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RESEARCH ARTICLE

DESIGN OF MULTIBAND MICROSTRIP PATCH ANTENNA FOR WIRELESS 1 GHz TO 5 GHz BAND APPLICATIONS WITH MICROSTRIP LINE FEEDING TECHNIQUE

Dr. R.K. Khola[1], Naveen Kumar Gupta[2]
[1] Suresh Gyan Vihar University, Jaipur, Rajasthan, India
[2] M.Tech Student Suresh Gyan Vihar University, Jaipur, Rajasthan, India
[1] rkmkhola176@gmail.com, [2] guptanaveen888@gmail.com

ABSTRACT-—In recent years many studies are concentrated on multiband micro strip antenna structures for important purposes in wireless communication systems, medical imaging, and radar sensor resolution. In this paper, we printed a square radiator patch on FR4 substrate material. The relative dielectric constant was 4.4, and the thickness of the substrate material was 1.6 mm. The patch was fed by a transmission line feeder, and there was a gap between the patch and the ground plane. Antenna design is simulated on electromagnetic (EM) simulation software IE3D and anechoic chamber with a network analyzer was used during the experimental tests. The simulated and measured results demonstrated that the proposed antenna achieved a wide impedance bandwidth from 1.0 GHz to 5.0 GHz with a return loss of less than -10 dB. The proposed antenna is easy to integrate with microwave circuitry for low manufacturing cost. The antenna structure is flat, and its design is simple and straightforward.

Keywords - Patch antenna, Radiation pattern, Fractal slot, Returns loss.

I. INTRODUCTION

The commercial use of the frequency band 1.0 to 5.0 GHz for radar, positioning and data transmission has been released by the Federal Communication Commission (FCC) in 2002 [1]. In this UWB antennas have enormous attention in both academia and industry for applications in wireless transmission systems [2]. Impulse-Ultra wideband (I-UWB) is a carrier less short range communications technology in which its transmission occupies a bandwidth of more than 20% of its center frequency (> 500 MHz) [3]. Wireless communication systems have developed rapidly in recent years, an antenna as a front component is required to have a wide band, good radiation performances and sometimes switchable ability [4].

From a systems point of view, the response of the antenna should cover the entire operating bandwidth, and the antenna should be non-responsive to signals outside the specified band [5]. UWB have wide applications in short range and high speed wireless systems, such as ground penetrating radars, medical imaging system, high data rate Wireless Local Area Networks (WLAN), communication systems for military and short pulse radars for automotive even or robotics. The antenna is one of the crucial components, which determine the performance of UWB system [6]. In the past, one serious limitation of the micro strip antenna was its narrow bandwidth characteristics, being 15 to 50% that of commonly used antenna elements such as dipoles, slots, and waveguides horns [7]. This limitation was successfully removed achieving a matching impedance bandwidth ratio it was necessary to increase the size, height, volume or feeding and matching techniques [8]. Generally, UWB communication antennas require low voltage standing wave ratio (VSWR < 2), constant phase center, constant group delay, and constant gain over entire operating frequency band [1].

II. FRACTAL SLOTS

Fractals mean broken or irregular fragments. Fractals describe a complex set of geometries ranging from self similar/self-affine to other irregular structure. Fractals are generally composed of multiple copies of themselves at different scales and hence do not have a predefined size which makes their use in antenna design very promising. Fractal antenna engineering is an emerging field that employs fractal concepts for developing new types of antennas with notable characteristics. Fractal shaped antennas show some interesting features which results from their geometrical properties [8].

The unique features of fractals such as self-similarity and space filling properties enable the realization of antennas with interesting characteristics such as multi-band operation and miniaturization. A self-similar set is one that consists of scaled down copies of itself. This property of self-similarity of the fractal geometry [11] aids in the design of fractal antennas with multiband characteristics. The self-similar current distribution on these antennas is expected to cause its multiband characteristics. The space-filling property of fractals tends to fill the area occupied by the antenna as the order of iteration is increased. Higher order fractal antennas exploit the space-filling property and enable miniaturization of antennas. Fractal antennas and arrays also exhibit lower side-lobe levels. Fractals have been applied successfully for miniaturization and multi-band operations of simple antennas mainly dipole, loops and patch antennas. It has been observed that such as approach result in reduction of the input impedance bandwidth [9].

