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SATO RFID
White Paper

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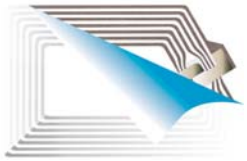


Overview

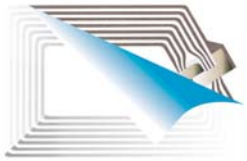
This white paper describes the basic components of a Radio Frequency Identification (RFID) system and explores the technology, applications, and competitive advantages of RFID technology and its uses for Automatic Identification Data Collection (AIDC).

1. Introduction

Traditional bar-coding technology provides an economical solution for Automatic Identification Data Collection (AIDC) industry applications. However, this technology has a primary limitation: each bar-coded item has to be scanned individually, thus limiting the scanning speed. Extra costs are incurred through the use of manual labor or automating the scanning process. And when the scanning is manually performed, there is the added possibility of human error. As a result of these limitations, RFID technology has been making inroads in AIDC applications.

RFID offers greater flexibility, higher data storage capacities, increased data collection throughput, and greater immediacy and accuracy of data collection.

An increasing number of companies in a variety of markets worldwide are embracing RFID technology to increase quality and quantity of data collection in an expeditious manner, a feat not always possible with barcoding systems. The technology's enhanced accuracy and security makes it an ideal data collection platform for a variety of markets and applications, including healthcare, pharmaceutical, manufacturing, warehousing, logistics, transportation and retail.



2. Components of an RFID System

A basic RFID system consists of these components:

- A programmable RFID tag/inlay for storing item data;
  - Consisting of an RFID chip for data storage
  - And an antenna to facilitate communication with the RFID chip

- A reader/antenna system to interrogate the RFID inlay

The RFID Tag

The RFID tag consists of an integrated circuit (IC) embedded in a thin film medium. Information stored in the memory of the RFID chip is transmitted by the antenna circuit embedded in the RFID inlay via radio frequencies, to an RFID reader. The performance characteristics of the RFID tag will then be determined by factors such as the type of IC used, the read/write capability, the radio frequency, power settings, environment, etc.

RFID tags are categorized as either **passive** or **active**. Passive tags do not have an integrated power source and are powered from the signal carried by the RFID reader. Active tags have a built-in power source, and their behavior can be compared to a beacon. As a result of the built-in battery, active tags can operate at a greater distance and at higher data rates, in return for limited life, driven by the longevity of the built in battery, and higher costs. For a lower cost of implementation, passive tags are a more attractive solution.

The information stored in an RFID chip is defined by its read/write characteristics. For a **read-only** tag**,** the information stored must be recorded during the manufacturing process and cannot be typically modified or erased. The data stored normally represents a unique serial number, which is used as a reference to lookup more details about a particular item in a host system database. Read-only tags are therefore useful for identifying an object, much like the “license plate” of a car.

For a **read / write** tag, data can be written and erased on demand at the point of application. Since a rewriteable tag can be updated numerous times, its reusability can help to reduce the number of tags that need to be purchased, and add greater flexibility and intelligence to the application. Additionally, data can be added as the item moves through the supply chain, providing better traceability and updated information. Advanced features also include locking, encryption and disabling the RFID tag.

RFID systems are designed to operate at a number of designated frequencies, depending on the application requirements and local radio-frequency regulations:

- Low Frequency (125kHz);
- High Frequency (13.56MHz);
- Ultra High Frequency (860-960 MHz)
- Microwave (2.45 GHz)

Low-frequency tags are typically used for access control & security, manufacturing processes, harsh environments, and animal identification applications in a variety of industries, which require short read ranges. Low frequency spectrum is the most adaptive to high metal content environments, although with some loss of performance. Read ranges are inches to several feet.

High-frequency tags were developed as a low cost, small profile alternative to low-frequency RFID tags, with the ability to be printed or embedded in substrates such as paper. Popular applications include: library tracking and identification, healthcare patient identification, access control, laundry identification, item level tracking, etc. Metal presents interference issues and requires special considerations for mounting. Similarly to the low-frequency technology, these tags have a read range of up to several feet.

