MICROSTRIP PATCH ANTENNA USING CROWN AND SIERPIENSKI FRACTAL SLOT

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ABSTRACT

This paper presents a design of microstrip patch antenna combining Crown and Sierpienksi fractal slots by cutting different slots on rectangular microstrip antenna and experimentally studied on IE3D software. This design is achieved by cutting multi shapes in square pattern combining with Crown & Sierpienksi fractal slots & placing a microstrip line 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 1.524mm and relative permittivity of 4.4 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.

Keywords : Microstrip antenna, Radiation pattern, Returns loss.

I 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 Microstrip Patch antenna using Crown & Sierpienksi fractal slots on the rectangular microstrip antenna[2].The assembly is usually contained inside a plastic radome, which protects the antenna structure from damage .These are the original type of microstrip antenna in which the two metal sheets together form a resonant piece of microstrip transmission line with a length of approximately by one-half wavelength of the radio waves. The radiation mechanism arises from discontinuities at each truncated edge of the microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used.

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.

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.

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.

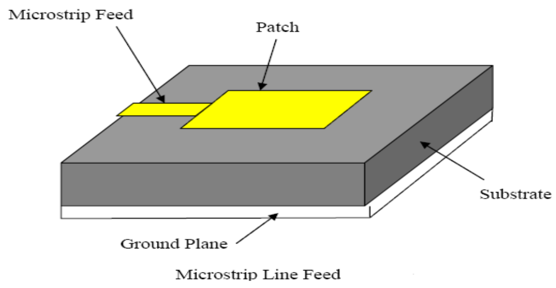

Fig.1- Microstrip line feed

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 square slots in iteration I, different sierpinski fractal slots[13] in iteration II and designs of both iteration I, and iteration II are combined to get 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 crown and Sierpinski Fractal slots was IE3D, it can be used to calculate and plot return loss, VSWR, radiation pattern, smith chart and various other parameters.

4.1 ITERATION I

The geometry of iteration I of proposed microstrip patch antenna using Crown & Sierpienksi fractal slots presented in fig.1 with front (top) view.

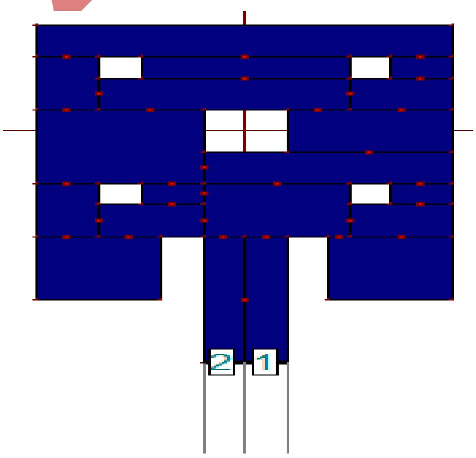

Fig. 2- Geometry of iteration 1 with t=1.524, Permittivity=4.4 and grid size=.025

The design of iteration I is achieved by cutting crown square fractal slots on a rectangular microstrip antenna. In the centre one crown square fractal slot is taken and 4 crown square fractal slots are taken on each corner of the central slot. The dimension of the central crown square fractal slot is 2-2(length-width) and the dimensions of each of the four corner fractal slots are 1-1(length-width).

