New E-Shape Rectangular Antenna Using the Square and Giuseppe Peano Fractals for Ultra Wide Band Application

Pradip P.Patel, Sameena Zafar

Abstract—In this paper, a compact design and construction of microstrip Ultra Wide Band (UWB) antenna is proposed. The proposed antenna has the capability of operating between 3.2 GHz to 10 GHz. The antenna parameter in frequency domain analysis has been investigated to show its capability as an effective radiating element. The fractal antenna is preferred due to small size, light weight and easy installation. A fractal micro strip antenna is used for Ultra Wide Band application in this paper provides a simple and efficient method for obtaining the compactness. A New E-Shape Rectangular fractal antenna is designed for Ultra Wide Band. It should be in compactness and less weight is the major point for designing an antenna. This antenna is providing better efficiency.

Keywords— Component, New E-Shape Rectangular fractal antenna, Giuseppe peano fractal.

I. INTRODUCTION

Antenna becomes a part of electronics devices in wireless communication system after late 1888, Heinrich Hertz (1857–1894) were first demonstrated the existence of radio waves .The UWB technology opens new door for wireless communication system, since the current wireless system increasing exponentially. Back from spark-gap impulse to pulse radio, UWB system plays a dominant role in communication system as the antenna is one of the wireless communications components. Recently, UWB technology with an extremely wide frequency range has been proposed for imaging radar, communications, and localized applications. In 2002, Federal Communication

Commission (FCC) authorized unlicensed use of UWB band ranging from 3.1 GHz to 10.6 GHz. Since then, the design of broadband antennas has become an attractive and challenging area in the research of the system design. In general, the antennas for UWB systems should have sufficiently broad operating bandwidth for impedance Matching and high-gain radiation in desired directions. Among the UWB antenna design in the recent literature, the monopole planar antenna type is widely used due to its wide bandwidth, simple structure and low cost. It has become one of the most considerable candidates for UWB application. Several designs of monopole planar UWB antenna have been proposed. However, some of these antennas involve complex calculation and sophisticated fabrication process.

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Therefore, we propose a simpler method to design the UWB antenna based on Fractal microstrip rectangular patch calculation using simple transmission line model. This paper is organized as follows. In Section 2, the proposed antenna design geometry is presented. Section 3 discussed on the results and discussion using the IE3D software tools. Fractals are a class of shapes which have not Characteristics size. Each fractal is composed of multiple iterations of single elementary shapes.

Fractals have the following features.

1. It has a fine structure at arbitrarily small scales.
2. It is too irregular to be easily described in traditional
3. Euclidean geometric.
4. It is self-similar.
5. Simple and recursive.

A fractal is "A rough of fragmented geometric shape" that is generated by starting with a very simple pattern that grows through the application of rules. In many cases the rules to make the figure grow from one stage to next involve taking the original figure and modifying it or adding to it. The process can be repeated recursively an infinite number of times. The self-similarity property of certain fractals results in multiband behavior. Using the self-similarity properties a fractal antenna can be designed to receive and transmit over a wide range of frequencies. While using space filling properties, fractal makes reduce antenna size. Fractal antenna engineering is the field, which utilize fractal geometries for antenna design. It has become one of the growing fields of antenna engineering due to its advantage over conventional antenna design.

II. ANTENNA DESIGN

A. Equation

The transmission line model represents the Microstrip Antenna by two slots each of width 'W' and height 'h' separated by two impedance Z_C transmission line of length L. the essential parameters for the design an antenna according the transmission line method are dielectric constant of the substrate (ε),resonant frequency (fr) and the height of substrate h. The conventional Microstrip rectangular antenna is designed by following the standard procedures:

1. Calculation of the width W of antenna, which is given by:

$$W = \frac{C}{2\,fo\sqrt{\frac{(\mathcal{E}r+1)}{2}}}$$

2. Calculation of effective dielectric constant, $\varepsilon_{reff,}$ which is given by:

$$\varepsilon reff = \frac{\mathcal{E}r+1}{2} + \frac{\mathcal{E}r-1}{2}\,[[1/\sqrt{(1+12(h/W))}]$$

3. Calculation of the effective length, L_{eff} which is given by:

$$Leff = \frac{\lambda 0}{2fr\sqrt{\varepsilon eff.}}$$

4. Calculation of the length extension, ΔL, which is given by:

$$\Delta L = 0.412h\frac{(\mathcal{E}r + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon eff + 0.258)(\frac{W}{h} + 8)}$$

5. Calculation of the effective length extension of patch L which is given by:

$$L = L_{eff} - 2\Delta L$$

6. Ground plane dimension Ls and Ws which are given by:

$$Ls = 6h + L$$
$$Ws = 6h + L$$

B. Design

The parameter taken into account for the design are the resonant frequency (fr=2.77GHz), dielectric constant (ε_r=2.45) and thickness of the substrate (h=1.58mm). the patch antenna is shown in figure-1with dimensions. The rectangular Microstrip patch antenna is based on E shape design cuts. For designing this fractal antenna IE3D software is used. The RT Duroid material is used as substrate. The thickness of the substrate is 1.58mm. The dielectric constant ε_r of the antenna is 2.45. The E shape design cuts fractal shapes is used in this paper with single iteration. The proposed antenna design with dimension in figure 1.

