ISSN: 2278-0181
ICONNECT - 2k18 Conference Proceedings

A Design of Square Fractal Antenna with Microstrip Feed for Ultra Wideband Applications

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Abstract: **- The paper presents the design of a square fractal antenna.The proposed antenna is designed on FR-4 glass epoxy substrate with dielectric constant Er of 4.4 and is fed by microstrip line.The proposed antenna provide contribution in the field of ultra wide band application.This proposed design operates over the frequency range 2GHz to 8GHz.For the proposed design return loss -21dB has achieved.Also,VSWR<1 for entire operating frequency range.The proposed design exhibits gain upto 6.32dB over frequency range.The simulation of the proposed antenna design has done by Advanced Design System(ADS).**

Keywords: FR4, square shape,Micro strip patch antenna,Return loss,Gain,VSWR.

I. INTRODUCTION

In military as well as recent communication applications, ever growing demand is antenna.The desired requirement of antenna design are small size,easy of fabrication,conformal,low cost and multiband capabilities.These requirements are fulfilled by the microstrip patch antenna[1]. A patch antenna is a compact, narrow band, wide-beam, light-weight,conformal-shaped antenna which is fabricated by etching the antenna element pattern in metal trace conjoined to an insulating dielectric substrate.It is incorporated with a flat rectangular sheet or “patch” of metal, mounted over a larger sheet of metal called the ground plane[2]. A patch antenna is mainly built on a dielectric substrate employing the same materials & lithography techniques in order to make printed circuit boards. Microstrip or patch antennas are becoming more and more useful because they can be printed directly onto a circuit board[3].

The concept of fractal antenna was initially exposed by the French Mathematician B. B. Mandelbrot during 1975,research on several naturally occurring irregular and fragmented geometries[4]. The word fractal is derived from the Latin word “fractals” meaning broken, uneven, any of various extremely irregular curves or shape that repeat themselves at any scale on which they are examined[5]. Fractal antenna engineering is an engineering field that employs fractal concepts for developing new types of antennas with notable characteristics.Some properties of fractal antenna are: small scale, simple recursive processes, self- similarity, fractal dimension. Among many, main property of fractal antenna is self-similarity and space filling characteristics[6]. It helps to achieve wideband frequency band or multiband frequencies[7]. Because of self-similarity and space-filling characteristics, fractal concepts have emerged as a novel method for designed compact UWB, wideband, and multiband antennas.

Use of fractal geometry is to improve the several features and performance of antennas[8]. Several slot geometries are as: square, rectangular, triangular, trapezoidal, circular, elliptical in combination with either a rectangular, fork like or circular tuning stub, optimized for wide band operations[9].

In this paper, we have presented a design of microstrip patch antenna using square shape fractal slot with rotated 45 angles and also with an aim to achieve a smaller size antenna[10]. In the present work, a combined square fractal antenna has been designed to operate between 2-8GHz around the resonant frequency of 0.5575GHz[11]. Four iterations were carried out in this antenna for a wideband behavior.The results are carried out by simulating the antenna by using Advanced Design System(ADS)software.

II. ANTENNA PERFORMANCE MEASUREMENTS

To successfully design an antenna a number of measurements must be made to quantify the antenna performance. Below are the various antenna performance measurements.

1. Impedance and Antenna Bandwidth:

Antenna impedance is typically measured as return loss or VSWR. The equipment used to measure this parameter is a Network Analyzer. The impedance measurement often requires special fixtures and assemblies to allow access to the antenna terminals.

2. Gain and Radiation Patterns:
Calibrated measurements of antenna gain and radiation patterns are made in an Anechoic Chamber. The anechoic environment eliminates all reflections and allows precise and repeatable measurements to be made. The device under test is typically rotated 360 degrees in multiple orientations to determine the shape of the radiation pattern from many different directions. Reference antennas are used as calibrated gain standards. As with impedance measurements, gain and radiation patterns should be measured using a complete product.

