Designing of Rectangular Microstrip Patch Antenna for Wireless Communication at 2.4 GHz

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Abstract

This paper presents a rectangular Microstrip patch antenna for wireless communication. In its simple form, a Microstrip patch antenna consists radiating patch at one side of a dielectric substrate Rogger RT/Duroid (5880tm) that has on the other side a ground plane. Microstrip patch antennas are used for communication purposes especially in WLAN. In this paper a simple microstrip patch antenna is designed in HFSS with coaxial feeding at a resonant frequency of 2.4GHz. The gain of the designed antenna is 7.37 dB and VSWR of 1.05.

Keywords: Gain, directivity, VSWR, radiation pattern, beamwidth

I. INTRODUCTION

Antennas play a vital role in the field of communications. Some of them are parabolic reflectors, patch antennas, slot antennas, and folded dipole antennas have their own properties and applications. Antennas are classified as the backbone and the driving force behind the recent advances in wireless communication technology.

One of types of wireless communication at 2.4GHz is LAN. A WLAN enabled device such as a personal computer, video game console, smartphone or digital audio player can connect to the Internet when within range of a wireless network connected to the Internet [4]. A simple Microstrip patch antenna consists of a conducting patch and ground plane between them is a dielectric medium called the substrate having a particular value of dielectric constants shown in Figure 1. The dimensions of a patch are smaller as compared to the substrate and ground. Dimensions of a microstrip patch antenna depend on the resonant frequency of operation and value of the dielectric characteristics.

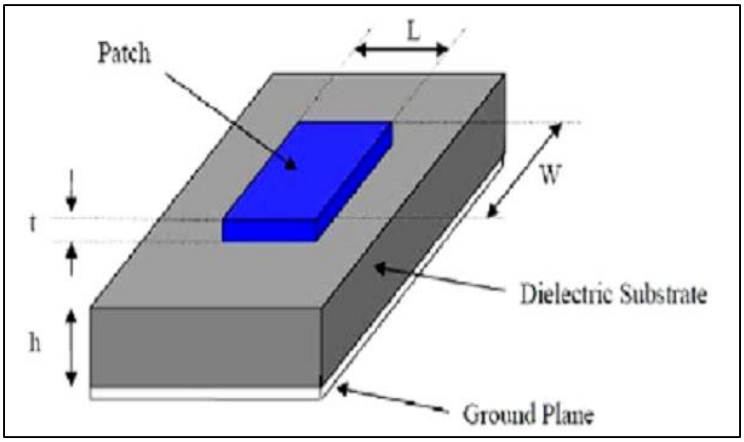

Fig. 1. Structure of Microstrip Patch Antenna [3]

II. DESIGN ANALYSIS

A. Method of Analysis:

For designing of a microstrip patch antenna select the resonant frequency and a dielectric constant for which antenna is to be designed. The parameters to be calculated as,

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1) Width (W):
The patch width can be calculated using the following equation [1]

$$w = \frac{c}{2f_0}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (1)$$

Where,
W=Width of the patch C_0= Speed of light ε_r=value of the dielectric constant
2) Effective refractive index:
The value of effective refractive index for a patch is an important parameter in the designing procedure of a microstrip patch antenna. The radiations emitted by the patch towards the ground travels through the air and few through the substrate (called as fringing effect). Bath the air and the substrates have different dielectric values, to calculate this we find the value of effective dielectric constant. The value of the effective dielectric constant (ε_{reff}) is calculated using the following equation [1]

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

3) Length:
Due to fringing, the size of the antenna is increased by (ΔL) electrically. Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation [1]:

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

Where '*h*'= height of the substrate
The length (*L*) of the patch is now to be calculated using the below mentioned equation [1]:

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

4) Length (Lg) and width (Wg) of ground plane:
The transmission line model is useful for analysis w.r.t. infinite ground planes. However, for real time practice, a finite ground plane is essential. Finite and infinite ground plane can be obtained for the size of the ground plane whose the patch dimensions are greater by approximately six times the substrate thickness all around the periphery. The length of a ground plane (Lg) and the width of a ground plane (Wg) are calculated using the following equations [2]:

$$L_g = 6h + L \quad (6)$$

$$W_g = 6h + W \quad (7)$$

For feeding the microstrip patch antenna, there are different methods for example, feed line method, coaxial probe feeding method etc. But mostly coaxial probe method is used.

