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# Design and Analysis of Single Microstrip Patch Antenna with Proximity Coupler Fed Technique for Wireless LAN Application

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***Abstract:*** *This paper presents an analysis and designing single patch microstrip antenna with proximity coupler fed technique at 2.4 GHz resonant frequency appropriate for wireless LAN (WLAN) application. The software used to simulate the patch antenna is Computer Simulation Tools (CST) Microwave Environment. This antenna is fed by a 50 Ω single microstrip line feeding based on quarter wave impedance matching technique with width 1.68 mm. In this paper, the effects of antenna parameters like the frequency, return loss, voltage standing wave ratio (VSWR) and gain (dB) are analyzed by using proximity coupler fed technique. The construction of the antenna consists of the microstrip feed line on a substrate proximity coupled to a single rectangular microstrip patch etched in top of surface. The dielectric constant of antenna is 3, the tangent loss 0.03 and thickness of the antenna is 0.76 mm.*

***Keywords:*** *patch antenna, proximity coupler fed technique, return loss, VSWR, WLAN*

## I. Introduction

Microstrip antenna have been one of the most innovative topics in antenna theory and design in recent years, and are increasingly finding application in a wide range of modern microwave systems [1]. It provide small size antennas as there is much acute space available in these devices due to their compact sizes [2-4]. The microstrip patch antennas are well known for their performance and their robust design, fabrication and their extend usage [5]. Microstrip antennas are spreading widely in all the fields and areas and now they are becoming in the commercial aspects due to their low cost of the substrate material and the fabrication. There are many applications of microstrip patch antenna due to the increasing of their usage, such as mobile and satellite communication application, Global Positioning System (GPS) application, Radio Frequency Identification (RFID) application, radar application, telemedicine application and so on. Microstrip patch antennas are widely used because of their many advantages, such as the low profile, light weight and conformity. However, patch antennas have a main disadvantage which is narrow bandwidth [6]. The basic construction of microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has aground plane on the other side [7].

Recently, wireless local area network (WLAN) applications are very popular. WLANs can achieve lower transmission latency in the presence of more powerful networks [8] and also capable of providing a high data rate to the end user. The frequency of 2.4 GHZ offers a data rate up to 11 Mb/s [9].

Microstrip patch antennas have several well-known feeding techniques, which are coaxial probe fed (CPF), microstrip transmission line fed (TLF), proximity coupled fed (PCF) and aperture coupled fed (ACF). In proximity coupler fed microstrip patch antennas [10] technique, offer various advantages conventional edge or coaxial probe fed patches. It allow the patch to exist on a relatively thick substrate for improve bandwidth. The feed line with thinner substrate reduces the spurious radiation [1] and coupling. An advantage of proximity coupling is that it provides large bandwidth and low spurious radiation [11]. The dielectric layers need the proper alignment and increase the overall thickness of the patch antenna.

In this paper, Figure 1 shows the geometric structure of a single patch antenna with proximity couple fed. The configuration of the proposed antenna consists of two substrates, a top substrate called the antenna substrate and a bottom substrate called the feed substrate [12]. On the top of feed substrate, the feed line is designed to have a characteristic impedance of 50 Ω. The bottom of feed substrate has a copper ground plane. The antenna substrate has a copper patch etched on it.

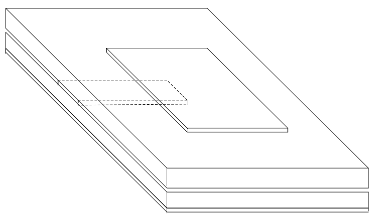


**Figure 1:** Geometry of single patch antenna with proximity coupler fed

## II. Antenna Design and Structure

A single patch antenna has been designed with over all dimensions width, W (mm) x Length, L (mm). The designing of proximity coupler fed patch antenna is set at resonant frequency $f_r = 2.4$ GHz and the dielectric substrate Taconic RF-30 (loss free) is used. The dielectric constant of the substrate is $\varepsilon_r = 3$, the tangent loss 0.03 and thickness of the substrate h = 0.76 mm. The width and length of the microstrip antenna are calculated using following equations.

$$W = \frac{1}{2f_r\sqrt{\mu_o\varepsilon_o}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{V_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

Where $V_0$ is the free-space velocity of light.

The dimensions of the patch along its length have been extended on each by a distance $\Delta L$, which is a function of the effective dielectric constant $\varepsilon_{reff}$ and the width-to-height ratio (W/h) and the normalized extension of the length.

