Enabling Global Competitiveness

Radio frequency identification (RFID)

Radio frequency identification (RFID) is one of the most promising and anticipated technologies in recent years. Magazine articles, television shows, analyst papers and the like are frequently trumpeting the potential benefits to users of RFID. It is time that Production engineers, Supply chain analysts, Quality and Security auditors get an in-depth understanding of what RFID is, how it works, the current standard and compliance environment and some considerations to make sure that one can deliver a successful implementation and get the most from a real-time environment.

Arming yourself with a good understanding of the technology and important considerations can ensure that the decisions that you make minimize any wrong step and maximize your experience. Manufacturers can especially benefit from RFID because the technology can make internal processes more efficient and improve supply chain responsiveness.

For example, early RFID adopters in the consumer goods industry reduced supply chain costs between 3 and 5 percent and grew revenue between 2 and 7 percent because of the added visibility RFID provided, according to a study by AMR Research.

Many drivers have seen RFID in action at automatic toll collection stations used at bridges, tunnels and turnpikes.

In business, RFID will be commonly used to identify pallets, containers, vehicles, tools and other assets, monitor inventory, and route materials through production processes.

RFID can provide immediate and tangible benefits throughout the production cycle up to supply chain. Organizations who take the time to understand the technology's capabilities and limitations can increase their inventory visibility while streamlining their operations.

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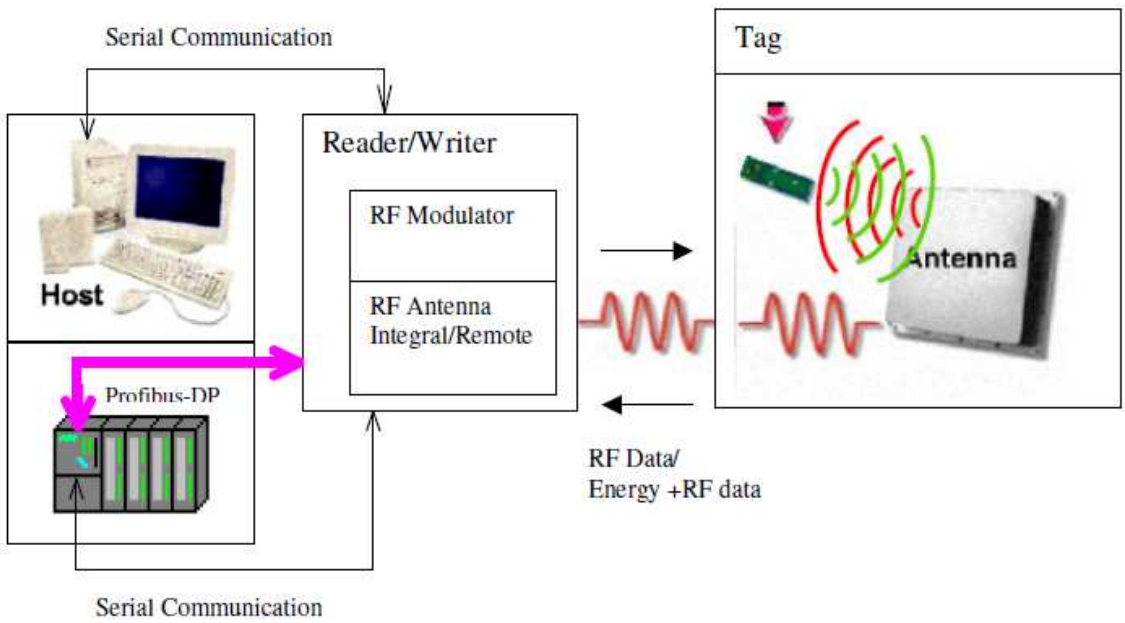
Technology for Real-time application

RFID is Radio Frequency Identification; RFID systems are used to wirelessly exchange information between a tagged object and a reader/writer. However the reader/writer is normally interfaced with an Automation Platform (a PLC or a PC). This makes it possible that the Tag indirectly becomes the part of totally integrated automation setup!

