

BY WARREN WEBB • TECHNICAL EDITOR

RFID IN EMBEDDED DESIGNS:

YOUR MOVE



WITH A BUILT-IN RFID READER, EMBEDDED SYSTEMS CAN EXCHANGE DATA WITH TAGGED ITEMS TO CREATE A NEW CATEGORY OF APPLICATIONS IN TUNE WITH THEIR SURROUNDINGS.



RFID (radio-frequency-identification) technology has the potential to become a common and important element in embedded-system design. In addition to the traditional role of the technology in inventory management, recent advances in RFID tags and high-speed, long-range readers allow embedded-system designers to easily incorporate features such as access control, counterfeit prevention, simplified payments, medical authentication, dynamic pricing, product histories, and remote asset tracking. Embedded-RFID applications typically incorporate a reader within the product or system to add local data-gathering features that enhance the primary functions of the product. You can now


find embedded-RFID applications in hotels, prisons, hospitals, retail outlets, farms, casinos, toll roads, and factories, along with a host of commercial and military vehicles. These nontraditional RFID applications will become commonplace as embedded-system developers recognize the value and adopt the technology in new designs.

RFID has verged on being the next big thing since its conception in the middle of the 20th century. The US military used an early form of RFID as far back as World War II to distinguish between enemy and friendly aircraft. The first commercial RFID applications evolved during the 1970s and '80s to track or identify items within a single location. However, developers of many of the early RFID deployments based them on proprietary technology, each using a unique method for communications and requiring specialized reader hardware from the same company as the tag. This lack of standardization resulted in industry fragmentation, slow adoption, and

failure to live up to the RFID-technology hype. Today, developers are rectifying most of the early problems, and RFID is a growing industry with dedicated systems in logistics, access control, counterfeit prevention, item-level inventory, contactless payments, and a host of new embedded-system applications.

One of the most basic but widespread uses of RFID technology is the EAS (electronic-article-surveillance) systems that retailers use to wage a high-tech war on shoplifting. The crime costs the industry billions of dollars per year; losses are so high that retailers easily justify the purchase of expensive electronic systems to deter theft. EAS systems employ large antenna panels at store exits and security tags of all sizes attached to high-risk goods. The basic principle behind all EAS systems includes the use of a transmitter to create an electromagnetic field across the store's exit area and a receiver that can detect variations in the field. Small tuned circuits or magnetic material inside security tags that pass through





the exit modifies the field enough for the receiver to detect the change and activate an alarm. Clerks must remove or deactivate security tags when a buyer purchases the item to prevent the alarm from sounding when the customer exits the store.

REFLECTED DATA

Developers of most of the newer RFID architectures based them on low-cost transponders, or tags, which consist of an IC for data storage and communications plus an external antenna. Tags come in two basic varieties: passive and active. Passive tags contain no power source and rely on the RF signal from the reader to induce a small electrical current in the antenna; this current is sufficient to transmit a response. RFID tags transmit data by varying the amount of reflected energy from the reader's RF signal. Passive tags have a range as long as 30 feet, depending on the reader's power output, antenna configurations, and the operating frequency. The RF-LoopTag from Bielomatik, an expandable antenna arrangement, provides both short-range and midrange passive-RFID tags (**Figure 1**).

You can considerably extend the range with an active-RFID tag that contains its own power source, such as an internal battery. Active tags can transmit data at a higher power level and are generally more accurate than the passive variety. Active tags generally find use with high-ticket items, such as military vehicles or cargo containers. The antenna configurations for RFID systems depend on the application, the environment during read sessions, and the operating frequency.

Governments have allocated several frequency bands for RFID; however, they are not uniform worldwide. LF (low-frequency) devices operate in the 125- to 134-kHz range and find use in applications such as access control, animal identification, asset

AT A GLANCE

Although RFID (radio-frequency identification) dates back to the 1940s, noninteroperable proprietary products and the lack of standards have hindered the technology's potential.

Passive-RFID transponders contain no power source and rely on the incoming RF signal to induce a small electrical current in the antenna sufficient to transmit a response.

Depending on the size of the antenna and the transmitting power, embeddable RFID readers can interrogate transponders moving at highway speeds with ranges exceeding 30m.

Global standards and business and government mandates have extended the reach of RFID; however, privacy and security concerns continue to hinder universal acceptance.

tracking, and automobile-security key fobs. The HF (high-frequency), 13.56-MHz tags find use in applications with a required reading range of less than 3 feet. Unlike other frequency bands, HF

tags are not susceptible to interference when transferring data near metals or water. The UHF (ultrahigh-frequency) band of 860 to 960 MHz is popular for new applications because of the 3 to 5m reading range and the higher data-exchange rates. Typical UHF applications include asset tracking with tags attached to pallets and shipping containers that operators can discover and log as they pass through reader-mounted portals.

