Compact Circularly Polarized Tag Antenna for UHF RFID System

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***Abstract* - This work describes a novel compact design of planar circularly polarized (CP) tag antenna for UHF RFID system. By introducing the meander strip into the right-arm of the square-ring structure, the measured half-power bandwidth of the proposed CP tag antenna can be more than 100 MHz (860 ~ 960 MHz), which includes the entire operating bandwidth for worldwide UHF RFID system. The obtained 3 dB axial-ratio (AR) bandwidth can be about 33 MHz (902~935 MHz), suitable for American (902~928 MHz), Euro (918~926 MHz) and Taiwan UHF RFID (922~928 MHz) applications. Since overall antenna dimension is only 54 × 54 mm^2, the proposed tag antenna in this study can operate with antenna size reduction of 42 % than conventional CP antennas. Meanwhile, with bidirectional reading pattern, the measured reading distance is about 8.5 m. Good tag sensitivity is obtained across the desired frequency band.**

***Index Terms* —Bidirectional, circularly polarized, UHF RFID tag.**

I. INTRODUCTION

UHF (860 ~ 960 MHz) band radio frequency identification (RFID) system had recently received more attention in supply chain, tracking and inventory management due to the merits of longer reading distance, fast reading speed and large information storage capability than that for low- or high-frequency band. Tag antenna is the pivotal element for UHF RFID system to transmit / receive the modulated information. Several tag antennas for UHF RFID system have been presented with linear polarization [1-10] or dual-polarized operation [11-12]. To overcome high orientation sensitivity, circularly-polarized (CP) antennas become the most popular candidates to improve the reliability of communications between readers and tags. In this article, we present a novel compact CP design of UHF RFID tag antenna with bidirectional reading pattern. By introducing the meander strip into the right-arm of the square ring tag, a novel circularly polarized (CP) tag antenna is proposed and suitably attached on the vehicle windshield for UHF Electronic Toll Collection (ETC) system. The measured half-power bandwidth of the proposed CP tag antenna can be more than 135 MHz (865 ~ 1000 MHz), which comply with the entire operating bandwidth (860 ~ 960 MHz) for worldwide UHF RFID system. The obtained 3 dB axial-ratio (AR) bandwidth can be about 33 MHz (902 ~ 933 MHz), suitable for American (902 ~ 928 MHz), Euro (918 ~ 926 MHz) and Taiwan UHF RFID (922 ~ 928 MHz) applications. Moreover, with bidirectional reading pattern, the maximum reading distance is about 8.5 m. Furthermore, in the aspect of considering overall antenna dimension, our proposed antenna with a small size of 54 × 54 mm^2 has more than 42 % antenna size reduction than that of the smallest CP tag antenna with the dimension of 40 × 40 × π mm^2 [13] for UHF RFID application.

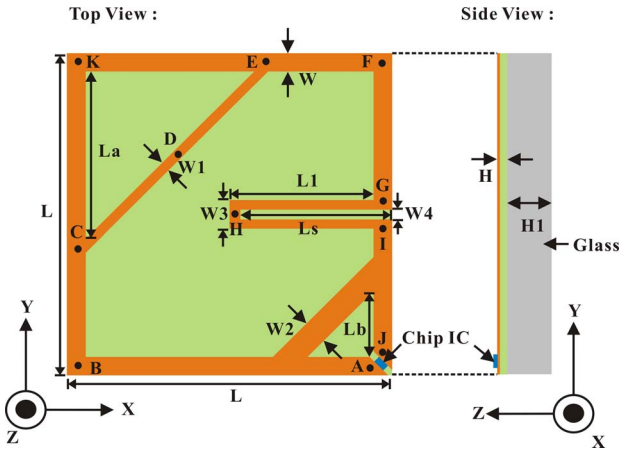

Fig. 1. Geometry of the proposed compact circularly polarized (CP) tag antenna for UHF RFID system.

II. ANTENNA DESIGN AND EXPERIMENTAL RESULTS

Figure 1 shows the geometry of the proposed compact square-ring tag antenna with circular polarization (CP) operation. This tag with the antenna size of 54 × 54 mm^2 is printed on an FR4 substrate (ε_r = 4.4, thickness = 0.2 mm, loss tangent = 0.0245) and attached on the glass with the thickness of 5 mm, like as the vehicle windshield. The Alien Higgs-2 microchip is connected at the right-bottom of the square-ring tag antenna, which is with the impedance of (13 - j140) Ω at the operating frequency of 925 MHz band. The proposed meander strip with the length of L1 and the gap of W4 is embedded into the square slot to disturb the induced electric field along the x- and y-axis in quadrature-phase. Moreover, the shorted strip (section CDE) embedded into the square slot are employed to extend the distributed surface currents for decreasing the operating frequency for compact operation. The electromagnetic simulator HFSS based on the finite element method [14] has been applied for the proposed tag antenna design.

