Journal of Computing and Electronic Information Management

ISSN: 2413-1660

A CPW-Fed Wideband Circularly Polarized Microstrip Antennas

Teng Dong [a], Junyu Chen [b, *] and Peixun Du [c]
College of Automation, Chongqing University of Post and Telecommunications,
Chongqing, China

[a]dongteng0412@163.com, [b]156120631@qq.com, [c]970778405@qq.com

Abstract: In this paper, a wideband circularly polarized microstrip antennas is designed and fabricated. The antenna is composed of a “Human” feed end, a square patch, two inverted L-shaped grounded strip lines, and some rectangular gaps. By adjusting the length and width of the "L-shaped" orthogonal arms and the perturbation branches of the upper left and lower right corners of the "human type" radiation plate, two orthogonal resonance modes of equal amplitude and a phase difference of 90° can be excited to radiate polarized wave. The proposed antenna has a very small size of 40 ×40 mm2 that covers the measured impedance bandwidth(S11＜-10dB)of 40.7% from 2250MHz to 3400MHz with axial ratio bandwidth of 14.4% from 2250MHz to 2600MHz for WLAN frequency band. The greatest gain of the antenna is almost 2.7dBi within the axial ratio bandwidth.

Keywords: circularly polarized microstrip antennas, wideband, impedance bandwidth, axial ratio bandwidth.

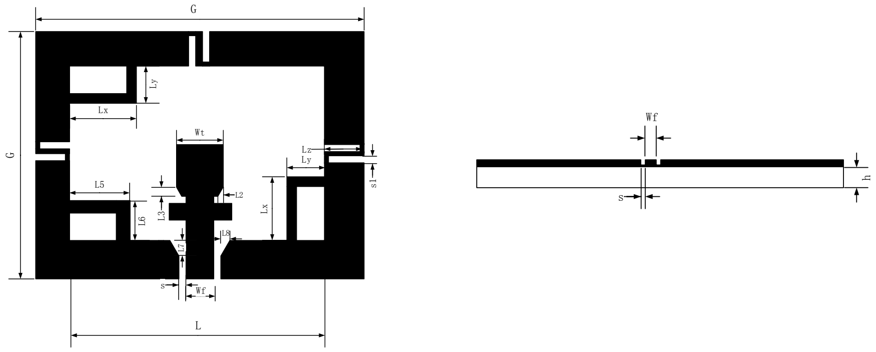
1. Introduction

With recent ongoing progress in the next generation communications, there is an inevitable demand for broad band antennas which support high data rate capacity. In recent years, compact circularly polarized (CP) antennas is becoming more attractive in various applications such as short range wireless communication, satellite positioning, radar and sensing. Since the CP antennas do not affected by multipath and transceiver’s orientations, they have several important advantages over linearly polarized ones. On the other hand, In order to overcome polarization mismatch between transmitter and receiver, circular polarization (CP) is becoming popular in wireless communications to enhance system performance [1]. CP feature can be realized when two orthogonal modes with equal amplitude and in phase quadrature are excited. Owing to features such as wide impedance bandwidth, low profile, low cost of manufacturing, and easy integration with monolithic integrated circuits attract more attention in wireless systems. The main challenge in design of wideband CP antennas is broadening axial ratio (AR) while keeping a compact and low profile design. Recently, researchers have been using some effective techniques such as embedding inverted-L grounded strips around two opposite corners of the slot [1–3], embedding lightning-shaped feed line and inverted-L grounded strips [2], and embedding tuning stubs in a feed line structure [1–3] to generate CP bandwidth of antennas. In [4], author has proposed a dual-band circularly-polarized square microstrip antenna for GPS. The geometry of the patch conductor in [4] is a square with one pair of L-shaped slits at each edge to miniaturize the patch's size and achieve a circularly polarized wave in the dual band (1.227GHz and 1.575GHz). In [5] and [6], an open slot and an asymmetric CPW feed line was introduced as asymmetric perturbations to obtain circularly polarization respectively. However, configurations of these antenna designs are so complicated and not easy to be integrated with devices in the applications.

In this paper, a very small rectangular slot antenna fed by coplanar waveguide (CPW) feed-line with enhanced impedance bandwidth and AR bandwidth is proposed.

