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Design of Microstrip Patch Antenna for WLAN Applications

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Abstract— **In this paper, we present a rectangular microstrip patch antenna for 2.4GHz for WLAN application. The proposed antenna is designed and simulated using Advanced Design System at 2.4GHz. The reduced size, low cost, higher bandwidth, good radiation parameters and easy fabrication are the advantages of this antenna design. This microstrip patch antenna can be easily designed, built and applied for wireless communication.**

Keywords—microstip, patch antenna, return lossstyle; styling; insert (key words)

I. Introduction

An Antenna is a transducer, used to convert RF field into AC or vice versa. Now a day, the microstrip antennas are commonly used because of its reduced costs and easy of fabrication. These antennas are primarily used for space borne applications and commercial applications. The microstrip antennas are low profile, simple and inexpensive to fabricate using modern printed circuit technology. These antennas can be used in a surface for spacecraft, satellites, missiles and handheld mobile telephones. The antennas are comfortable to planar and nonplanar surfaces. Wireless applications are easy to install anywhere based on choice. This flexibility is one of the great benefits of wireless network.

A microstrip patch antenna has a radiating patch on one side of a dielectric substrate with a ground plane on the other side. The radiating patch and the feed lines are usually photoetched on the dielectric substrate. Microstrip patch antennas radiate between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation [1]. Microstrip patch antennas are increasing popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc.

In this paper, a new microstrip patch antenna for WLAN applications is proposed. The technique consists and optimizes a microstrip antenna with full ground plane at 2.4GHz with reduced return loss. The antenna has special features like conformability low profile, durability, compactness comparing to other antennas. Due to advancement in technologies is become smaller in size to transmit and receive signals. Studies of microstrip patch antenna for WLAN applications with DGS are shown in [2]. However these also have disadvantage like low efficiency and narrow bandwidth [3]. The designed antenna is studied for return loss and bandwidth.

II. Antenna Design

Microstrip patch antennas has a very high quality factor Q representing the losses associated with the antenna where a large Q provides a narrow bandwidth and low efficiency. The Q factor can be reduced by increasing the thickness of the dielectric substrate but the increase in thickness increases the total power delivered by the source into a surface wave which can be effectively considered as an unwanted power loss because it is ultimately scattered at the dielectric bends and causes degradation of characteristics of antenna. Other issues such as lower gain and lower power handling capacity can be overcome by using an array configuration for the elements which is a collection of homogeneous antennas oriented to get greater directivity and gain in a desired direction [4]. The inset-fed microstrip antenna provides impedance control with a planar feed configuration.

A microstrip antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on other side as shown in the figure below. The patch is generally made of conducting material such as copper or gold. The basic antenna element is a strip conductor of length L and width W, on a dielectric substrate. The thickness of the patch being h with a height and thickness t is supported by a ground plane. The rectangular patch antenna is designed so that it can

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operate at the resonance frequency. The length of the patch for a rectangular patch antenna normally would be 0.333λ< L < 0.5λ, where λ is the free space wavelength. For a rectangular patch, the length *L* of the element is usually $L < \lambda g/2$, where λg is the guide wavelength on the substrate. Thicker substrates with lower dielectric constant provide better efficiency and larger bandwidth but at the expense of larger element size. Thin substrates with higher dielectric constants lead to smaller element sizes, minimize coupling, but are less efficient and have relatively smaller bandwidths.

The length of the patch can be calculated by the equation

L ≈ 0.49 λd = rελ49.0 (1)

The height *h* of the dielectric substrate is usually $0.003\lambda o \leq h \leq 0.05\lambda o$. The dielectric constant of the substrate (ε_r) is typically in the range $2.2 \leq \varepsilon_r \leq 12$. The patch of the antenna is being excited by feed which can be a edge feed, a probe feed or coaxial feed or an aperture feed. When the patch is excited by feed a charge distribution is established between the ground plane and the underneath of the patch. The underneath of the patch is charged to positive and the ground plane is charged to negative after the excitation by feed. The attractive forces are being setup between the planes i.e., patch underneath and the ground plane. The patch antennas radiates due to the fringing fields between the underneath of the patch and the ground plane [1,6]. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size. In order to design a compact microstrip patch antenna, substrates with higher dielectric constants must be used which are less efficient and result in narrower bandwidth.

