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The Use of RFID in Manufacturing and Packaging Technology Laboratories

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abstract

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THE USE OF RFID IN MANUFACTURING AND PACKAGING TECHNOLOGY LABORATORIES

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ABSTRACT

Mandated use of Radio Frequency Identification (RFID) on goods at pallet, case and item level continues to churn the Consumer Product Goods (CPG), logistics and retail industry. The statement “Internet of things” is slowly becoming true; with concerted efforts from standard setting bodies such as Electronic Product Code (EPC) global, International Standards Organization (ISO), Fast Moving Consumer Goods (FMCG) companies like Gillette, P&G and major retailers like Wal-Mart, TESCO, and the US DoD, to replace barcodes with RFID tags. RFID bridges many areas of manufacturing including inventory management, assembly operation, material handling, packaging and shipping by providing an accurate and real time access to materials and products information.

This paper reviews the RFID technology and its significance in engineering and technology education. The conceptual design of four packaging-based RFID projects are presented. The major costs involved in setting up an RFID system for educational applications are also discussed.

INTRODUCTION

Rapid advances in factory automation in general and packaging operations in particular have posed a challenge for engineering and technology programs for educating a qualified workforce to design, operate and/or maintain cutting edge technologies such as RFID system. It is no different at industrial technology program of California Polytechnic State University (CalPoly). The institution's mission embraces a "learn-by-doing, technology-oriented" education with emphasis on laboratory exercises in all programs particularly in engineering, business and industrial technology.

Recently, the packaging laboratory of industrial technology program has acquired an RFID system. RFID is an emerging technology that is gaining wide acceptance in many industries particularly in pharmaceutical, health care and retail (Malone, 2004). This paper reviews advantages and some of the recent developments of RFID technology, followed by the description of four potential RFID-based laboratory projects. These projects are intended to provide students with a detailed practical knowledge of automated part tracking systems. They will also create a learning opportunity for managing various phases of a RFID project development from the “ground up,” including hardware/software integration and setup.

The first three projects expose the students to read characteristics of RFID tagged consumer product in a packaging/warehouse environment under real world situations. Issues such as RFID tag placement, read distance, reader/antenna placement for best reads, etc. at item, case and pallet level will be explored. In the last project, students will integrate the RFID system with an automatic package sorting and label printing station. The educational values as well as the costs of the projects are also discussed

THE NEED FOR RFID EDUCATION

Radio Frequency Identification (RFID) is evolving as a major technology enabler for tracking goods and assets around the world. It can help hospitals locate expensive equipment more quickly to improve patient care, pharmaceutical companies to reduce counterfeiting and logistics providers to improve the management of moveable assets. While the technology has received more than its fair share of media coverage over the last 12 to 18 months, many are still unfamiliar with RFID and the benefits it can offer. A Microsoft-commissioned study of the retail and manufacturing industries, found that 31 percent senior decision makers in large UK manufacturing companies have never heard of RFID.

With this minimal exposure of the technology in the retail and manufacturing industries along with the non-conductive environments for radio frequency such as metal and liquids, there exists a great need for research to be conducted in the hardware as well as the middleware (software that connects two otherwise separate

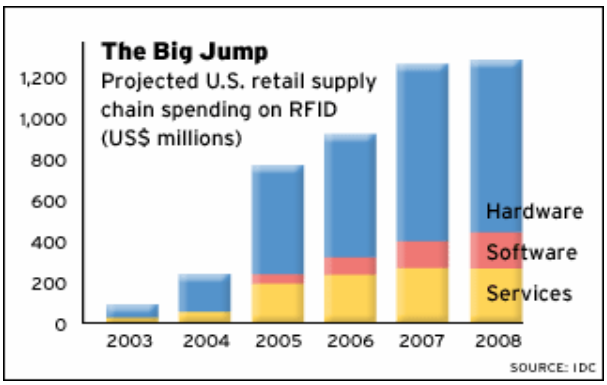

FIGURE 1. PROJCTED U.S. RETAIL SUPPLY CHAIN SPENDING ON RFID. (Source: IDC)

applications) portions of the RFID picture. Effort is underway to dedicate a section of packaging laboratory of CalPoly to real world testing RFID-based packaging situations.

