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Design and Implementation of Dual Circular Polarized Antennaswith Integrated RFID Reader

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Abstract: The Design and Implementation of Dual Circular Polarized Antennas with Integrated RFID Reader is proposed in this paper. It consists of an annular ring slot radiator and a hybrid patch coupler. The hybrid patch coupler is integrated with the annular ring slot antenna to radiate the circular-polarized wave, while size of the antenna remains the same. Both the impedance bandwidth and axial ratio bandwidth of the proposed design almost cover the entire UHF band of RFID system and it has the features of easy fabrication and low cost. To verify the proposed design, a prototype is fabricated. Measured results agree well with the simulated results.

1. INTRODUCTION

Radio frequency identification (RFID) mainly consists ofa reader and a tag. For the reader antenna, circular polarization (CP) is preferred because it can reduce the losscaused by the multi-path effects between the reader andthe tag antenna. In addition, a compact size is often required because of the limited space in the portable dev-ices. CP can be realized by the perturbation method orthe orthogonal feed technique. CP is formed by the perturbation method in. By introducing asymmetry in thering slot and arranging the feeding point in, CP is realizedfor the annular and rectangular ring slot antennas. The CPis realized by selecting a proper length of the shortedsection in the ring slot in. In, CP is realized by placing ametal strip across the diagonal line of the aperture. However, the axial ratio bandwidth is very narrow usingthis method. To address this issue, power divider or coupler, which generates the same amplitude but 90–phasedifferences at the two output port, is used to feed theantenna to obtain wide AR bandwidth in. Wilkson powerdivider is place inside the rectangular ring antenna to obtainCP in and an additional matching network is needed forthis method. Dual-Fed method is used to form CP in.Circular ring slot antenna is fed by strip line hybrid couplerin. Since multilayer structure is used in, it is not easy to fabricate. Patch hybrid coupler is integrated with therectangular ring antenna in [9] to achieve a compactcircular polarized antenna, but the radiation bandwidth isnarrow for this design. In addition, because of the compactsize of the ring and ring slot antenna, it has been widelyused for different antenna designs such as UWB and dual band applications. In this paper, annular ring slot antenna is integratedwith the hybrid patch coupler to radiate the circular polarized wave. Meanwhile, because hybrid patch coupleris at the bottom of the annular ring slot antenna, the innerground of the ring slot antenna can be considered as theground plane of the hybrid patch coupler. With this novelconfiguration, CP is realized with broad bandwidth. In addition, the antenna size is not affected bythe additionalpatch coupler and a very compact structure is obtained.Both the impedance bandwidth and axial ratio bandwidthof the proposed antenna almost cover the entire UHFband for RFID system

The Proposed Antenna Design

As shown in Figure 1, the proposed antenna consists ofan annular ring slot radiator on the top layer and a hybridpatch coupler on the bottom layer. When the annular ring slot antenna operates at its fundamental mode TM11,circumference of the annular ring should be one free spacewavelength [14], which means the radius of the annularring slot antenna is only about 0.32 free space wavelength.To match the antenna to the 50-ohms feed line, the coupledopen-ended microstrip line is used here to feed the slotring antenna, as shown in Figure 2. By tuning lf and wf,the input impedance of this antenna can be changed easily,and a good matching condition can be achieved.

Following the design guideline in [15], a miniaturized hybrid patch coupler is designed to feed the antenna. Itis employed here to provide power assignment with thesame amplitude but 90– phase difference and is placed on the bottom of the FR4 substrate. By this arrangement,the inner ground plane on the top layer can be consideredas the ground plane of the hybrid coupler. As a result, the proposed antenna can radiate circular polarized wave withan integrated compact configuration.