3. Efficiency :
As mentioned earlier, efficiency may be the single most important parameter to be measured, especially for an embedded antenna which can have degraded efficiency due to its tight integration with the device. Efficiency can be calculated from the calibrated gain and radiation pattern measurement but this can be a time-consuming effort.

III. ANTENNA DESIGN

The propounded antenna is designed on 1.6mm thick FR4 glass proxy substrate with dielectric constant Er of 4.4 and is fed by microstrip line. The basic shape of proposed antenna consist of square patch of each side length 20mm has been mounted on the ground plane substrate of length = 20mm and width =1.6mm.

Design values for the proposed antenna:

ANTENNA PARAMETERS	DESIGN VALUE
Dielectric constant	4.4
Substrate height(mm)	20
Loss tangent	0.001
Length of patch(mm)	20
Width of patch (mm)	1.6
Length of substrate (mm)	20

These are three essential parameters for design of a rectangular microstrip Patch Antenna. The dielectric constant of the substrate material is an important design parameter. Firstly, the dielectric material of the substrate is selected for the design. For feeding, transmission feeding method is used. For all iterations, the location of feed is same and the length of feed is 10mm .Same procedure is repeated and the result of simulation studies. The frequency range is used from 2GHz to 8GHz.
In the antenna design, substrate thickness is another important design parameter. Thick substrate increases the fringing field at the patch periphery like low dielectric constant and thus increases the radiated power. The height of dielectric substrate employed in this design of antenna is h= 1.6mm.this design only. Lastly, the resonant frequency (fr) of the antenna must be selected appropriately. The frequency range used is from 2GHz – 8GHz and the design of antenna must be operated within this frequency range.The resonant frequency selected for this design is 0.5575 GHz.

IV. ITERATION TECHNIQUE

The iteration is the procedure in which the same process is repeated for specified number of times.Here,the process of cutting square is repeated to obtain the proposed design of antenna.In this paper four iteration were done to increase the antenna parameters.

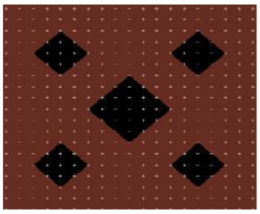
1. First iteration :
It is achieved by cutting square fractal slot is deploying square geometry of each side length 4mm in the center of the square patch as shown in fig.1. Return loss of -33.97db and VSWR of 1.067.

2. Second iteration :
Fig.2. shows the results of the second iteration of the proposed fractal antenna. In the centre one square fractal slot deploying square geometry each of side length 4mm is taken and similar four slots each of side length 2mm are taken on each corner of the central slot. A VSWR of 1.04 and return loss of -34.01 are available at the resonant frequency.

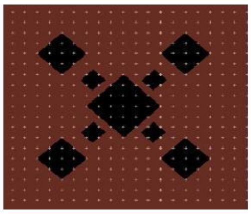
3.Third iteration :
In this one central square fractal slot deploying square geometry is cut and similar structured fractal taken on each corner of the central slot with reduction in their sizes These fractal slots have dimension of each side equals L1=4mm, L2=2mm, L3=1mm. shown in fig.3.

4.Fourth iteration :
In the fourth iteration the square fractal with 1mm dimension of equal side is deployed in the square geometry which were having each of side length 4mm.

