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WHITE PAPER

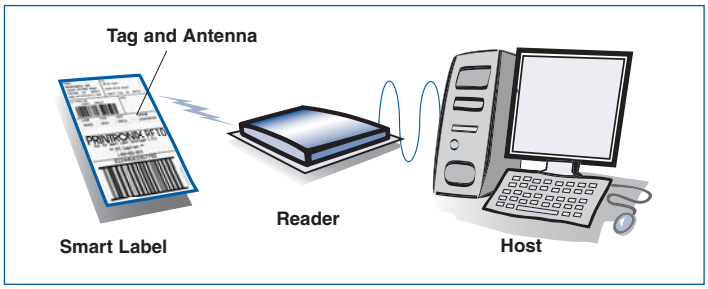
RFID for the Supply Chain: Just the Basics

Radio Frequency Identification, a proven technology developed during the second world war, uses radio waves to automatically identify individual items. During the war the items were airplanes, identified through RFID as friend or foe. Today items can range from car parts to shampoo to livestock. RFID is further automating manufacturing and materials handling by moving beyond barcodes to provide tracking capabilities from manufacturer to retail shelves.

June 2003 was an important milestone for the adoption of RFID technology in the supply chain, as Wal-Mart issued a directive to its top 100 suppliers to put RFID tags on all pallets and cases by January 1, 2005. The remaining suppliers must comply by 2006. The Department of Defense followed suit with the requirement that their top 100 suppliers begin using RFID technology by January 2005, their top 500 by July 2005, and the rest of their 43,000 suppliers by 2006. These mandates set in motion an overall trend in advanced automation, forcing suppliers to focus their resources on implementing RFID.

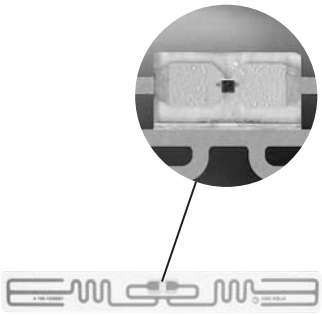
RFID SYSTEM COMPONENTS

A typical RFID system consists of the four main components: tags, antennas, readers and a host computer. The RFID tag is made up of a microchip with a flexible antenna. The reader emits a radio wave to scan the microchip via the antenna. When the RFID tag gets in range of a reader, the tag reflects the information that's programmed into its memory. The tags can be read by the reader from a distance without physical contact or line-of-sight. The distance from which a reader can reliably communicate with a tag is called the read range.



TAGS, INLAYS, AND LABELS

RFID tags can be placed in a plastic inlay and embedded in a shipping label. As a suppy chain application, this is the label that will be printed and



A microchip and a flexible antenna, which form a tag, are placed in a plastic inlay and embedded in a shipping label to make a smart label.

placed on each case or pallet shipped to Wal-Mart. The common term for shipping labels with tags is "smart label," a name derived from their multiple, dynamic capabilities. While some smart labels have programmed fixed data, others can be programmed or updated in the field and even reused to serve multiple needs or various applications.

BENEFITS OF SMART LABELS:

- A convenient and economical vehicle for housing the tag, smart labels carry traditional barcodes and printed text. By combining barcode information with electronic data in the same label, redundancy is provided should one aspect of the system go down, enabling product movement to continue.
- Smart labels offer unattended processing capabilities.
- Smart labels can be produced easily by RFID printers for on-demand applications or pre-printed and pre-coded for batch processing.
- Smart labels require no line-of-sight placements for the reader to collect their data.
- Smart labels are generally unaffected by heat, dust, humidity or other harsh environmental conditions.
- Labels provide added protection to the inlay for increased reliability.

READERS

Readers work with tags to transmit or receive data. They can be portable devices or fixed terminals that are positioned at key locations within a facility such as entrances, dock-doors, forklifts, conveyors or assembly lines. Readers include an antenna or antenna array for sending or receiving signals and a processor for decoding data. As data is collected, it is sent through cabled or wireless local area networks to a host computer.

PRINTERS

RFID printers have a reader, sometimes called an encoder, that encodes the smart label and then immediately checks to verify if the tag is readable. Once the labels are encoded, they are printed with barcodes or text.

