# T Shaped Fractal Geometry Based Microstrip Patch Antenna

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***Abstract-*** *One of important concept to design antenna is that antenna have small size. For mobile applications, one may want that antenna must have small size and must be capable to resonate at multiple frequency bands. There are number of techniques that can be useful for designing of antenna which include making use of fractal geometry, use of slot and DGS.. In this paper, T-shaped Patch antenna has been designed and fractal geometry has been applied to it in order to obtain self-similar characteristics. square. Patch length has been taken as square of length 36mm. Dimension of ground has been taken as been taken as 50 mm. The substrate used in this paper is FR-4. Parametric analysis has been applied in terms of changing microstrip line, feed point, thickness and geometry. Antenna resonates at frequency in range 3 Ghz to 8 Ghz.*

***Keywords-*** Wireless applications, WLAN , Fractal Misrostrip Patch Antenna

## I. INTRODUCTION

Antenna is one of the largest components of the low profile wireless communication. In order to transmit and receive antenna information; modulation is done in which career wave is superimposed over modulating signal. At the required destination, the modulated signal was then received and the original information signal can be recovered by demodulation. Over the years, techniques have been developed for this process using electromagnetic carrier waves operating at radio frequencies as well as microwave frequencies.

In the current scenario small, compatible and affordable microstrip patch antennas are developed in wireless communication industries keep on improving antenna performance. A patch antenna is a narrowband antenna with large beam width. It is fabricated by etching the antenna element pattern in metal trace which is bonded to an insulating dielectric substrate such as a printed circuit board with a continuous metal layer bonded to the opposite side of the substrate known as a ground plane. Fractal geometry is used to reduce the size of patch antenna. Fractal geometries are different from Euclidean geometries which have two common properties: space-filling and self-similarity. It is found that by applying fractal geometry, self-repeating structures are obtained. Fractal geometries that are used in this dissertation are Koch curve, Minkowski fractal geometry and many other self-similar shapes.

By applying fractal geometry on patch, area of patch decreases, resonant length increases and number of frequency bands of antenna increases. Also it is good to achieve wideband characteristics apart from multiband characteristics; hence defected ground structure has been applied to antenna. There are different DGS that can be applied to antenna which include H shaped, plus shaped DGS. It is found that by applying DGS to antenna, characteristics of antenna improved. Radio waves and microwaves play an important role in daily life. Television signals are transmitted by satellite using microwaves, military uses microwave for surveillance and navigation purposes. Telephone and data signals are transmitted by microwaves. Also in today's scenario, technology demands such an antenna that can operate on different wireless band and must have different features like low cost, less weight, low profile antenna which are capable of maintaining high performance over a chromatic spectrum of frequencies.

Microwave spectrum is usually called as electromagnetic spectrum, since it ranges from 1GHz to 100 GHz. There are different microwave bands which are classified into many frequency bands. Applications most commonly used are of range 1 to 40 GHz. Hence different bands within this range are L band (1-2 GHz), S band (2-4 GHz), C band (4-8 GHz), X band (8-12 GHz), Ku band (12 - 18 GHz), K band (18-26.5 GHz) and Ka band (26.5-40 GHz).Microstrip antenna finds applications from 1 GHz to 12 GHz. Hence microstrip antenna can be designed for L band, S band, C band and X band applications. Standard band designations for microwave frequencies listed as per Institute of Electrical and Electronics Engineering (IEEE) is the industry standards.

