RFID and UHF: A Prescription for RFID Success in the Pharmaceutical Industry

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About this paper

This white paper represents a collaborative effort by ADT/Tyco Fire & Security, Alien, Impinj, Intel, Symbol and Xterprise for the purposes of providing educational information on UHF RFID technology to the market, and to examine the suitability of UHF RFID for item level applications in the pharmaceutical industry. As manufacturers and developers of leading UHF RFID products and solutions, these companies determined through interactions with customers — and at the suggestion of customers — that there was a market need for accurate information on the UHF Generation 2 protocol, from a technical and strategic aspect. The information contained in this paper represents collective knowledge and data from all six companies.

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Wal-Mart speaks out about UHF...

"Many thought UHF tags could not be read around water or metal and that only HF tags could meet these tests. However, our team and our technology partners proved that the new UHF Gen 2 tags could, in fact, be read in water and on metal. That's nothing short of a breakthrough."

Rollin Ford

Executive Vice President and Chief Information Officer

Wal-Mart Stores, Inc.

EXECUTIVE SUMMARY

Companies across many industries are now looking at RFID to streamline operations, meet regulatory requirements and prevent the introduction of counterfeit product into the supply chain to protect both consumer safety and company profitability. In order to implement RFID systems, enterprises must make a critical decision: which protocol/frequency band should be implemented — High Frequency (HF) or Ultra High Frequency (UHF)? HF protocols have been in existence longer than UHF — the UHF Gen 2 standard was ratified on December 16, 2004. But the UHF next generation RFID standard was developed to deliver the features and functionality missing from the prior generation of standards as defined by key customers and applications — and specifically to provide the enterprise class functionality required to support the ubiquitous adoption of RFID.

In the year and a half since its ratification, UHF Gen 2 has enjoyed an extremely rapid development cycle — so rapid that much of the publicly available information and perceptions of UHF are not current. As a result, there is much confusion in the industry regarding which frequency — HF or UHF — to implement for item level RFID applications. The goal of this paper is to present a single document with the most up-to-date, accurate information on the capabilities of UHF RFID.

In this white paper, we will examine the myths associated with UHF for item-level RFID applications — and the physics and real-world tests and implementations that disprove them, illustrating that UHF Gen 2 near field:

- Can and does work on and in liquids
- Not only works on metal, but is able to effectively utilize the metal for improved performance
- Is easily constrained to the controlled read ranges necessary in item-level applications
- Enables the smallest of tags for the smallest of items, with complete form-factor flexibility
- Can offer the same level of security as HF systems
- Tags can be read in very close proximity — even when tags are actually touching
- Is effectively impervious to noise
- Provides superior enterprise-level read rates — up to 500% higher than HF read rates
- Does not present any increased safety risks associated with altering the chemical makeup of medicines

In addition to the above technical capabilities, this paper will also address the major strategic business requirements for RFID systems, and how UHF elegantly and completely addresses those issues, including:

- The ability to provide a single platform for item, case and pallet level RFID applications, eliminating the need for multiple RFID infrastructures — resulting in significant efficiencies in cost and inventory visibility from the point of manufacture to the point of sale
- Why UHF RFID tags are less costly than HF tags
- The ability to match the speed of your operations today, eliminating any impact on profitability due to the implementation of RFID

- How and why it is the UHF Gen 2 standard that will provide the true foundation and cost efficiencies required to bring the vision of a single global RFID network for worldwide supply chain visibility to fruition

While the capabilities and benefits of UHF discussed in this paper apply to any and all industries, this paper will focus on how UHF meets the needs of the industry with some of the most demanding applications and most stringent regulations — the pharmaceutical industry.

BACKGROUND

The benefits of RFID are well established across many industries and applications. From the manufacturing line to the distribution center to the retail floor, the application of RFID technology can automatically provide the information needed to achieve full visibility of products and assets across entire supply chains. From reduced out of stocks, better inventory management, just-in-time manufacturing, and reduced labor costs to protection against the introduction of counterfeit product into the supply chain and reduced shrinkage, RFID offers companies hard quantifiable benefits. For example, in distribution centers, where labor constitutes the majority of operating costs, RFID has been used to eliminate the need to manually track and scan products, reducing labor costs by 30% or more. And regardless of the significant ongoing annual expenses for tag purchase associated with RFID systems, the benefits far outweigh the costs. According to the HDMA Healthcare Foundation, large manufacturers in the pharmaceutical industry can expect to achieve a projected 250% to 275% annual return on investment, and large distributors can expect a projected 300% to 500% annual return on investment.[1]

Counterfeiting is a global problem for all industries, and is growing at an alarming rate. Despite sophisticated measures in place today, criminals are not only producing counterfeit goods on an industrial scale, but are also able to produce fakes of such high quality that detection often requires significant technical expertise. The impact is staggering:

- Global economic damage across all industries is estimated at over $600 billion annually.[2]
- In the United States, seizure of counterfeit goods has tripled in the last five years.[5] And in Europe, over 100 million counterfeit and pirated goods were seized in 2004 — a 12% increase over 2003, and over a 1,000% increase since 1998.[3]
- In the U.S., California alone loses about $34.5 billion every year to counterfeit products.[2]
- Fake products cost business in the United Kingdom approximately £10 billion ($17 billion USD).[2]
- In India, about 15% of fast-moving consumer goods and 38% of auto parts are counterfeit.[2]

And for the pharmaceutical industry, the effect reaches beyond profitability to consumer safety:

- The World Health Organization (WHO) estimates that counterfeit drugs account for 10% of the global pharmaceutical market[6] — and in developing countries, up to 25% of the pharmaceuticals are counterfeit, and may not even contain the active ingredient.[2]
- In the year 2004, the increase in counterfeit drug investigations in the United States by the Food and Drug Administration (U.S. FDA) nearly doubled from the previous year, representing a 600% rise in frequency since 1997.[4] And the rise in counterfeit medicines in Europe increased 45% over 2003.[3]

In the year and a half since its ratification, UHF Gen 2 has realized an extremely rapid development cycle — so rapid that much of the publicly available information and perceptions of UHF are not current. As a result, there is much confusion in the industry regarding which frequency — HF or UHF — to implement for item-level RFID applications. The goal of this paper is to present a single document with the most up-to-date, accurate information on the capabilities of UHF RFID.

By providing item level supply chain visibility, RFID provides the information required for product authentication, providing an effective measure to combat the growing counterfeit problem.

In the pharmaceutical industry, RFID reaches beyond counterfeit protection to also offer a number of other critical benefits for consumers and manufacturers, as well as health and safety officials. Consumers benefit from improved product safety, quality and availability. Pharmaceutical manufacturers benefit from reduced liability, brand protection and additional revenue that was previously diverted to makers of counterfeit drugs. Health and safety officials achieve a controlled and authenticated supply chain.

Achieving these benefits ultimately requires the realization of a global RFID network — just like the Internet provides a single network for access to websites around the world, this single RFID network provides businesses with full visibility and track and trace capabilities from the birth of a product through to delivery to the final customer. In order to achieve this vision, organizations must be able to implement a single technology operating under a uniform global standard. But to date, there has been an adoption delay in the standards required to achieve this vision. As enterprises begin implementing RFID to meet mandates and regulatory requirements as well as to realize the associated business advantages, they are faced with standardizing on either one of the two available frequencies — UHF (Ultra High Frequency) Generation 2 or HF (High Frequency) — or both.

If upstream suppliers select a different frequency than you do, it will require you to implement both UHF and HF infrastructures to read tags.

This frequency selection reaches far beyond your own walls. If upstream suppliers select a different frequency than you do, it will require you to implement both UHF and HF infrastructures to read tags. If you select a different frequency than your downstream suppliers, you require them to implement both UHF and HF infrastructures to read tags. Dual-frequency scenarios significantly elevate the cost of RFID by requiring companies to purchase and support hardware, application software and tags for both frequencies – something many retailers using EAS anti-theft tags have already experienced.

If you select a different frequency than your downstream suppliers, you require them to implement both UHF and HF infrastructures to read tags.

Today, UHF is the de facto choice for case and pallet tracking applications, well-proven and deployed around the world and across industries. Until now, conventional wisdom has asserted that HF is the proven and better technology for item level (or near-field) applications. While it is true that HF is a proven mature technology, it is now becoming clear that UHF is equally as reliable and can even offer better performance than HF at the item level. And while HF is limited to operation in the near-field only, UHF offers enterprises a single protocol and infrastructure for all applications — from item level applications on the conveyor belt in the manufacturing plant to the case and pallet applications in the warehouse, distribution centers and loading docks to the shelves on a retail floor. UHF truly offers a global platform that can enable the worldwide and end-to-end supply chain visibility required to eliminate counterfeiting and theft as well as streamline operations and reduce costs.

