Compact and Planar Near-field and Far-field Reader Antenna for Handset

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Abstract-In this paper, we proposed a compact near-field and far-field RFID reader antenna with a dimension of 50 mm × 50 mm × 0.8 mm in the UHF band. The fabricated antenna printed on a FR4 substrate operates from 915 to 935 MHz with reflection coefficient less than ~10dB, covering the China UHF band. The strong and uniform magnetic field is excited by magnetic dipole source. The measured reading distance are up to 58 mm and 110 mm for near-field and far-field applications, respectively. This antenna can be applied for handset in mobile applications due to its small size.

I. INTRODUCTION

Radio frequency identification (RFID) in ultra high frequency (UHF) is gaining popularity in a number of practical applications, due to automatic identification for efficiently tracking and managing of objects. Based on types of objects and applications, inductively coupled near-field operation are used to transfer information between reader and tag. Far-field communication is widely used due to its long read range. Near-field reading can be useful for objects having metals and liquids in their vicinity, because normal far-field tags’ performance is affected by the presence of these objects [1], [2]. Inductive coupling is conventionally used at low frequency (LF) and high frequency (HF). Due to promising performance at item-level tagging (ITL) of small, expensive, and sensitive objects and different applications such as pharmaceutical logistics and bio-sensing applications, it is considered as a possible solution for ITL in pharmaceutical and retailing industry.

To design a UHF near-field and far-field RFID antenna for handset, the challenge is that the reader antenna must be miniaturized, and at the same time, the antenna have a uniform magnetic field in the near field region. Some structure have been presented. Shrestha et al use a segmented loop and a patch, respectively, to achieve near-field and far field operation, but they have too large size of 184 mm×174 mm [3]. Borja et al’s antenna has a dimension of 72.3 mm×72.3 mm [4].

In this paper, a UHF RFID reader antenna was proposed with simple and compact configuration for both near-field and far-field operations. The impedance bandwidth is suitable for China standard (920-925MHz), and it can provide the strong and uniform magnetic field in an adequate interrogation zone. Both simulation and measurements results are provided to illustrate the good performance of the designed antenna.

II. ANTENNA DESIGN AND STRUCTURE

Fig. 1 Current distributions of (a) one-wavelength-perimeter loop and (b) folded-dipole loop.

Loop antennas are commonly used for inductively coupled near-field RFID systems. At UHF band, the optimal size of the loop antenna is electrically large or comparable to the wavelength. The amplitude and phase distribution of the current, in the case, is not uniform, and it reverses at every half-wavelength, which results in a weak and nonuniform magnetic field at the center of the loop [5], as shown in Fig.1.(a). Some ideas were proposed to solve the problem of current reverse. A segmented loop antenna can avoid in-phase of current [6]. Dual-dipoles also can achieve a uniform magnetic field in near-field region for pure near-field operation [7].

A novel folded-dipole loop antenna was proposed as shown in Fig.1.(b). This antenna can achieve a uniform magnetic field easily, and has a good far-field gain. The folded-dipole is fabricated on the FR-4 substrate with a dimension of 50 mm×50 mm, dielectric constant εr=4.4, loss tangent tanδ=0.02, thickness h=0.8 mm. Detailed dimensions are shown in the Fig.2 (a), s=3 mm, s1=8.5 mm, the antenna size is L(45mm)×L(45mm), Line width is 0.75 mm.

Fig. 2 prototype of the folded-dipole loop antenna
III. RESULTS AND DISCUSSION

Simulations were performed using Ansoft High Frequency Structure Simulator (HFSS) software, which uses the finite element method (FEM).

Fig.2 (b) shows the fabricated antenna after parameter optimization. The measured S11 agrees with the simulated one with a slight deviation to the right side by 1 MHz as shown in Fig.3. The measured bandwidth ranges from 916 to 936 MHz, which covers the China UHF band.

The simulated current distribution along this folded-dipole loop is shown in Fig.4. We can see that the current reverses at outer loop, however, which is unidirectional along the inner loop. Fig.5 shows the resulting z-component of the magnetic field on an xy-plane above the antenna at z=0 and z=10mm. We can see that the field distribution is uniform in the center region.

Based on the fabricated antenna, we measure the read range and width by using the Impinj UHF button [Fig.6(c)]. The test scene is presented in Fig.6(a), Fig.6(b) shows the prototype of the presented antenna. Under the transmission power level of 15dBm, the measured reading distance is 58 mm. When the tag is attached to a water-item container, the reading range is still the same. Additionally, a far-field tag is also measured, reading range is around 110 mm due to the good far-field gain of the reader antenna. When the far field tag is attached to the bottle of water, the reading range is reduced to 4.5 mm.

The Impinj UHF button whose diameter is around 1cm measured read width is shown in Fig.7. From Fig.7 (a), we use the square lattice, its size is 1cm × 1cm.

The simulated and measured radiation patterns of the proposed antenna are respectively shown in Fig.8 which makes the antenna suitable for far-field application.
Fig. 8 Simulated and measured far-field radiation patterns
(a) xz-plane
(b) xy-plane

IV. CONCLUSION

In this paper, a novel UHF reader antenna was proposed for near-field and far-field simultaneous operation. A magnetic dipole was folded to produce a uniform magnetic field distribution at UHF. This RFID reader antenna is designed for the China UHF RFID band. With the Impinj UHF button near-field tag, the maximum read range obtained was 58 mm under 15 dBm transmission power. The near-field reading performance was not degraded when the tag was attached to a water container. The far-field read range, with a commercial far-field tag, was approximately 11 mm. This novel RFID reader antenna can be applied for near-field and far-field operations.

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