What is Radio Frequency Identification (RFID)?

A basic RFID system consist of three components:

1. An antenna or coil
2. A transceiver (with decoder)
3. A transponder (commonly called an RF tag) that is electronically programmed with unique information

The antenna emits radio signals to activate the tag and read and write data to it. Antennas are the conduits between the tag and the transceiver, which controls the system's data acquisition and communication. Antennas are available in a variety of shapes and sizes; they can be built into a door frame to receive tag data from persons or things passing through the door, or mounted on an interstate toll booth to monitor traffic passing by on a freeway. The electromagnetic field produced by an antenna can be constantly present when multiple tags are expected continually. If constant interrogation is not required, the field can be activated by a sensor device.

Often the antenna is packaged with the transceiver and decoder to become a reader (a.k.a. interrogator), which can be configured either as a handheld or a fixed-mount device. The reader emits radio waves in ranges of anywhere from one inch to 100 feet or more, depending upon its power output and the radio frequency used. When an RFID tag passes through the electromagnetic zone, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer for processing.

RFID tags come in a wide variety of shapes and sizes. Animal tracking tags, inserted beneath the skin, can be as small as a pencil lead in diameter and one-half inch in length. Tags can be screw-shaped to identify trees or wooden items, or credit-card shaped for use in access applications. The anti-theft hard plastic tags attached to merchandise in stores are RFID tags. In addition, heavy-duty 5- by 4- by 2-inch rectangular transponders used to track intermodal containers or heavy machinery, trucks, and railroad cars for maintenance and tracking applications are RFID tags.

RFID tags are categorized as either active or passive. Active RFID tags are powered by an internal battery and are typically read/write, i.e., tag data can be rewritten and/or modified. An active tag's memory size varies according to application requirements; some systems operate with up to 1MB of memory. In a typical read/write RFID work-in-process system, a tag might give a machine a set of instructions, and the machine would then report its performance to the tag. This encoded data would then become part of the tagged part's history. The battery-supplied power of an active tag generally gives it a longer read range. The trade off is greater size, greater cost, and a limited operational life (which may yield a maximum of 10 years, depending upon operating temperatures and battery type).

Passive RFID tags operate without a separate external power source and obtain operating power generated from the reader. Passive tags are consequently much lighter than active tags, less expensive, and offer a virtually unlimited operational lifetime. The trade off is that they have shorter read ranges than active tags and require a higher-powered reader. Read-only tags are typically passive and are programmed with a unique set of data (usually 32 to 128 bits) that cannot be modified. Read-only tags most often operate as a license plate into a database, in the same way as linear barcodes reference a database containing modifiable product-specific information.

RFID systems are also distinguished by their frequency ranges. Low-frequency (30 KHz to 500 KHz) systems have short reading ranges and lower system costs. They are most commonly used in security access, asset tracking, and animal identification applications. High-frequency (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) systems, offering long read ranges (greater than 90 feet) and high reading speeds, are used for such applications as railroad car tracking and automated toll collection. However, the higher performance of high-frequency RFID systems incurs higher system costs.

The significant advantage of all types of RFID systems is the noncontact, non-line-of-sight nature of the technology. Tags can be read through a variety of substances such as snow, fog, ice, paint, crusted grime, and other visually and environmentally challenging conditions, where barcodes or other optically read technologies would be useless. RFID tags can also be read in challenging circumstances at remarkable speeds, in most cases responding in less than 100 milliseconds. The read/write capability of an active RFID system is also a significant advantage in interactive applications such as work-in-process or maintenance tracking. Though it is a costlier technology (compared with barcode), RFID has become indispensable for a wide range of automated data collection and identification applications that would not be possible otherwise.

Developments in RFID technology continue to yield larger memory capacities, wider reading ranges, and faster processing. It is highly unlikely that the technology will ultimately replace barcode — even with the inevitable reduction in raw materials coupled with economies of scale, the integrated circuit in an RF tag will never be as cost-effective as a barcode label. However, RFID will continue to grow in its established niches where barcode or other optical technologies are not effective. If some standards commonality is achieved - whereby RFID equipment from different manufacturers can be used interchangeably - the market will very likely grow exponentially.

