The Latest in Networking and Wireless Technologies

Open Communication

Radio Frequency Identification (RFID)

Wireless technology comes in all shapes and sizes these days. Radio Frequency Identification or RFID is one of them. You have probably seen the initials RFID and didn't really know what they meant. Yet, you may already be using it.

If you have a company identification badge where you work and you have to wave it in front of a box to get in, you are using RFID. If you use an E-Z Pass on your windshield to pay your tolls, or use you ExxonMobil SpeedPass to buy gasoline, you are using RFID. If you shop at Walmart, you have experienced RFID. If you are in the military, you may be wearing RFID or using it to keep track of your equipment.

In any case, RFID is an electronic method of identifying objects and things with an electronic code, then transmitting it wirelessly when asked. It is just like the bar code that appears on almost every object we buy and use, but you don't have to have a laser reader to scan it. You can read the RFID code by radio many feet away. Here is an introduction to this rather hot wireless topic of the day.

How Does it Work?

The main component of an RFID system is the tag. Also called a smart card or a transponder, this is a tiny silicon chip containing a small memory containing a unique electronic product code.

The chip is usually bonded to a flat piece of plastic containing a loop antenna. The chip is typically only a few millimeters on a side, but the copper antenna loop on the plastic can be several inches wide. See Figure 1. The tag is then pasted to a box, pallet, carton, or other object just like a mailing label.

The other part of the system is the reader or interrogator. This is a radio transmitter/receiver designed to interrogate the tag and read its stored code. Figure 2 shows the complete system. Here's what happens.

To read the tag, the transmitter in the reader powers up and transmits a signal to the tag. Unlike standard radio, in RFID, the signal transmitted is not the usual electromagnetic signal. The electromagnetic signal occurs only when it travels more than about one wavelength from the antenna. This is called the far field. At a distance less than one wavelength (λ) where a wavelength is $\lambda = 300/f_{MHz}$ meters where f_{MHz} is the operating frequency.

The tag only sees the magnetic field from the reader antenna. This is called the near field. In fact, the reader antenna acts like the primary winding of a transformer. The magnetic field it produces cuts across the tag antenna that acts like the secondary winding of a transformer. The voltage induced into the tag antenna is sent to a rectifier and a filter on the tag chip where it develops a low DC voltage that is used to power the circuits in the tag. Neat, huh? The tag doesn't have its own power source. Instead, it uses the RF power from the reader and converts it to DC to operate the circuits.

When the tag powers up, it transmits the special electronic code in the memory back to the reader. The memory is an electrically erasable read-only memory (EEPROM). The code is written into the memory by the manufacturer. The serial data is used to modulate the reader signal.

What the tag does is modify the impedance of the antenna in such a way that the reader detects a loading and unloading of the circuits. It is the same as putting a heavier load on a transformer and that, in turn, causes a change in the amplitude of the primary signal. The result is a form of amplitude modulation known as amplitude shift keying (ASK). The form of ASK is referred to as backscatter modulation.

Back at the reader, a peak detector — usually a type of voltage-doubling diode rectifier circuit — demodulates the ASK and the slicer shapes it up into a clean serial data signal that is then usually transmitted back to a computer via an RS-232, RS-422, USB, or other interface. The computer then identifies the tag and goes on to perform whatever the application requires.

Some More Technical Details

A major factor in the use of RFID is the frequency of operation. The most common ones are 125 kHz, 13.56 MHz, and 915 MHz. Sometimes 2.4 GHz is used. In any case, these frequencies are those blessed by the Federal Communications Commission

Figure 1. A typical RFID tag for 13.56 MHz. The chip is too small to see, but you can make out the fine copper loop pattern that is the antenna. Courtesy of Texas Instruments.