An RFID system is comprised of the following components-

- Tags (also called transponders), which includes a semiconductor chip (Theses are RFID memories and normally specified w.r.t the memory size. The size does matter, as the data volume to be stored in to the tag will depend upon the process/application!
- The tag also always has an integrated antenna as an information receiver/sender
- Read/Write devices (also called interrogators, or simply, readers); these devices convert the data electrically sent to it from an automation solution in to RF and transmits to the tag and the data received from tag through RF is converted in to electrical and sent back to the automation solution.
- The RF transmit and receive job is done by an antenna which may be integral part of the Read/Write device or can be remote (Physically displaced), connected to the read/Write device through cable.

The following diagram shows these components together in a setup:



There are two types of tags namely active and passive; most of the tags get the energy from the

Read/Write device through another RF frequency channel (Passive Tags) while some tags (primarily used in locating applications) have battery within for the energy requirement (Active tags).

In the above setup, the data to be written in to the tag is communicated by the host computer or PLC on a suitable communication link with the Read/Write devices. This data is converted into radio waves in the read/write device and then data transfer of data takes place between the Read/Write device and RFID tag (transponder). It is essential here that the Tag and the read/Write device are tuned the same frequency.

This also means that a particular tag requires a specific Read/Write device.

The interrogator (Read/Write device) sends out a signal, which is received by all tags tuned to that frequency that are present in the RF field. This is of course possible if the Read/Write device supports multi tagging!

Tags receive/send the data signals with their antennas, the selected tags when in the RF field produced by the Read/Write device respond by transmitting the data stored or accepting the sent data depending upon Read/Write job initiated by the interrogator.

The read/write device receives the tag signal with its antenna, decodes it and transfers the data to the host computer system over a suitable communication link while writing job being done, it is exactly reverse!

The tag can hold many types of data about the item, such as its serial number, configuration instructions, what time the item traveled through a certain zone, even temperature and other data provided by sensors.

The read/write distance is very critical; one must always refer to the specifications of the tag to conclude on this issue!

Range (Read/Write distance)

A RFID system's "read/write range" is the distance at which the reader/writer antenna must be from the tag in order to read/write the information properly on/from a memory chip of the tag.

This range varies from a few centimeters to tens of meters and depends mainly on following factors:

- Frequency used
- Power output
- Whether a tag is active or passive
- The directional sensitivity of the antenna.
- The presence of metal and liquids also affects range and read/write performance because these materials may cause interference.

For read/write tags, the read range is typically greater than the write range. Active tags are capable of much longer ranges than passive tags. For example, 433MHz active tags can transmit data about 300 feet, but passive tags at the same frequency are typically readable from up to 25 feet.

Frequency

Frequency is one of the leading factors that effects range. Virtually all RFID systems used today fall into one of four frequency bands.

The following table illustrates the typical frequencies and range relationship

Frequency Band	Description	Range
125 – 134 KHz	Low frequency	To 18 inches
13.553 – 13.567 MHz	High frequency	3 -10 feet
400 – 1000 MHz*	Ultra-high frequency (UHF)	10 - 30 feet
2.45 GHz	Microwave	10+ feet

RFID tags can be attached to virtually anything – from a semi tractor, to a pallet, to a case, to an item on a store shelf. If multiple tags are present in the field, more efficient RFID implementations have anti-collision algorithms, which determine the order of response so that each tag is read once and only once.

Types of tags

Various types of tags are needed for use in different environmental conditions. For example, tags that perform well when attached to cardboard cases are not the best choice for wooden pallets, metal containers or glass.

Tags may be as small as a grain of rice, as large as a brick, or thin and flexible enough to be embedded within an adhesive label and run through a bar code label printer.

