

White Paper

**ITEM-LEVEL VISIBILITY IN THE
PHARMACEUTICAL SUPPLY CHAIN:**

**A COMPARISON OF HF AND
UHF RFID TECHNOLOGIES**

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EXECUTIVE SUMMARY

The numbers are astounding and the stakes couldn't be higher for consumers, pharmaceutical manufacturers, distributors and retailers. Up to 7 percent of all drugs in the international supply chain may be counterfeit. Retail and pharmaceutical markets must absorb more than \$2 billion in product returns each year caused by overstocked or outdated products. Faced with some 1,300 recalls in 2001 alone, the industry is seeking ways to better monitor the international drug supply from "manufacture to medicine cabinet."

The pharmaceutical industry is looking to radio frequency identification (RFID) as a primary way of solving these problems. RFID technology's ability to ensure the validity of data in the pharmaceutical industry is providing many new opportunities for reducing costs, while improving product quality and drug safety. The Food and Drug

Up to 7 percent of all drugs in the international supply chain may be counterfeit. RFID-based solutions could save the industry more than \$8 billion by 2006.

Administration (FDA)'s main interest in RFID is as a technology that can keep the drug supply safe and secure. According to the agency, RFID provides the most promising approach for reliably tracking, tracing and authenticating pharmaceutical products, and it is recommending widespread use of RFID in the pharmaceutical supply chain at the item level by 2007.

Industry pilots involving several retailers, distributors and manufacturers have been launched, and some studies estimate that RFID-based solutions could save the industry more than \$8 billion by 2006. In addition to anti-counterfeiting, RFID benefits include improved inventory management through the reduction of out-of-stock items and safety stock, a decrease in shrinkage and diversion, and faster, more efficient product recalls.

There has been much discussion about the potential of RFID in the pharmaceutical market. Up until now, much of the focus has been on passive tags in the ultra-high frequency (UHF) band due to the Wal-Mart RFID mandate for case and pallet-level supply chain tracking, which requires the use of UHF technology. In support of this mandate, the industry is on track in 2004 to have its first global UHF RFID tag standard, known as EPC Gen 2. Manufacturers are developing tag and reader technology based on the new standard and Wal-Mart suppliers are moving forward with RFID supply chain pilots. In addition, EPCglobal, Inc. is now turning its attention to continuing the development of existing EPC standards for high frequency

(HF), 13.56 MHz technology. There are a number of other established global standards developed by ISO/IEC for HF, item-level tracking, including ISO/IEC 18000-3 and ISO/IEC 15693.

In the retail sector, many experts don't expect item-level RFID tagging of low-cost consumer goods to occur for five or more years. In the pharmaceutical market, there is a strong business case for item-level RFID tagging today due to the higher value of products and margins relative to retail products, in addition to the inherent concerns surrounding product safety.

Despite RFID's high-profile backing, industry momentum and indisputable benefits, there are still many obstacles, misconceptions and issues to be resolved along the way. This includes the choice of which RFID technology to implement, and in particular, which frequency would be most appropriate. This paper sheds light on the myths and confusion surrounding RFID and addresses the choice of HF versus UHF technology for item-level pedigree pharmaceutical tracking. It also provides an overview of some of the commercial pharmaceutical and healthcare field trials and implementations.

MARKET DRIVERS: RFID IN THE PHARMACEUTICAL SUPPLY CHAIN

The benefits of RFID go well beyond the fight against counterfeit drugs. The pharmaceutical industry relies upon the integrity of many forms of data throughout the process of drug trials, manufacturing, distribution and retail sale. RFID's ability to uniquely identify each item (often called mass serialization), and securely capture data without line-of-sight throughout the supply chain has many benefits in the pharmaceutical industry, including:

Insight, Visibility And Efficiency

At the item level, RFID can provide 100 percent visibility of inventory no matter where it is in the supply chain, making it easier and quicker to move goods to the right place within the channel. The technology can improve productivity in shipping and receiving, reduce touch labor, increase the assurance of shipping and dispensing accuracy, and expand product availability at the retail store, thus reducing customer complaints and charge backs.

At the item level, RFID can provide 100 percent visibility of inventory, dramatically reducing inventory losses and write-offs due to shrinkage. RFID can track both lot and expiration dates, improving expiration management.

