As RFID Applications Increase, Suppliers Look To Lower Its Cost

By Patrick A. Toensmeier

Radio frequency identification is poised to be a significant component of supply-chain management. The wireless technology records and transmits data on a range of product-tracking needs. Targeted primarily at retail and industrial end-users, RFID can streamline operations and reduce product-handling costs. Though broad commercialization is at least five years away, companies attracted by its benefits are adding RFID and mandating that suppliers follow suit.

Wal-Mart, the world's largest retailer, has probably received the most attention for its rollout. In January, Wal-Mart began using RFID on a test basis at three Texas warehouses that supply 150 stores. The test involves 137 suppliers, but Wal-Mart wants all vendors RFID-capable by the end of 2006. In Europe, retailer Metro AG of Germany is in the first phase of its RFID implementation, which involves 250 stores and warehouses and 100 suppliers. Boeing and Johnson Controls use RFID for internal operations. The U.S. Department of Defense will soon mandate that its 43,000 suppliers adopt RFID, and the U.S. Food & Drug Administration (FDA) wants the technology in use by U.S. drug suppliers in 2007 to help combat counterfeiting of drugs.

Studies find that RFID can lower supply-chain costs 3% to 5% and increase revenue 2% to 7%. Retailers in particular benefit by reducing out-of-stock items and theft. Theft alone costs retailers an average 1.7% of gross sales.

"RFID is here and it's successful, though there are bugs to work out," says Robert Steinberg, president of Productivity by RFID, a consultant and systems integrator in Shaker Heights, Ohio. "Implementation is happening at a faster rate than with barcodes."

All indicators point to significant growth for the technology. The global market for RFID hardware and software in 2004 totaled $1.5 billion, says ABI Market Research, Oyster Bay, N.Y., and will increase to $8.5 billion in 2009.

Though RFID is a significant advance in product management, implementation is a thorny issue for suppliers owing to cost concerns. Developments in product design coupled with recent efforts to standardize the technology, however, have the potential to substantially reduce the cost of RFID and create the applications necessary for economies of scale. (A recent study by Dallas consultant Incucomm bodes well for the economics of RFID. Wal-Mart's suppliers are spending an average of $500,000 each on the technology, far less than the $1 million and more some analysts predicted.)

At the heart of RFID technology is a tag consisting of a silicon chip with an etched circuit and copper antenna that transmits data to a reader. There are two main types of tags. A *passive* tag contains a semiconductor, integrated circuit and antenna, and won't transmit data until energized, usually by a reader. An *active* tag contains a chip, antenna and battery, and is always emitting a signal. The data in tags usually relate to product information. RFID tags are limited by regulation to a half dozen or so frequencies. The low range is between 100 and 500 kHz; medium range is 10 to 15 MHz; and the high band, the UHF and microwave range, is 430 MHz and between 800 MHz and 1 GHz. Each frequency has advantages suited to particular applications.

The tag is a significant cost of implementation and one reason why the technology is largely confined to pallets and shipping containers and not individual items. Tags average 22 cents ($0.22) apiece but can cost 40 to 50 cents ($0.40 to $0.50) or more. In businesses where profit margins are tight, applying tags costing 22 cents to items is a big expense. Add to that investments in hardware, software, and training, and most suppliers are reluctant to acquire RFID this early in commercialization.

R&D is focusing on reducing the cost of tags. One route is developing alternatives to silicon chips. A promising technique is the use of inherently conductive polymers (ICPs) to print circuits and antennas on flexible substrates (typically polyethylene terephthalate, polyethylene naphthalate (PEN), polyimide, and paper) or to fabricate chips and print circuitry on them. The polymers, called organics, are usually polythiophene and pentacene, aromatics with a double-conjugate structure. Proponents say organic tags will eventually cost 1 cent ($0.01) apiece or less when fully commercial.

This "penny-per-tag" price is the holy grail of RFID. At this price, tagging of individual items is economically feasible, and the business takes a quantum leap in volume. While it's difficult to estimate how many tags will be required annually for individual retail items, the number may be in the trillions. Organic tags costing a penny ($0.01) or less can compete economically with printed barcodes. The ability to tag individual items is

also a jumping-off point for implementation of advanced retail electronics like "smart shelves," which utilize RFID to signal product levels and restocking needs, and automatic checkout, where tagged items are price-scanned while still in a shopping cart.

Printed organic tags have a trade-off: they are not as powerful as tags with silicon chips; nor is data storage as high. For most supply-chain applications, however, their performance will be acceptable. No company has yet commercialized an organic tag, but many are working toward this with the expectation that they will eventually account for much if not most of market demand. The operational frequency most often cited for organic tags is 13.56 MHz.

