

Development of Micro patch Antenna with Proximity Coupler Fed Technique for WLAN Application

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Abstract

This paper presents an analysis and designing single patch microstrip antenna with proximity coupler fed technique at 2.40 GHz resonant frequency appropriate for wireless LAN application. The software used to simulate the patch antenna is HFSS. This antenna is fed by a 50Ω single microstrip line feeding based on quarter wave impedance matching technique with width 1.67 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 micro patch etched in top of surface. The dielectric constant of antenna is 3.0, the tangent loss 0.02 and thickness of the antenna is 0.77mm.

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

Introduction

The antenna is a vital part of any wireless communication system. Micro patch 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. It provides small size antennas as there is much acute space available in these devices due to their compact sizes. The micro-patch antennas are well known for their performance and their robust design, fabrication and their extend usage.

Micro patch 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 micro 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. micro 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. The basic construction of micro patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the

other side.

Micro patch antennas have several well-known feeding techniques, which are coaxial probe fed (CPF), micro transmission line fed (TLF), proximity coupled fed (PCF) and aperture coupled fed (ACF). In proximity coupler fed micro patch antennas 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 and coupling. An advantage of proximity coupling is that it provides large bandwidth and low spurious radiation. 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. On the top of feed substrate, the feed line is designed to have a characteristic impedance of 50Ω . The bottom of feed substrate has a copper ground plane.

The antenna substrate has a copper patch etched on it.

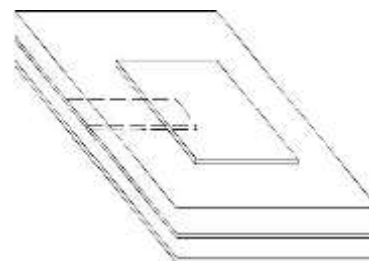


Figure 1: Geometry of single patch antenna with proximity coupler fed

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 $\epsilon_r = 3.0$, the tangent loss 0.02 and thickness of the substrate $h = 0.77$ mm. The width and length of the microstrip antenna are calculated using following equations.

$$W = \frac{1}{2f_r \sqrt{\mu_o \epsilon_o}} \sqrt{\frac{2}{\epsilon_r + 1}} = \frac{V_0}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}}$$

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 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.

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[\frac{h}{W} \right]^{-1.2}$$

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

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

$$L = \frac{1}{2f_r \sqrt{\epsilon_{\text{reff}} \mu_o \epsilon_o}} - 2\Delta L$$

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 0.77 mm of thickness, h . Dielectric constants, ϵ_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.

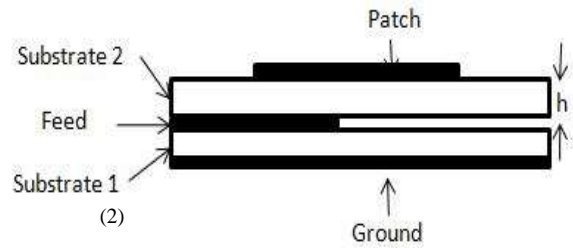


Fig2: Side view of the single patch with proximity coupler feed

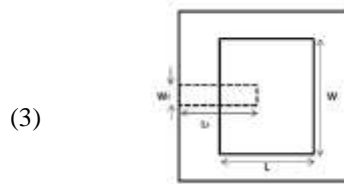


Figure 3: Top view of single patch antenna with proximity coupler

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, ϵ_r	3 mm
Thickness, h	0.77 mm
Tangent Loss	0.02

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.