In this paper, we will put UHF to the toughest test — can UHF meet the needs of the pharmaceutical industry, the industry that has some of the most demanding item level RFID requirements? We will take a look at the needs driving RFID implementation in the pharmaceutical industry and share the successes of some of the organizations that have already implemented UHF for item level applications. We will examine the business benefits of UHF versus HF. We will look at the physics that enable UHF to deliver those business benefits, including outstanding performance for all types of RFID applications — item, case and pallet. And finally, we will validate that UHF can do what HF cannot: provide a single standard that can perform equally well in near and far-field applications at a level of cost efficiency that will truly pave the path to ubiquitous implementation of RFID technology throughout the supply chain.

THE MAJOR ISSUES IN THE PHARMACEUTICAL INDUSTRY

Combating Counterfeiting

The pharmaceutical prescription drug supply chain is unlike any other in the world, handling regulated and controlled substances as they move through a very complex global distribution system. Between the time of manufacture and the time the product reaches the end-consumer, these products have often changed hands as much as five times — contract packagers, primary and secondary distributors, retail pharmacies, hospitals and more may have handled the drugs. Each handoff represents a vulnerable point in the supply chain where counterfeit products can be introduced, and where authentic drugs can be diluted or diverted to more profitable channels, without regard for impact on the effectiveness of active ingredients.

Actual Events: Counterfeit and Adulterated Drug Incidents

Following are some of the major counterfeit incidences in which diluted, mislabeled and substitute versions of drugs threatened patient safety and health:

Lipitor - Cholesterol-lowering medication used to help prevent serious heart disease
Over 200,000 bottles recalled due to a large quantity of counterfeit product entering the U.S. market.

Zerit - HIV treatment
Counterfeit and mislabeled product potentially exposed patients to the possibility of an overdose — capsules containing 40 mg of the active ingredient were labeled as containing 30 mg.

Clarithromycin - Antibiotic used to treat pneumonia, bronchitis and other infections — including infections in children
Counterfeit product, known as Biaxin, was found to contain absolutely no active ingredients.

Neurontin, Accupril and Celebrex - Respectively used to treat seizures and shingles pain, high blood pressure, and debilitating arthritis pain
Counterfeit doses of all three medications found in California were actually vitamins, containing no active ingredient.

Allegra (Fexofenadine) - Allergy medication
Medication ordered through an Internet resource proved to be a fexofenadine-based product that was not approved by the U.S. FDA, and had an expiration date of 1/03 — when actually the product had already expired in 1/02. Although the website appeared to promise products from the UK, the medication actually came from Vanuatu, an island off the coast of New Zealand well known for businesses that traffic illegitimate prescription drugs to the U.S.

Losec (Omeprazole - sold as Prilosec in the U.S.) - Treatment for ulcers and other gastric conditions
Counterfeit Prilosec was manufactured with such sophisticated techniques that only the manufacturer had the technical information required to determine the product was fake.

Procrit (Epoetin alpha) - Anemia medication for patients with cancer, chronic kidney disease and HIV
Despite sophisticated anti-counterfeiting technology used by the manufacturer on this product, counterfeit product discovered at two large wholesalers and a number of retail outlets contained either bacteria-contaminated water instead of active ingredients, or 20 times less active ingredient than the real drug.

SOURCE: Excerpt from the Congressional Record of Congressman John D. Dingell's statement before the House of Representatives, July 24, 2003

The sharp rise in counterfeit drugs

The counterfeit drug problem is on the rise, with a dramatic increase in cases: the U.S. FDA investigated 58 cases in 2004 involving hundreds of thousands of fake dose units — nearly double the number of cases in 2003, and a 600% rise in frequency since the five cases in 1997.

SOURCE:

United States Food and Drug Administration. "Combating Counterfeit Drugs:
A Report of the Food and Drug Administration Annual Update." May 18 2005.
www.fda.gov/oc/initiatives/counterfeit/update2005.html

Purdue Pharma speaks out about UHF...

"At the individual item level, UHF has performed excellently. We originally initiated the OxyContin RFID pilot program to meet a customer's needs for UHF at the item level. Through the implementation, we have met those needs and have found the technology to be feasible for mass-tagging of item level product."

Harry Ramsey
Sr. Package Development Engineer
Purdue Pharma L.P.

This problem is a major concern for the pharmaceutical industry, posing a very real and growing public health threat — the ersatz drugs may contain only inert (inactive) ingredients, incorrect ingredients, improper doses of the right ingredients, ingredients that are either too potent or not potent enough, or some form of contamination. As a result, thousands of people all over the world die every year,[6] either from ingesting counterfeit drugs that contain ingredients that are directly dangerous when ingested, or do not contain needed ingredients to control a disease or illness, resulting in serious medical complications. In the acclaimed book "Dangerous Doses," investigative reporter Katherine Eban reports that consumers who received counterfeit medications purchased those prescriptions from major legitimate pharmacy chains — often receiving replacement substances such as tap water, insulin and fertility hormones instead of the intended drug formulary. And while the U.S. FDA reports that less than 1% of the drugs in the U.S. are counterfeit, with 3.2 billion prescriptions written in the U.S in 2004[15] (nearly a dozen for every man, woman and child), that still translates into millions of people at risk of either ingesting a dangerous substance or not receiving the required dose of medication to control or resolve a medical condition.

In addition to the public health threat, the economic toll of counterfeit drugs on the pharmaceutical companies is astronomical. In a recent study, the World Health Organization (WHO) stated that counterfeit drugs represent over 10% of global sales,[6] an estimated annual $32 billion. Now very big business, counterfeiters are no longer limited to a few people in a garage in a small operation. Today's counterfeiters are often well-organized with international criminal operations that are well financed with very sophisticated manufacturing capabilities.[7] These operations are fueled by "high profits — as well as the fact that the criminal penalties are less severe than those for selling illegal narcotics, such as heroin or cocaine."[6]

Compliance with government regulations

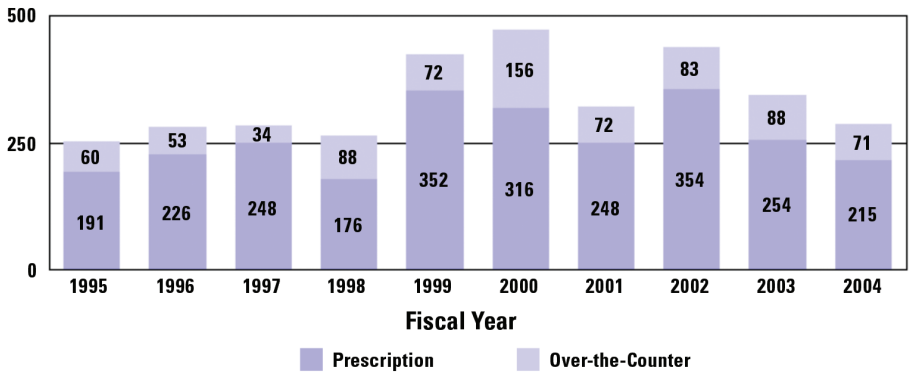
State and federal laws have been enacted in order to address the increasing threat to public health posed by counterfeit drugs. At the federal level, the U.S. FDA enacted the Prescription Drug Marketing Act (PDMA), which will go into effect December 2006, with a mandated requirement that every drug must have a full pedigree (information required to ensure the security and authenticity of a drug as it travels through each step in the pharmaceutical supply chain). In addition, many states are enacting their own pedigree laws. Florida's pedigree law, which enables companies to select either paper or electronic record keeping, takes full effect on July 1, 2006, and requires full documentation of the drug from the manufacturer to the store, requiring each shipment to be accompanied by the amount of the drug, dosage form and strength, lot numbers, name and address of each owner with owner signature, and complete shipping information.[8] California's pedigree law, which specifies the requirement for an electronic pedigree, goes into effect on January 1, 2007. Many other states are considering similar laws, including Arizona, Arkansas, Illinois, Indiana, Iowa, Kansas, Maryland, Missouri, Nebraska, New Jersey, Oklahoma, Oregon, Texas, Utah, and Virginia.[9] And in March of 2006, a new bill, the Reducing Fraudulent and Imitation Drugs Act of 2006, was introduced in the U.S. Congress, which if passed, will require the incorporation of counterfeit-resisting technologies, such as RFID, into the packaging of any prescription drug.

