RFID IN SUPPLY CHAIN MANAGEMENT

*Vineet Singla** *Munish Bansal*** *Iqbal Singh***
*N.C College of Engineering, Israna **MIMIT, Malout

ABSTRACT: RFID is emerging as a strong tool in mean supply chain management. Radio-frequency identification, consists of a passive radio-frequency tag with a printed antenna and a radio-frequency (RF) emitter/reader. The tag emits a signal using energy coming from an RF emitter/reader. The signal from the tag on a product or pallet specifies a unique 96-bit product identification code. RFID passive radio-frequency tags, which can be about the size of a dust particle (350 microns), are projected to cost a penny or less each by the end of the decade. Currently, the cost to produce RFID tags ranges depending on the application and the features; the lowest cost reported to date is approximately $0.05 per tag. These tags uniquely identify every product without requiring a "line of sight" for reading.

KEYWORDS: Manufacturing, Product Security, Warehousing, Shipping, Logistic

INTRODUCTION : RFID uses low power radio signals to exchange data wirelessly between chips and readers/encoders. No direct line of sight is needed between the tag and read/write device, eliminating many of the labour and item-orientation requirements associated with other forms of automated data collection. RFID readers can simultaneously recognize and process hundreds of tags within their read fields. RFID tags consist of an integrated circuit (IC) attached to an antenna—typically printed or etched conductors on a thin plastic sheet. Data is stored on the IC and transmitted through the antenna. Tags can be smaller than a grain of rice or as large as a brick. RFID tags are either passive (no battery) or active (self-powered by a battery). Data transmission speed and range depend on the radio frequency, antenna size, power output, and interference. Tags can be read-only, read-write, or a combination, in which some data (such as a serial number) is permanently stored, while other memory is left available for later encoding or to be updated during usage. In passive systems, which are the most common, an RFID reader transmits an energy field that "wakes up" the tag and provides power to the chip, enabling it to transmit or store data. Encryption algorithms that ensure security and integrity of the data passing between the tag and reader protect transmissions. In active systems, batteries typically are used to boost the effective range of the tag. Active tags also may transmit a signal periodically, much like a lighthouse beacon, so that data may be captured by readers distributed throughout a facility.

Readers may be integrated into handheld terminals; fixed and positioned at strategic points, such as a facility entrance, dock door, or assembly line; or integrated into forklifts and other equipment. Readers include one or more antennas for sending and receiving signals to and from tags and a processor for decoding received signals and data. Collected data is then passed through normal interfaces (such as a cable or wireless LAN) to the host computer system. Based on the amount of memory in a tag and how it is designed, readers also may program new data into tags. Readers will operate in accordance with local (national) RF emission regulations; tags and readers must conform to particular specifications and standards in order for them to communicate in a well defined manner. "Frequency agile" readers are capable of recognizing multiple frequencies and are highly advantageous in environments where tags of different frequencies must be processed. The alternative is to install multiple readers that support different frequencies at each read point to ensure all tags will be processed. Application requirements determine the frequency, memory, and performance requirements for the tags to be used. Other considerations include whether the tag will be used globally and what interoperability standards (if any) the tag must meet.

DEFINITION : RFID (Radio Frequency Identification) is a means of storing and retrieving data through electromagnetic transmission to an RF compatible integrated circuit, thus enhancing data handling processes.

SYSTEM COMPONENTS

RFID systems have several basic components or technical characteristics that define them. These are:

- A reader, including an antenna The device that is used to read and/or write data to RFID tags.
- A tag A device that transmits to a reader the data.
- The communication between them

RFID uses a defined radio frequency and protocol to transmit and receive data from tags.

Antenna

An antenna achieves this inductance through a combination of wire thickness, antenna diameter, and the windings of wire that comprise the antenna. Based on our various antenna configurations and from generalizing the formula, a general rule is that the required number of antenna wire windings increases exponentially as the diameter of the antenna increases. In practice, we found designing an antenna within the required inductance was easiest not by formula but rather by winding the antenna while it was attached to an RCL meter. The meter provided real-time measurements of the antenna inductance, allowing us to add or remove windings to stay within 600-700 μH.

