A Low-Profile Directional UHF Near-field RFID Reader Antenna

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Directional near-field antennas are desirable in many applications including magnetic resonance imaging (MRI) and radio-frequency identification (RFID). In such inductive coupling systems, the most used loop-type antennas are with bidirectional radiation. The common approach to achieving a directional near-field distribution is to back the antenna with a metallic ground plane (X. Qing et al., IEEE Trans. Antenna Propag., 58(12), 3829–3838, 2010). However, the eddy current induced on the ground plane is in the opposite direction to that on the antenna, and it therefore weakens the near-field intensity significantly unless the metallic ground plane is positioned $\lambda_0/4$ away from the antenna (with λ_0 being the free-space wavelength at the operating frequency), which would increase the thickness of the antenna, in particular, at lower frequency bands. One effective approach is to use a high-impedance surface (HIS) to replace the metallic ground plane, which can not only greatly reduce the thickness of the antenna, but also increase the field intensity (G. Saleh et al., Proc. EUCAP., 1399–1401, 2012). However, designing a HIS is relatively time consuming, and the fabrication cost also increases significantly when complex structures are employed.

Recently, a very low-profile metallic ground backed dipole antenna with enhanced radiation is proposed (Z. N. Chen et al., IEEE Trans. Antenna Propag., 64(11), 4868–4871, 2016). A parasitic strip is added in between the dipole and the metallic ground plane, which introduces an additional phase shift to compensate for the effects of the out-of-phase current induced on the metallic ground plane. With this, the dipole antenna can be positioned very close to the metallic ground plane. In this abstract, such a concept is extended to the near-field antenna case wherein a low-profile directional zero-phase-shift-line (ZPSL) loop antenna is designed for ultra-high frequency (UHF) near-field RFID applications. The proposed near-field antenna is formed by a main ZPSL loop, a parasitic ZPSL loop, and a metallic ground plane. A directional magnetic field distribution is achieved in the near-field zone of the antenna with an antenna thickness of 0.045 λ_0 at 915 MHz. A parametric study is carried out to investigate the relation between the magnetic field distribution and the physical topologies of the antenna that include different designs of the parasitic loop. The field distribution is measured to validate the simulation. The proposed antenna is also tested as a UHF near-field RFID reader antenna to verify its performance. A much enlarged reading range is achieved with a 100% RFID tag detection rate.