

# Broadband Circularly Polarized Patch Antenna

Chin-Ying Hung<sup>1</sup>, Kuo-Chien Chao<sup>1</sup>, Saou-Wen Su<sup>2</sup>, and Fa-Shian Chang\*<sup>1</sup>

<sup>1</sup> Dept. of Electronics, Cheng Shiu University, Kaohsiung County, 83347, Taiwan

<sup>2</sup> Network Access S.B.U., Lite-On Technology Corp., Taipei 23585, Taiwan

E-mail: changfs@csu.edu.tw

## Introduction

Circularly polarized (CP) antennas are attractive to wireless communications applications simply because less strict orientations are required for mobile stations (the end user) with respect to base stations. To achieve CP operation, many designs of patch antennas have been reported in the literature. However, for the designs utilizing dielectric substrates, single-feed, single-element patch antennas are usually with a narrow CP bandwidth of about 2% or less [1-5], which limits their practical applications. In this paper, we demonstrate that by introducing a new feed structure (see Fig. 1), a single-element patch antenna can achieve a wide CP bandwidth. With the proposed probe feed and ground configuration, good impedance bandwidth with VSWR below 1.5 over the 2.4 GHz WLAN band can be obtained. In addition, good broadside, CP radiation characteristics have also been observed. The design prototype has been built and aimed for operation in the 2.4 GHz (2400-2484 MHz) WLAN band. The proposed antenna is designed for access-point applications in the WLAN environment. Details of the antenna design are described, and experiment results are discussed.

## Antenna Design

Fig. 1 shows the perspective view of the proposed, broadband CP patch antenna for operation in the 2.4 GHz band. Detailed dimensions are given in Fig. 2. The radiating patch is in the shape of a rectangle with size 60 mm ( $L$ )  $\times$  70 mm ( $W$ ) and has a small bent portion (7 mm in length) at one of the patch radiating edges. At two diagonal corners of the patch, two isosceles-triangle portions (side length of 22 mm) are cut to realize perturbations of excited surface currents for obtaining two orthogonal, near-degenerated resonant modes for CP operation. The antenna ground plane is bent three times into a step-shaped structure and consists of four portions: two horizontal plates, one vertical plate, and one inclined plate. The angle between the inclined and horizontal plates is 135°. A 50- $\Omega$  SMA connector of the probe feed is located in the center of the inclined plate below a via hole. In this case, the probe pin of the probe feed is inclined at an angle of 45° (see Fig. 2). For matching the input impedance of the antenna, the length of the probe pin was carefully tuned. When a thick air substrate is utilized for the radiating patch, large inductance introduced by the probe pin may occur, which can be compensated for additional capacitive reactance arising between the vertical plate (of the ground) and the patch bent

portion and between the inclined plate and the bent portion. At last it should be noticed that an optimal feed location for the proposed design is set in the middle of the patch radiating edge facing the inclined ground plane. The parameters of the design prototype can be obtained with the aid of Ansoft HFSS.

### Experimental Results and Conclusion

Based upon the antenna configuration shown in Fig. 2, a design prototype has been constructed and tested. Fig. 3 shows the measured and simulated return loss for the design prototype. Good impedance bandwidth defined by 1.5:1 VSWR (14 dB return loss) can be obtained and reaches 590 MHz (2010-2600 MHz) or about 24% with respect to the center operating frequency at 2450 MHz, easily covering the 2.4 GHz band. Measured axial ratio in the broadside direction for the designed prototype is presented in Fig. 4. The obtained 3-dB axial-ratio bandwidth reaches 150 MHz (2390-2540 MHz) (about 6% with 1.5:1 VSWR). Notice that in this study, the minimum value of the axial ratio also occurs at about 2450 MHz, the center frequency. In addition, from the measured return loss shown in Fig. 3, the operating frequencies within the obtained CP bandwidth are also seen to be with return loss better than about 17 dB. Fig. 5 shows the measured, spinning-linear radiation patterns with the two principal planes at 2450 MHz for the constructed prototype studied in Fig. 2. Slight asymmetrical radiation patterns are first seen, which is owing probably to the presence of the vertical ground in the proposed design. As for the backward radiation, it is seen to be less than -10 dB, compared with the main lobe in the broadside direction. Fig. 6 plots the measured peak antenna gain for the operating frequencies within the obtained CP bandwidth. The peak antenna gain reaches about 10.5 dBi, and the peak-gain level is about 9.5 dBi. More related results will be presented in the upcoming Conference.