TAG CLASSES

There are several different classes of RFID tags, ranging from simple read-only devices to more powerful tags that can broadcast their own signal and require their own power source. The EPC standards call for four classes of tags over time that will eventually address performance and price requirements of the marketplace.

The following outlines the EPC tag class types:

Class 0-	Read Only, 96 bit
Class 1-	Read/Write, 96 bit
Class 1-Gen 2	Read/Write, 96 bit harmonized global standard
Class 2-	Read / Write, 256 bit
Class 3-	Read / Write Battery Enhanced for Long Range
Class 4-	Read / Write Active Transmitter

FREQUENCIES

There are a number of RFID technologies, that operate at different frequency ranges. The application determines what technology should be implemented based on frequency, required read range, memory capacity and the desired system performance.

Low Frequency	~ 125 kHz	read range of up to 20 inches (508mm).
High Frequency	13.56MHz	read range of up to 3 feet (1 meter).
Ultra-High Frequency	868 MHz, 915 MHz, or 2.45 GHz	Read range is 3 to 10 feet (1 to 3 meters). Except at 915 MHz the read range may be 20 feet (6 meters) or more under current FCC regulations.

EPC - THE ELECTRONIC UPC

To meet Wal-Mart's mandate, suppliers are required to use electronic product codes (EPC), UHF-compliant tags that operate at 915 MHz, and accept Class 0 or Class 1 protocols for communicating with readers. The EPC is a unique 96-bit number and it is the only information that is stored on the RFID tag.

The EPC code identifies a specific item in the supply chain. Standards for the EPC number are being developed by EPCglobal. EPCglobal is a joint venture of the EAN International and Uniform Code Council. Together, EAN International and the UCC represent 100 member organizations worldwide with more than one million members representing 102 countries.

Like the UPC (Universal Product Code) or barcode, the EPC is divided into numbers that identify the manufacturer, product and version. In addition, the EPC uses an extra set of digits to identify unique items. The general structure of the EPC consists of four elements: Header, EPC Manager, Object Class, and Serial Number.

ELECTRONIC PRODUCT CODE TYPE 1 96-bit

02 . 0000A68 . 00010D . 000112DED

Header	EPC Manager	Object Class	Serial Number
8-bits	28-bits	24-bits	36-bits

- Header – identifies the EPC's version number and allows for the evolving of different lengths or types of EPC.
- EPC Manager – identifies the manufacturer of the product. (ABC Manufacturing).
- Object Class – refers to the exact type of product. (16-oz. widget, red)
- Serial Number – the specific serial number of the individual item.

The code possibilities of a 96-bit tag would accommodate as many as 268 million companies, each having 16 million classes with 68 billion serial numbers in each class.

GLOBAL STANDARDS

RFID tags are a wireless technology. The frequency bands and the frequencies available vary from country to country and region to region. Though not ideal, there is unlikely to be a single global frequency in the foreseeable future, as countries have already allocated much of the spectrum for different uses. Agile RFID tags and agile frequency readers will be required when goods are shipped internationally.

EUROPEAN ADOPTION OF RFID

Together with Intel Corporation, Europe's three largest retailers, Tesco PLC, Carrefour Group and Metro Group, formed

the EPC Product Retail Users Group of Europe. This independent working group complements the efforts of EPCglobal, actively piloting EPC and RFID technologies in their supply chains.

Tesco, the largest retailer in the United Kingdom, and among the most active retailers testing RFID technology based on EPCglobal's work, will put RFID tags on cases of nonfood items at its distribution centers and track them to stores.

Metro Group, Europe's third largest retailer, unveiled an RFID "Future Store" in Germany, showcasing the benefits of the technology for shoppers. The company announced an initiative that will see RFID extended to its suppliers, mirroring Wal-Mart's mandate.

Carrefour, Europe's largest retailer and second largest in the world, sees global implementation of RFID as assurance that customers can have better product availability and value. Carrefour operates almost 10,400 stores in 30 countries across four formats: Hypermarket, Supermarket, Hard Discount and Convenience.

