TRADITIONAL AND EMERGING TECHNOLOGIES AND APPLICATIONS IN THE RADIO FREQUENCY IDENTIFICATION (RFID) INDUSTRY

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Abstract

The Radio Frequency Identification (RFID) industry is growing exponentially. Although RFID has been used for automatic data collection since World War II, its growth has been relatively slow through the 1990s. Recent technological developments have opened the door to many new applications of RFID technology that, combined with end-user education, should drive excellent growth through the end of this decade and beyond. Current and emerging uses for RFID technology include a variety of applications such as: toll road and parking area access, intermodal freight container identification, pallet tracking, railroad and truck (rolling stock) tracking, animal identification, work-in-progress tracking, and matching passengers with bags at airports. The strongest new trend in the industry is entry of large semiconductor companies into the marketplace.

Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) technology uses electromagnetic energy as a medium for sending information. The two basic elements--a reader and a tag--are connected to a host computer that controls the reader. The basic concept is that the tag contains data that can be retrieved over the air by the interrogator.

Radio frequency identification (RFID) technology overcomes the limitations of other automatic identification approaches that use light to communicate, (such as bar codes and infrared technology) because a tag may be hidden or invisible to the eye and can be used in harsh or dirty environments. Readers can be set to remotely and automatically read without labor-intensive manual scanning of the object as in most bar code systems.

With RFID technology, one can tag anything from containers to individual assets, to animals, to people, and then automatically track them via an interrogator or reader. Interrogators are connected to a host computer which may contain additional data tied to the object's identification number. The tag contains programmed information about the object to which it is attached. The reader, via its antennae, can then query its working volume to see if a tag is present.

An RFID tag typically includes a receiver and some type of transmitter, an antenna, and memory. Performance specifications for many types of RFID tags can be forged from the following list of choices:

- read-write or read-only memory
- battery powered (active), or without battery power (passive),
- active transmit or modulated backscatter (MBS) (passive or reflective transmit)
- large or small size
- long or short range (maximum distance between tag and reader)
- high frequency (above 100Mhz), low frequency (usually 125 Khz).

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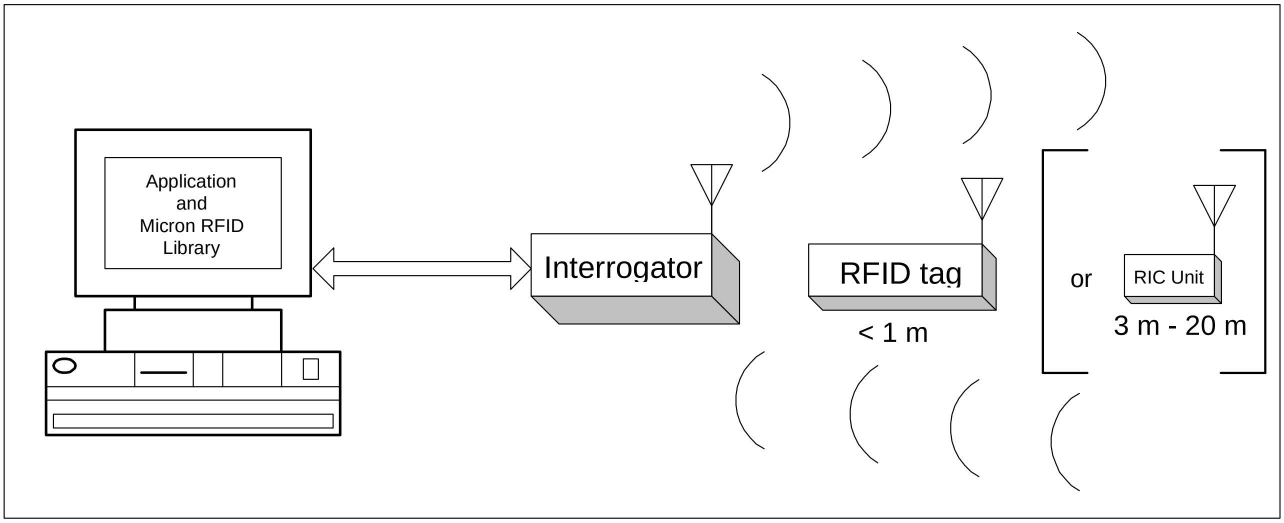

Figure 1. Block diagram of a basic RFID system.

Much of the language to describe RFID tag functionality comes from the computer, memory, and communications industries. For example, read-write RFID tags have a type of memory that can be read and written to, at will, via commands from a reader. However, read-only tags have an identification number "burned in" one time, either at the factory or at the end user's facility, and cannot be changed after that—only read.

There are two categories of tags—active and passive--that represent the types of RF communication. Tags without batteries are known as passive tags because they derive their power from the RF energy transmitted from a reader. Smaller RFID tags tend to be passive (without batteries), read-only, and short range (under six feet), whereas battery-powered, active tags, tend to be larger, but usually offer read-write and long range capability.

There is another use of the words "active" and "passive" when describing the type of data transmission from the RFID tag to the reader, which can be confusing. Active transmitters actually send data back to the reader with radio power generated from the tag. Passive tags, on the other hand, use modulated backscatter (MBS) transmit to reflect energy, dictated by the data stream from the tag, back to the reader. MBS is better in gate or lane applications where you don't want to wake up (see) any tags beyond a certain distance and where there are few obstructions in the energy path. With MBS, the energy from the reader must pass through obstructions twice--once moving from the reader to the tag and again moving from the tag to the reader. Unlike MBS transmit, active transmitters are used in applications involving significant obstructions (because they don't depend upon energy from the reader) and for longer ranges (say, over 100 feet).

