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Design of an Ultra Wideband Fractal Antenna for Microwave Applications

Debashish Pal

Abstract— **In this paper a compact fractal monopole antenna for ultra wideband application is proposed with microstrip feed technique. The fractal structure generates multiple frequencies and increases the bandwidth of the patch antenna. Fractal antenna gives better performance in terms of return loss, efficiency and directivity. The proposed antenna is designed on an inexpensive FR4 Epoxy substrate of thickness 1 mm and a dielectric constant of 4.4. Theoretical investigations done by Ansoft Designer reveal that the structure resonates at 8.16 GHz and has an Ultra Wide Bandwidth of 2.8 GHz.**

Index Terms*— *Fractal Antenna, Microstrip Feed, Microstrip Patch, Return Loss, Ultra Wide Band.

I. INTRODUCTION

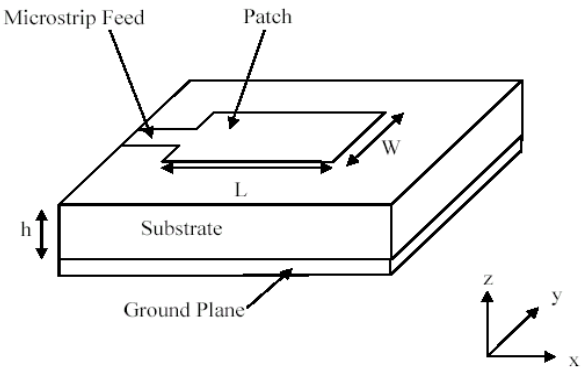

Figure 1. Microstrip line feed Patch Antenna

Microstrip patch antenna has attracted a lot of attention in recent years because of a number of attractive features like light weight, low profile, planar configuration, low cost, high efficiency, simple to fabricate and easy to integrate .

The basic structure of a patch antenna consists of a ground plane in the underside with a dielectric region separating the ground and the radiating patch. The electromagnetic waves fringes from the radiating patch into the substrate and are reflected by the ground plane into air. The length of the patch determines the operating frequency whereas the width controls the input impedance. Patch width regulates the bandwidth as well as the radiation pattern of the antenna. For example an increase in the width of the patch increases the bandwidth of the antenna [1]-[2].

However major disadvantages of these antennas include low gain, high quality factor and narrow bandwidth. Thus a number of techniques were introduced by design engineers to improve the bandwidth of patch antennas. Some of these techniques include utilization of thick substrates with low dielectric constants and introduction of slots in the patch [1],[3].

Introduction of fractal structures in the patch improves the radiation resistance, gain and bandwidth of the antenna significantly [4]. To attain wider bandwidths, improved radiation pattern, rectangular slots of various dimensions can be incorporated in the ground plane and also the corners of the rectangular patch can be removed to make the electric current path mender [1],[5]-[7]. To meet the increasing demand for operation in multiple bands in recent years the antenna design engineers adopted self similar geometrical fractal structures [8]. The main advantage of using transmission line feeding is that it is very easy to fabricate and simple to match by controlling the inset position and relatively simple to model.

Ultra Wide Band (UWB) antennas have found a lot of applications in military and commercial systems. For example the UWB antenna is widely used in radar systems due to its high speed data rate and immunity to multipath interference [7].

In this paper an attempt has been made by the author to design a small size, low cost, compact planar antenna structure which achieves an ultra wide bandwidth by introduction of fractal shapes in the patch and slots of various dimensions in the ground plane.

II. ANTENNA DESIGN

The proposed antenna was designed on an inexpensive FR4 Epoxy substrate of dielectric constant 4.4 and thickness of 1 mm which seperates the ground plane of dimensions 40 X 40 mm and the metallic patch. The microstrip line feed technique is used to feed the input signal. Some rectangular shaped fractal slots are introduced in the patch which is expected to enhance the bandwidth of the antenna as compared to a conventional patch antenna. In addition the edges of the rectangular patch are removed to obtain an orthogonal shape and slots of various dimensions are introduced in the ground plane to obtain better radiation pattern.

