

AC 2007-971: A THOROUGH HANDS-ON PROCESS TO IMPLEMENT A RFID SYSTEM

Ben Zoghi, Texas A&M University

Dr. Ben Zoghi is currently a Professor and Director of RFID/Sensor Lab in the Engineering Technology and Industrial Distribution Department at Texas A&M University. He has served the department as Industrial Distribution Program Coordinator, Executive Director of Thomas and Joan Read Center and Associate Department Head for Research since he joined Texas A&M in 1987. His research activities include RFID/Sensors and engineering leadership development. Dr. Zoghi is a senior member of IEEE, member of ASEE, TAP, TBP. He has over 100 educational and research publications.

Ryan Beasley, TAMU

Dr. Ryan Beasley joined the EET/TET program at Texas A&M as an Assistant Professor in Fall 2006 upon the completion of his PhD from Harvard. He has extensive experience in image processing, robotics, and control for medical applications.

Wei Zhan, Texas A&M University

Dr. Wei Zhan is an Assistant Professor of Electronics Engineering Technology at Texas A&M University. Dr. Zhan earned his D.Sc. in System Science from Washington University in 1991. From 1991 to 1995 he worked at University of California, San Diego and Wayne State University. From 1995 to 2006, he worked in the automotive industry as a system engineer. In 2006 He joined the Electronics Engineering Technology faculty at Texas A&M. His research activities include control system theory and applications to industry, system engineering, robust design, modeling, simulation, optimization, and RFID.

A thorough hands-on process to implement a RFID System

The purpose of this paper is to walk you through a step by step practical process of implementing RFID for your application. The process addresses technical issues, benefits, return of investment (ROI) and future upgrade. When the business problem is identified, you shall ask the following questions:

1. Does RFID help capture the data that is needed?
2. Is there any Physics issue that prevents RFID?
3. Is there enough ROI for RFID use?
4. What else can I gain with the RFID implementation once the problem is solved?

Once you have answered the above questions and have identified that RFID is indeed helpful, the next stage is process mapping, and identifying the areas and processes that need data capturing. The RFID data can be based on capturing transactions or counting inventory or both. This RFID data that is captured from the readers is huge in its volume, rules need to be formulated to determine who needs this data and in what form to avoid network congestion. Questions like “Who needs this data and for what purposes?” need to be answered.

The third stage for an RFID implementation is the hardware and software design. Design requirements for system and components need to be established. First question here that need to be answered is “What frequency do I Use?” Choosing the right frequency, the right readers, and tags is vital to a successful implementation. In some environments the Low Frequency (LF) and High Frequency (HF) systems work fine, while on others the Very High Frequency (VHF), Ultra High Frequency (UHF) or microwave (MW) might work well. After the hardware has been decided upon, the question of software design arises. The software should allow for certain levels of automation as determined by the organizations requirements and policies. Also the software should allow the optimal use of the RFID hardware and should control the efficient data flow. Data might also need to be stored into a database. When the system is designed, comprehensive testing shall take place to validate that all the requirements are being met. This testing includes component level (hardware, software) testing and system level testing. Upon satisfactory testing completion, an integrated system implementation starts. After final system testing, a comprehensive documentation with proper training plans will be prepared for the customer. The teaching/learning philosophy is to start with the end in mind, work on a real-world industry sponsored problem, brainstorm different solutions, work in team, design, process map, implement, test, implement, document, present the final deliverable. Students in the Electronics Engineering Technology program at Texas A&M have used the above practical process to successfully implement more than a dozen projects so far that also has enabled them to learn the topics more effectively.

Introduction

Due to the Wal-mart initiatives there has been a wide uproar in the industry about RFID. As a result of this mad rush people are implementing RFID systems without truly understanding the benefits and negatives of the implementation. The industry tends to think that RFID is a solution to every enterprise problem today! That is clearly not true. RFID is not a solution; instead it is merely an enabling technology and needs to be understood clearly to get the maximum benefit. This paper aims at clearly defining the potential of RFID by clearing the myths and by laying out a procedure for entrepreneurs to implement their RFID systems.

Before we go deeper into the implementation, it is first important to understand what RFID is? The next section gives a brief description of the technology itself.

RFID

RFID technology is based on the simple idea that an electronic circuit or tag, self powered (using a battery) or powered intermittently through radiation from a distance, can transmit information in air that can be read by a reader located at a distance. These tags are nothing but plain antennae bonded to a silicon chip kept inside a plastic or glass case. Tags operate differently depending on the frequency of operation.

