Design of Single Band Rectangular Patch Antenna for WLAN Application

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ABSTRACT
A microstrip patch antenna for WLAN application is proposed. The antenna has a frequency bandwidth of 196 MHz (5103MHz - 5300 MHz). The microstrip antenna has a planar geometry and consists of a ground, a substrate, a patch and a feed. The basic theory and design are analyzed, and simulation using CST Microwave Studio commercial software is employed to optimize the antenna's properties. Results show that the proposed antenna has promising characteristics for WLAN application at 5.21 GHz frequency.

General Terms
Microstrip line feed, single frequency.

Keywords
Microstrip Antenna, WLAN Communication Standard, CST Microwave Studio.

1. INTRODUCTION
The microstrip antenna have a number of useful properties such as small size, low-cost fabrication, low profile, light weight, conformability, ease of installation and integration with feed networks but one of the serious limitations of these antennas have been their narrow bandwidth characteristics as it limits the frequency ranges over which the antenna can perform satisfactorily. These features are major design considerations for practical applications of microstrip antennas. Recent technologies enable wireless communication devices to become physically smaller in size. Antenna size is obviously a major factor that limits miniaturization. With the rapid growth of the wireless mobile communication technology, the future technologies need a very small antenna.

Wireless local area network (WLAN) and Worldwide Interoperability for Microwave Access (Wi-MAX) technology is the most rapidly growing area in the modern wireless communication [1]. This gives users the mobility to move around within a broad coverage area and still be connected to the network. This provides greatly increased freedom and flexibility. For the home user, wireless has become popular due to ease of installation, and location freedom. Naturally, these applications require antennas. This being the case, portable antenna technology has grown along with mobile and cellular technologies. It is important to have the proper antenna for a device. The proper miniaturized antenna will improve transmission and reception, reduce power consumption, last longer and improve marketability of the communication device. In this paper, a single band microstrip patch antenna for WLAN application is designed and simulated using CST Microwave Studio [4]. The proposed patch antenna resonates at 5.21 GHz frequency.

2. GEOMETRY OF MICROSTRIP PATCH ANTENNA
In this antenna, the substrate has a thickness h=1.6 mm and a relative permittivity ε_r = 4.4. The length and width of patch are L=12.636 mm and W=25.8 mm respectively. The length and width of ground are L=22.83 mm and W=27.154 mm respectively. Edges along the width are called radiating edges and that along the length are called non radiating edges [2].

It can be fed by different methods like microstrip line feed, coaxial probe feed, aperture coupling, electromagnetic coupling and coplanar waveguide (CPW). In this work, microstrip line (50 ohm) feed has been used. Antenna is designed for a resonating frequency of 5.21 GHz and is analyzed using CST Microwave Studio software. For the designing of rectangular microstrip antenna, the following relationships are used to calculate the dimensions of rectangular microstrip patch antenna [3].

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

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\varepsilon_{reff}}}$$

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

$$L = L_{eff} - 2\Delta L$$

$$f_r = \frac{1}{2L\sqrt{\varepsilon_r \varepsilon_0 \mu_0}} = \frac{v_0}{2L\sqrt{\varepsilon_r}}$$

$$W = \frac{1}{2 f_r \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$L_g = 6h + L$$

$$W_g = 6h + W$$

where,
h = substrate thickness
L = length of patch
L_{eff} = effective length
W = width of patch
c = speed of light
f_0 = resonant frequency

ε_r = relative permittivity

ε_{reff} = effective permittivity

L_g = Length of ground plane

W_g = Width of ground plane

3. DESIGN PARAMETERS

Figure 1(a) and 1(b) show the front view geometry and the structure designed on CST Microwave Studio software of proposed microstrip line fed patch antenna with single band operation for WLAN application. The dimensions and feed point location for proposed antenna have been optimized so as to get the best possible impedance match to the antenna. The following parameters are used for design of proposed antenna.

