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Products and Services

RFID Basics Updated

Including Gen 2

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PAXAR
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RFID Basics Updated

Introduction

Radio Frequency Identification (RFID) technology has been attracting considerable attention with the expectation of improved supply chain visibility for consumer goods, apparel, and pharmaceutical manufacturers, as well as retailers and government procurement agencies. It is also expected to improve the consumer shopping experience by making it more likely that the products they want to purchase are available.

Recent announcements from some key retailers have brought the interest in RFID to the forefront. This guide is an attempt to familiarize the reader with RFID technology so that they can be asking the right questions when considering the technology.

What is RFID?

RFID (Radio Frequency Identification) is a method of identifying unique items using radio waves. Typical RFID systems are made up of 2 major components: readers and tags. The reader, sometimes called the interrogator, sends and receives RF data to and from the tag via antennas. A reader may have multiple antennas that are responsible for sending and receiving the radio waves. The tag, or transponder, is made up of the microchip that stores the data, an antenna, and a carrier to which the chip and antenna are mounted.

RFID technology is used today in many applications, including security and access control, transportation and supply chain tracking. It is a technology that works well for collecting multiple pieces of data on items for tracking and counting purposes in a cooperative environment.

Is All RFID Created Equal?

There are many different types of tags to support a variety of applications. Tags can vary in terms of frequency at which they communicate, the protocol (or language) they speak, how they are powered, and how they store data.

Tag Frequency

There are many different versions of RFID that operate at different radio frequencies. The choice of frequency is dependent on the requirements of the application.

Three primary frequency bands have been allocated for RFID use.

- Low Frequency (125/134KHz) – LF: Most commonly used for access control and asset tracking.
- High Frequency (13.56 MHz) – HF: Used where medium data rate and read ranges are required.

- Ultra High Frequency (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) – UHF: Offers the longest read ranges and high reading speeds.

Applications for RFID within the supply chain can be found at multiple frequencies and different RFID solutions may be required to meet the varying needs of the marketplace. Most supply chain applications for item, carton, and pallet labeling will be addressed with either the UHF or HF frequency. The following chart outlines the basic properties of these frequencies.

Characteristic	HF (13.56 MHz)	UHF (860 - 960 MHz)
Maturity	In use since 1995	Widespread use recent - 2004/2005
Read Range	Typically less than 5 feet	Up to 20 feet
Field Consistancy	Read zone well-defined	Peaks and valleys in read field
Liquid Performance	Better able to penetrate liquids	Absorbed by liquids
Performance on or near Metal	Lower read range on metal	Unpredictable performance near metal
Tag Form Factor	Many more options for small tags in variety of form factors including washable 'buttons'	Fewer options currently available. New options being developed rapidly
Global Standards	13.56 Mhz is generally available throughout the world	860 MHz to 960 Mhz interferes with existing bands in many countries

Since UHF (Ultra High Frequency) can cover dock door portals up to 9 feet wide it has gained widespread industry support as the choice bandwidth for inventory tracking applications including pallets and cases.

For item level applications, the read range requirements are not as long. In addition, it becomes more difficult to place tags in positions to avoid liquids and metals for some item level tagging applications such as pharmaceuticals. Therefore, the industry is still debating whether item level tagging will be best served with UHF, HF, or a combination of both.

Tag Protocol:
Each RFID tag is designed to a specific protocol. The protocol defines how the tag will communicate to the outside world. It is much like speaking different languages. If a reader is

set to speak one protocol and the tag is designed to a different protocol, then the reader and the tag will not be able to communicate. Built within the protocol are features such as security (data encryption, lock abilities, etc.) and anti-collision algorithms.

Technology providers are developing readers that work with multiple system protocols and frequencies so that users will be able to choose the RFID products that work best for their market and products.

Active Tags versus Passive Tags:
RFID tags are further broken down into two categories:

- **Active RFID Tags** are battery powered. They broadcast a signal to the reader and can transmit over the greatest distances (100+ feet). Typically they can cost $4.00 - $20.00 or more and are used to track high value goods like vehicles and large containers of goods. Shipboard containers are a good example of an active RFID tag application.