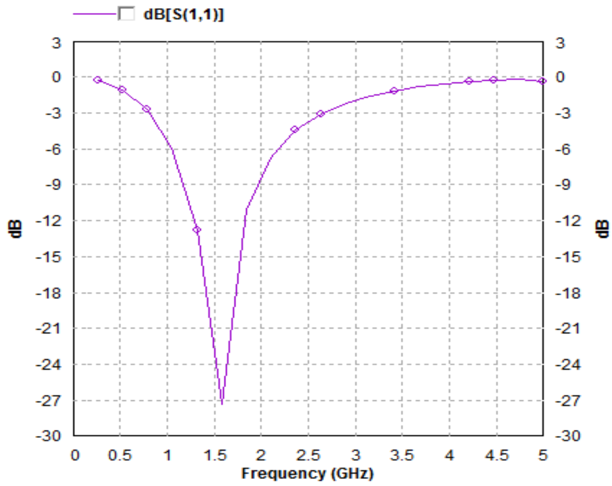

Fig. 3- Return loss vs. Frequency curve of iteration I for proposed antenna

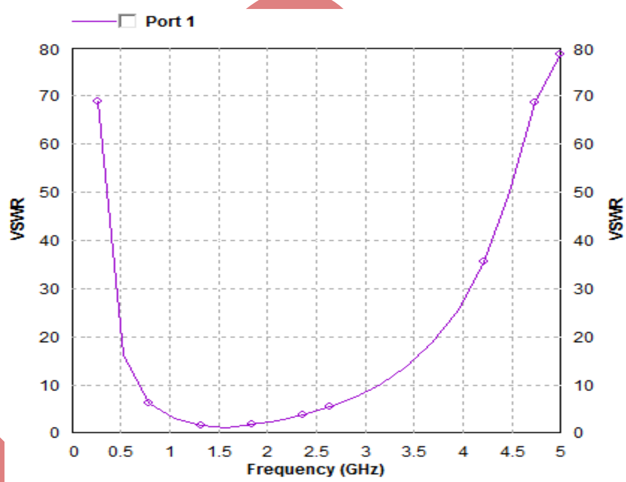

Fig. 4- VSWR v/s Frequency curve of iteration 1 for proposed antenna

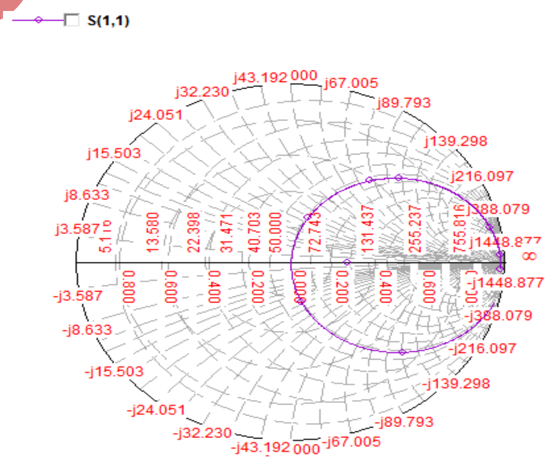

Fig.5- Input impedance loci using smith chart of iteration I

4.2 ITERATION II

The geometry of iteration II of proposed microstrip patch antenna using Crown & Sierpienksi fractal slots presented in fig.6 with front (top) view..

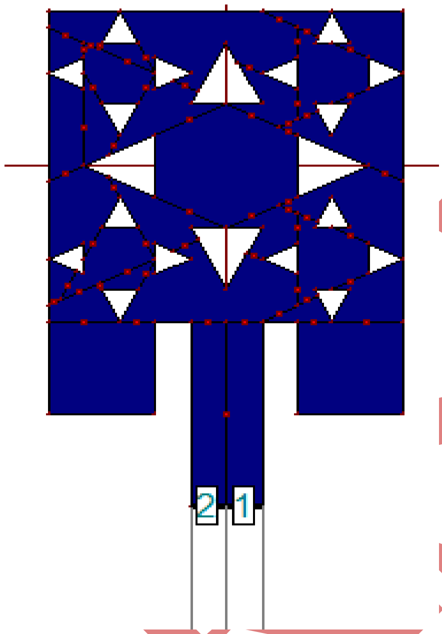

Fig. 6- Geometry of iteration II for proposed antenna

In this design four Sierpienksi fractal slots are cut facing each side of the rectangular microstrip antenna. The dimensions of these four Sierpienksi fractal slots are 2-2(base-height) Then between each of these Sierpienksi fractal slots and the corners of the rectangular microstrip antenna four Sierpienksi fractal slots, with dimensions of 1-1(base-height) each, in the same design are cut.

