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PLANAR LOOP TAG ANTENNA WITH BANDWIDTH ENHANCEMENT FOR UHF RFID SYSTEM

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ABSTRACT: *A novel planar loop tag antenna mounted on the plastic pallets for ultra-high frequency (UHF) radio frequency identification (RFID) system is proposed. By insetting the U-shaped slot and a pair of rectangular parasitic strips into the proposed loop tag antenna, the resonant mode close to ultra-high frequency (UHF) 900-MHz band is excited to enhance the operating bandwidth. The obtained impedance bandwidth across the operating band can reach about 174 MHz (18.8%) for UHF band. Also, with bidirectional pattern, the measured reading distance is about 2.0 m as the proposed loop tag antenna mounted on the plastic pallets.* © 2011 Wiley Periodicals, Inc. Microwave Opt Technol Lett 53:2711–2713, 2011; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.26361

Key words: *loop antenna; UHF RFID; RFID tag*

1. INTRODUCTION

Recently, ultra-high frequency (UHF) (860–960 MHz) band radio frequency identification (RFID) system becomes more attractive for many industrial services such as supply chain, tracking, inventory management, and bioengineering applications because it can provide longer reading distance, fast reading speed, and large information storage capability. Tag antenna is the pivotal role for UHF RFID system to transmit/receive the modulated information. The detection range and accuracy are directly dependent on the performance of reader/tag antennas.

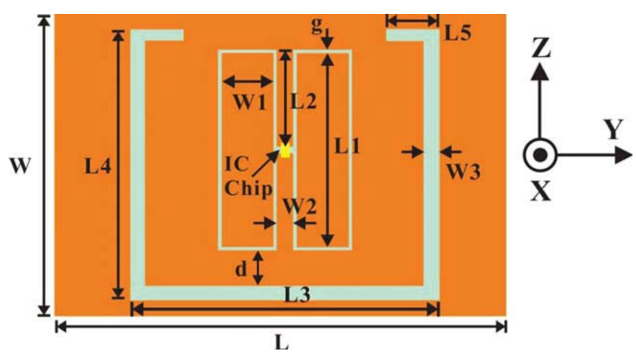

Figure 1 Geometry of the proposed loop tag antenna with bandwidth enhancement for UHF RFID system. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

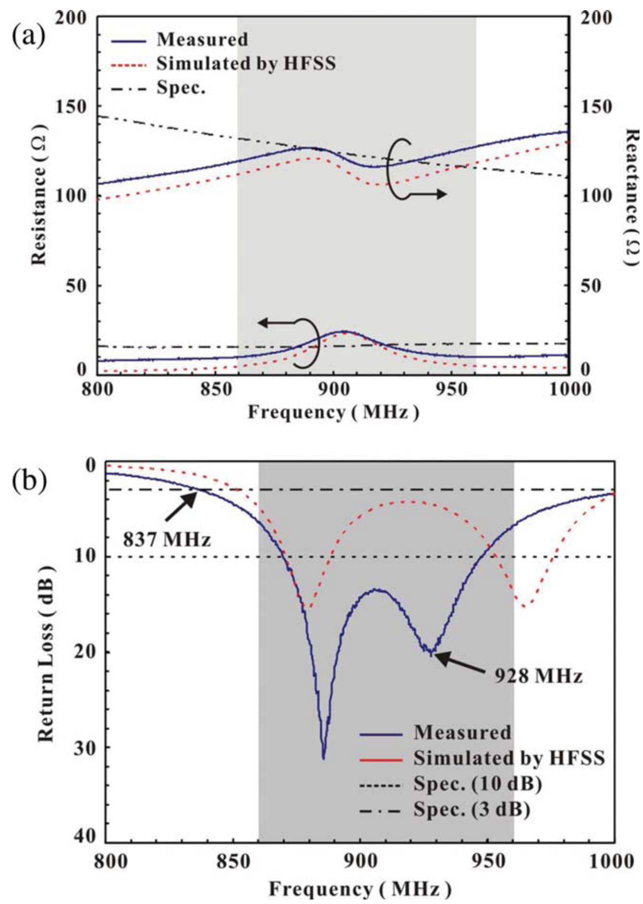

Figure 2 Simulated and measured input impedance and return loss against frequency for the proposed loop tag antenna; antenna parameters are given in Table 1. (a) Input impedance and (b) return loss. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

