, undetected blanks and the people who are left under collapsed buildings [1-4]. Antenna is needed for transmitting the signal and gathering the reflected wave as well as collecting information about the properties and the distance of the buried object. Size, weight and the price of an antenna are the chief challenges for designing. Additionally, impedance bandwidth for increasing the data resolution is important. Also, operating frequency is the key factor of signal penetration [5 and 6]. In literature, circularly polarized antenna was proposed for reaching a deeper distance and passing more layers [7 and 8]. As shown in Figure 1, the fractal objects have a combination of similar structures at different scales that are identical with themselves [9 and 10]. The first shape of recurring structure is called the generator. Repeating the initial shape with different scales, directions and positions are parts of the fractal method. In this work, Bow tie antenna is preferred for designing because of lower weight and smaller size in comparison with Horn and Vivaldi antenna. The operation frequency of the designed antenna is quite decreased for more penetration. Fractal method is chosen for increasing the impedance bandwidth and obtaining double band frequency. Ansoft HFSS program is used for simulation analyses.

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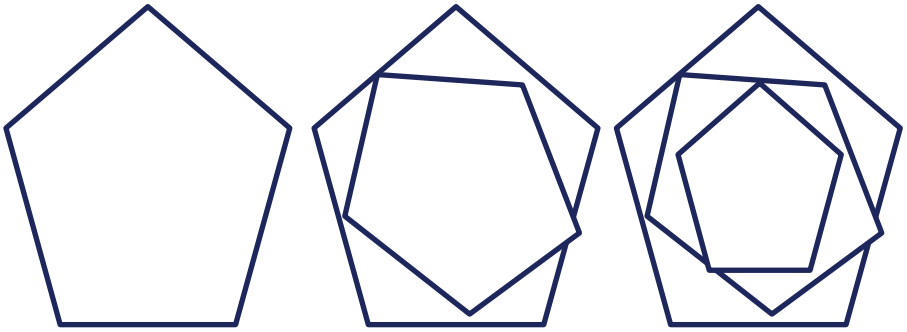
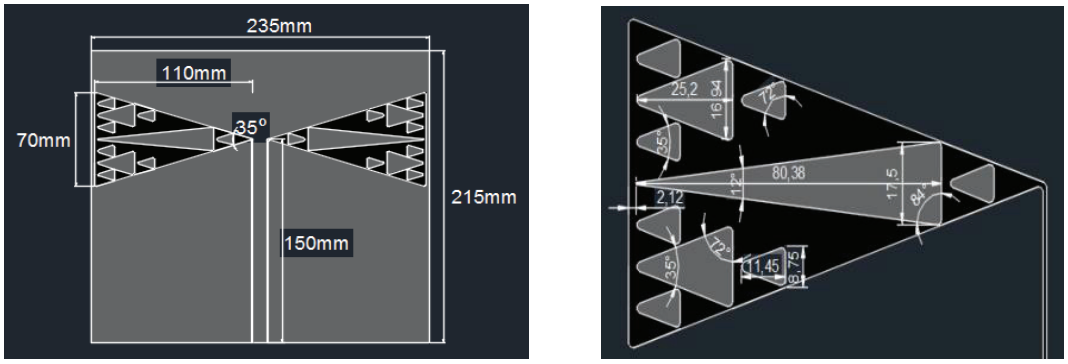


Figure 1. Fractal structure is repetitive of its own structure

2. Design of Antenna

Proposed antenna structure is shown in Figure 2. Epoxy material εr=4.4 which is called FR4 with H=0.8 mm. thickness, is used as the substrate of the designed antenna.