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

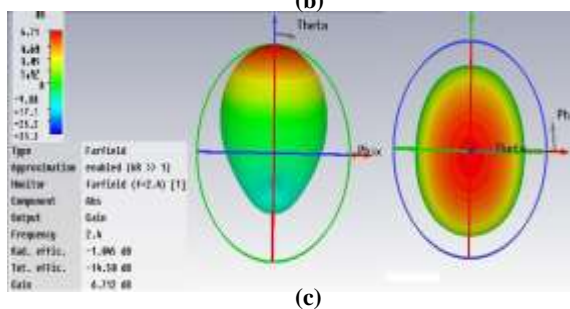
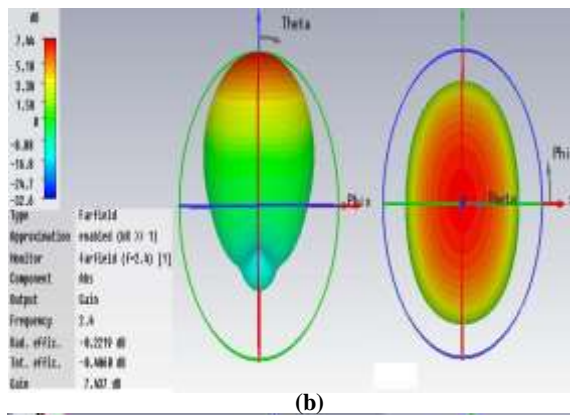
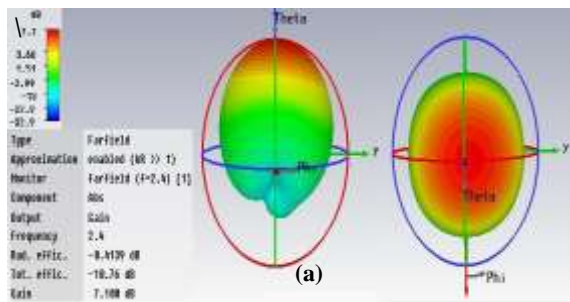
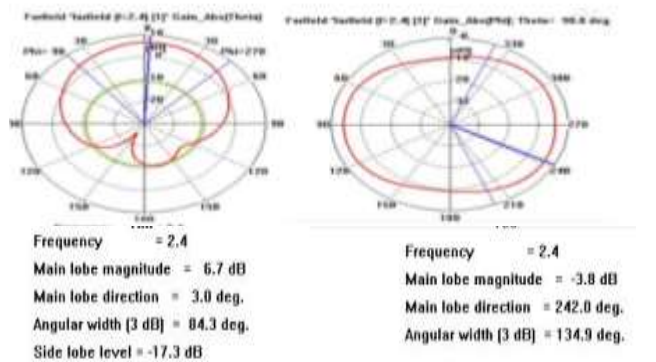
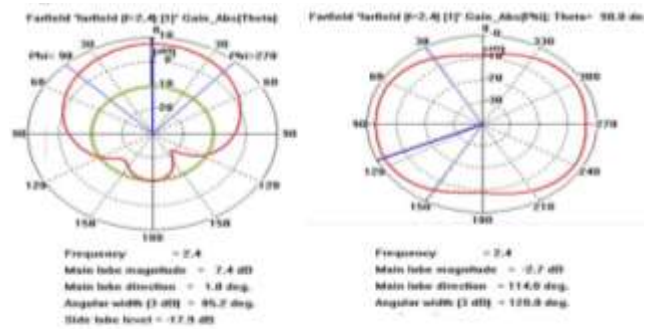
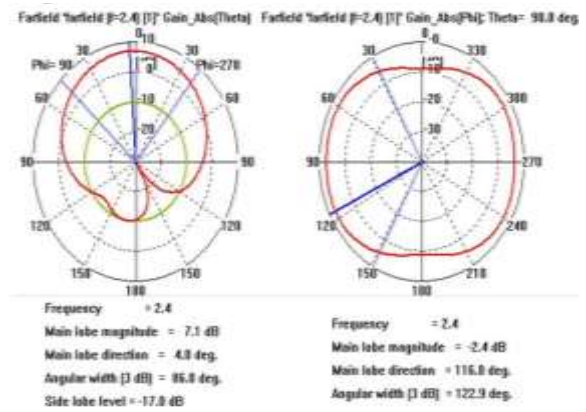


Figure 4: Simulated Far-Field Amplitude at different Frequencies at different of patch length.
 (a) 2.57 GHz (b) 2.4 GHz (c) 2.23 GHz

Below Figure shows the simulated radiation pattern at 2.23, 2.4 and 2.57 GHz. 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.



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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