A Miniature Circularly Polarized Patch Antenna

Kwai-Man LUK and Ka-Yan HUI*

Department of Electronic Engineering, City University of Hong Kong

83 Tat Chee Avenue, Kowloon, Hong Kong SAR, PRC

Email: eekmluk@cityu.edu.hk and 50187870@student.cityu.edu.hk

Tel: (852) 27844998 Fax: (852) 27887791

Abstract -- A small size circularly polarized (CP) microstrip patch antenna is presented. The proposed single-fed circularly polarized design is achieved by adding eight U-shaped tails at the patch edges. Five rectangular-shaped slots and four L-shaped slots are also inserted inside the patch. The patch antenna is a one-layer structure. It is designed to achieve a reduction in size as compared to standard printed antennas. In this way, our design induces the projection area of the antenna to be reduced by 75% in comparison with a conventional small patch antenna. Details of the design of this circularly polarized patch antenna are described. Experimental results of its performances are presented and discussed.

I Introduction

There are always huge demands for the miniaturization of the mobile communications equipments. Recently, a number of single-fed circularly polarized microstrip antennas are described. These circularly polarized designs include the use of four T-shaped slits at the patch edges [1], and the use of aperture-coupled [2]. It is true that the required antenna sizes of these designs cannot be smaller than those of the conventional regular-size signal-band circularly polarized designs for a fixed circularly polarized operating frequency [3].

The potential use of this “Compact Circularly Polarized Antenna” is for the Global Positioning System (GPS). Users of a global positioning system can calculate their location anywhere on the earth. Our microstrip antenna has the fascinating feature of low profile, low cost and lightweight. These pleasing characteristics will create new opportunities for current GPS users and offer the antenna for sale or licensing to the automated data collection market.

This antenna design employs the use of “slots” which aims to increase the resonant length of the current density leading to a smaller patch size. Base on this technique, some modifications have been done on the present design in order to reduce the size of the original antenna. For commercial use, the size of the existing antenna for the current GPS system is too large to be

0-7803-7846-6/03/$17.00 ©2003 IEEE

implemented in palm or watch. Thus, the size reduction of the original antenna will be the main focus of this paper.

II Antenna Design

The first approach is to use a higher dielectric constant substrate. It is a microwave substrate called Duriod 6010.5 which with $\varepsilon_r = 10.5$ and a thickness of 2.56mm. The length of the literature result abstracted from IEEE Transactions on Antennas and Propagation, VOL. 49, NO. 3, MARCH 2001[1], is reduced by 50% and the projection area of the new designed antenna is reduced by 75%. The feeding position is kept as the same scale as the proposed design. That is 3/4 of the length of the patch from the left hand boundary and bottom boundary of the patch. The entire dimension is scaled down by 50% respectively. By simulator IE3D, it was found that the resonant frequency of the proposed design is located at 2GHz.

Then two types of slots and eight U-shaped tails are added inside and outside of that patch respectively: Four L-shaped slots are inserted inside the boundary of the patch. They are all symmetric and are located at a length 2mm from the boundary of the patch. Besides, five rectangular-shaped slots are introduced inside the border of the patch. They are symmetric and are located at a length 5.25mm from the boundary of the patch. Again, eight tails are added outside the boundary of the patch. They are all symmetric and are located at a length 1mm at the boundary of the patch. The feeding position is kept as the same scale as the proposed design. That is 3/4 of the length of the patch from the left hand boundary and bottom boundary of the patch. The corresponding geometry of the patch is shown in Figure 1 and its simulated return loss is also shown. Through simulation, it was found that the resonant frequency shifted to 1.36GHz.

As we can see from the above results that the frequency range of our design does not match the bandwidth requirement for the GPS. Thus, we need to turn the structure of the antenna experimentally. It is found that the length of the tails controls the length of path of the current density and thus the impedance resonant frequency. We want to have a higher resonant frequency at about 1.575GHz. For this reason, the length of the tails outside the boundary of the patch must be shortened. In this case, the eight tails have been cut by 3mm each.

The size of the middle rectangular-slot is being shortened to 4mm. It will affect the mode of resonant of the antenna and therefore, the resonant frequency of the axial ratio is also shifted and resonant at about 1.575GHz. The corresponding structure of the antenna and its measured return loss is shown in Figure 2. The coordinate of the feeding position is 3mm along the x and y directions away form the center of the patch which is found to optimize the impedance and axial bandwidth respectively. The corresponding measured radiation patterns and the axial ratio are shown in Figure 3 and Figure 4.

III Discussion

As we can note from the above results that the back lobe of the design is undesirable. One of the main reasons is the size of the ground plane of the antenna. Now I am using a ground plane size of around 50% larger than the patch. It is not big enough so that a number of radiations will go to the backside. If the size of the ground plane is bigger, let's say a double of the patch size, then this back lobe problem can be improved.

As discussion above, the potential use of our design is imbedded in palm or watch for the Global Positioning System (GPS). However, the frequency range of the proposed antenna does not wide enough to cover the bandwidth requirement of the GPS which is from 1.535GHz to 1.615GHz. Thus, our next step is to widen its frequency range in order to suit the bandwidth requirement for the GPS.

IV Conclusion

In this paper, a new design of using single-layer slot-loaded square microstrip patch antenna for achieving reduced-size circularly polarized radiation is proposed. That is, the required antenna size of the present proposed design can be significantly reduced as compared to the sizes of the conventional circularly polarized designs. In this way, the final size of our designed antenna has a reduction of 75% as compared to the original one.