III. MICROSTRIP LINE FEED

In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch as shown in the figure below.

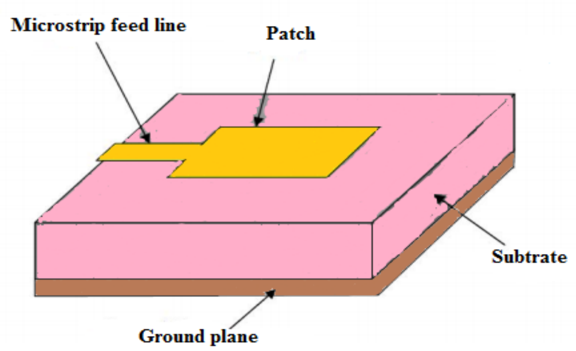

Figure 1: Microstrip line feed

The conducting strip is smaller in width as compared to the patch & this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication & simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases surface waves & spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation [2].

IV. ANTENNA DESIGN

Designing an antenna in the Wi-max band meant that the antenna dimension could be bulky which is not desired. Considering this objective is to design a reduced size wide band microstrip antenna; the design idea was taken from broadband antennas to make the antenna work in a large band of frequencies of the many broadband antennas, square patch antenna was chosen. Hence the chosen shape of the patch was cutting of different crown rectangular fractals slots in iteration I, with an aim to achieve smaller size antenna [4]. The software used to model and simulate the Microstrip Patch Antenna using crown rectangular fractal slots was IE3D, it can be used to calculate and plot return loss, VSWR, radiation pattern, smith chart and various other parameters.

ITERATION I

The geometry of iteration I of proposed microstrip patch antenna using square and rectangular fractal slots presented in figure 2 with front (top) view.