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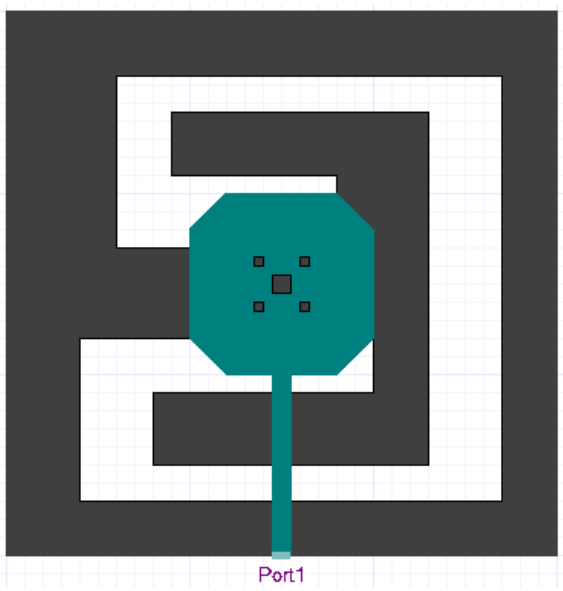

Figure 2. Proposed Patch Antenna

The dimensions of the Ground Plane and the Patch are labeled separately as shown in Figs. 3 and 4 respectively.

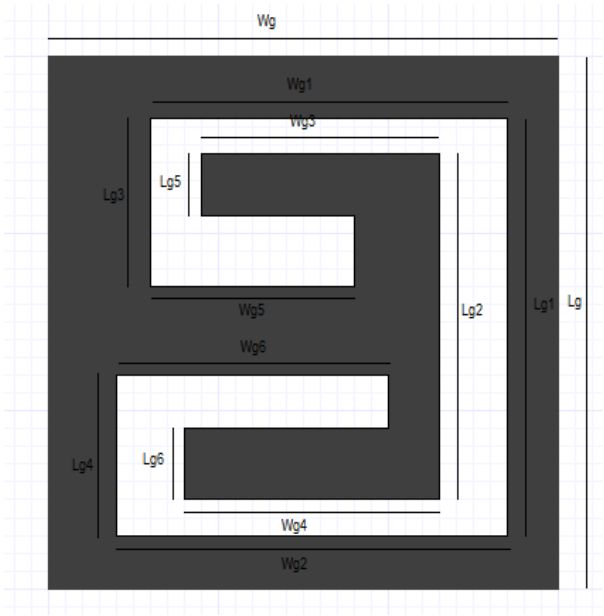

Figure 3. Ground plane dimensions

At the centre of the patch a slot of dimension 1 X 1 mm is placed around the edges of which self similar fractal shapes of 0.5 X 0.5 mm are also introduced with the overall structure resembling that of the Serpinski carpet.

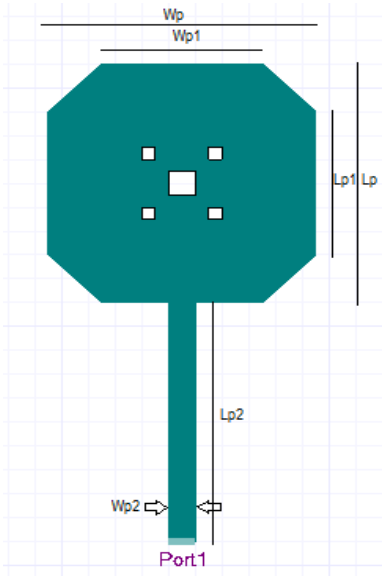

Figure 4. Patch dimensions

TABLE 1: Dimensions of the Ground Plane and Patch

Sl. No.	Ground Plane Dimensions	Length (mm)	Patch Dimensions	Length (mm)
1	Wg	30	Wp	10
2	Wg1	21	Wp1	6
3	Wg2	23	Wp2	1
4	Wg3	14	Lp	10
5	Wg4	15	Lp1	6
6	Wg5	12	Lp2	10
7	Wg6	16		
8	Lg	30		
9	Lg1	23.5		
10	Lg2	19.5		
11	Lg3	9.5		
12	Lg4	9		
13	Lg5	3.5		
14	Lg6	4		