Over the past few years, there has been a concentrated effort to create a uniform set of standards for tags and readers in each frequency band. The ISO (International Organization for Standardization) and the IEC (International Electrotechnical Commission) have created a number of RFID standards covering many aspects, such as frequencies, data-encoding methods, and uses of RFID technology. For example, the ISO/IEC 14443 and 15693 standards define the communications-interface protocol for RFID tags used in payment systems and contactless smart cards and in vicinity cards. ISO has also created standards for testing the performance of RFID tags and readers. In addition, the ISO/IEC 18000 series covers the air-interface protocol for automatic identification and

item-management systems to track goods in the supply chain.

TRANSPONDERS

Several manufacturers produce RFID-transponder chips for use in tags. For example, Texas Instruments offers a line of Tag-it HF-1-plus-transponder ICs that conform to the ISO/IEC 15693 global standard for product-authentication, access-control, asset-tagging, supply-chain-management, and ticketing applications. These products offer a user-accessible memory as large as 2048 bits in 64 blocks and an extensive command set to select a tag and read, write, or lock stored data. The device identifies multiple transponders appearing in the reader's RF field

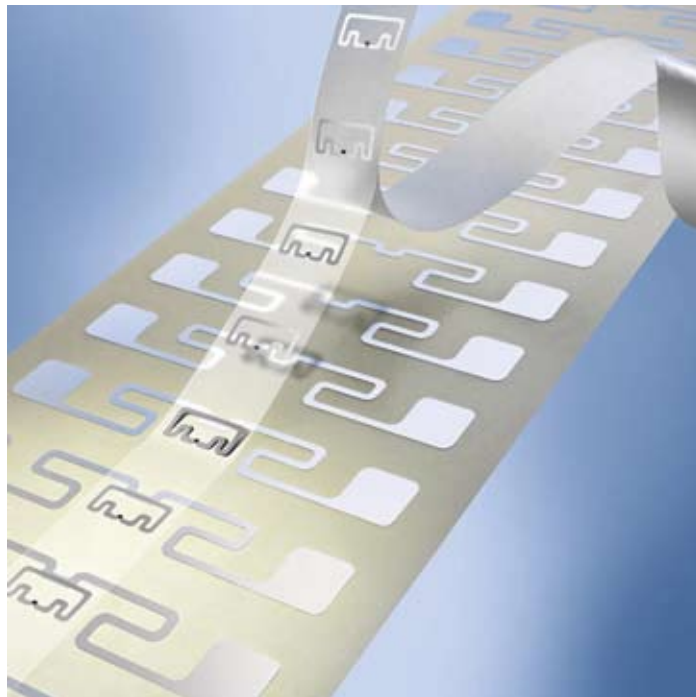


Figure 1 The RF-LoopTag from Bielomatik combines an NXP Semiconductors chip with an expandable antenna arrangement to provide both short- and long-range RFID tags.

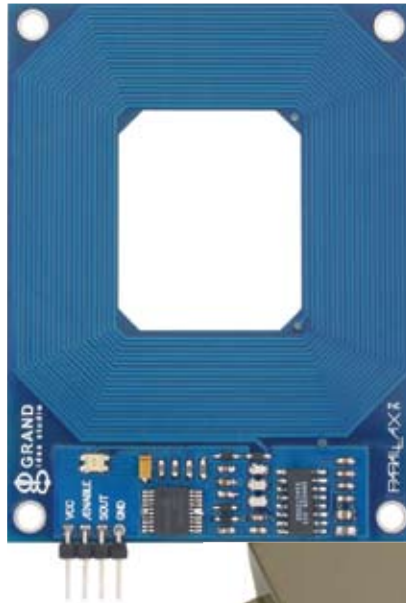


Figure 2 Selling for less than \$40, the Parallax reader provides a low-cost, entry-level device to read passive-RFID tags for experimentation or embedded-system applications.

Figure 3 The Model 236002 UHF RFID reader/writer from GAO RFID supports two external antennas and reads moving tags at 10m/sec at a range as long as 7m.



by a unique identifier code that is programmed and locked at the factory. According to ISO/IEC 15693, communication between the reader and the transponder or downlink communication takes place using ASK (amplitude-shift-keying) or FSK (frequency-shift-keying) modulation operating with either a high or a low data rate. The transponder answers in the same mode that the reader used to interrogate it. The technology frame-synchronizes uplink and downlink communications and secures them using a CRC (cyclic-redundancy-check) check sum.