Management of Product Recalls

Product recalls in the pharmaceutical industry for prescription and non-prescription drugs, whether due to counterfeit product or contamination on the manufacturing line, number in the hundreds each year, representing many millions in administrative costs and lost sales. Even when a problem is identified before a product reaches consumers, the cost of product recalls can be extraordinary. The economic cost of conducting a recall, from tracking the drugs and initiating the actual recall to managing the incoming shipments can run into the tens of millions of dollars, but often even more significant is the toll on the brand and loss of consumer confidence. A University of Wisconsin study estimates lost shareholder value following a recall at 12 times the total cost expense of the recall, including the labor involved in the actual recall, litigation and the cost of replacement product.[10]

In the 1982 Tylenol tampering incident, the entire U.S. inventory of 31 million bottles of Tylenol worth over $100 million USD was recalled — without track and trace technology, they could not be certain of the whereabouts of tampered prouduct. Despite masterful marketing execution of this recall, the poisoning of the first victims led consumers to avoid the product, resulting in a market share decline for the brand from 37% to 8% at the end of 1982.[12]

Managing the administration of recalls in the most rapid and cost-effective means becomes crucial to protecting consumer safety as well as company profitability.



Every year, recalls of prescription and over-the-counter medications cost pharmaceutical manufacturers millions in administrative costs and lost sales. By providing the ability to track and trace at the item level, RFID enables product recalls to be performed efficiently and rapidly, minimizing the risk to consumers as well as costs.

Source: Center for Drug Evaluation and Research (CDER) Report to the Nation. 2004. http://www.fda.gov/cder/reports/rtn/2004/rtn2004-4.htm

UHF in action at Purdue Pharma

Purdue Pharma is using RFID technology at the item level for tagging individual bottles of OxyContin. Bottles are each read individually on the manufacturing line at a speed of approximately 100 bottles per minute, and again in cases consisting of 48 bottles in approximately five seconds. The pilot, implemented in November of 2004, was developed to meet a specific customer request for UHF at the item level.

The ROI of RFID

Pharmaceutical industry projected benefits of RFID deployment:

For distributors, benefits totaled $5.5 million per $10 billion in revenue.

For manufacturers, benefits totaled $10 million per $1 billion in revenue.

SOURCE:

HDMA Healthcare Foundation; Adopting EPC in Healthcare: Cost & Benefits, 2004

RFID BENEFITS FOR THE PHARMACEUTICAL INDUSTRY

For pharmaceutical manufacturers and distributors, RFID provides a solution for these three critical issues:

- Improve counterfeit protection: Protects the safety of products — and the public health — as drugs travel throughout the entire supply chain.
- Regulatory compliance: Provides the ability to create a complete electronic pedigree, automatically, without human intervention, without adding labor costs.
- Rapid and cost-effective recalls: Provides the ability to instantly and automatically identify the location of product that must be recalled, enabling pharmaceutical manufacturers to
  - increase consumer safety
  - dramatically reduce the costs typically associated with recalls executed with time-consuming and expensive manual processes

In addition to resolving major concerns, RFID provides risk management and operational efficiencies that ultimately contribute to the company's bottom line through:

- Improved operational efficiencies: Delivers an increase in productivity through high levels of automation.
- Increased brand protection: Provides the traceability needed to protect against a wide variety of events that can reduce the value of the brand, including counterfeiting, recalls, diversion, tampering and theft — a value leading global management consulting firm A. T. Kearney estimates at $10 to $20 million a year.[10]
- Improved data accuracy and integrity: The removal of paperwork and data entry to track prescription drugs moving through the supply chain eliminates the many errors inherent in the manual processes. The ability to lock the information on the tag further adds to the security of the data by nearly eliminating the possibility of unauthorized alteration of or access to data on the tag.

Factor in the dollar value of some of these benefits, and RFID delivers an undisputable rapid and strong return on investment.

THE ROI OF RFID IN THE PHARMACEUTICAL INDUSTRY

The HDMA Healthcare foundation commissioned A. T. Kearney to produce a research report designed to help large pharmaceutical manufacturers and distributors understand the return on investment for RFID systems. Working closely with four companies in order to develop realistic assumptions, researchers gathered roughly 200 data points, from wages for workers to gross margins for specific products.

In the following table, the results, published in a report in 2004, illustrate that the benefits of RFID more than outweigh the initial investment and ongoing tag costs.

Estimated Aggregate Quantitative Business Case Results[1]		
	Large Manufacturer	**Large Distributor**
One-time benefits		$2 Million - $4 Million
Annual benefits	$20 Million - $55 Million	$10 Million - $20 Million+
One-time startup costs	$15 Million - $20 Million	$9 Million - $20 Million+
Annual ongoing costs	$20 Million - $40 Million initially $8 Million - $20 Million (after tag prices fall)	$3 Million - $4 Million

Source: HDMA Healthcare Foundation; Adopting EPC in Healthcare: Cost & Benefits, 2004
Assumptions include: Tagging of 50% to 100% of items; An average cost of $65 per item

BUSINESS REQUIREMENTS FOR RFID SYSTEMS IN THE PHARMACEUTICAL INDUSTRY

The need and value of RFID in the pharmaceutical industry are well recognized and documented. With the need to meet U.S. federal and state regulatory compliance in the very near future (FDA PDMA December 2006; Florida state pedigree law July 1 2006; and California state pedigree law January 1 2007), many companies in the pharmaceutical industry are aggressively seeking to implement RFID now.

Instead of asking if and when RFID technology should be implemented, companies are now asking what RFID technology should be implemented. In order to answer that question, leading companies have defined critical strategic and business needs, as well as the system specifications that will meet those needs.

These requirements are some of the most demanding and stringent of any RFID applications to date.

Strategic Issues

- Security: The system must offer the level of security required for the highly sensitive pharmaceutical RFID data, both during transmission of information from tag to reader as well for the data stored on the tag.

- Operational speed: The RFID system must provide accurate reads at all levels — item, case and pallet — without requiring any reduction in throughput.

- Cost: The system must offer maximum cost efficiency by providing:

  - a single protocol that can easily be deployed globally throughout the enterprise and its extended supply chain. Allowing multiple infrastructures to accommodate multiple protocols adds complexity and cost. For example, two sets of hardware would need to be purchased, deployed and maintained, not to mention the complex operational logistics required to accommodate multiple RFID flows inside and outside the enterprise. These implications extend both upstream and downstream in your supply chain. And the implementation of a dual protocol would necessarily force suppliers and customers to maintain the same multiple infrastructures.

  - tags that are cost-effective at mass volumes will be required to meet pharmaceutical item level tagging requirements.

RFID improves operational efficiencies for Wal-Mart

Wal-Mart stores equipped with RFID technology were 63% more effective in replenishing out-of-stock products.[13]

A study on Wal-Mart's use of RFID led to speculation that RFID tecnology could increase sales by approximately 0.5% by enabling tighter stock management — representing an annual increase of $1.5 billion for the $300 billion dollar company.[14]

Physical Issues

- Read points: The RFID system must offer flexibility in read ranges to accommodate the needs of the various read zones throughout the enterprise: at the loading dock (pallet level), in the warehouse (case level), and on the conveyor belt (item level).

- Materials: The system must work in the presence of materials characteristically found in pharmaceutical products and packaging, including liquids (for example, vials of vaccines and bottles of liquid medication) and metals (found in blister packs) – packaged together with the RFID tags at much closer ranges than CPG or other types of products.

- Tag form factor/size: Full flexibility in tag sizing is required in order to accommodate the smallest bottles and vials as well as cases and pallets — with the same high level of reliability and performance in all tags. In addition, tags must be able to be rigid as well as flexible, for example, to accommodate the curve of a pill bottle. And regardless of how tiny or flexible the tag must be, read range requirements must still be met.

- Tag proximity and orientation: From items placed in a tote at a distribution center to items on the shelf in the store, tags must be able to be successfully read, regardless of how close they are to each other, or their orientation to the reader.

- Environmental noise: Since there may be other equipment operating in the environment that generates electromagnetic energy (for example, cordless phones, mobile radios, fluorescent lighting, electrical equipment, and other RFID readers), the RFID system you select must be able to reject the interference these products produce in order to ensure predictable and reliable system performance every second of the day.

The impact of frequency selection cannot be overstated. This single decision will have strategic, technical and financial ramifications for your enterprise, as well as your downstream supply chain.

FREQUENCY SELECTION: UHF OR HF?

With business needs established, technical specification of the RFID system begins. One of the key decisions is frequency: Ultra High Frequency (UHF) or High Frequency (HF) — or both. The impact of frequency selection cannot be overstated. This single decision will have strategic, technical and financial ramifications for your enterprise, as well as your downstream supply chain. The objective of this paper is to provide all of the latest fact-based information available today on the capabilities of the UHF and HF protocols to best support this critical business decision.