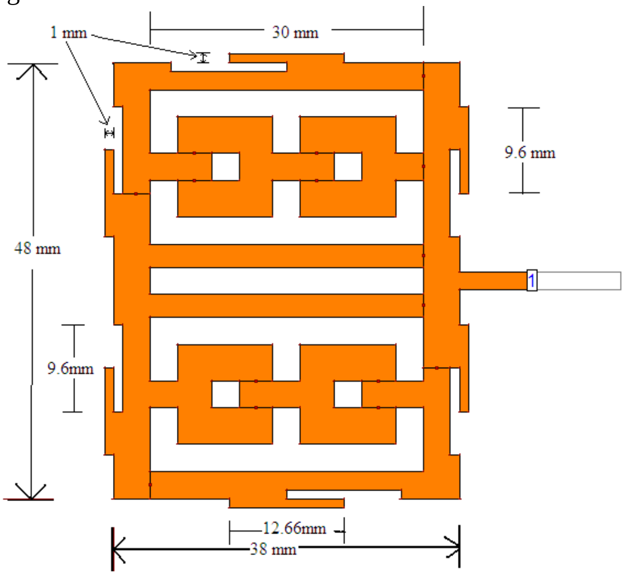

Figure1.Design of proposed E-Shape antennas with dimensions.

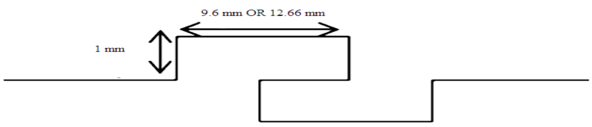

Figure2.Dimensions of the Generator of the Giuseppe Peano Fractal.

The initiator and generator of the Giuseppe Peano fractal are shown in Fig. 2, where the horizontal line sections are equal and the vertical ones are also equal. The fractal dimension may be changed by varying the length of horizontal and vertical line sections, as shown in Fig. 2. Any fractal is characterized by its unique overall geometrical shape and configuration. The realized size of its line sections in various iterations may be arbitrarily specified, which are constrained to satisfy the following formula. The square patches with different lengths of indentations are effective for antenna miniaturization, because they generally lie inside the original square patch. We have actually selected long and narrow strip teeth for the indentations. However, the metallic patch area remains the same. In Giuseppe Peano fractal, as the number of the iteration increases the areas of metallic patch remain constant and this is in contrast to common fractals.

III. RESULT AND DISCUSSION

A. Simulation Setup.

The software used to model and simulate the Microstrip patch antenna is Zeland Inc’s IE3D. IE3D is a full-wave electromagnetic simulator based on the method of moments. It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antennas, wire antennas, and other RF/wireless antennas. It can be used to calculate and Return loss plot, VSWR, current distributions, radiation patterns etc.

B. Return Loss Characteristics

The Inset feed used to design the rectangular patch antenna. The center frequency is selected as the one at which the return loss is minimum. The bandwidth can be calculated from the return loss (RL) plot. The bandwidth of the antenna is said to be those range of frequencies over which the return loss is greater than 7.3 dB, which is equivalent to 2.5:1 VSWR. Return loss graph is shown in figure 3.

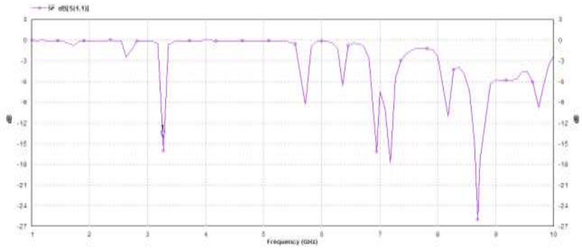

Figure3. Return loss vs. frequency

As shown in above graph this antenna gets maximum return loss at frequency 3.272GHz (-16.11db), 5.721 GHz (-9.274db), 6.952 GHz(-16.21db), 8.691 GHz(-26.06db), and 9.742 GHz(-9.812db).It means proposed antenna resonant on above five frequencies.