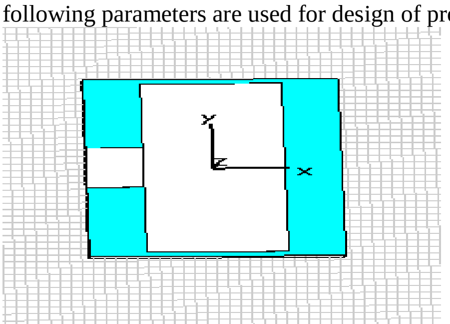

Figure 1 (a): Front view geometry of proposed antenna

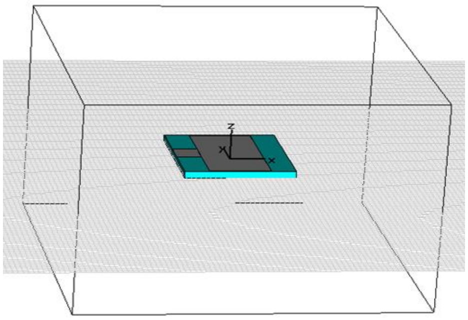

Figure 1 (b): Designed structure on CST microwave studio

Design frequency = 5.21 GHz
Substrate permittivity = 4.4
Thickness of substrate = 1.6 mm
Length of patch (L) = 12.636 mm
Width of patch (W) = 25.8 mm
Length of Ground (L_g) = 22.83 mm
Width of Ground (W_g) = 27.154 mm

4. SIMULATED RESULTS

The S_{11} parameters for the designed antenna were calculated and the simulated return loss results are shown in Figure 2. The bandwidth at the resonating frequency 5.21 GHz is 190 MHz with the corresponding value of return loss as -47 dB. The bandwidth of 190 MHz is achieved as shown in Figure 3. The antenna covers the WLAN standard IEEE 802.11 (5.2 GHz band). The achieved value of return loss is small enough and frequency is closed enough to the specified frequency band for 5.2 GHz WLAN applications. The return loss value i.e. -47 dB suggests that there is good matching at the frequency point below the -10 dB region. The achieved antenna impedance is 50.89 ohm as shown in Figure 4, which is very close to the required impedance of 50 ohm. The VSWR ratio is 1:1.032 is shown in Figure 5, which should lie in between 1 and 2.

Figure 6 shows the simulated 3-D radiation pattern at frequency of 5.2 GHz. It shows that proposed antenna radiates in omni-directional nature. It also shows that the directivity of proposed antenna is 6.394 dBi at resonating frequency of 5.2 GHz.

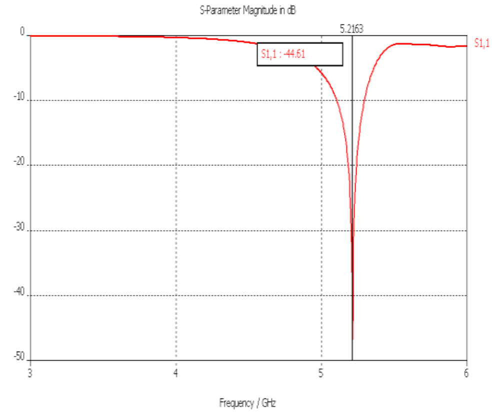

Figure 2: Simulated Return Loss Curve

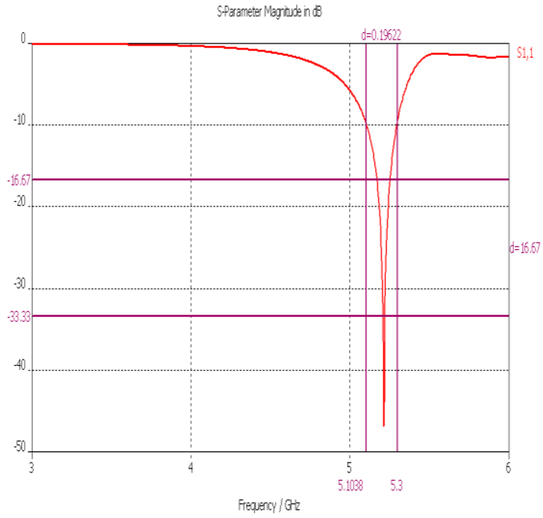

Figure 3: Bandwidth plot

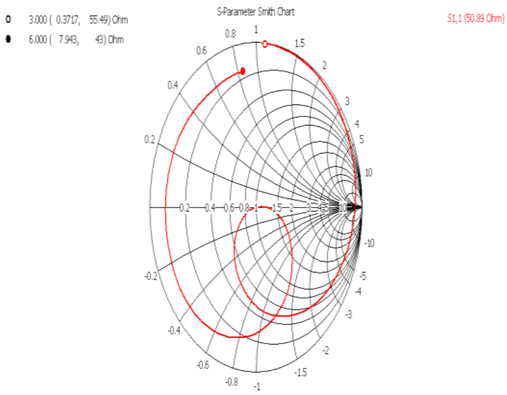

Figure 4: Curve showing antenna characteristic impedance

Figure 7(a) and 7(b) show the Elevation (E-plane) and Azimuthal (H-plane) radiation patterns at the resonating frequency of 5.2 GHz.
The maximum achievable gain over the entire frequency band is 7.898 dB.