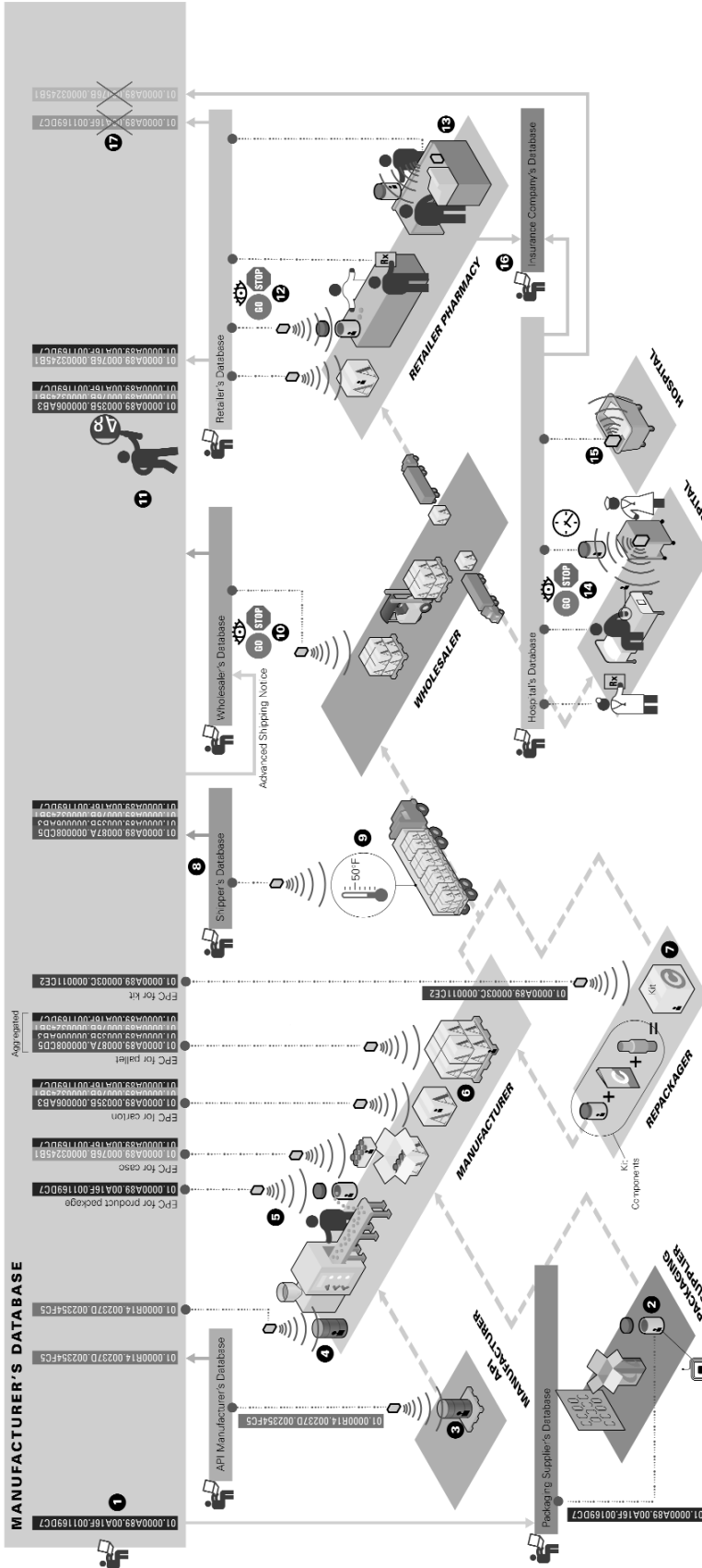
Accountability And Brand Protection

Having a more accountable supply chain at every point using RFID can dramatically reduce inventory losses and write-offs due to shrinkage. It is estimated that 6-10 percent of U.S. retail inventory is stolen or diverted. The technology can positively identify if returns were originally shipped from a particular manufacturer and at what price. RFID also helps to prevent “gray market” distribution (products diverted to unauthorized channels), which costs companies and their customers hundreds of millions of dollars each year.

Product Safety, Recalls And Regulatory Requirements

In addition to anti-counterfeiting, RFID can track both lot and expiration dates, improving expiration management. The technology can store pedigree information, satisfying regulatory requirements. By zeroing in on individual items and capturing manufacturing data, such as lot number and location information, RFID can significantly reduce the time spent identifying products targeted for recall as well as reducing the likelihood of a mass market recall of branded products.