Tags also vary greatly by their performance, including read/write ability, memory and power requirements. Depending upon the application and environment, RFID tags have a range of durability.

Paper-thin labels often referred to as “smart labels” are typically used for disposable applications and, as such, are not as durable as other tag types.

Many tags are used for permanent identification applications and can be encased in materials to withstand extremely high heat, moisture, acids and solvents, paint, oil and other conditions that make text, bar code or other optical-based identification technologies unusable in the environment.

RFID tags can be reusable and suitable for lifetime identification, which can provide a total cost of ownership (TCO) advantage over bar code labels or other identification methods that are disposable and need periodic replacement and have critical line of sight requirements for reading!

Because direct line of sight between the reader and tags is not necessary, there are many more placement options for RFID readers than were possible with bar code labels.

Readers can be either placed in a fixed-position or be portable, just like bar code scanners.

Fixed-position readers can be mounted to read items traveling through dock doors, conveyor belts, loading bays, gates, doorways and other areas.

Readers may also be attached to lift trucks and other material handling equipment to automatically identify pallets and other items that are being moved. Interrogator capabilities have also been engineered to now be able to fit into smaller mobile devices.

Please note that most RFID systems in the UHF band operate between 860 and 930 MHz.

No single frequency is ideal for all applications, even within a single industry. Just as separate bar code symbologies are used at different levels of consumer goods packaging, from U.P.C./EAN symbols at the item level to Code 128 and two-dimensional symbologies on cases and pallets.

RFID tags of different frequencies and functionality will be used together within overall production cycle up to supply chain operations. Current logistics and supply chain applications tend to use the UHF band, either between 860 and 930 MHz or 13.56 MHz.

Smart labels are special tag that can be sized and printed suitably as per the demand of the user. “Smart label” tags are typically initially programmed by special printers that have the capability to print bar codes or other visible information on the paper outside of the label while also writing to the memory located on the RFID chip inside the label.

Performance features and benefits

Radio frequency is not an optical technology and does not require line of sight between the tag and reader, which is an important distinguishing feature that gives RFID many performance advantages, compared to bar code and other automatic identification technologies.

As RFID is a radio based technology performance considerations for its implementation are as follows-

- RFID can be susceptible to interference from other radio transmissions and metal
- Some materials absorb RF signals more readily than others
- Sensitivity to interference varies by frequency and the usage environment. These factors can impact the tag read/write range and speed that is seen.
- Most scenarios can be handled by using the proper specific tags, readers and applications.

- As no line of site is required, RFID-tagged objects can be read in different orientations at very high speeds.
- Orientation sensitivity depends on the antenna:- In some environments tags may be read in any orientation/design and the amount of interference that is present. This gives product and package designer's tremendous flexibility in tag placement options, and eliminates the need for human intervention to scan labels or to ensure items are placed properly for reading in conveyor belt or retail checkout applications.
- RFID is a flexible technology that is convenient, easy to use and well suited for automatic operation.
- It combines advantages not available with other identification technologies: RFID can be supplied as read-only or read/write; does not require contact or line-of-sight between the reader and the object to be identified; can function in harsh environments; enables multiple tags to be read simultaneously; and provides a high level of data integrity.
- RFID can also provide security and product authentication because tags can be applied discreetly and are extremely difficult to counterfeit.

Security

It is extremely difficult to counterfeit radio frequency identification chips. A hacker would need specialized knowledge of wireless engineering, encoding algorithms and encryption techniques.

Different levels of security can be applied to data on the tag, so information could be readable at some points of the supply chain but not others.

RFID is very valuable as an authentication technology as well as an identification technology, and some consumer goods manufacturers are embedding it into their products to fight counterfeiting and diversion.

Applications

The different available frequencies, tag and reader designs give users many choices to consider when planning an RFID application.

Finding the right combination of features is fairly straightforward once users begin planning their applications and develop an understanding of their needs and goals.

