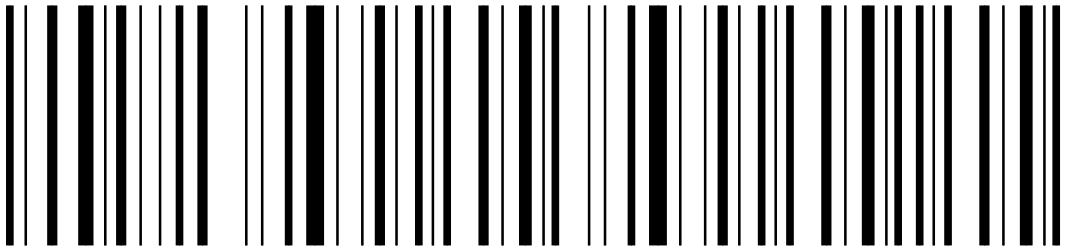
RFID: The Next Generation of AIDC



APPLICATION WHITE PAPER

Zebra Technologies

Executive Summary

Radio frequency identification (RFID) is one of the most rapidly growing segments of today's automatic identification data collection (AIDC) industry. Applications that make use of RFID's features and capabilities are demonstrating significant process improvements through implementing this technology.

Industry experts view RFID as a complement to bar code technology—in many cases, such as in the tracking of pallets, cartons and cases in a warehouse, both are used. RFID technology, in fact, overcomes certain limitations found in some bar code applications. Because it is not an optical technology like bar coding, no inherent line of sight is required between the reader and the tagged RFID object. In addition, RFID transmits data wirelessly and is a "read-write" technology, so it can update or change the data encoded in the tag during the tracking cycle.

RFID usage is steadily increasing. According to Allied Business Intelligence, annual shipment volume of RFID tags, or transponders, is expected to grow from 323 million in 2002 to several billion in 2007. The research suggests that despite this growth, RFID will not significantly displace bar codes. In fact, most of the RFID growth will come from emerging "smart label" technology in supply chain logistics, which combines the cost benefits of bar coding with the functionality of RFID. New printers combine the ability to print bar codes, human-readable text, and graphics on the surface of a "smart label" while encoding information on an RFID chip embedded in the label, hence the now common term "smart label".

This paper introduces prospective users to the basics of RFID technology, including applications, benefits, and technical specifications.

Introduction to RFID

RFID systems are used in a wide variety of industry applications, including automatic fare collection on bridges, toll roads, and public transit; wireless pay-at-the-pump payment programs like ExxonMobil's Speedpass; and hands-free access control security systems in offices and factories. Competitors in marathon races are often required to wear an RFID tag in their shoelaces so that they are accurately and automatically identified along the course and at the instant they cross the finish line.

RFID tags consist of an integrated circuit (IC) attached to an antenna—typically printed or etched conductors on a thin plastic sheet. Data is stored on the IC and transmitted through the antenna. Tags can be smaller than a grain of rice or as large as a brick. RFID tags are either passive (no battery) or active (self-powered by a battery). Data transmission speed and range depend on the frequency used, antenna size, power output, and interference. Tags can be read-only, read-write, or a combination, in which some data (such as a serial number) is permanently stored, while other memory is left available for later encoding or to be updated during usage.

Information is sent to and read from RFID tags over RF signals. In passive systems, which are the most common, an RFID reader transmits an energy field that "wakes up" the tag and provides power to the chip, enabling it to transmit or store data. In active systems, batteries typically are used to boost the effective operation range of the tag. Active tags may also periodically transmit a signal, much like a lighthouse beacon, so that data may be captured by readers distributed throughout a facility. Encryption algorithms that ensure security and integrity of the data passing between the tag and reader may protect transmissions.