III. RESULTS

The Return Loss vs. Frequency, VSWR, the Radiation Pattern and the 3D Gain Plots of the proposed antenna are shown. The proposed antenna has an upper cut off frequency (-10 dB frequency) at 8.85 GHz and a lower cut off frequency (-10 dB frequency) at 6.05 GHz and has a resonant frequency of 8.16 GHz. The value of the Return Loss at the resonant frequency is 26.5 dB. Thus an ultra wide bandwidth of 2.8 GHz is attained using this simple structure which is useful for radar applications.

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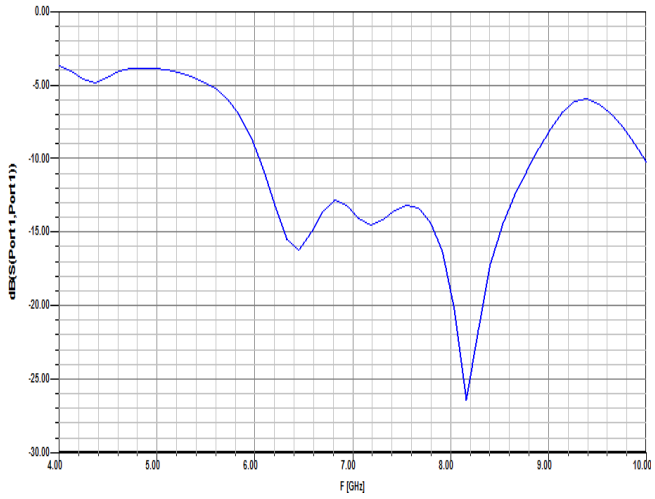