How RFID Technology Protects Pharmaceutical Supply Chain



- 1 Manufacturer** assigns a unique EPC number to each product to allow track and trace throughout the supply chain.
- 2 Packaging supplier** "writes" to the tag the EPC number assigned by the manufacturer and embeds the tag in empty packaging materials.
- 3 Raw materials** are tagged to allow the product's pedigree to extend back as far as needed.
- 4 Manufacturer** receives raw materials and records their EPC numbers in the manufacturer's database, linking raw material data to final product EPC and building pedigree.
- 5 EPC number** and product information are recorded in the manufacturer's database at the end of the manufacturing process. Only products with valid EPC numbers can move through the supply chain.
- 6 Additional EPC numbers** are assigned to cases, cartons, and pallets as products are aggregated. The aggregation information is recorded in the manufacturer's database.
- 7 Kits** can be assembled with both tagged and untagged products. If needed, a kit can have its own unique EPC number.
- 8 Sharing data** among trading partners removes the burden of collecting and storing every detail. The EPC number serves as a key to ensure a quick and accurate match between their data. Security rules prevent unauthorized parties from accessing sensitive data.
- 9 Sensors** can record conditions throughout the supply chain and provide information to the product's history.
- 10 Advance Shipping Notices (ASN)** give the wholesaler detailed EPC data about shipments before products arrive. Retailer pharmacy can check incoming shipping cases or pallets to ensure they match and catch any mismatches before products come off the truck.
- 11 Virtual agents** continually monitor EPC numbers throughout the supply chain and make adjustments to EPC numbers that are out of place, duplicated, or out of place.
- 12 Prescription errors** can be reduced by automatically comparing the data associated with a product's EPC number to customer's records.
- 13 POS system** detects when a product is purchased at a pharmacy and leaves the supply chain.
- 14 Administering errors** can be reduced by scanning patient ID and drug EPC number and automatically comparing the associated information and verifying and to ensure a match to the physician's prescription.
- 15 RFID readers on recycling bins** can detect the tags of discarded products and ensure they have reached the end of the supply chain.
- 16 Insurance companies** can collect a wealth of accurate and useful information when the EPC number of a drug is linked to a specific patient. The patient when a drug is actually administered.
- 17 EPC numbers become inactive** when the product reaches the end of the supply chain, but product information remains in the database.



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ADVANTAGES OF RFID VS. BAR CODES

No matter what frequency is used, RFID has several advantages over bar codes, a technology that initially triggered a revolution in automatic identification systems in a wide range of industries. Storage of re-programmable data on a silicon chip that can be accessed through a wireless interface is a much more robust solution for automatic identification systems. With RFID, the radio signals are used to both power silicon chips as well as transmit data to and from them. Data can be read from passive, battery-less RFID chips in a range of distances from several inches to up to 30 feet (9 meters).

The Advantages Of RFID When Compared With Bar Codes Include The Following:

Simultaneous Identification

Unlike other auto ID methods where items must be physically separated or read individually, numerous RFID smart label transponders can be read simultaneously – identifying multiple labels, containers or items all at the same time as they pass a reading location or are read with a handheld scanner. This need is critical in supply chain logistics, especially at the item-tagging level, where there could be 25 different items in a box traveling on a pallet with 30 other boxes passing through a tunnel reader or portal all at the same time. RFID is the only technology that can read individual items simultaneously.

Non Line-Of-Sight

RFID provides a contactless data link without the need for line-of-sight. With this technology, labels can be hidden or embedded in items, but still read. This isn't possible with other auto ID methods such as bar codes.

Data Storage

RFID can store upwards of 30 times more data than bar codes, allowing the tag to carry a range of real-time information about an item at multiple points in the supply chain. Mass serialization or the ability to store a unique serial number for each and every item is something that cannot be accomplished with bar codes. Tag size is also a factor. To store all the data pharmaceutical companies would like to track at vari-

ous points in the supply chain would require large bar codes – perhaps larger than the item it’s adhered to – or may even require the application of multiple bar codes.

Read/Write

RFID tags act as data carriers. Information can be written to and updated on the tag, which is specific to an item, container or pallet in the supply chain. This information is then held with that item, acting as a traveling item history or self-contained database. Read/write tags could also potentially provide a migration path to the EPC Network once it has been built to support electronic track and trace using networked databases.

Read Reliability

First-pass accuracy is important in supply chain applications. With RFID, the need for spending time scanning items multiple times is eliminated. Using other auto-ID technologies requiring line-of-sight, tags sometimes have to be run through the system a second time or be manually read.

Durability

Without concerns about harsh or dirty environments that restrict other auto ID technologies, the durability of RFID technology is especially suited to fit the needs of supply chain and warehousing applications. In warehouses where harsh environments are the norm, RFID smart labels can be read through dirt, soiled packaging or other materials.

Difficult To Replicate

While linear or 2-D bar codes can easily be replicated by counterfeiters by simply scanning and printing them, the RFID tag manufacturing process would require a great deal more expertise, investment, and time to copy. Counterfeiters would potentially have to build or have access to a semiconductor wafer fabrication facility in order to manufacture the chips and assemble them to inlays or labels. It would also require significantly more time to replicate the individual EPC serial numbers.