Tags
RFID tags can be segregated into two major classifications by their power source:

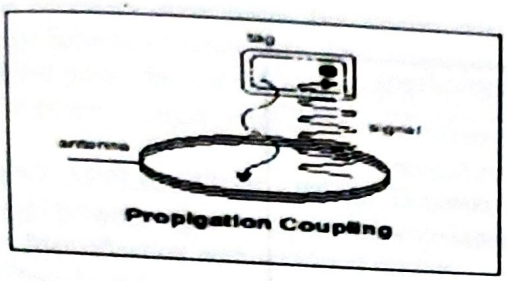
• **Active tags:** Active tags contain both a radio transceiver and battery to power the transceiver. Because there is an onboard radio on the tag, active tags have substantially more range (~300 feet) than passive or "active/passive tags." Active tags are also considerably more expensive than passive tags and, as with any battery-powered product; the batteries must be replaced periodically.

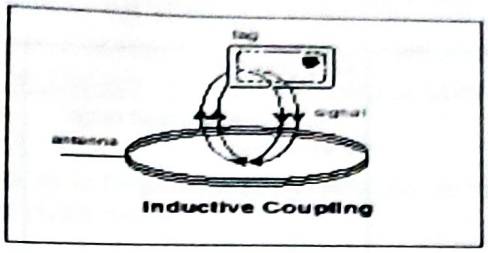
• **Passive tags:** Passive tags can be either battery or non-battery operated, as determined by the intended application. Passive tags reflect the RF signal transmitted to them from a reader or transceiver and add information by modulating the reflected signal. A passive tag does not use a battery to boost the energy of the reflected signal. A passive tag may use a battery to maintain memory in the tag or power the electronics that enable the tag to modulate the reflected signal.
RF tags can also be distinguished by their memory type:

- **Read / write:** Read / write memory just as the name implies, can be read as well as written into. Its data can be dynamically altered.
- **Read only (typically "chip less"):**

Read only type of tag memory is factory programmed and cannot be altered after the manufacturing process. Its data is static. Read only memory is the less expensive of the two. As RFID markets and applications grow, this price difference will become less for overall system cost justification.

TYPES OF COMMUNICATIONS



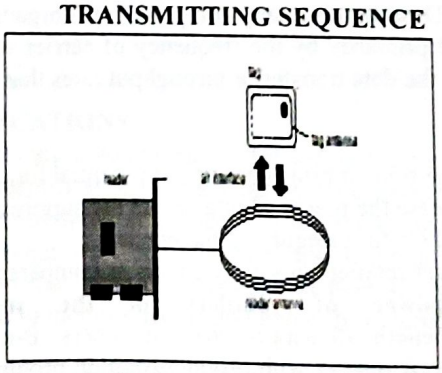


Tags and a reader communicate by wireless signal in a process known as *coupling*. Two methods of wireless signal distinguish and categorize RFID systems:

- Close proximity electromagnetic or inductive coupling
- Propagating electromagnetic waves.

Coupling is via antenna structures forming an integral feature in both tags and readers. Transmitted data is influenced by the channels through which it must pass, including the *air interface*. Structuring the bit stream to ensure error-free, synchronous data transfer through this channel is often referred to as *channel encoding*. Although transparent to the user of an RFID system this coding scheme is important to engineers as often appears in system specifications. Various encoding schemes can be distinguished, each exhibiting different performance features. Transferring data efficiently via the air interface requires the data to be superimposed upon a rhythmically varying (sinusoidal) field or carrier wave. This process of superimposition is referred to as *modulation*, and various schemes are available for this purpose. They are essentially based upon changing the value of one of the primary features of an alternating sinusoidal source, its amplitude, frequency or phase in accordance with the data carrying bit stream. In this way it is similar to the way AM or FM radio works. On this basis one can distinguish amplitude shift keying (ASK), frequency shift keying (FSK) and phase shift keying (PSK).

