Design and Analysis of Rectangular Microstrip Patch Antenna for Global WLAN Applications Using Matlab and CST Microstudio Software

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Abstract:
In the recent years the development in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequency. This technological trend has focused much effort into the design of a Microstrip patch antenna. However, the difficult of antenna design increases when the number of operating frequency band increase. In additional, for miniaturization the wireless communication system, the antenna must also be small enough to be placed inside the system. In order to transmit and receive more information large bandwidth are required, and bandwidth enhancement is currently a popular research area. The aim of this thesis is to design a rectangular microstrip path antenna for global WLAN systems and study the effect of various antenna parameters such as the performance of the antenna in term of radiation pattern Directivity, gain, bandwidth, VSWR, return loss and, far-field etc. here line feed method was used to exited the patch antenna. The First antenna was designed to operate at a resonant frequency of 2.45GHz dielectric substrate (Rogers RT5870) with relative permittivity (εr=2.33) and thickness of 0.787mm, for applications such as IEEE 802.11 Wi-Fi, IEEE 802.15.1 Bluetooth, IEEE 802.15.4 ZigBee, wireless USB, microwave oven, codeless phone etc. The proposed antennas have been design using Matlab, modeled and simulated by using computer simulation technology (CST) micro studio. The simulation results of designed antennas indicate that the proposed antenna fulfils the excellent requirements and characteristics for various frequency bands and showing the good radiation patterns and characteristics in the interested WLAN communication.

INTRODUCTION
The field of wireless communications has been growing since the invention of portable mobile phones some decades ago. The success of the second-generation (2G) cellular communication services leads to the development of wideband third-generation (3G) and fourth-generation (4G) cellular phones and other wireless products and services, including wireless LAN, Bluetooth etc. The devices using these communication services are mostly portable and run on batteries. That means, components in these devices should be of small size and consume low power. Moreover, some wireless devices are required to support multiple wireless services and very high data rate. As an antenna is the crucial part of any wireless device, the development of highly efficient, low-profile, small-size, multi-band and wide band antennas that can be made embedded into wireless products are very much demanded.

Microstrip patch antennas are more popularly used now a days due to its various advantages such as light weight, low volume, compatibility with integrated circuits, easy to install on the rigid surface, low cost, very low profile, are mechanically rugged and are inexpensive to fabricate. Microstrip patch antennas are design to operate in single band, dual-band and multi-band applications either dual or circular polarization. These antennas are used in different handheld communicating devices [4]

The simple Microstrip patch Antenna [3] consists of a dielectric substrate having fixed dielectric constant. Radiating patch is present on one side of a dielectric substrate and a ground plane is present on other side of a substrate. The metallic patch may take any geometrical shapes like rectangular, triangular, circular, helical, ring, elliptical etc. The dimension of the patch corresponds to the resonant frequency of antenna. However, microstrip patch antennas are having narrow bandwidth and bandwidth enhancement is necessary for most of the practical applications, so for increasing the bandwidth different approaches have been utilized. In addition most of the applications which uses microstrip antenna in communication systems like mobile handheld communicating devices require smaller antenna size. Different advance tools to the design of very compact microstrip patch antennas have been introduced over years. [3]
DESIGN AND SIMULATION RESULT

DESIGN PARAMETER
Figure 1, 2 and 3 shows the proposed view, front view and the geometrical structure designed on CST microwave studio software of proposed microstrip slotted feed patch antennas operating for WLAN Standards IEEE, 802.11/b, 802.11/a, 802.15.1 Bluetooth, 802.15.4 ZigBee, 802.15.3 UWB, WiMAX and 802.11/a/b/g Wi-Fi applications respectively. The dimensions and feed point location for proposed antenna have been optimized to get the best possible impedance match to the antenna. The following parameters were used for design of proposed antenna.

The three essential parameters for the design of a rectangular Microstrip Patch Antenna:
- **Frequency of operation** \((f_r)\): The resonant frequency of the antenna must be selected appropriately. Antenna designed must be able to operate in the frequency range, so resonant frequency selected for the design was used to calculate the antenna parameters.
- **Dielectric constant of the substrate** \((\varepsilon_r)\): The dielectric material should be selected for design which has a dielectric constant value. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.
- **Height of dielectric substrate** \((h)\): For the microstrip patch antenna to be used in wireless devices, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is also selected. Hence, the essential parameters for the design are as follows:

**Design 1**
- **Resonant frequency** \(f_r = 2.45GHz\)
- **Dielectric constant** \((\text{Rogers RT5870}) = \varepsilon_r = 2.33\)
- **Thickness/height of the Substrate** \(h = 0.787mm\)
- **Speed of light** \(c = 3 \times 10^{11}mm/s\)

