UHF reader loop antenna for near-field RFID applications

H.-W. Liu, K.-H. Wu and C.-F. Yang

A novel reader loop-type antenna for ultra-high-frequency (UHF) near-field radio frequency identification (RFID) applications is presented. This antenna, printed on a 0.8 mm-thick FR4 substrate with a diameter of 16 cm, is composed of four curved strips and four pairs of coupled stubs, and achieves a wide impedance bandwidth from 840 to 1300 MHz. The proposed structure can make large currents along the loop so that a strong and uniform magnetic field distribution is excited in the region around the antenna. Measurements show that the antenna operating with a commercial reader demonstrates good performance of tag identification with inductive coupling for near-field RFID applications.

Introduction: Radio frequency identification (RFID) systems for ultra-high-frequency (UHF) near-field communications (NFC) [1] have been rapidly developed in various applications, such as the point of sale (POS) and intelligent shelf. Generally, the tags used in the near-field region can be detected by inductive and capacitive couplings. Conventional reader antennas for far-zone reading may not perform well in near-zone applications. Particularly for tags closely stacked or lined up together, the performance of the tags will be reduced significantly owing to severe mutual coupling among them [2, 3]. To solve these problems for tag identification with inductive coupling, a planar composite antenna [4] and a segmented loop antenna [5] have both been designed to have large current distributions on the antenna surface to generate strong magnetic fields in the interrogation region.

In this Letter, we present a UHF reader loop-type antenna based on inductive coupling for near-field RFID applications. The proposed loop structure uses curved strips and coupled stubs to achieve good impedance matching over the operating band, as well as uniform magnetic field distribution surrounding the antenna. An EM solver, HFSS™, is employed to analyse the near-field characteristics of the antenna. Experiments on tag reading by using the designed antenna connected to a commercial reader have also been performed. The proposed antenna shows good capability for tag reading through the inductive coupling in the near-zone.

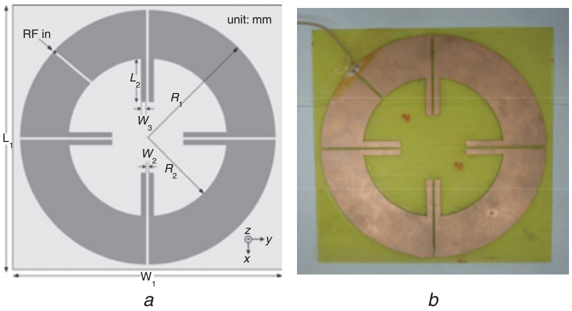

Fig. 1 *Proposed loop-type antenna*

a Antenna geometry (L_1 = 170 mm, L_2 = 28.5 mm, W_1 = 170 mm, W_2 = 2 mm, W_3 = 4 mm, R_1 = 80 mm, and R_2 = 45 mm)
b Photograph

Antenna design: Fig. 1 shows the geometry of the proposed near-field loop-type antenna. This antenna with a size of 160(L) × 160(W) × 0.8(H) mm is composed of four curved strips and four pairs of coupled stubs, and is fabricated on an FR4 substrate with a dielectric constant of 4.4 and a loss tangent of 0.02. By using the coupling structure, large surface currents along the loop flow in two opposite directions even though the perimeter of the loop is comparable to the operating wavelength. The main difference between the proposed loop antenna and conventional loop design is the reading direction of the magnetic field (H-field), as shown in Fig. 2. For Case 1, the conventional loop antenna has often been designed with a single current direction to generate an H-field vertical to the antenna. Hence the tag parallel to the antenna can be identified in the near-zone. However, for specific near-field RFID systems, such as POS and intelligent book shelf, the small tag is attached to the object vertical to the reader antenna, so that the performance for tag reading of the above loop design may be degenerated obviously as expected. To address this problem, the proposed loop antenna has been designed to have two opposite currents distributed on the antenna surface, as illustrated in Case 2. As can be seen, this loop-type antenna can generate a strong and uniform H-field parallel to the antenna for reading small loop tags vertical to the antenna. Good performance for tag reading in the near-field region can be achieved. It is noted that these coupled stubs also offer good impedance matching between the antenna and the 50 Ω RFID reader over the operating band. Compared with conventional loop design, the proposed antenna is more suitable for use in specific near-field RFID applications.