Readers may be integrated into handheld terminals, or they may be fixed and positioned at strategic points, such as a facility entrance, dock door, or on an assembly line. Readers include antennas (one or more) for sending and

receiving signals to and from tags and a processor for decoding received signals and data. Collected data is then passed through normal interfaces (cabled or by wireless local area network—WLAN) to host computer systems.

There are a wide variety of RFID technologies. The performance and memory characteristics of tags for the chosen application determines the correct technology that should be implemented, including important characteristics such as frequency, system performance, and tag memory.

Here are the common types of passive RFID tags and their performance characteristics:

- Low Frequency RFID systems operate at about 125 kHz with a typical maximum read range of up to 20 inches (508 mm).
- High Frequency RFID systems operate at 13.56 MHz with a typical maximum read range of up to 3 feet (1 meter).
- Ultra-High Frequency RFID systems operate at 868 MHz, approximately 915 MHz, or 2.45 GHz. Read range is typically 3 to 10 feet (1 to 3 meters), but at about 915 MHz may be 20 feet (6 meters) or more under current FCC regulations.

RFID tags can be read through packaging, shipping containers, and most materials except metal. Beer kegs, gas cylinders, and other metal objects are commonly identified with special RFID tags that are modified and positioned to minimize interference. Another important difference from bar codes is that dozens of RFID tags can be read effectively by the same reader simultaneously. This feature, coupled with RFID's ability to read and write through packaging material, creates interesting opportunities for unattended identification of the entire contents of pallets, transit containers, and the items inside them.

Smart Labels

"Smart labels" refer to labels with embedded ultra-thin RFID tags, which are often called 'inlays.' Inlays for smart labels in the 13.56 MHz, 860–930 MHz, and 2.45 GHz frequency ranges are available. Many leading semiconductor manufacturers, including Philips Semiconductor and Texas Instruments, produce a wide variety of RFID chips. Zebra supports a broad range of RFID technologies in its card and label printer products and sells smart labels through its supplies division.

Smart labels are called "smart" because of the flexible capabilities provided by the RFID tag embedded in the label. The tag, in most cases, can be programmed and/or updated in the field, so the same label can be reused to serve multiple needs and disparate applications. Hence, the label is no longer effectively static as is a bar code label, but rather is dynamic in its capability when equipped with RFID.

Passive smart label RFID systems overcome the limitations of many existing bar code based automatic data capture systems in that they:

- Provide error-free, wireless data transmission that is battery-free and maintenance-free;
- Do not require line-of-site scanners for operation;
- Allow stored data to be altered during sorting or to capture workflow process information; and
- Work effectively even in harsh environments with excessive dirt, dust, moisture, and temperature extremes.

Printing and Encoding Smart Labels

Smart label printers, such as Zebra's R-140™ and R402™, enable users to create smart labels on demand and encode variable information in the tags. The printers use label stock that incorporates blank RFID integrated circuits sandwiched between the face stock and the adhesive layer. Thus, the ICs may be invisible to the human eye.

Smart label printers function as traditional printers when creating bar codes, graphics, and human-readable text. However, they also have RFID encoders and readers embedded inside. Before the label is printed, the RFID data is encoded on the tag; data for encoding is selected by application design and automatically managed by system software. Following encoding, the tag is read to confirm data accuracy. The label is then fed forward for printing. With Zebra smart label printers, an error message prints over the label if the tag does not read or its data does not verify, voiding the label for use. Hence, printed and encoded smart labels created using a Zebra printer/encoder offers the highest achievable data integrity.

The encoding and verification process, which can take milliseconds to seconds depending on the amount of RFID data and the type of tag, makes smart label throughput somewhat slower than comparable bar code printers. In practice, this slower speed has not been a drawback because smart labels generally are not used for high-volume, high-throughput applications. The tags used in smart labels are made from flexible material that does not damage the printhead. The IC may create an uneven surface, which can affect print quality, but this problem is easily avoided by using thicker label material or by avoiding printing directly over the IC.

