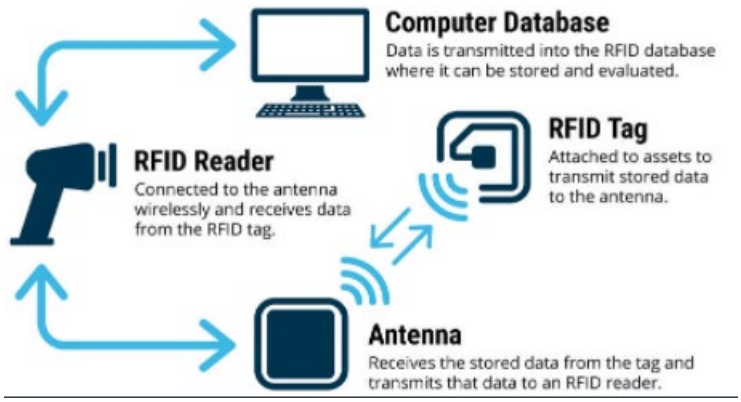
Basics of RFID Technology



2

Professional Development Hours (PDH) or
Continuing Education Hours (CE)
Online PDH or CE course

Introduction

1. RFID stands for Radio-Frequency Identification. The acronym refers to small electronic devices that consist of a small chip and an antenna. The chip typically is capable of carrying 2,000 bytes of data or less. RFID is a general term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object wirelessly, using radio waves. This is sometimes referred to as contact-less technology and a typical RFID system is made up of three components: tags, readers and the host computer system. An RFID tag is a tiny radio device that is also referredto as a transponder, smart tag, smart label or radio barcode. The tag comprises of a simple silicon microchip attached to a small flat aerial and mounted on a substrate. The whole device can then be encapsulated in different materials (such as plastic) dependent upon its intended usage. The finished tag can be attached to an object, typically an item, box or pallet and read remotely to ascertain its identity, position or state.

History and Technology Background

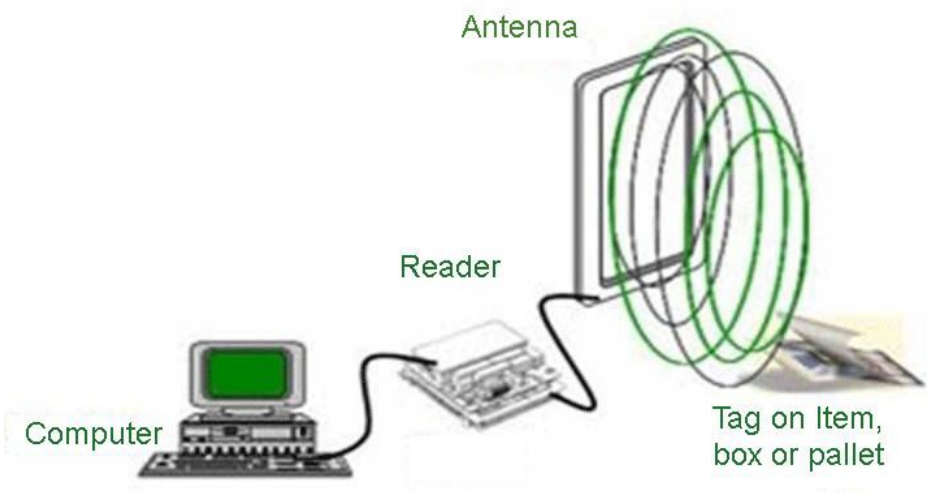
2. In 1946 Harry Stockman invented an espionage tool for the Soviet Union which retransmitted incident radio waves with audio information. Sound waves vibrated a diaphragm which slightly altered the shape of the resonator, which modulated the reflected radio frequency. Even though this device was a covert listening device, not an identification tag, it is considered to be a predecessor of RFID technology, because it was likewise passive, being energized and activated by electromagnetic waves from an outside source. Another early work exploring RFID is the landmark 1948 paper by Harry Stockman, titled "Communication by Means of Reflected Power". Stockman predicted that "... considerable research and development work has to be done before the remaining basic problems in reflected-power communication are solved, and before the field of useful applications is explored."