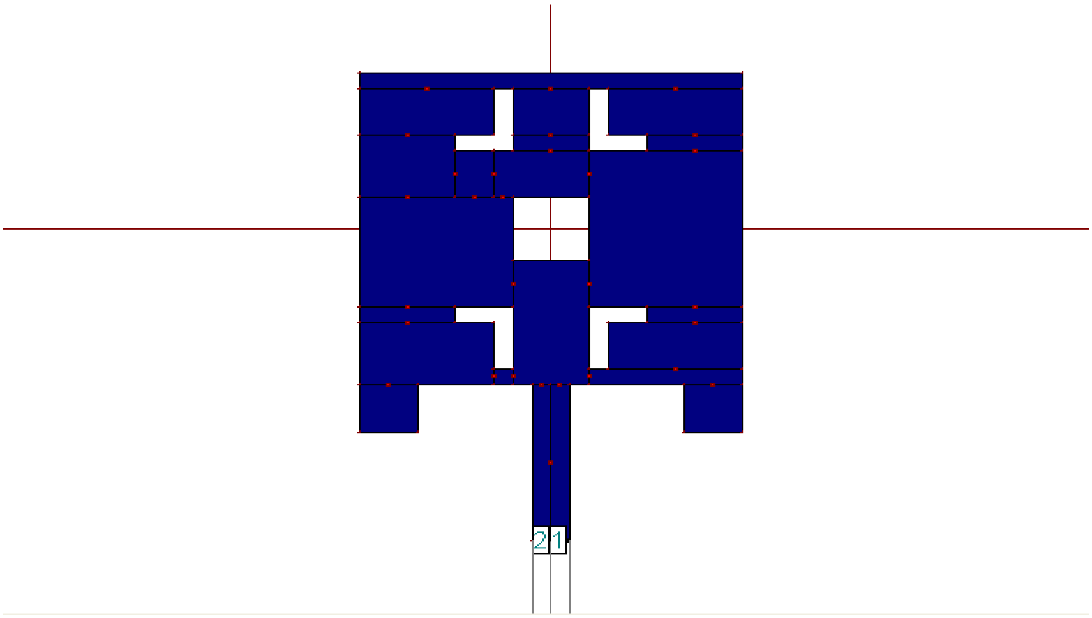

Figure 2. Geometry of iteration 1 with h = 1.6, Permittivity = 4.4 and Grid size = .025, L = 20, W = 20, big square = 4mm × 4mm, small horizontal arm = 1mm × 3mm, small vertical arm = 3mm × 1mm.

The design of iteration I is achieved by cutting crown rectangular and square fractal slots on a rectangular microstrip antenna. In the centre one crown square fractal slot is taken and two crown rectangular fractal slots are taken on each corner of the central slot. The dimension of the central crown square fractal slot is 4mm × 4mm (width × length) and the dimensions of each of the two corner fractal slots are, small horizontal arm = 1mm × 3mm and vertical arm = 3mm × 1mm.