Here is a more detailed and technical description of RFID basics, Frequency Characteristics of RFID Systems, and a Glossary of Terms

RFID
Transportation/Distribution

As suggested earlier, RFID systems are uniquely suited for use in the rigorous rail environment. Field programmable tags permit the full 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 facilities. Combined with weigh-in-motion scales, the same systems can be used for transaction recording at refuse dumps, recycling plants, mines and similar operations, or for credit transactions at truck stops or service depots.

Industrial

In the plant environment, RF systems are ideally suited for the identification of high-unit-value products 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:

1. Tote boxes, containers, barrels, tubs, and pallets;
2. Tool carriers, monorail and power, and free conveyor trolleys; and
3. Lift trucks, towline carts, automatic guided vehicles.

Primary applications fall into two basic categories:

1. Direct product identification wherein the tag specifically identifies the item to which it is attached (e.g., by part number or serial number or, in the case of read/write systems, assembly or process instructions for the item).
2. Carrier identification where content is identified manually (or with a bar code reader) and fed to the control system along with the carrier's machine-readable RF "license plate number." Subsequent load tracking is accomplished by strategically deployed RF readers.

The automotive industry uses RFID systems to track vehicles through assembly, where tags must perform even after repeated subjection to temperatures of 150 to 200 C, painting, etc. A primary objective for use of the technology in this environment is verification of vehicle identity prior to execution of given assembly tasks. Although manufacturers sequentially track vehicles through assembly, undetected removal of a single vehicle from the line could be costly. Because RFID tags need not be "seen" to be read, they can be buried within pallets, tote boxes, and other containers and provide solid performance for the life of the carrier. As an example, in a casting operation RF tags are attached to wire baskets which travel through a variety of degreasing, etching and cleaning tanks by means of an overhead power and free conveyor - not a job for optical or magnetic identification media.

In a manner similar to carrier identification, RF tags can be used for tool management. Miniature tags can be placed within tool heads of various types such as block or Cat V-flange, or even within items such as drill bits where individual bits can be read and selected by reader guided robot arms. RFID systems are used for lift truck and guided vehicle identification in a number of installations. One approach buries tags at strategic locations throughout the facility and verifies vehicle location via on-board DC-powered readers. Other users station readers at the ends of warehouse aisles to monitor lift truck activity. Here, throughput rates permit multiplexing multiple antennae per reader.

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.

Animal Identification

Valuable breeding stock, laboratory animals involved in lengthy and expensive research projects, meat and dairy animals, wildlife, and even prized companion animals all present unique identification problems that can be solved by innovative applications of RFID technology.

Frequently Asked Questions:

Radio Frequency Identification

Do you have a question that is not listed below? Send it to us and we will be happy to respond.

Q. When would I want to use read write (R/W) versus read only (R/O) tags in my application that employs radio frequency identification?

A. It is necessary to assess your entire information management infrastructure before selecting the best type of tag for your application. There are pros and cons to both centralizing your data processing (using R/O tags) or de-centralizing (using R/W, and using the tag as a data carrier.) RFID tags collect a wealth of real-time data. To put this to the best use for good decision-making, the information has to be quickly available up and down the supply chain to all the individuals who can use the input. Typical legacy systems often do not have this capacity nor capability. And, in fact, the information about an item usually moves more slowly through the supply chain than does the item itself. Therefore, it might be best to store data right on the R/W tag with the moving item so that it can be updated and others can take advantage of it locally. If, however, your operation does have an advanced central data processing capability, then a less expensive R/O tag that uniquely identifies an item, can be coupled with time/date stamping or other information at certain points, and relate back to a file held in a central location. AIM would like to thank Texas Instruments for providing the answer to this question.

Q. I would like to use an RFID system, but I already rely on a wireless data network and I can't tolerate any interference. Is this a problem?

A. Not at all. In most cases, the wireless network and the RFID system will not even use the same frequency band, and therefore it is no more of an interference problem than trying to watch television while talking on a cordless phone. Even when the two systems use the same frequency it is not a problem if some simple steps are taken. For example, you would not want to install an RFID reader right next to, or aimed directly at, an RFLAN access point unless the two radio systems were controlled by a single machine that made sure they did not both transmit at once. AIM would like to thank ID Systems Magazine for providing the answer to this question.