## II. PROPOSED SYSTEM

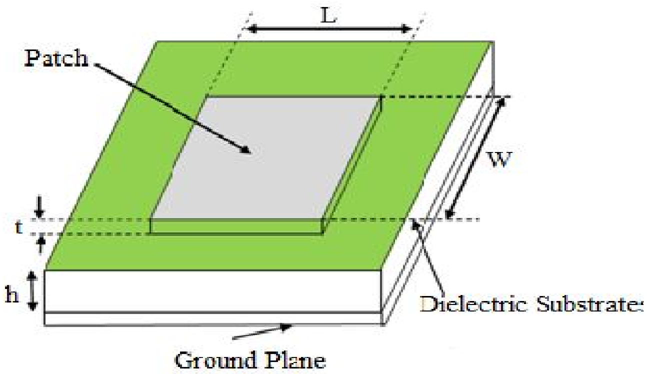


Fig 1. Structure of Microstrip Antenna

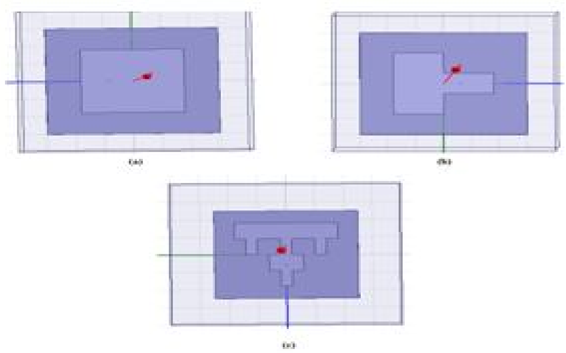

Fig 2. T- Shaped FMPA (a) Initial Iteration, (b) 2nd Iteration and (c) 3rd Iteration

In order to design any microstrip antenna it is necessary tohave knowledge of ground and patch dimensions, application for which antenna is designed. There are different applications at different frequency, based on applications, frequency is decided which further decide dimensions. Benefit of carrying out this procedure is that one can first design zero iteration basic antennas for desired applications, then improve its characteristics by use of fractal geometry, slot configuration and DGS. There are three basic parameters that are decided for designing antennas. Following are steps used in process.

**Step 1: Substrate selection:**

In order to have good antenna performance, a thick dielectric substrate with a low dielectric constant is desirable since it help in achieving larger bandwidth, better efficiency and better radiation. However, such a configuration causes increase in antenna size. If one want to make a patch microstrip antenna, higher dielectric constants are required which make antenna not only less efficient but also result in narrow bandwidth. As the result compromise is made between these two configurations.

It is important parameter that decides dimensions of patch. There are two most commonly substrate used which are FR-4 epoxy with dielectric constant of 4.4, loss tangent of 0.02 and Rogers RT Duroid 5880 with dielectric constant of 2.2 and loss tangent of 0.0009. It was found that as dielectric constant increases, dimensions of antenna decreases and efficiency and gain also decreases. Hence for selection, these factors are taken into account.

**Step 2: Substrate thickness (h)**

It is find that increase in thickness of substrate causes efficiency and bandwidth to increase but this makes antenna more bulky. In proposed design substrate of thickness 2.4 mm has been used. Comparison is made by changing thickness at different values and characteristics of antenna are compared to obtain best results.

Table 1: Dimensions of Reference Antenna

| Variable | Value |
|---|---|
| Length of patch | 36 mm |
| Width of patch | 36 mm |
| Length of ground | 50 mm |
| Width of ground | 50 mm |
| Thickness of substrate | 2.4 mm |
| Feeding technique used | Coaxial Feeding |
| Substrate used | FR-4 |
| Dielectric constant | 4.4 |
| Feed point | (0, 6, 0) |
| First Iteration slot | 12X18 mm2 |
| Second iteration slot | 4X9 mm2 |
| Loss tangent of substrate | 0.09 |
| Feed Length of Probe | 4mm |
| Dimensions of Microstrip Feed | 2X7mm |
| Geometry | Minkowski Fractal |
| Simulation Software | HFSS |

**Step 3: Choosing square dimensions:**

After selecting all three parameters, dimensions can be obtained. It is not necessary that whatever calculations obtained will be used. Optometric analysis has been carried out in order to select that dimensions that give best results.

**Step 4: Selection of feed point:**

There are five different feeding techniques but most commonly used are microstrip and coaxial feeding technique. Advantage of using coaxial feed is that feed point can be adjusted such that impedance matching takes place. Parametric analysis has been done for feed point selection.