- **Passive RFID Tags** do not contain a battery. Instead, they draw their power from the reader. The reader transmits a low power radio signal through its antenna to the tag, which in turn receives it through its own antenna to power the integrated circuit (chip). The tag will briefly converse with the reader for verification and the exchange of data. As a result, passive tags can transmit information over shorter distances (typically 10 feet or less) than active tags. They have a smaller memory capacity and are considerably lower in cost ($.50 or less) making them ideal for tracking lower cost items.

Data Storage:
There are two basic types of chips available on RFID tags, **Read-Only** and **Read-Write**. Read only chips are programmed with unique information stored on them during the chip manufacturing process. The information on read-only chips can never be changed.

With Read-Write chips, the user can add information to the tag or write over existing information when the tag is within range of the reader. Read-Write chips are more expensive that Read Only chips. Another method used is called a "WORM" chip (Write Once Read Many). It can be written once and then becomes "Read Only" afterwards.

Chips can also vary widely in the data storage capacity of the chip.

How Will RFID Affect the Apparel and Retail Supply Chain Industry?

RFID is expected to provide huge advantages to manufacturers by offering the tools to better plan production and respond more quickly to market demand. It will facilitate automation of inventory counts and speed shipping and receiving at the distribution level. For retailers, it will help to reduce stock-outs, enable product tracking and potentially reduce theft and streamline the POS function. RFID will also open other merchandising opportunities and help with the overall consumer buying experience.

Due to the current cost of the technology (both tags and infrastructure), the initial phase of adoption for most retailers is at carton and pallet marking applications. The current

technology being adopted for carton and pallet labeling is passive UHF tags (850 MHz – 950 MHz). As the cost of tags and readers comes down, a wider adoption at the item marking level is developing.

Open Loop versus Closed Loop Applications

Among the many applications for RFID technology, the solutions can be either closed loop or open loop. In a closed loop application, the user has complete control of the items to be tracked throughout the application. There is no need to share data outside the user organization and users outside the organization do not need to be able to read the RFID tags. In this case the chosen protocol does not need to necessarily comply to an open standard.

For many RFID applications, the tagged items must be readable by many companies such as manufacturers, logistics hubs, and retailers. In this case, it is essential to have open loop standards for the tag protocol as well as the data being stored to the tag.

Organizations Focused on Developing RFID Standards

EPCglobal, Inc., a division of GS1 (Global Standards 1 is an organization created by combining the former UCC and EAN organizations), has developed a new Electronic Product Code (EPC) as the next standard for tracking products through the supply chain. Their goal is not to replace existing bar code standards but to expand the information available down to unique identifiers for each marked item, and to enable more automatic reading. EPC utilizes the basic structures of the Global Trade Item Number (GTIN) and Serialized Shipping Container Code (SSCC), as well as others.

EPCglobal, Inc. is also working to develop a global standard for transmission and storage of data via the internet. Full implementation of this data sharing capability will be critical to realizing the full potential of the RFID technology.

EPCglobal, Inc has also defined a global protocol operating in the UHF range for carton and pallet labeling. This protocol, referred to as EPC Class 1 Generation 2 (or "Gen 2"), will replace several older Class 1 protocols that did not provide global interoperability. The tags and readers to support the Class 1 Gen 2 protocol are in full production and readily available today.

EPCglobal, Inc. continues efforts to determine the optimal protocol and frequency for item level applications.

While EPCglobal focuses mainly on open-loop supply chain tracking applications, ISO (The International Organization for Standardization) has many RFID protocols defined at various frequencies and for numerous applications. In addition, ISO is working on a new standard, ISO 18000-6C, that will be compliant with the EPCglobal Class 1 Generation 2 protocol.

The Electronic Product Code (EPC)

The EPC is a 96-bit number made up of a header and 3 sets of data. There are several iterations of the EPC, depending upon the specific application. An example of a typical EPC code is shown below. The header identifies the EPC version number – which identifies the type of EPC data to follow (for example SSCC versus GTIN). The second part of the number identifies the EPC manager – typically this would be the manufacturer of the item the EPC is attached to. The third part is called object class and refers to the exact type of product– most often the stock-keeping unit (SKU). The fourth series of numbers is the serial number that is unique to the item. (The second and third sets of data are similar in function to the numbers in UPC barcodes.)

A 96-bit EPC will allow sufficient capacity for 268 million companies. Each manufacturer will have the ability to create up to 16 million object classes with 68 billion serial numbers in each class. This should provide sufficient capacity to cover all products manufactured in the world for many years to come.

