# Circularly Polarized Square Microstrip Antenna Fed by Proximity Coupling

Junho Choi [1], Sang-Min Han [2], Seongmin Pyo [1], #Young-Sik Kim [1]

[1] Department of Computer and Radio Communications Engineering, Korea University
Seoul, 136-713, Korea, yskim@korea.ac.kr

[2] Department of Information and Communication Engineering, Soonchunhyang University
Asan, Chungnam, 336-745, Korea

## 1. Introduction

Circularly polarized (CP) patch antennas have been paid much attention to mobile wireless and satellite communications because they provide for greater flexibility in orientation angle between transmitter and receiver antennas, better mobility and weather penetration, and reduction in multipath reflections [1].

Although CP antennas can improve the system sensitivity, they have a disadvantage of a complex dual feedline and a relatively large form-factor [1, 2]. The degenerating methods such as notches and/or slots on a radiator have been reported for CP operation of an antenna that has no dual feedline [3-5]. However, these methods yield an antenna gain decrement.

In this paper, a square patch antenna fed by proximity coupling for CP operation is presented. Due to the coupling structure, the proposed feeding structure achieves impedance matching by controlling the coupling factor without redesigning the radiating element. Therefore, the proposed antenna can radiates with non-distorted CP and cannot alter the resonant frequency of the patch itself.

## 2. Antenna and Feedline Design

Figure 1 shows the layout of the proposed square microstrip antenna fed by proximity coupling. A 50-Ω microstrip input is divided into two 100-Ω feedlines at the lower left corner of the square patch. Each feedline is side coupled to the antenna. But, one of the feedline is lengthen in the y-direction.

With a side coupling, $TM_{10}$ and $TM_{01}$ modes are simultaneously excited. Figure 2 shows the simulated surface current distributions of the side coupled square patch. The antenna design is simulated by the Ansoft HFSS [6]. In these modes, the diagonal directed current distribution is observed.

For a 90° phase difference and orthogonal-fed, one of the feedline is extended parallel to the outer side length $L$ of the square patch, and the length is one-quarter of the patch circumference. The extended feedline is folded inside at the edge of the patch for the side coupling. As each feedline is coupled to the patch orthogonally with a quadrature phase difference, the CP operation is achieved in the square patch without any perturbation.

Figure 3 shows the surface current distribution of the feedline and the square patch at each phase. In Fig. 3(a), the direct coupled feedline has a maximum current while the extended feedline shows a minimum. After the 90° phase progression, the extended feedline has a maximum. This dual orthogonal coupled feeding may generate a clockwise surface current on the square patch antenna. Hence, a left-handed circular polarization (LHCP) is obtained.

## 3. Experimental results

The proposed square patch antenna with a side length, $L$, of 15.5 mm is fabricated on a substrate with a dielectric constant of 2.5, a loss tangent of 0.0019, and a thickness of 0.635 mm. The feedlines are designed with lengths of $l_1 = l_2 = 9$ mm, a folded-line separation of $s = 0.5$ mm, and a coupled-line gap of $g = 0.2$ mm, respectively.

Figure 4 shows the measured and simulated reflection coefficients of the proposed antenna. The measured impedance bandwidth is 130 MHz from 5.724 GHz to 5.854 GHz. The simulated and measured axial ratios are shown in Figure 5. The measured CP bandwidth, determined by a 3 dB axial ratio, is 31.1 MHz. The minimum axial ratio is 0.8 dB with a peak gain of 5.2 dBic at the frequency of 5.76 GHz.

Figure 6 shows the measured radiation patterns in the *xz*- and *yz*-planes. With a low cross-polarization level of less than 25 dB in the main beam direction, the CP radiation patterns of the antenna are pretty symmetric, because the proposed coupled feedline structure may efficiently generates CP radiation without perturbing the original radiator.

## 4. Conclusions

A circularly polarized square microstrip antenna fed by proximity coupling is proposed. The CP bandwidth of 31.1 MHz, the minimum axial ratio of 0.8 dB and the peak gain of 5.2 dBic are obtained experimentally. The proposed feeding method does not require an additional impedance transformer. Without perturbing the original radiators, the proposed antenna shows excellent CP radiation performances.