The following section will provide an overview of how common RFID applications work, the functionality they require and the benefits they provide in different fields! You will also find a general application list at the end of this document.

- **Asset management**

  RFID tags can be permanently attached to capital equipment and fixed assets including pallets, RPCs, cylinders, lift trucks, tools, vehicles, trailers and equipment. Fixed position readers placed at strategic points within the facility can automatically track the movement and location of tagged assets with 100 percent accuracy.

  This information can be used to quickly locate expensive tools or equipment when workers need them, eliminating labor-wasting manual searches. Readers can be set to alert supervisors or sound alarms if there is an attempt to remove tagged items from an authorized area.

  By tracking pallets, totes and other containers with RFID, and building a record of what is stored in the container as items are loaded, users can have full visibility into inventory levels and locations. With visibility and control, manufacturers can easily locate items necessary to fill orders and fulfill rush orders without incurring undue managerial or labor time.

  RFID tags or labels on pallets, cylinders, RPCs and other shipping containers can be automatically read at the dock door as they leave with an outgoing shipment. By matching the reading with specific shipment information in a database, manufacturers could automatically build a record of what specific shipping containers were sent to each customer.

  This information could be used to document cycle times, improve returns and recoveries and aid in disputes with customers about lost or damaged assets. Chep, the world's largest pallet pooling company, is applying RFID tags to the 250 million pallets it manages to gain the automated tracking benefits.

  Applications like these enable manufacturers to lower their asset base and realize some of the cost savings identified in the Auto-ID Center and AMR Research studies.

- **Production Tracking**

  The Auto-ID Center study found manufacturers could reduce their working capital needs between 2% and 8% by taking advantage of RFID to provide greater visibility into work-in process tracking and materials inventory.

  By applying RFID tags to subassemblies in the production process, rather than to finished goods, manufacturers can gain accurate, real-time visibility into work-in-process in environments where bar codes are unusable. Industrial control and material handling systems can integrate with RFID readers to identify materials moving down a production line and automatically route the items to the appropriate assembly or testing station.

  This capability, which requires no human intervention to look up item serial numbers or other identification marks, provides the accuracy and labor savings needed to efficiently execute complex sequencing and make-to-order production.

- **Inventory Control**

  The main benefits to using RFID in the supply chain come from improved inventory tracking, especially when the technology's capabilities are used to collect information and provide visibility in environments where tracking was not done before.

  Manufacturers, distributors, logistics providers and retailers can all use RFID for inventory applications, and in carefully planned systems, may share the same tags to reduce implementation costs.

  As it can be read through packaging, without concern to orientation, without direct line of sight between object and reader and can withstand exposure to dirt, heat, moisture and contaminants that make bar codes unusable, RFID can remove blind spots from inventory and supply chain operations.

  By using the highly accurate, real-time and unattended monitoring capability of RFID to track raw materials, work-in-process and finished goods inventory manufacturers can improve visibility and confidence into their inventory to enable overall inventory levels, labor costs and safety stocks to be reduced.

Readers covering warehouse racks, shelves and other storage locations could automatically record the removal of items and update inventory records. If an item was misplaced or needed urgently to complete an order, fixed-position readers or a worker with a mobile computer and RFID reader could automatically search for the item by reading for its specific ID number.

To secure inventory from theft and diversion, readers could be set to sound alarms or send notification if items are placed in unauthorized areas of the facility or removed from storage without prior approval.

An Auto-ID Center study found consumer goods manufacturers would reduce shrink (inventory loss) by an estimated 10 percent by implementing secure storage areas.

Direct store delivery (DSD) and other remote sales and service personnel could take advantage of RFID readers integrated with mobile computers to quickly and accurately count inventory held in stores or in the vehicle.

The automated counting would save significant time in the field, enabling representatives to visit more customers in a day. For field service applications, permanent asset tags applied to equipment could store its ID; configuration and service history information to ensure accurate and appropriate service is performed in the field where access to a central records database may be unavailable.