2. Mechanical Analysis

The geometry of the circular polarized microstrip antenna operating at 2.45GHz is shown in Figure 1. The circularly polarized antenna is mainly composed of a dielectric layer, a top surface radiation patch of the dielectric layer, and a GND .The CPW-powered broadband circularly polarized microstrip antenna designed in this paper uses a fiberglass epoxy resin (FR4) as the dielectric substrate. Its dielectric constant is 4.4, and its loss tangent is 0.02. The thickness of the antenna is 1.8mm. The whole antenna is a square outline. A square-shaped slot is cut in the middle of the ground, and a rectangular frame is formed around. A rectangular gap is left on the upper edge, the left edge, and the right edge of the rectangular frame. What's more, a meandering technique is applied to reduce the size of the antenna. The middle of the antenna is a "human" feed end, and two "L-shaped" perturbations are added to the upper left and upper right corners of the "human" feed end to excite two positive amplitudes with a phase difference of 90° to radiate circularly polarized waves. Another "L-shaped" microstrip is added at the lower left corner of the "human" feed end to widen the axial ratio bandwidth of the circularly polarized antenna. A pair of triangular-shaped gaps are designed in the left and right of the "human" feed end to broad the impedance bandwidth of the antenna.



(a)Top view (b)Side view

Fig. 1: Geometry of the circular polarized microstrip antenna

In order to achieve the impedance matching of the microstrip antenna, a 50 ohm impedance matching line is generally designed at the lower end of the antenna feed line. The impedance size is mainly determined by the width Wf of the microstrip impedance line. The impedance line width Wf can be estimated according to the following equation (1-1):

$$Z = \frac{87}{\sqrt{\varepsilon_r + 1.41}} \ln \frac{5.98 \times h}{0.8 \times W + T} \qquad (1\text{-}1)$$

In the formula, Z represents the impedance of the microstrip line, where the value is 50Ω. is the dielectric constant of the dielectric plate，and its value is 4.4. H is the thickness of the dielectric plate, and the value is 1.8mm. T is the thickness of the radiation patch, and is ignored here. The remaining structural parameters in Figure 1 are: G=40mm，L=32mm，s=0.8mm，Wt=6mm，Lx=5mm，Ly=7.75mm，Lz=4mm，L2=0.6mm，L3=2.33mm，L5=7.62mm，L6=6.13mm，L7=3.12mm，L8=1mm. In order to supplement and optimize the antenna structure, it is first necessary to analysis the relationship between the structural parameters and the antenna performance. The performance of the antenna mainly refers to the impedance bandwidth and axial ratio bandwidth of the antenna. Figure 2 shows the Influence of Parameter G on Return Loss of the antenna. From Figure 2，there is a linear relationship between the length of G and the resonant frequency of the antenna. When G increases from 38mm to 40mm, the resonant frequency of the antenna moves from high frequency to low frequency. Therefore, it can be concluded that resonant frequency of the antenna decreases with the increase of G, and vice versa.

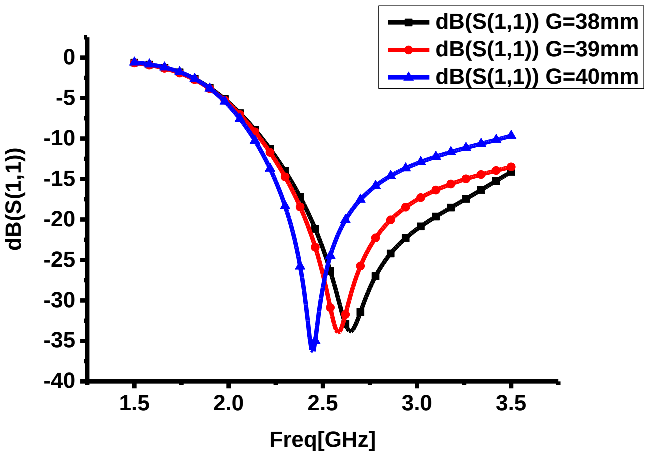


Figure 2: The Influence of Parameter G on Return Loss of the antenna

Figure 3 shows the Influence of Parameter L on Return Loss of the antenna. From Figure 3，there is a linear relationship between the length of L and the resonant frequency and impedance bandwidth of the antenna. When L increases from 30mm to 32mm, the resonant frequency of the antenna moves to the low frequency, and the impedance bandwidth of the antenna gradually increases. Therefore, it can be concluded that the resonant frequency of the antenna decreases as the parameter L increases, and the impedance bandwidth increases as L increases.