Matlab Calculation results

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Descriptions</th>
<th>Value (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wf</td>
<td>Width of Microstrip Feed</td>
<td>2.3</td>
</tr>
<tr>
<td>W</td>
<td>Width of the Patch</td>
<td>47</td>
</tr>
<tr>
<td>T</td>
<td>Thickness of Patch</td>
<td>0.07</td>
</tr>
<tr>
<td>Lf</td>
<td>Length of Microstrip Feed</td>
<td>32</td>
</tr>
<tr>
<td>L</td>
<td>Length of the Patch</td>
<td>39</td>
</tr>
<tr>
<td>H</td>
<td>Thickness/Height of Substrate</td>
<td>0.787</td>
</tr>
<tr>
<td>G</td>
<td>Gap between Microstrip &amp; Patch</td>
<td>1.0</td>
</tr>
<tr>
<td>D</td>
<td>Distance inset Feed</td>
<td>12.7</td>
</tr>
</tbody>
</table>

**Table 1: Table of results at 2.45GHz**
SIMULATION RESULTS

The parameters for the designed antenna were calculated and the simulated results are shown in Figures below. The bandwidth at the resonating frequency 2.45GHz is 25.5MHz with the corresponding value of return loss as -10.007 dB. The bandwidth of 25.5MHz is achieved as shown in Figure 4. The antenna covers the WLAN standard IEEE 802.11 (2.4 GHz band). The achieved value of return loss is small enough and frequency is closed enough to the specified frequency band for 2.45 GHz WLAN Standards IEEE 802.11 Wi-Fi, IEEE 802.15.1 Bluetooth, and IEEE 802.15.4 ZigBee applications. The return loss value i.e. -22.5851 dB suggests that there is good matching at the frequency point below the -10 dB region. The achieved antenna impedance is 50 ohm as shown in Figure 5, which is very close or equal to the required impedance of 50 ohm. The VSWR ratio is 1:1.1604 is shown in Figure 5.11 which should lie in between 1 and 5.

![Figure 5: Simulated reflection coefficients [S1, 1] of the microstrip patch at 2.45GHz](image)

Figure 5 shows the smith chart of the proposed antenna. It is a graphical representation of the normalized characteristic impedance. The Smith chart is one of the most useful graphical tools for high frequency circuit applications. The goal of the Smith chart is to identify all possible impedances on the domain of existence of the reflection coefficient.

![Figure 6: Bandwidth plot at 2.45GHz](image)

Figure 6 shows the VSWR (voltage standing wave ratio) plot for the designed antenna. The value of VSWR should lie between 1 and 2. SWR is used as an efficiency measure for transmission lines. Electrical cables that conduct radio frequency signals used for purposes such as connecting radio transmitters and receivers with their antennas, and distributing cable television signals. Here the value of the VSWR for the proposed microstrip patch antenna is 1.1604 at the specified resonating frequency. The achieved values of reflection coefficient and VSWR are small enough and frequency is closed enough to specified frequencies bands for 2.45 GHz WLAN applications.
Radiation pattern is a graphical depiction of the relative field strength transmitted from or received by the antenna. The antenna should not have the side lobes and back lobes ideally. We cannot remove them completely but we can minimize them. Figure 10 and 11 shows the simulated 3-D radiation pattern with directivity of 8.012 dBi and gain of 6.655 dB for the proposed antenna configuration at the resonating frequency of 2.45 GHz respectively.

![Figure 9: VSWR Curve Plot](image)

![Figure 10: 3-D Radiation Pattern (Directivity) of Patch antenna at 2.45GHz](image)

![Figure 0.4: Elevation radiation pattern (Directivity) at 2.45GHz](image)
Conclusion
In this study, a design and analysis of simple line fed microstrip patch antenna for global WLAN applications has been achieved. The proposed antenna was designed to operate at 2.45GHz for Standards IEEE 802.11 Wi-Fi, IEEE 802.15.1 Bluetooth, IEEE 802.15.4 ZigBee, applications. Good results were obtained due to proper impedance matching at the optimized feed point on the design the Voltage standing wave ratio (VSWR) is 1.1604 and the bandwidth of 25.5MHz were obtained. It can also be noticed that acceptable broadside radiation patterns were obtained at the resonating frequency, where a directivity of 8.012 dBi and gain of 6.655dB where investigated for the design. It can be concluded that the aim and objectives of the paper has been reached with little or no short comings.

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