UHF: Reality Versus the Myths

The selection of frequency has sparked a major debate in the industry, and is of particular importance in the pharmaceutical industry, which requires item level as well as case and pallet level applications. It has been commonly believed that HF, which is limited to near-field operation, is the better performer for item level applications — and UHF is the stronger performer for far-field applications (case and pallet), but cannot deliver the performance required at the item level, particularly in pharmaceutical applications. This naturally leads to the conclusion that enterprises with near- and far-field requirements need to implement both technologies: HF for item, and UHF for case and pallet. In addition, the general view has been that the physics of the UHF protocol render it unsuitable due to the physical makeup of pharmaceutical items, which often include liquid-filled vials and metallic blister packs.

UHF is often cited as an inappropriate choice for item level tagging in pharmaceutical and other industries because of the physics involved. In actuality, it has been demonstrated that the physics

clearly favor UHF for item level applications, regardless of the material that will be tagged. In many cases, UHF significantly outperforms HF solutions.

Following is a discussion of the major perceptions of the respective strengths and weaknesses of UHF and HF for RFID — and myths versus reality, complete with salient proof points.

Materials and Surfaces: Liquids and Metal

The myth:

HF is the only frequency choice for item level pharmaceutical applications due to its ability to perform on liquids and metals.

The reality:

It is true that HF is well proven to perform reliably and accurately on liquids and metals, although the HF readers that deliver this performance are not the inexpensive $50 HF readers, but high-performance HF readers that range from $3,000 to $7,000 and up. However UHF can perform equally well — if not better — from both a reliability and accuracy point of view on both liquids and metals.

The facts:

Liquid

Near-field RFID utilizes the magnetic field to power tags; far-field RFID uses electromagnetic waves to power tags. It is true that far-field UHF electromagnetic waves tend to get absorbed by liquids directly in the reader field. But the magnetic waves of near-field UHF are not subject to RF absorption. In actuality, in the magnetic near-field, UHF Gen 2 tags work, not only ***on*** containers filled with liquids, but also ***in*** containers filled with liquids. Recent demonstrations that prove this fact include:

- UHF tags working ***in*** liquids, including water, hand lotion and shampoo – not just ***on*** a bottle filled with liquid — clearly demonstrating the flexibility that UHF can provide for any application where liquids are involved (Impinj technology demo)

- UHF tags working on a Gatorade bottle (Impinj technology demo)

- 100% read rate for boxes of 10 pouches, each containing liquid vials (Symbol customer demo)

- 100% read rate for UHF item level tagged liquid vials inside a case, at a range of up to two feet (Alien technology and customer demo)

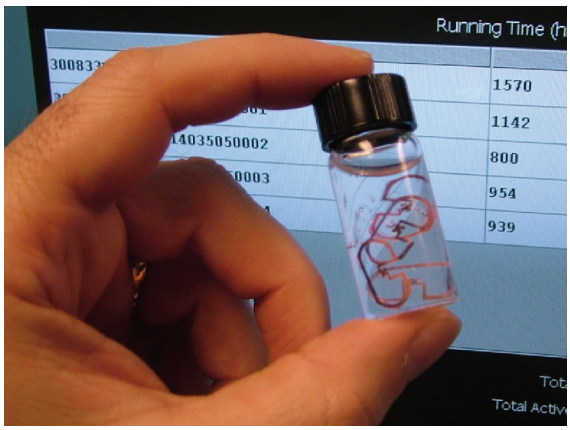
Metal:

All electromagnetic fields are affected by metals – near and far field, HF and UHF. But only UHF can take advantage of the metal. With UHF, the tag antenna can be easily designed to work with metal, actually allowing the metal to help couple the electrical field into the tag. The results are outstanding performance on metal — performance that can exceed that of free space. A real-world example is Tyco's use of RFID tags in combination with Electronic Article Surveillance (EAS) tags. The UHF tags are designed to be placed directly under the EAS tag, and to take advantage of the metal in the EAS tag to deliver outstanding performance.

It is because of the physics that UHF tags can offer superior performance on metal. All that is required is a properly designed tag. Conversely, while HF does perform on metal, the low frequency does not typically deliver a robust coupling, which can impact the performance of HF on metals.

UHF is often cited as an inappropriate choice for item level tagging in pharmaceutical and other industries because of the physics involved. In actuality, it has been demonstrated that the physics clearly favor UHF for item level applications, regardless of the material that will be tagged. In many cases, UHF significantly outperforms HF solutions.

Takeaway:
UHF provides the flexibility for pharmaceutical companies to achieve the performance required on metal, and on — or in — liquids.



Contrary to popular opinion, UHF tag performance is not degraded due to the presence of liquid. UHF RFID tags can be designed to work on — or in — bottles or vials of liquids, as illustrated by the PaperClip™ Gen 2 tag from Impinj which is immersed in fluid in this vial without any impact on performance.

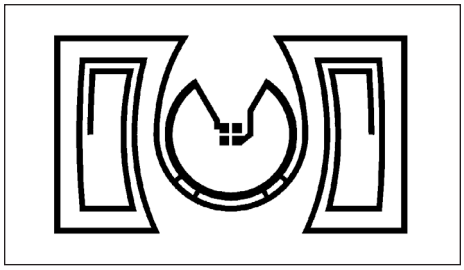
UHF can perform equally well — if not better — from both a reliability and accuracy point of view on both liquids and metals.

Controlled Read Range

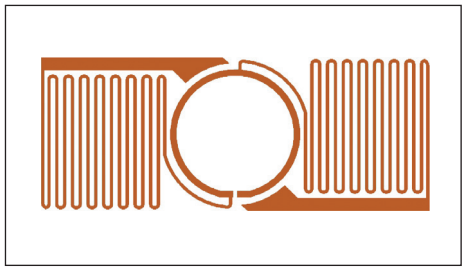
The myth:
UHF cannot provide the constrained read range required for some item level RFID applications due to its longer read range, and the inability to control where or how far the wave travels.

The reality:
UHF can provide the full spectrum of ranges required by the enterprise, from constrained near-field read ranges as small as 2 in./5.08 cm to far-field read ranges as great as 32 ft./10 m.

The facts:
Read range control is NOT a function of frequency or the protocol. It is strictly a function of tag and reader antenna design, and of RF power. Antennas can be designed for short range, long range or both, and range is easily reduced by simply reducing the RF power in the reader. With UHF, read range is literally selectable — a tag designed for use in a clothing store obtains 100% reads as garments move through a portal as they are placed in and out of inventory, as well as at the point of sale (POS) terminal.



Impinj Satellite™
.70 in. x 1.26 in/18mm x 32mm (inlay dimension)



Alien Mini-Squiggle™
.39 in. x 1.06 in./10mm x 27mm (inlay dimension)

The antenna designs illustrated above exploit magnetic and electromagnetic field coupling, enabling both near and far field reads in a single tag.

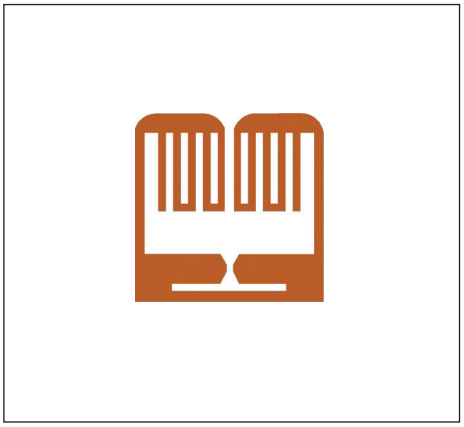
Takeaway:
UHF provides flexibility for use in near- and far-field applications, providing enterprises with the ability to use a single frequency to support item, case and pallet applications.

Tag Size

The myth:
UHF tags are too large for item level tag applications.

The reality:
UHF tags have no size constraint — in one successful trial, a major healthcare facility is placing a 9 mm tag inside specimen vials to track specimens from the moment they are taken. Tag antenna size, which drives the size of the tag, is a function of the required read distance.

The facts:
While UHF RFID tags used in supply chain operations are often four to six inches in dimension, this is driven by the need to read cases and pallets in warehouses and on loading docks at long distances. In UHF RFID systems, the smaller the tag, the shorter the read range — and the larger the tag, the longer the read range. The size of a UHF tag is driven by the range and orientation requirements. The very short ranges required by item level tagging are easily met with small tag antennas.



Alien 1x1 RFID inlay
Shown at actual size: .98 in. x .98 in./25mm x 25mm

Symbol RFX6000 1x1 Pharmaceutical RFID tag
Actual size: 1.00 in x 1.383 in./25.4mm x 35.1mm

Above are examples of two small one inch Gen 2 tags currently on the market, designed for use in Pharmaceutical item level applications.

Takeaway:
UHF RFID tags provide the flexibility to meet item, case and pallet requirements, from short range tags small enough to fit in the cap of a vial to large tags that harvest the RF energy required for robust performance in the longest of read ranges.

