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A Hybrid Uniform Geometrical Theory of Diffraction(UTD) Solution for Predicting the Performance of RFID Tags on Large Metallic containers

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Abstract

This paper presents a hybrid UTD approach for the prediction of the performance of RFID tag antennas on electrically large metallic containers such as rectangular boxes and cylinders. The RFID tag antennas are typically small compared to the radiated wavelength, while the containers on which they are placed may be very large in terms of the wavelength. Thus it is natural to treat the tag antenna via a numerical full wave method and combine its pattern and impedance information appropriately in a hybrid fashion with the high frequency UTD ray method for taking into account the performance of the tag antenna which now radiates in the presence of the metallic container on which the tag is actually placed. Here one initially solves for the radiation pattern and the impedance of the tag antenna on an infinite flat ground plane using a numerical full wave solver and then combine it systematically with the UTD ray solution for the fields of a point current on the container geometry. The tag antenna on a flat ground plane can be analyzed via commercially available full wave software such as the CST or the HFSS. Also, the tag antenna can be designed with such full wave solvers so that the antenna parameters provide an antenna impedance which is the complex conjugate of the so called chip impedance that is connected to the feed terminals of the tag antenna. Alternatively a measurement of the tag antenna pattern and impedance on a finite ground plane with appropriately treated edges can also be utilized in place of characterization of the tag antenna in terms of a numerical full wave treatment. One candidate tag antenna considered here, for the sake of being specific,is a thin incomplete rectangular slot in a metal patch over a thin dielectric substrate, which is then placed directly on the large metallic container. When the combined tag-container geometry is interrogated by a reader antenna/array, then the complete field backscattered by this configuration contains a component of the field radiated by the tag antenna when illuminated by the reader; this component is modulated by the chip and provides the desired information to the reader. The full wave solver/measurement for characterization of the tag provides information on an “equivalent UTD” tangential point magnetic current source located at the center of the tag which thus replaces the tag and provides the same radiation pattern as the tag. This equivalent point current changes its strength and orientation as a function of observation. Placing this equivalent UTD point magnetic current on the container now simulates the effect of the tag in the presence of the container via a systematic UTD procedure. The rays emanating from the tag-container configuration then provides information on the radiation performance of the tag. Such analysis is useful in predicting the performance of the complete reader-tag-container system including power considerations.

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