Experts say it will be at least five years before production and demand of organic tags reduce cost to the penny-per-unit level. But even at early stages of introduction, prices will be less than the lowest cost projected for silicon tags, 5 cents ($0.05), which could take five years or more to achieve. Some observers think silicon chips will never go below 12 cents ($0.12) per unit, because of the expense of fabrication. A silicon chip-making plant costs up to $3 billion. A facility for organic chips and printed circuits, by contrast, costs as little as $10 million to $30 million.

Another step in cost reduction is standardization of UHF tags and labels. Called Class 1 Generation 2, the standard was issued in December 2004 by EPCGlobal Inc., Lawrenceville, N.J., a group formed to promote RFID technology. (EPC stands for "electronic product code.") Gen 2 is designed to provide global interoperability of tags and readers and higher read speeds—up to 1700 tags/sec in the U.S. and 600/sec in Europe (regulation of bandwidths and power use account for the difference). It replaces two incompatible protocols, Class 0 and Class 1. Suppliers claim most Class 0 and 1 readers can be upgraded for Gen 2 compatibility. Generation 2 is seen as the breakthrough in standardization that will increase investment by suppliers in RFID, thereby reducing the cost of equipment, software and tags.

Developers of printed organic circuits include Xerox. Scientists at the company's Research Center of Canada, in Mississauga, Ontario, devised a process for converting polythiophene into an ink that can be used to print the components of an RFID circuit on a plastics sheet. Xerox has no timetable for commercialization, but says the circuits will initially sell for less than 5 cents ($0.05).

PolyIC GmbH, Erlangen, Germany, seeks to develop 13.56-MHz organic tags that replace barcodes. Commercial production could begin in 2006 or 2007, says Wolfgang Clemens, head of applications. A joint venture formed in late 2003 by Leonhard Kurz, the hot-stamping and coating specialist, and electronics giant Siemens, PolyIC is one of the first to have fabricated a printed integrated circuit.

Companies working on conductive inks for printing organics include Precisia LLC, Ann Arbor, Mich., and

Continued on page 14

Continued from page 13

Cabot Superior MicroPowders, Albuquerque, N.M. Precisia, which last year unveiled a line of inks, says its products can print antennas as well as circuits in one location, thus speeding fabrication cycles and reducing costs. The company claims that with its inks a modified flexographic or gravure press can print up to one trillion antennas per year.

Cabot's ink utilizes silver nano-particles for conductivity. After printing, ink is heated at 100°C to 150°C. This bonds the nano-silver to the polymer, creating a stable and conductive ink, says Chuck Edwards, general manager of printed electronics and displays. Cabot's ink is for circuits and antennas. Sampling begins in February. Edwards says that tags can be produced for 2 cents ($0.02) with the ink.

A start-up specializing in printing organic circuits and chips, Organic ID, Colorado Springs, Colo., is working with International Paper Co. to combine printed circuits with high-speed printing and advanced package technology. OrganicID is developing a multilayer 13.56-MHz circuit for PEN sheet. A prototype is due by year-end, says Jon Barad, VP of business development. Sampling begins in 2006 and volume production could start in 2007. One goal is to adapt the process so converters can print tags inline on packages or apply them during printing.

Many RFID tags are attached to pressure-sensitive adhesive labels and applied to pallets and containers. This "slap-and-ship" technique works in trials, but fast, repeatable processing for high-volume production is a growing need. Printing is an option for flexible substrates, but for rigid items, processors will need techniques for molding tags to parts. One company stands virtually alone in perfecting such a process. EmbedTech Industries, Raymond, Maine, has worked with RFID since 1991, when tags cost $5 to $7 apiece. EmbedTech and subsidiary Chipco can injection mold a multilayer tag with printed circuitry and antenna onto parts fabricated of any moldable material at a per-tag cost of 30 to 65 cents ($0.30 to $0.65).

Chipco developed the technology for encapsulating RFID circuits in poker chips to prevent counterfeiting in casinos, says John Kendall, president of the companies. The cost proved prohibitive. The company has achieved lower prices with printed circuits and antennas. He declines to reveal details, but credits tool design, which is done in-house. Kendall says the process starts with robotic insertion of a 0.010-inch-thick laminate of PET film that contains a printed circuit and antenna. Active tag versions include a near-microscopic air gap for a vibrating capacitor. The mold protects the circuit from being crushed or melted during processing. Circuits are tested before and after molding. EmbedTech molds tags in presses ranging from 45 to 300 tons in molds with up to eight cavities.