Tag Proximity

The myth:
UHF tags will not work on items that are stacked or packaged in close proximity.

UHF RFID tags have no size constraint, providing the flexibility to meet item, case and pallet requirements — from short range tags small enough to fit in the cap of a vial to large tags that harvest the RF energy required for robust performance in the longest of read ranges.

Mallinckrodt Pharmaceuticals speaks out about UHF...

"We have been using UHF for two years and we have been very pleased with the results. We have experienced a large amount of success with UHF and our customers are happy with our RFID efforts. We have looked at some recent reports comparing UHF and HF and we are not convinced that these comparisons are truly comparing similar things. The near-field attributes of UHF must be compared to the near-field attributes of HF to show a pertinent comparison. We remain excited about the successes we have had with UHF Gen 1 technology and we are looking forward to even better results with UHF Gen 2."

Darrell Biggs Jr.
Sr. RFID project engineer
Mallinckrodt Pharmaceuticals, a division of Tyco Healthcare

The reality:
UHF tags provide excellent performance, regardless of item or tag proximity.

The facts:
HF tags require many turns of stamped or etched copper resulting in a large mass. UHF tags, on the other hand, by virtue of their very short wavelength and inherently powerful near-field coupling, requiring only a very small simple loop antenna. This antenna has the additional advantage of reducing magnetic shielding that can block visibility of nearby tags (unlike the dense mass presented by the HF tag), enabling even stacked tags to be visible to readers. Furthermore, the Gen 2 standard also provides singulation and anti-collision algorithms that outperform HF protocols, enabling more rapid and reliable reads (up to 1,000 tags per second) on large tag populations. Successful customer tests include scenarios where tagged items were in very tight proximity — stacks of DVDs, racks of clothing and even scenarios where tags were actually in direct contact with each other.

Takeaway:
UHF offers a higher level of performance than HF, regardless of how close RFID tags may be in relation to each other.

Noisy RF Environments

The myth:
UHF tags cannot provide the same level of performance as HF tags in noisy RF environments.

The reality:
UHF item level applications are no more susceptible to RF noise than HF systems. Noise and interference are primarily associated with long read ranges — near-field UHF is essentially noise-immune.

The facts:
For the short read range of UHF near-field applications, the impact of noise is negligible. Because the inductive field attenuates very rapidly with distance, other noise sources would need to be extremely close to cause any interference. The ability to constrain the read field in UHF item level applications greatly reduces the ability for any noise or interference to affect the system. And even in far-field UHF applications, which can be affected by noise, noise rejection is a systems design issue — not a frequency issue. For far-field applications where noise can be an issue strictly due to the distance, the UHF Gen 2 specification provides specific measures that mitigate interference between readers operating in close proximity, and additional interference rejection can be designed into tag integrated circuits (ICs), producing a UHF system that can function in the noisiest of environments.

Takeaway:
Operating in the near field, UHF is effectively impervious to noise for item level applications. And even in far-field UHF applications, the systems are already designed to deliver superior performance in situations with environmental interference and noise.

Technology Maturity

The myth:
HF is more mature technology than UHF, proven in deployments across industries around the world – including the pharmaceutical trade.

The reality:
The reality is HF is the more mature of the two technologies, and has been deployed successfully in a range of applications. It is also true that HF is reaching the top of its technology curve — the performance you see today is likely to be the maximum level of performance for HF for the next decade. However, just because a technology is mature, that does not always mean it is the best.

While UHF technology has only recently emerged, its usefulness and performance at the item level in the pharmaceutical industry has also been proven through:

- Actual customer implementations (including one of the largest pharmaceutical manufacturers, Purdue Pharma)

- Customer pilots and demonstrations on actual production lines running at full operational speed

And unlike HF, UHF is still at the beginning of its technology development curve. While today, UHF can already successfully read tags on or in liquids as well as on metals, UHF performance and the availability of systems and tags can be expected to improve rapidly in the coming months, and continue to do so for a number of years. And UHF will, because of the physics, yield performance and cost-efficiency improvements for item, case and pallet level applications.

The facts:
UHF — and in particular, UHF near-field — is not new or untested. In fact, if you are using RFID technology today, you are most likely using near-field UHF technology already, though you may not be aware of it. Near-field UHF couplers are utilized in printers to read and write tags, and were selected for their superior control of read/write functionality as well as selectivity.

In addition, a major RFID label manufacturer is using UHF near-field technology on its own production line to test and program tags in a high-speed roll-to-roll production system. Furthermore, such concepts of near field and UHF were initially presented by Dr. Peter Cole in one of the original Auto-ID white papers.[18]

Takeaway:
HF technology may be more mature than UHF, but it is likely at the end of its technology curve. Near-field UHF and UHF in general offer a technology that is both:

- Proven in specific applications and in use in high-speed manufacturing today

- At the start of the technology curve with much innovation, both performance and cost, in the very near future and beyond

Standards

The myth:
HF offers the only global standard available today.

The reality:
HF does enjoy global operation at a single frequency, but with multiple competing and non-compatible standards. UHF Gen 2 however, is indeed a single, global standard. While the regulated frequency for UHF RFID varies somewhat across different regions, reader and tag manufacturers can develop products that operate at all of the regional frequencies using the same communications protocol. In a global supply chain, users will then be able to choose Gen 2 tags that can be programmed and read by any Gen 2 reader operating at the locally-regulated frequency in any part of the world — very unlike HF tags.

UHF in action in Mallinckrodt Pharmaceuticals

Mallinckrodt, one of the fastest growing generic pharmaceutical companies in the United States has been using RFID for the past two years. The initial RFID solution provided by ADT for Mallinckrodt involves tagging bottles of selected strengths of Mallinckrodt Pharmaceuticals Generics' Oxycodone and Acetaminophen family of products, pain relievers that are indicated for the relief of moderate to moderately severe pain. RFID tags are placed on bottles of the analgesic drug as they leave Mallinckrodt's distribution center in Hobart, N.Y. The RFID tags can then be used by retailers to continue to track the product throughout their supply chain, including inventory tracking.

HF offers a single frequency with multiple and often competing standards, which can result in a network full of incompatible systems. UHF, on the other hand, offers the power of a single worldwide standard that can be implemented across the entire enterprise and throughout the global supply chain, and works across the different frequency ranges specified by various geographic regulatory organizations.

The facts:
HF offers a single frequency, with all equipment in any geographic location operating at 13.56 MHz — however, it does not offer a single standard. HF has a variety of protocols (or standards), including ISO 14443A, ISO 14443B, ISO 15693, ISO 18000-3 Mode 2, and EPCglobal™ HF Class 1, to name a few. However, these protocols:

- Have different data structures
- Require different infrastructures that are not compatible — even though they operate on the same frequency
- Often operate on readers that have non-standard features and functionality, resulting in a proprietary instead of standards-based platform
- Often compete for adoption

As different enterprises select the various flavors of HF infrastructure, depending upon which HF protocol is selected, the result can be a network full of incompatible systems, impeding the ability to achieve true global supply chain visibility.

In addition to hindering the ability to achieve the RFID global network, the multiple standards of HF can also translate into major costs. Enterprises who elect to utilize HF for item level tagging must still implement UHF as well for case and pallet level applications (since HF cannot perform in the far-field). However, since the various HF protocols are designed for different applications, multiple HF infrastructures may also be required to meet tagging needs. When companies need to deploy two, three or more RFID infrastructures, the complexity and the cost of RFID technology increases, thereby eroding the benefits and potentially rendering RFID as cost prohibitive.

HF can be considered to have multiple, though incompatible, global standards. UHF, on the other hand, has converged to a true global standard. Any Gen 2 reader can read any data on any UHF Gen 2 tag. The UHF Gen 2 standard was developed to deliver true interoperability between readers and tags, promoting increased competition among RFID suppliers, product development and better product availability — which lead to lower prices. UHF readers can use a simple change of antenna or other hardware modification to enable operation in the various regulatory frequency ranges. With adoption nearly complete around the world, UHF offers a true global standard, a common worldwide platform poised to enable the realization of the single RFID network.

Takeaway:
Where HF offers a single frequency with multiple standards, UHF offers the power of a single worldwide standard that can be implemented across the entire enterprise and throughout the global supply chain, and works across the different frequency ranges specified by various geographic regulatory organizations.

Safety: Biologics

The myth:

The UHF frequency has the capability to heat medications and possibly alter the chemical makeup of the medication, creating possible safety issues for consumers.

The reality:

In the typical RFID item level deployment, items are approximately 18 to 24 inches from the reader, and the item remains in the reader field for less than 10 seconds. In order to obtain a measurable rise in temperature in recent tests, substances were exposed to UHF energy at a very close range (just a few inches from the reader) for one or more hours — not a feasible real-world implementation scenario.