Potential Issues That Need Consideration When Choosing The Type Of RFID And Method For Application To Your Products Or Packaging.

Although RFID technology promises great improvements in supply chain visibility, it is important to embrace the technology with a bit of caution. The following are some of the issues that require close scrutiny when investigating RFID:

- ***Tag Cost*** – This should not to be confused with chip cost. Although the goal is to bring the cost of the tag (chip and antenna) down to 5 cents, this goal is in the future since it both assumes manufacturing breakthroughs and is predicated on consumption in the billions of tags per year. Today, the cost is closer to "less than 20 cents" for a read/write solution in high (millions) volume. Ultimate tag cost will also be very much dependent on the type of chip required (read only versus read/write), size of the antenna needed and how it is packaged to meet a specific application.

- ***Tag Size*** – Tag size is dependent on the read range desired. Although the chips are very tiny, they will not operate without being mounted to an antenna. In general, the size of the antenna will determine the read distance performance of the tag so understanding the size of the antenna needed for the application is more important than the size of the chip alone. RFID antenna design is becoming very specialized so that there are antennas being designed to deal with specific applications such as the presence of liquid or metal. An end user should be sure to work with a reputable supplier who will help them determine the best antenna design for the application.

- ***Infrastructure Cost*** – Much focus appears to be placed on the tag cost since it is a recurring expenditure. Reader cost and infrastructure costs for implementing RFID must also be looked at very closely as well. Both the software systems requirements and physical environment in which RFID is intended to be used, are critical to the ultimate performance of a system and may require changes to accommodate using it effectively. As an example, RFID chips cannot be read through metal objects. Other forms of electromagnetic interference may also impede performance of the technology and require changes to the physical environment where RFID will be used. The number and types of readers will also be a major expenditure depending on the application.

- ***Read Distances*** – Read distances for RFID are very much dependent on the frequency chosen for the application. Tag orientation also affects the read range as the range diminishes as the tag is rotated from being perpendicular to the path to the reader. Reading reliability is quite good when labels are alone in a reader field like cases on a conveyor line, but less certain when the labels are randomly oriented as with labeled cases on a skid. The antenna size (both on the tag and the readers) will also be a determining factor. Hand held readers are not capable of using as much power as stationary readers and as a result provide shorter read distances.

- ***Government Regulation*** – Governments around the world regulate the use of the frequency spectrum. Different countries have already assigned certain parts of the spectrum for other uses and as a result, there is virtually no part of the spectrum that is available everywhere in the world for use by RFID. This means that a RFID tag may not work in all countries. As an example if you choose the Ultra High Frequency (UHF) frequency that operates at 915MHz in the U.S. and you ship your product to Europe, they may not be able to read it as well since Europe operates in the UHF spectrum at 869Mhz and with lower power. This is an important consideration when operating in a global environment.

- ***Anti-Collision*** – This is an important feature of RFID chips/readers since it will allow multiple tags to be read while grouped in one reader field. It is not available on all RFID tags but is an important feature if you are planning to use RFID for inventory counts, shipping and receiving where multiple tags need to be read at the same time.

- ***Privacy Issues*** – Consumer groups have expressed concern over the potential (real or imagined) privacy invasion that might result with widespread RFID item marking. These groups are pushing for legislation that will require manufacturers to advise consumers that the products contain RFID devices and must provide a means so that the devices can be disabled at point of purchase. These issues are most prevalent at the item marking level and will have little impact on the implementation of carton and pallet labeling.

What Is PAXAR's Commitment To RFID?

Paxar Corporation is committed to aggressively participate in the developing market for RFID products. Our goal is to become a major worldwide source for RFID supplies and the printers which program them for all popular RFID systems, targeting particularly the supplies used for apparel and retail applications.

Paxar is positioned to meet the RFID carton, pallet, and item labeling requirements of our customers with our Monarch brand line of products. The Monarch® Model 9855™ RFMP printer writes and verifies EPC-compliant data to a variety of UHF RFID protocols then prints the human readable and barcode data on the same label. Paxar offers a compete range of UHF and HF supplies in a variety of sizes for most supply chain applications. Paxar's state of the art RFID lab is designed to help customers determine the best tag type and the best tag placement for optimal performance in real world applications. In addition, Paxar's Fastrax™ and Service offerings help our customers optimize their processes in order to provide the peace of mind needed when entering into a new technology. Only Paxar products offer this full line of RFID printers, supplies, and service.