A recent report from International Data Corporation (2003), projects that over $1 billion will be invested in RFID hardware, software and services by 2007 (Figure 1). This is a rise from $91.5 million last year.

Some of the major recent developments in the RFID technology have been:

- In early 2003, British retailer Tesco conducted a pilot with tagged packages of Gillette razors and “smart shelves.” The shelves are equipped to register movement of RFID-tagged products on and off the shelf, helping to alert store personnel of out-of-stock situations and pilferage.
- Also in 2003, drug store chain CVS tests an RFID tracking system on prescription drugs in two of its pharmacies.
- The Red Cross announces plans to run a pilot test using RFID to track blood packets.
- John Hopkins hospital and medical school becomes one of the first medical centers to use RFID tags to keep track of medicines.
- Late last year, DoD asked its top 100 suppliers to use RFID tags on cases and pallets by January 1, 2005.
- The most significant driver to date, though, has been Wal-Mart’s RFID initiative. By January 2005, the retailer’s top 100 vendors - the world’s leading consumer packaged goods (CPG) manufacturers – will have to label pallet loads and individual cases with RFID tags for circulation through Wal-Mart’s distribution centers.

These industries are backing RFID because there are billions of dollars lost each year through supply chain inefficiencies. Some of the more transparent advantages of RFID are:

- RFID doesn’t require line of sight to capture data, saving time and labor by eliminating the need for unloading a pallet and identifying the load.
- RFID is able to read the contents of an entire pallet load in seconds and saves time and labor.

- RFID can be a read/write system so one can update data through the supply chain, providing insight into possible trouble spots in distribution, such as theft and damage.

In spite of growing applications of RFID in industry the technology is not fully mature and suffers from issues of attenuation and interference (Asif and Mandviwall, 2005). Typically, the tracking of goods and assets starts with the information exchange between the reader and the RFID tag and within such system, the "readability" of tags plays a critical role on performance of tracking system. In other words, the usefulness of the RFID system depends on the integrity of the data and in ensuring that there is no single point of failure. With the growing multitude of hardware (readers and tags), with very little to no standardization, it becomes extremely important to test the same for readability. Wal-Mart's mandated 100 percent readability of pallet tags through dock doors and 100 percent readability of case tags on distribution center conveyor belts (Hall, 2004), have prompted many experts to declare this first phase a failure due to harsh distribution environments.

Research and laboratory experimentation along these lines in academic laboratories are needed to first, overcome the existing shortcomings of RFID systems. Second, with leaders like Wal-Mart, it will not be long before the entire retail industry adopts the beneficial radio frequency technology for individual consumer products. Universities such as MIT, University of Florida and Michigan State University have already identified RFID as an "emerging technology" with tremendous potential to impact everyday lives and are pursuing research for various applications in retail and manufacturing industries.

LABORATORY PROJECTS

Recently packaging laboratory in industrial technology program of Calpoly has acquired a number of hardware and software for developing RFID-based laboratory projects. The new RFID laboratory facility has the potential for variety of student projects including recreating packaging assembly lines, warehousing operations and experimenting with the following proof-of-concept and what-if scenarios:

- Size and material of the tags
- Tag placement on packages
- Influence on the reads of contents of the package
- Read distances between the tag and reader
- Antenna/Reader placements
- Influence of speed of tagged packages on readability
- Mapping the read range for the readers
- Antenna placement on fork lift truck for palletized loads

The followings are the conceptual design of a few RFID projects. It is expected that industrial technology students with packaging minor to transform these concepts into a working project using current designs or variation of them.

a. RFID/Conveyor Packaging

In a commercial operation, RFID tags in label forms will be programmed and applied while the

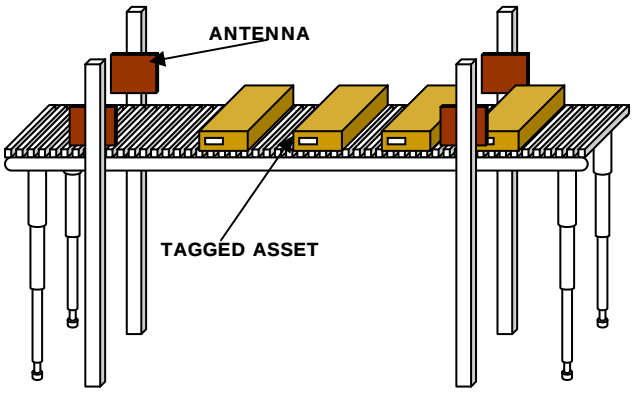

FIGURE 2. RFID SET-UP FOR CONVEYOR TRACKING SYSTEM.