V References

[1] K.P. YANG and K.L. WONG; 'Dual-Band Circularly-Polarized Square Microstrip Antenna'; IEEE Transactions on Antenna and Propagation, VOL. 49, NO. 3, Mar., 2001

[2] DAVID M. POZAR and SEAN M. DUFFY; 'A dual-band circularly polarized aperture-coupled stacked microstrip antenna for global positioning satellite'; IEEE Transactions on Antenna and Propagation, VOL. 45, NO. 11, Nov., 1997

[3] P.C. SHARMA and K.C. GUPTA; 'Analysis and optimised design of single feed circularly polarized microstrip antennas'; IEEE Transaction on Antenna and Propagation, VOL. 31, pp.945-955, 1983.

[4] JAMES M.TRANQUILLA and STEVEN R. BEST; 'A Study of the Quadrifilar Helix Antenna for Global Positioning System (GPS) Applications'; IEEE Transaction on Antenna and Propagation, VOL. 38, NO. 10, Oct., 1990

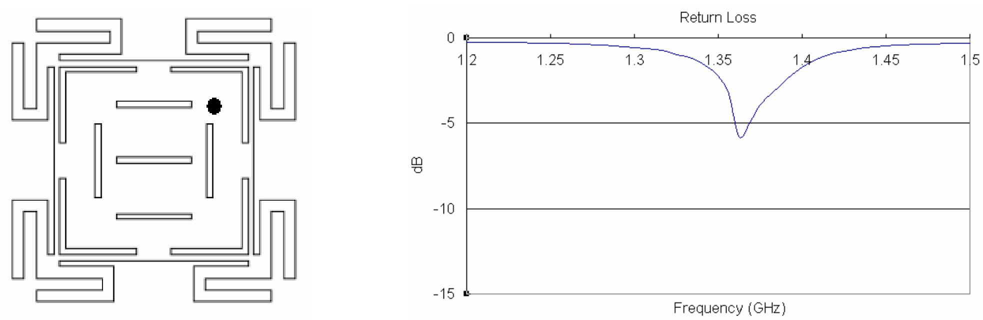


Figure 1: Design of the patch and its return loss.

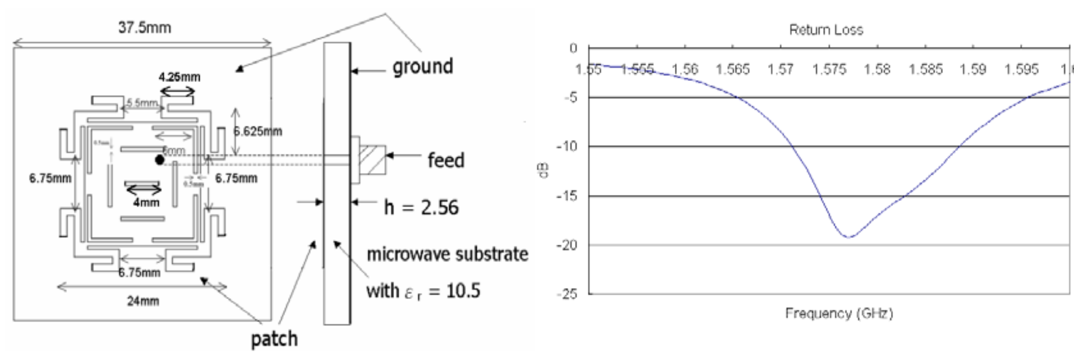
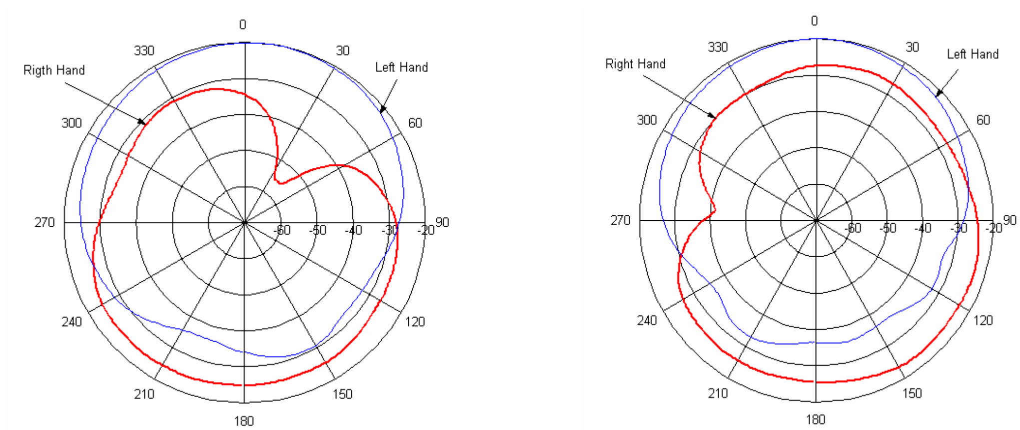


Figure 2: The structure and its measured return loss of the CP antenna.



(a) (b)

Figure 3: Measured radiation pattern of the CP antenna in (a) the xz plane and (b) the yz plane.

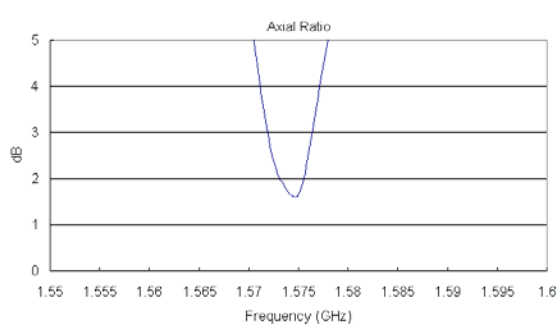


Figure 4: Measured axial ratio of the CP antenna design.