The various radio frequencies that are being used by Wireless systems are illustrated in Figure. 1. There are four dominant bands in which most modern day communication occurs. The first is the Low Frequency (LF) band which spans the area around 100KHz. It is followed by the High Frequency (HF) band in the 10 MHz area. The other frequencies are the Ultra High Frequency (UHF) and the Microwave that are in the 900MHz and the 2GHz area respectively. UHF is used worldwide for cellular phones, while microwaves are used for Wifi, Bluetooth, and other recent broadband data communication systems.

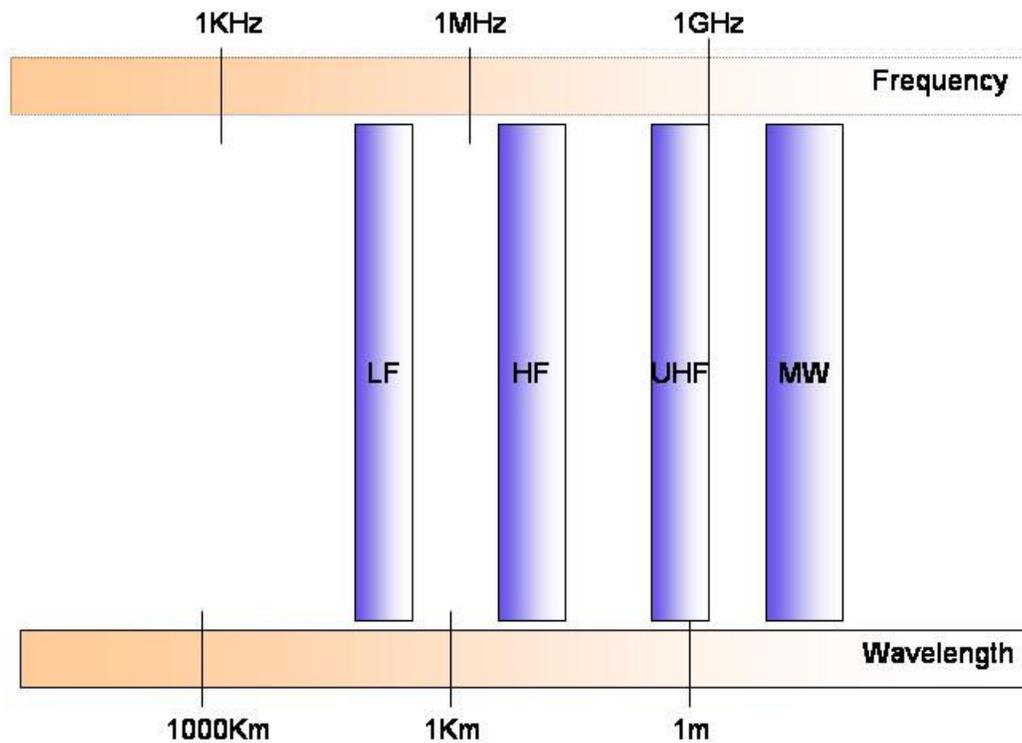


Figure. 1 Radio Communication Bands

Most RFID standards are also based on the above mentioned frequency bands. Due to the short range nature of the RFID applications (max. 100m) and the long wavelengths in the LF and the HF bands, the communication is not exactly “radio frequency”. The LF and HF RFID systems use a magnetic (inductive) method of communication instead of an Electromagnetic. This is illustrated in Figure. 2. The reader charges up the transponder using a magnetic field created through large coils. The transponder in turn created its own magnetic field that the reader detects. Due to the low frequencies of operation, these systems can operate in metallic and liquid environments, without significant loss of performance.