BEYOND BARCODES

For the past 25 years, barcodes have been the primary means of identifying products in the supply chain. Though barcodes have been effective, they are line-of-sight technology, a limitation in that they require human intervention to aim the scanner towards the code in order to be read, and read one at a time. If a label is torn, soiled or falls off, there is no way to scan the item.

RFID tags can be read as long as they are within range of a reader. They hold more encoded information about the product, distinguishing each item from all the others. Tags can be read through visual and environmental obstacles such as fog, paint and grime – where barcodes or other optically read technologies can't perform. RFID works in these challenging conditions at remarkable speeds.

LONG-TERM BENEFITS OF RFID

RFID promises to improve supply chain visibility – optimally companies will be able to know exactly where every item in their supply chain is at any moment in time. Retailers can expect immediate cost savings but manufacturers may face delayed benefits. As the technology matures and benefits accrue back through the distribution channel to the manufacturer, there's promise for rewards for all.

Shipping/Receiving

Shipping will become more efficient. Using RFID tags to build advance ship notices (ASN) as trucks are loaded allows suppliers to tell a customer exactly what has been shipped. Automatically, the ASN will be matched against the receiving data at the dock door to verify receipt and direct the warehouse management system to store or cross-dock the received inventory. Theft will also be significantly reduced, both in transit and when the merchandise reaches the store.

Improving out-of-stocks
Problems like stock-outs and in-stock items which can't be located will be eliminated by mature RFID technology. Transmittal and use of RFID information can reduce the amount of bad data in the supply chain, improve demand planning and reduce stock-outs. Manufacturers and retailers can communicate to track materials, components and finished goods in production and in transit. With RFID real-time data, output can be adjusted to demand, and manufacturers can reduce expensive downtime from shortage of supplies.

Distribution centers
Automatic tag reading eliminates the need for workers to stop, pick up scan guns and shoot the barcode labels on pallets, cases, rack locations and loading docks. RFID streamlines and speeds up operations while improving accuracy, productivity and ergonomics. Returnable containers can also be located and retrieved for dispensation.

Preventing counterfeits
RFID tags on products, packaging and pharmaceuticals helps to validate products, potentially saving millions of dollars and ensuring safety as well.

With the adoption of RFID technology across the supply chain, logistics will begin a new age of efficiency as manufacturers, retailers and carriers track exactly what they ship or receive in real time. Speed, productivity and security will increase, while stock-outs, theft and counterfeiting will decline. Scanning and searching for misplaced inventory will no longer be a time sink. All improvements will contribute to lower costs and increased profits, better customer service and brand loyalty.

ISSUES WITH RFID
The supply chain faces key issues and challenges when implementing RFID at this early adoption stage, all which will need to be resolved in order to realize the true benefits:

Package contents can affect radio frequency.
Some liquids and metals absorb, distort or reflect radio waves, which can make tracking metal and high water content products a challenge. Researchers are finding ways to avoid these problems. Careful application of tags to cartons above the liquid or metal contents is required in items such as foil-bagged chips, liquid detergent, and canned goods.

Standards of RFID are still developing.
Current RFID systems such as highway toll reading, libraries, or animal identification have used closed-loop systems, which means they are tracking goods that never leave their own control. In the supply chain, there are a number of competing technologies and vendors, and tags applied by one company need to be read by readers at another company. Though the EPC global has set standards for the U.S., they are busy developing standards for the technologies and equipment used for RFID in Europe and Asia. It becomes

even more important for global supply chain companies to invest in products from vendors that are adaptable to emerging standards and protocols.

A vast amount of data is created.
With every carton and pallet bearing tags with unique identifiers, the data will mount quickly. High-speed, high-volume RFID-based systems may require a real-time in-memory event database (RIED), to take the EPC data generated in real-time and store it intelligently so that other enterprise applications have access to the information, without overloading the databases.

Tags prices.
RFID tags can be expensive in this early stage, making them fairly impractical for identifying billions of items that cost only a few dollars. To make item level marking a possibility in the future, there are innovations in sight to reduce the costs. Shrinking the size of the chip, developing a less expensive antenna, and significantly improving manufacturing efficiency will all help reduce costs. Other cost considerations lay in equipment and software. Companies may install hundreds or thousands of readers to cover every identification point (in factories, in warehouses and stores), and integrate RFID into their organizations.