HF/UHF PRIMER – PHYSICS AND TECHNOLOGY CHARACTERISTICS

In addition to low frequency (125 kHz – 134.2 kHz), passive RFID tags operate in the high frequency band of 13.56 MHz, and in the ultra-high frequency band of 860 – 960 MHz. Both types of tags derive the energy needed to operate from the antenna’s radio frequency signal.

This radio frequency signal propagates from an antenna and is comprised of electromagnetic waves of energy. HF systems use the magnetic field to transfer power and data where as UHF systems use the electric field.

In HF systems, the magnetic field powers up an RFID tag through a process known as induction. A magnetic field is created as a result of electrical current flow in a closed loop of electrically conductive material (e.g. copper tubing, copper tape, etc.) acting as an antenna. The magnetic field induces an electric current flowing on the antenna

of an RFID tag that is within the magnetic field (also a closed conductive loop). This induced electric current is then used to power the RFID tag’s circuitry, enabling the interpretation of and response to commands that are sent to it from a reader.

In UHF systems the electric field powers up an RFID tag that enters an area within this field of energy. The power of the electric field is used for the RFID tag’s circuitry in a fashion similar to what occurs with HF tags, but using capacitive coupling.

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Read Range And Read Nulls

The intensity of the magnetic field in HF systems can be well defined for a specific read zone, but its relative strength falls off quickly as a function of distance from the antenna, equating to a short read distance of typically less than five feet in conventionally designed systems. In comparison, the electric field used in UHF systems has a relative strength that extends much farther, enabling read distances of up to 30 feet.

Fishnet vs. Swiss Cheese Analogy

Unfortunately, due to areas known as field nulls, the UHF frequency’s electric read zone is not as well defined when compared to that of a magnetic field. Detuning of

the tags, which renders them ineffective, can occur when item-level tags are in close physical proximity to one another or have materials with high permittivity, such as liquids, or high reflectivity such as metals (see next section). A simple analogy illustrates the difference between HF and UHF tags for item and pallet identification: picture the HF “signal” resonating as a fine fishnet and wrapping around the tagged packages. Next, envision the UHF signal as a piece of swiss cheese wrapping around the same tagged packages. As mentioned earlier, the swiss cheese or field null phenomenon requires the use of alternative techniques to compensate for these holes. The HF “fishnet” captures all of the tags including those on items packed closer to the center of the package, while the UHF “swiss cheese” interrogating signal misses many of the tags that may be positioned in the inner portion of the package because they fall into these field nulls.

Many consider UHF technology better suited for reading cases and pallet tags from portal or conveyor antennas, while HF technology's shorter read range allows for more well-defined read zones that can better enable smart shelf and item-level applications.

The presence of field nulls requires the use of a more complex signaling scheme, involving a common technique known as frequency hopping. Due to its longer read range, many consider UHF technology better suited for reading case and pallet tags from portal or conveyor antennas, while HF technology’s shorter read range allows for more well-defined read zones that can better enable smart shelf and item-level applications.

Liquids And Metals

High frequency RF signals are better able to penetrate water and other liquids because the longer wavelengths of HF systems are less susceptible to absorption. UHF’s shorter wavelengths are more susceptible to absorption by liquids. In practical applications, HF tags are better suited for tagging water or liquid-bearing containers. A UHF tag can be made to work, but its effective read range would be drastically reduced.

Metallic environments affect all RFID frequencies. Radio frequency signals do not pass through metal, and when metallic materials are close to the reader’s antenna or the tag’s antenna the characteristics of the system are changed. One effect on both HF and UHF tags is that the metal changes the inductance of the antenna and basically

re-tunes its resonant frequency, reducing the overall read range. Another effect on both frequencies is that RF energy is absorbed by the metal, instead of radiating through it. While both frequencies cannot penetrate through a metal object, absorption affects HF tags and UHF tags differently. With HF tags, there is a lower read range, however, UHF tags can have increased read range if there is a sufficient air gap between them and the metal surface. This situation is unique to each particular application using UHF tags on metal surfaces and cannot have the same predictable results in all cases. In situations where metallic materials are in part of the application, it is best to make use of the metal as an antenna (e.g. implementing an air gap between metal surface and tag). If this is not possible, shielding techniques are required.

Anti-Collision And Simultaneous Reading Of Tags

In pharmaceutical applications, anticollision allows for all 100 individually tagged bottles in a package to be identified and read instantaneously without opening the package or using a handheld bar code reader to scan each item.