There are three essential parameters for the design of a rectangular microstrip patch antenna is operating frequency, substrate's dielectric constant and thickness of the dielectric substrate. The resonant frequency of the antenna designed in this paper is 2.4GHz with the substrate having dielectric constant of 4.3.

The patch is the main line which is feed by the microstrip feed line with the input impedance of 50Ω. The main line has an input impedance of less than 50Ω which is 10Ω. The input is given through the feed line to the main line where the return loss occurs [7, 8]. The parameters are calculated using the line calculator in the software. The electrical parameters are given and the physical parameters are calculated. The calculated physical parameters are used in the design. The structure of the patch antenna is shown in figure 1.

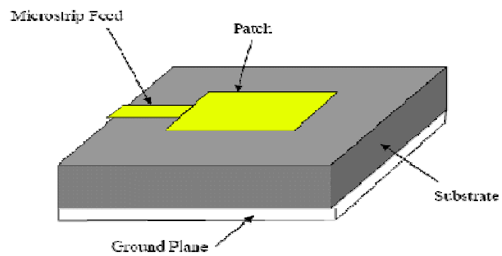

Figure 1. Structure of Patch Antenna

The width of the microstrip patch antenna is given by

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

where c is the free space velocity, ε_r is relative dielectric constant and f_0 is operating frequency.

The effective dielectric constant is given by

$$\varepsilon_{reff} \approx \frac{\varepsilon_r + 1}{2} \quad (3)$$

The effective length [9,10] is given by

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

The length extension is obtained using the expression

$$\Delta L = 0.412 \frac{\left(\frac{W}{h} + 0.264\right)(\varepsilon_{reff} + 0.3)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (5)$$

The actual length is obtained by

$$L = L_{eff} - 2\Delta L \quad (6)$$

The design parameters are dielectric constant (ε_r) is 4.3, dielectric thickness (H) is 1.5mm, conductor thickness (T) is 20µm, loss tangent (tan δ) is 0.003, operating frequency is 2.4GHz, input impedance (Z_0) is 10Ω and effective permittivity is 180°. From the electrical parameters, the physical parameters length and width are obtained. The value of length is 31.248mm and width is 24.0659mm. [6] discussed about E-plane and H-plane patterns which forms the basis of Microwave Engineering principles.

DESIGN 1

The design has input feed line and microstrip line and a port. These components are connected through the wire. The input feed line has a width of 2.9mm and a length of 10mm. The microstrip line has a width of 24mm and a length of

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31mm. The design can be structured in schematic and further converted into layout. Figure 2 shows the schematic window of the patch antenna and Figure 3 shows the layout design of patch antenna converted from the schematic window.

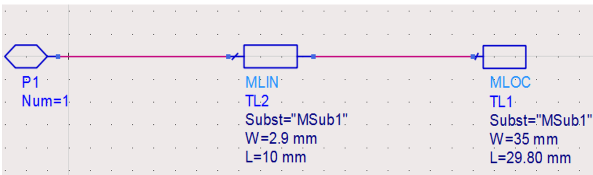

Figure 2. Schematic representation of microstrip patch antenna design 1

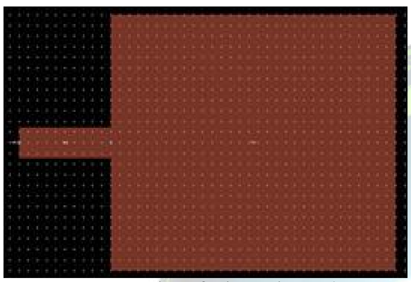

Figure 3. Layout representation of microstrip patch antenna design 1

DESIGN 2

In this design along with input feed line and microstrip line a MACLIN3 which is taken from microstrip feed line is placed in between the input and the output feed line. In this the length of input feed line is 10mm and the width is 2.9mm.The length and width of output feed line is 29.80mm and 35mm.The length of MACLIN3 is 8.7mm and has a width of 13.15mm, 2.9mm, 13.15mm. The subset values S_1 and S_2 are 2.9mm. Figure 4 shows the schematic design of the patch antenna and figure 5 shows the layout design of patch antenna converted from the schematic window.