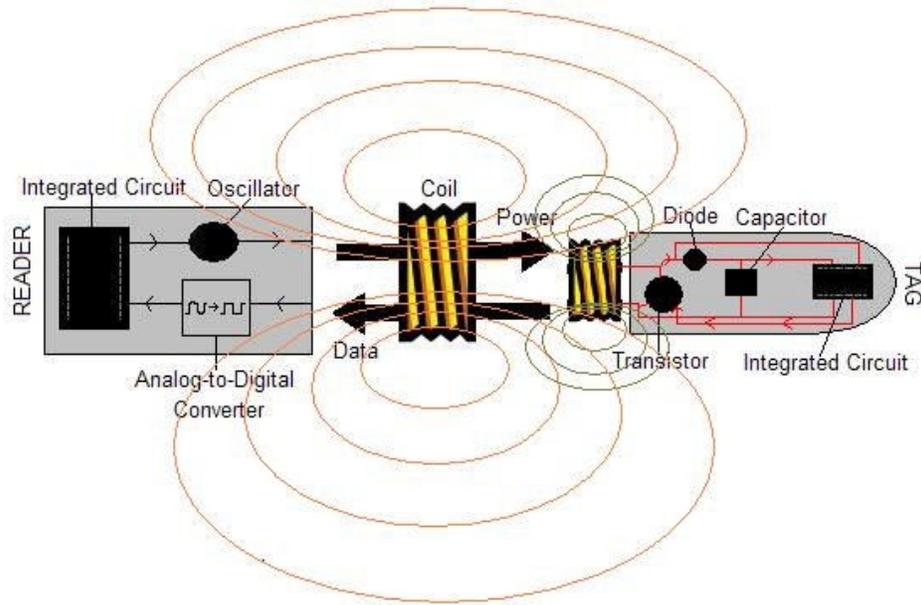


Figure. 2 Inductive RFID Systems

The higher frequency RFID systems, i.e. those that operate in the UHF and MW bands are electromagnetic in nature as illustrated in Figure. 3. The reader emits electromagnetic signals that are picked up by the transponder. The transponder charges up and transmits signals back to the reader. Due to the high available bandwidth in these higher frequency systems, the data transfer is much faster and the tags can therefore be read faster. However, these systems are seldom used in metallic or liquid environments, due to the high loss of performance.

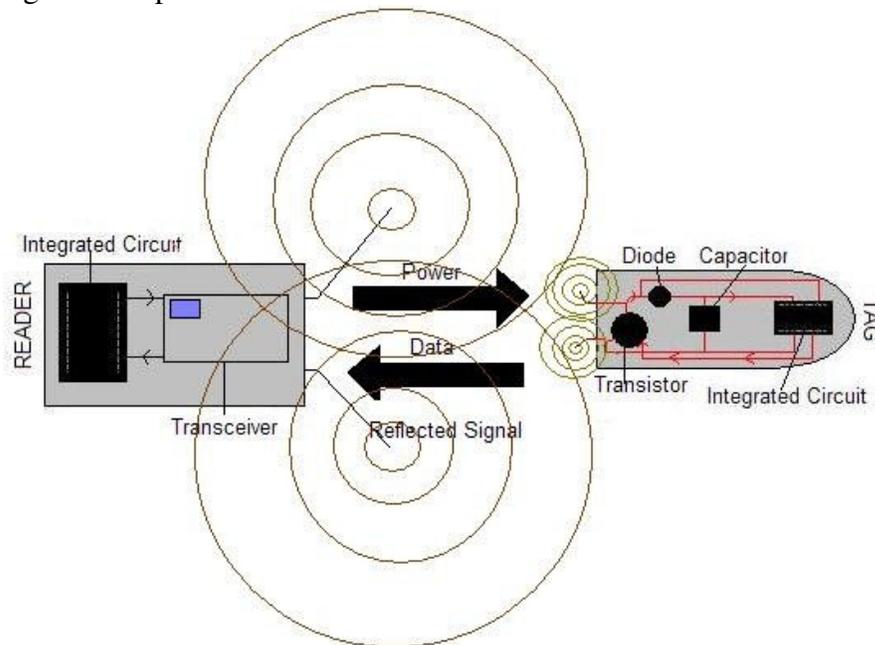


Figure. 3 Electromagnetic RFID Systems

Several organizations like the EPC Global and the ISO are working towards standardizing the RFID systems. While EPC has produced standards in the UHF band, ISO has standardized the RFID operations in the HF band. With this basic understanding of RFID systems, let's look at how this technology can benefit an enterprise.

Identify Business Problem

The first step in an RFID installation is to identify a "pain point" for the organization. RFID opportunities include problems with data collection and management, where data visibility is a key requirement and there are no effective ways of capturing information. Examples include Identification (personnel, animals etc.), Asset Management, Supply Chains, Transportation, etc.

Once an opportunity has been identified, the organization needs to answer the following questions. Why RFID? Is there no other more identification scheme? What does RFID provide that others like Bar Codes, etc. cannot provide? If RFID is the only solution, then what are the challenges with the RFID implementation? What is the cost-benefit ratio (ROI) of RFID?

For most businesses, it is really difficult to come out of this web of questions with a "Yes, I need RFID". If the enterprise still sees value in RFID implementation, then it has to come up with a plan to install the system.

The RFID data can be captured in a variety of ways including

1. Capturing transactions – The data is captured only when an item changes state, i.e, it moves from one point to another (e.g., shipping, receiving, door access). The RFID readers capture the tag ID and forward it to the associated servers that record this transaction. In this type of an installation, it may only be necessary to install readers and antennas on the premise doorways (e.g., receiving and shipping facilities, POS, access doors)
2. Inventory counting – This is the other method to capture RFID data is Inventory counting. This is done by polling all the items that there are within the range of an RFID antenna. The items may or may not change state or location. This type of data capture may be useful in applications like Asset Management, theft prevention, warehouse management, etc. In this type of installation, it is important to span the entire premise with readers and antennas.