B. Design Specification

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are:

1) The Operating Frequency: The resonant frequency of the antenna should be selected appropriately. The resonant frequency selected for this design is 2.4 GHz.
2) Dielectric constant of the substrate (ε*r*). The dielectric material selected for the design is Rogger (5888) which has a dielectric constant of 2.2.
3) Height of dielectric substrate (h) Because of using Rogger, so height of dielectric substrate is 3.2 mm. So, the essential parameters for the design are:
4) *f*0 : 2.4 GHz
5) ε*r*: 2.2
6) *h:* 3.2 mm

III. FINDINGS AND RESULTS

Using the equations mentioned above, a rectangular Microstrip patch antenna is designed at a resonant frequency of 2.4 GHz. The width (W) and length (L) of the patch at a resonant frequency of 2.4 GHz is found to be W= 49.4 mm and L=40.3 mm while the feeding offset position is 9.7 mm. the height of the substrate is 3.2 mm. for ground plane, the length (Lg) and width (Wg) of the ground plane is calculated to be Lg=59.5mm and Wg=68.6 mm.
For feeding the microstrip antenna, coaxial probe feeding is used that has offset feeding position as 9.7 mm. the simulation is carried out in HFSS software.
The figure 2 shows pattern of the antenna in the farfield w.r.t gain. The direction of the maximum gain of the antenna is above the patch (i-e, in the direction of theta), while minor lobes are on the opposite side.

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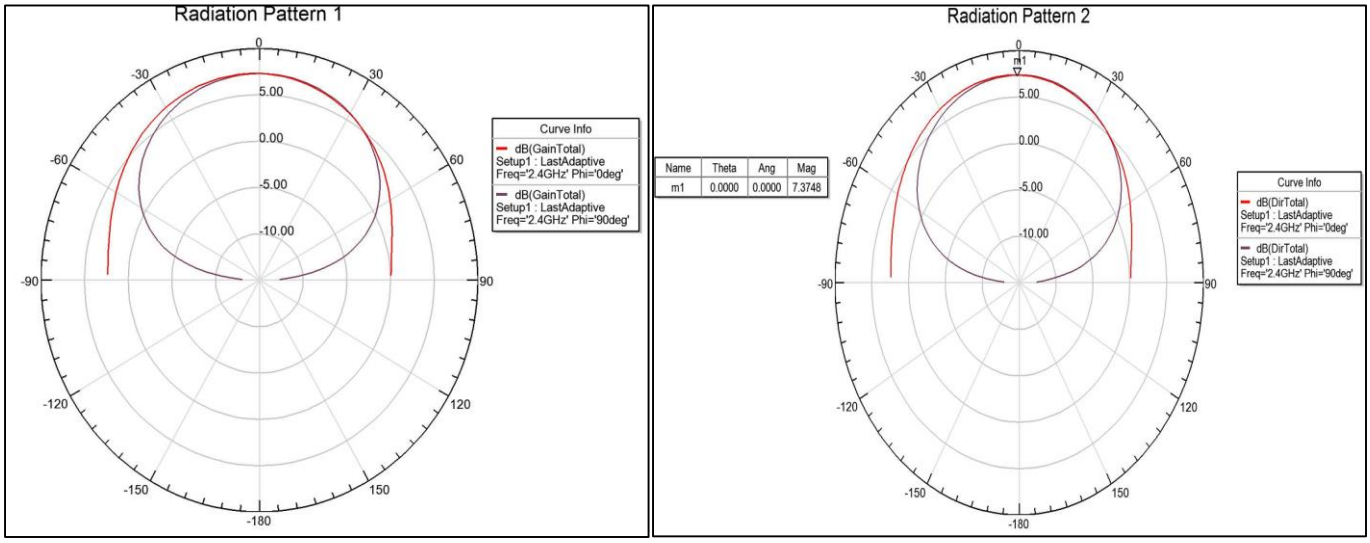

Fig. 2: Radiation Pattern

The figure-3 shows the S-parameter of the antenna. The return loss of the antenna is minimum at 2.4 GHz.