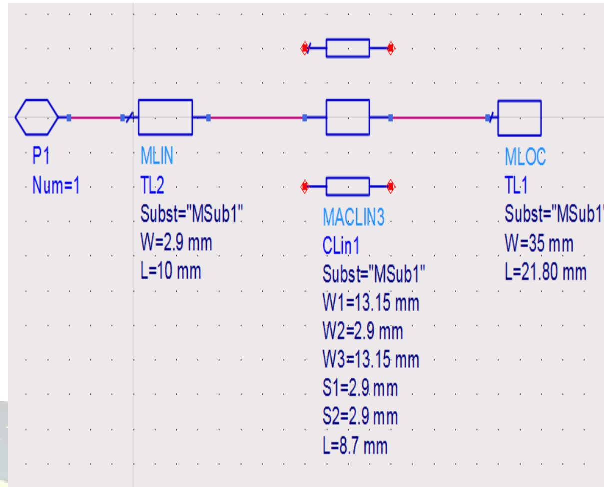

Figure 4. Schematic representation of design 2 microstrip patch antenna

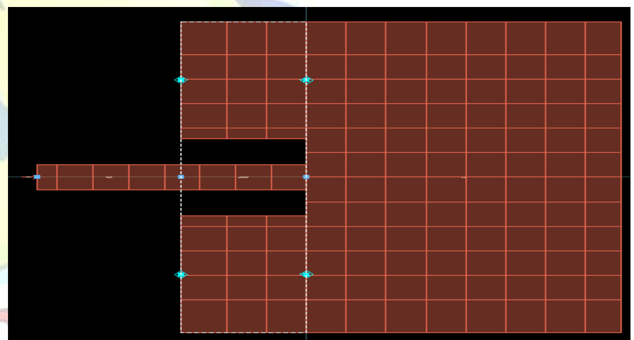

Figure 5. Layout representation of design 2 microstrip patch antenna

DESIGN 3

For the above two designs, TLine microstirp components are used. In this design lumped components are used. The two Antparche are selected after microstrip components are selected with one MTEE_ADS and two MCURVE selected.The MLIN is placed between MCURVE and MTEE_ADS and also between MCURVE and Antparche. The MTEE_ADS is also connected with two input feed line and a port. The width and the length of MLIN is 2.9mm and 12.5mm.The MCURVE has a width of 2.9mm,radius of2.5mm and an angle of 90.The MTEE_ADS has a width of W_1=2.9mm,W_2=2.9mm and W_3=4.95mm.All the components are connected through wire. The schematic design is shown in figure 6. The layout design shown in figure 7 is converted from schematic design. The substrate for all three designs has three layers dielectric, conductor and ground. The dielectric is placed above the ground and the conductor is placed above the dielectric. The dielectric medium used in the design is alumina.

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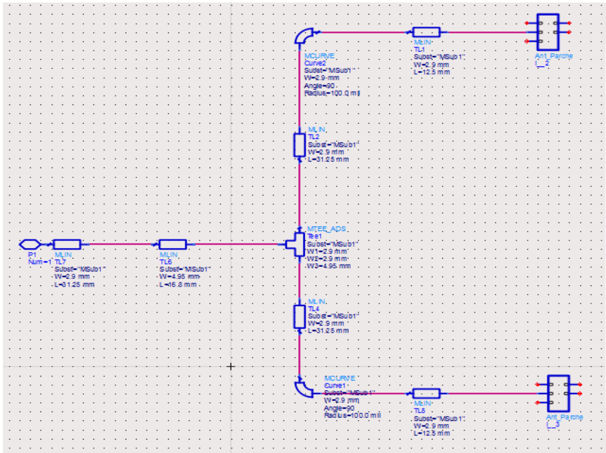