product is being packaged on the packaging line. Variables such as conveyor speed and the distance of the tags from the antennas will play a crucial role in obtaining mandated readability. The experimental set-up for real life experimentation are depicted in Figures 2 and 3. A variable speed conveyor system with approximately 20 feet long and 6 feet wide will operate in an oval fashion. The learning benefits of this project are numerous. Students can explore various capabilities and configurations of RFID systems including:

- Tag placement on packages
- Influence on the reads of contents of the package
- Read distances between the tag and reader
- Antenna/Reader placements

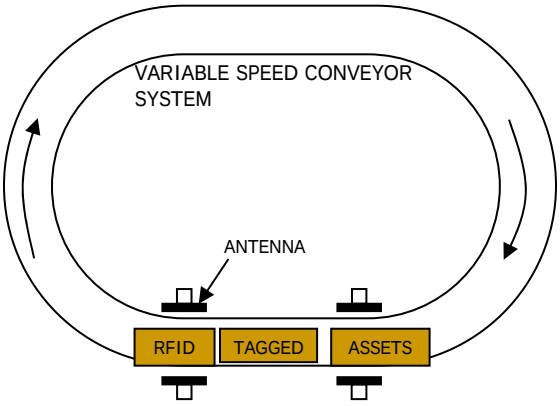

FIGURE 3. CONCEPTUAL DESIGN OF RFID CONVEYOR TRACKING SYSTEM.

b. Warehouse Dock Door/Fork Lift Project

This project demonstrates the application of RFID in shipping and receiving operations in which, goods entering or leaving a manufacturing plant or warehouse will be automatically inventoried at the dock doors. There are a number of options possible to arrange the antennas (distance, angles, types, etc.) to obtain the best read position in relationship to the tagged items. In a warehouse, palletized loads are primarily moved around by mechanical means such as pallet jacks and fork lift trucks. These mechanical devices can be equipped with readers and antennas to streamline the loading and unloading operations. The project set-up is shown in Figures 4 and 5. The educational benefits of this project include exploring:

- Tag placement on packages
- Influence on the reads of contents of the package
- Read distances between the tag and reader
- Antenna/Reader placements
- Influence of speed of tagged packages on readability
- Antenna placement on fork lift truck for palletized loads

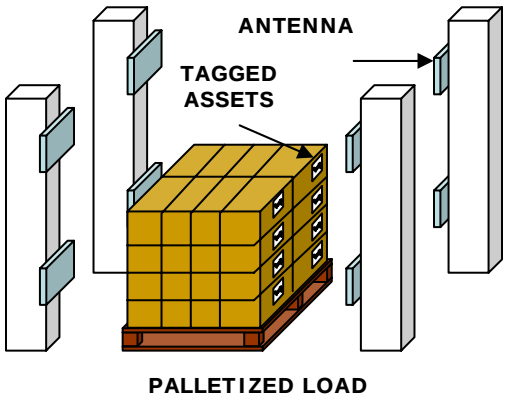

FIGURE 4. EXPERIMENTAL SET-UP FOR DOCK DOOR.

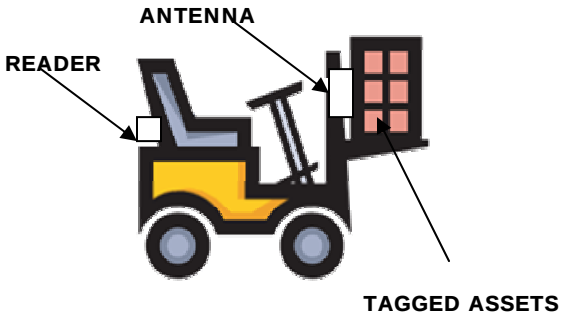

FIGURE 5. RFID SET-UP FOR FORK LIFT TRUCK .

c. Reader "read" range mapping in 3 dimensions

Each individual antenna has its own read pattern, it ceases to read a RFID tag after a certain distance and angle. It is of great importance to recognize this pattern before adopting any antenna for any application. A chart as shown in Figure 6 will be created and used to map the limits of read range for tag-reader combinations. The results can be presented in 2 or 3 dimensional plots. The following capabilities can be tested from this experimental set-up:

- Size and material of the tags
- Tag placement on packages
- Influence on the reads of contents of the package
- Read distances between the tag and reader
- Antenna/Reader placements
- Mapping the read range for the readers

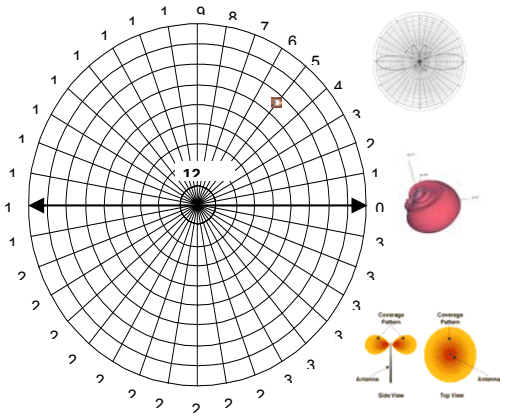

FIGURE 6. READ RANGE MAPPING CHART SET-UP

d. Automated Package Sorting

Figure 7 depicts the conceptual design of an RFID-based package sorting system. Various scenarios can be implemented by reconfiguration of the hardware and software. For example, in one scenario, the operation cycle starts with writing the tracking code to the tags on incoming boxes, determining which packaging station, dock door, truck or carrier the boxes travel down. Then the conveyor delivers the boxes to one of two downstream stations. The boxes can be redirected while in transit if plan change. These stations can be designed for additional packaging activity such as auto label printing. The label may contain serial number, part name and model or other information. At this point the RFID system transmits the tag data to a central PC for data analysis and documentation. The major educational aspects of this project includes:

a) hands-on learning of setting up an automated packaging line including hardware design, fabrication, acquisition, and installation
b) programming control software including PLC, and RFID software
c) understanding the role of RFID system in tracking, sortation of packages and realtime decision-making

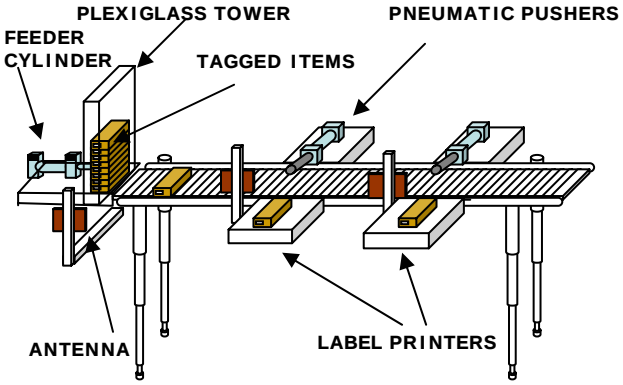

FIGURE 7. CONCEPTUAL DESIGN OF AN RFID-BASED PACKAGE SORTING SYSTEM.

COST CONSIDERATION

A common limiting factors in setting up automated workstations in school laboratories is normally the high cost of hardware and software, compounded by high cost of adopting modern technologies. Nonetheless, engineering and technology educators still can make a great impact by seeking outside grants and donations. For instance, the power conveyor used in the projects is donated by one of the leading manufacturer of table top conveyors (approximate value $20,000). Many components used in structuring workstations are either fabricated by students or are low cost standard parts such as pneumatic cylinders or RFID tags. An RFID developer's kit can be acquired with approximate cost of $2500.

It is worthwhile to note that the addition of new technologies such as RFID is an appealing project for obtaining external funding.

CONCLUDING REMARKS

The changes brought about by new technologies place great pressure on universities to integrate innovative and hands-on teaching approaches in educational programs. In this paper we reviewed the benefits and progresses of the emerging technology of RFID. We also presented four laboratories projects including a variable speed conveyor, smart dock

doors and automated package sorting for teaching RFID technology in engineering or technology programs. Although setting up these laboratory projects may demand a great deal of physical and logistical effort by students and faculty, nonetheless, first, most students appreciate the value of education they are getting. Second, educational programs such as packaging program in our case are in a better position to meet the demands of industry for qualified graduates for integrating and managing new technologies such as RFID.

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