UHF tags boast greater read distances, superior anti-collision capabilities increasing the ability to identify a larger number of tags in the field at a given time. The primary application envisioned for UHF tags, is supply chain tracking. The ability to

identify large numbers of objects as they are moving through a facility and later through the supply chain, has an enormous opportunity for ROI in retail. Among others reduction of wasted dollars in inventory, lost sales revenues due to out of stock inventory, and the elimination of the human factor required today for successful barcode data collection. There are large number of additional markets with demand for UHF RFID technology, such as transportation, healthcare, aerospace, etc.

Microwave tags are mostly used in active RFID systems. Offering long range and high data transfer speeds, at significantly higher cost per tag,making them more suitable for railroad car tracking, container tracking, and automated toll collection.

The table[1] on the following page highlights the different characteristics of the three RFID operating frequency ranges:

[1] www.samsys.com/default.php?alpha=company&beta=what&gamma=tech

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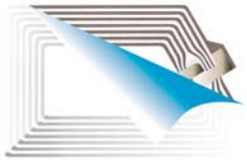


Frequency Range	LF 125 KHz	HF 13.56 MHz	UHF 868 - 915 MHz	Microwave 2.45 GHz and 5.8 GHz
Typical Max Read Range (Passive Tags)	< 0.5 m	- 1 m	- 3 m	- 1 m
General Characteristics	Relatively expensive, even at high volumes. Low frequency requires a longer more expensive copper antenna. Additionally, inductive tags are more expensive than a capacitive tag. Least susceptible to performance degradations from metal and liquids, though	Less expensive than inductive LF tags. Relatively short read range and slower data rates when compared to higher frequencies. Best suited for application that do not require long range reading of multiple tags	In large volumes, UHF tags have the potential for being cheaper than LF and HF tags due to recent advances in IC design. Offers good balance between range and performance - especially for reading multiple tags	Similar characteristics to the UHF tag but with faster read rates. A drawback to this band is that microwave transmissions are the most susceptible to performance degradations due to metal and liquids, among other materials. Offers the most directional si
Tag Power Source	Generally passive tags only, using inductive coupling	Generally passive tags only, using inductive or capacitive coupling	Active tags with integral battery or passive tags using capacitive, E-field coupling	Active tags with integral battery or passive tags using capacitive, E-field coupling
Typical Applications Today	Access control, animal tracking, vehicle immobilizers, POS application including SpeedPass	Smart Cards, Item-level tracking including baggage handling (Non-US), libraries	Pallet tracking, electric toll collection, baggage handling (US)	SCM, electronic toll collection
Notes	Largest install base due to the mature nature of low frequency, inductive transponders	Currently the most widely available high frequency worldwide, due mainly to the relatively wide adoption of smart cards	Japan does not allow transmissions in this band. Europe allows 868 MHz whereas the US permits operation at 915MHz, but at higher power levels	
Data Rate	Slower	_	_	Faster
Ability to read near metal or wet surfaces	Better	_	_	Worse
Passive Tag Size	Larger	_	_	Smaller

3. Applications

Library Information Systems

Tracking a library's assets and loan processing is a very time-consuming process. Traditional bar-coding systems help to improve the process. However, RFID technology offers additional enhanced features:

Efficient processing – When each library item contains an embedded RFID tag on a printed label, its availability can be tracked much more efficiently (versus manual tracking). Library items can be checked in and out much faster than manual barcode or human readable data processing. In fact, with RFID, processing returned items no longer requires any human intervention. This enables libraries to provide certain services around the clock, without incurring additional costs.

Security – If a tagged library item has not been checked out, any attempt to remove it from the library premises will be detected via the RFID antenna at the entrance gate, hence the RFID tag doubles as a EAS anti-theft device.

Inventory management – Book inventory that previously took ***weeks or months*** to execute can now be shortened to ***hours*** using RFID tagging. Using a portable RFID device, a librarian needs only to walk through a corridor of book shelves to check the status of the books available. The RFID reading device reads item information from the books' IC chips and then automatically interfaces with library inventory software systems to update the appropriate databases. In addition, it can notify the operator immediately if an item is not in its designated location.

