ANTENNAS key to defining RFID future

A number of factors contribute to making antennas one of the last great hurdles facing RFID technology. Understanding antenna design and use of new and innovative antenna solutions are helping to drive down RFID cost while improving performance.

By Cheryl Ajluni, Editor

Radio frequency identification (RFID) systems comprise three components: an antenna and transceiver (often combined into a single reader), and a transponder (also known as the tag). The tag can be either active or passive and houses the antenna, electronic circuitry and information to be transmitted. An active tag requires an internal power source, whereas a passive tag does not. During operation, the reader uses RF waves to transmit a signal that activates the tag. In turn, the tag transmits data back to the reader where it can be transferred to a processing device.

RFID systems are distinguished by their frequency ranges. Low-frequency RFID systems (30 kHz to 500 kHz) generally have short transmission ranges of less than six feet and lower system costs. They are used for applications like security access, asset tracking and animal identification. High-frequency RFID systems (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz), on the other hand, offer a longer transmission range of more than 90 feet and have high reading speeds. They are typically used for railroad car tracking and automated toll collection.

While on the surface RFID technology may seem strikingly simple, the antenna is where things can quickly get complicated and expensive. Effectively addressing those complications is key to driving down RFID cost and enabling its widespread and pervasive adoption.

A closer look at the antenna

One of the primary reasons for the antenna's complexity lies in its basic physics. Consider that antennas are reciprocal devices. They often perform the same in the receive mode as they do in the transmit mode. In transmit mode, the antenna from a passive tag, for example, is fed energy from a transmitter. Most conventional readers have an output driving impedance of about 50 Ω and use a length of 50 Ω coaxial transmission cable to feed the antenna. Adjusting the antenna's impedance match ensures that most of the energy available goes into the field radiation energy and that minimal energy is wasted on reflections. Passing energy from the source to the antenna requires that the antenna terminals are matched to a 50 Ω input impedance. If the impedance is not matched, additional energy losses may be incurred.

This input impedance match constitutes one of three primary parameters associated with high-frequency antenna design. Center frequency resonance and bandwidth "Q" are the other two parameters.

The antenna must be tuned to a resonance at the center frequency in which the RFID system will operate. High-frequency labels operate at a center frequency of 13.56 MHz, while UHF EPC labels operate on center frequencies of 860 MHz to 960 MHz. The RFID antenna can be tuned by matching a combination of inductance and capacitance. If the antenna is not tuned broadly enough, the sidebands won't fit into the bandpass of the antenna. If the antenna is tuned too wide, the sidebands will pass through along with unwanted random ambient noise.

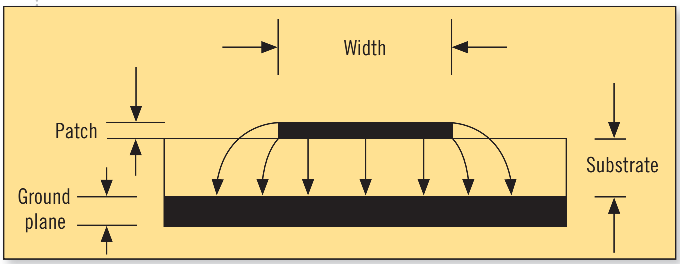

Figure 1. This graphic provides a cross section of a microstrip patch.

Figure 2. The M/A-COM MAANAT0123 antenna for the U.S. market (902 MHz to 928 MHz operation) features 6.5 dBi typical, VSWR of 1.4:1 typical and 10 KΩ sensing circuit resistor. It measures just 19.6 inches x 8.8 inches x 1.6 inches.

As a result, the quality of the received signal will be degraded.

Bandwidth "Q" describes relative bandwidth. To accommodate the wide variety of configurations in which the RFID antenna will need to operate, the antenna must be de-tuned for the widest bandwidth that the RFID system will allow. This may be accomplished by changing the inductive or capacitive components of the antenna.