Passive RF tags manufactured to the EPC Class-1 (write once, read many) and EPC Class-2 (multiple read/write) specifications, whether HF or UHF, will have a built-in anti-collision feature. This capability enables multiple simultaneous reading of tags with greater than 98 percent accuracy at a rate of up to 1,000 tags per second. Anti-collision features have been available on HF tags from several manufacturers for a number of years. In pharmaceutical applications, anti-collision allows for

all 100 individually tagged bottles in a package to be identified and read instantaneously without opening the package or using a handheld bar code reader to scan each item. Due to the detuning phenomenon discussed earlier and the very nature of RFID frequency physics, locating a tagged item within a small area – containing multiple tagged items – can be far easier with HF due to the field patterns and relative tag signals.

Memory And Data Storage

An RF tag's data storage capabilities are available in many different memory sizes and vary depending on the manufacturer. There are several HF products available today that offer anywhere from 96 bits up to 8K bytes or more of memory, enabling a "mobile database" application where data is stored on the RFID tag instead of in a networked database. This also facilitates speed in capturing data because there is no

time required for remote database access. Current UHF products have data storage capabilities in the lower end of the range described above, which tend to be suited for only carrying “license plate” information mainly desired by the consumer packaged goods industry. It may make sense for all tags on pharmaceutical products to carry a lot number and an expiration date in addition to an EPC number, which requires at least 175 bits of memory.

Tag Size And Form Factor

Bottles, vials, syringes and/or tube sizes will ultimately dictate the need for a small, rigid disc module type of RF tag, while blister packs and multiple unit dose packages may require somewhat larger self-stick, flexible tags that can be laminated to cardboard, paper, plastic or other non-ferrous materials. In instances where a foil seal is required, such as on blister packs or syringe vials, a small stand off, which creates an air gap, may be used to insulate the tag from the disruptive properties of metal. In some cases, it may be necessary to apply the tag inside of a small liquid-filled vessel. Tested for many years in the textile and garment/uniform rental industries, millions of HF tags have been field-proven to withstand liquid, pressure and precipitous temperature swings. Regardless of package configuration at the item level, it is clear that HF tags have demonstrated satisfactory efficacy and are well suited for pharmaceutical applications due to their form factor adaptability.

Passive UHF tag implementations are still in their infancy, so it remains unclear as to exactly what issues may arise in pharmaceutical applications going forward. A number of technical issues are yet to be explored. Generally speaking, UHF tags are significantly larger in size when compared to HF tags. An appropriately scaled UHF tag can accommodate the requirements of item-level tagging of smaller pharmaceutical products, however there would be a distortion and shortening of the emitted frequency wave. A UHF antenna is known as a dipole and it is comprised of two equal rods extending in opposite directions. When bending or wrapping such a tag around an object, each different tag application orientation (e.g. wrapping around 25%, 50% or 75% of the bottle or vial circumference) will cause a substantial variation in tag performance and require a more complex system design.

Packaging And Placement For Anti-Counterfeiting Protection

Because of their adaptability, flexibility, and cost, EPC Class-1 and EPC Class-2 tags are recommended for assuring the drug's pedigree throughout the supply chain. Stressing that the process would be most effective if covertly executed at the point of manufacture, two types of HF anti-counterfeiting tags may be considered for introduction into the packaging and labeling of all drugs. Embedded, robustly designed and more diminutive tags of a 9mm diameter or smaller can be injection molded into plastic caps and would address the need for concealment, thus eliminating the possibility of tag removal by a would-be counterfeiter. This tiny round tag could be passive, one-time-programmable (OTP) write once, read many (WORM), or have a multiple read/multiple write memory. One benefit of an OTP device would be low cost, but a database operating in concert with the tag would be required in order to track pedigree. With a multiple read/ write integrated circuit, you can put all of the product tracking information on the tag and subsequently do not have to depend on the database and supporting background network for the information. The data that is stored on the tag is up to the user. It all boils down to the requirements of the application and the cost benefit realized from having localized data written to the tag, stored at the database level, or in both locations. Either scenario would track, trace and assure authenticity from the point of origin to the end user.

HF/UHF TECHNOLOGY DEPLOYMENT CONSIDERATIONS

Technology Maturity

Compared with UHF technology, HF is far more mature. It has been commercially available since 1995 with the inception of the global ISO/IEC 15693 standards in 1999. Several manufacturers have produced hundreds of millions of HF tags achieving yields of more than 99 percent. The learning curve has been established not only for tag manufacturing, but also for data protocol sharing and the necessary infrastructure to build an RFID application. More than 100 companies supplying chips, inlays, labels, readers, antennas, printers and software currently support the ISO/IEC 15693 standard. Many more companies support proprietary HF products. HF technology has been commercially deployed in markets such as library systems, textile rental and industrial laundry with an extremely high success rate.