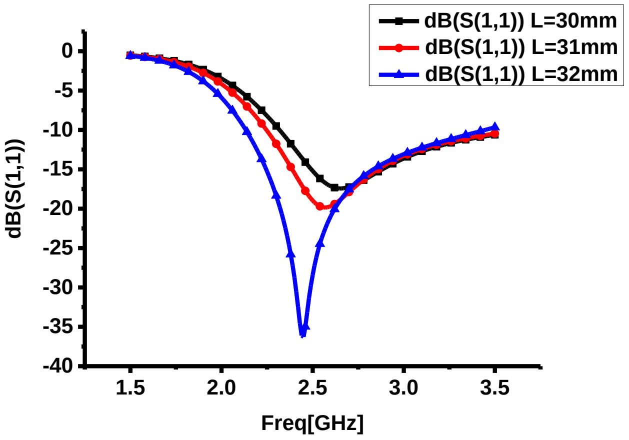


Figure3: The Influence of Parameter L on Return Loss of the antenna

Figure 4 shows the Influence of Parameter Wf on Return Loss of the antenna. From Figure 4，the length of the feed width Wf has a certain influence on the impedance bandwidth of the antenna. When the feed width Wf gradually increases from 3mm to 5mm, the impedance bandwidth of the antenna gradually decreases, but the antenna's resonance effect gradually increases. Therefore, it can be concluded that as the parameter Wf increases, the impedance bandwidth of the antenna decreases while the resonance effect is enhanced.

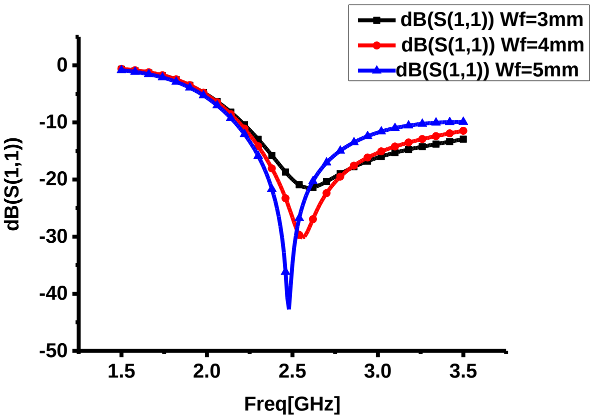
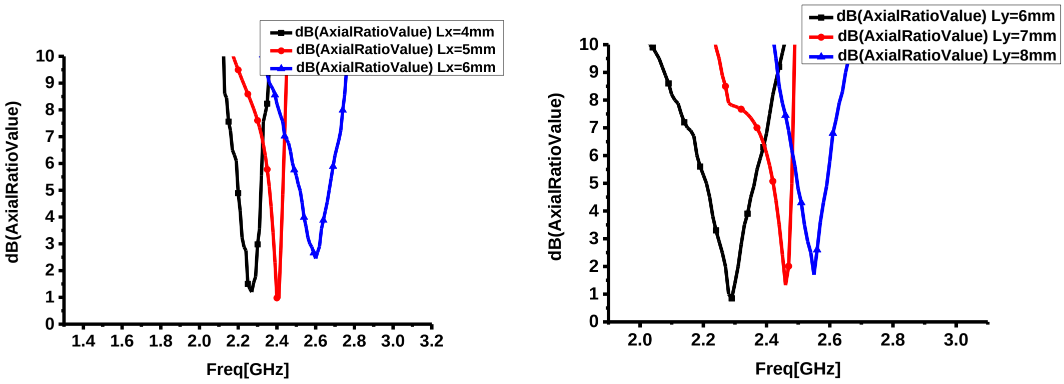