The facts:

It is true that UHF, as well as HF energy, is absorbed by certain materials and is, therefore, capable of increasing the temperature of a given substance. However, due to the extremely low power, substances would need to be exposed to the frequency for many hours. UHF reader output in the U.S. can be no greater than 1 watt, and in Europe, it is 0.5 watt. Those amounts are 1/100th and 1/200th of the power in a 100-watt light bulb, respectively. In order to raise the temperature, a substance would need to remain in the reader field for hours. However, in real-life RFID applications, that does not occur — bottles or vials of medication and cases on a conveyor belt are exposed to the reader field for just a few seconds — not long enough to effectively or measurably raise the temperature of any item.

A study primarily involving computer modeling with limited physical testing conducted by the U.S. FDA validates this statement.[16] Based on a non-feasible worst-case scenario instead of actual deployment metrics, the FDA study states that a 14.4 cm/5.6 in. vial of insulin placed 5 cm/2 in. away from a UHF RFID antenna will heat up 1.7° C/3° F after an hour of continual energy transmission from the reader. However, in the typical item level RFID application, items would only be exposed for seconds to the reader transmission, and would be an average distance of 18 – 24 inches/46 – 60 cm from the reader. The FDA tests illustrate that, in order to obtain a measurable increase in temperature, items must be exposed at very close range at maximum reader power for a long period of time — criteria typically not found in item level RFID implementations.

The results from informal testing in an actual lab environment conducted by this consortium further validate the results from the FDA computer modeling. In a simple experiment, a saline solution at ambient temperature 72° F (22.2° C) was continuously exposed at extremely close range to full power from an RFID UHF reader. It required 24 hours of constant exposure to UHF energy for the saline to heat up 3° F/1.7° C — an unlikely scenario for a real-world RFID deployment.

HF readers, by comparison, use a much higher wattage. In the U.S., maximum HF reader wattage is 2 watts, and in Europe, HF readers can put out up to 10 watts. In spite of the increase in reader power, a test conducted by Magellan Technology on HF readers produces the same results as the FDA tests and this consortium's informal test. An item had to be exposed to continual energy in the company's Tunnel Reader MSTRP 5050 for 16 hours in order to obtain a one-degree temperature rise.[17]

The metrics that were required to produce a measurable increase in heat would not occur in real-world RFID item level implementations.

The FDA tests illustrate that, in order to obtain a measurable increase in temperature, items must be exposed at very close range at maximum reader power for a long period of time — criteria typically not found in item level RFID implementations.

Security is not a function of frequency. UHF systems can provide the same level of security for sensitive data as an HF-based system. Gen 2 provides built-in security measures, including 32-bit access and kill password protection, cover-coding of transmitted data, and more.

Additional security beyond those standards, driven by customer and application requirements, is easily integrated into a UHF RFID system — there is no limitation due to frequency.

UHF vs. HF: Myth vs. Reality

HF and UHF Capabilities at the Item Level

Performance Factor	Myth	Reality
Fluids & Metals	Only HF works well on containers with fluids as well as metals, both of which are heavily used in the item level pharmaceutical applications.	UHF works well on — or in — fluids. It delivers outstanding performance when attached to metal due to the ability to actually leverage the metal itself.
Controlled Read Range	Only HF offers the controlled read ranges required for robust item level applications.	UHF can easily be contained to near-field ranges by utilizing the proper antenna and reducing reader power levels.
Security	Only HF provides required level of security for critical data associated with item level pharmaceutical tags.	Security is not a function of frequency. UHF systems can provide the same level of security as HF systems.
Tag Size	Only HF tags can easily fit on the smallest of items.	Tag size is a function of read distance in RFID systems. Typical large UHF tags are for cases and pallets that are being read at longer distances. At shorter ranges, UHF tags can be tiny enough to fit in the lid of a small vial.
Tag Form Factor	Only HF tags offer the form factor flexibility required to accommodate the variety of surfaces found throughout the pharmaceutical industry.	UHF tag antennas can be printed with conductive inks, instead of the many coils of etched metal required in HF tags. As a result, UHF tags offer superior form factor flexibility, and can be easily and cost effectively integrated into package labels, or bent to accommodate the curved surface of a bottle.
Tag Proximity	Only HF can read tags that are located in a very close proximity to each other.	The small simple loop antenna of a UHF tag reduces the magnetic shielding that can block visibility of nearby tags, enabling UHF to read tightly stacked tags — as well as tags that are actually touching.
Noise Susceptibility	HF tags offer superior performance in noisy RF environments, and are not susceptible to noise from other equipment that emits electromagnetic energy, such as a WLAN or forklift.	Due to near-field physics, UHF is effectively impervious to RF noise in item level applications.
Technology Maturity	The safer technology choice — more mature and field proven.	Already proven in some of the largest pharmaceutical environments today, UHF is just at the beginning of its technology curve, offering major innovation and cost reductions in the very near future — unlike HF technology, which, fully mature, is at the top of its technology development curve.
Read Rates	HF offers read rates that are ideal for enterprise applications, able to read up to 200 tags per second.	The UHF standard was built for enterprise requirements, able to read up to 1,000 tags per second to support the largest warehouse and on-the-shelf applications without affecting throughput.
Standards	HF offers the only worldwide RFID standard today.	UHF offers a true global standard, designed to deliver WiFi-style interoperability. HF offers a single frequency with multiple non-compatible standards.
Biologics	At the item level, UHF can heat substances, potentially altering the chemical composition, posing a possible health risk to consumers.	In tests, in order to raise the temperature, items required exposure to UHF energy at very close range (about 2 inches) at maximum power for an hour or more — instead of the typical metrics of 18+ inches and less than 10 seconds at a fraction of maximum power in real-world item level UHF deployments.

Takeaway:
Normal operation on a conveyor belt exposes products to RFID energy for less than 10 seconds — even in read/write operations. Under normal conditions of reader/product separation and RF exposure times, there is no real, practical or noticeable temperature rise. Medicines are at more risk on a hot summer day where they may be left in a car for an hour or more, or on a kitchen windowsill exposed to the sun for many hours. And available research to date illustrates that, in order to raise the temperature just a few degrees, readers must broadcast full power for a long period of time at the object — a scenario that is not realistic in real-world RFID applications.

Why So Many Discrepancies in Information?

Why is there so much misinformation regarding the performance of UHF at the item level? Part of the reason is that it is only recently that the demand for RFID implementations are reaching the pharmaceutical item level — the bulk of the demand to date has been for case and pallet implementations to meet the timeframes required for various mandates. In real time, many manufacturers and distributors are now beginning to focus on item level pilots and implementations — hence the recent major increase in the development and use of UHF near-field technology at the item level. Near-field UHF is just now being examined by potential customers with successful tests in laboratories and on production lines as well as in actual pilot trials.

UHF VS. HF: MEETING BUSINESS REQUIREMENTS

Now that the erroneous physics-related information regarding UHF and HF capabilities at the item level have been dispelled — from the ability to constrain the data in the near-field to the ability to read on and in liquids as well as on metals, and more — let's assess how UHF and HF address the strategic business requirements in the pharmaceutical industry.

Security

There is a perception that UHF is unable to provide the same level of security as HF for the following reasons:

- The physics of the frequency broadcasts the wave well beyond the reader, making the data traveling over the air vulnerable to hackers that are eavesdropping with an unauthorized reader

- UHF cannot offer the robust security mechanisms that HF provides, such as AES or 3DES

The reality is that security is not a function of frequency. UHF systems can provide the same level of security for sensitive data as an HF-based system. Gen 2 provides built-in security measures, including 32-bit access and kill password protection, cover-coding of transmitted data, and more.

Additional security beyond those standards, driven by customer and application requirements, is easily integrated into a UHF RFID system — there is no limitation due to frequency. The level of sensitivity of the data that is encoded drives the security level required on the tag. Just as in any application, the greater security required, the greater the cost. For example, to protect your home, you can choose a gate, an alarm system or a complete closed circuit video surveillance system, depending upon the level of security required. Each incremental step in security brings an increase in cost. It is the same for RFID — for both UHF and HF technologies. The lower cost systems deliver lower levels of security, appropriate for consumer goods, such as paper towels. Any level of security can be provided — it is simply a matter of adding computing power to the chip (silicon) to handle the processing, which in turn increases the costs of the tags. The HF systems in place today providing high levels of security are utilizing RFID tags in the $2 per tag range.

Oracle speaks out about UHF...