Global Standards And Power Requirements

Government bodies in various regions of the world regulate the bands of the radio frequency spectrum. The 13.56 MHz HF frequency occupies an International Scientific and Medical (ISM) band, which is available worldwide. With Japan's approval to harmonize the HF frequency in December 2002, the power levels also became the same across the world. Unfortunately this is not the case with UHF. Standards organizations, such as EPCglobal, Inc., are working with governments to

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harmonize UHF frequencies. However, today the bandwidth of this frequency, which ranges from 860 MHz to 960 MHz varies from region to region. The United States has specified 915 MHz, while the European Union has specified 868 MHz for RFID applications. In one country, the entire UHF band has been allocated to military applications. This variation in UHF frequency allocation requires that manufacturers produce country or

region-specific tags and readers, causing a potential disconnect for companies attempting to create a seamless international supply chain. Japan is just beginning the regulatory process of opening up a viable UHF band for RFID applications. This is true for many other countries in Asia with the exception of China who has not responded with a standard in the UHF frequency band.

When it comes to power requirements, Europe’s ETSI EN 300-220 regulations have two main limitations that make them ‘unfriendly’ to UHF RFID technologies. The first is a power restriction of 500 mW ERP, and the second is a bandwidth restriction that results in an inability to frequency-hop the reader and also imposes a limitation on the tag anti-collision arbitration speed. The power restriction impairs the achievable reading distance, and the lack of frequency hopping means tag visibility and reading robustness are not optimum. In 2004, changes to European regulations are expected to permit reader power in the 869 MHz band of 2 Watts ERP. Even with this new power level the continued restriction on signal modulation between the tag and the reader leads to inequality in performance between U.S. and European systems.

Environmental Factors

The performance of HF and UHF RFID systems is strongly dependent on the environment in which the communication between the reader and the tag occurs. We discussed the effects of metal and water and touched on the basic physics surrounding electromagnetic interference. HF technology’s near field inductive coupling reduces potential wireless interference issues because no real power is being radiated. Therefore, HF technology has an excellent immunity to environmental noise and electrical interference. UHF’s far-field technology does radiate real power and its higher signal strength makes it more prone to electrical interference. In hospital settings the interference potential of RFID is of high concern. HF technology has been used in hospitals for many years and has met the electromagnetic radiation limits of 3V/m, showing no electromagnetic interference (EMI) with critical medical devices. (See chart below).

CLASSIFICATION	SIGNAL STRENGTH*	
RESIDENTIAL:		* Frequency and source dependent, with conditions for the proximity of local radio transmitters. If transmitters exceed conditions (power, distance), then field strengths could be higher.
RURAL	UP TO 3 V/m	
URBAN	UP TO 10 V/m	
COMMERCIAL	UP TO 10 V/m	
LIGHT INDUSTRIAL	UP TO 3 V/m	
HEAVY INDUSTRIAL	UP TO 30 V/m	
TRAFFIC	UP TO 30 V/m	
DEDICATED COMMUNICATIONS CENTER	UP TO 1 V/m	
HOSPITAL	UP TO 3 V/m	

1- Medical Devices and EMI: the FDA’s Perspective 1/2000 <http://www.fda.gov/cdrh/emc/persp.html>

Consumer Privacy Issues

Assumptions about what RFID technology can and cannot do are often incorrect or just misunderstood. As with the introduction of any new technology, companies that manufacture and deploy these important tools have an obligation to understand, explain, and respond to real and legitimate concerns about the path on which RFID technology may lead.

From a technical perspective, RFID doesn't work like a Global Positioning System (GPS) network. Read zones are very limited and are not setup to be real time locators to track tagged items at all times. Most RFID chips today use EEPROM (memory) technology, which allows data to be permanently removed from the chip. Implementation of a disabling feature or kill command has been specified by standards organizations such as EPCglobal, Inc. This feature provides the option for the chip to be turned off at the point of sale, affecting the consumer's ability to take advantage of any after-sale benefits that would require future interactions with the chip. This feature is embedded in all EPC products and will be incorporated in all of the integrated circuits that are based on EPC standards.

In addition, security encryption methods can be embedded onto the tag to ensure that the information on it can only be read or written by authorized users. The creation of encryption specifications for RFID tags by the standards organizations, now in progress, is a vital step for ensuring widespread protection. Security encryption algorithms have already been established for the 13.56 MHz-based ISO/IEC 14443 standard used for automatic fare collection in public transit applications.

