Detection Range Enhanced Antenna Using a Triple Polarization Switching for Mobile UHF RFID Applications

Dongjin Lee[#1], Seung-Tae Khang[#2], Soo-Chang Chae[#3], Soo-Ji Lee[#4], Jong-Won Yu[#5]
[#]*Department of Electrical Engineering, Korea Advanced Institute of Science and Technology (KAIST)*

335, Gwahangno, Yuseong-gu, Daejeon, Korea
[1]dong905@kaist.ac.kr
[2]stkhang@kaist.ac.kr
[3]wintbud@kaist.ac.kr
[4]sooji0408@kaist.ac.kr
[5]drjwyu@ee.kaist.ac.kr

***Abstract*—In this paper, we present a detection range enhanced antenna for mobile ultra-high frequency (UHF) RFID (Radio-frequency identification) applications. For the detection rage enhancement, triple polarization switching is used with a pair of parallel dipoles and a feeding network. The pair of parallel dipoles placed orthogonally each other to make a three polarization states by controlling the switches on the feeding networks. With the compact size of the antenna, the proposed antenna can generate two orthogonal linear polarizations and right hand circular polarization. The use of the proposed antenna may lead to reduce polarization mismatch loss thus increasing the possible tag reading distance. Experimental results show that the proposed antenna of size 76 $\times$ 76 $\times$ 15 mm^3 has the peak gain of 2.05dBi for linear polarization and 1.45dBic for RHCP.**

I. Introduction

In recent years, radio frequency identification (RFID) has gained a great attention in various application such as health care, supply chain and sensor networks [1]. RFID readers can be handheld and used by, for example, individuals walking through a retail store or business reading RFID tags of products on shelves or in a storage area [2]. For these mobile environment, the RFID reader antenna size should be minimized but it reduce the detecting range due to the limited antenna gain. Meanwhile, the RFID reader antenna generally have circular polarization (CP) to detect various tags despite the rotation of the RFID readers or tags [3]. However, there is 3dB loss between CP reader and linear polarized (LP) tags theoretically and it reduces the reading range. Hence the polarization matching could enhance the detection range of tags effectively in the mobile RFID applications with various polarized tags. In this paper, we proposed a novel detection range enhanced RFID reader antenna for UHF RFID applications with compact size. The proposed antenna can generate two orthogonal LP and RHCP to detect various tags which have any kinds of polarization with longer detection range.

II. Design of the Detection Range Enhanced Antenna

As shown in Fig. 1, the proposed antenna has a pair of parallel folded dipole radiators which are placed orthogonally each other. Each dipole needs 0^o and 180^o input signal same as conventional dipole antenna. Thus the feeding networks below radiators has two ports and each port has T-junction power divider and 180^o delay line to make 0^o and 180^o input signal with equal power. With the internal feeding network and dipole radiators can generated two orthogonal LP.

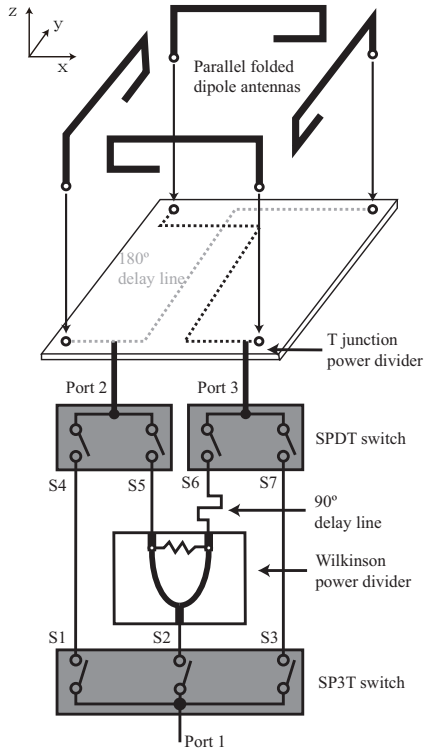

Fig. 1. The geometry of the proposed antenna with feeding network for mobile UHF RFID applications

To make additional CP, the distance between pair of dipoles are symmetrically optimized and it needs 90^o delay signal between two dipole radiators. RHCP or LHCP can be generated depends on dipoles rotation. In this paper, RHCP is chosen as

TABLE I. SWITCHING OPERATION FOR EACH POLARIZATION MODE

Polarization mode	S1	S2	S3	S4	S5	S6	S7
Vertical LP	○	-	-	○	-	-	-
Horizontal LP	-	-	○	-	-	-	○
RHCP	-	○	-	-	○	○	-

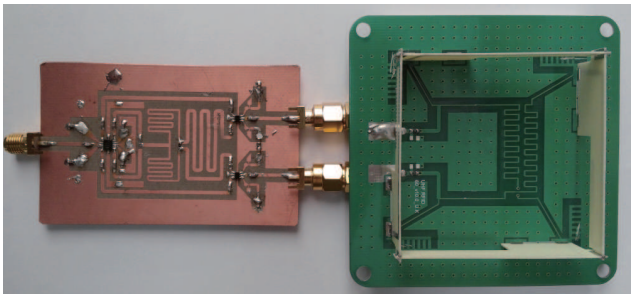

Fig. 2. The implemented polarization diversity antenna for UHF RF energy harvesting.

the radiators rotate clockwise direction. For RHCP, the vertical dipole placed along Y-axis have to have 90^o earlier signal than the horizontal dipole placed along X-axis. Therefore the feeding network for making three polarization (two orthogonal LP and RHCP) is made by a SP3T switch, wilkinson power divider, 90^o line, two SP2T switches. The condition for each polarization is summarized in Table I.