Figure4: The Influence of Parameter Wf on Return Loss of the antenna

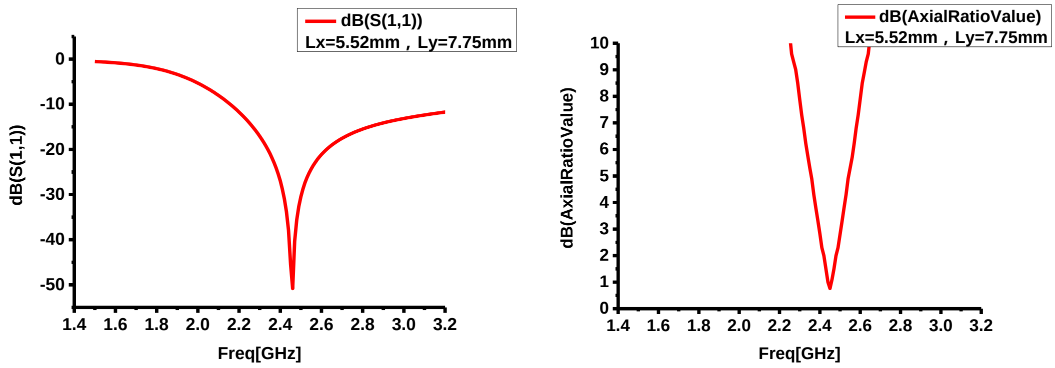
Figure 5 shows the Influence of the length and width Lx and Ly of L-shaped ground microstrip on the performance of antenna axial ratio. The "L-shaped" ground microstrip in the upper left and lower right corners of the antenna is a degenerate separation element of the circularly polarized antenna, which is used to generate a phase difference of 90° to form circularly polarized radiation. So the "L-shaped" is the key to generate circular polarized waves and it is critical to analyze the influence of the parameters of the "L-shaped" microstrip on the antenna axis ratio . Figure 5(a) shows the influence of the Lx on the performance of antenna axial ratio. From Figure 5(a)，the width Lx of "L-shaped" ground microstrip affects the antenna's axial ratio (AR). When the Lx increases from 4mm to 6mm in order, the axis of the antenna increases from the corresponding resonance point. At the same time, the 3dB axial ratio bandwidth of the antenna is narrower under the three conditions. Figure 5(b) shows the influence of the Ly on the performance of antenna axial ratio. From Figure 5(b)，when Ly is increased from 6mm to 8mm in order, the antenna axis also increases compared to the corresponding resonance point, but the axial ratio of the antenna gradually deteriorates.



(a) (b)

Figure5: The Influence of the Lx and Ly on the performance of antenna axial ratio

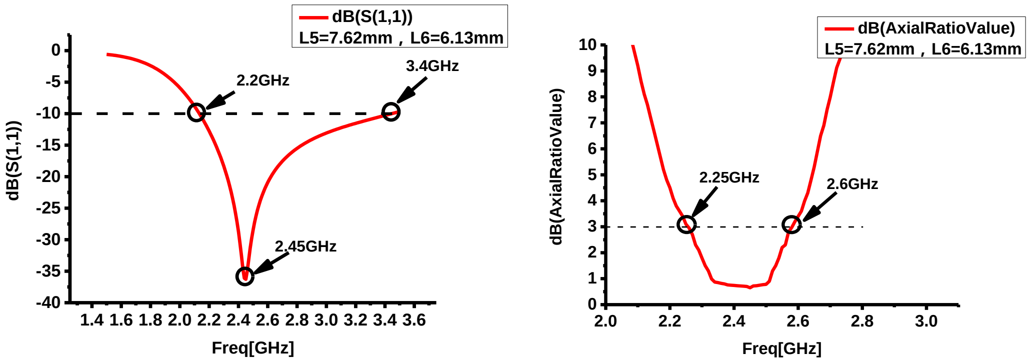
The parameter Lx and parameter Ly are both optimized. Figure 6 shows the resut of the parameter Lx and parameter Ly simultaneously optimized. Figure 6(a)is return loss，and Figure 6(b)is axial ratio of the antenna. From Figure 6，the antenna covers the impedance bandwidth(S11＜-10dB)of 37% from 2200MHz to 3200MHz with axial ratio bandwidth of 4% from 2400MHz to 2500MHz at this time.



