CIRCULAR POLARIZED SINGLE FEED MICROSTRIP PATCH ANTENNA

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Abstract

Circularly polarized single feed microstrip patch antennas are widely employed in radar, GPS and mobile communication systems. Circular polarization is brought about by embedding slot in a cross shaped patch. Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Microstrip antennas are becoming very widespread within the mobile phone market. Microstrip patch antennas are low cost, have a low profile and are easily fabricated. In this paper, the design and simulation of the right hand circularly polarized microstrip patch antenna at GPS frequency of 1.575GHz are proposed. Design simulation technique is using CST microwave studio software.

Keywords: microstrip, patch antenna, GPS, circular polarized

1. INTRODUCTION

Microstrip antenna was first introduced in the 1950s. However, this concept had to wait for about 20 years to be realized after the development of the printed circuit board (PCB) technology in the 1970s. Since then, microstrip antennas are the most common types of antennas with wide range of applications due to their apparent advantages of light weight, low profile, low cost, planar configuration, easy of conformal, superior portability, suitable for array with the ease of fabrication and integration with microwave monolithic integrate circuits (MMICs). Microstrip antennas continuously developed to become one of the most attractive antenna options in wide range of modern microwave systems. This fast growth in microstrip antenna applications and uses derived a continuous research effort for developing and improving its characteristics (R. Garg, et al, 2001). Recently, circularly polarized (CP) antennas are attracting much attention in current wireless communication systems, such as satellite, radar, and wireless local area network (WLAN), since they can provide better mobility and weather penetration than linearly polarized (LP) antennas (Sarawuth C et al., 2012).

2. ANTENNA CONFIGURATION PROCEDURES

The main purpose of this paper is to design and simulate a right hand circularly polarized microstrip patch antenna operating using CST microwave studio at frequency \( F_r = 1.575 \text{GHz} \), dielectric constant \( \varepsilon_r=4.3 \), thickness of substrate \( h=1.6 \text{mm} \), free space speed of light \( C=3\times10^8 \text{m/s} \), length of Microstrip transmission line \( L_f = 51 \text{mm} \), width of Microstrip transmission line \( W_f = 3.137 \text{mm} \), the gap between the patch and microstrip field line \( G_{pf} \)
=1mm and the height of the conductor (t) =0.035mm. The specifications require the right hand side circularly polarized microstrip patch antenna at 1.575 GHz. More importantly, the physical requirement is to reduce the size of the patch antennas (E. Arvas, 2012). We choose one type of substrates which is εr = 4.3, h=1.6mm to be designed. The design procedures of those antennas are followed. First, we designed substrate of the microstrip patch antennas at width =58mm and length =44.4mm and height of conductor is 0.035mm and then designing the real face of the substrate which namely ground plane. Subsequently, we continued with designing the patch of the proposed antenna which has a half width of the substrate width 29mm and length of 22.2mm. After that we started to design the microstrip transmission line namely empty space which has width of microstrip transmission line of 51 mm. Finally we designed the microstrip line with width of microstrip transmission line (Wf) 3.137mm. Figure 1 shows the design configuration of microstrip antenna design. All the previous designs go through some steps which are similar to each other; by clicking on the brick icon in the software and press escape key from the keyboard to show you the icon on the screen and in that icon insert the instructions of the design that is needed. Subsequently, use the material library to choose the appropriate option for the suitable design.

![Design configuration](image)

Table 1 shows the parameter of microstrip patch antenna used in this design.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>58</td>
</tr>
<tr>
<td>L</td>
<td>44.4</td>
</tr>
<tr>
<td>fi</td>
<td>15</td>
</tr>
<tr>
<td>Wf</td>
<td>3.137</td>
</tr>
<tr>
<td>Gpf</td>
<td>1</td>
</tr>
<tr>
<td>Lg</td>
<td>2*L</td>
</tr>
<tr>
<td>Wg</td>
<td>2*W</td>
</tr>
<tr>
<td>ht</td>
<td>0.035</td>
</tr>
<tr>
<td>hs</td>
<td>1.6</td>
</tr>
</tbody>
</table>
3. METHODOLOGY

Figure 2 shows the flowchart of design process. The process start with the study of microstrip patch antenna through books and journal. Then the process continued with design the circularly polarized microstrip patch antenna using CST. The process continued with simulated and optimize the design. If the result is not satisfied, the antenna should redesign. The process finished when the result meets the requirement.

BASIC ANTENNA DESIGN PARAMETERS

One of the most common methods for designing antenna is using the Microstrip technology. Microstrip antennas have several popular patch antennas such as rectangular and circular shapes. In this assignment, we focus on the rectangular shape. A microstrip or patch antenna is a low profile antenna that has a many advantages over other antennas. It is lightweight, inexpensive, and easy to integrate with accompanying electronics. The essential parameters for the design of a rectangular microstrip patch antenna:

**Frequency of operation (f):**
The dimensions of the antenna must be selected appropriately so that it is able to operate in frequency of 1.575 GHz.
Dielectric constant of the substrate (εr):
The relative permittivity, εr of dielectric substrate is in range 1 to 10. Each material has its own value of dielectric permittivity. As it is known, when the dielectric constant εr is small the fringing fields will be more "bowed" and the better radiation we got. On the other hand, during using a microstrip transmission line, in this case, a high value of εr is needed. In this assignment the dielectric constant (εr) = 4.3.