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

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

The actual length, L of the patch can be determine as follows

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_o\varepsilon_o}} - 2\Delta L \qquad (4)$$

The proposed geometry on Figure 2 shows the five layers for four components which are ground, feed substrate named as substrate 1, feed line, antenna named as substrate 2 and patch. Feed line placed in between two substrates, substrate 1 and substrate 2 and used copper material. The bottom line also used copper material and designed for ground. Figure 3 shows the top view of the proximity coupled fed patch antenna. The width and length for ground same with the width and length for substrate 1 and substrate 2 which is (88mm X 72 mm). In the design, a single rectangular patch is etched on the top surface of substrate 2 with the width, W is 44mm and length, L is 36mm. Both of substrates used Taconic RF 30 (loss Free) with 0.76 mm of thickness, h. Dielectric constants, $\varepsilon_r$ for these substrates is 3 mm. The microstrip feed line length, $L_f$ is 22mm and the $W_f$ calculated in order to get the feed line impedance of 50 Ω. The dimensions of the single patch antenna with proximity coupled fed are shown in Table 1. The single patch antenna with proximity couple is simpler in construction but to get the frequency of 2.4 GHz and return loss, $S_{11}$ smaller than -10dB, the dimension of length, L of patch need to be optimized.

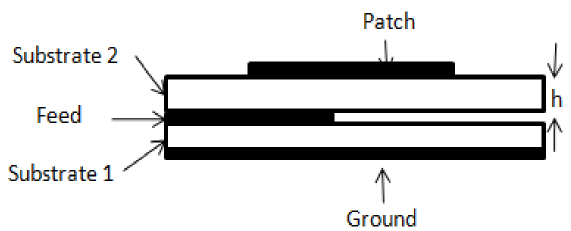



**Figure 2:** Side view of single patch antenna with proximity coupler

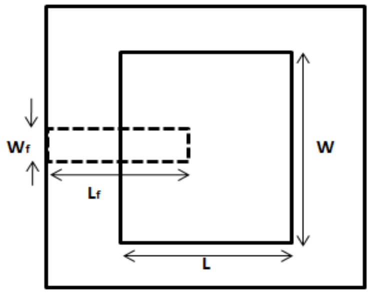



**Figure 3:** Top view of single patch antenna with proximity coupler

**Table 1:** Dimensions of the Optimization Antenna

| | |
|---|---|
| Frequency, $f_r$ | 2.4 GHz |
| Patch | Copper |
| W | 44.0 mm |
| L | 33.325 mm |
| Fed | Copper |
| $W_f$ | 1.68 mm |
| $L_f$ | 22 mm |
| Substrate 1, Substrate 2 | Taconic RF 30 (loss free) |
| Dielectric constant, $\varepsilon_r$ | 3 mm |
| Thickness, h | 0.76 mm |
| Tangent Loss | 0.03 |

## III. Results and Discussions

The design of this proximity coupler fed patch antenna need to be optimized the length of patch to get the resonant frequency at 2.4 GHz. Simulation results show that the antenna exhibits three different lengths to get the resonant frequency. For the first simulation, the value of resonant frequency is 2.233 GHz with length of 33mm. When optimized the length of patch to 31 mm, the resonant frequency is at 2.568 GHz and when optimized again the length of patch, the resonant frequency is at exactly at 2.4GHz. The length of patch is optimized to 33.325mm to get 2.4GHz. Figure 4 and 5 show the results for three resonant frequencies of return loss and VSWR respectively. These results are tabulated in Table 2.

Return loss is the property of an amount of power which is reflected back to the source from an incorrectly terminated line. It should be as large a negative number as possible. The simulated result shows that all frequencies have good return loss which is lower than -10 dB.

VSWR is a measure of how much power is delivered to an antenna. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0, in which case none of the power is reflected, which is the ideal case. From the VSWR result, it was observed that the VSWR operated resonant frequency at 2.4 GHz is 1.511.

At resonant frequency of 2.4 GHz, the bandwidth estimated is about 1.3 %. It can be said that the proposed proximity coupler fed patch antenna operated at narrow bandwidth.