The R-140, Zebra's first RFID smart label printer/encoder, is capable of printing and encoding smart labels embedded with 13.56 MHz RFID tags in a single pass. Based on the technology of the 140*Xi*III, the most popular thermal transfer bar code printer in Zebra's high-performance *Xi*™ Series, the R-140 offers the same rugged construction and standard features as the 140*Xi*III. The R-140 is designed to make smart label encoding as easy as traditional bar code labeling. In addition, the ZPL II programming language has been enhanced to include RFID extensions, allowing users to program the tag data with the same ease as defining the data for a bar code label. The R-140 has a PCMCIA card socket for wireless network connectivity, and can take advantage of ZebraLink™ remote printer control, management, and instant alert messaging capabilities.

The new, compact Zebra R402 Smart Label Printer/Encoder is a flexible tool for both printing and programming 13.56 MHz smart labels, tickets, and tags. It supports the widest variety of RFID tags, including those conforming to the new international ISO 15693, ISO 18000-3 and 13.56 MHz Electronic Product Code (EPC™) specification standards. Additionally, it can print tags as large as 3.54" x 5.1" (90 x 130 mm) and as small as .36" x 1" (9 x 25 mm), as well as wristbands for healthcare patient ID or amusement park access control and concession charging. The R402 allows label converters or end users to program the encoding position so they can place tags wherever they prefer within the smart label.

Applications

RFID provides a quick, flexible, and reliable electronic means to detect, identify, track, and hence manage a variety of items. The technology is well-suited for many operations in all types of industries. Implementation has been severely limited by cost comparisons between RFID tags to bar code labels, a lack of common standards, and the resulting reluctance to invest in RFID infrastructure. Many potential users of RFID technology try to make comparisons between the relative cost of the two technologies, when comprehensive return on investment

analyses should be conducted. In recent years, interoperable products have emerged, helped by renewed standards efforts. These efforts, leading to the resultant increase in usage, have lowered the cost of RFID systems—making them appropriate for many new classes of users. Because RFID tags are rewritable, they can be reused numerous times. This feature can provide a lower total cost of ownership compared with disposable identification labels.

According to Allied Business Intelligence, only 1% of all RFID tags currently used are for supply chain management. Those applications, however, are expected to account for 46% of RFID implementations by 2007. RFID usage is expected to grow dramatically because users can now produce and read smart labels more cost-effectively using widely available equipment.

The following brief examples show how RFID can improve efficiency and save money in different industries and applications.

Logistics

Global supply chain logistics is expected to be the largest and fastest growing application for UHF RFID. This will most likely be done through smart labeling of cases, cartons and pallets. The key benefits are the ability to read the entire contents of mixed pallets all at once during material handling operations such as truck loading or unloading.

Managing pallets, totes, and other returnable transit containers with RFID represents one of the most dramatic cost-saving opportunities this technology can provide. Many returnable containers are never brought back from customer sites after shipment, forcing companies to carry excess inventory to ensure adequate supplies of shipping materials where they are needed. Identifying returnable containers with smart labels or fixed tags enables companies to augment their legacy bar code shipping applications by automatically recording materials shipped to customers. Companies can then find their own pallets in shipping yards or docks stacked with thousands of items belonging to dozens of companies.

Active RFID tags, such as those used in local area real-time location systems, also pave the way for improved warehouse yard management operations by enabling wireless, long-range searches of numerous pallets without having to take the time to find and scan a bar code or read a serial number on each object. Higher degrees of tracking will enable shippers to lower their material costs and will provide an audit trail that can be used to bill customers if materials are not returned. Several leading consumer goods manufacturers, logistics providers, and pallet producers are conducting RFID trials and may soon begin limited rollouts.

Shipping and Receiving

Incoming pallets or cartons with smart labels can be automatically routed for cross-docking or delivery directly to the manufacturing line. Fast-reading RFID enables instant identification of the shipping container plus all of the individual items inside. For shipping, RFID readers can help packers quickly locate and aggregate all the items needed to complete an order.