Height of dielectric substrate (h):
The thickness of substrate (h) is selected as 1.6 mm.

Dimension of antenna
Based on the theory rectangular patch antenna, the dimensions of patch antenna in desired the frequency calculate according equation 1, 2, 3 and 4.

\[
W = \frac{c}{2 f \sqrt{\frac{ \varepsilon_r + 1}{\varepsilon_r}}} \quad \text{W} \approx 58\text{mm (after calculation)}
\]

\[
L = L_{\text{eff}} - 2\Delta L
\]

\[
\Delta L = 0.41 \times h \frac{(\varepsilon_r eff + 0.3) (W_r + 0.264)}{(\varepsilon_r eff - 0.258) (W_r - 0.8)}
\]

\[
L_{\text{eff}} = \frac{c}{2 f \sqrt{\varepsilon_r eff}} \quad \text{L} \approx 44.4\text{mm (after calculation)}
\]

Where L is the length of the patch, W is the width on the patch, C is the free space speed of light
\( f_r \) is the frequency and \( \varepsilon_r \) is the dielectric constant
The equation shows, increasing the dimensions lead to decreasing desired the frequency.

Return Loss
The return loss is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the input power from transmission line. The return loss of an antenna is calculated by:

\[
\text{Return Loss (dB)} = -20 \log \left[ \frac{(Z_A - Z_0)}{(Z_A + Z_0)} \right]
\]

Radiation Pattern
Radiation Pattern is defined as a graphical representation of the radiation properties of the antenna as a function of space coordinate. Radiation pattern is determined in the far field region. The radiation patterns can be represented in 2-D and 3-D version. For a linearly polarized antenna, its performance is often described in terms of its principle E-plane and H-plane patterns. The E-plane is defined as the plane containing the electric-field vector and the
direction of maximum radiation. The H-plane is defined as the plane containing the magnetic-field vector and the direction of maximum radiation (C. Balanis, 2005).

**Gain and Directivity**
Directivity, $D$, is the ratio of radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. Power gain $G$, is normally defined in the direction of maximum radiation per unit area (C. Balanis, 2005).

$$G = \frac{\text{Power radiated by an antenna}}{\text{Power radiated by a reference antenna}}$$

**Bandwidth**
The bandwidth of the antenna refers to the range of the frequencies in which the antenna can operate (Balanis 2005). Generally, in wireless communications, the antenna is required to provide a return loss less than -10 dB over its frequency bandwidth.

**4. SIMULATION RESULTS**
Figure 3 and 4 shows the design of microstrip patch antenna for GPS. The design is based on basic design for microstrip patch antenna and the operating frequency is equals to 1.575GHz. Then, the design is simulated to get the radiation pattern, directivity, antenna gain and other related properties.

![Figure 3: Configuration of the proposed antenna.](image-url)
Figure 4. The specification Patch of the proposed antenna

Figure 5 and 6 shows the simulation result of microstrip patch antenna for GPS at operating frequency equals to 1.575GHz. This shows that the result is acceptable.

Figure 5: The Return Loss of the proposed antenna.
Figure 6: The excitation signal of the proposed antenna.

Figure 7 shows the simulation result of 3D radiation pattern of Farfield plot of the proposed antenna for GPS at 1.575GHZ operating frequency. This shows that the result is acceptable.

Figure 7: 3D radiation pattern of Farfield plot of the proposed antenna.

Figure 8 shows the radiation pattern of the microstrip patch antenna for GPS in polar plot. The peak gain maximum directivity almost cover the upper part of the ground plane. This shows strong directivity for the antenna design.
Figure 8: Polar plot

Figure 9 shows the return loss at -10 dB with bandwidth equals to 29.5 MHz.

Figure 9: The bandwidth

5. CONCLUSION

A microstrip patch antennas is a type of radio antenna with a low profile. For the purpose of designing and simulating this antenna, CST microwave studio simulation software had been used. In this design was successfully managed an antenna which work in the frequencies of 1.575 GHz on the FR4-epoxy substrate of thickness 1.6 mm and $\varepsilon_r=4.3$. The results of the simulation show that this antenna resonates at 1.575 GHz and return loss at -25.178 dB. The directivity of the antenna is equals to 7.115 dB and the antenna gain is equals to 4.376 dB. In this work, an optimization of this antenna design also had been done to see the effect of the different parameters to the S-parameter result. Three parameters had been used for the optimization, which were W, L and Fi. From the result, it shows that different value of the dimension of antenna would cause the antenna to resonate at different frequency and affect the bandwidth of the antenna. This design and simulation, the width of the feedline, $W_f$ is calculated using CST Microwave Studio by taking the input impedance equals to 50Ω. The
Wf is approximately to 3.137mm. These four values of W, L, Fi and Wf could affect the result of the simulation. As conclusion, the design and simulation of right hand circularly polarized microstrip patch antenna is best working at 1.575 GHz frequency. In future, this design should be improved in order to get more accurate simulation result.

REFERENCES