Much of the range that various tags claim to offer has to do with the RF frequency at which they operate. Low frequency tags tend to use hundreds of turns (windings) of copper wire because they are coupled by the magnetic fields. High frequency tags tend to use single-turn loop or dipole antennas, which, fortunately, are more efficient than multiple windings. It is important for the high-frequency tags to have more antenna efficiency since, because of free space patch loss, the tags must use more power to transmit over the same range compared with lower frequency tags.

RFID Advantages

RFID systems overcome the limitations of other automatic identification approaches, such as bar coding, because they do not require unobstructed line-of-sight between the transponder and the reader. This means that they work effectively in hostile environments where excessive dirt, dust, moisture, and/or poor visibility would normally hamper rapid identification. The primary benefit of RFID is its ability to read through nasty environments and at relatively remarkable speeds—often responding in less than 50 milliseconds. In addition, RFID is normally completely automatic and transparent, eliminating the need to scan an object manually or activate a magnetic stripe by swiping it through a slot.

Remote Intelligent Communications (RIC)

Although remote intelligent communications (RIC) units also may use active or passive transmit technologies, they differ from the traditional RFID units because RIC units usually have a battery, a microprocessor, more memory, a high-frequency radio, and long range capability. The term RFID doesn't adequately describe this level of technology and capability. The acronym RFID would be misleading and imply limitations that don't exist in RIC systems.

Micron Communications, Inc. has coined the RIC acronym and developed the MicroStamp RIC family of products, which are smaller, less expensive, and higher performing than other currently available RIC units. The MicroStamp unit contains the MicroStamp Engine and integrated circuit (IC), which combines a direct sequence spread spectrum (DSSS) microwave frequency radio, a microcontroller, and a low power static random access memory (SRAM) into a single chip. The MicroStamp Engine IC, when coupled with an antenna and a battery, forms the MicroStamp unit. Because the IC combines hundreds of thousands of components on one small chip, and because efficient antennas are small at these higher frequencies, the MicroStamp may be assembled, with a small battery, into very small packages. Other companies, such as Amtech, SAVI and AT/Comm also manufacture RIC products.

Emerging Technologies & Trends

Emerging uses of RFID technology and industry trends are determined by enabling technology combined with market forces. Technology users are looking for a variety of RFID applications solutions, interoperability between systems, and new technologies that are smaller and less costly than those currently in use. Industry leaders are developing solutions for these needs. The dominant process leading to reduced cost is integration onto Silicon. The holy grail is the "single-chip" solution—for either RFID tags of RIC units. That is why large semiconductor companies are entering the field. Motorola bought Indala, Raytheon bought SAVI, and Micron Technology started Micron Communications.

RFID manufacturers are creating systems that meet the demands of consumers. Some of the developments using RFID technologies in use today are: aircraft identification, rail car and shipping container identification, animal identification, sports timing, toll road control, electronic vehicle keys, electronic article surveillance systems, personnel access, and production control.

According to industry experts, the growth of RFID, despite its potential, has been stymied by the inability of RFID systems to communicate with each other. The trend in the industry was to create specific standards for each separate application. Single-source supplying of RFID technology creates a monopoly, which drives prices up—and deters customers. Some companies are addressing this problem. To help untangle the numerous conflicting standards, many manufacturers in the industry are working to create a standard open protocol that allows global communications, interfaces with existing radio frequency systems, and is transparent to the new radio frequency networks.

Recent developments in RFID technology will help provide more cost effective RFID solutions—combining high performance with small size and low cost through the process of integration. For example, engineers at Micron Communications, Inc. have integrated computer memory, a microcontroller, and a microwave radio on a single chip (15.64 sq mm) that they have named the MicroStamp Engine™ integrated circuit (IC). The Silicon chip contains a 2.45 GHz microwave radio, a microcontroller, 256 bytes of static random access memory (SRAM), and a 10-byte user ID. The integration of these components onto a single chip has reduced the size of RFID tags, with comparable capabilities, as much as 90 percent. The company produces its MicroStamp RIC units by combining the chip with a battery and an antenna. This technology has significantly lowered the size and cost of active tags.

The Future of RFID

The time constant of exponential growth of the RFID industry will be determined by the availability of smaller size, lower cost, and higher performance RIC units and peripherals, the rate at which industry can absorb and adopt the enabling technology, and the establishment of industry standards.

According to industry analysts, the market for RFID systems is expected to grow approximately 30 - 35 percent each year for the next four years, reaching $800 million by the year 2000; but this does not incorporate the effect of any new or emerging technologies and thus is probably low. Annual RFID industry revenues are in the $200 - $250 million range for 1996. Going forward, RFID applications that the marketplace has expressed a desire for are:

- Airline passenger/baggage tags.
- Asset Management.
- Medical Identification.
- Weapons Control.
- Critical Parts Tags.
- Lot Control.
- Part Recall Data.
- Calibration Data.
- Contactless or remote "Smart Cards"
- Product Tracking.
- Inventory Control.
- Counterfeit Control.
- Tool Management.
- Security Passes.
- Prisoner Identification.
- Clean Room Tags.
- Process Control.

Conclusion

As more industries become familiar with the flexibility and usefulness of RFID and RIC technologies, demand for solutions to new application requirements will increase. In addition, the emerging technologies will be seen as enabling and become even more attractive as performance is improved and the size and cost of systems is reduced. Recent technological developments should mean excellent growth for the industry. The trend toward the increased involvement of the semiconductor manufacturers suggests vigorous and continued exponential future growth will occur in the RFID and RIC industries.