We have an obligation to understand, explain and respond to real and legitimate concerns about the path on which RFID technology may lead. Encryption specifications for RFID tags being developed by the standards organizations are a vital step for ensuring widespread protection.

REPORT FROM THE FIELD – HF ITEM-LEVEL PILOTS

A number of HF pilots are already underway in the pharmaceutical supply chain and healthcare markets for item-level management. While there is still much to be learned about the efficiencies and safeguards that can result from the use of RFID solutions in these markets, companies implementing RFID pilots are experiencing process improvements and safety benefits today. Suppliers to the medical industry, from garment to surgical instrument providers, as well as healthcare institutions managing blood and tissue sample processing, are investigating the viability and reliability of HF technology solutions and they are seeing significant return in the field.

Surgical Garment Inventory Management

A major medical garment supplier implemented an RFID-based solution to track, trace and manage more than one million reusable class II surgical garments within its

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supply chain. In order to withstand the intense heat and moisture conditions of the cleaning process, an injection-molded tag was developed and then affixed to the surgical gowns and drapes. Reaching nearly 100% read accuracy, the medical garment supplier significantly improved inventory control, increased quality monitoring, and achieved productivity enhancements compared with the traditional bar code scanning process formerly in place. A substantial short-term ROI was realized and longer-term ROI is anticipated.

Locating Tissue Samples

A tissue-sample processing lab is using miniature HF tags to create efficiencies in locating single test tube samples among the hundreds in the lab at any given time. The HF tag contains a unique serial number as well as memory that can be read, modified and protected. The serial number is then linked to a database containing critical information on each tissue sample, including patient data and tissue treatments. Using a fixed desktop or lightweight hand-held reader at a distance of a few inches, researchers and lab technicians searching for a specific sample on a tray of 100 tubes can quickly and easily read all of the tags in less than 3 seconds. What was previously a pain-staking and time-consuming task of locating and identifying samples can now be completed quickly with a simple pass of an RFID reader over the existing inventory.

Tracking Pathology Samples

The Cell and Genetic Therapy Center of the Paoli Calmette Institute in Marseille, France, began a study in June 2003 to determine RFID technology's resistance to precipitous temperature variances for use in tracking biological pathology samples. Working with a group of partners, HF tags were embedded into the caps of test tubes, which were then immersed in liquid nitrogen and frequently removed during a test period of one year.

After the first year of the pilot, the Center found that HF technology withstands liquid nitrogen at a range of extreme temperature variations from +104°F to -321°F (40°C to 196°C), even when drastically changing temperatures within only a few seconds. The Center's findings demonstrate that RFID technology can be used to track and trace biological samples, even when these samples are subjected to dramatic temperature changes as part of sample processing and storage. Additionally, the results of the study show that researchers in the field using HF technology are in compliance with quality assurance guidelines such as those recommended by the GBEA and the BPL in France, and ISO worldwide.

Matching Blood Samples To Patients

Currently undergoing trials at the Pathology Laboratory of the Portsmouth NHS (National Health Service) Trust in the UK, a positive ID system has shown significant reductions in administration time, both during sampling and laboratory processing. In the trial, the doctor or nurse taking the blood sample enters the patient information into a hand-held RFID device at the start of the blood sampling process. This data is stored on an HF label on the patient's blood sample tube and can be read by fixed readers and automatically transferred to the facility's database, enabling a fully-automated process and replacing an entirely manual one.

By reducing errors and allowing faster processing of samples, costs are reduced and patients have access to their results more quickly. In addition, because the patient data is entered in electronic format at the beginning of the process, integration of results into the patients' records is quick and simple.

Patient Identification And Care

The U.S. Navy is using HF technology to more efficiently track the status and location of hundreds of wounded soldiers and airmen, prisoners of war, refugees and others arriving for treatment at Fleet Hospital Three, a 9-acre, 116-bed facility in Southern Iraq. ScenPro's Tactical Medical Coordination System (TacMedCS) allows medical professionals to use RFID-enabled wristbands from Precision Dynamics Corporation to identify patients, and to update their status, location and medical information in the system's electronic whiteboard automatically.

The Navy implemented TacMedCS to replace a labor-intensive, entirely manual system consisting of pen and paper, cardboard tags, and a centrally located whiteboard to show patient movement throughout the hospital. With the new electronic system, each patient receives an HF-enabled wristband, on which basic identification information is stored. Medical professionals use a handheld RFID device to read the unique identification number, and to add or change data to create a digital treatment record that travels with the patient as he or she is moved throughout the facility. Using a wireless LAN, patient information is transferred to an electronic patient management system, further eliminating manual re-entering of data at a central computer terminal.

