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Research Article

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Designing of Rectangular Fractal Microstrip Patch Antenna using Iteration Methods

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ABSTRACT

This paper presents a design of Rectangular Fractal microstrip patch antenna using Iteration Methods by cutting different slots on rectangular microstrip antenna and experimentally studied on IE3D software. This design is achieved by using three stages of iteration and a Probe feed. This design has been studied in 3 iterations. The radiation pattern of the proposed fractal shaped antennas maintained because of the self similarity and centro-symmetry of the fractal shapes. With fractal shapes patch antenna is designed on a FR4 substrate of thickness 1.6mm and relative permittivity of 2.2 and mounted above the ground plane at a height of 6 mm. Details of the measured and simulated results of the individual iterations are presented & discussed.

Key words: Microstrip antenna, radiation pattern, returns loss.

INTRODUCTION

In telecommunication there are several types of microstrip antennas the most common of which is microstrip patch antenna [12]. A patch antenna is a narrow band, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate. A patch antenna is a type of radio antenna which can be mounted on flat surface. It consists of a flat rectangular sheet or “patch” of metal, mounted over a larger sheet of metal called a ground plane. A patch antenna is usually constructed on a dielectric substrate using the same materials & lithography processes used to make printed circuit boards.

Microstrip or patch antennas [6] are becoming increasingly useful because they can be printed directly onto a circuit board. These antennas are also becoming very widespread within the mobile phone market[1]. Patch antennas are low cost, low profile & easily fabricated. These are relatively inexpensive to manufacture & design because of the simple 2-dimensional physical geometry. These are also light weight, conformal shaped, capable of dual & triple frequency operations. These are highly efficient, easily integrated to circuits, comfortable to planer & non-planer surfaces and are compatible with MMIC design. All these features make Microstrip antennas widely implemented in many applications, such as high performance aircrafts, wireless communication satellite and missile applications. However Microstrip antennas suffer from some disadvantages also, Narrow bandwidth being a serious limitation. Different techniques are proposed to improve it, and one of the methods proposed by various researchers is by cutting slots on it In this paper we have designed a Rectangular Microstrip Patch antenna using Iteration Methods [2].

The purpose of this work is to design a microstrip patch antenna using commercial simulation software like IE3D. IE3D, from zeland software Inc. [7] is an electromagnetic simulation and optimization software useful for circuit and antenna design. IE3D has a menu driven graphic interface for model generation with automatic meshing, and uses a field solver based on full wave, method-of-moments to solve current distribution on 3D and multilayer structures of general shape.

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].

Probe-Fed Patches

Probe feeding a microstrip patch antenna is another form of the original excitation methods. A schematic diagram representing this configuration is shown in Fig. 1 in which a probe of radius r0 extends through the ground plane and is connected to the patch conductor, typically soldered to it. The probe or feeding pin is usually the inner conductor of a coaxial line; hence, probe feeding is often referred to as a coaxial feed. The probe position provides the impedance control in a similar manner to inserting the feed for an edge-fed patch. Because of the direct contact between the feed transmission line and the patch antenna, probe feeding is referred to as a direct contact excitation mechanism [2].

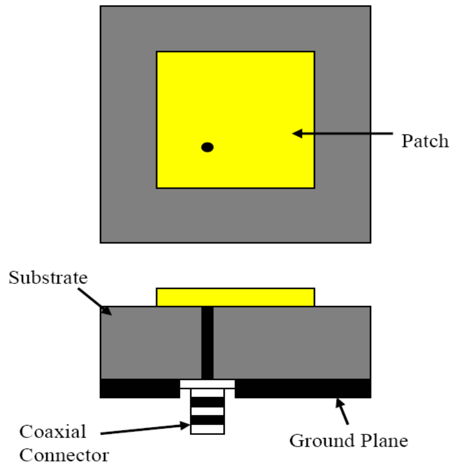

Fig 1 Schematic diagram of Probe-fed Microstrip Patch Antenna

The probe-fed patch has several key advantages. First, the feed network, where phase shifters and filters may be located, is isolated from the radiating elements via a ground plane. This feature allows independent optimization of each layer. Second, of all the excitation methods, probe feeding is probably the most efficient because the feed mechanism is in direct contact with the antenna and most of the feed network is isolated from the patch, minimizing spurious radiation. The high efficiency of this printed antenna has seen a renaissance of the probe-fed-styled patch, despite the added complexity of developing a connection.