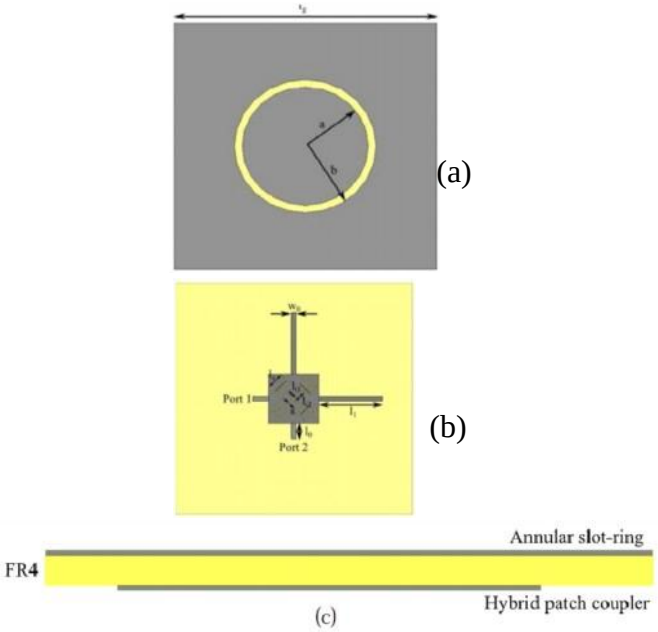


Figure 1: Configuration of the proposed antenna. (a)Top view. (b) Bottom view. (c) Cross view.

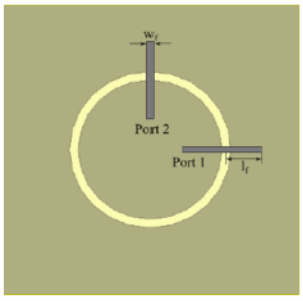


Figure 2: Annular ring slot antenna with open-endedmatching microstrip line.

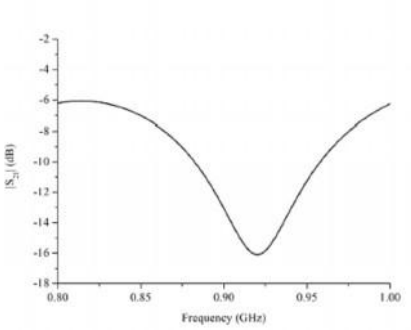


Figure 3: Isolation between two input ports of theannular ring slot antenna

The proposed antenna is simulated with the commercial full wave solver HFSS, and the final dimensions of the proposed antenna are shown in Table
1. Figure 3 shows the isolation between the two inputports of the annular ring slot antenna. As can be seen,isolation between the two ports is almost lower than ¡10dBwithin the operating bandwidth. The performances of thehybrid patch coupler are depicted in Figure 4 too. It isfound that there is a good amplitude balance with 90– phase difference at two output ports. Then the annularring slot antenna and the hybrid patch coupler are integrated together to radiate the circular polarized wave with compact size. The simulated jS11j of the integratedantenna is shown in Figure 5. It is found the proposedantenna operated from 830MHz{950MHz (jS11j <
¡10dB) and almost covers the entire UHF band. As shownin Figure 6, a bidirectional radiation pattern is obtained.Gain of the

Table 1: Final dimensions of the proposed antenna(unit: mm).

Parameters	value	Parameters	value
a	36	s	0.5
b	40.5	ls	10
lg	150	lt1	5.25
w0	3	lt2	6.25
l0	10	h	1.6
l1	40		

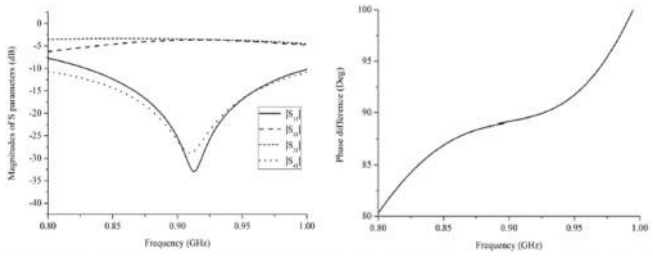


Figure 4: Performances of the hybrid patch coupler.

(a) Magnitudes of S parameters of hybrid patchcoupler. (b) Phase difference of two output ports of hybrid patch coupler

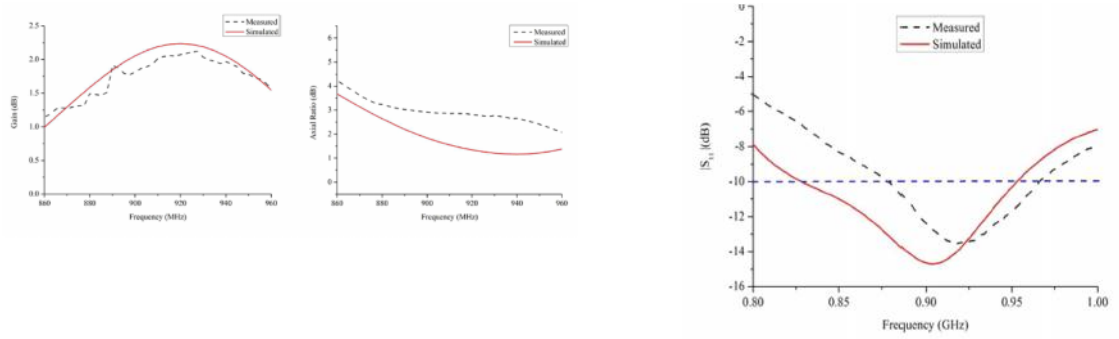
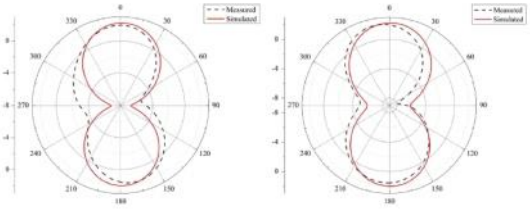