(a) (b)

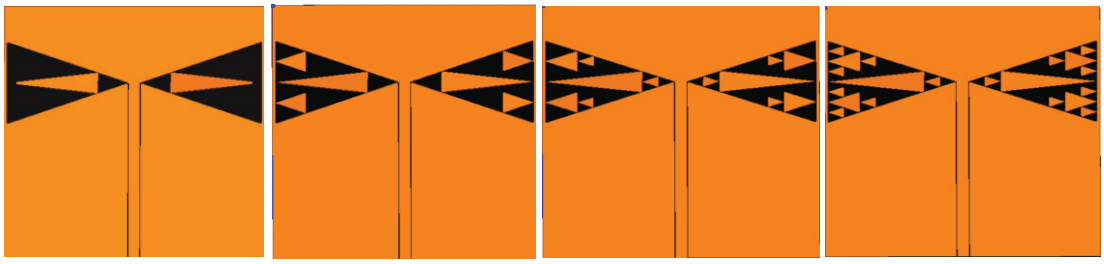
(c)

Figure 2. The geometric structure of the proposed antenna (a) Top view and angle representation of the antenna (b) One side triangle and its interior (c) Side view

The dimensions of the antenna are 215×235×0.8 mm. The feed path length of the antenna is h=150 mm; feed length width is W=0.8 mm and the gap between two ways is S=10 mm. These diameters have been found after so many simulation processes and the best result was chosen. Feed line is designed for connecting the 50 Ω SMA connector.

3. Result and Discussion

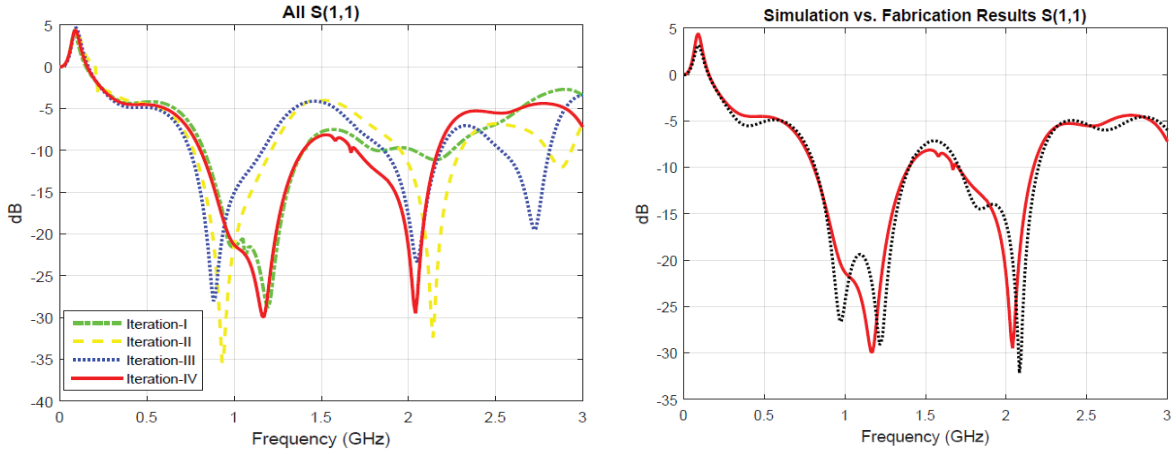
Figure 3 shows the steps of the fractal antenna design. According to the results of these steps, high resolution data regarding the buried object can be obtained by increasing the frequency bandwidth. Furthermore, more depth of penetration was successfully obtained by decreasing the operation frequency. The steps of improvement were continued as follows:



(a) (b) (c) (d)