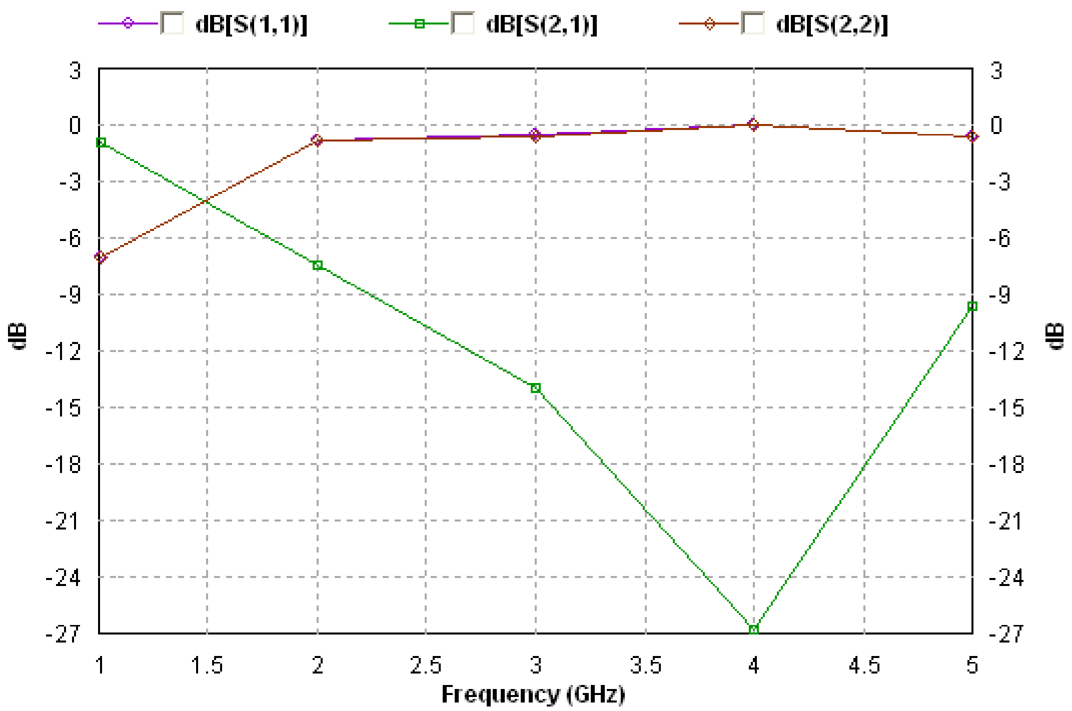

Figure 3. Return loss vs. Frequency curve of iteration I for proposed antenna

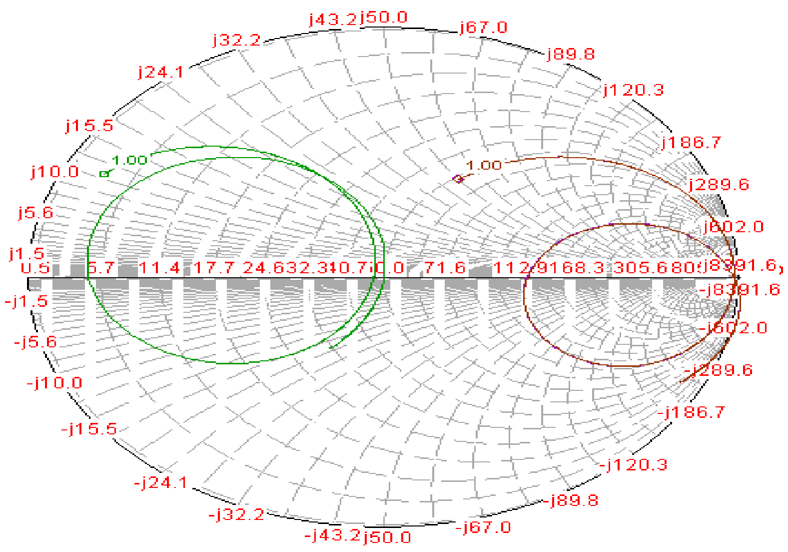

Figure 4. Input impedance loci using smith chart of iteration I

Table 1 Result of iteration I

Types	Iteration I
Resonant Frequency	4 GHz
VSWR	1.09
Return Loss	-27dB
Bandwidth	50%

V. RESULTS AND DISCUSSION

The proposed antenna has been simulated by using IE3D by Zealand Software Inc.[7]. It is considered as a benchmark for electromagnetic simulation packages. The primary formulation of the IE3D is an integral equation obtained through the use of Green's functions. In the IE3D, it is possible to model both the electric current on a metallic structure & a magnetic current representing the field distribution on a metallic aperture.

In this paper, square microstrip patch antenna combining Crown square and rectangular fractal slots is fabricated on a FR4 substrate of thickness 1.6 mm and relative permittivity of 4.4. It is mounted above the ground plane at height of 6 mm [5].

Table 1 shows the variation of return loss with frequency, VSWR and Bandwidth for iteration I. Figure 3 shows resonant frequency 4 GHz and minimum Return Loss for iteration I is -27 dB. Figure 4 shows the input impedance loci using smith chart for iteration I. In I iteration Input impedance curve passing near to the 1 unit impedance circle that shows the perfect matching of input and total available impedance bandwidth is 50% for iteration I.

VI. CONCLUSION

Traditional wideband antennas (spiral and log-periodic) and arrays [10] can be analyzed with fractal geometry to shed new light on their operating principles. More to the point, a number of new configurations can be used as antenna elements with good multiband characteristics. Due to the space filling properties of fractals, antennas designed from certain fractal shapes can have far better electrical to physical size ratios than antennas designed from an understanding of shapes in Euclidean space.

The measurement results show a maximum patch size reduction is achieved by the proposed fractal antennas, without degrading the antenna performances, such as the return loss and radiation patterns. The essence of this size reduction technique is loading the inductive elements along the patch edges, and loading Self-similar slots inside the patch, to increase the length of the current path. The essence of the maintenance of the antenna radiation patterns is the self-similarities and centro symmetry of the fractal shapes [9]. The main advantages of the proposed method are: (a) Great size reduction achieved (more than 4 times), (b) The radiation patterns maintained, (c) Wider operating frequency bandwidth achieved, (d) No vias to the ground, and (e) Easiness of the design methodology. To the best of our knowledge, this is the most effective technique proposed for the miniaturization of microstrip patch antennas so far. The small-size patches derived from this technique can be used in integrated low-profile wireless communication systems successfully. With the aim to preserve compactness requirements and to maintain the overall layout as simply as possible and keeping the realization cost very low. In future fractal microstrip antenna reduced patch size and improved bandwidth can be achieved.

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