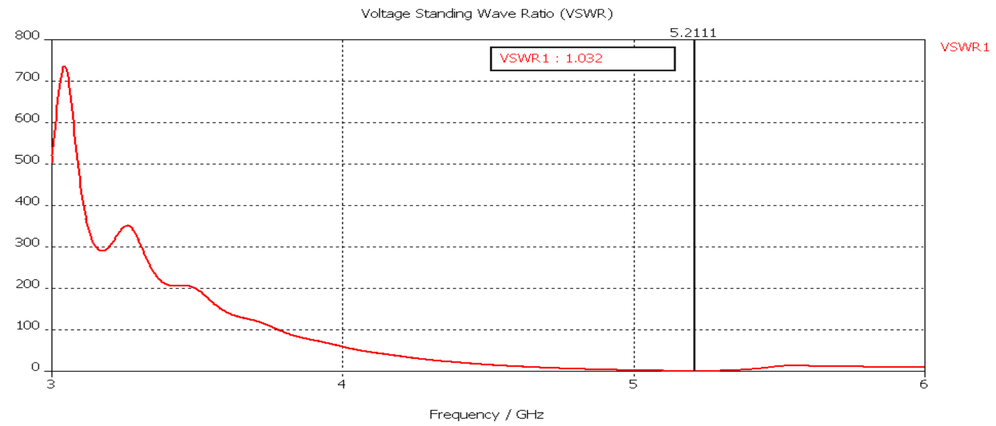

Figure 5: VSWR curve

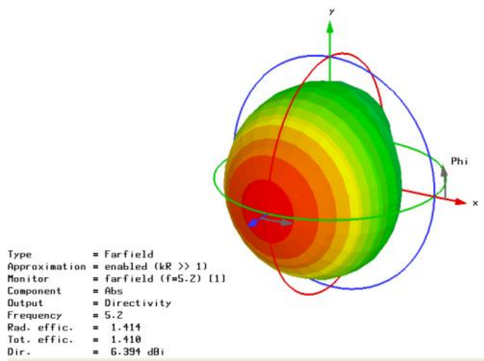

Figure 6: 3-D Radiation Pattern of Patch antenna at 5.2 GHz

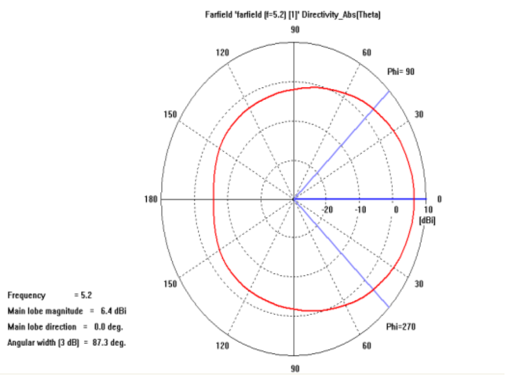

Figure 7 (a): Elevation radiation pattern of proposed patch antenna at 5.2 GHz

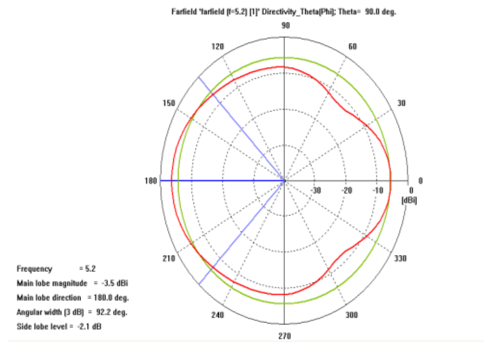

Figure 7 (b): Azimuthal radiation pattern of proposed patch antenna at 5.2 GHz

5. CONCLUSION

A microstrip line fed single frequency microstrip patch antenna has been designed and simulated using CST Microwave Studio software. This is operating in the frequency band of 5.108 GHz – 5.298 GHz covering 5.2 GHz WLAN communication standard. The simulated impedance bandwidth at the 5.2 GHz band is around 190 MHz with the corresponding value of return loss as -47 dB which is small enough and frequency is closed enough to the specified frequency band feasible for WLAN application. This return loss value i.e. -47 dB suggests that there is good impedance matching at the frequency point below the -10 dB region.

An omni-directional radiation pattern result has been obtained which seems to be adequate for the envisaged applications. The antenna also shows quite good gain of 6.948 dB at 5.2 GHz frequency band of wireless communication with a good impedance matching of 50.89 ohm.

However, the size of the microstrip antenna, reported here, is not very small. Cutting inclined slots on the patch, the size of the microstrip antenna may be reduced, also the bandwidth may be enhanced. Work is going on to achieve even better results with good axial ratio over a wide bandwidth.

6. ACKNOWLEDGEMENTS

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7. REFRENCES

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