Figure 2 illustrates the related simulated and experimental results of the input impedance, return loss and axial ratio (AR) for the proposed tag antenna of Figure 1. For the realization of impedance matching between the tag antenna and IC chip, the half-power (3 dB return loss) bandwidth specification had been adopted in the presented designs [7-11]. From the experimental results shown in Figure 2, the measured bandwidth (RL ≧ 3 dB) can be more than 139 MHz (861 ~ 1000 MHz) for UHF band, which totally covers the worldwide RFID UHF band. Meanwhile, this CP antenna also provides a 3-dB AR bandwidth ranging from 902 to 935 MHz, which can cover the American (902~928 MHz), Euro (918~926 MHz) and Taiwan (922~928 MHz) UHF band. Figure 3 shows the measured tag angular sensitivity patterns for the E/H planes at 915 MHz band. The principal-polarized patterns were similar to those of a typical dipole antenna. The bi-directional radiation pattern in the Y-Z plane (E-plane) is observed with the maximum reading distance of 8.5 m, however, the measured pattern in the X-Z plane (H-plane) still presents a fairly good omnidirectional performance.

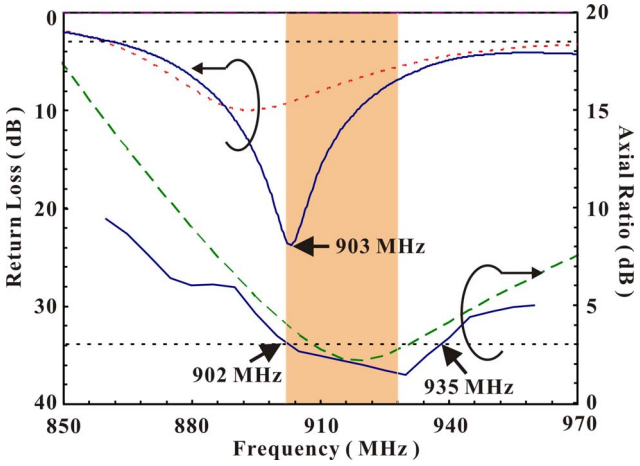

Fig. 2. Simulated and measured input impedance, return loss and axial ratio (AR) against frequency for the proposed CP tag antenna.

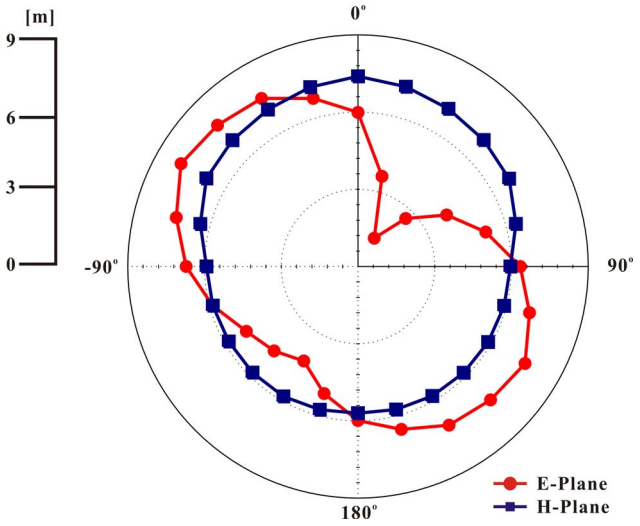

Fig. 3. Measured reading range pattern for the proposed CP tag at 925 MHz band.

III. Conclusions

A novel compact design of planar circularly polarized (CP) tag antenna for UHF RFID system has been proposed. By introducing the meander strip into the right-arm of the square-ring structure, the measured half-power bandwidth of the proposed CP tag antenna can be more than 100 MHz (860 ~ 960 MHz), which includes the entire operating bandwidth for worldwide UHF RFID system. The obtained 3 dB axial-ratio (AR) bandwidth can be about 33 MHz (902~935 MHz). Since overall antenna dimension is only 54 × 54 mm^2, the proposed tag antenna in this study can operate with antenna size reduction of 42 % than conventional CP antennas. Meanwhile, with bidirectional reading pattern, the measured reading distance is about 8.5 m. Good tag sensitivity is obtained across the desired frequency band.

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