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Designing and Analysis of T-Shape Microstrip Antenna for the 4G Systems

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Designing and Analysis of T-Shape Microstrip Antenna for the 4G Systems

Amit Kumar [α] & Sanjay Singh [σ]

Abstract - In this paper, the designing and analysis of T-shape microstrip patch antenna presented. The shape will provide the broad bandwidth which is required for the operation of fourth generation wireless systems. The operating frequency of antenna is 2.5 GHz, the dielectric constant and thickness of the antenna is 4.2, 1.6mm respectively. The simulation results of antenna are done by the help of IE3D Zeland Software (Version 12.0) and MATLAB programming. For the analysis of antenna we used the popular Finite difference time domain method (FDTD). This antenna is fed by a co-axial probe feeding. In this paper, the effects of different types of antenna parameters like return loss, voltage standing wave ratio (VSWR), impedance etc. are also studied.

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I. Introduction

The MSA in 1953 [1] and practical antennas were developed by Munson [2, 3] and Howell [4] in the 1970s. The numerous advantages of MSA, such as its low weight, small volume, and ease of fabrication using printed-circuit technology, led to the design of several configurations for various applications [5–9]. With increasing requirements for personal and mobile communications, the demand for smaller and low-profile antennas has brought the MSA to the forefront. An MSA in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The T-shape of microstrip patch antenna as shown in Figure 1. However, other shapes, such as the square, circular, triangular, semicircular, and annular ring shapes etc. In this paper, we present a designing of T-shaped microstrip patch antenna and show the results for return losses operating at different frequencies. The dielectric constant (ε_r=4.2) of the dielectric substrate and thickness of the substrate h=1.6 mm.

II. Designing Of T-Shape Microstrip Patch Antenna

The Figure 1. Shows the T-shaped microstrip patch antenna. The T-shaped microstrip patch antenna is simpler in construction. The geometry is shown in figure 2.

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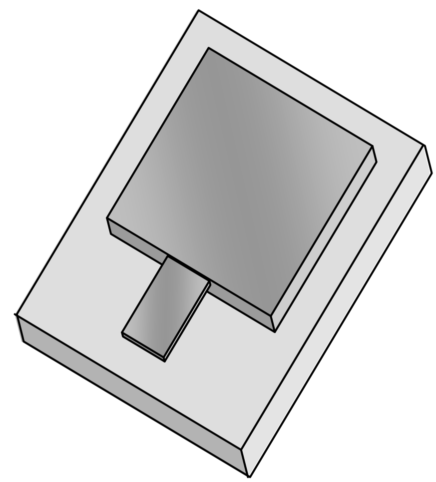

Figure 1 : T-shaped of microstrip antenna

The T-shaped microstrip patch antenna has width (w) and length (L). Outer patch strip width is w_1. The patch is fed at position p0 by a coaxial probe. The dielectric substrate materials are used for fabrication of antenna element. Designing of the T-shaped microstrip patch antenna as shown in Figure 2. The designing of T-shaped microstrip patch antenna the resonant frequency f_r 2.5 GHz and the dielectric substrate is used for the design the T-shaped of microstrip patch antenna. The dielectric constant of the substrate is ε_r = 4.2 and thickness (h) of the substrate h= 1.6 mm to design the T-shaped microstrip patch antenna.