With worldwide manufacturing, including service bureaus, Paxar is uniquely positioned to offer innovative, market-driven RFID solutions to major retailers and apparel manufactures.

Paxar is actively involved with EPCglobal, Inc. and ISO, the organizations setting standards for RFID use throughout the world.

For more information, contact Paxar at **800.543.6650, press 5.** You can also visit us on our website at www.paxar.com.

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RFID
Glossary of Commonly Used Terms

A

Active Tag – An RFID tag that uses a battery to power its microchip and communicate with a reader. Active tags can transmit over the greatest distances (100+ feet). Typically they can cost $20.00 or more and are used to track high value goods like vehicles and large containers of merchandise.
Agile Reader – A reader that can read different types of RFID tags – either made by different manufacturers or operating on different frequencies.
Antenna – A device for sending or receiving electromagnetic waves.
Anti-Collision – A feature of RFID systems that enables a batch of tags to be read in one reader field by preventing the radio waves from interfering with one another. It also prevents individual tags from being read more than once.
Automatic Data Capture (ADC) – Methods of collecting data and entering it directly into a computer system without human intervention. Automatic Identification (Auto-ID) Refers to any technologies for capturing and processing data into a computer system without using a keyboard. Includes bar coding, RFID and voice recognition.
Auto-ID Center – A group of potential RFID end users, technology companies and academia. The Auto-ID center began at the Massachusetts Institute of Technology (MIT) and is now a global entity. It is focused on driving the commercialization of ultra-low cost RFID solutions that use Internet like infrastructure for tracking goods throughout the global supply chain. The Auto-ID Center organization is now called EPCglobal.

B

Bit – The smallest unit of digital information - A binary code – a single '0' or '1', where many different codes can be developed to represent pertinent information. A 96-bit EPC is a string of 96 zeros and ones.
Byte – 1 byte = 8 bits. One byte of memory is needed to generate an alpha character or digit. So bytes can be thought of in terms of characters.

C

Chip Based RFID –Refers to RFID tags that contain a silicon computer chip and therefore can store information and transmit it to a reader.
Collision – Radio Signals interfering with one another. Signals from tags and readers can collide.

D

Die – A tiny square of silicon with an integrated circuit etched on it – more commonly known as a silicon chip.

E

Electronic Article Surveillance Tags (EAS) – Single bit (either 'on' or 'off') electronic tags used to detect items for anti-theft purposes. EAS technology is similar to RFID in that it uses similar frequency bands.
Electromagnetic Compatibility (EMC) – The ability of a technology or product to coexist in an environment with other electro-magnetic devices.

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Electronic Product Code (EPC) – A standard format for a 96-bit code that was developed by the Auto-ID Center. It is designed to enable identification of products down to the unique item level. EPC's have memory allocated for the product manufacturer, product category and the individual item. The benefit of EPC's over traditional bar codes is their ability to be read without line of sight and their ability to track down to the individual item versus at the SKU level.
EPCglobal – The association of companies that are working together to set standards for RFID in the retail supply chain. EPCglobal is a joint venture between EAN International and the Uniform Code Council, Inc.

F

Frequency – Refers to a band of operation for radio-based technologies. Frequencies allocated for RFID use exist in the low, high, ultra-high and microwave frequency bands. Each frequency has its own advantages and disadvantages such as read distance, tag size and resistance to electronic noise.

G

GTAG (Global Tag) – A standardization initiative of the Uniform Code Council (UCC) and the European Article Numbering Association (EAN) for supply chain tracking applications using UHF RFID frequencies.
Global Trade Item Number (GTIN) – A superset of bar code standards that is used internationally. In addition to manufacturer and product category, GTIN also includes shipping, weight and other information. The EPC is designed to provide continuity with GTIN.
Gen 2 – The second generation global protocol operating in the UHF (ultra high frequency) range. The current choice for many retail supply chain carton and pallet compliance applications, starting in 2006.