"An increasing percentage of prescription drugs on the world market are mislabeled or fake, with the counterfeit medicines posing a significant threat to patient safety. RFID has been identified as an enabling technology that delivers effective counterfeit measures to assure patient safety and provide a safe and secure supply chain. Both UHF and HF provide the same level of security, enabling health-care and life sciences enterprises to select the frequency that best meets the enterprise requirement — without compromising data protection."

Siamak Zadeh, Ph.D.
Senior Director
Life Sciences
Oracle Corporation

Both UHF and HF are capable of providing the same level of security for the data residing on the tag, as well as during data transmission between tag and reader. But in order to ensure the cost effectiveness of RFID solutions (UHF or HF), enterprises need to match the security level to the type of data by assessing the risks associated with a security breach.

Conclusion: Both UHF and HF can provide the same level of security — but increased security will come at a cost.

Operational Speed

RFID item level implementations must be able to keep pace with existing operations in order to eliminate any negative impact on operations — or profitability. The UHF Gen 2 specification is designed for high-speed enterprise applications, providing 14 to 30 times the bandwidth of HF. Designed for real-world performance in real-world supply chains, UHF offers:

- The speed and throughput capabilities required to match the speed of conveyor belts on a manufacturing line

- The ability to strip inefficiencies and data inaccuracies from receiving, picking, put-away and shipping functions, enabling streamlining of warehouse and distribution center operations

The UHF Gen 2 specification is designed for high-speed enterprise applications, providing 14 to 30 times the bandwidth of HF.

In addition, UHF offers an anti-collision technology called bit broadcasting instead of HF's time slot technology. Combined with the increased bandwidth, UHF systems can read up to 1,000 tags per second. By comparison, the fastest HF systems on the market today offer the ability to read a maximum of approximately 200 tags per second — and that data rate may degrade in applications that require simultaneous reading of multiple tags due to collisions.

HF is not well suited for high tag volumes moving at high speeds. HF has been most successful in item level applications where speed is not critical — where there is no conveyor belt or other specific speed of process, but rather single tags read at relatively low speeds, such as smart card purchases, corporate ID cards, and loyalty cards.

Conclusion: Designed for high-speed, large volume applications, UHF Gen 2 is best suited to deliver the speed and throughput required in enterprise environments.

Tag Cost

UHF tags are able to offer much greater cost-effectiveness than HF tags for two reasons: physics and production efficiency.

Physics

Let's start with Faraday's law, which states that magnetic coupling is intensified as frequency increases. Assuming that the UHF band ranges from 860MHz to 960MHz, the coupling strength of UHF is between 63 to 71 times as strong as HF (13.56MHz). This increase in coupling strength translates to a major savings in tag costs.

How? HF tags require a highly conductive coil antenna, typically copper, connected to an RFID integrated circuit (IC), or chip. Because of the low frequency and low strength of the magnetic coupling at 13.56 MHz, the antenna requires many coils (also known as loops) to develop enough voltage to power the chip.

Compare this to the physics of a UHF tag. The UHF frequency is ~70 times higher than HF, enabling UHF tags to use much simpler antenna designs that can still capture more energy than an HF tag — even with only one loop. Importantly, a single loop antenna can simply be closed with the RFID chip, and no additional crossover element is needed to bridge multiple coils — unlike HF. In addition, copper or aluminum wire is not required for UHF — low-cost conductive inks can be used with little impact on performance.

These important differences in the physics of operation between UHF and HF translate into major differences in manufacturing cost. It is because of the physics that UHF tags will remain significantly less expensive:

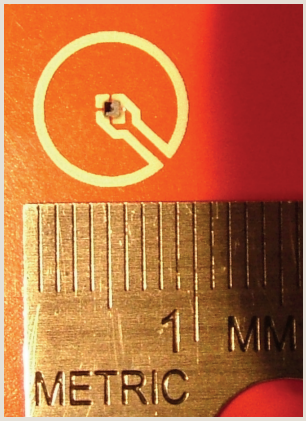
- **Less materials = less cost:** The materials required to create UHF tags cost significantly less than HF tags, effectively reducing the cost of the tag. (Proof points: UHF antennas require only one simple turn and can be printed with conductive inks, versus many turns of etched metal for the equivalent HF tag antenna.)

- **Easier to manufacture = less cost:** UHF tags are much less complex to manufacture, effectively reducing manufacturing costs. (Proof points: UHF allows for high-speed, direct attachment of the IC to the antenna, with no need for bridging the coil, as well as fewer turns and the ability to print the tag antenna versus requirement to fabricate/etch metal.)

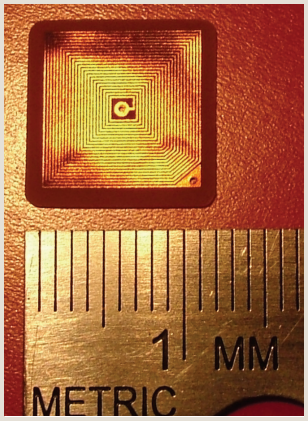
It is because of the physics that UHF tags will remain significantly less expensive than HF tags.

The Cost of Tags: UHF vs HF

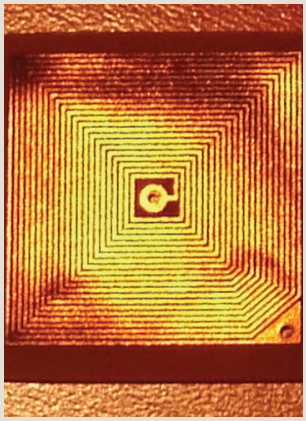
Design Simplicity Reduces Manufacturing and Materials Cost to Deliver Lowest Priced Tag – Today and Tomorrow



UHF Antenna
Impinj Button™
1 turn conductive ink
1 layer 9mm



HF Antenna
Many turns of fine
resolution etched copper
2 layers 12 mm



HF Antenna Close-Up

The above photos illustrate why UHF tags are less expensive to manufacture than HF tags. The UHF antenna requires only a single turn, and can be printed with conductive inks. By contrast, the HF antenna requires many turns (or coils) of etched metal, typically copper. It is the simplicity of design and reduction in materials requirements that result in the significant savings — and lower per tag cost.

Purdue Pharma speaks out on RFID infrastructure cost...

"As a manufacturer, there is definitely a financial benefit to having a single frequency in use: individual tag cost can be lowered ideally by ordering greater volumes of a single tag. At a minimum, having a single chip produced by the foundry should ultimately lower overall tag costs, even if those chips are placed in different inlays to become different tag designs. In addition, using the same or similar readers on both the packaging line and the warehouse can make hardware support much easier than the alternative of having to support disparate systems."

Harry Ramsey
Sr. Package Development Engineer
Purdue Pharma L.P.

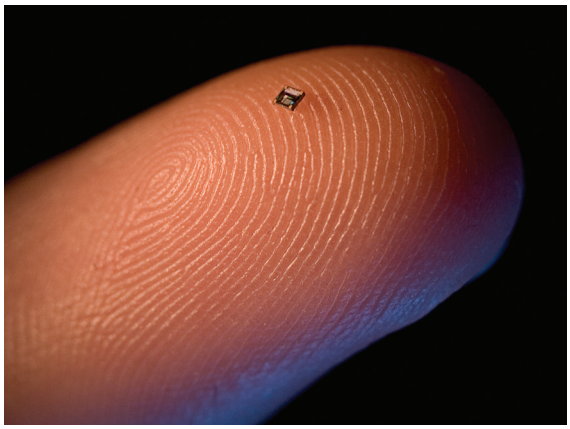
Today, many finished UHF tags sell for approximately 10 to 12 cents — less than half the price of the average HF tag. And due to the reduced manufacturing complexity, combined with the development efforts underway currently to develop high speed, high volume antenna manufacturing processes, UHF tags are poised to drop even more significantly in the near future — further enabling cost-effective item level tagging in many product categories. By contrast, comparably featured HF tags will continue to cost more due to the additional materials cost and manufacturing complexity.

While these differences may seem modest, a large manufacturer tagging a billion products a year would spend $100 million a year for UHF tags, and $200 million a year for HF tags — representing a substantial annual savings of $100 million.

Mass production

The rapid pace of adoption of UHF RFID systems across industries is being fueled by government initiatives in the pharmaceutical industry and U.S. Department of Defense as well as mandates in the retail supply chain by leading global retailers. Wal-Mart alone anticipates that suppliers will use billions of tags each year. As a result, UHF tags are poised to move into the level of mass production necessary to offer superior economies of scale, compared to HF tags.

Conclusion: UHF tags are less expensive today, and will remain so due to lower materials requirements and simplicity of structure. In the coming months and years, as tag demand increases due to mass adoption across industries, tag prices will drop even further, ultimately achieving the price levels required for true ubiquitous item level tagging.