(a)Return loss (b)Axial ratio

Figure 6: the resut of the parameter Lx and parameter Ly simultaneously optimized

From Figure 6，it is easy to find that the antenna has a narrower axial ratio bandwidth. Therefore, it is necessary to optimize the design of the antenna to extend the 3dB axial ratio bandwidth of the antenna and maintain the ideal impedance bandwidth. The axial ratio bandwidth of the antenna is optimized by adding the "L-type" microstrip line in the lower left corner of the "human" feeder of the antenna. The added structural parameters are L5 and L6 in Figure 1(a). The result of the final optimization is showed in Figure 7.



(a)Return loss (b)Axial ratio

Figure 7: result of the final optimization of the antenna

From Figure 7，the most optimal impedance bandwidth covers from 2200MHz to 3400MHz and the most optimal axial ratio bandwidth covers from 2250MHz to 2600MHz. It meets the requirement of broadband.

3. Simulation and experimental verification

In this section，the simulated and measured results of the antenna are discussed. In order to verify the proposed CP antenna, a prototype is fabricated, as shown in Fig 8.

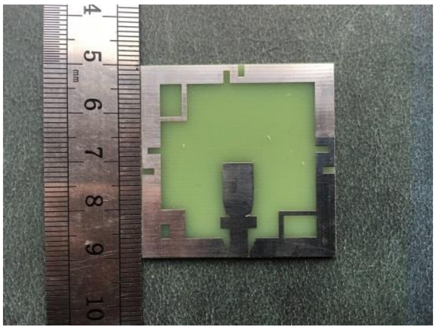


Fig 8:Prototype photograph of the proposed CP antenna

Fig. 9 is depicted the comparison of simulated and measured results of -10dB S11. The measured results for return loss is 40.7%(2250-3400MHz)and the simulated results is 42.8% (2200-2400MHz). The measured result is basically consistent with the simulation result.

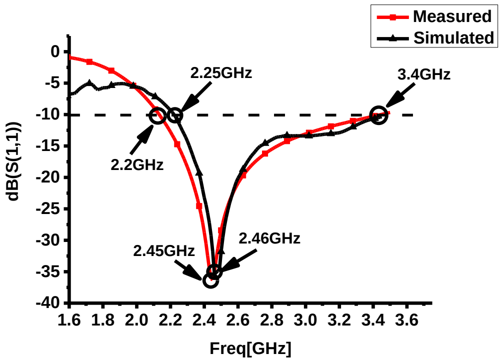


Fig. 9:Measured and simulated S11 of the proposed antenna

The peak gain is depicted in Fig 10，and the peak gain is 2.7dBi within the AR band.

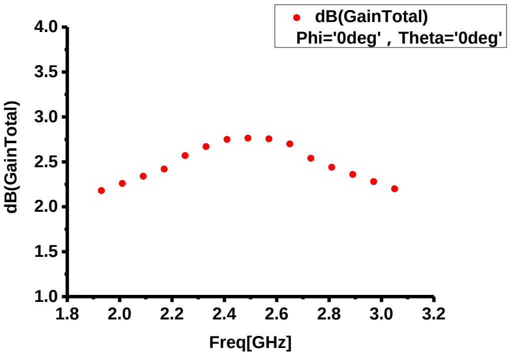


Fig 10:Simulated gain of proposed antenna

The radiation pattern of the antenna at 2.4 GHz and 2.45 GHz are shown in Fig. 11 respectively.

Cellular automation is a modeling method which assumes that time; space and state are all discrete. The basic idea of cellular automation is that defining the law of adjacent cells for each time step, than let the time going step by step. As the entire car in the road has been defined, we could change the every cell states, when a fast car will overtake a slow one, the lane change happened.