Supply Chain Management

Key challenges faced by companies in their supply chain, is the visibility, tracking and traceability of materials and products as well as the quality and quantity of data collected in real time. RFID's ability to increase data collection throughput and accuracy enable companies to identify materials, products and trends in supply and demand with greater accuracy and in nearly real-time, compared to data collection technologies utilized to date. Minimal human effort is required in this process, when RFID technology is fully integrated, thus reducing errors and costs. By providing accurate, real-time data and information, RFID solutions enable companies to capture "live" data, converting it to meaningful information and automating all associated transactions and processes.

Healthcare

Erroneous patient data, including administering incorrect medications or dosages, is a major factor resulting in serious, and in some cases fatal, medical mishaps. According to the Institute of Medicine[2]:

- Between 44,000-98,000 Americans die from medical errors annually (Institute of Medicine, 2000; Thomas et al., 2000; Thomas et al., 1999)
- Only 55% of patients in a recent random sample of adults received recommended care, with little difference found between care recommended for prevention, to address acute episodes or to treat chronic conditions (McGlynn et al., 2003)
- Medication-related errors for hospitalized patients cost roughly $2 billion annually (Institute of Medicine, 2000; Bates et al., 1997)

These statistics have dramatically increased the demand for fail-safe accuracy in managing patient care; RFID is providing an effective solution.

[2] Institute of Medicine web site (www.iom.edu/subpage.asp?id=14980)

In RFID-equipped hospitals, patients wear wristbands with RFID tags containing encoded medical information. All prescription bags contain an embedded RFID tag containing details of the medication. Before any medication is administered to a patient, an RFID reader verifies the information between patient's tag and the prescription bag's tag. Information about the patient's medical allergies or other relevant patient care criteria is also highlighted on the RFID host computer. This secure patient-data system greatly reduces the possibility of human error, thereby preventing a majority of unnecessary medical mishaps.

4. Benefits

The primary benefits of RFID technology over standard barcode identification are:

- Information stored on the tag can be updated on demand
- Large data storage capacity (up to 4k bits);
- High read rates
- Ability to collect data from multiple tags at a time
- Data collection without line-of-sight requirements
- Longer read range
- Greater reliability in harsh environments
- Greater accuracy in data retrieval and reduced error rate

What About Bar Codes?

As barcodes approach their middle ages (it's been 30 years since a pack of gum was scanned at a Marsh grocery store in Ohio), they are as alive and useful as ever. And while RFID provides advantages, the demise of the barcode is greatly exaggerated. The Auto-ID Center, the research and development group that formulated and standardized much of the RFID technology evolution did not set out to make barcodes extinct. According to its spokesperson, "The Auto-ID Center does not advocate replacing barcodes, as barcode-based systems such as the UPC are a

standard automatic identification technology in many industries and will be an important complimentary technology for many years."[3]

5. Caveats

The main caveat of RFID technology is the high cost of the physical RFID tag. A typical barcode label costs about $0.02, whereas an RFID tag label can costs upwards of $1.00. The initial implementation costs for RFID are also higher, depending on requirements and equipment specifications.

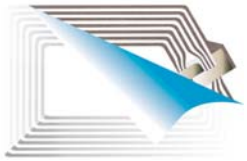
Although initial RFID implementation may currently cost more, as companies adopt the technology, the cost will gradually drop to a competitive level in the coming years. Meanwhile, companies that can exploit the strategic benefits of RFID today stand to gain significant advantages over their competitors slower to adopt RFID. Early adopters can clearly benefit from cost savings and intangible long-term competitive advantages, which outweigh the cost of the RFID implementation.

6. RFID Summary

Over the last two years RFID technology has been attracting considerable attention. Most recently giants such as Wal-Mart, U.S. Department of Defense (DoD), Tesco, and Metro Group announced RFID mandates, instructing their top suppliers to start utilizing RFID technology as a part of supply chain compliance program.