C. Gain vs. Frequency

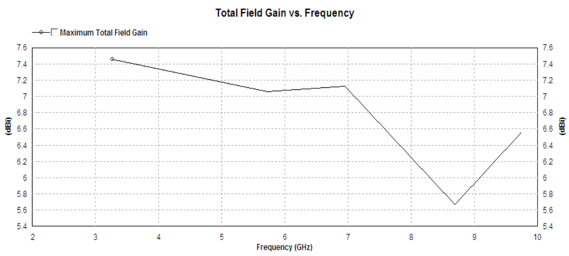

Figure4. Gain vs. Frequency

As observed in Fig.4, gain vs. frequency plot, it is found that the gain is around 7.44 dB at frequency (3.272 GHz), 6.946 dB at frequency (5.721 GHz), 6.77 dB at frequency (6.952 GHz), 5.67 dB at frequency (8.691 GHz), 6.55 dB at frequency (9.742 GHz).The Average gain of the simulated and measured results is about 6.675 dB at the resonant frequency.

C. Antenna efficiency and radiation efficiency

Antenna efficiency and radiation efficiency graph is shown in figure 5.

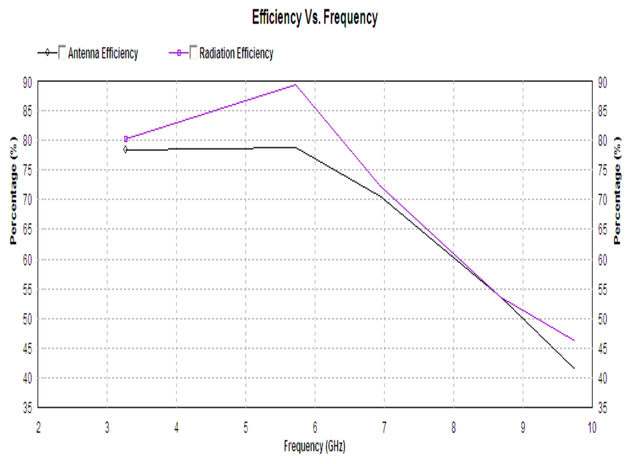

Figure5. Antenna efficiency plot & radiation efficiency plot

As observed in Fig.4, Antenna efficiency plot & radiation efficiency plot, it is found that Antenna efficiency & radiation efficiency as per below table.

Sr. No	Frequency	Antenna efficiency	Radiation efficiency
1	3.272 GHz	78.00%	88.00%
2	5.721 GHz	78.84%	89.38%
3	6.952 GHz	70.45%	72.19%
4	8.691 GHz	53.45%	53.60%
5	9.742 GHz	41.46%	46.29%

Table2. Antenna efficiency & radiation efficiency

D. Input Impedance Plot.

We expect pure impedance at frequencies where the patch resonates, and see table 2 and Figure 5.

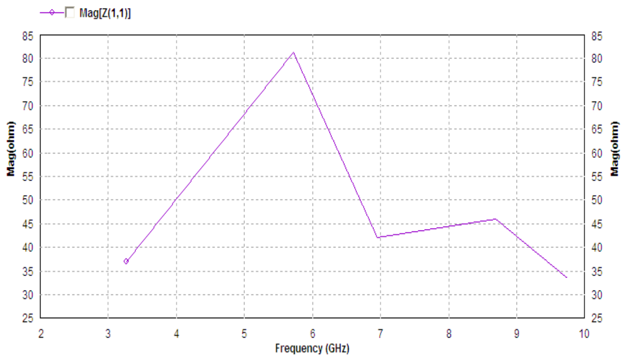

Figure6. Graph between frequency and magnitude input impedance

Frequency(GHz)	Impedance(Ω)
3.272 GHz	37
5.721 GHz	81.15
6.952 GHz	42.07
8.691 GHz	45.96
9.742 GHz	33.58

Table2. Frequency and impedance

E. Radiation Pattern.

The radiation patterns of an antenna provide the information that describes how the antenna directs the energy it radiates. There are five resonant frequencies we get different radiation patterns.