The choice of the type of installation may be made by answering the questions "Who needs this data and for what purposes? Who are the stakeholders?"

RFID Site Survey

Once the choice of installation has been made, exact plans need to be made about the hardware and software installation. RFID planning should start with infrastructure, process and systems analysis. Understanding the existing infrastructure; processes and

systems and how they will be impacted by RFID will help establish project requirements that will determine the tag and reader selection criteria. This will also help in mapping the existing processes and identify RFID 'touch points'. A systematic site inspection leveraging scientific RF tools such as the spectrum analyzer to identify possible RF interferences needs to be performed. Based on this survey the following questions need to be answered.

1. What is the frequency of choice?(LF/HF/VHF/UHF/MW)
2. What is the desired RFID system?(Active/Passive)
3. Where the readers and antennas should be placed? How many antennas? How many readers?
4. How to communicate from the readers to the control computer?

System Design & Development (Pilot Project)

Once the site has been surveyed, and the implementation details are fixed, the system should be implemented in a closed environment. Any RFID installation has two distinct parts Hardware and Software. Clearly, any one of these is incomplete without the other. Moreover, each should be optimized for best operation with the other.

Hardware

Assuming the choice of frequency has already been made, vendors need to be found that supply tags and readers that match the exact specification of the project. For example, a tag that is supposed to go into textiles is a lot different from the tags that are put on metal containers or even those that are placed on pallets and cases. Based on the tags and readers obtained, readability tests should be performed comprehensively.

Based on a *statistical analysis* of best readability and other factors, the choice of locations of the antennas, their orientations, design of mounting units and placements should be done. In addition to this, the best orientation and placement for insertion of tags should also be carefully chosen. If the tags are being put on clothes, then the comfort of the wearer should be the top priority. On the other hand if the tags are being placed on a metal cylinder or a concrete slab, it should be placed in a position with the minimum probability of damage.

Software

Software includes everything from “Reader drivers”, to “databases” to the “front end Graphical User Interface (GUI)”. The reader driver functionality includes “control of the reading cycle of the readers to prevent interference among different readers” and “capture and interpret the data coming from the readers.”

Depending on the scale of applications, all these modules can reside on one single computer, on a local network of computers, or a wide area network of computers. The “glue software” that connects these different parts has to consider the scale of operations and has to be optimized for minimal and error free data flow on the network to avoid congestion.

System Implementation and Testing

After the design phase is complete, the system has to be tested, implemented and retested. The hardware test includes analysis of read rates. Any “miss conditions” should be studied and avoided. For example, in a “class attendance” type of implementation, students were each given an RFID tag, which was picked up by a reader when they walked into the classroom. The reader did not miss many tags except when the students had placed the tags next to their calculators or laptops. They were therefore instructed not to do so to ensure reliable attendance.

Software Testing includes things like debugging the code, giving feedback to the design team. Failure accelerated tests should be run on the system to test its reliability. The speed of computation should be optimized. Another important test parameter is that the new software should not interfere with any existing enterprise software.

Once this independent testing of hardware and software is complete, the complete system should be implemented and tested. System testing should include aspects like “problems in integration”, “network traffic analysis and congestion control”, “identification and removal of data ambiguity”. Another important test domain is “data security and integrity”. Based on these tests, feedback should be given to the design team.

Documentation, Training & Support

As with all other projects, the final step in any RFID implementation should be documentation, training and support. RFID is a new technology and not many people are educated in this regard. It is therefore important to document all the manuals and troubleshooting guides in great detail to avoid extensive costs in support. These documents should include, the complete system layout diagrams, training guides, and perhaps videos to demonstrate the functionality.

The handling staff should be properly trained to use the new system. This is a key step for smooth operation. If the working staff is not comfortable with the system, then no matter how full-proof the system is, it will not be seen as a good implementation. Like good documentation, good training also reduces support costs.

Conclusion

More than a dozen project shave been implemented by the Electronics and Telecommunication Engineering Technology students using the proposed implementation processes. Overall feedback has been very positive from students’ learning perspective since the process has been improved and enhance by students and faculty on real project in real-time.

References

1. "The History of RFID Technology," RFID Journal, 2002.
<http://www.rfidjournal.com>
2. "Activator." 2004. Axcoss Inc., <http://www.axcossinc.com>
3. "Asset Beacon Tags." 2004. Axcoss Inc., <http://www.axcossinc.com>
4. "Network Receiver." 2005. Axcoss Inc., <http://www.axcossinc.com>

Biographies