Figure 5: Simulated and measured magnitudes of jS11j



(a) (b)

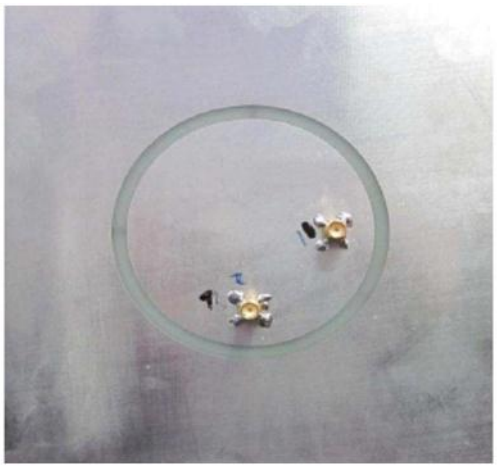
Figure 6: Simulated and measured radiation @ 915MHz. (a) E plane. (b) H plane. proposed antennaat the operating band is shown in Figure 7.

The peak gain over the entire UHF band is from1dBi to 2.2dBi. Figure 8 shows the simulated axial ratioof the proposed antenna, the bandwidth of axial ratio (AR
< 3dB) is 870MHz{960MHz. Based on the simulated results, the proposed antenna has a good performance inthe entire UHF band and is a good candidate for the RFIDreader antenna.

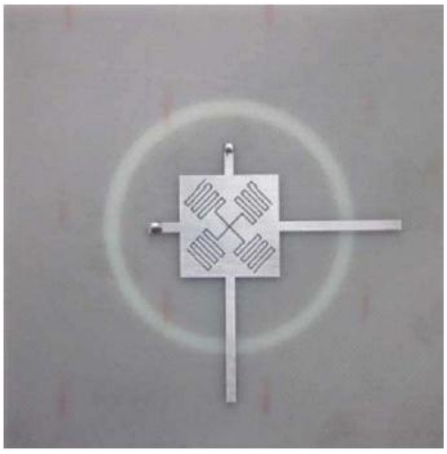
2. EXPERIMENTAL RESULTS AND DISCUSSION

To verify the proposed antenna, a prototype is fabricatedand measured. Photograph of the fabricated antenna isshown in **Figure 9.**
Measure jS11j is shown in Figure 5. It agrees wellwith thesimulated results except a slightly frequency shift, which is mainly caused by the poor characteristics of the cheap FR4 substrate. The radiation pattern of this antennais measured in a microwave chamber, and a good symmetry of the bidirectional radiation pattern is observed, asshown in **Figure 6.**
Figure 7 shows the measured gain of the proposedantenna, good agreement is obtained between the simulatedand measured results. The measured gain is larger than1dB in the entire UHF RFID band with small actuation.However, there is a discrepancy between the simulatedaxial ratio and measured axial ratio. It is because that axial

Figure 7. Simulated and measured gain of theproposed antenna.
Figure 8. Simulated and measured axial ratio of theproposed antenna



(a)



(a)

Figure 9. Photograph of the fabricated antenna. (a)Top view. (b) Bottom view.

Ratio is sensitive to the amplitude balance and phasedifferences, and both of them are related to the unstableFR4 substrate. The axial ratio bandwidth with AR < 3dBfor the simulated result covers from 870MHz{960MHz,while the measured one is 885MHz{960MHz.

3. CONCLUSION

The Design and Implementation of Dual Circular PolarizedAntennas with Integrated RFID Reader is designed, fabricated and measured in this paper. The measuredresults show that the proposed antenna not only has awide impedance bandwidth, but also has a wide axial ratiobandwidth. It almost covers the entire UHF band of theRFID system. In addition, the proposed antenna has thefeatures of easy fabrication and low cost and is suitablefor mass production.

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