Some tag antennas for UHF RFID system have been proposed using symmetrical dipole antenna [1–4], meander antenna [5], planar inverted-E antenna [6], and slit antenna mounted on metal materials [7, 8]. However, tag antenna using loop structure applied for the plastic pallets is very scant in the literature. Therefore, in this article, we present a novel design of UHF RFID tag antenna with bidirectional reading pattern. This RFID tag antenna is composed of the loop antenna with the U-shaped slot and a pair of rectangular parasitic strips. Owing to the U-shaped slot inset into this proposed loop tag antenna, a resonant mode near 900-MHz band can be excited to obtain a new matching mode close to the fundamental matching mode of the conventional loop antenna to have a wider operating bandwidth for UHF band. The obtained impedance bandwidth across the operating band can reach about 174 MHz (18.8%). And, with bidirectional reading pattern, the maximum reading distance is

TABLE 1 Simulated and Measured Return Loss Against Frequency for the Proposed Loop Tag Antenna

Proposed Tag Antenna	f_L–f_H (MHz)	BW (MHz/%)
Simulated	852–1004	152/16.4
Measured	837–1011	174/18.8

$L = 60$ mm, $L_1 = 26$ mm, $L_2 = 12.8$ mm, $L_3 = 39$ mm, $L_4 = 36$ mm, $L_5 = 7$ mm, $W = 40$ mm, $W_1 = 6.2$ mm, $W_2 = 2.4$ mm, $W_3 = 2$ mm, $g = 1$ mm, $d = 5.5$ mm

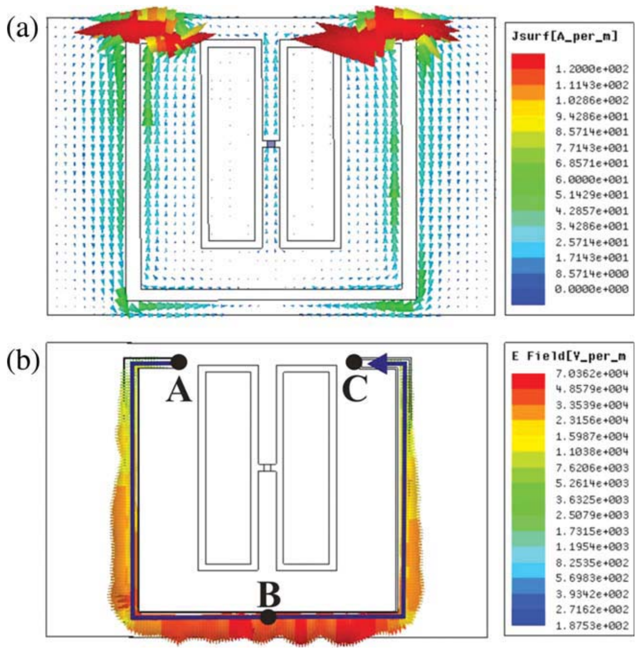

Figure 3 Simulated distributions of the surface current and electric field for the proposed loop tag antenna; antenna parameters are given in Table 1. (a) Surface current and (b) electric field. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

about 2.0 m as the loop tag antenna mounted on the plastic pallets. Details of the proposed loop tag antenna designs are described, and experimental results for the obtained performance operated at 900-MHz band are presented and discussed.

2. ANTENNA DESIGN

The geometry of the proposed loop tag antenna is shown in Figure 1. The loop antenna with the antenna size of 60 × 40 mm^2 is printed on an FR4 substrate (ε_r = 4.4, thickness = 0.8 mm, and loss tangent = 0.0245). Two stub strips with the same dimension of $L_2 \times W_2$ are arranged at the inside slot's center of the loop antenna to feed with the integrated circuit (IC) microchip. A pair of rectangular parasitic strips with the dimension of $L_1 \times W_1$ are embedded into the inside slot with the gap of g to

