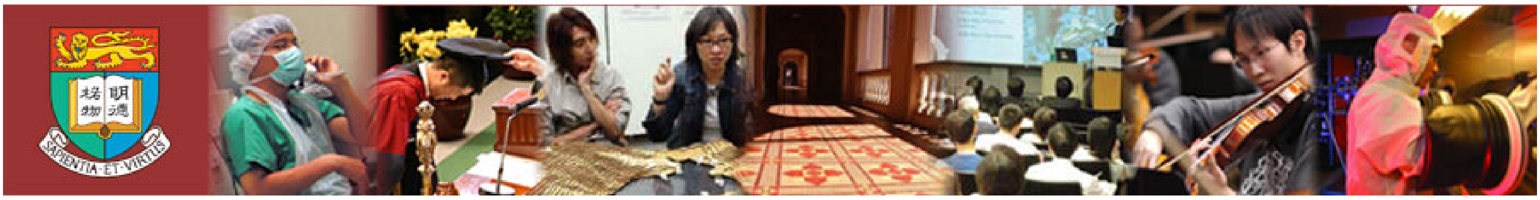

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A Circular Polarization Hybrid-Integrated Rectangular Ring Antenna for RFID Reader

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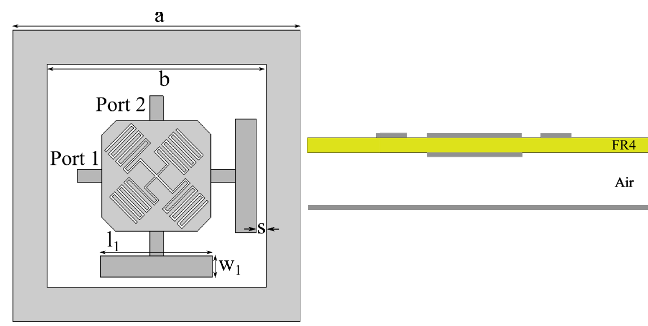
***Abstract*—In this paper, a compact hybrid-integrated microstrip rectangular ring antenna with circular polarization is proposed for RFID reader. By integrating a cross-slotted patch hybrid with a rectangular ring antenna in the same plane, the proposed antenna has the features of circular polarization, compact size, low cost, light weight and unique flexibility for RFID applications. A prototype operating at 915 MHz is designed and fabricated. The measured results agree well with the simulated results.**

I. INTRODUCTION

Microstrip antenna has been widely used in modern wireless communication system, because of its unique features such as low cost, light weight, and easy integration with the other carriers [1]. However, the conventional microstrip patch antenna operates at the half-wavelength frequency and its size is too large for the UHF RFID antenna. For a rectangular ring antenna operated at its fundamental mode [2], [3], the length of each side is only about quarter-wavelength. Hence, the ring antenna has received considerate attentions [4]-[9] and can be a good candidate for the UHF RFID antenna. By introducing the perturbation segments along the ring resonator, two orthogonal modes can be excited to obtain circular polarization [4]-[6]. However, the circular polarization bandwidth is very narrow with this method. Another approach to obtain the CP operation is to utilize two points feeding technique with the same amplitude and 90° phase difference at two excitation ports [7]-[9]. A series microstrip-line-feed was used to excite two ports for two orthogonal modes [7]. However, 90° phase difference can be only obtained at the center frequency, which results a narrow impedance bandwidth. On the other hand, wide impedance bandwidth can be obtained by utilizing a hybrid coupler feed network [8] or a power divider with a 90° phase shifter [9]. In order to obtain a smaller size, the power divider can be placed inside the ring resonator, where the bidirectional circularly polarized radiation pattern can be obtained with a broad impedance bandwidth and circular polarization bandwidth [9].

In this paper, we propose to integrate a miniaturized patch hybrid coupler with a ring antenna. In order to feed the ring antenna with high input impedance at its fundamental mode [10], the parallel-coupled feeding is used here as a matching network. Since the meandered cross-slot line is used for the patch hybrid coupler design [11], the resultant hybrid coupler is highly compact and easy to embedded into the ring antenna for the CP operation. Finally, a hybrid-integrated ring antenna prototype has been designed, implemented, and verified experimentally.



(a) (b)

Fig.1. Physical configuration of the proposed hybrid-integrated retangular ring antenna (a) Top view. (b) Cross-section.