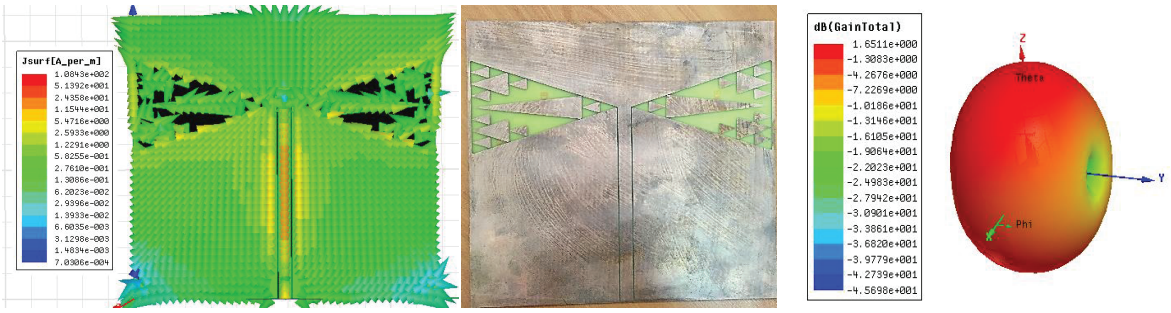
Figure 3. The improving steps of the proposed Double Band Fractal Bow-Tie Antenna (a) Iteration I (b) Iteration II (c) Iteration III (d) Iteration IV

In figure 4(a), the -10dB s11 shows that the improvement observed in the results has occurred stepwise. In the last iteration (of the proposed antenna), the starting frequency is sufficiently low for good penetration (0.8 GHz) and the two bandwidths are good enough for resolution (0.8 – 1.4 and 1.5 - 2.2 GHz). Figure 4(b) shows that the fabricated and the simulation results of the proposed antenna are significantly close. According to Figure 5(a), the current distribution is uniform at every point of the antenna, which helps with the improvement of radiation pattern and gain. The fabricated double band fractal bow-tie antenna is demonstrated in Figure 5(b). Also, Figure 5(c) shows the 3D graphic of the antenna pattern. Figure 6 shows the radiation patterns of the last version of the double band fractal bow-tie antenna in different θ and φ angles at operating frequency.



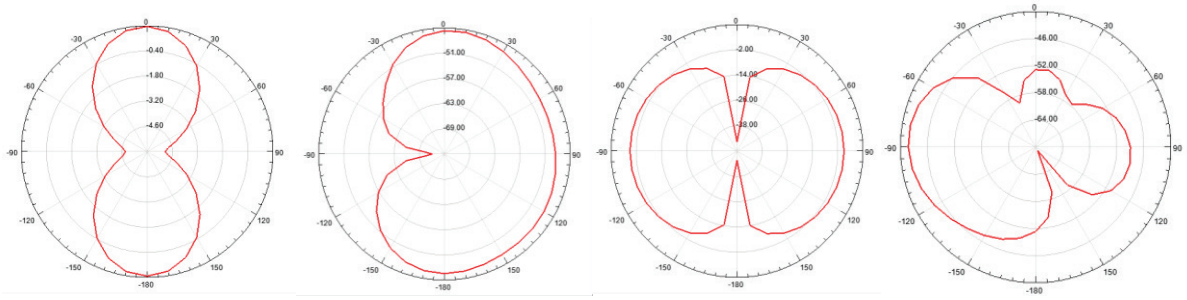
(a) (b)

Figure 4. (a) s11 graph of all iterations (b) Experimental (red line) and Simulation (black-dashed line) results for proposed antenna



(a) (b) (c)

Figure 5. (a) Current distribution of antenna at operation frequency. (b) A photograph of fabricated double band fractal Bow-tie Antenna (c) 3D antenna gain plot



(a) (b) (c) (d)

Figure 6. The radiation pattern of Double Band Fractal Antenna at operation frequency (a) φ=0°, (b) φ=90°, (c) θ =0°and (d) θ =90°

4. Conclusion

In this article, double band Fractal Bow Tie antenna has been designed and fabricated. Using the fractal method, the antenna bandwidth is increased. The bandwidth of designed antenna was analyzed by being initiated from 0.8 GHz and 1.4 GHz for the first band and from 1.6 GHz and 2.2 GHz for the second band. Thanks to the results accumulated from the proposed antenna, obtaining more details and reliable information regarding the buried objects will be possible.

5. Acknowledgment

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