Near-Field Analysis and Polarization Control in EM Simulation of UHF RFID Smart Shelf Antennas: A Review

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During the last decade, the radio frequency identification (RFID) technology has matured and became an indispensable tool in a variety of applications, such as security, retail tracking, counterfeit prevention, and healthcare to name just a few. The operation of UHF RFID systems is based on the activation of RFID tags by the EM field produced by the reader antenna so that an accurate field characterization plays an important role in improving the system reliability and data capacity. Due to the practical needs to expand the RFID read range from the conventional far-field to the radiative and reactive near-field antenna zones, new concepts of the near field antenna operation have been required.

Various designs of the near-field reader antennas utilized for different UHF RFID applications have recently been proposed [1]. Typically, small-size linearly polarized antenna elements of the most widely used RFID tags respond to the incident E-field of the reader antenna. In the conventional operation, right hand circularly polarized (RHCP) E-field radiation is used to activate the tags arbitrary oriented in the plane normal the propagation direction. For the so-called smart shelf antenna applications, UHF RFID tags are placed on the reader antenna surface and may occupy various interrogation volumes ranging from a few mm to 50cm in height. In such a case, reliable operation of the RFID system depends on the antenna's ability to produce uniform E-field distribution and "quasi-CP" radiation in the reactive near field zone. Accurate numerical analysis of the near field distribution and E-field polarization control at different distances from the antenna surface are necessary to ensure 100% tag read rate.

We present a comprehensive review of the design of planar periodic EM coupled strip UHF (916-920 MHz) reader antennas and accurate near-field analysis of E-field distribution within the RFID interrogation volume. The antenna design producing the CP radiation in the near field of planar antenna has been presented in [2]. Full-wave EM simulation by CST MS commercial software has been used for the parametric study and optimization of the antenna layout. The concept of near field circular polarization will be introduced. Various antenna designs radiating both linearly polarized and CP/elliptically polarized E-field in the near field zone will be presented. It will be shown how the CP antenna performance depends on the 2D layout of the periodic EM coupled printed strips. Numerical optimization has been employed to produce uniform E-field distribution required to activate the RFID tags within the entire interrogation volume. Time-domain 3D E-field vector distribution illustrates the effect of the reactive near field quasi-CP field-to-the radiative near field CP transformation at different distances form the antenna surface. Next, the extension of the interrogation volume in the near field by introducing the progressive phase shift between the antenna periodic elements will be presented. Calculated E-field distributions illustrate how the antenna beam scanning in the far field changes the near field antenna radiation. It will also be shown that the simple modification of the layout of the microstrip feed line results in simultaneously producing RHCP and left hand circularly polarized (LHCP) E-field radiation within different volumes of antenna near field. In addition to RFID applications, these antenna designs can be utilized in the wireless communication systems requiring the polarization diversity operation with both RHCP and LHCP performance.

References

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[2] A. S. Andrenko, "Optimized Near-Field Antenna for UHF RFID Smart Shelf Applications," *Proc. of 2015 IEEE Int Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting*, July 2015, pp. 1576-1577, doi: 10.1109/APS.2015.7305177.