

Design of High Performance RFID Systems for Metallic Item Identification

by

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To my parents

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Abstract

Although the origins of Radio Frequency Identification (RFID) technology can be traced back for many years, it is only recently that RFID has experienced rapid growth. That growth is mainly due to the increasing application of this technology in various supply chains. The widening of the implementation of RFID technology in supply chains has posed many challenges and one of the biggest is the degradation of the RFID system performance when tagging metallic objects, or when the RFID system operates in a metallic environment. This thesis focuses on tackling the issue of having metallic objects in an Ultra High Frequency (UHF) RFID system.

The work presented in this thesis contributes to the research on UHF RFID systems involving metallic objects in several ways: (a) the development of novel RFID tags that range from a simple tag for general applications to tags suitable for metallic object identification; (b) the tag designs target the criteria of minimal tag size and cost to embrace the vision of item level tagging; and (c) the analysis of the performance (through theoretical predictions and practical measurements) of an RFID tag near metallic structures of various shapes and sizes.

The early part of this thesis provides a brief introduction to RFID and reviews the background information related to metallic object identification for UHF RFID systems. The process of designing a basic tag, and additional information and work done related to the process, are outlined in the early part of this thesis. As part of this fundamental research process, and before proceeding to the designing of tags specifically for metallic objects, a small and low cost RFID tag for general applications was developed. Details of the design of this tag, with the application of this tag for animal identification, are presented.

In the later parts of the work, different tag design approaches were explored and this has generated three rather different RFID tags suitable for attaching to metallic objects. The aim of this research is not just to design tags for metallic objects but also to tackle the constraints of having tags that are small in size, cost effective and suited in size

to some familiar objects. Hence, in the later part of this research, the work took a step further where one of the three tags designed for metallic objects addressed the challenge of identifying individual small metallic beverage cans.

RFID involves tagging of different types of objects and a tag may be required to be located in a depression of a metallic object. In the final part of this research, the read range performance of one of the RFID tags designed for metallic objects was analysed when the tag was located in metallic depressions of various shapes and sizes. The analysis was performed from a combination of theoretical calculation and simulation perspectives, and also through practical real-life measurements.

Metallic objects are very common around us. Their presence is unavoidable and so to identify them, having the appropriate RFID tags suitable for operation on metallic surfaces is essential. Frequently the tags must be small in size and low in cost to allow identification at item level of individual small metallic objects. Understanding and being aware of the potential effects of metallic structures of various shapes and sizes on the tag performance is thus important. The research in this thesis into all the above can bring the industry further towards full deployment of RFID down to item level tagging.

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.

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Signed

Date

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Mun Leng Ng (June 2008)

Conventions

Typesetting

This thesis is typeset using the L^AT_EX2e software.

The fonts used in this thesis are Times New Roman and Sans Serif.

Referencing

The referencing and citation style adopted in this thesis are based on the Institute of Electrical and Electronics Engineers (IEEE) Transaction style [1].

For electronic references, the last accessed date is shown at the end of a reference.

Units

The units used in this thesis are based on the International System of Units (SI units) [2].

Prefixes

In this thesis, the commonly used numerical prefixes to the SI units are “p” (pico; 10^{-12}), “n” (nano; 10^{-9}), “ μ ” (micro; 10^{-6}), “m” (milli; 10^{-3}), “k” (kilo; 10^3), “M” (mega; 10^6) and “G” (giga; 10^9).

Phasors

Where phasors are used to represent sinusoidal quantities, peak value phasors rather than r.m.s. phasors are used.

Conventions

Spelling

The Australian English spelling is adopted in this thesis.

Illustrations

The illustrations in this thesis are drawn using the CorelDRAW 11 software.

Publications

Book Chapter

- [1] M. L. Ng, K. S. Leong, and P. H. Cole, "RFID tags for metallic object identification," in *RFID Handbook: Applications, Technology, Security, and Privacy*, S. Ahson and M. Ilyas, Eds. CRC Press, 2008.
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