Warehousing

The same principle is applied to improve warehouse picking. Workers scan shelves and bins with an RFID reader that automatically detects the storage location of the sought items. The system can also detect items that are stored in the wrong location and alert operators to the problem. Using RFID for these applications enables items to “self-report” their locations, rather than requiring human intervention to find them, thus reducing errors, saving labor, and lowering costs.

Pharmaceutical

In one real-world application, RFID tags are embedded in prescription bottles used by the blind and vision-impaired. Patients in the program are given compact reading devices that are activated when a prescription bottle is held near. The reader identifies the contents and then, using text-to-speech conversion software, "speaks" the drug contents to the patient. This technology helps ensure that patients take the correct medication. Other information, such as dosage instructions and drug interaction warnings, may also be encoded.

Pharmaceutical companies can use RFID to manage the movement of medications and containers through assembly and packaging lines to ensure medicines are put into correctly labeled packages. In addition to controlling production flow, this type of system can automatically build a paperless audit trail for the purposes of providing a high integrity, accountable supply chain.

Healthcare

RFID is commonly used on patient wristbands to provide tamper-proof, accurate identification for facility access control and security. Many Alzheimer's disease facilities install RFID readers at all their doors to lock down and sound alarms automatically if patients try to wander through. For Pediatrics only staff or parents may be permitted to take infants or children from a specific area or confines of a ward. In the United Kingdom such RFID application has eliminated opportunities for "baby-snatching" or kidnapping to occur on hospital grounds.

Hospitals can also use RFID to track medication dispensing, laboratory samples, and blood bags—much like bar codes are used today. RFID saves time and improves accuracy because it automatically records all item movements and does not require human intervention to scan a bar code or record data on a form.

Amusement Park and Event Management

A growing number of amusement parks and recreational facilities give their guests wristbands or ID tags with RFID chips, which can be used to control or limit access to certain facilities. Another application is keeping track of patrons, such as children, who might become separated from their group. By presenting their ID tags at "location stations," separated individuals can be more easily located by other group members.

Cards or wristbands with embedded RFID chips can also be used for a cashless payment system, by having guests prepay and loading the monetary value onto the card. Because the IC is rewritable, if required, guests can recharge the card or wristband after the stored value has been depleted.

Manufacturing

Smart labels applied to subassemblies enable automated, unattended work-in-process tracking and can be integrated with industrial control systems to route items automatically through assembly processes. Many automotive manufacturers apply RFID tags to chassis to track them through painting stations. RFID tags embedded within products are especially effective for routing and tracking materials in cleanroom applications. Product serial numbers and lot identification data can be securely encoded in read-only memory during manufacturing of personal computers to provide lifetime tracking and product authentication. Some manufacturers take advantage of this functionality to verify eligibility for returns and warranty repairs and detect counterfeit products. Maintenance history can be stored on the tag and updated whenever service is performed.

Library and Video Store

Many large libraries around the world have implemented RFID to speed material check-in, checkout, shelf inventory, and security applications. Low-cost, flexible smart labels are inserted in books and can be made invisible to patrons. Counter personnel can check dozens of books in or out in mere seconds without manually handling and orienting each item. The tags can also be used for theft detection, much like anti-shoplifting technology currently used by retailers. Librarians using portable computers with RFID readers can take inventory and find misfiled materials simply by walking down an aisle of bookshelves. The reader can automatically detect missing materials and alert the operator.

Video stores are increasingly using RFID for similar applications. Readers are positioned at the checkout, unattended return bins, and doorways to record transactions and detect shoplifted items automatically. These library and video store operations are essentially in-store inventory management applications that can be adapted for use in many other industries.