Figure 6. Schematic representation of design 3 microstrip patch antenna

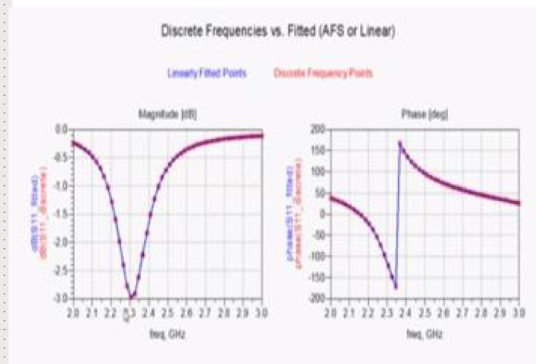

Figure 8. Simulated results for microstrip patch antenna design 1

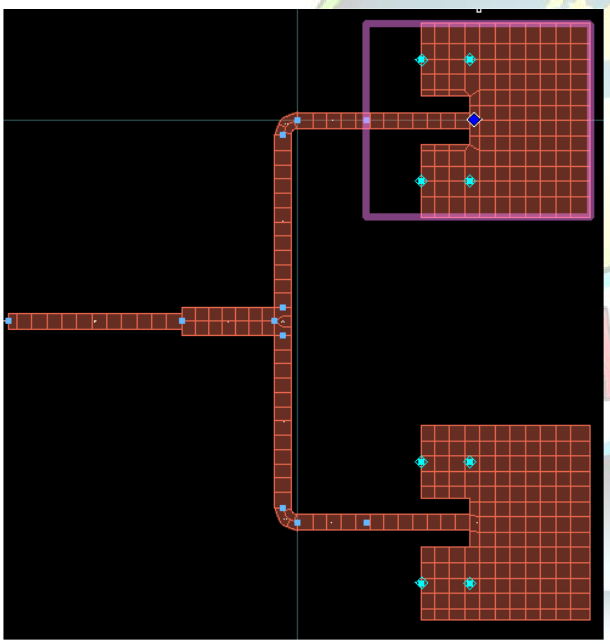

Figure 7. Layout representation of design 3 microstrip patch antenna

III. Simulation Results

The simulation results for the microstrip patch antenna design 1 are shown in figure 8. The results shows a deviation in operating frequency from 2.4GHz to 2.3 GHz. This deviation can be rectified by changing the width and length of the microstrip patch antenna. The S_{11} dB shows the return loss which indicated the amount of power that is lost to the load and does not return as a reflection.

The simulated return loss for the presented structure for design 2 is shown in figure 9 and figure 10. In both linearly fitted and the discrete fitted points the resonant peak achieved at 2.4GHz and 2.8GHz. Thus the antenna is showing the dual band character. The bandwidth for the -10db return loss is 275 MHz at 2.4 GHz. The resulting or achieved bandwidth can cover WLAN standards, Bluetooth standards and even WiMAX standards.

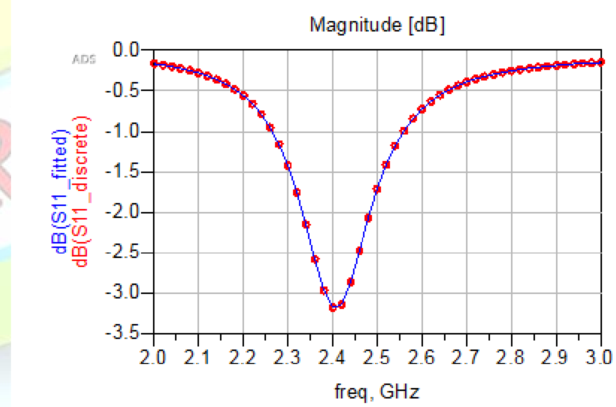

Figure 9. Return loss (dB) for design 2 patch antenna

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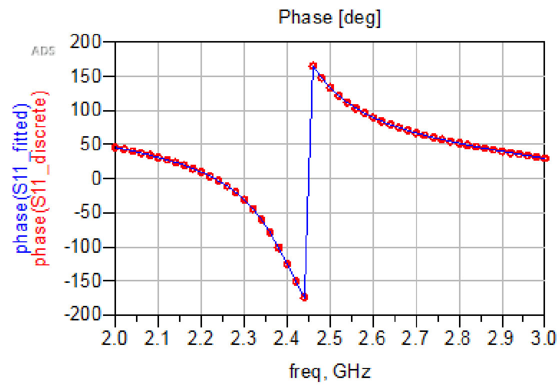

Figure 10. Return loss (phase) for design 2 patch antenna

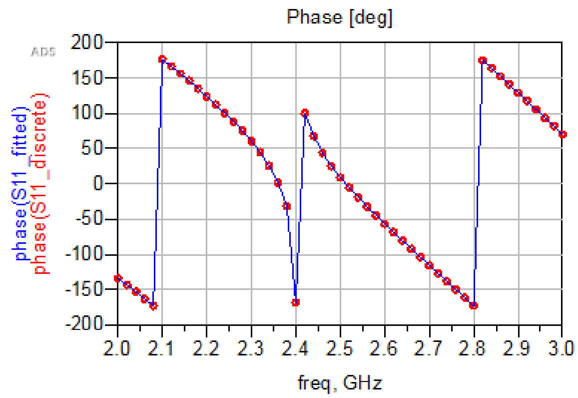

Fig 12: Return loss for discrete frequency points for design 3 patch antenna

The simulated return loss for the presented structure for design 3 is shown in figure 11 and 12. In both linearly fitted and the discrete fitted points the resonant peak achieved at 2.4GHz and 2.8GHz. Thus the antenna is showing the dual band character.