**Step 5: Applying fractal geometry iterations:**

Fractal geometry has biggest advantage of providing multiband characteristics. There are different fractal geometries like Koch, Minkowski, Sierpinski carpet, cantor shape. Of all cantor shape fractal geometry has been used to make antenna in which two rectangles from two sides of same level are removed to make T-shape antenna. Different Iterations are performed and results are compared in terms of antenna parameters.

**Step 6: Calculation of ground dimensions:**

It is essential to have finite ground plane for practical considerations. The size of ground plane is selected to be greater than patch dimensions by approximately six times the substrate thickness all around periphery. Ground length and width are given by equations below.

$Lg = 6h+L$

$Wg = 6h+W$

Here L and W correspond to patch length and width, h is substrate thickness and Lg and Wg are ground length and width. Hence dimensions of ground depend on thickness of substrate and dimensions of patch

**Step 7: Selection of resonant frequency for desired application:**

Different wireless band applications use different frequency of operation. Entire frequency band is divided into different bands. Each band has a frequency range with different application ,hence frequency is decided first.

## III. ADVANTAGES AND APPLICATION

**Advantages:**

1) Fractal geometry causes reduction in size of antenna. By applying fractal geometry, area of metal portion decreases and hence size of antenna decreases.
2) Fractal geometry helps in better impedance matching of antenna.
3) By applying fractal geometry, bandwidth of antenna can be improved. Hence fractal geometry is helpful in achieving large bandwidth.
4) It allows antenna to operate over large range of frequency thus making antenna independent of frequency.

**Applications:**

1) Wi Fi And WiMAX
2) Missile telemetry
3) Doppler and other radar
4) Satellite communication.

## IV. RESULTS

T-Shaped Fractal Patch Antenna In this section, simulation results of different iterations of fractal geometry are compared. T shape fractal antenna is made by cutting slots as shown in figure 3. These cause self-similar T-shaped structure. Return loss vs. frequency for various iteration of T-shaped fractal geometry are shown in figures below. One frequency is chosen among all the Iterations. Furthermore ,the antenna has been tested by Network Analyzer and the obtained results have been also shown in figures below.

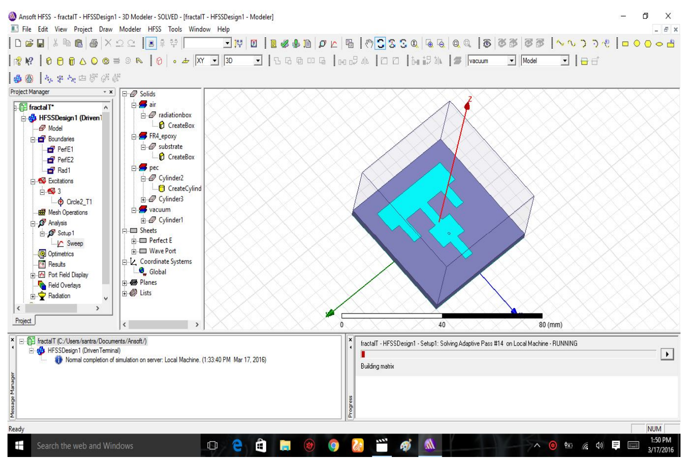

Figure 3: Model of T shape micro strip patch antenna (Top view)