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, rectangular patch antenna was chosen. Hence the chosen shape of the patch was cutting of different rectangular slots in iteration I, different rectangular fractal slots [13] in iteration II and designs of resultant geometry of iteration III, with an aim to achieve smaller size antenna [4]. The software used to model and simulate the Microstrip Patch Antenna using 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 fractal slots presented in fig.2 with front (top) view. The base shape of rectangular patch is of L=17.88 mm & W= 39.52 mm The design of iteration I is achieved by cutting rectangular fractal slots on a rectangular microstrip antenna. In the centre one rectangular fractal slot is taken. The dimension of the central Rectangular fractal slot is of size L1=6mm & W1=12 mm

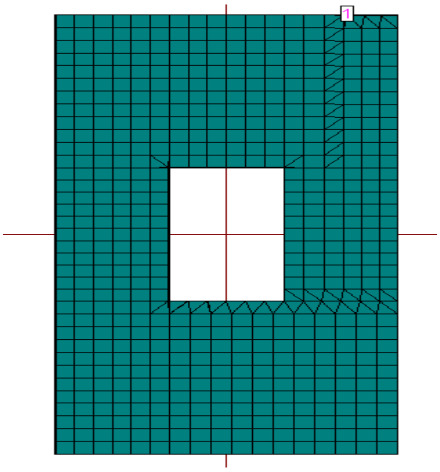

Fig 2 Geometry of iteration 1 with t=1.6, Permittivity=2.2 and grid size=.025

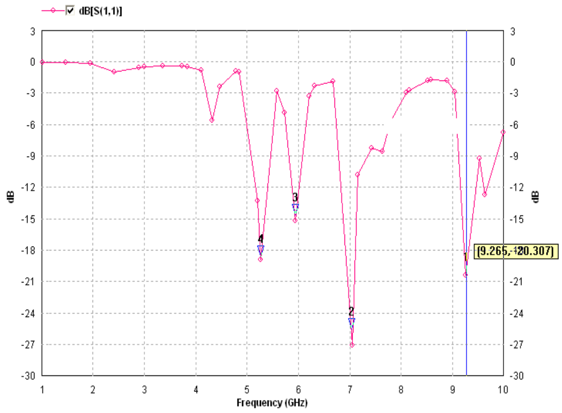

Fig 3 Return loss vs Frequency curve of iteration I for proposed antenna

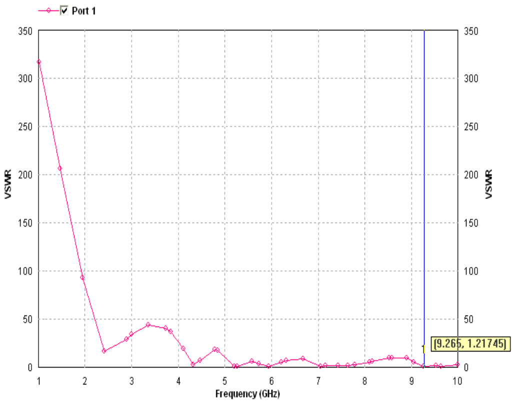

Fig 4 VSWR vs Frequency curve of iteration 1 for proposed antenna

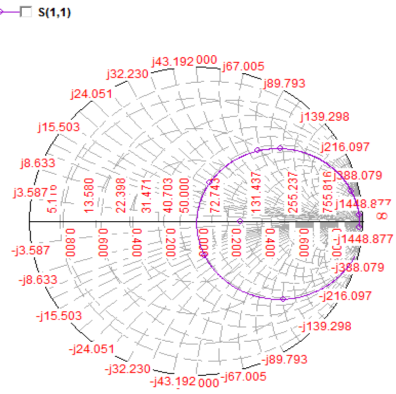

Fig5 Input impedance loci using smith chart of iteration I

Iteration II

The geometry of iteration II of proposed microstrip patch antenna using rectangular fractal slots presented in fig.6 with front (top) view. In this design four rectangular fractal slots are cut facing each side of the rectangular microstrip antenna The dimensions of these four fractal slots are L2=3mm & W2=6mm.