II. CONFIGURATIONS OF THE PROPOSED ANTENNA

Fig. 1 shows the top-view and the cross section of the proposed circular polarization hybrid-integrated ring antenna. It consists of a microstrip rectangular ring antenna and a cross-slotted patch hybrid coupler. Firstly, the rectangular ring resonator is formulated on the top of two substrate layers, i.e., FR4 and air layers. A cross-slotted hybrid patch coupler is then embedded inside the ring on the FR4 substrate (ε_r = 4.4 and thickness = 1.6 mm). There are two unique features for this novel configuration: 1) compact size by integrating the ring and hybrid coupler on the same layer; 2) high design flexibility with two grounds that the equivalent permittivity and thickness of substrate for the ring resonator can be adjusted independently.

A. Antenna design

Since the input impedance of the ring antenna is very large, it is very difficult to feed it with the coaxial probe directly. Hence, the parallel-coupled feeding is employed to feed the ring resonator, and the matching condition can be achieved by

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properly tuning the gap between the coupled strip and the ring (s), the length of the strip (l_1) and the width of the strip (w_1).

B. Coupler design for circular polarization

For the circular polarization, two orthogonal modes along the ring resonator are excited by integrating a miniaturized hybrid coupler inside a ring. Following the design guideline shown in [11], a compact patch hybrid coupler operated at the UHF RFID band was designed. It provides 3-dB power assignment with 90° phase difference between two output ports.

C. Hybrid-integrated ring antenna

Finally, the hybrid-integrated ring antenna is designed with the total physical size of 150 mm × 150 mm × 20 mm, which is about 0.5λ × 0.5λ × 0.067λ in UHF RFID band.

III. EXPERIMENT VERIFICATION

To verify our proposal, a prototype of the proposed hybrid-integrated ring antenna is designed and fabricated. Fig. 2(a) shows the photograph of the fabricated antenna. As shown in Fig. 2(b), the 10-dB return loss is obtained at the whole operating band. The measured and simulated radiation patterns, gain and axial ratio are shown in Fig. 3 and Fig. 4, respectively. Both of them have a good agreement between the measured and simulated results. At the center of the operating band, the gain is about 6.5 dB. Due to the undesired characteristics of low-cost FR4 substrate, a discrepancy can be observed between the measured and simulated axial ratios, which are very sensitive to the feeding amplitude and phase difference.

IV. CONCLUSION

In this paper, a compact circular polarization RFID reader antenna is proposed. The performance of the antenna with CP operation can be optimized independently by adjusting the thickness of the air layer, while the responses of hybrid coupler are primarily dominated by the local FR4 ground plane.

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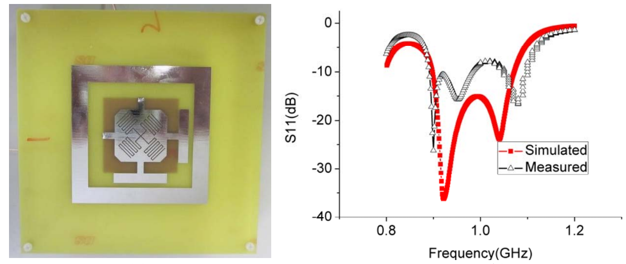
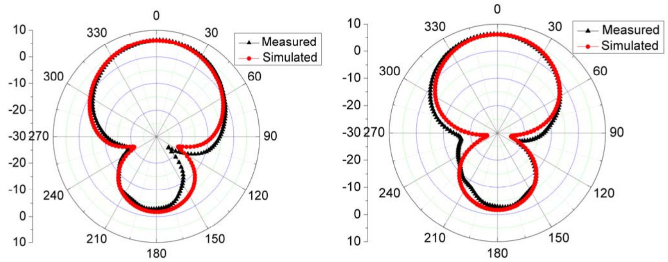


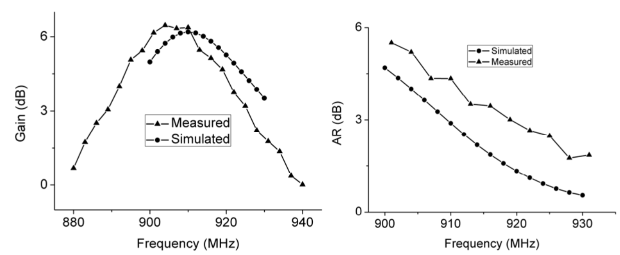
(a) (b)

Fig. 2. (a) Photograph of the fabricated antenna. (b) Measured and simulated return loss.



(a) (b)

Fig. 3. Measured radiation pattern at 915 MHz. (a) E-plane. (b) H-plane.



(a) (b)

Fig. 4. Measured gain and axial ratio of the proposed CP ring antenna. (a) Gain. (b) Axial ratio.

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