Blood Transfusion Safety

Precision Dynamics Corporation and Georgetown University Hospital's (GUH) Blood Bank began a pilot study on March 1, 2004 to explore how RFID wristband solutions increase the efficiency and reliability of blood transfusion safety.

For more than two years, GUH's Outpatient Infusion Service has used a bar code solution as standard practice for double-checking and verifying blood transfusions. GUH is interested in learning whether RFID solutions can increase the efficiency and reliability of transfusion safety in instances where a bar code ID isn't as effective.

To ensure positive patient identification, the RFID wristband system acts as a portable, dynamic database that carries patient information to be used and updated during a patient's stay. This accurate, automated system ensures the integrity of information between patient, host device, and hospital information system.

Hospital Item Management

Designed for use in operating rooms, catheter labs, as well as for radiology, orthopedics, neuroradiology, and cardiology departments, Mobile Aspects' HF-based inventory system has been implemented at 4 of the top 15 U.S. hospitals. The system automatically manages equipment and supply inventory, allowing real-time reports as supplies are removed from RFID-enabled cabinets, and integration with the hospital's information systems to facilitate seamless item replenishment.

Supplies are tagged with HF inlays, and the cabinet compartments contain RFID readers. Once an item is removed from the cabinet, the software requests a scan of the existing inventory, identifying all remaining items and noting which item was removed, by which particular staff person, and at what time. RFID allows this to occur automatically, without manual reading of bar codes. This item management system increases productivity, enhances quality of care, reduces costs, and simplifies the overall process.

With its installations, Mobile Aspects has proven a less than one-year return on investment, a significant improvement on the typical two to three-year payback for hospital inventory management technologies.

CONCLUSIONS

The promise of a safer, more accountable and highly efficient supply chain combined with FDA support for the technology is driving interest and demand for RFID in the pharmaceutical industry. Manufacturers, distributors and retailers are poised to take advantage of the technology's many benefits and are in the midst of conducting pilots to better understand and apply the technology to their businesses. This paper discussed the technical characteristics of HF and UHF RFID technologies. When it comes to the choice of frequency, each has its advantages. Due to a number of technical and deployment characteristics including read range, form factor, maturity, global standards and worldwide availability, HF technology provides the most effective path with the lowest technical and business risk to achieving item-level identification and pedigree tracking for pharmaceutical and healthcare applications.

ABOUT THE AUTHORS

Royal Philips Electronics

Royal Philips Electronics of the Netherlands (NYSE: PHG: AEX, PHI) is one of the world's biggest electronics companies and Europe's largest, with sales of EUR 29 billion in 2003. It is a global leader in color television sets, lighting, electric shavers, medical diagnostic imaging and patient monitoring, and one-chip TV products. Its 165,600 employees in more than 60 countries are active in the areas of lighting, consumer electronics, domestic appliances, semiconductors, and medical systems. News from Philips is located at www.semiconductors.philips.com/identification.

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TagSys

TAGSYS ranks among the top five RFID technology companies in the world. With a global brand presence of over 40 million RFID tags, ten thousand reader systems and 500 installations, TAGSYS has today taken the leadership position as the premier global independent RFID systems supplier for item level tracking, tracing and secure authenticity solutions. Underscoring TAGSYS' core competencies is enabling complete efficiency-driven, ROI-weighted solutions for identifying and tracing items in highly specialized vertical markets and embedded systems. For further information, call 1-866-666-RFID or visit the Web site at www.tagsys.net.



ABOUT THE AUTHORS

Texas Instruments Inc.

Texas Instruments Incorporated provides innovative DSP and analog technologies to meet our customers' real world signal processing requirements. In addition to Semiconductors, the company's businesses include Sensors & Controls, and Educational & Productivity Solutions. Texas Instruments is an industry leader in radio frequency identification (RFID) technology and the world's largest integrated manufacturer of RFID tags, smart labels and reader systems. With more than 400 million tags manufactured, Texas Instruments RFid Systems' technology is used in a broad range of applications worldwide including access control, automotive, document tracking, livestock, product authentication, retail, sports timing, supply chain, ticketing and wireless payment. TI is headquartered in Dallas, Texas and has manufacturing, design or sales operations in more than 25 countries. Texas Instruments is traded on the New York Stock Exchange under the symbol TXN. For more information, contact TI-RFid Systems at 1-888-937-6536 (North America) or +1 972-575-4364 (International), or visit the Web site at www.ti-rfid.com, or the main company site at www.ti.com.



NOTES

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Item-Level Visibility in the Pharmaceutical Supply Chain: A Comparison of HF and UHF RFID Technologies

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Texas Instruments Inc.