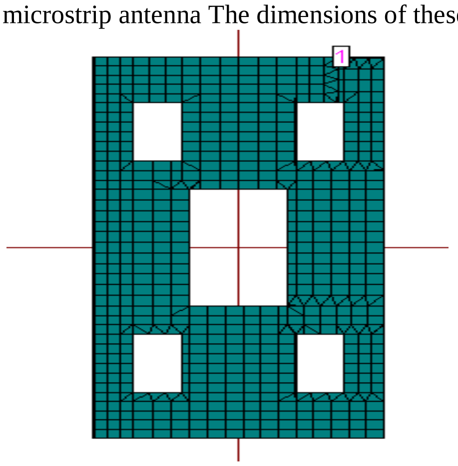

Fig 6 Geometry of iteration II for proposed antenna

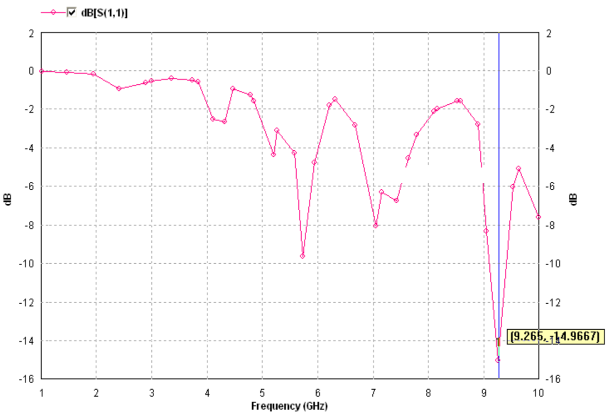

Fig7 Return loss vs Frequency curve of iteration II for proposed antenna

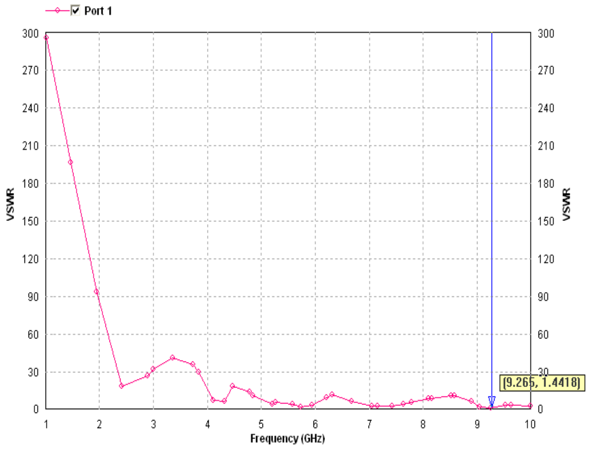

Fig 8 VSWR vs Frequency curve of iteration II for proposed antenna

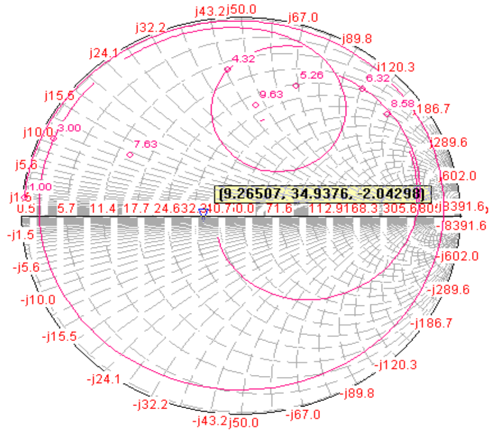

Fig9 Input impedance loci using smith chart of iteration II

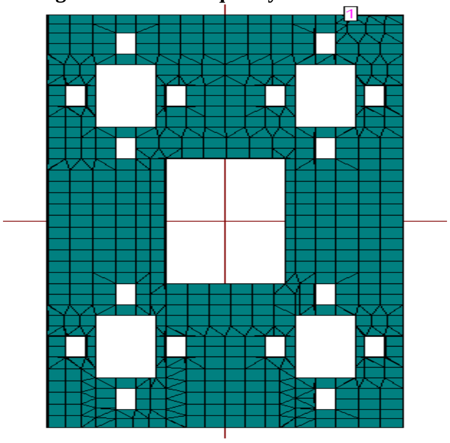

Fig10 Geometry of iteration III for proposed antenna

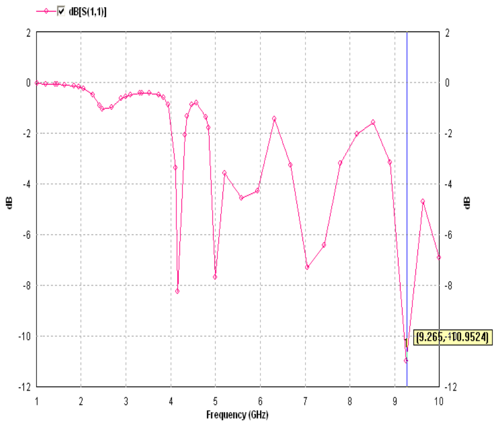

Fig11 Return loss vs frequency of iteration III for proposed antenna

Iteration III

The geometry of iteration III of proposed microstrip patch antenna using fractal slots presented in fig10 with front (top) view. Resultant geometry of iteration III is obtained by cutting sixteen rectangular slots in microstrip patch of size L_3=1mm & W_3=2mm. This is done so that better result can be achieved with Iteration III in comparison to the individual iterations, the feed point is decided as per given the formulae that is (6.20mm, 19.76mm)

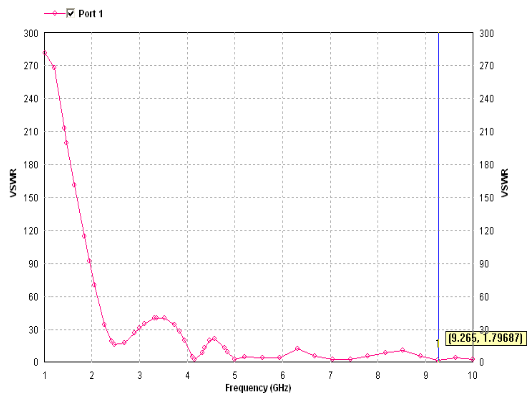

Fig12 VSWR vs Frequency curve of iteration III for proposed antenna

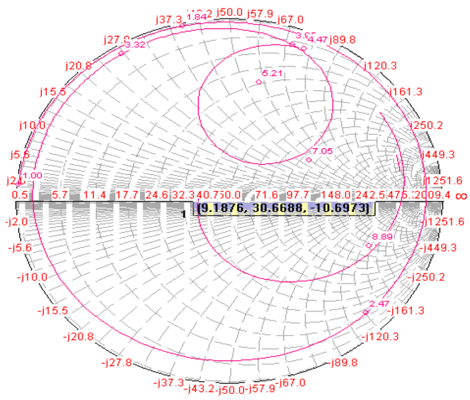

Fig 13 Input impedance loci using smith chart for iteration III

Table1: Comparison of Different Results of Iteration I, II & III

Types	Iteration I	Iteration II	Iteration III
Resonant Frequency	9.265	9.265	9.265
VSWR	1.21245	1.4418	1.79687
Return Loss	-20.307	-14.9667	-10.9524
Bandwidth	37%	40%	42%

These results from the table1 show that the Iterations I & II, Iteration III produced better results than the individual iterations. The results for VSWR & Return loss for Iteration have improved. Also the bandwidth of Iteration is 42%. These results are in line with the objective of this paper.