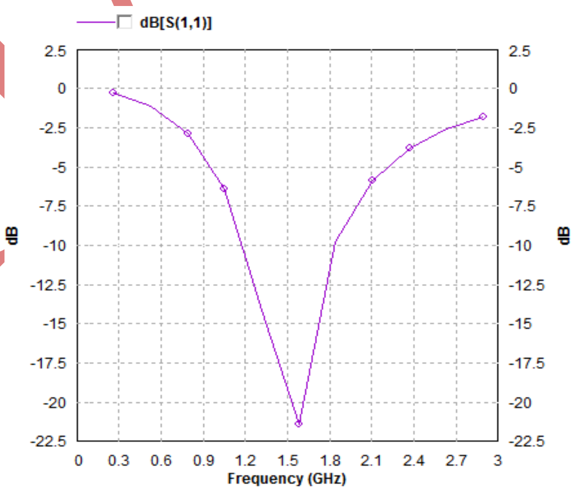

Fig.7- Return loss v/s Frequency curve of iteration II for proposed antenna

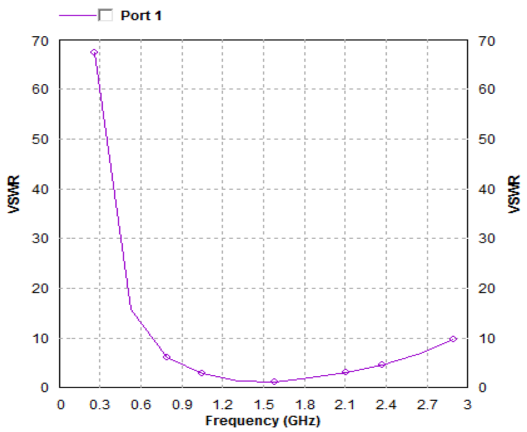

Fig.8- VSWR v/s Frequency curve of iteration II for proposed antenna

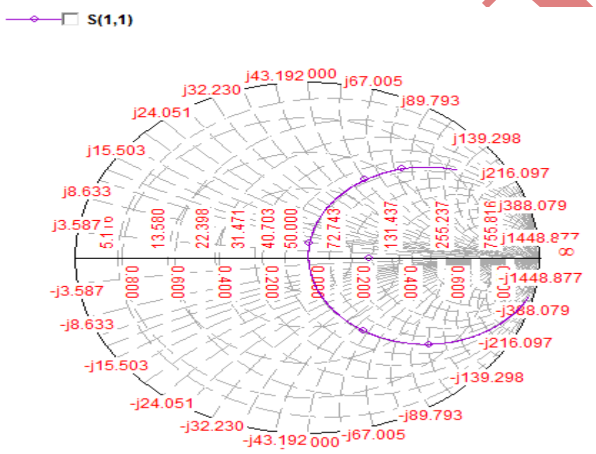

Fig.9- Input impedance loci using smith chart for Iteration II.

4.3 ITERATION III

The geometry of iteration III of proposed microstrip patch antenna using Crown & Sierpienksi fractal slots presented in fig.15 with front (top) view.

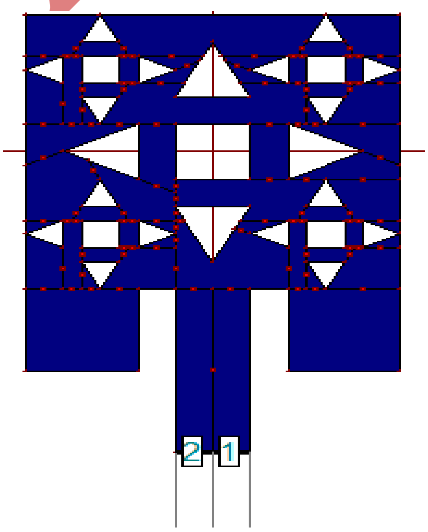

Fig.10- Geometry of iteration III for proposed antenna

Resultant geometry of iteration III is obtained by combining the geometry of both iterations I & II. This is done so that better result can be achieved with Iteration III in comparison to the individual iterations.