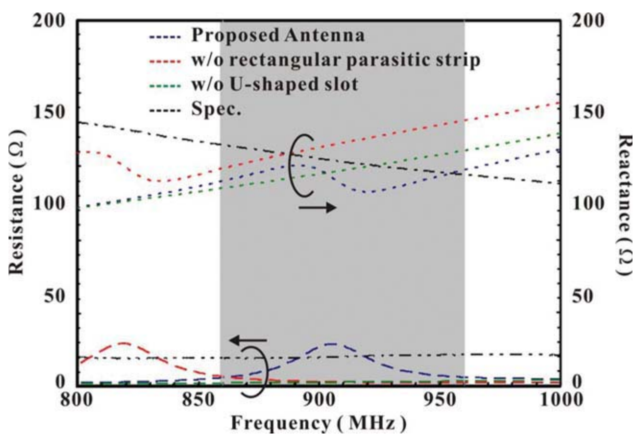

Figure 4 Measured input impedance against frequency for the proposed loop tag antenna with the inset U-shaped slot and a pair of rectangular parasitic strips or not; other antenna parameters are given in Table 1. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

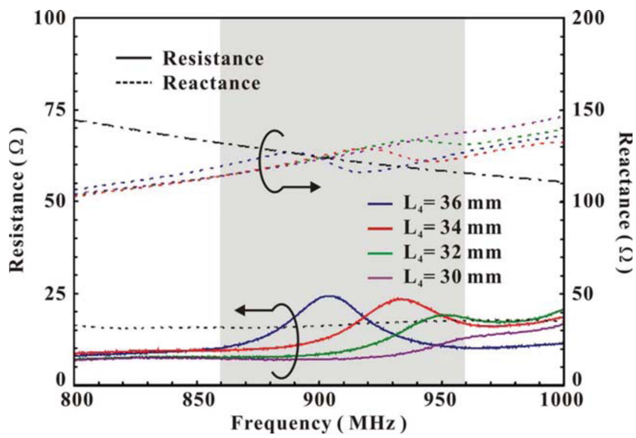

Figure 5 Measured input impedance against frequency for the proposed loop tag antenna with various lengths (L_4) of the U-shaped slot; other antenna parameters are given in Table 1. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

the inside edge of the loop antenna. And, by insetting the U-shaped slot with the total length of 124 mm (about 0.5λ_g) into the loop tag antenna, a resonant mode near 900-MHz band can be excited to have the new matching mode slightly higher than the fundamental matching mode for enhancing the operating bandwidth for UHF RFID system. The impedance of the microchip (Higgs-2), which is connected between two feed points of the closed loop, is (17 -j120) Ω at the operating frequency of 925 MHz in this study.

3. EXPERIMENTAL RESULTS AND DISCUSSION

To demonstrate the above deduction and guarantee the correctness of simulated results, the electromagnetic simulator HFSS based on the finite element method [9] has been applied for the proposed loop tag antenna design. The input impedance of the proposed tag antenna is measured on an Agilent Vector Network Analyzer 8722ES with two-port calibration kit N1020A. Figure 2 shows the related simulated and experimental results of the

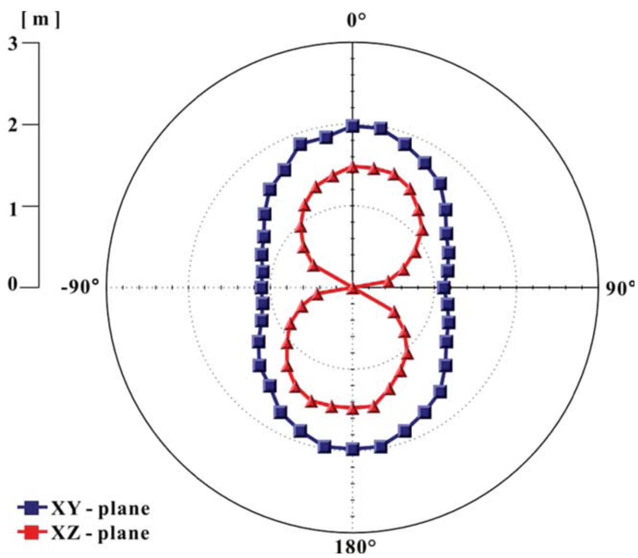

Figure 6 Measured reading range patterns in the XY and XZ plane for the proposed loop tag antenna operating at 900 MHz. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

input impedance and return loss for the proposed tag antenna of Figure 1. The related results are listed in Table 1 as comparison. Results show the satisfactory agreement for the proposed tag antenna design operating at UHF band. In Figure 2(a), it is seen that a resonant mode near 910-MHz band can be excited with good matching to the input impedance of the IC microchip. 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 proposed designs [1, 8]. From the related results shown in Figure 2(b), the measured half-power bandwidth (RL $\geq$ 3 dB) can reach about 174 MHz (837–1011 MHz), which totally covers the worldwide UHF RFID band. Because of the little difference of the input reactance between the simulated and measured results, the simulated higher matching frequency is slightly higher than the measured matching frequency.