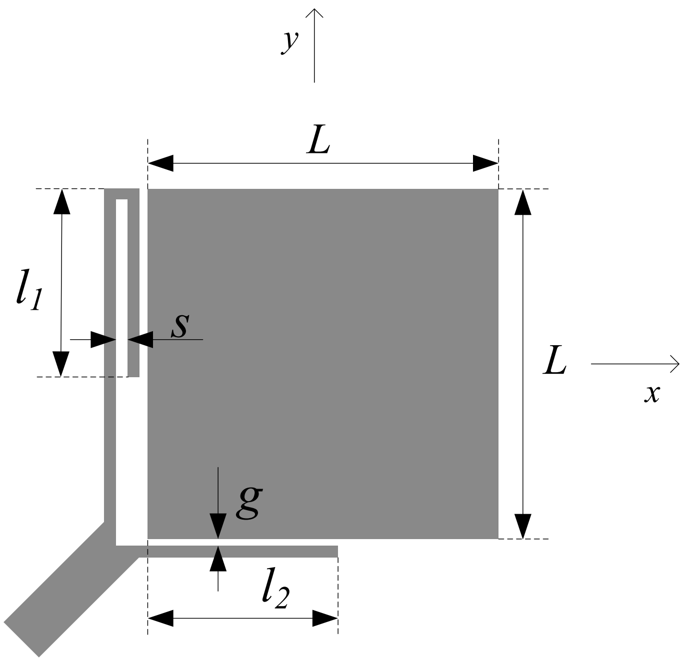
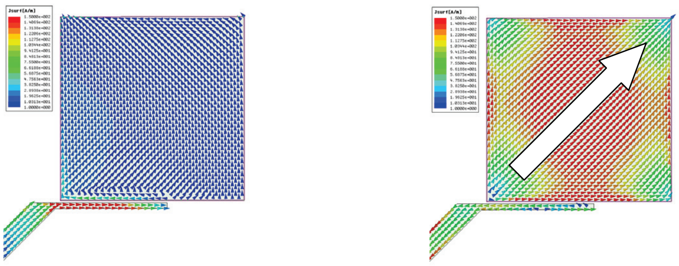
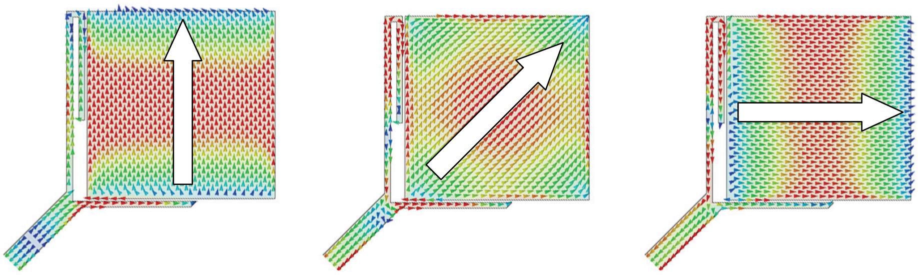



Figure 1: Layout of the proposed antenna structure



(a) 0 deg (b) 90 deg

Figure 2: Surface current distribution of the side coupled-fed square patch at each phase