RFID enabled device

3. Mario Cardullo's U.S. Patent 3,713,148 in 1973 was the first true ancestor of modern RFID; a passive radio transponder with memory. The initial device was passive, powered by the interrogating signal, and was demonstrated in 1971 to the New York Port Authority and other potential users and consisted of a transponder with 16 bit memory for use as a toll device. The basic Cardullo patent covers the use of RF, sound and light as transmission media. The original business plan presented to investors in 1969 showed uses in transportation (automotive vehicle identification, automatic toll system, electronic license plate, electronic manifest, vehicle routing, vehicle performance monitoring), banking (electronic check book, electronic credit card), security (personnel identification, automatic gates, surveillance) and medical (identification, patient history). A very early demonstration of reflected power (modulatedbackscatter) RFID tags, both passive and semi-passive, was performed by StevenDepp, Alfred Koelle, and Robert Freyman at the Los Alamos National Laboratory in 1973. The portable system operated at 915 MHz and used 12-bit tags. This technique isused by the majority of today's UHFID and microwave RFID tags.

Basic Operation

4. The reader, sometimes called an interrogator or scanner, 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 radio waves. The data acquired by the readers is then passed to a host computer, which may run specialist RFID software or middleware to filter the data and route it to the correct application, to be processed into useful information.



RFID Basic Operation

5. RFID technologies are grouped under the more generic Automatic Identification (Auto-ID) technologies. Examples of other Auto-ID technologies include Smartcards and Barcodes. RFID is often positioned as next generation barcoding because of its obvious advantages over barcodes. However, in many environments it is likely to co-exist with the barcode for a long time. The barcode labels that triggered a revolution in

identification systems back in the 1970"s are now cheap and commonly used, but have several limitations:

- low storage capacity
- they only represent a series of items and not an individual or unique item
- durability (as mostly printed paper)
- low read range
- they can only be read when line of sight is established
- they can only be read one at a time
- they cannot be written to or reprogrammed

Features and benefits of RFID over barcodes

Technology	Barcode	RFID	RFID Benefit Example
Capacity			
Line of sight requirement	Required	Not required	No need to orientate scanned items
Number of items that can be scanned	One	Multiple	Very fast inventory count
Automation and Accuracy	Manual read errors and prone to mis-scanning	Fully automated and highly accurate	Error free inventory count
Identification	Only series or type	Unique item level	Targeted recall
Data Storage	Only a meaningless code	Up to several KB	Real time data access in any location

Rather than using light to collect or read a number from a barcode, radio waves are used to read a number from the RFID tag. RFID therefore does not need line-of-sight to operate. Using radio means that the tag no longer has to be visible on the object to which it is attached; the tag can be hidden inside the item or box that is to be identified and still be read. This minimizes/eliminates the need for a person to have to present the reader to the tag as it can now be fixed to a wall. As the item is passed by the reader it will be read automatically, thus saving in labour costs or substantial increase in throughput of scanned items.

6. Another feature of RFID is the ability to read many tags together at once. It is not necessary to present each tag to the reader separately (as is required for barcodes),

instead all tags within the range of the reader can be read almost simultaneously as they pass the reader. Again, there is a huge savings potential in not having to manually present the reader to each item to be identified. Furthermore, data can also be written tothe tag, a feature not possible with barcodes. This latter feature has tremendousimplications for IT systems and the potential benefits of RFID.

Different Types of RFID

7. There are several versions of RFID that operate at different radio frequencies. Three primary frequency bands are being used for RFID:

- **Low Frequency** (125/134 KHz) – Most commonly used for access control, animal tracking and asset tracking.
- **High Frequency** (13.56 MHz) – Used where medium data rate and read ranges up to about 1.5 meters are acceptable. This frequency also has the advantage of not being susceptible to interference from the presence of water or metals.
- **Ultra High-Frequency** (850 MHz to 950 MHz) – Offer the longest read ranges of up to approximately 3 meters and high reading speeds.

8. 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. Since UHF (Ultra High Frequency) has the range to cover portals and dock-doors it is gaining industry support as the choice frequency for inventory tracking applications including pallets and cases. RFID tags are further broken down into two categories:

(a) Active RFID Tags are battery powered. They broadcast a signal to the reader and can transmit over the greatest distances (100+ meters). They can be 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.

(b) Passive RFID Tags do not contain a battery. Instead, they draw their power from the radio wave transmitted by 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, passivetags can transmit information over shorter distances (typically 3 meters or less) than active tags. They have a smaller memory capacity and are considerably lower in cost making them and ideal for tracking lower cost items. There are two basic types of chips available on RFID tags, Read-Only and Read-Write.

9. **Read only chips** are programmed with unique information stored on them during the manufacturing process – often referred to as a „number plate" application. The information on read-only chips can not 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 than Read Only chips. Applications for these may include field service maintenance or „item attendant data" – where a maintenance record associated with a mechanical component is stored and

updated on a tag attached to the component. Another method used is called a "WORM" chip (Write Once Read Many). It can be written once and then becomes "Read only" afterwards.