By January 2005 there will be in excess of 400 major companies worldwide required to use RFID technology as a result of the current RFID supply chain mandate schedules.
With an estimated 50,000+ suppliers who may eventually be affected by these plans, RFID solutions and their adoption is a large driver for future business growth.

[3] www.autoidlabs.org/researcharchive



The short-term focus in the US is on the estimated 130 top Wal*Mart suppliers, who are scheduled to become compliant by January 2005. Collectively they are expected

to spend approximately $500 million to become compliant. Near term, this expenditure will be just that. Longer term, however, the “early adopters” will move beyond compliance-only and attempt to use RFID to increase efficiency and start gaining return on their hefty investment. This means more upgrades and additional spending on enterprise solutions. DoD-related investments in RFID are not quantified in the short-term; however, in the long term they will follow the same suit.

The dominant RFID dynamic behind the supply chain applications is the ePC standard currently using the UHF frequency band - 902-928MHz (North America) and 868MHz (Europe). EPC Global is a joint venture between EAN International and the Uniform Code Council (UCC). The EPC Global Network ideally intends to transform the global supply chain through a new, open global standard for real-time, automatic identification of items in the supply chain of any company, in any industry, anywhere in the world. There are other standards available on this band, open (ISO18000) as well as proprietary (EM Marin).

7. SATO & RFID

SATO is positioned to be a leader in the RFID market. The most immediate RFID demand comes as an addition to existing compliance labeling processes. Offering a one-step print and encode solution is the fastest and most effective approach for a user to adopt RFID and comply with current mandates. SATO is a popular choice, with a large installed base, among Fortune 500 companies, which are directly affected by the short-term (and certainly long term) RFID requirements. Building on past experience with 13.56MHz RFID technology, SATO has been involved in the forefront of RFID applications, most recently, working directly with Wal*Mart and its top suppliers, the DoD and in Europe with leading RFID adopters.

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SATO has introduced the industry's first complete multi-protocol EPC-compliant RFID solution for customer pilots and beta tests. SATO delivers not just RFID printing solutions, but complete EPC-compliant RFID solutions including pre-planning consultation, on-site surveys, pilot planning and implementation and post-pilot consultation and customer service.

SATO also fully supports the Uniform Code Council's (UCC) Electronic Product Code (EPC) initiatives and the recent Wal-Mart mandate, requiring their Top 100 suppliers to embed RFID tags at the case and pallet level by 2005. The SATO EPC Class 1-compliant RFID printing solution is now running in the Wal-Mart RFID testing and development lab located in Bentonville, Arkansas.
The complete SATO RFID solutions include the new CL408*e* and CL412*e* UHF RFID printers, utilizing multi-protocol RFID read/write technology, which supports EPC Class 1, and ISO18000. Also, the CL408*e* and CL412*e* RFID printers can be easily upgraded as new standards and protocols are established for new generations of RFID tags such as EPC Class 1 Generation 2. Utilizing multi-frequency technology compliant with FCC (902-928 MHz), ETSI – Europe (868 MHz), SATO's CL408*e* and CL412*e* RFID printers are designed to ensure compatibility today and as new RFID tags and protocols evolve tomorrow.

Using ultra-high frequency (UHF) chips embedded in the labels, the built-in RFID module enables SATO RFID printers to print the label and program the chip inside the label simultaneously. These RFID enabled "smart labels" can be read even if the label is not in the line of sight of the reader, allowing reading operations to be done automatically, reducing labor costs and improving accuracy. Additionally, the information encoded onto many smart labels can be changed during their lifetime, eliminating the need to remove and re-label items. SATO's printers with RFID capability are designed for many applications, including anti-theft, asset tracking, supply chain logistics, baggage tags, and factory automation.

Since 1979, SATO America has been leading the way in barcode printing solutions and now, in complete UHF RFID system solutions…from printing a product smart label, to tracking product at the dock door and conveyor systems.

8. General Information

There are numerous sources of information regarding the latest RFID developments. Several good places to start are:

- www.epcglobalinc.org
- www.auto-id.org
- www.uc-council.org
- www.satoamerica.com