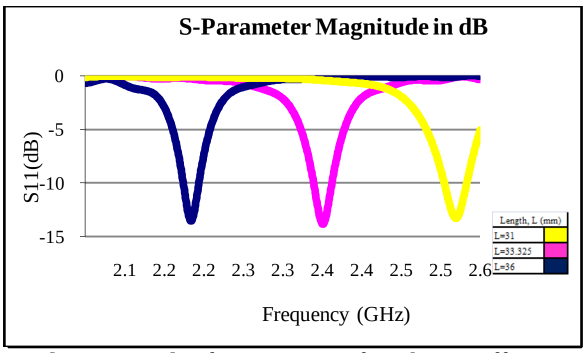



**Figure 4:** Simulation Result of Return Loss for Three Different Frequencies.

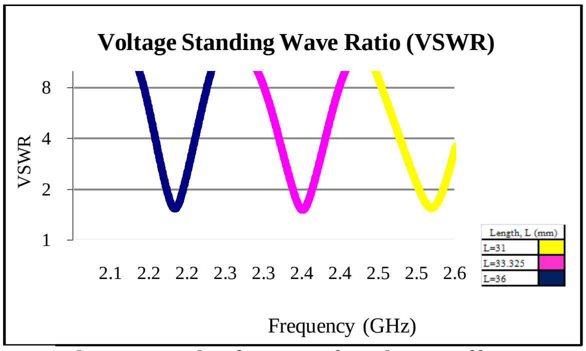
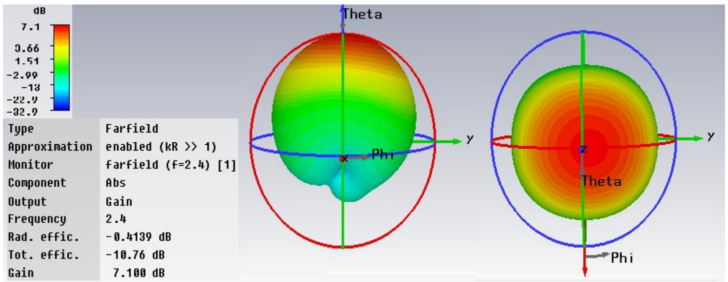



**Figure 5:** Simulation Result of VSWR for Three Different Frequencies.

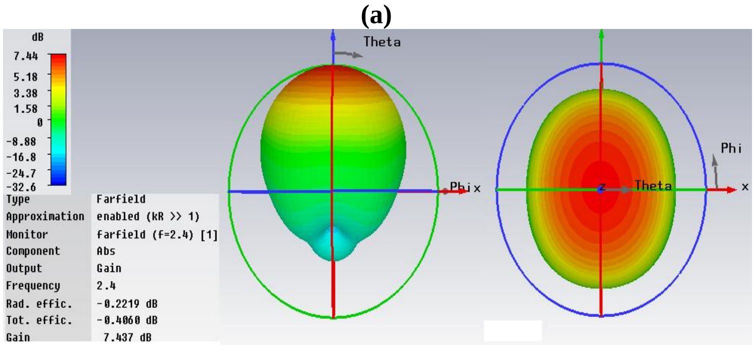
**Table 2:** Tabulated Results of Frequency, Return Loss and VSWR

| | Length, L (mm) | | |
|---|---|---|---|
| | L=31 | L=33.325 | L=36 |
| Frequency (GHz) | 2.57 | 2.4 | 2.23 |
| Return loss, $S_{11}$ (dB) | -13.28 | -13.82 | -13.57 |
| VSWR | 1.511 | 1.554 | 1.534 |

Figure 6 shows the simulated far-field amplitude at three frequency bands. The figure shows that the maximum gain is 7.437, 7.1 and 6.712 dB at 2.4, 2.568 and 2.233 GHz respectively. Besides, the figure shown that this antenna has good directional radiation pattern at 2.4 GHz compared to another frequency.