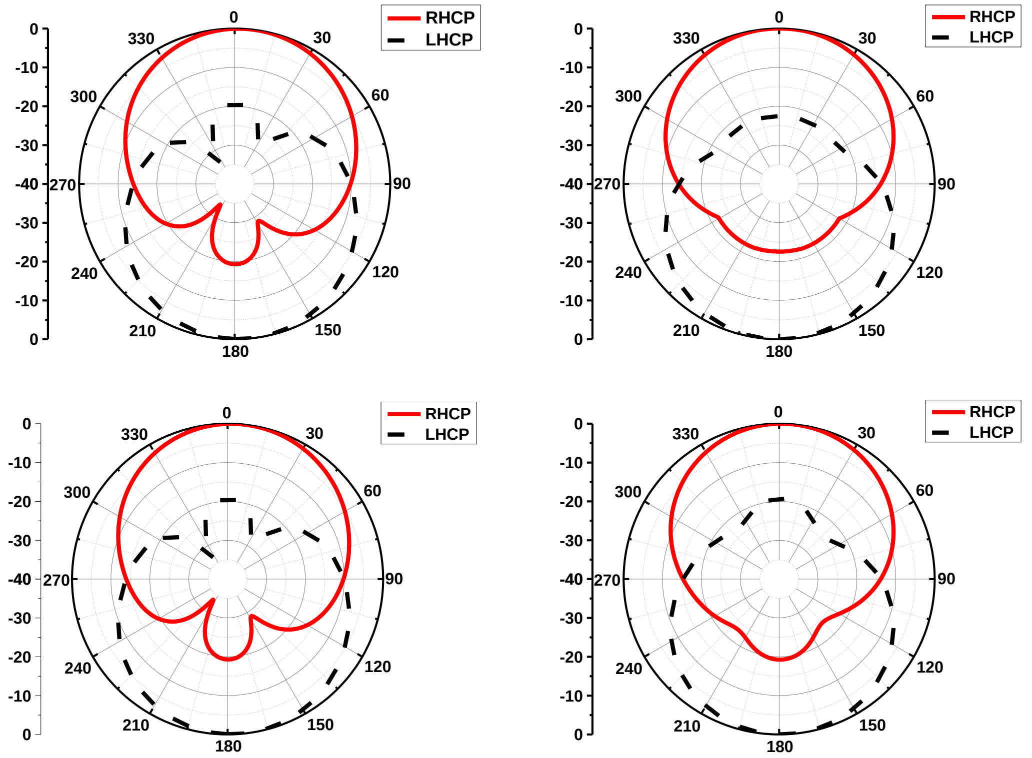


Fig. 11: Simulated RHCP and LHCP patterns of proposed antenna (Left isφ=0°and Right isφ=90°)

4. Conclusion

A CPW-Fed circular polarization antenna is proposed for WLAN applications. Results show that the proposed antenna has an operating frequency of (2250-3400MHz) and AR bandwidth of (2250-2600MHz) with small size of 40×40mm2. The antenna exhibits an peak gain of about 2.7dBi within axial ratio band. The proposed antenna is a suitable candidate for WLAN applications due to its simple structure and broad bandwidth.

Acknowledgements

This paper was financially supported by Junyu Chen and Peixun Du. They provided many valuable opnions, and help to measure the performance of the antenna.Thank you for their supports.

References

[1] Pourahmadazar J, Ghobadi C, Nourinia J, et al. Broadband CPW-Fed Circularly Polarized Square Slot Antenna With Inverted-L Strips for UWB Applications[J]. IEEE Antennas & Wireless Propagation Letters, 2011, 10(6):369-372.

[2] Sze J Y, Hsu C I G, Chen Z W, et al. Broadband CPW-Fed Circularly Polarized Square Slot Antenna With Lightening-Shaped Feedline and Inverted-L Grounded Strips[J]. IEEE Transactions on Antennas & Propagation, 2010, 58(3):973-977.

[3] Felegari N, Nourinia J, Ghobadi C, et al. Broadband CPW-Fed Circularly Polarized Square Slot Antenna With Three Inverted-L-Shape Grounded Strips[J]. IEEE Antennas & Wireless Propagation Letters, 2011, 10(1):274-277.

[4] Fujimoto T, Yoshitake Y, Yagyu D. Design and simulation based studies of a dual-band circularly-polarized square microstrip antenna[j]. Progress in Electromagnetics Research Letters, 2015, 52:129-134.

[5] Zhou S W, Li P H, Wang Y, et al. A CPW-Fed Broadband Circularly Polarized Regular-Hexagonal Slot Antenna With L-Shape Monopole[J]. IEEE Antennas & Wireless Propagation Letters, 2011, 10(3):1182-1185.

[6] Fu S, Fang S, Wang Z, et al. Broadband Circularly Polarized Slot Antenna Array Fed by Asymmetric CPW for L-Band Applications[J]. IEEE Antennas & Wireless Propagation Letters, 2009, 8(4):1014-1016.