RFID IN YOUR FUTURE
As RFID technology matures and experiences broader usage, its refinements will grow and costs will drop. Its development will be ongoing, as it is expected to co-exist with barcodes for a long time. An adoption cycle will at first bring in early adopters willing to invest on the promise of the competitive advantage while a larger group will wait until the technology is proven and less risky. The late adopters will enter when risks and costs are minimal, but their reactive stance and late entry will translate into lost opportunities in their market.

Whatever the stage of your RFID development, it is clear the technology is on track to dramatically transform business in the supply chain in the next few years. If you are armed with an understanding of its cost and value to your business, and the trusted partnerships of experts to help you implement a comprehensive deployment plan – as the technology moves forward, you will have the clear advantage.

About Printronix Inc.

Printronix Inc., (NASDAQ: PTNX) is a global leader enabling printing technologies for the industrial marketplace and distribution supply chain. It is the world's best-selling line matrix manufacturer and has earned an outstanding reputation for its high-performance thermal and fanfold laser printers. In addition, Printronix adapts new technologies to create innovative programs, including RFID "smart label" and wireless mobile printers. Printronix's integrated network programs, such as Online Data Validation (ODV™) and PrintNet® Enterprise, improve the printing of bar codes, labels and forms while verifying accuracy and offering flawless diagnostic technology. Based in Irvine, California, Printronix has operations worldwide. For more information: www.printronix.com.

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GLOSSARY

Antenna:
A device for sending or receiving electromagnetic waves.

Barcode:
A standard adopted to make it possible for machines to automatically identify labeled objects. The barcode was adopted because the bars were easier for machines to read than characters that humans could read. The main drawbacks of the barcode system in common use are that it can't distinguish one can of soup from another and scanners have to have line of sight to read the label.

Electronic Product Code (EPC):
A 96-bit code that identifies the manufacturer, product category and an individual item. Created by the Auto-ID Center/EPCglobal, EPC is backed by the United Code Council and EAN International, the two main bodies that oversee barcode standards.

Frequency:
The number of repetitions of a complete waveform in a specific period of time. 1 KHz equals 1,000 complete waveforms in one second. 1 MHz equals 1 million waveforms per second.

Inlay:
The combined chip and antenna mounted on a substrate and attached to label stock to create a smart label.

Line-of-sight technology:
Technology that requires an item to be "seen" to be automatically identified by a machine. Barcodes and optical character recognition are two line-of-site sight technologies.

Microchip:
A microelectronic semiconductor device comprising many interconnected transistors and other components. Also called a chip or an "integrated circuit."

Radio Frequency Identification (RFID):
A method of identifying unique items using radio waves. The big advantage over barcode technology is lasers must see a barcode to read it. Radio waves do not require line of site and can pass through materials such as cardboard and plastic.

Radio waves:
Electromagnetic waves that fall within the lower end of the electromagnetic spectrum.

Reader:
Also called an interrogator. The reader communicates with the RFID tag and passes the information in digital form to a computer system.

Read range:
The distance from which a reader can communicate with a tag. Range is influenced by the power of the reader, frequency used for communication, and the design of the antenna.

Read-only memory (ROM):
A form of storing information on a chip that cannot be overwritten. Read-only chips are less expensive than read-write chips.

Read-write:
The ability to read and overwrite stored information. Chips for read-write RFID tags are more expensive than equivalent read-only chips.

Smart label:
A label that contains an RFID tag. It's considered "smart" because it can store information, such as a unique serial number, and communicate with a reader.

Tag:
The generic term for a radio frequency identification device. Tags are sometimes referred to as smart labels.

Ultra-high frequency (UHF):
The term generally given to waves in the 300 MHz to 3 GHz. UHF offers high bandwidth and good range, but UHF waves don't penetrate materials well and require more power to be transmitted over a given range than lower frequency waves

Universal Product Code (UPC):
The barcode standard used in North America. It is administered by the Uniform Code Council.