1. Radiation pattern for 3.272 GHz

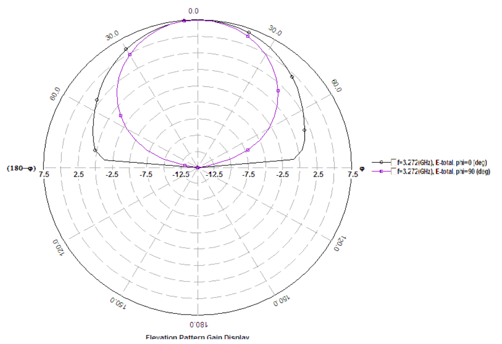

Figure.7. 2D pattern for 5.721 GHz

2. Radiation pattern for 5.721 GHz

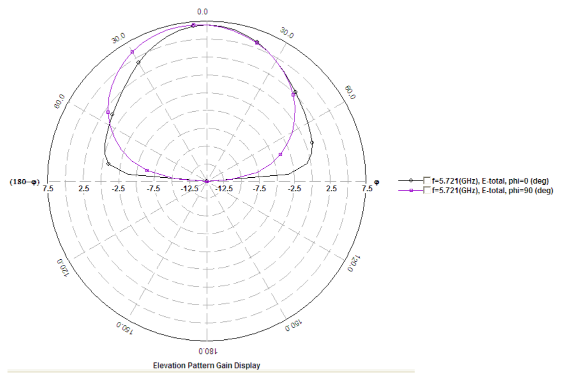

Figure.8. 2D pattern for 5.721 GHz

3. Radiation pattern for 6.952 GHz

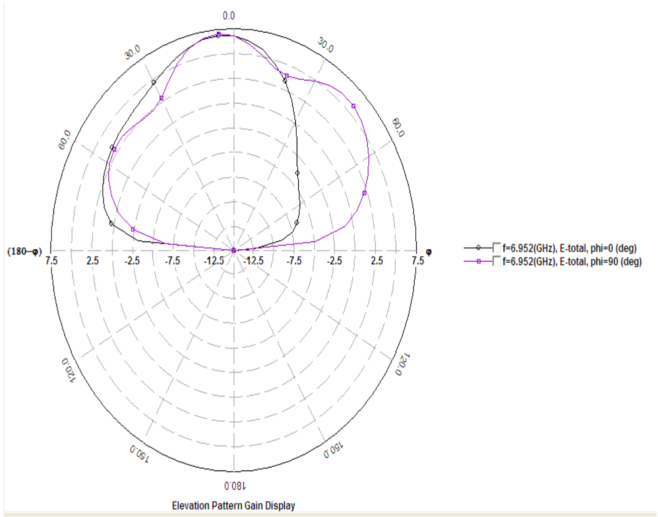

Figure.9. 2D pattern for 6.952 GHz

4. Radiation pattern for 8.691 GHz

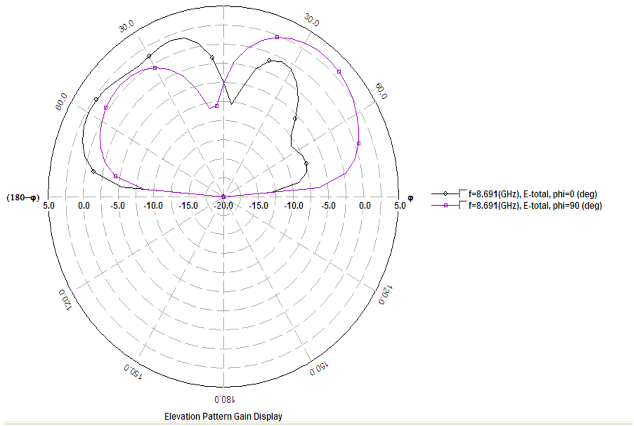

Figure.10. 2D pattern for 8.691 GHz

5. Radiation pattern for 9.742 GHz

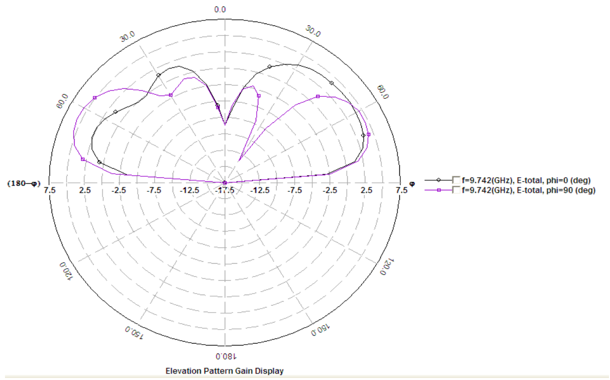

Figure.11 2D pattern for 8.691 GHz

IV. CONCLUSION

The aspects of Microstrip antenna have been studied in this paper. The aspect is the design of typical rectangular Microstrip antenna. A simple and efficient technique of design has been introduced for an impedance matching Improvement of antenna in this paper. The Microstrip fractal antenna is proposed for the wireless various applications. The antenna is designed for Ultra Wide Band (UWB) application. The proposed antenna resonant for frequencies 3.272 GHz, 5.721 GHz, 6.952 GHz, 8.691 GHz and 9.742 GHz. The simulation results are obtained using IE3D Software. The miniaturization is obtained by placing a Giuseppe peano fractal strip along the microstrip patch antenna. The proposed antenna show a significant size reduction compared to the conventional Microstrip antenna. The designed antenna is compact enough to be placed in typical wireless devices.

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