### References

- [1] P. C. Sharma and K. C. Gupta, "Analysis and optimized design of single feed circularly polarized microstrip antenna," *IEEE Trans. Antennas Propagat.*, vol. 31, pp. 949-955, 1983.
- [2] J. R. James and P. S. Hall, *Handbook of Microstrip Antennas*, London, UK: Peter Peregrinus, 1989.
- [3] C. W. Su, F. S. Chang and K. L. Wong, "Broadband circularly polarized inverted-L patch antenna," *Microwave Opt. Technol. Lett.*, vol. 38, pp. 134-136, 2003.
- [4] C. Y. Huang, J. Y. Wu and K. L. Wong, "Slot-coupled microstrip antenna for broadband circular polarization," *Electron. Lett.*, vol. 34, pp. 835-836, 1998.
- [5] W. K. Lo, J. L. Hu, C. H. Chan, and K. M. Luk, "Circularly polarized patch antenna with an L-shaped prob fed by a microstrip line," *Microwave Opt. Technol. Lett.*, vol. 24, pp. 412-414, 2000.
- [6] F. S. Chang, K. L. Wong and T. W. Chiou, "Low-cost broadband circularly polarized patch antenna," *IEEE Trans. Antennas Propagat.*, vol. 51, pp. 3006-3009, 2003.

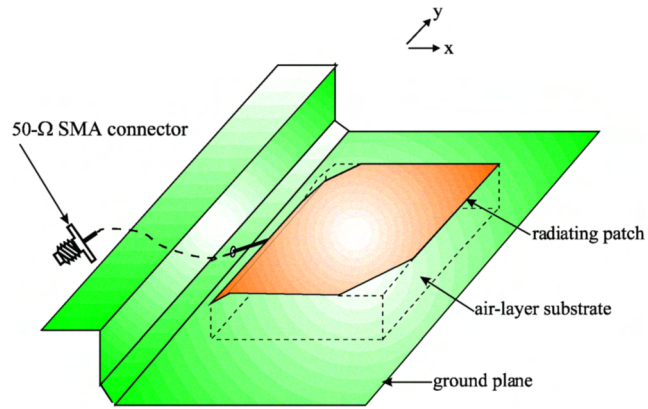


Fig. 1 Perspective view of the proposed, broadband, CP patch antenna.

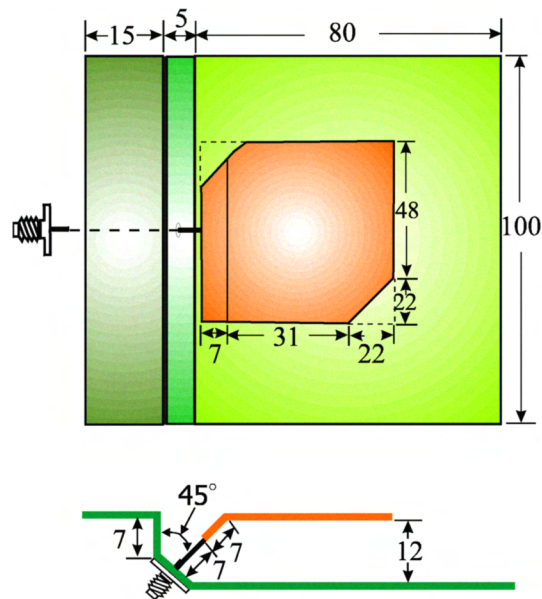


Fig.2 Geometry of the CP patch antenna with a step-shaped ground.

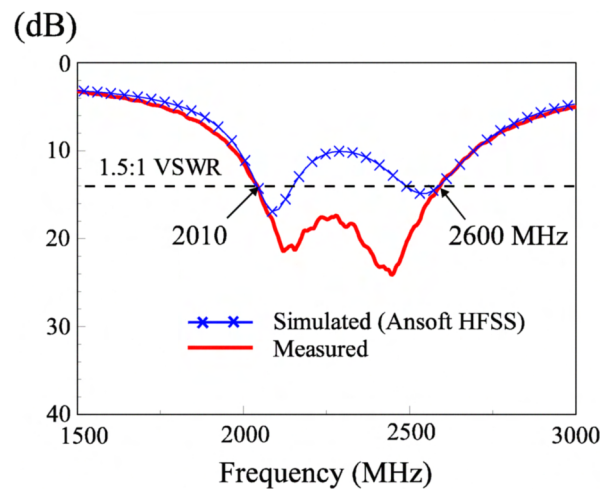


Fig. 3 Measured and simulated return loss for the design prototype.