III. EXPERIMENTAL RESULT

The proposed antenna for mobile UHF RFID applications is simulated based on the finite difference time domain method and a prototype is fabricated to verify the simulation as shown in Fig. 2. The fabricated pattern is printed on the 0.5mm thick IS680 substrate, which has relative permittivity 3.45 and loss tangent 0.0035. For the compactness of feeding network, meander line is used in the delay lines and wilkinson power divider. The feeding network has three switches and SPDT switch has 0.25dB insertion loss and SP3T switch has 0.55dB insertion loss.

The reflection coefficient for each mode is below -15dB at the center frequency 920MHz and the insertion loss is -0.8 $\sim$ -1.0 dB for LP and -1.1 $\sim$ 1.5 dB for CP. The insertion loss is mainly caused by the switches. The phase difference between two output signal is 89.8^o at 920MHz. Fig. 3 shows the measured reflection coefficient of the proposed antenna system which is the combination of the dipole radiators and feeding network. The proposed antenna well-resonates at the center frequency and has the reflection characteristic of less than -10dB from 913MHz to 928MHz for LP and from 900MHz to 934MHz for CP.

The peak gain of the proposed antenna for each mode is also measured from 910 MHz to 930 MHz in an authorized anechoic chamber as shown in Fig 4. The vertical LP has 2.05 dBi, the horizontal LP has 1.82 dBi, and the RHCP has 1.45 dBic peak gain at the center frequency of 920HMz. The relative low peak gain of CP is shown and it is due to the loss of wilkinson power divider and 90^o delay line. The axial ratio is less than 2dB from 910MHz to 930MHz.

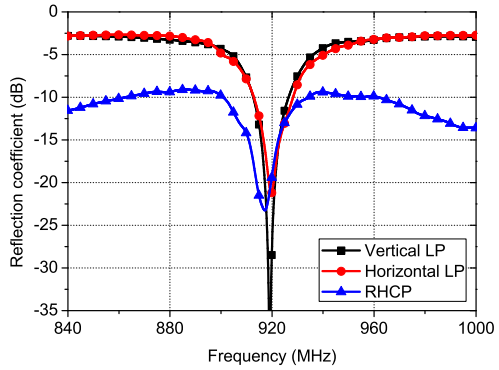

Fig. 3. The measured reflection coefficient of the proposed antenna system.

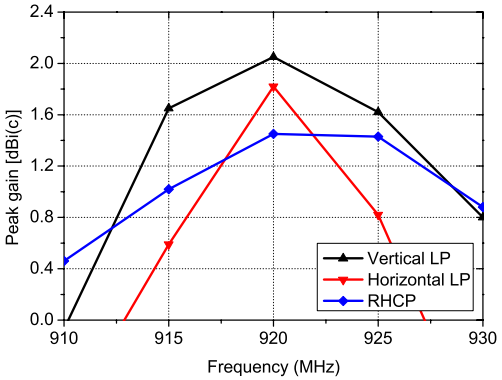

Fig. 4. The measured peak gain of the proposed antenna system.

IV. CONCLUSION

A compact detection range enhanced antenna using a triple polarization switching for mobile UHF RFID applications has been presented. The proposed antenna has been optimized using a pair of dipoles to make two pair of orthogonal linear polarization and one circular polarization. The feeding network which is composed of SPDT, SP3T switches, wilkinson power divider and 90^o delay line has been studied for making three polarization. Excellent performance of the fabricated polarization diversity antenna have been verified by experiment as well in the authorized anechoic chamber. The proposed antenna resonate well in the UHF band and has a peak gain of 2.05dBi for linear polarization and 1.45dBic for RHCP. The use of polarization switching may lead to avoid the polarization mismatch loss and enhance the possible reading range with various types of tags.

REFERENCES

[1] W. -G. Lim, S. -Y. Park, W. -I. Son, M. -Q. Lee, and J. -W. Yu, "RFID reader front-end having robust Tx leakage canceller for load variation," *IEEE Trans. Microwave Theory Tech.*, vol. 57, no. 5, pp. 1348-1355, May 2009.

[2] K. Finkenzeller, *RFID Handbook*, 2nden. New York: Wiley, 2004.

[3] T. Q. Wu et al., "A Compact and Broadband Microstrip Stacked Patch Antenna With Circular Polarization for 2.45-GHz Mobile RFID Reader," *IEEE Antennas Wireless Propag. Lett.*, vol. 12, pp. 623626, 2013.