Cashless Payment

The most widespread example of this RFID application is ExxonMobil's Speedpass program, which is saving millions of drivers countless hours at the pump. Participating consumers can opt for either a passive tag, which is clipped to their key chain, or a battery-powered active tag attached to a car window similar to one of the families of "toll tags." The tag contains a unique identification code. When the tag enters the reader field at a gas pump, it turns on the pump and automatically charges the gas purchase to the driver's registered credit card account, promoting quicker service while maintaining complete account number confidentiality. McDonald's restaurants are now offering a similar application to speed transactions at the counter and drive-thru window. This class of RFID application is growing rapidly.

Retail

Some retailers are fitting fashions with smart tags so salespeople with handheld computers can track inventory better. The labels help salespeople locate and read tags at a distance, which can improve customer service by helping customers quickly locate their desired style, size, and color in a rack of garments. Some companies have conducted trial studies employing "smart shelf" technology. With this application, the retailer places RFID readers in shelves and racks to trigger automatic replenishment programs. Every time an item is removed from the shelf or whenever inventory falls below pre-set levels, a notice is sent automatically. The same smart label used for item identification can also provide anti-shoplifting protection, which would eliminate the need for a separate electronic article surveillance (EAS) system. High-end retailer Prada implemented RFID technology as part of a total customer experience in its New York City store. Every item in the store is tagged with a smart label or removable tag. Items are placed in "intelligent closets" within dressing rooms, which can automatically identify all of the items taken into the rooms. Items are then displayed on a touch screen monitor, where the customer can obtain additional information about each item.

Security

Personal badge and tracking systems are very widespread RFID applications to ensure employee security and safeguard corporate property. RFID transponders embedded in employee personnel ID tags provide hands-free access to secured buildings and a tamper-proof form of identification that ensures only authorized personnel are admitted. Smart labels can also be applied to computers, furniture, files, and other objects for asset tracking and theft deterrence.

Transportation Management

Dozens of toll roads and bridges take advantage of RFID to let drivers pay their tolls without stopping at the fare booth. Transponders that can be read at up to 50 mph (80 kph) are attached to the vehicle and are read when the vehicle passes an antenna mounted in the toll collection lane. Drivers may either receive a monthly bill or have the toll debited from a prepaid value stored on the transponder. Similar technology is used in public transit to collect bus and train fare from prepaid passenger fare cards.

Hospitality

Hotels, restaurants, and entertainment facilities can print and encode tickets and guest identification or membership cards. The RFID card can be used for cashless payment, as a room key, and for access control to the health club and other facilities.

Conclusion

RFID is a stable Auto-ID technology that holds great promise for improving business processes; its use is becoming increasingly widespread. It should be considered for any application that could realize a clear benefit in terms of efficiency, reduced loss, or improved service. RFID offers strong performance and functionality, but at a price—considering tags relative to simple labels. The added cost of RFID, weighed against bar codes' outstanding value and the enormous installed, working infrastructure (supported by international standards), ensures the two technologies will coexist, just as our nation's roads are still full of cars despite the growth of commercial air travel over the last 50 years.

Because RFID tags are reusable, don't require line of sight to read or write, enable unattended reading, and offer read/write data storage, they can improve efficiency in many operations by reducing labor and materials costs. Potential users must carefully evaluate the long-term impact and total cost of ownership for RFID systems, and not automatically rule out use of the technology because of the initial investment required.

Zebra Technologies is a world leader in providing on-demand bar code labeling solutions that deliver information in forms that enable organizations to improve security, productivity, quality, and customer service. This leadership extends to RFID technology. Zebra was the first company to introduce an RFID printer/encoder, which simultaneously prints a bar code and encodes the embedded RFID chip in a smart label. Zebra can offer its customers the expertise and products necessary to support their bar code and RFID label printing needs. As a member of the Auto-ID Center Technology Board, Zebra has access to and supports the latest supply chain EPC RFID technology and standards development activities. Contact Zebra to see how your organization can gain a competitive advantage by using the right combination of bar coding and RFID smart labels.

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