Figure 5. Return Loss Vs. Frequency

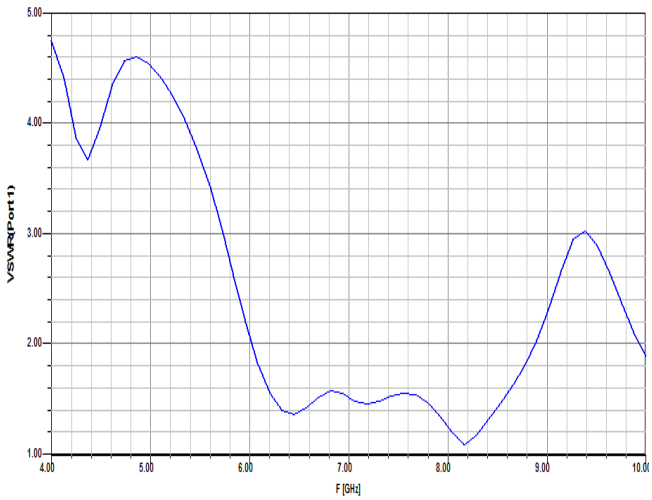


Figure 6. VSWR Vs. Frequency

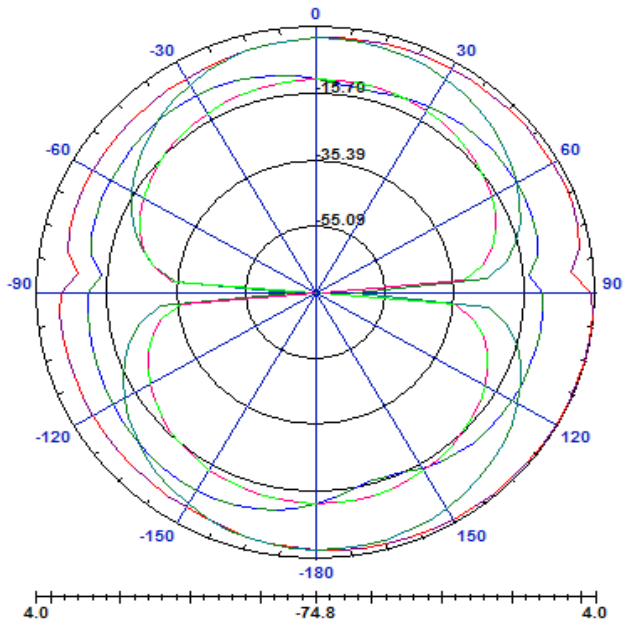
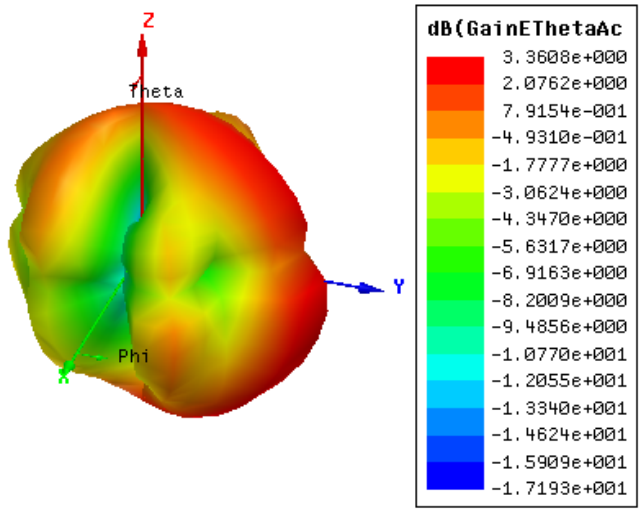


Figure 7. Radiation Pattern



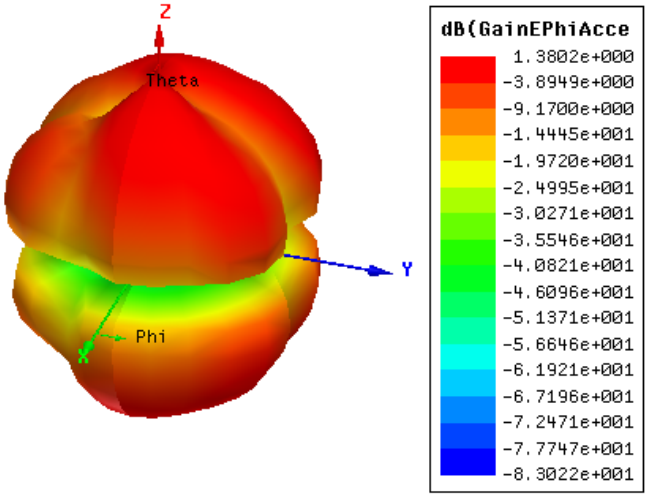


Figure 8. 3-D Gain Plot

IV. CONCLUSION

In this paper a compact monopole fractal patch antenna has been designed which can be used for high speed data transfer in Ultra wideband applications. Ansoft Designer was employed for simulating the results. A large bandwidth was obtained by incorporating self similar fractal slots in the patch and introducing slots in the ground plane. It is expected that this antenna will find applications in microwave devices, wireless LAN, radars and amateur radio.

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Debashish Pal obtained B.E in Electronics and Communication Engineering from Gandhi Institute of Engineering and Technology, Orissa in 2006. He completed M.Tech from Institute of Engineering and Management, Kolkata in 2013. He is currently working as an Assistant Professor in Surendra Institute of Engineering and Management (Dept. of ECE), Siliguri and his broad areas of interest include VLSI design and Antenna design.

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