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, the antenna is fabricated on a FR4 substrate of thickness 1.6 mm and relative permittivity of 2.2. 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, II and III. Plot result shows resonant frequency 9.265 GHz. Minimum return loss for iteration I and II is -20.307 and -14.9667 respectively Minimum -10.9524 db return loss is available at resonant frequency for iteration III which is significant Fig5, 9 and13 shows the input impedance loci using smith chart for iteration I, II and III respectively. In each 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 37%for iteration I, 40%for iteration II and 42% for iteration III [3].

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:

- (i) great size reduction achieved (more than 4 times),
- (ii) the radiation patterns maintained,
- (iii) wider operating frequency bandwidth achieved,
- (iv) no vias to the ground, and
- (v) easiness of the design methodology. To the best of our knowledge, this is the most effective technique pro- posed 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.

Compact and broadband 4×4 Butler matrix is realized on silicon substrate Novel hybrid with adjacent port compensation is being implemented. The wide band Butler matrix is fabricated together with the antenna array to form beam forming systems working at dual frequency within same dimensions as of single band assembly. Single band switched beam assembly provides gain of 88 dBi, whereas dual band provides typically around 8 dBi. Good isolation, return losses and radiation characteristics of the antenna arrays validate the adopted approach. The silicon substrate has added advantage of micromachining which can provide overall higher efficiency. Slight mismatch between simulated and measured performance can be easily overcome by depositing oxide layer over high resistivity silicon using CMOS technique. This is first reported switched beam topology on silicon having additional feature of small size and light weight. Microstrip implementation provides ease of implementation of the proposed topology. This assembly will pave way for low cost complex dual band RF-CMOS architecture fully implementable on silicon substrate with standard fabrication techniques.

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