Applications for RFID

10. Applications fall into two principal categories: firstly, short range applications where the reader and tag must be in close proximity (such as in access control) and secondly, medium to long application, where the distance may be greater. A sample of applications is shown below:

- **Access control for people**: There are many areas where RFID tags are carried by people to allow them to gain access to facilities or services like secure access to work place, safety access to dangerous/secure equipment , access to a computer or vehicle, access to travel on trains/buses or access to leisure facilities.
- **Access control for vehicles** e.g. secure access on site, road tolling, instant payment for fuel.
- **Manufacturing automation** like control of flexible manufacturing processes by recognising items being built on a production line (mass customization enabler) or labeling key components for later recycling.
- **Logistics and distribution** like tracking parcels from shipment to end customer, tracking goods from manufacture through to retail.
- **Retail:** To maintain **s**upply chain management, Stock taking, reducing loss through shrinkage, reverse logistics, Product availability.
- **Maintenance** for Plant & Equipment, Fixed assets, patients.
- **Product security** to prevent tampering of evidence, product authentication or anti-counterfeiting

Standards

11. When an organisation trades globally and intends using RFID systems across national boundaries, standards and regulations are more important to ensure safety and the interoperability of tags and readers between trading partners. Where an orgainisation wishes to operate a 'closed-loop' system which is solely intended for internal use within the one organisation - then it is relatively easier to select and optimise a system for those specific internal requirements.

RFID Label

12. A common misunderstanding is that RFID is regulated by one trade body; however, it is in fact influenced by a number of official bodies for different aspects. Frequencies, power levels and operating cycles are regulated in Europe by the European Telecommunications Standards Institute (ETSI) and in the UK by OFCOM (Office of Communications). Protocols for communication between tags and readers areproposed by a number of bodies and equipment manufacturers. There are various frequencies, standards, power levels, protocols, tag types and architectures with differing operational and performance characteristics. This complexity can be cut through to enable the correct RFID technology and application for your specific environment with the assistance of an expert body such as the RFID Centre. Use of RFID technology can increase business productivity and reduce associated costs. To ensure that companies benefit from the advantages RFID provides, it is important to understand how to adopt this technology.

13. The RFID Centre can give you an insight into how other companies have approached such implementations and the business benefits that have been derived in a number of business sectors namely Retail & CPG, Clothing & Apparel, Food & Drink Manufacturing, Leisure industry & Service sector, Logistics & Transportation, Health & Pharmaceuticals, Building & Construction, IT, Electrical & Electronics, Defence, Automotive and Livestock. By analysing current practices and procedures eight main areas of benefit can be identified. These are:

(a) **Improved Productivity and Cost Avoidance:** Identifying items by RFID involves less work than using barcode scanning and other less automated ways. This leads to greater process effectiveness in many tasks such as receiving and putting away, picking and shipping goods where the time required and cost of identifying items by RFID is substantially less than other methods.

(b) **Decreased Cycle Time and Taking Costs Out:** RFID scanning is not a serial process, like traditional Barcode scanning, so the business can perform identical tasks much more quickly. This means processes moving goods through a supply chain are more efficient leading to a reduction in the need for larger inventories.

(c) **Reduced Rework:** As RFID scanning has a greater first time pass accuracy this reduces the number of errors that are generated and retries needed.

(d) **Reduced Business Risk & Control of Assets:** RFID tagging enables better audit and asset control. The ability to track and trace items means assets can be located more easily. The opportunity for enhanced data collection leads to increased accuracy of record keeping and improved asset maintenance. Regulatory compliance can be achieved more effectively.

(e) **Improved Security and Service:** Being able to validate information relating to an item enables increased security. This individual identification contributes to more effective access control, reductions in shrinkage and other losses and the ability to provide fast and efficient services at the

point of need. Ability to authenticate information can prevent activities like counterfeiting and fraud.

(f) **Improved Utilisation of Resources:** Information obtained by RFID scanning can be used to improve planning. Processes can be improved, time can be saved, assets can be utilised better.

(g) **Increased Revenues:** By eliminating uncertainty companies will suffer less “out of stock” situations and obtain greater item availability, reducing lost sales and increasing choice leading to more sales.

(h) **Exception Management:** RFID enables processes and procedures to be measured better. Until a process can be measured accurately it often can‟t be improved. Decisions that are based on limited, inaccurate, out-of-date information are often poor decisions. The contribution information captured by RFID offers to IT applications will allow managers in companies to be alerted when compensatory business decisions need to be taken.