(a) 0 deg (b) 45 deg (c) 90 deg

Figure 3: Surface current distribution of the proposed antenna at each phase

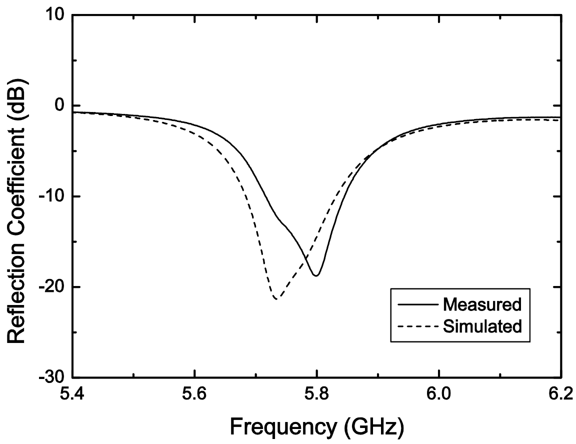



Figure 4: Measured and simulated reflection coefficients of the proposed antenna

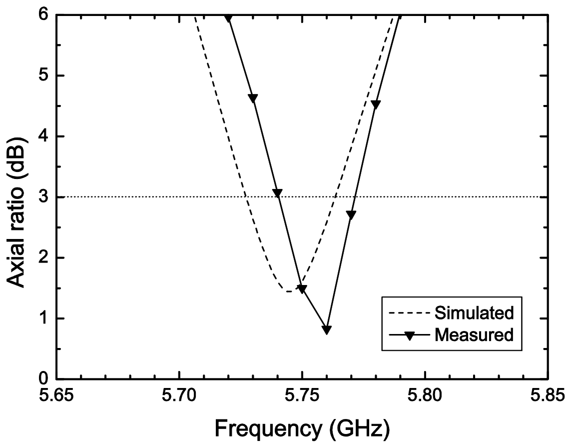
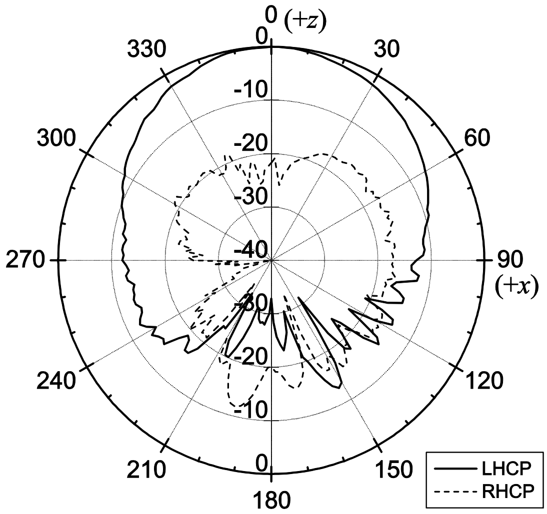
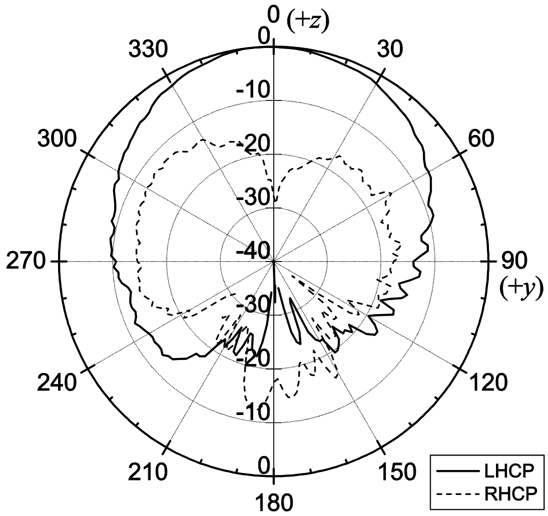



Figure 5: Measured and simulated axial ratios of the proposed antenna




(a) *xz*-plane




(b) *yz*-plane
Figure 6: Measured radiation patterns

# References

[1] W.-S. Yoon, S.-M. Han, J.-W. Baik, S. Pyo, J. Lee, Y.-S. Kim, "Crossed dipole antenna with switchable circular polarisation sense", Electron. Lett., vol. 45, No. 14, pp. 717-718, 2009.
[2] D. G. Kurup, A. Rydberg, "Amplifying Active Reflect-Antenna Using a Microstrip-T Coupled Patch—Design and Measurement", IEEE Trans. Microw. Theory Tech., vol. 51, No. 8, pp. 1960-1965, 2003.
[3] W. F. Richards, Y. T. Lo, P. Simon, "Design and Theory of Circularly Polarized Microstrip Antennas", Proc. Int. Conf. on Antennas Propag., vol. 17, pp. 117-120, 1979.
[4] S.-L. Yang, K.-M. Luk, "A Wideband L-Probes Fed Circularly-Polarized Reconfigurable Microstrip Patch Antenna", IEEE Trans. Antennas Propag., vol. 56, No. 2, pp. 581-584, 2008.
[5] F. Yang, Y. Rahmat-Samii, "Patch Antennas with Switchable Slots (PASS) in Wireless Communications: Concepts, Designs, and Applications", IEEE Antennas Propag. Mag., vol. 47, No. 2, pp. 13-29, 2005.
[6] HFSS User Manual, Release 11, Ansoft Corporation.