TRANSMITTING SEQUENCE



A transmission sequence consists of a system handshake, data modulation, and data encoding.
System Handshake: the typical handshake of a tag and reader is as follows:

- The reader continuously generates an RF carrier sine wave, always watching for modulation to occur. Detected modulation of the field indicates the presence of a tag

- When a tag enters the RF field generated by the reader, once the tag has received sufficient energy to operate correctly, it begins clocking its data against an output transistor, which is normally connected across coil inputs.
- The tag's output transistor shunts the coil, in a way which corresponds to the data stored in the memory array.
- Shunting the coil causes a momentary fluctuation (dampening) of a carrier wave, which is seen as a slight change in amplitude (or frequency) of the carrier.\

The reader peak-detects the amplitude-modulated data and processes the resulting bit stream according to the encoding and data modulation methods used.

DATA MODULATION

A modulation is a periodic fluctuation in the amplitude of the Radio Frequency carrier sine wave, which is used to transmit data back from tag to reader. Data are transferred to the host by amplitude modulating the carrier. For passive RFID tags, it's called *backscatter modulation*. In this case the RF link behaves essentially as a transformer; as
The secondary winding is momentarily shunted, the primary winding experience a momentary voltage drop. The reader must peak detect this data at about 60dB down(about 100 mV riding on a 100 V sine wave).this amplitude-modulation of readers transmitted field provides a communication path back to the reader. The data bits can then be encoded or further modulated in a number of ways.

DATA ENCODING

Data encoding refers to processing or altering the data bit stream in between the time it is retrieved from the RFID chip's data array and its transmission back to the reader. The various encoding algorithms affect error recovery, cost of implementation, bandwidth, synchronization capability, and other aspects of the system design.

Frequency Band	Characteristics	Typical Applications
Low 100-500 kHz	Short to medium read range Inexpensive low reading speed	Access control Animal Identification Inventory Control Car immobiliser
Intermediate 10-15 MHz	Short to medium read range Potentially inexpensive medium reading speed	Access control Smart Cards
High 850-950 MHz 2.4-5.8 GHz	Long read range High reading speed Line of sight required Expensive	Railroad car monitoring Toll collection systems

RADIO FREQUENCY AND RANGE

Because RFID uses electromagnetic radio signals to operate, its effective operation is subject to the same physical laws any RF operating device is. The RF field distance or space between an RFID interrogator antenna and the corresponding RFID tag, and the frequency of operation are directly interrelated. Thus, different RFID frequencies have different RF effective ranges. Two terms used often are *near field*, and *far field*.
Early in the technology's development, three carrier frequencies were identified and used to refer to different ranges: Low (125kHz), Intermediate (13.56 MHz) and High (2.45 GHz). Today there are eight frequency bands in use around the world for RFID applications, identified by number and not name. Despite this, many companies still organize their products by low, intermediate, and high range. The rate of data transfer is influenced primarily by the frequency of carrier wave used to carry the data between the tag and its reader. The higher the frequency the higher the data transfer or throughput rates that can achieved.

Rfid in Supply Chain Impacts

RFID brings with it many opportunities. At the same time, it brings enormous potential for change in the supply chain dynamic. Three impacts appear especially powerful:RFID may increase the power of retailers in the supply chain relative to suppliers.

1. RFID may reduce retailers' reliance upon suppliers for category management.
2. RFID may increase the economic power of larger retailers in supply chains as compared to smaller retailers.

Impact 1: RFID may increase the power of retailers in the supply chain relative to suppliers. The information created by RFID promises to benefit all supply chain members. But some may be reluctant to share certain information. Consider the product-rotation example. A retailer with product-rotation problems may not want to share that information with the manufacturer that is compensating the retailer for obsolescence and spoilage. Yet the manufacturer would want this information so that it could stop compensating for spoilage and obsolescence resulting from poor product rotation at the retail level. On the other hand, if the retailer is managing product rotation well, it may seek to leverage this capability to negotiate higher compensation for obsolescence and spoilage that is not its fault. In the case of direct store delivery (DSD) from the supplier, the

retailer can monitor the supplier's product rotation in the store and notify those vendors that are not practicing good product rotation. When it is in their best interest, retailers may even share the information with the suppliers, giving them additional leverage in the relationship.RFID could provide a range of information on consumer behavior that would be useful to both retailers and suppliers. Consider the ability to monitor sales of identical SKUs selling in different parts of the store. Such information is beneficial to the retailer in terms of optimizing in-store replenishment. Yet the retailer can also use it to demonstrate to the manufacturer the need for different sizes of retail-ready display (RRD) cases. These cases are opened and put on the shelf directly as opposed to putting each item on the shelf individually. RRD cases are designed to reduce in-store stocking labor costs.

