Antenna Positioning Analysis and Dual-Frequency Antenna Design of High Frequency Ratio for Advanced Electronic Code Responding Labels

by

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To

My Parents

Contents

Abstract

The research background of this thesis is Radio Frequency Identification (RFID), where an object can be identified remotely using electromagnetic waves. The focus of this thesis is on the in-depth investigation of two major problems in the RFID deployment in supply chain applications, namely the reader collision problem in dense reader environments and the tag performance problem in hostile environments.

To resolve the reader collision problem, the first part of this thesis offers a comprehensive path loss model for the analysis of the positioning of RFID reader antennas. Simulation software was developed to predict the signal strength at a certain distance from a reader antenna in a dense reader environment.

This simulation software was also utilised to publish insights and research results in four major areas, which are: (i) Investigation on the sources of error in RFID simulation, to provide sensible and meaningful simulation results before actual deployment of RFID readers. (ii) The development of the idea of reader synchronisation, mainly to address the strict regulations imposed on the deployment of RFID readers in Europe. (iii) The determination of the threshold value for second carrier sensing in RFID, to enable the proper enforcement of second carrier sensing to avoid tag confusion in dense reader environments. (iv) The examination of Specific Absorption Rate (SAR) to ensure human safety in a dense RFID reader environment.

The second part of this thesis addresses the RFID tag performance problem in hostile environments. The focus is on the development of HF and UHF tags, from the initial tag antenna design, tag antenna simulation, tag antenna prototyping and measurement, to the manufacturing of fully functional RFID tags at laboratory standards by combining RFID chips on to tag antennas.

Though there are existing commercial grade HF and UHF RFID tags, they are mostly aimed at pallet level applications and are not suitable for deployment in hostile environments. The study cases presented in this thesis are mostly industrially driven, where there is a need to design specialty HF and UHF tag antennas.

With a strong foundation in the development of HF and UHF RFID tags for various industrially driven applications, the research then concentrates on the development of a novel dual-frequency RFID antenna, which operates in both the HF and UHF regions. This dual-frequency RFID tag antenna embraces the benefits of both the HF and UHF tag antenna, which enable it to have a good read range while operating in environments that pose difficulties for RFID technology, for example applications in which ionised liquid is present, such as in cases of wine or bottled drinks.

Several methodologies were used to develop a dual-frequency antenna, including the merging of HF and UHF antennas, and having a UHF resonance point on a typical HF antenna. With the successful development of an original dual-frequency antenna, the research was then expanded to miniaturise this dual-frequency antenna.

The benefits of RFID deployment in supply chains are undoubtedly massive, though there are still issues and challenges to be resolved before a world-wide adoption is possible. This thesis contributes in recommending various reader antenna positioning and deployment techniques, and also contributes in developing HF tag antennas and UHF tag antennas for hostile environments, and a novel dual-frequency tag antenna to progress towards the aim of ubiquitous object identification.

Statement of Originality

This work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis being made available in the University Library.

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Signed

Date

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Kin Seong Leong
Dec. 2007

Conventions

Typesetting

This thesis is typeset in Times New Roman and Sans-Serif using $\LaTeX$2e. Referencing and citation style are based on the Institute of Electrical and Electronics Engineers (IEEE) Transaction style [1]. For an electronic source, the last updated date of the source is enclosed within round parentheses, and is placed immediately behind the author(s)' name [2]. The last access date is included within square parentheses and can be found at the end of the entry.

Units

The International System of Units (abbreviated SI units) [3] is used in this thesis. Prefixes "nano", "micro", and "milli" are preferred but prefix "cm" is avoided.

Spelling

English spelling in this thesis is based on Australian English. One exception is in some special cases where the proper noun is used. For example: "Auto-ID Center", not "Auto-ID Centre". Also, the plural of "antenna" is chosen to be "antennas" not "antennae", to be in line with most of the international technical publications.

Publications

Book Chapter

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