Chapter 1
Introduction to Chipless and Conventional Radio Frequency Identification System

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ABSTRACT

The book provides a comprehensive coverage on most recent developments in chipless and conventional RFID. It covers a wide range of topics from component level design, analysis, and development, to system integration, middleware, anti-collision, and security protocols. The chipless RFID will bring revolutionary impacts on low-cost item tagging in this millennium. The RFID based sensors and RF sensors play a vital role in real time condition monitoring of objects. The designs of various chipless RFID tags and printing techniques to achieve a goal toward less than a cent tag are presented. The reading methods of RFID tags of various types, system perspective design, and analyses, detection techniques, sensor nodes for RFID system, security risk and vulnerability of the RFID technology and their remedies, anti-collision protocols, middleware and enterprise software implementation, and innovative applications of RFIDs in various fields are all presented in the book. The book will make a valuable reference in the RFID field, which has been growing exponentially.

INTRODUCTION TO CHIPLESS AND CONVENTIONAL RFIDS

Radio frequency identification (RFID) is an emerging wireless technology for automatic identifications, access controls, tracking, security and surveillance, database management, inventory control and logistics. The RFID has two main components: a tag and a reader. The reader sends an interrogating radio signal to the tag. In return the tag responds with a unique identification code to the reader. The reader processes the returned signal from the tag into a meaningful identification code. Some tags coupled with sensors can also provide data on surrounding environment such as temperature, pressure, moisture contents, acceleration and location. The tags are classified into active, semi-active and passive tags based

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on their on-board power supplies. An active tag contains an on-board battery to energize the processing chip and to amplify signals. A semi-active tag also contains a battery, but the battery is used only to energize the chip, hence yields better longevity compared to an active tag. A passive tag does not have a battery. It scavenges power for its processing chip from the interrogating signal emitted by a reader, hence lasts forever. However, the processing power and reading distance are limited by the transmitted power of the reader.

The main constraint of mass deployment of RFID tags for low-cost item tagging is the cost of the tag. The main cost comes from the application specific integrated circuit (ASIC) or the micro-chip of the tag. If the chip can be removed without losing functionality of the tag, then the tag can have the potential to replace the optical barcode. The optical barcode has several limitations in operation, including: (a) each barcode is individually read; (b) needs human intervention; (c) has less data handling capability; (d) soiled barcodes cannot be read; and (e) barcodes need line of sight operation. Despite these limitations, the low cost benefit of the optical barcode makes it very attractive as it is printed almost without any extra cost. Therefore, there is a pressing need to remove the ASIC from the RFID tag to make it competitive in deployment to co-exist or replace trillions of optical barcodes printed each year. The solution is to make the RFID tag chipless. Similar to the optical barcodes, the tag should be fully printable on low cost substrates such as papers or plastics. A reliable prediction by the respected RFID research organization IDTechEx (2009) advocates that 60% of the total tag market will be occupied by the chipless tag if the tag can be made less than a cent. However, removal of ASIC from the tag is not a trivial task as it performs many RF signal and information processing tasks. It needs tremendous investigation and investment in designing low-cost but robust passive microwave circuits and antennas using conductive ink on low-cost substrates. However, obtaining high fidelity response from low cost lossy materials is very difficult. In the interrogation and decoding aspects of the RFID system is the development of the RFID reader, which is capable to read the chipless RFID tag.

Currently, only a few chipless RFID tags, which are in the inception stage, are reported in the literature. They are: a capacitive gap coupled dipole array (Jalaly & Robertson, 2005); a reactively loaded transmission line (Zhan, 2006); a ladder network (Mukherjee, 2007); and finally, a piano and a Hilbert curve fractal resonators (McVay et al., 2006). These tags are in prototype stage and no further development in commercial grade is reported so far. To the best of the author knowledge, there is no chipless RFID reader reported in open literature besides the work reported from the author's group (Preradovic and Karmakar, 2010). To fill up the gap in the literature for the potential chipless RFID field, the author's chipless RFID research team has been working on the paradigm chipless RFID tag since 2004 (Karmakar, 2010, Preradovic, 2011). The designed tag has mainly targeted to tag chipless RFID tags as replacement of optical barcodes. Significant strides have been achieved to tag not only the polymer banknotes but also many low cost items such as books, postage stamps, secured documents, bus tickets and hanging cloth tags. The technology relies on encoding spectral signatures and decoding the amplitude and phase of the spectral signature. The other methods are phase encoding of backscattered spectral signals and time domain delay lines. So far as many as more than ten varieties of chipless RFID tags and three generations of readers are designed by this team. The proof of concept technology is being transferred to the banknote polymer and paper for low cost item tagging. These tags have potential to co-exist or replace trillions of optical barcodes printed each year. To this end it is imperative to invest on low loss conducting ink, high resolution printing process and characterization of laminates on which the tag will be printed. The design needs to push