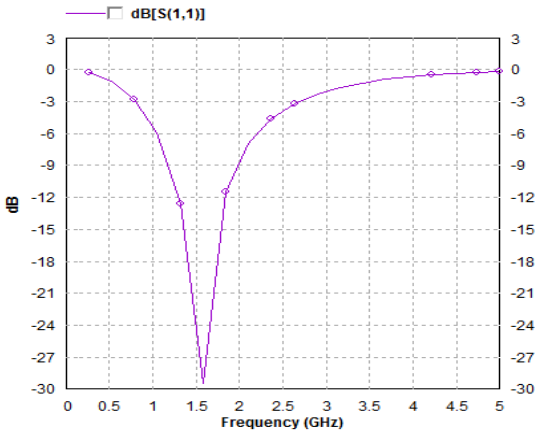

Fig.11- Return loss v/s frequency of iteration III for proposed antenna

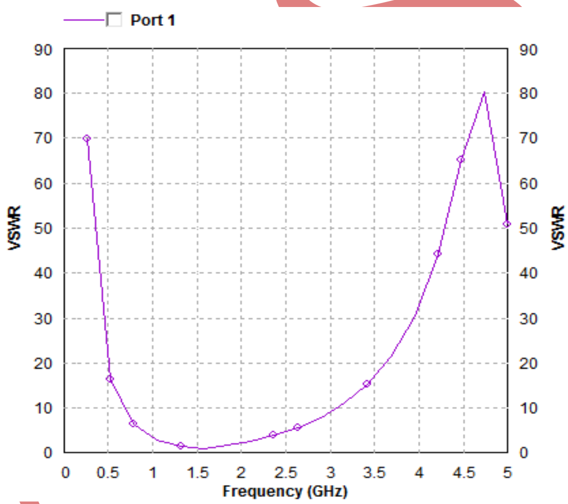

Fig.12- VSWR v/s Frequency curve of iteration III for proposed antenna

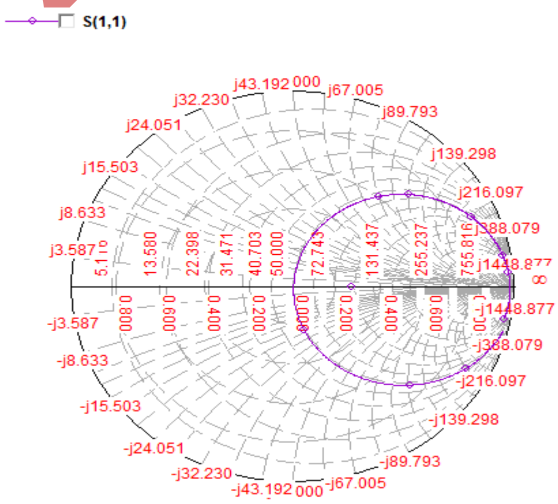

Fig.13- Input impedance loci using smith chart for iteration III

Table1: Comparison of different results of Iteration I, II & III

Types	Iteration I	Iteration II	Iteration III
Resonant Frequency	1.579	1.579	1.579
VSWR	1.09	1.10	1.07
Return Loss	-27.35	-26.36	-29.4
Bandwidth	45%	40%	44%

These results from the table1 show that the combination of Iterations I & II, Iteration III produced better results than the individual iterations. The results for VSWR & Return loss for Iteration III have improved compared to Iteration I & II. Also the bandwidth of Iteration III is 44%.These results are in line with the objective of this paper.

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 and Sierpienksi fractal slots is fabricated on a FR4 substrate of thickness 1.524 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, II and III. Plot result shows resonant frequency 1.579 GHz. Minimum return loss for iteration I and II is -27.35 and-26.36 respectively .Minimum -29.4db return loss is available at resonant frequency for iteration III which is significant. Fig.5, 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 45%for iteration I, 40%for iteration II and 44% for iteration III.[3]

Based on the measurement results, we can discuss the size reduction property of the proposed fractal patch antennas. From these results, it is observed that the proposed technique can achieve a maximum size reduction percentage that is greater than the results obtained from other techniques reported so far.

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.

Modern communication systems require antennas with broadband and/or multi-frequency operation modes. These goals have been accomplished employing fractal patch for the radiating element, it is experimentally found that the resonant frequency of the fractal antenna lowered greatly, and this property can be used to reduce the size of the patch antennas. 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.

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