Impact 2: RFID may reduce retailers' reliance on suppliers for category management.
Category management is a collaborative process between a supplier and a retailer in which data are analyzed and decisions are made on category breadth and depth, new product introductions, shelf layout decisions, and so on. In making their decisions, retailers often rely upon category-specific studies conducted by suppliers. The retailer typically is concerned with hundreds of different categories, whereas the supplier focuses only on a small fraction of that number. Therefore, the supplier can justify studying a category because it spreads those costs over many different retailers.

Impact 3: RFID may increase the economic power of larger retailers in the supply chain as compared to smaller retailers:
Suppliers likely will bear the cost of acquiring the passive radio-frequency tags that will go on the cartons or pallets. Yet there are significant other costs involved in making RFID operational that the retailers will bear. These include readers, computer hardware and software, and analytical capabilities to utilize the data generated. Larger retailers see the benefits of RFID and have the resources to make the necessary investments. But smaller retailers, even those that understand RFID's potential, may be slow to adopt RFID technology because of these costs. This competitive disadvantage may result in a portion of these small retailers exiting the market. On a related point, the costs of becoming RFID ready may heighten entry barriers for retailers entering the market, further tilting the balance of power to larger, established retailers

CURRENT APPLICATION AREAS: The main features of radio frequency tagging are ability to identify objects without a clear line of sight between tag and reader, read/write capability, and cluster reading.

- **Identification without visual contact**
  People, items, and cartons can be identified even if material comes between the reader and the tag.
- **Read/write:** Unlike barcode identification technology, certain RFID tags can store data, allowing system designers to place "handling codes" directly on the object as it travels through a system.
- **Cluster reading:** Specially-designed readers can read many tags at once, increasing the throughput of automated accounting procedures. These features determine the applications of RFID technology in every industry, commerce and service where data needs to be collected.

The three principle areas of application are:
- Transportation and Distribution
- Manufacturing and Processing
- Security and Law Enforcement

Secondary areas of application, some of which are steadily growing in terms of application numbers, include:
- Animal tagging
- Waste management
- Time and attendance
- Postal tracking
- Airline baggage reconciliation
- Road toll management

SPECIFIC EXAMPLES OF RFID APPLICATIONS
Transportation/Distribution: RFID systems are uniquely suited for use in the rigorous rail environment. Field-programmable tags permit the industry standard, 12-character identification of each car by type, ownership and serial number. Tags are attached to the vehicle undercarriage; antennae are installed between or adjacent to the tracks and readers or display devices are typically located within 40 to 100 feet in a wayside hut along with other control and communications equipment. A primary objective in rail applications is the improved fleet utilization that permits reductions in fleet size and/or deferral of investment in new equipment. Commercial truckers are using RFID systems to monitor access and egress from terminal

Industrial : In the plant environment, RF systems are ideally suited for the identification of high-unit-valueproducts moving through a tough assembly process (e.g., automobile or agricultural equipment production where the product is cleaned, bathed, painted and baked). RF systems also offer the durability essential for permanent identification of captive product carriers such as:
- Tote boxes, containers, barrels, tubs, and pallets;
- Tool carriers, monorail and power, and free conveyor trolleys;

• Lift trucks, towline carts, automatic guided vehicles.

Security and Access Control : The movement and use of valuable equipment and personnel resources can be monitored through RF tags attached to tools, computers, etc. or embedded in credit-card-size security badges. This type of monitoring also provides an extra measure of security for personnel working in high risk areas in case of an emergency evacuation.