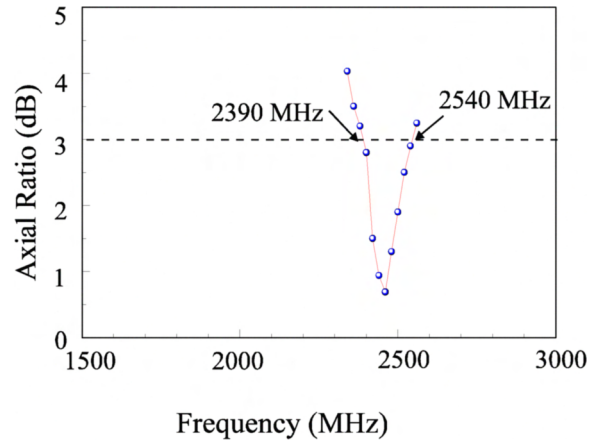


Fig. 4 Measured axial ratio in the broadside direction for the design prototype.

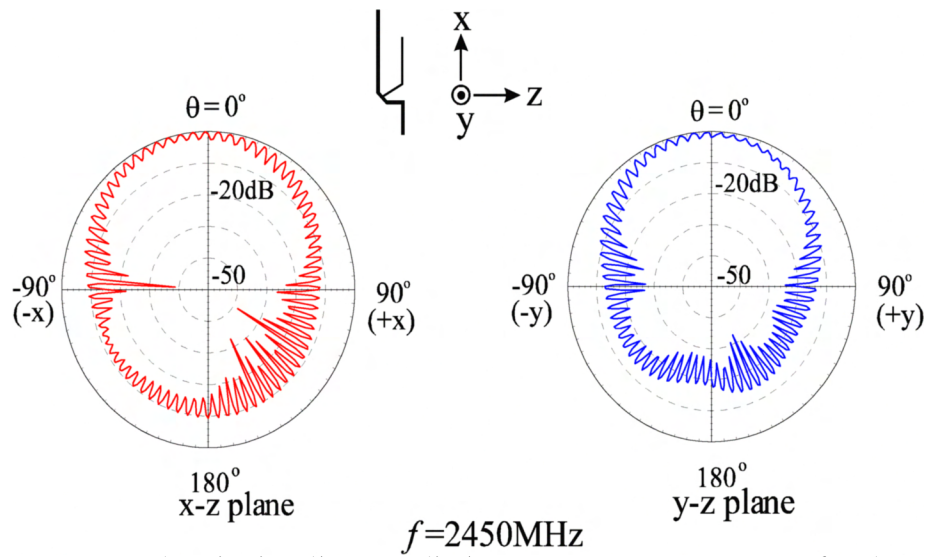


Fig. 5 Measured, spinning-linear radiation patterns at 2450 MHz for the patch antenna studied in Fig. 2.

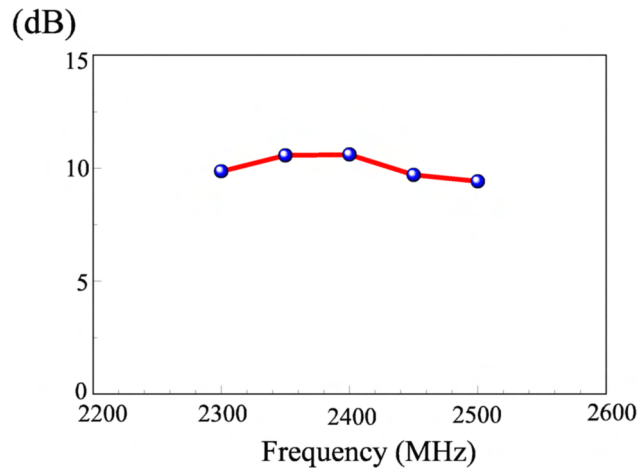


Fig. 6 Measured peak antenna gain against frequency.