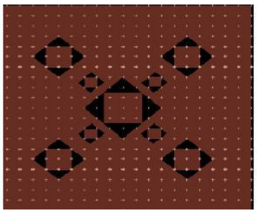
Models of iterations :



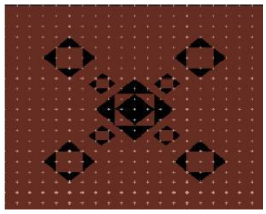
1^{st} iteration



2^{nd} iteration

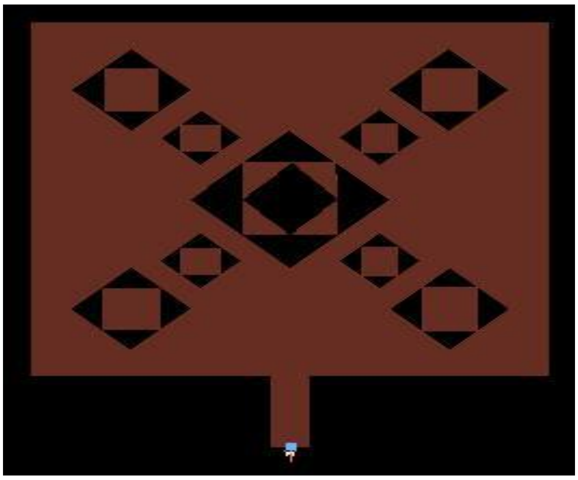


3^{rd} iteration



4^{th} iteration

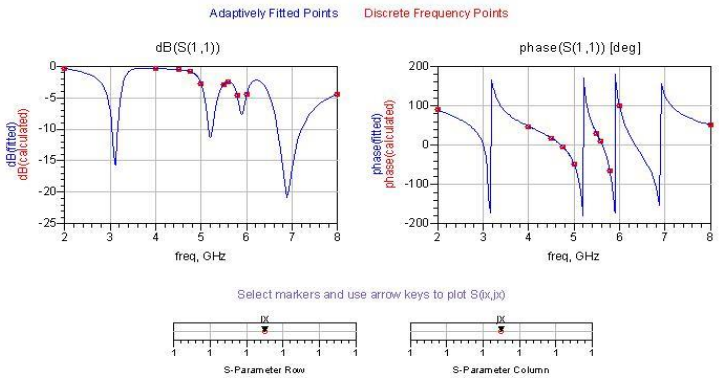
V. ANTENNA LAYOUT



V. RADIATION RESULTS

The radiation pattern shows the values of VSWR,return loss,resonant frequency and gain of the proposed antenna.It helps to understand the behavior of the antenna structures and determine the parameters of antenna.The result was obtained by simulating the antenna using the Advanced Design System(ADS) software.

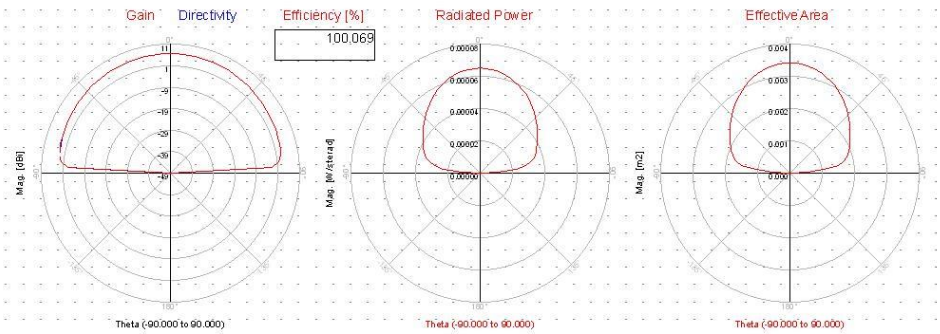
1. Return Loss and Resonant Frequency :



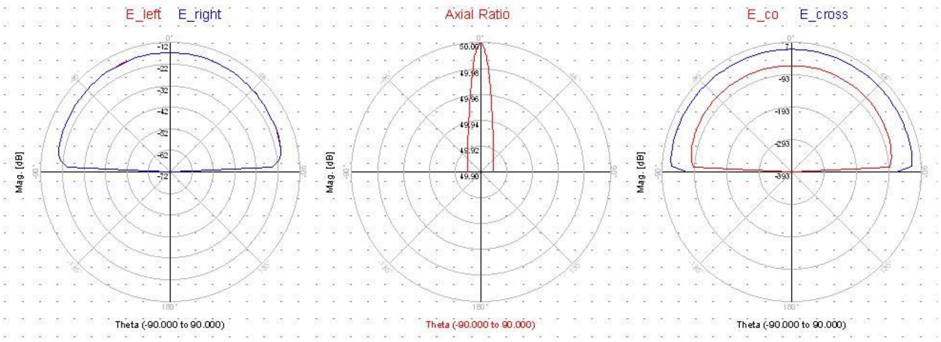
2.VSWR :