H

High-Frequency RFID (13.56 MHz) – RFID that uses the high-end 13.56MHz radio frequency band. Features medium sized tags with relatively good reading distances. In the U.S. 13.56MHz tags can be typically read at approximately 3-4 inches with a handheld reader and 4 to 6 feet with a portal reader.

I

Integrated Circuit (IC) – Another name for a chip or microchip
Interrogator – An RFID reader

L

Line-of-Sight – Technology that requires an item to be "seen" to be automatically identified by a machine. Unlike bar codes and OCR technologies, RFID tags can be read "through" merchandise and most packaging with no line of sight required.
Low-Cost RFID – Typically refers to RFID tags that cost less than $.50 with typically 3 feet of read range.

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Low Frequency RFID (125 & 134 KHz) – Low frequency radio band allocated for RFID use. The main disadvantage of low frequency RFID is its cost and relatively slow data transfer as well as its inability to read many tags at the same time.

M

Multiple Tag Read/Write – Refers to the ability of RFID systems to read multiple tags at the same time. Reading and writing of multiple tags is achieved through the anti-collision feature of RFID.
Microwave RFID Frequency (2,450MHz or 2.45GHz) –A microwave frequency band allocated for RFID use. Used for Item level tracking including retail merchandise. Typically microwave RFID technologies feature the smallest label footprint and read distances up to 18 inches with a handheld reader and perhaps up to 4 feet with a portal reader. This frequency also offers fast data transmission, but is somewhat more bothered by shielding of liquid products and reflections from metal structures, etc.

P

Passive RFID Tag – An RFID tag that does not use a battery. Passive tags draw their power from the reader. The reader transmits a low power radio signal through its antenna. The tag in turn receives it through its own antenna to power the integrated circuit (chip). Using the energy it gets from the signal, the tag will briefly converse with the reader for verification and the exchange of data. As a result, passive tags can transmit information over shorter distances (typically 10 feet or less) than active tags. They are considerably lower in cost ($.50 or less) making them ideal for tracking lower cost items.***Perpetual Inventory*** – The ability to know one's inventory position at any given time. RFID offers the promise of being able to perform automatic inventory counts.

R

Radio Frequency Identification (RFID) – A method of identifying items uniquely using radio waves. Radio waves do not require line of site and can pass through materials like cardboard and plastic but not metals and some liquids.
Read Range – The distance from which a reader can communicate with a tag. Several factors including frequency used, orientation of the tag, power of the reader and design of the antenna affect range.
Reader – Also called an interrogator. The RFID reader communicates via radio waves with the RFID tag and passes information in digital form to the computer system. Readers can be configured with antennas in many formats including handheld devices, portals or conveyor mounted.
Read Only Tags – Tags that contain data that cannot be changed. Read only chips are less expensive than read-write chips.
Read-Write Tags – RFID chips that can be read and written multiple times. Read/Write tags can accept data at various points along the distribution cycle. This may include transaction data at the retail point of sale. They are typically more expensive than read only tags but offer more flexibility.
RFID Transponder – Another name for a RFID tag. Typically refers to a microchip that is attached to an antenna, which communicates with a reader via radio waves. RFID tags contain serial numbers that are permanently encoded, and which allow them to be uniquely identified.

RFID
Glossary of Commonly Used Terms

RFID tags vary widely in design. They may operate at one of several frequency bands, may be active or passive and may be read-only or read-write.

S

Savant – Distributed network software that manages and moves data related to Electronic Product Codes (EPC)
Smart Label – A label that contains an RFID chip and antenna. These labels can store information such as a unique serial number and communicate with a reader.

T

Tag – The generic term for a radio frequency identification device. Also sometimes referred to as smart labels.
Tag Collision – Interference caused when more than one RFID tag sends back signals to the reader at the same time.
Transponder – A combination transmitter-receiver that is activated when it receives a predetermined signal. RFID tags are sometimes referred to as transponders.

U

Ultra-High Frequency (UHF; 850 to 950 MHz) – Ultra-high frequency radio band allocated for RFID use. UHF RFID can send information faster and farther than high and low frequency tags. UHF RFID is gaining industry support as the choice bandwidth for inventory tracking applications including pallets and cases. UHF RFID features larger tags and readers with the longest read distances (2-3 feet with handheld readers and more than 9 feet with portal readers)

W

"WORM" Chip (Write Once Read Many) – It can be written once and then becomes "Read Only" afterwards.

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