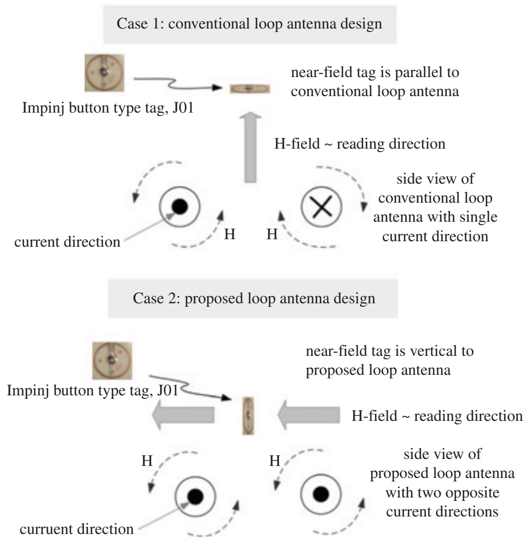

Fig. 2 *Magnetic field (H-field) directions of proposed antenna and conventional loop antenna*

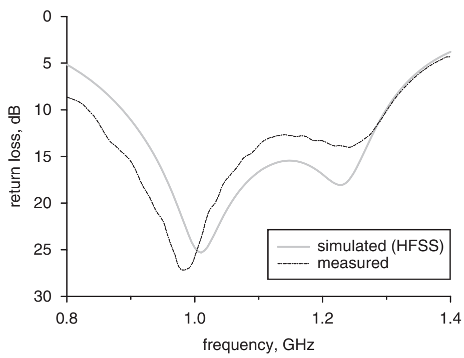

Fig. 3 *Simulated and measured return loss of proposed antenna*

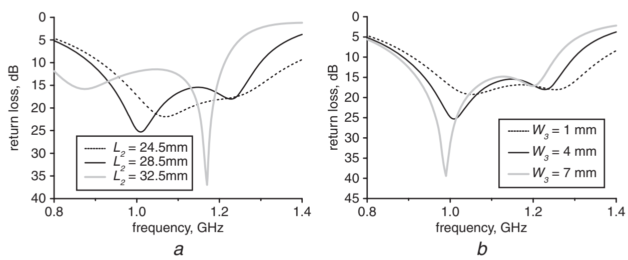

Fig. 4 *Simulated return loss for various designed parameters*

a Length L_2
b Width W_3

Results: Fig. 3 shows the simulated and measured impedance bandwidth of the proposed antenna with 10 dB return loss from 840 to 1300 MHz, which also covers the UHF RFID band. Figs 4*a* and *b* show that the length L_2 and width W_3 of the coupled stubs are optimised to be 28.5 and 4 mm, respectively, to achieve good impedance matching across the operating band. Simulations of the surface current and magnetic field distribution of the antenna at 925 MHz are shown in Figs 5*a* and *b*, respectively. Two opposite currents along the loop and uniform field distribution surrounding the antenna are clearly observed, so that the tags with inductive coupling can be interrogated in the near-field region.

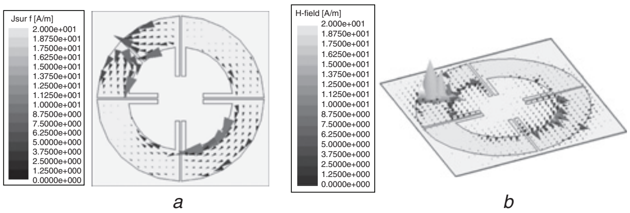

Fig. 5 *Simulated near-field characteristics at 925 MHz (z = 0 mm)*

a Surface current distribution
b Magnetic field distribution

To examine the antenna performance, experiments on tag reading have been performed; the test setup is illustrated in Fig. 6. An Impinj Speedway reader was used to detect item-level loop tags (Impinj button type tag, J01) with inductive coupling in the frequency range 922–928 MHz. Measurements show that the proposed near-field antenna has a maximum readable range of 20 cm for the loop tag with a diameter of only 9 mm located at the centre. At the edge of the antenna, a readable distance of 15 cm can still be achieved.

Fig. 6 *Experimental setup for testing proposed antenna in reading item-level loop tags*

Conclusions: A novel loop-type antenna operating at the UHF band has been proposed to meet the near-field RFID applications. This antenna is capable of producing a strong magnetic field with a fairly uniform field distribution, so that the tags used in the near-zone are able to be detected well through the inductive coupling. For these reasons, the proposed design is a very promising candidate for UHF near-field RFID reader applications.

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One or more of the Figures in this Letter are available in colour online.

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