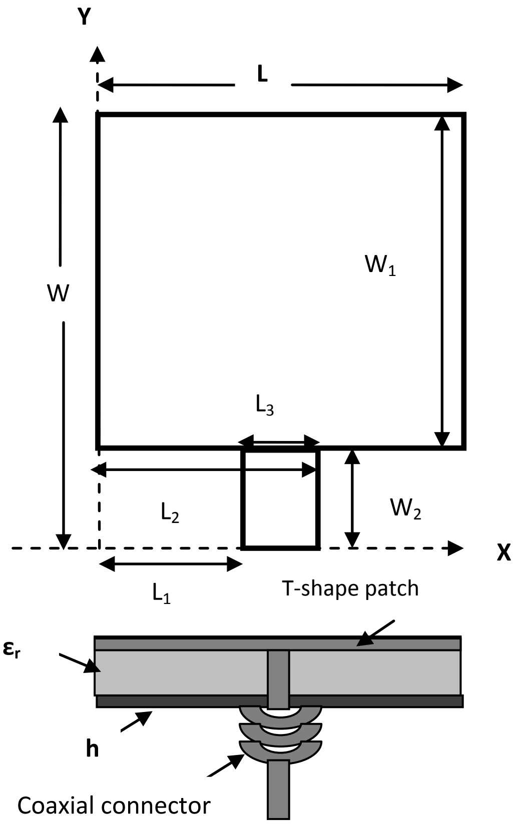

Figure 2 : Geometry of the T-shaped microstrip patch antenna

The width and length of the microstrip antenna are determine as follows

$$W = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{v_0}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

Where v_o is the free-space velocity of light.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-1/2} \quad (2)$$

Where the dimensions of the patch along its length have been extended on each end by a distance ΔL, which is a function of the effective dielectric constant ε_{reff} and the width-to-height ratio (W/h), and the normalized extension of the length, is

$$\Delta L = h\, 0.412 \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (3)$$

The actual length of the patch (L) can be determine as

$$L = \frac{1}{2 f_r \sqrt{\varepsilon_{reff}} \sqrt{\mu_0 \varepsilon_0}} - 2\Delta L \quad (4)$$

The designing of the microstrip patch antenna by the used of IE3D electromagnetic three dimensional simulators and MATLAB programming. The dimensions of the T-shaped microstrip patch antenna parameters as shown in table 1.

Table 1 : Dimension of the optimization antenna parameters

Frequency fr	2.5 GHz
W	37.21
W_1	27.21
W_2	10
L	28.89
L_1	12
L_2	16.89
L_3	4.89
Dielectric constant ε_r	4.2
Thickness of the substrate h	1.6

III. Analysis of Antenna using FDTD Method

The basic FDTD space grid and time-stepping algorithm trace back to a seminal 1966 paper by Kane Yee in IEEE Transactions on Antennas and Propagation (Yee 1966). The descriptor "Finite-difference time domain" and its corresponding "FDTD" acronym were originated by Allen Taflove in a 1980 paper in IEEE Transactions on Electromagnetic Compatibility (Taflove 1980). The FDTD method has been used for the analysis for the probe-fed microstrip patch antennas and can indeed yield very accurate highly result. The FDTD method uses Maxwell's equations which define the propagation of an electromagnetic wave and the relationship between electric and magnetic field, these are

$$\mu \frac{\delta H}{\delta t} = -\nabla \times E \quad (5)$$

$$\varepsilon \frac{\delta E}{\delta t} + J = \nabla \times H \quad (6)$$

$$\nabla \cdot E = \frac{\rho}{\varepsilon} \quad (7)$$

$$\nabla \cdot H = 0 \quad (8)$$

By applying appropriate boundary conditions on sources, conductors and mesh walls an approximate solution of these educations can be find over a finite three-dimensional domain. The equation in the *i* direction gives:

$$\mu \frac{\Delta H_x}{\Delta t} = \frac{\Delta E_Y}{\Delta Z} - \frac{\Delta E_Z}{\Delta y} \quad (9)$$

The maximum time step that may be used is limited by the stability restriction of the finite difference equations. This is given by

$$\Delta t \leq \frac{1}{c}\left[\frac{1}{\Delta x^2}+\frac{1}{\Delta y^2}+\frac{1}{\Delta z^2}\right]^{\frac{1}{2}} \qquad (10)$$

Where c is the speed of light (300 000 000 m.s^{-1}) and Δx, Δy and Δz are the dimensions of the unit element.