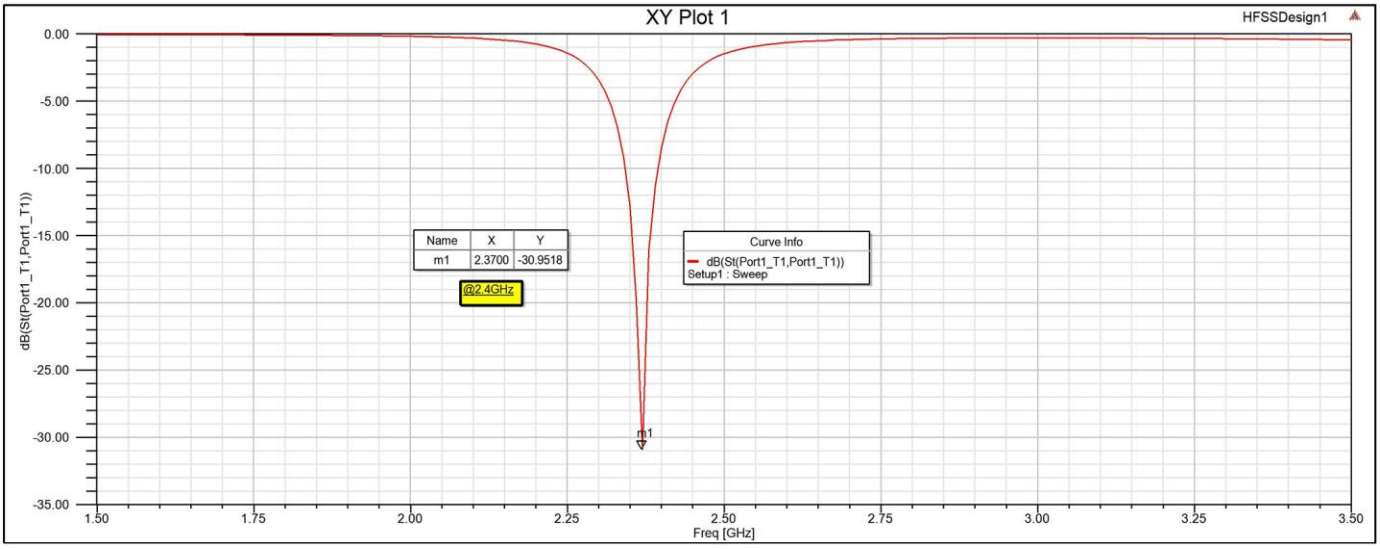

Fig. 3: S Parameter Versus Frequency

The figure 4 shows the Voltage Standing Wave Ratio (VSWR) v/s frequency plot of the designed patch antenna. The VSWR is minimum (equal to 1.0583) at 2.4 GHz.

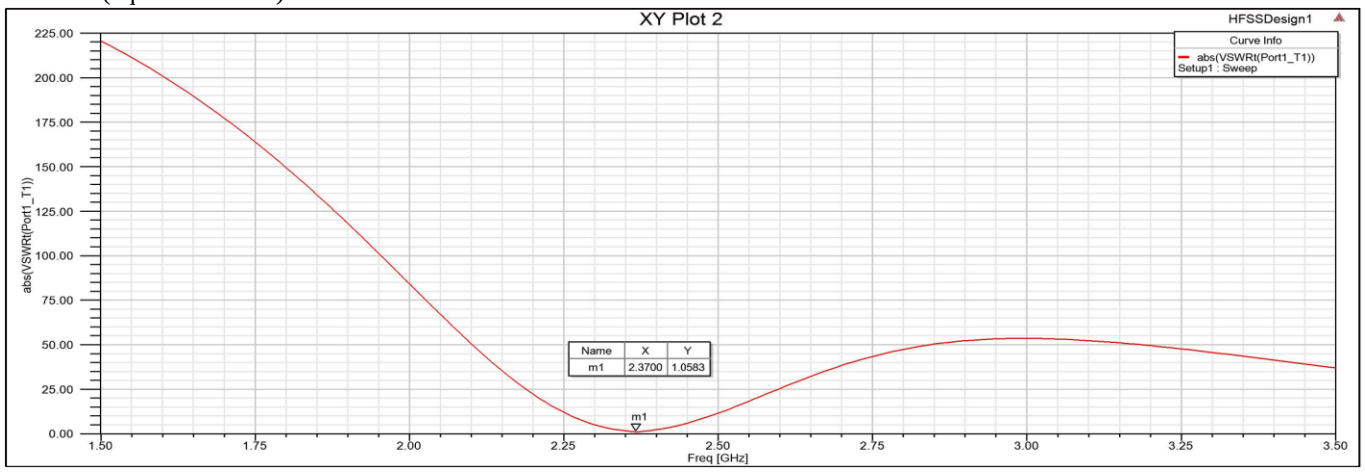

Fig.4 VSWR Versus Frequency

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IV. CONCLUSION

In this paper a Microstrip rectangular patch antenna is successfully designed at a resonant frequency of 2.4 GHz. The antenna shows a healthy gain if 7.37dB. The VSWR of the antenna is 1.05.

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