3.Gain and Efficiency:

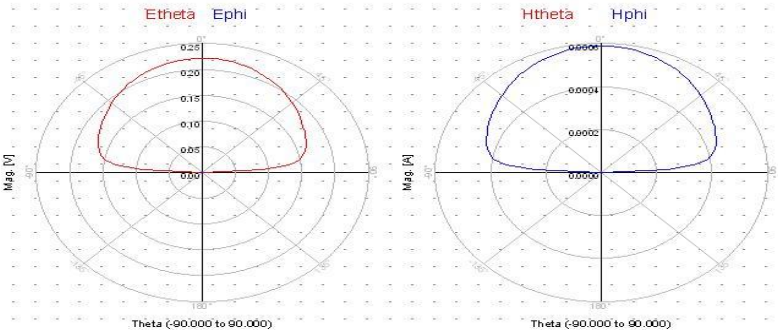
S(1,1)



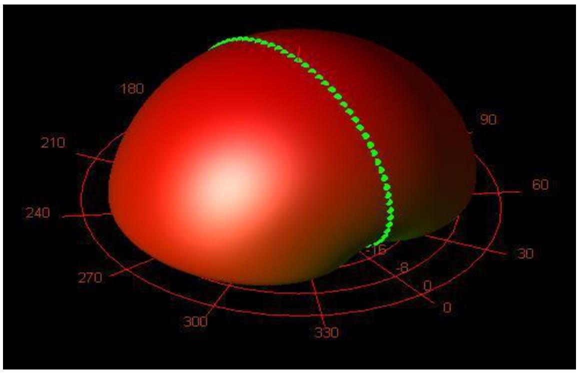
4.Circular and Linear Polarization :



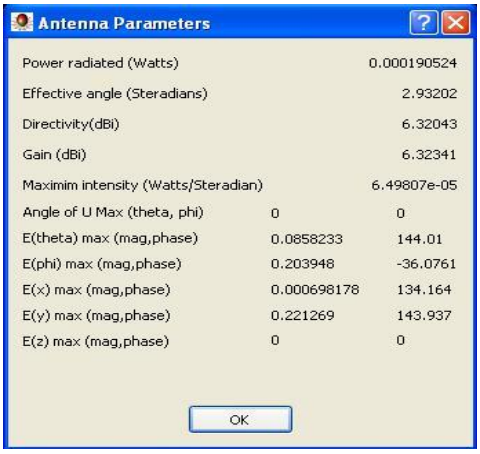
5.Absolute Fields :



6.Far Field :



VI. ANTENNA PARAMETER



VII. CONCLUSION

The antenna is simulated by using ADS Software. The results demonstrated a maximum patch size reduction by the proposed any type fractal antennas, without degrading antenna’s performance, such as the return loss and radiation pattern, VSWR. The basis of the maintenance of the antenna radiation patterns is the self-similarity and Centro-symmetry properties of the fractal shapes.The main advantages of the discussed method are: (i) miniaturization (ii) maintained radiation patterns (iii) wider and better operating frequency bandwidth,(iv) simple and easy to design. This paper presented a modified square shape antenna on substrate relative permittivity of 4.4 & thickness 1.6 mm.The variation of return loss with frequency, VSWR and Bandwidth for iteration I, II, III and IV for transmission line feed this geometry shows high self-similarity and symmetry.

VIII. REFERENCES

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