Libraries and Video Stores: Many large libraries around the world have implemented RFID to speed material check-in, checkout, shelf inventory, and security applications. Low-cost, flexible smart labels are inserted in books and can be made invisible to patrons. Counter personnel can check dozens of books in or out in mere seconds without manually handling and orienting each item. The tags also can be used for theft detection, much like anti-shoplifting technology currently used by retailers. Librarians using portable computers with RFID readers can take inventory and find misfiled materials simply by walking down an aisle of bookshelves. The reader can automatically detect missing materials and alert the operator. Video stores are increasingly using RFID for similar applications. Readers are positioned at the checkout, unattended return bins, and doorways to record transactions and detect shoplifted items automatically. These library and video store operations are essentially in-store inventory management applications that can be adapted for use in many other industries.

THE FUTURE OF RFID : Due to new emerging possibilities that come with RFID and Internet connectivity, RFID has celebrated a renewed interest and resurgence in the market. RFID has moved past the limited market of manufacturing logistics and security access, and gained acceptance in the consumer market with such applications as automatic toll payments and fueling applications. Research into future visions for RFID technology, showed however, that although the market is rapidly growing, there is a limited number of compelling future visions for RFID systems. In fact, based on a study conducted by Venture Development Corporation (VDC), it is agreed among many industry players that a killer application has yet to be defined for RFID. With the exception of the extension of current applications such as e commerce and tracking, there is little "blue sky" thinking going on in the field of RFID implementation. The most interesting and visionary thinking of RFID implementation is currently being conducted by Xerox PARC, some telecommunications companies such as Nokia, and MIT's Auto ID Group who is currently funded by a number of large companies such as Coca Cola, Johnson & Johnson, Pfizer, UPS, Wal-Mart, Intel, NCR Corporation, and Philips Semiconductors. This involvement of large corporations and key players indicates that there is an agreement that RFID technology does have the potential of becoming a very prominent technology with some strategic thinking and innovative applications.

Cost : In order for adoption of RFID to become ubiquitous, the cost needs to be low enough that it is a viable solution for both small and large businesses. This means both a reduction in the hardware costs, as well as (again) the standardization of systems, eliminating duplicate efforts, conflicting systems, and eventually more costly development. Currently, the Auto ID group is working to make the technology cost efficient through researching both hardware and systems integration to promise a greater return on investment for companies interested in RFID technology. However, these are clearly the visions of cost for the future, while today's reality is very different. The ability to reach Auto ID Center's goal of a 5 cent RFID tag is questionable according to some current research in RFID smart tag manufacturing. Supply Chains Systems magazine January 2002 issue states that for a million smart labels today you'll pay about 75 cents or a dollar each, depending on tag size and capability. The path to the development of a 50 or 40-cent tag, is clear, whereas the 5-cent tag timeframe is unclear if even possible. If we are to reach the 5 cent smart tag, the capabilities are most likely to be very different from what we currently expect from an RFID smart tag.

CONCLUSION : RFID is a stable automatic identification technology that holds great promise for improving business processes; its use is becoming increasingly widespread. Indeed, some early adopter companies applying RFID at the carton and case level to mixed merchandise to automate creation of receiving and shipping manifests, have observed that RFID gives them unexpected opportunities to perform goods handling processes in efficient, entirely different ways. RFID should be considered for any application that could realize a clear benefit in terms of efficiency, reduced loss, or improved service. RFID offers strong performance and functionality, but at a price—considering tags relative to simple labels. The added cost of RFID, weighed against bar codes' outstanding value and the enormous installed, working infrastructure (supported by international standards), ensures the two technologies will coexist, just as our nation's roads are still full of cars despite the growth of commercial air travel during the last 50 years. Because RFID tags can be reusable, don't require line of sight to read or write, enable unattended reading, and offer read/write data storage, they can improve efficiency in many operations by reducing labor and materials costs. Potential users must carefully evaluate the long-term impact for improved business operations relative to total cost of ownership and not automatically rule out use of the technology because of the initial investment required.

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