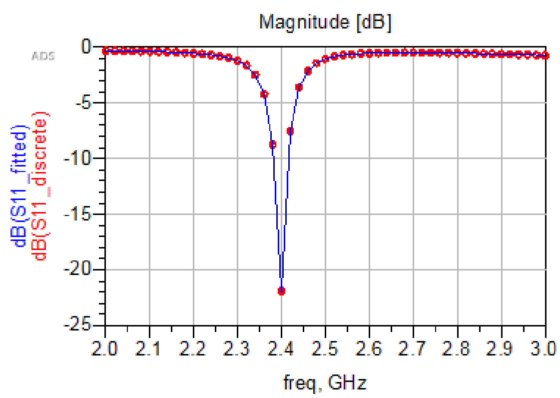

Fig 11: Return loss for linearly fitted points for design 3 patch antenna

For all the designs the resonant frequency is about 2.4 GHz. The parameters achieved for the proposed antenna design has the directivity of 3.207 dBi, Antenna efficiency of 64.1%, gain of 2.053 dB, Return loss of -20.10 and VSWR of 1.21.

IV. Current Distributions

The current distribution for all the three designs is shown in figure 13, 14 and 15.

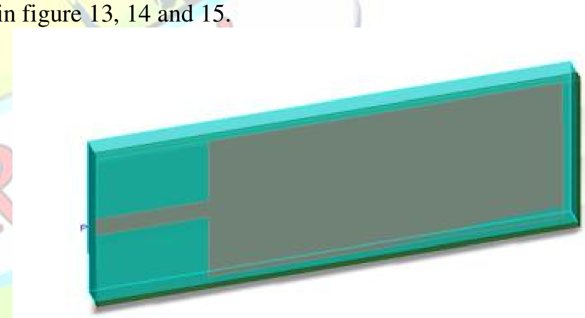

Figure 13. Current distribution for design 1 microstrip patch antenna

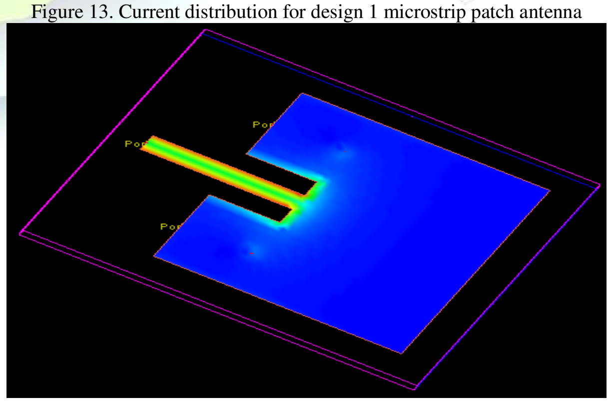

Figure 14. Current distribution for design 2 microstrip patch antenna

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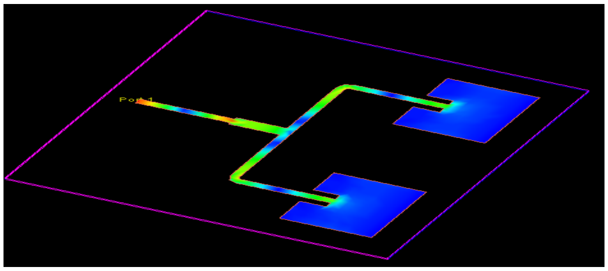

Figure 15. Current distribution for design 3 microstrip patch antenna

V. CONCLUSION

In this paper, microstrip patch antenna for WLAN applications at 2.4GHz is proposed. The condensed size, low cost, ease-of fabrication, large bandwidth and excellent radiation parameters in the comparison with earlier reported designs are the advantages of the proposed antenna. The proposed antenna is compact in size and provides 25.5% and 11.8% dual band performance covering 2.4/5.2 GHz WLAN applications and also in wireless telecommunication systems. The main aim of this paper is to obtain a minimum return loss compared to other frequency designs.

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