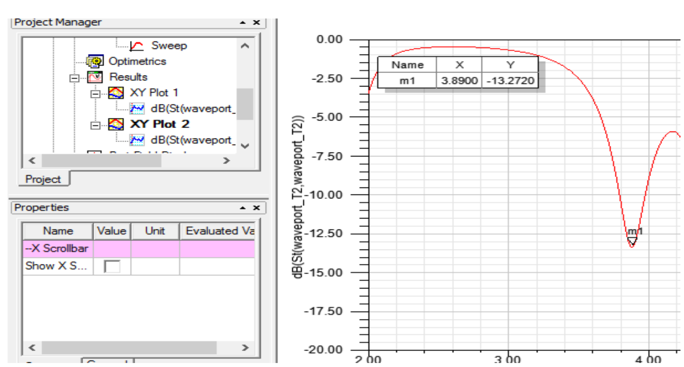


Figure 4: Return loss at initial model 3.9 GHz resonant frequencies

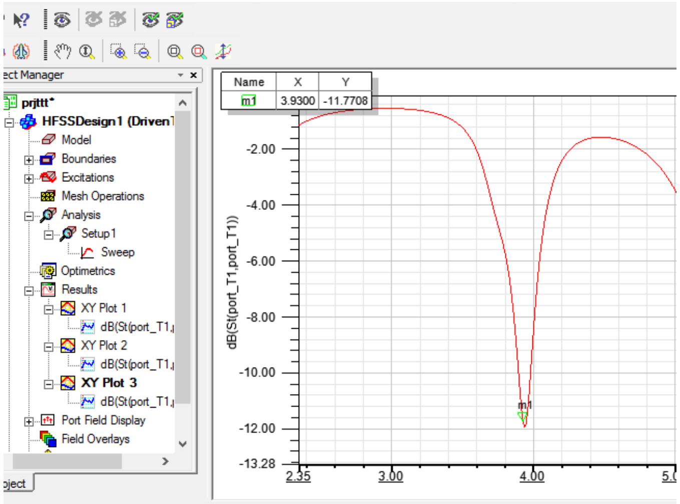


Figure 5: Return loss at initial model 3.9 resonant frequencies for second iteration

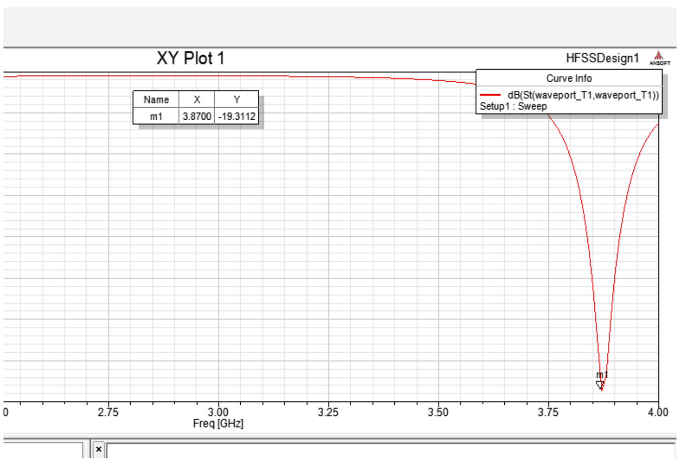


Figure 6: Return loss at initial model 3.9 GHz resonant frequencies for third iteration