**(a)**




**(b)**

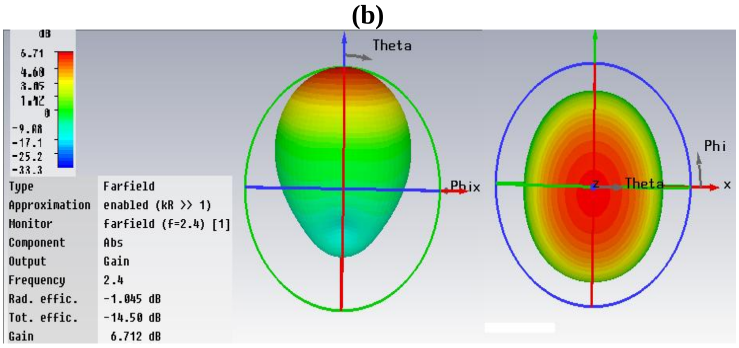



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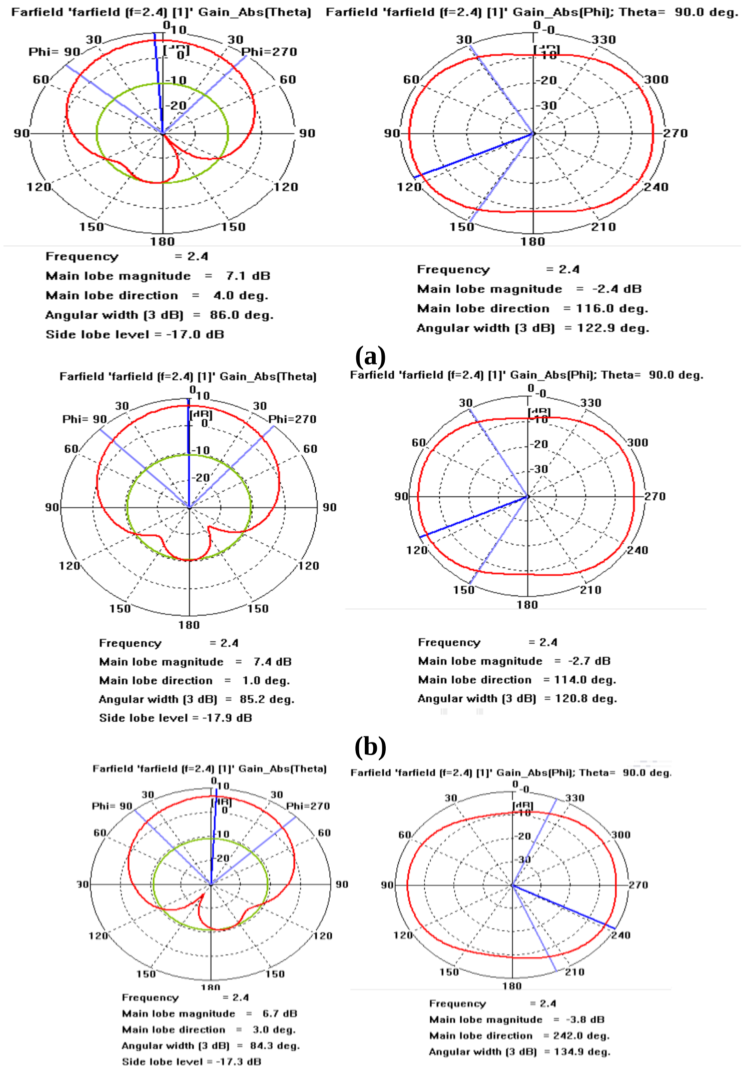
**Figure 6:** Simulated Far-Field Amplitude at different Frequencies at different of patch length.(a) 2.57 GHz, (b) 2.4 GHz and (c) 2.23 GHz

Figure 8 shows the simulated radiation pattern at 2.23, 2.4 and 2.57 GHz.dy9 Half power beamwidth (HPBW) is the angle between the two directions in which the radiation intensity is one-half value of the beam in a plane containing the direction of the maximum of a beam. On the other words, the HPBW (-3 dB) is a measure of the directivity of the antenna.




**(c)**

**Figure 7:** Simulated Radiation Pattern at (a) 2.23 GHz, (b) 2.4 GHz and (c) 2.57 GHz

A side lobe is a radiation lobe in any direction other than the intended lobe. The side lobe of far field radiation pattern at 2.4 GHz can be observed in Figure 7(b). The radial distance from the center represents signal strength. The signal strength for the side lobes is **-**17.9 dB. It can be observed in Figure 7(b) that the antenna's gain is in forward direction (0°) at 2.4 GHz. This is better as compared to 2.23 and 2.57 GHz frequency that attains to the left and right direction respectively.

## IV. Conclusion

The single patch antenna with proximity coupler fed is presented in this paper for coverage standard IEEE 802.11 in 2.4GHz band resonant frequency. By only adjusting the length of the patch, it can obtain the desired result at the resonant frequency and satisfactory performances. From the simulation results, it can be conclude that the antenna operate optimally at resonant frequency 2.4 GHz with good return loss, VSWR and gain compared to other frequencies.

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