IV. Results

The simulated results of the return loss, VSWR, and Radiation pattern of E and H plane as shown in fig 3 (a) (b) and (c).The return loss is -13.63 dB, VSWR 1.562, and the bandwidth of the antenna is 123 MHz at the 2.5 GHz resonant frequency. The result of the return loss (-16.78 dB) by using MATLAB programming as shown in Figure 4. The results of the T-shape microstrip patch antenna as shown in Table 2 Simulation results using IE3D and MATLAB programming.

Table 2 : Simulation results using IE3D and MATLAB programming

S.No.	Parameters	Results	Software
1	Return loss 1	-13.63 dB	IE3D
2	VSWR	1.562	IE3D
3	Return loss 2	-16.78	MATLAB
4	Bandwidth	123MHz	Theoretical

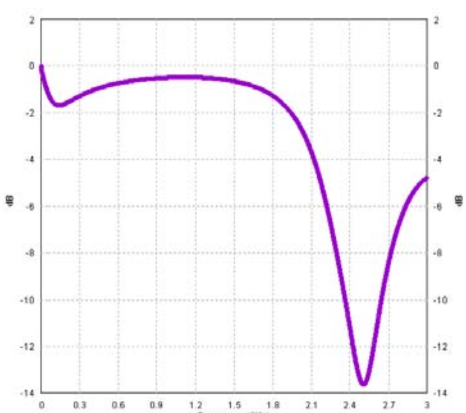

Figure 3(a)

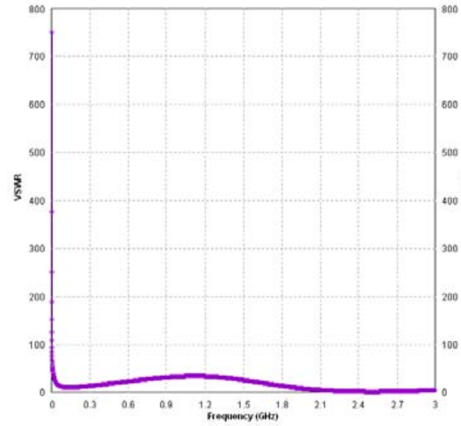

Figure 3(b)

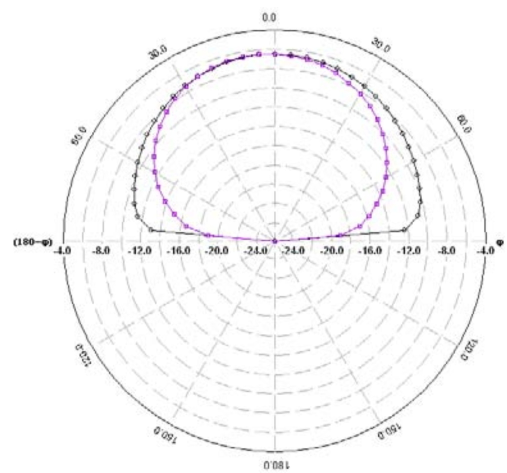

Figure 3(c)

Figure 3 : (a) & (b) Simulation results of return loss and VSWR using IE3D software & (c) Radiation pattern of E and H plane at operating frequency 2.5 GHz

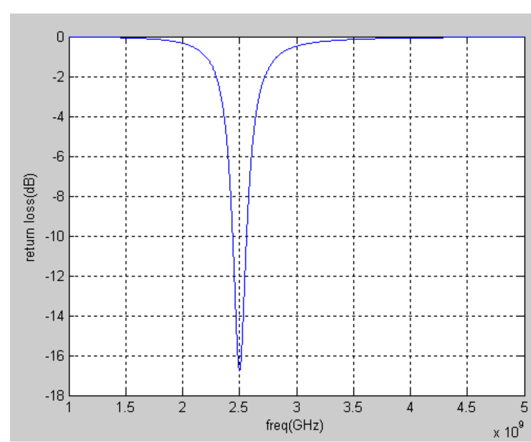

Figure 4 : Simulation results of return loss operating frequency 2.5 GHz using Matlab programming

In 4G systems, or any microstrip antenna the frequency range is 2.4-2.5 GHz and VSWR range is 1.2-1.7 required. Hence, this antenna is best suited for 4G systems.

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