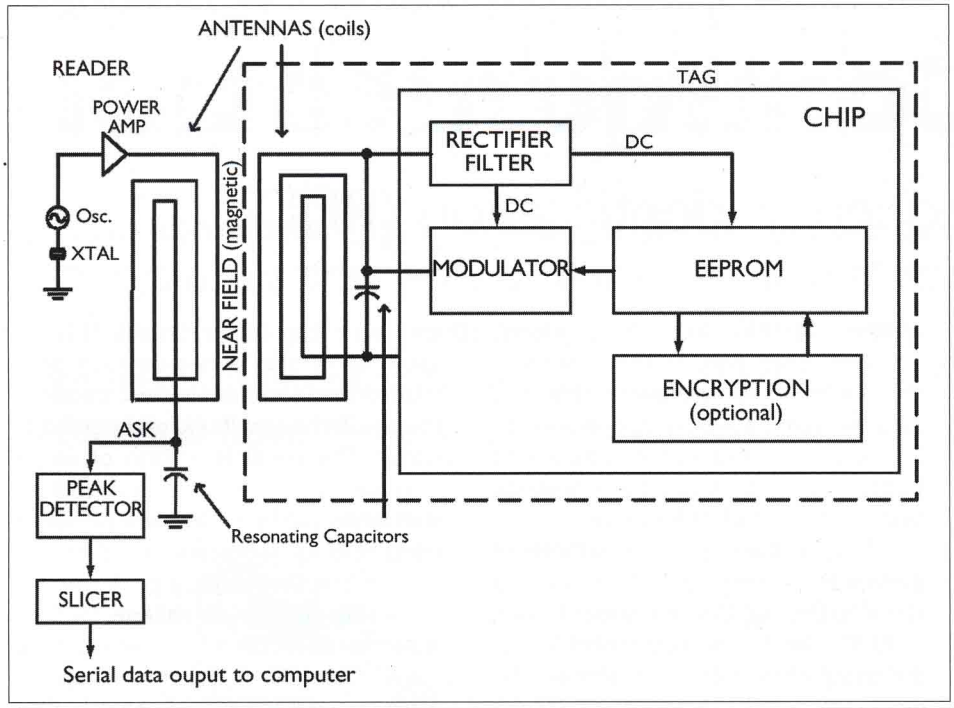

Figure 2. Complete block diagram of a basic RFID system. The reader has an output power of about one watt and is good for up to three feet or so at 13.56 MHz (the most common frequency). The resonating capacitor on the tag is a surface-mount type that is outside the chip. Anti-collision circuits are not shown.

(FCC) for unlicensed uses. These are what are known as the industrial-scientific-medical (ISM) bands and they are covered under the FCC's Part 15 rules and regulations.

The first tags available decades ago used the 125 kHz frequency. This frequency works best if there is lots of metal nearby or if water is involved. The 125 kHz tags work best on humans and animals because they are mostly made up of water, anyway. Tags are widely used for animal tracking and are at the heart of tracking the mad cow problem of recent years. The read range at this frequency is pretty short, no more than about 18 inches or so.

The most popular frequency is 13.56 MHz. The tag's antennas can be smaller at this frequency and the read range is much greater — up to three feet or so. The 915 MHz UHF tags give the best reading range of six feet or more. The forthcoming Generation 2 tags use this frequency and can achieve a read range up to 30 feet, in some cases.

Another technical issue is the data rate or the speed with which the data in the tag memory is read out. The low frequency tags have a very low data rate of only a few kilobits per second (kbps). The 13.56 MHz tags have a faster rate in the 50 to 100 kbps. This is usually fast enough, given that the amount of data in the tag is not great — only 64 to 96 bits in the simpler tags. So even at this low speed, the reading seems almost instantaneous to us.

Basically, the higher the operating frequency, the higher the potential data rate. The new UHF tags have a 212 kbps rate and the newer standards call for 424 kbps (and even higher) rate. The higher rates are desirable especially when the reader is trying to read lots of tags in sequence or tags that are together in a batch.

That brings up another issue — tag interference. If a reader tries to read two tags next to one another, both tags power up and try to send data to the reader. The result is interference, read errors, or no read. To prevent this problem, many of the newer tags have an anti-collision feature that prevents this problem.

Different manufacturers handle this in different ways. One tag maker uses a time division multiplexing scheme where each tag responds in its own assigned time slot. Another uses an access method that causes each tag to wait a random length of time before transmitting, which ensures that no two tags transmit at the same time. With anti-collision and high data rate features, readers can read a whole

slew of items together in a pile.