Other factors contributing to the complexity of the antenna, whether low or high frequency, are its size, shape and thickness. The size of the antenna is directly proportional to the signal and range; thus the larger the antenna, the larger the signal and the greater its range. Typical tag antenna sizes, for example, range from less than an inch to four or five inches. Antennas also come in a variety of shapes, although the vast majority are built using rectangular or circular shapes and have a relatively low number of turns (e.g. between four and 10). With regard to thickness, the greater the antenna thickness, the longer its read range. Effectively addressing the antenna's size, location and thickness will help to determine its optimum layout.

Antenna options

A variety of antenna options are available for use in RFID systems. These innovative new options, coupled with things like unique tag packaging (such as chipless tags based on nanotechnology), will play a central role in defining future uses of RFID technology.

To better understand the nature of antenna innovation, consider that RFID antennas have traditionally been made by taking a sheet of copper and etching away layers until the desired thickness is achieved. This process can be an expensive and time-consuming proposition. One possible alternative is the printed antenna.

Printed antennas from Precisia (www.precisia.com), for example, use conductive ink instead of copper, and are fabricated via standard printing processes. Similarly, a low-cost metal antenna comes from collaboration between the England-based QinetiQ (www.qinetiq.com) and Coates Screen (www.coates.com). With the QinetiQ method of "growing" antennas, specially formulated ink is printed on a substrate material such as cardboard or polystyrene. The substrate is then passed through an electroless solution, which uses chemicals, as opposed to electric current, to deposit metal onto a surface. The metal in the solution reacts with chemical in the ink and is deposited on the substrate wherever there is ink.

This method of producing antennas is considered much more cost-effective than the conventional method of etching copper antennas in terms of the cost of materials, capital equipment and floor space used. It is also less expensive than antennas printed with metallic inks or conductive polymers. And since the "grown" antenna has the same physical and electrical properties of ordinary metal, RFID tags with antennas made from this process perform as well as tags manufactured conventionally.

Another innovation, the microstrip patch antenna, is suitable for use in high-speed RFID reader systems (Figure 1). Its features include a low profile, low cost, low sensitivity to manufacturing tolerances, versatility, and a highly efficient design. It also takes advantage of the existing printed circuit board (PCB) processing infrastructure. The Arlon Materials for Electronics (www.arlon-med.com) FoamClad family of laminate composites is suitable for the manufacture of microstrip patches. It consists of a low-permittivity, microporous polymeric core bonded to an impermeable copper-clad polymer film overlay.

In addition to these companies, a number of other RFID providers are working to develop advanced RFID antenna solutions. Some of these providers include:

- Dynasys (www.rfidusa.com)—offers de-QTM high-frequency RFID antennas.
- Graphic Solutions International (www.graphicsolutionsinc.com)—offers printed RFID antennas.
- Hannita Coatings (www.hannitacoatings.com)—develops and manufactures low-cost, pure copper antennas and print substrates optimized for printing by conductive inks.
- HD Communications (www.hdcom.com)—offers a line of 915 MHz directional and omnidirectional antennas.
- Intermec (www.intermec.com)—offers the Intellitag RFID antenna family for fixed applications and vehicle-mount applications where shock and vibration can exceed average industry specifications.
- M/A-COM (www.macom.com)—offers compact, slimline antennas for fixed readers (Figure 2).
- Symbol Technologies (www.symbol.com)—offers general-purpose antennas, high-performance area antennas and dual-directional panel antenna arrays that feature a compact, low-profile housing designed for greater mounting and application flexibility.
- UPM Rafsec (www.rafsec.com—offers the OneTenna antenna that replaces four existing antenna designs and can function in every region of the world.

Emerging applications for RFID technology are varied, ranging from electronic car security, criminal penal monitoring and toll-booth electronic payments to finding lost golf balls on a golf course. Transponders can even be embedded in clothing and encoded with washing, folding and ironing information. Appliances could then interrogate the garments to set up their correct washing cycle, water temperature and spin cycles. While many more intriguing applications lay just beyond the horizon, reaching that point means that the industry must first decipher the complexity of RFID antennas. Understanding their physics is the first step. Continued development of advanced antenna solutions will also play a crucial role in reaching that goal. EWT