To fully comprehend the excitation of the UHF RFID band, the simulated distribution of the surface current on the metal portion and the electric field in the U-shaped slot of the proposed loop tag antenna at 910 MHz are shown in Figure 3, along with an additional blue arrow sign showing the excited path of the resonant mode. It can be seen that the excited surface currents along the U-shaped slot are strong and close to symmetric. Strong excited electric fields in the U-shaped slot (A $\rightarrow$ B $\rightarrow$ C) are seen at 910 MHz shown in Figure 3(b). These two characteristics indicate that the U-shaped slot is excited as a half-wavelength resonant structure operating at 910 MHz. Figure 4 shows the comparison of the simulated input impedance for the proposed tag antenna with or without the inset U-shaped slot and a pair of rectangular parasitic strips. First, by insetting the U-shaped slot in this conventional loop antenna, a resonant mode near 820-MHz band can be excited. Then, by embedding a pair of rectangular parasitic strips into the central slot of the loop antenna, the resonant frequency moves higher to 910 MHz due to more capacitance generated by the coupling effect between the parasitic strips and the loop antenna. The measured impedance for the proposed loop tag antenna with various lengths (L_4) of the U-shaped slot is illustrated in Figure 5. It can also be found that when the length of L_4 increases from 30 to 36 mm, the total length of the electric field distribution in the U-shaped slot (A $\rightarrow$ B $\rightarrow$ C) also increases from 112 to 124 mm to make the resonant operating frequencies significantly decreased. On the basis of the backscattering method, the measurement of the loop tag antenna with the microchip is carried out in anechoic chamber by introducing Tagformance lite Measurement System from Voyantic Company. A reader with the output power of EIRP 3.28 W was connected to the linear polarization (LP) antenna with peak gain of 8 dBi. The measured two-dimensional reading patterns in *XZ* and *XY* planes of the planar loop tag antenna mounted on the plastic pallets are plotted in Figure 4. It is easily found that the patterns are with bidirectional radiation pattern in the *XZ* and *XY* plane with the maximum reading distance of 2.0 m. Because of the polarized direction of the LP reader antenna parallel to *XZ* plane, the maximum reading distance in the *XY* plane is more than that in the *XZ* plane.

4. CONCLUSIONS

A novel loop tag antenna with the inset U-shaped slot and a pair of rectangular parasitic strips is proposed for the application of UHF RFID system. The measured half-power bandwidth of the proposed loop tag antenna is 174 MHz (18.8%), covering the entire UHF RFID band. Also, with bidirectional pattern, the measured reading distance is about 2.0 m as the tag antenna mounted on the plastic pallets for the practical supply chain system.

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HYBRID SUPERELLIPTIC HORN

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ABSTRACT: *The waveguide horn with elliptic flare has been shown to exhibit superior radiation and impedance properties. In this article, a horn is described that flares with a hybrid superelliptical profile. The radiation patterns in the principal planes are identical up to the -10-dB points.* © 2011 Wiley Periodicals, Inc. Microwave Opt Technol Lett 53:2713–2716, 2011; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.26360

Key words: *waveguide horn; superelliptic profile*

1. INTRODUCTION

Conventional pyramidal waveguide horns are popular structures and widely applied as primary radiators, feeds for reflector antenna systems and so forth. By modifying the linear flare of the pyramidal horn to an elliptic flare, it was shown in Ref. 1 that it is possible to dramatically improve the matching of the horn, as well as to eliminate the sidelobes. Although the radiation patterns of the elliptical horn did not vary as much as those of linear pyramidal horns, the radiation patterns in the principal planes retained the same shape, but the E-plane pattern was