One other feature found on some of the newer tags is security. These tags have encryption built in so that it scrambles the data so that no one else can read and understand it. For most applications, this is not necessary, but when RFID tags find their way into credit cards and passports, we won't want anyone else to hack into the system and steal our ID numbers and use them to charge up our credit cards.

While most RFID tags are passive (no internal power source), active tags containing a battery are also available. These tags are bulkier and more expensive, but with a battery, they can be read at distances up to a couple hundred feet. These are used on the more expensive items to be tagged like big pallets or shipping containers or capital equipment items like trucks or military equipment.

The big issue in getting RFID adopted is tag cost. Bar codes are super cheap since all you have to do is print them on the package. Passive RFID tags are relatively expensive. Today the cheapest tags are about 25-30 cents. If the item being tagged has a price or value near that, it is probably not worth tagging. Any item with a value of $10.00 or more can probably stand the extra cost of a tag. The hope is that technology will drive the tag price down to 5-10 cents, but that may never happen. Yet, at 25 cents, lots of items will get tagged.

Figure 3. A typical 125 kHz tag used for animal tracking. Courtesty of EM Microelectronic.

A Technology Solution Looking for a Problem

RFID is like many electronic products — an answer looking for a question. Yet, it has found many applications. Probably the most common use is in access and payment applications such as building access, access to parking lots, toll roads, and other for-pay facilities. As mentioned previously, animal tracking is a big one. See Figure 3.

The application with the greatest potential is supply chain manage-

ment where companies like Walmart, Gillette, Proctor & Gamble, and other big retailers will tag products rather than mark them with bar codes. The big benefit is that the tags can be out-of-sight, but be read anyway. You don't need direct line-of-sight as you do with a bar code laser reader.

Ultimately, the goal is to be able to read an entire basket full of groceries, price them, and charge the buyer's credit card in less than a second. The tags are currently still too expensive for small consumer applications, but putting the tags on cartons, pallets, and whole shipments of products will help track inventory, take inventory, and restock when supplies run low.

RFID is also showing up in manufacturing. Bar codes have been used for years to track work in progress and materials handling. Now, electronic tags are taking their place. These tags can be written to during processes to update them with related status information.

The military is also using RFID. The Department of Defense (DoD) mandated the use of RFID recently to track the tons of materials that go to Afghanistan and Iraq. It makes locating supplies much easier. With a hand-held reader, a soldier can find out which crates contain the new batch of MREs without unpacking everything else. Anyway, you get the idea.

Even credit cards are getting into the action. Cards with RFID chips are called smart cards and are already popular in Europe. American Express has their high-end Blue card with a chip inside. Soon Visa and MasterCard will follow.

The government will begin putting RFID chips in the new passports starting this year. You should expect states to begin putting them into driver's licenses since that credential is one of our most used forms of identification.

Something to Think About

RFID is one of the fastest-growing, wireless technologies. It is widely used now, but this is just the tip of the iceberg. The interesting thing — or maybe the scariest thing — is that RFID is nearly invisible. We don't readily see it and we may not know when it's being used. The chips will provide speed and convenience in the retail business and automate many things we now do manually.

Are our rights being violated? Maybe, maybe not. How do we feel about it? We'll probably just have to adjust to it whether we want it or not. And isn't that the way it is with most electronic technology we use right now? NV

Resources

EM Microelectronic
Manufacturer of tags and equipment.
www.emmicroelectronic.com

EPCGlobal
One of the organizations that develops standards for RFID.
www.epcglobalinc.org

How Stuff Works
Website with lots of info. Check this one out if you have never seen it.
www.howstuffworks.com

Intermec Technologies
System Integrator of RFID.
www.intermec.com

Philips Semiconductors
Large company with lots of RFID products.
www.semiconductors.philips.com

RFID Gazette
Online newsletter.
www.rfidgazette.com

RFID Journal
RFID magazine.
www.rfidjournal.com

Texas Instruments
Texas Instruments is a major supplier of RFID products.
www.ti-rfid.com

Zebra Technologies
Good source of general RFID information.
www.rfid.zebra.com