Most embedded-RFID applications require a dedicated reader as part of the design to interpret local tags. A vending machine provides a good illustration of an embedded-RFID application. With a built-in reader, the machine can accept contactless payments from RFID cards. In addition, if the dispensed items are tagged, the machine can keep track of its inventory to automatically order refills. Small and low-cost embeddable readers are essential to these applications and are available from Texas Instruments, Skyetek, Parallax, and others. For example, a low-cost RFID-reader module that Parallax developed in cooperation with Grand Idea Studio works in passive-transponder tags in access-control, automatic-identification, robotics, navigation, inventory-tracking, payment-system, and

car-immobilization applications (Figure 2). The module features a 2400-baud serial interface and requires a 5V-dc power source. Prices for the Parallax reader start at less than \$40 each.

For more rugged or industrial applications, GAO RFID offers a UHF RFID reader/writer supporting two external antennas (Figure 3). Operating in the 902- to 928-MHz frequency band, the Model 236002 targets high-speed warehousing, distribution, and manufacturing applications. The module can identify moving objects at 10m/sec at a range as long as 7m. The module requires 12V dc and communicates over serial RS-232 or Ethernet interfaces.

Embedded-RFID technology is also a perfect fit for high-speed casino-table games in which cheating and sleight-of-hand movements are difficult to detect. With the right data-capture tools, casino operators can monitor players' behavior to detect card counting, adjust promotions, and minimize dealer errors. For example, International Game Technology

and Progressive Gaming International have jointly developed the Table iD table-game-automation system, which combines a software-based table manager and a series of RFID-chip-scanner modules. The latest RFID-gaming chips operate at 13.56 MHz and store more than 10 kbits. During play, chip readers at each position identify and record each player's bets. The Table iD system calculates players' betting patterns, summarizes dealer activity, and records players' decisions once per hour. The system automatically updates information such as average bet and win/loss record without user interaction. Several suppliers manufacture RFID-based gaming tokens suitable for table automation. For example, Gaming Partners International produces the Safechip by Bourgogne et Grasset (Figure 4).

RFID technology is starting to replace traditional bar codes in many applications. For example, some libraries have begun to use RFID tags instead of bar codes to identify such information as a book's title, summary, and database information. During the transition, combina-

tion systems can read either bar codes or RFID tags during user checkout. RFID systems provide several advantages, such as eliminating the line-of-sight requirement, allowing simultaneous reading of multiple tags, and more data storage, over bar codes. RFID tags can also act as security devices to ensure that all borrowing is properly recorded before books leave the premises. Library cards can use RFID tags to further simplify borrowing by allowing patrons self-checkout of their products.

CHIPLESS RFID

Manufacturers have demonstrated several RFID systems that require no silicon-transponder IC. For example, manufacturers can embed aluminum fibers into printed documents or packaging materials in such a pattern that the fibers reflect an RF signal with identifying data. Another chipless system involves the



Figure 4 The Safechip from Gaming Partners International works in casino-chip-tracking and security applications and features a 256-bit transponder IC by NXP Semiconductors.

use of small chemical particles that possess varying degrees of magnetism. The chemical particles become active when you expose them to the electromagnetic waves from a reader and emit a unique signal that the reader interprets as a binary number.

With as many as 70 chemicals available, the reader can interpret a unique binary number from an item depending on the mixture of chemicals that the item embeds. Printed-electronics technology can also deposit transponder circuitry and an antenna from specialized ink-jet or high-speed printers directly onto production items or their packaging to create tags that work with both RFID and bar-code readers.

When RFID applications extend to the consumer level, designers must consider privacy issues. For example, strategically located read-



ers can surreptitiously interrogate many of the smart cards, key fobs, passports, and live transponder tags that use RFID technology. Similarly, as common consumer items such as clothing and acces-

⊕ For a look at some award-winning RFID technology, check out a winner of EDN's 17th annual Innovation Awards, the *SkyeModule M9* embedded RFID reader from *SkyeTek*, at www.edn.com/index.asp?layout=InnovationAwardComp&year=2006&order=40.

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sories become traceable, marketing experts could easily install low-cost readers at store locations to read clothing tags and learn more about the shopping habits of their customers. With item-level serialization, software analysis could determine where and how long ago a customer purchased—or even stole—an item. Retailers could easily devise intrusive marketing campaigns by combining the RFID data with matching customer information that is on file.

Although the use of RFID technology is widespread, it is not yet close to its full potential. Proponents of the technology have frequently predicted that you should be able to walk into a retail or grocery outlet, fill a shopping bag with products, and walk out of the store without going through checkout. RFID readers would simply scan the items in your shopping bag and automatically charge the items to the RFID credit card in your pocket. Now, with new tools and components for embedded-system designers, these types of RFID applications may be closer than you think. Stay tuned. **EDN**

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www.bielomatik.com

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www.gaoorfid.com

IEC (International Electrotechnical Commission)
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You can reach
Technical Editor
Warren Webb
at 1-858-513-3713
and wwebb@edn.com.