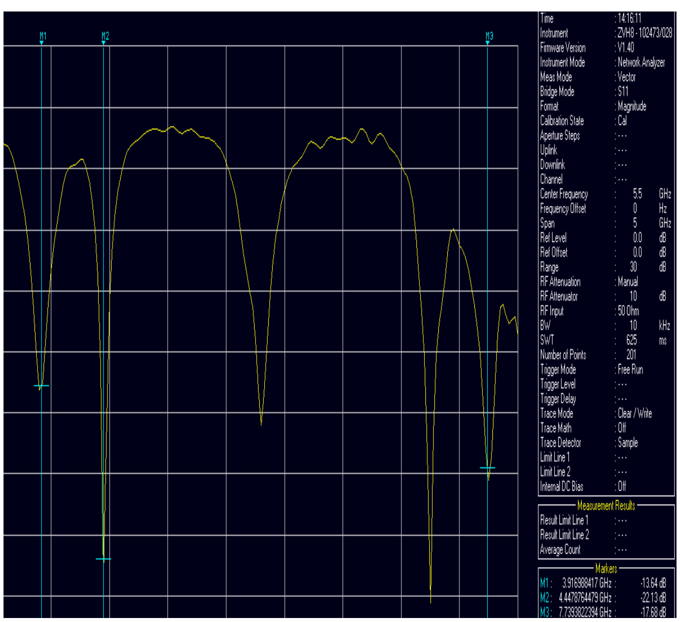

Figure 6.13: Hardware test results for initial iteration

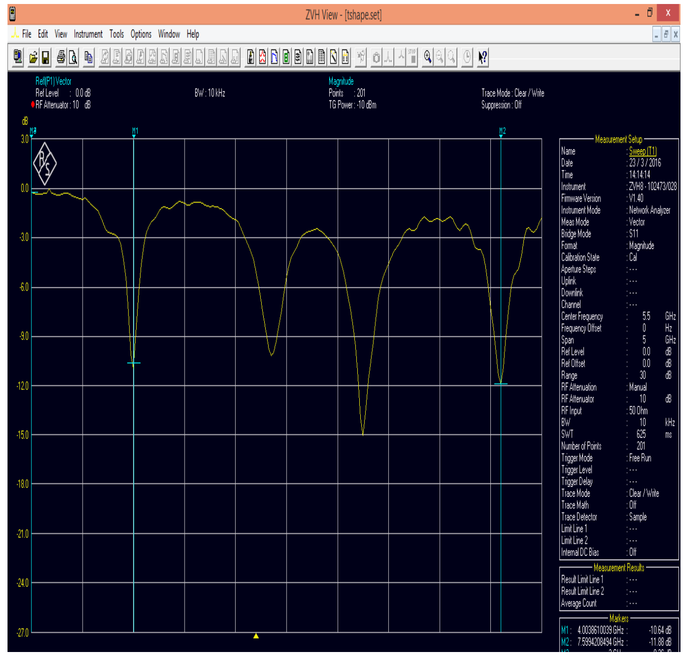

Figure 6.14Hardware test results for second iteration

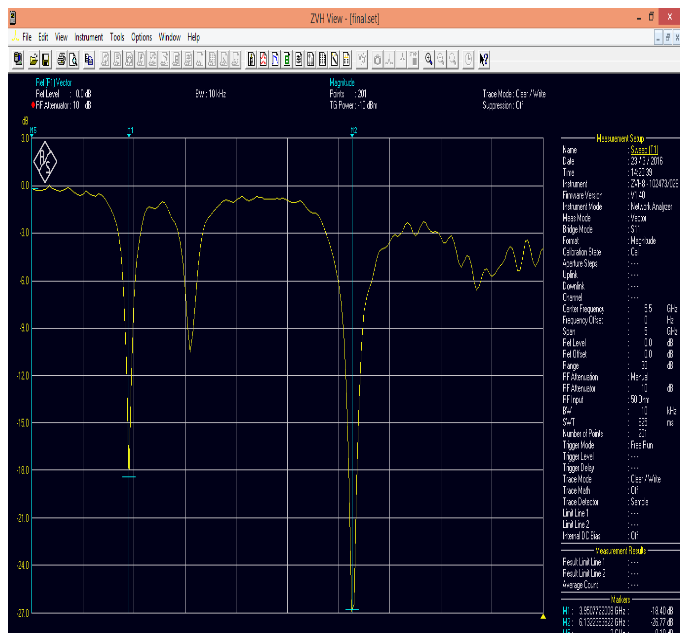

Figure 6.15:Hardware test results for third iteration

## V. CONCLUSION

From results it is found that parametric analysis had been carried out in termns of substrate thickness, feed point and number of iterations. It is found that by making use of fractal geometry, characteristics of antenna improves a lot. In this paper, T-shaped Patch antenna has been designed and fractal geometry has been applied to it in order to obtain self-similar characteristics. Patch length has been taken as square of length 36mm. Dimension of ground has been taken as been taken as 50 mm. The substrate used in this paper is FR-4.

Parametric analysis has been applied in terms of changing microstrip line, feed point, thickness and geometry

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