Incredible advances in technology have reduced RFID chips to the size of a grain of sand, like this UHF Gen 2 Monza™ tag chip from Impinj. The tiny size reduces material requirements and enables more chips to be produced per wafer, leading to significant reductions in tag costs.

Infrastructure Cost

Elimination of dual infrastructure costs

The HF protocol can only support near-field (or item level) RFID applications due to its read range limitations. If HF is used at the item level, UHF must be used for the case and pallet level due to HF limitations. The result of implementing multiple protocols is additional network complexity and cost — two different sets of hardware must be purchased, maintained and supported.

By contrast, UHF offers the ability to support item, case and pallet levels, enabling a single infrastructure for conveyor belts in the manufacturing plant, on shelves in the warehouse and at dock doors. With UHF, the same reader used in far-field applications can be used in the near field, offering the flexibility to meet any enterprise RFID application need with a single reader.

Reader costs

HF readers are often touted as much less expensive than UHF readers, which is both true and false at the same time. HF readers start at $50, where UHF readers start at $500. So for some applications, HF readers will offer lower infrastructure costs. However, to accurately assess relative reader costs associated with building out your RFID infrastructure, it is essential to compare the cost of UHF and HF readers designed for the same applications, and with the same capabilities.

For example, in the pharmaceutical industry, where metal and liquids are often present, very high-performance readers are required, as well as high read rates. The high performance HF readers typically found in pharmaceutical environments range from $3,000 to $7,000 per reader, with HF tunnel readers (often required for read performance) ranging up and over $15,000 per reader.

By comparison, a UHF reader that will deliver the same performance in the same application ranges in price between $2,000 to $3,000. At a minimum, the costs for UHF and HF readers in a pharmaceutical environment where metal and liquids are present are roughly the same. However, if the application demands HF tunnel readers where standard UHF readers can do the job, which is often the case, the HF reader cost is two to four times that of the UHF reader.

Additionally, the price of UHF readers is expected to continue to decline significantly, due to increasing integration of the electronics and increasing manufacturing returns to scale, again driven by governmental compliance and business mandates. Such integration has already taken place for HF readers, and prices for those products are expected to decline much more slowly.

Conclusion: UHF provides enterprises with the most cost-effective option for building out RFID infrastructures due to the following facts:

- The cost of UHF readers is often on par with that of HF, and can be significantly less
- Increased demand, fueled by rapid adoption in order to meet regulatory compliance and business mandates is expected to significantly reduce UHF reader prices in the near future
- The ability to enable item, case and pallet level RFID applications with a single UHF infrastructure eliminates the need for you and your downstream supply chain to purchase, maintain and support dual systems, and provides additional cost efficiencies due to volume purchase economies

BUSINESS REQUIREMENTS SUMMARY: UHF A CLEAR LEADER

How well do the two frequencies measure up to the pharmaceutical business needs for enterprise RFID deployment? The following chart summarizes the major RFID business requirements for pharmaceutical manufacturers and reveals that UHF, previously thought inferior to HF for item level pharmaceutical applications, offers clear advantages at the item level as well as from an enterprise perspective.

Wal-Mart speaks out on the benefits of a single frequency for all RFID applications in the enterprise...

"A single infrastructure is critical to achieving the total cost of ownership that makes RFID feasible. If two protocols are deployed, in addition to the infrastructure cost within the enterprise, there is also the cost that suppliers will need to incur as well. The industry is already experiencing high costs with duplicate infrastructures to maintain anti-theft devices due to the double standards associated with EAS. A single standard is the only path to achieving the economies of scale for readers and tags to enable cost-efficiency at the item level."

Richard Ulrich
Solutions Architect
Wal-Mart Stores, Inc.

Addressing RFID Business Needs in Pharmaceutical		
Business Needs	**UHF**	**HF**
Strategic Issues		
Accommodate high levels of security	**Yes**	**Yes**
Accommodate existing enterprise operational speeds	**Yes** Reads up to 1000 tags/second	**No** Reads up to 200 tags/second
Deliver cost efficiencies for infrastructure	**Yes**	**No** Requires implementation of two frequencies (HF – item; UHF – case/pallet)
Deliver the level of cost efficiencies for tags required for ubiquitous enterprise item level RFID use	**Yes** Converted tag prices are currently at approximately 10 to 15 cents, with additional price reductions expected in the near future	**No** Tags require more materials and are more complex to manufacture; cost will limit HF to a more constrained set of product categories
Single global standard across the entire enterprise — and throughout the supply chain	**Yes** UHF Gen 2 global standard, accepted worldwide	**No** A single frequency with multiple and sometimes competing standards
Physical Issues		
Accommodates all read points: item, case and pallet	**Yes**	**No** Item only
Accommodates all required materials and surfaces, including liquids and metals	**Yes** UHF advantage: can read in liquids in addition to on containers of liquids; can leverage metal surfaces for better performance	**Yes**
Tag size: flexibility for tiny tags for tiny items such as vials	**Yes**	**Yes**
Reliable performance regardless of tag proximity or orientation	**Yes**	**Yes** While HF tags can provide orientation insensitivity, by nature, they are inherently more orientation sensitive
Accommodates noisy environments	**Yes**	**Yes**

For many reasons, UHF is the right choice for enterprise-level RFID applications. While UHF can effectively offer the same performance as HF, the converse is not true.

UHF: THE RIGHT CHOICE FOR THE ENTERPRISE ENVIRONMENT

For many reasons, UHF is the right choice for enterprise-level RFID applications. While UHF can effectively offer the same performance as HF, the converse is not true. While it is true that HF is a very mature technology, older does not always mean better.

The newer UHF Gen 2 standard more than meets the technical RFID functionality requirements, while addressing the strategic business issues facing today's enterprises. In fact, UHF Gen 2 was developed precisely to address and correct the many shortcomings of other RFID protocols.

It is UHF that, because of the physics, outperforms HF at the item level. UHF can and does deliver: the same level of security; the same ability to function in noisy environments; the ability to accommodate nearly any size tag; and the flexibility to accommodate curved surfaces and enable integration of tags into package labels. But UHF reaches beyond the capabilities of HF to not only work on liquids, but also in liquids; to not only work on metal, but to utilize the metal for

better performance; and to deliver enterprise level read rates (1,000 tags/second for UHF, 200 tags/second for HF) and the full complement of read ranges (near to far), enabling implementation with current business processes to protect existing throughput levels.

It is UHF that is already globally implemented in some of the largest enterprises and across some of the most significant supply chains for case and pallet level applications. These entities will naturally look to UHF to complete the build-out of RFID systems to the item level, before considering implementing a completely different infrastructure to accommodate HF for the item level. That increase in demand will further accelerate the development of UHF solutions, effectively increasing functionality — and reducing costs.

It is only UHF that can support the full range of RFID enterprise applications — item, case and pallet — enabling the cost efficiencies of a single infrastructure in the enterprise, and throughout industry supply chains. UHF effectively eliminates the need for two or more separate RFID infrastructures (one or more HF infrastructures for item level, and a UHF infrastructure for case and pallet level) dramatically reducing the costs associated with the purchase of hardware, deployment and ongoing management and support.

It is UHF that can offer maximum cost-efficiency in RFID tags. UHF tags, due to the physics, require less materials and manufacturing time, and offer the flexibility for future manufacturing innovations that can further reduce costs.

Is HF a more mature technology? The answer is a resounding yes. Since the mid to late '90s, HF applications around the world have been working — and working well. But business requirements and government mandates have changed over the last 10+ years. This older technology is not designed to meet today's needs. Most HF applications are closed solution systems, one-at-a-time applications such as toll automation, bus passes and access control cards, where the slow HF read rates are not an issue, and there is no need for the application to interact with any other RFID system.

Today's businesses need an RFID solution designed for the enterprise, a single standard that can perform equally well in near and far-field at a level of cost efficiency that will truly pave the path to ubiquitous implementation of RFID technology throughout the world.

That solution is UHF Gen 2.

It is UHF that, because of the physics, outperforms HF at the item level. And UHF reaches beyond the capabilities of HF to not only work on liquids, but also in liquids; to not only work on metal, but to utilize the metal for better performance; and to deliver enterprise level read rates and the full complement of read ranges, enabling implementation of a single protocol for item, case and pallet RFID applications.

FOR MORE INFORMATION

For more information on UHF Gen 2 and how it can meet your RFID needs, please contact:

ADT/Tyco Fire & Security at 1.561.988.3600 or visit us on the web at http://www.adt.com

Alien Technology at 1.408.782.3900 or visit us on the web at www.alientechnology.com

Impinj, Inc. at 1.206.517.5300 or visit us on the web at www.impinj.com

Intel at http://www.intel.com/business/bss/technologies/rfid/

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