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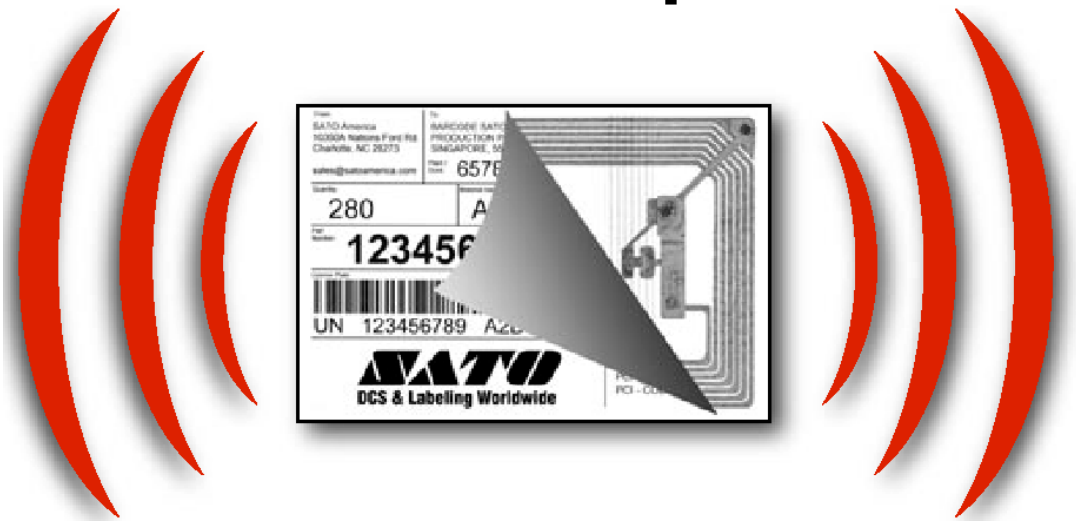
SATO RFID
White Paper



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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 barcoded 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
  - an antenna to facilitate communication with the RFID chip.
- A reader/antenna system to interrogate the RFID inlay.

The RFID Tag

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 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.

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. The low frequency spectrum is the most adaptive to high metal content environments, although with some loss of performance. Read ranges are typically several 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 and 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 such as 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 suitable for railroad car tracking, container tracking, and automated toll collection type applications as a re-usable asset.

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	**125 KHz** Low Frequency (LF)	**13.56 MHz** High Frequency (HF)	**868 - 956 MHz** Ultra-High Frequency (UHF)	**2.45 GHz & 5.8 GHz** Microwave
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	Less expensive than inductive low frequency 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; capable of reading multiple tags quickly	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
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 frequency worldwide due mainly to the relatively wide adoption of smart cards; common frequency worldwide	Different frequencies and power levels are used worldwide: Europe allows 868 MHz @ .5 to 2watts whereas the US permits operation at 915MHz @ 4w; Japan does not allow transmissions in this band at this time.	
Data Rate	Slowest	←- - - - - ♦ - - - - - - - - -	- - - - - - - ♦ - - - - - - -→	Fastest
Ability to read near metal or wet surfaces	Best	←- - - - - ♦ - - - - - - - - -	- - - - - - - ♦ - - - - - - -→	Worst
Passive Tag Size	Largest	←- - - - - ♦ - - - - - - - - -	- - - - - - - ♦ - - - - - - -→	Smallest

3. Applications

Library Information Systems

Tracking a library's assets and loan processing is very time-consuming and 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 at all. RFID 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 chain with greater accuracy in real-time, compared to data collection technologies utilized to date. Once RFID technology is fully integrated, minimal human effort is required in this process 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.

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

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

What About Barcodes?

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 cost of the physical RFID tag. A typical barcode label costs about $0.02, whereas an RFID tag label can costs upwards of $0.25 or more depending on quantity. The initial implementation costs for RFID are also higher, depending on requirements and equipment specifications.

Although initial RFID implementation may currently cost more, the cost will gradually drop to a competitive level in the coming years as companies adopt the technology. 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 past few years, RFID technology has been attracting considerable attention. Giants such as Wal*Mart, Target, BestBuy, U.S. Department of Defense (DoD), Tesco, REWE and Metro Group have announced RFID mandates instructing their top suppliers to start utilizing RFID technology as part of a supply chain compliance program. In January 2005, there were in excess of 400 major companies worldwide required to use RFID technology. As a result of the current RFID supply chain mandate schedules, an estimated 50,000+ suppliers who will ultimately be affected by these plans and RFID solutions are a large driver for future business growth.

The long-term focus in the United States will be on the retail and DoD adopters, who have to be compliant in the near future. Eventually, they will move beyond compliance only, and attempt to use RFID to increase efficiency and start gaining

[3] www.autoidlabs.org/researcharchive

return on their investment. This will almost certainly mean more upgrades and additional spending on enterprise solutions.

The dominant RFID dynamic behind supply chain applications is the EPC standard using the UHF frequency band: 902-928 MHz (North America) and 868 MHz (Europe). EPC Global, a joint venture between GS1, Inc. (formerly EAN International) and GS1 US (formerly the Uniform Code Council [UCC]) is focused on helping supply chains and industry implement the Electronic Product Code™ (EPC) through the development of global standards and support of the EPC global network™. 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.

7. SATO & RFID

SATO is a leader in the RFID market. Building on its past experience with 13.56 MHz RFID technology, SATO has been involved in the forefront of UHF RFID applications. SATO has introduced the industry's first complete multi-protocol EPC-compliant RFID solution for customer pilots and beta tests.

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. 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.

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, Class 0+, ISO18000-6 and Gen2. Also, the CL408*e,* CL412*e* and M8485S*e* RFID printers can be easily upgraded as new standards, protocols and frequencies are established for new generations of RFID tags globally. Utilizing multi-frequency technology compliant with FCC (902-928 MHz), ETSI – Europe (868 MHz), SATO's CL408*e* and CL412*e*

With a large installed base, SATO is a popular choice among Fortune 500 companies directly affected by RFID requirements. SATO delivers not only 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's printers with RFID capability are designed for many applications, including anti-theft, asset tracking, supply chain

logistics, baggage tags, and factory automation, and is actively working with key RFID technology adopters around the world at all levels of the retail and government supply chain.

SATO fully supports the Uniform Code Council's (UCC) Electronic Product Code (EPC) initiatives and the recent retail and DoD mandates requiring suppliers to embed RFID tags at the case and pallet level. The SATO EPC compliant RFID printing solution is now running in top Wal*Mart, Target, DoD, BestBuy, REWE and Metro suppliers.

Since 1979, SATO America has been leading the way in barcode printing solutions and now, with complete UHF RFID system solutions…from printing a product smart label, to tracking product at the dock door and conveyor systems. SATO's RFID printers are designed to ensure compatibility today and tomorrow as new RFID tags and protocols evolve.

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

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