Is RFID Technology Secure and Private?

14. Unfortunately, it is not very often in the systems to which consumers are likely to be exposed. Anyone with an appropriately equipped scanner and close access to the RFID device can activate it and read its contents. Obviously, some concerns are greater than others. If someone walks by your bag of books from the bookstore with a 13.56 Mhz "sniffer" with an RF field that will activate the RFID devices in the books you bought, that person can get a complete list of what you just bought. That's certainly an invasion of your privacy, but it could be worse. Another scenario involves a military situation in which the other side scans vehicles going by, looking for tags that are associated with items.

15. Companies are more concerned with the increasing use of RFID devices in company badges. An appropriate RF field will cause the RFID chip in the badge to "spill the beans" to whomever it activates. This information can then be stored and replayed to company scanners, allowing the thief access - and your badge is the one that is "credited" with the access. The smallest tags that will likely be used for consumer items don't have enough computing power to do data encryption to protect your privacy. The most they can do is PIN-style or password-based protection.

Next-Generation Uses of RFID

16. Some vendors have been combining RFID tags with sensors of different kinds. This would allow the tag to report not simply the same information over and over, but identifying information along with current data picked up by the sensor. For example, an RFID tag attached to a leg of lamb could report on the temperature readings of the past 24 hours, to ensure that the meat was properly kept cool. Over time, the proportion of "scan-it-yourself" aisles in retail stores will increase. Eventually, we may wind up with stores that have mostly "scan-it-yourself" aisles and only a few checkout stations for people who are disabled or unwilling.

Zombie RFID

17. One of the main concerns with RFID tags is that their contents can be read by anyone with an appropriately equipped scanner even after you take it out of the store. One technology that has been suggested is a **zombie RFID tag**, a tag that can be temporarily deactivated when it leaves the store. The process would work like this: you bring your purchase up to the register, the RFID scanner reads the item, you pay for it and as you leave the store, you pass a special device that sends a signal to the RFID tag to "die." That is, it is no longer readable. The "zombie" element comes in when you bring an item back to the store. A special device especially made for that kind of tag "re-animates" the RFID tag, allowing the item to reenter the supply chain.

Technical problems with RFID

18. Problems associated with RFID are discussed below:-

(a) **Problems with RFID Standards:** RFID has been implemented in different ways by different manufacturers; global standards are still being worked on. It should be noted that some RFID devices are never meant to leave their network (as in the case of RFID tags used for inventory control withina company). This can cause problems for companies. Consumers may also have problems with RFID standards. For example, ExxonMobil's SpeedPass system is a proprietary RFID system; if another company wanted to use the convenient SpeedPass they would have to pay toaccess it - an unlikely scenario. On the other hand, if every company had their own "SpeedPass" system, a consumer would need to carry many different devices with them.

(b) **RFID systems can be easily disrupted:** Since RFID systems make use of the electromagnetic spectrum (like WiFi networks or cellphones), they are relatively easy to jam using energy at the right frequency. Althoughthis would only be an inconvenience for consumers in stores (longer waits at the checkout), it could be disastrous in other environments where RFID is increasingly used, like hospitals or in the military in the field.

(c) **RFID Reader Collision:** Reader collision occurs when the signals from two or more readers overlap. The tag is unable to respond to simultaneous queries. Systems must be carefully set up to avoid this problem; many systems use an anti-collision protocol (also called a singulation protocol). Anti-collision protocols enable the tags to take turns in transmitting to a reader.

(d) **RFID Tag Collision:** Tag collision occurs when many tags are present in a small area; but since the read time is very fast, it is easier for vendors to develop systems that ensure that tags respond one at a time.

Conclusion

19. RFID combined with mobile computing and Web technologies provide an effective way for organizations to identify and manage their assets. Mobile computers, with integrated RFID readers, can now deliver a complete set of tools that eliminate

paperwork, give positive proof of identification and prove attendance. Errors are virtually unheard of as this approach eliminates manual data entry. Web based management tools allow organizations to monitor their assets and make management decisions from anywhere in the world. Web based applications now mean that third parties, such as manufacturers and contractors can be granted access to update asset data, for example, inspection history and transfer documentation online ensuring that the end user always has accurate, real-time data. Organizations within the Plant industry are already using RFID tags combined with a mobile asset management solution to record and monitor the location of their assets, their current status, whether they have been maintained and most importantly if they comply with regulations. Fitters within depots and those working remotely on project/client sites use mobile computers to complete and record job instructions. These completed work records are then synchronized with aweb based database allowing support and administration staff to respond accordingly.