- **Shipping & Receiving**

The same tags used to identify work-in-process or finished goods inventory could also trigger automated shipment-tracking applications. Items, cases or pallets with RFID tags could be read as they are assembled into a complete customer order or shipment.

The individual readings could be used to automatically produce a shipment manifest, which could be printed in a document, recorded automatically in the shipping system, encoded in an RFID tag, printed in a 2D bar code on the shipping label, or any combination.

For example the Serial Shipping Container Code (SSCC) data structure, which is commonly used in bar codes on shipping labels, could be encoded into RFID to facilitate automated handling.

The new RFID application could be very effectively integrated into existing business processes because it takes advantage of data structures that are already supported in enterprise databases and software applications.

Manifest information encoded in an RFID tag could be read by the receiving organization to simplify the receiving process and to satisfy requirements like those for advance shipping notices (ASN), so there would not be processing delays if the physical shipment arrived before the electronic data interchange (EDI) transmission with the ASN information.

Having complete shipment data available in an RFID tag that can be read instantly without manual intervention is very valuable for inter dock and high-volume distribution environments. Incoming shipments can be automatically queried for specific containers. If a sought-after item was present, it could be quickly located and selected.

List of Applications using RFIDs

- Warehouse/logistics
- Distribution channel automation and tracking
- Order picking
- Industrial production lines
- Assembly lines
- Transport/traffic management
- Transport/shipping logistics
- Locating/detecting

Regulatory Compliance

Companies that transport or process hazardous materials, food, pharmaceuticals and other regulated materials could record the time they received and transferred the material on an RFID tag that travels with the material. Updating the tag with real-time handling data creates

a chain-of-custody record that could be used to satisfy FDA, DOT, OSHA and other regulatory reporting requirements. RFID tags are also an effective way to satisfy the tire traceability requirements of the TREAD Act.

Standards

Standards initiatives for logistics and item-level tracking also specify these frequencies. Major retailers are basing RFID supplier tagging requirements on the proposed Electronic

Product Code (EPC) specifications that were developed at the MIT Auto-ID Center (and are now managed by EAN International and the Uniform Code Council through EPC Global). See table below for a summary of RFID standards of interest for supply chain and item tracking applications.

Specification	Description	Sponsor	Frequency	Status
ePC UHF Class 0	64 bit factory programmed (e.g. Read Only)	ePC Global	900 MHz	Draft specification
ePC UHF Class 1 Version 1	96/128 bit One-Time-Programmable (OTP)	ePC Global	860 - 930 MHz	Draft specification
ePC UHF Class 1 Generation 2	96/128 bit One-Time-Programmable (OTP)	ePC Global	860-960 MHz	Draft specification
ePC HF Class 1	96/128 bit One-Time-Programmable (OTP)	ePC Global	13.56 MHz	Draft specification
ANSI MH10.8.4	Returnable Transport Item – RTI (e.g. RPC)	ANSI	902 - 928 MHz	Approved - Published
AIAG B-11	Tire & Wheel ID	AIAG	862 - 928 MHz; 2.45 GHz	Approved - Published
ANS INCITS 256	Item Management	INCITS	13.56 MHz; 902 - 928 MHz; 2.45 GHz; 433 MHz	Approved – First revision published
ISO 18185	Cargo seals	ISO	433 MHz; 860 – 930 MHz	Committee Draft – in review
ISO/IEC 18000 Part 2	Item Management	ISO/IEC	<135 kHz	Final Draft International Standard (FDIS) ballot
ISO/IEC 18000 Part 3	Item Management	ISO/IEC	13.56 MHz	FDIS ballot
ISO/IEC 18000 Part 4	Item Management	ISO/IEC	2.45 GHz	FDIS ballot
ISO/IEC 18000 Part 6	Item Management	ISO/IEC	860 - 960 MHz	Final Committee Draft (FCD)