Gaining efficiencies and reducing cost in a competitive environment

Innovative RFID and NFC technologies offer increased process efficiency, accuracy and visibility. These benefits enable previously unattainable automation and manufacturing flow advances, result in superior productivity and deliver benefits throughout the supply chain.

Executive summary

Radio Frequency Identification (RFID) and Near Field Communication (NFC) are mature technologies that have already found their way into many aspects of everyday life. Their unique features of item level identification, no line of sight requirement, simultaneous tag reading, operation without requiring a power source, and interactive capability have increased process efficiency, visibility, and security in a wide variety of applications, and have also enabled innovative new human/machine interaction.

Whether or not to pick one technology over another depends on the application and the end goals for the project. To simplify, both of these technologies will be grouped under the RFID umbrella in the information below, but there are usually multiple ways to solve project challenges, and NXP is happy to guide any customer to the best solution for the job.

RFID technology benefits:

- Contains read / writeable memory
- Does not require line of sight to access
- Does not require own power source to operate (passive)
- Supports unique item level identification
- Can read hundreds of tags simultaneously

RFID brings a broad range of benefits to the manufacturing process including: enabling of process automation, providing better visibility into manufacturing flow, supporting more efficient operations, increasing security, delivering greater accuracy, and providing added value, all of which give rise to superior productivity at reduced capital and labor costs while increasing revenue.

Forward-thinking manufacturers not only benefit internally from inclusion of RFID, but also set themselves apart from competitors by offering an innovation that clients down the supply chain can use to their advantage.

RFID benefits summary

	Manufacturers	Distributors/ retailers	Service providers
Automation			
Automation of manual processes	•	•	•
Reduced labor cost	•	•	•
Increased safety	•		
Visibility			
Real time asset location	•	•	•
Insight into process manufacturing flow	•		
Real time inventory levels	•	•	
Electronic product history	•	•	•
Efficiency			
Reduced capital cost	•	•	•
More efficient forward and return logistics		•	•
Wireless configuration management	•	•	•
Accuracy			
Better productivity	•	•	•
More accurate inventory management	•	•	
Product track and trace at item level	•	•	•
Item-level masking/filtering capability	•	•	•
Improved quality assurance	•		
Security			
Invisible electronic serial numbers	•	•	•
Secure product authentication		•	•
Theft deterrence	•	•	•
Grey market diversion deterrence	•	•	
Protection against counterfeiting	•	•	•
Sustainability			
Improved hazardous waste tracking	•		•
Eased regulatory compliance	•		•
Value			
Improved customer satisfaction	•	•	•
Increased revenue from value-added features	•	•	
Brand protection	•	•	
Means to differentiate against competitors	•	•	•

Contents

RFID benefits for PCB manufacturing:

- Reduces labor cost
- Provides on-board means of unique PCB identification via electronic serialization
- Supports electronic work order traveler
- Greener, more accurate, more efficient process
- Fewer product returns due to overlooked failures
- Lot control for production run; use RFID tag to store "born-on" date
- Can provide downstream benefits, giving contract manufacurers a comptetive edge

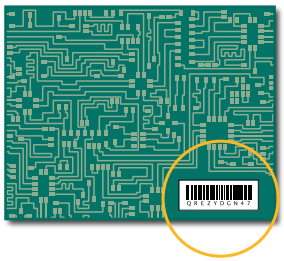
1. Production

Because passive RFID tags contain read/writeable non-volatile memory, do not need a constant power source, do not require line-of-sight for access, and can be applied to almost any surface, the inclusion of RFID technology helps to automate manufacturing operations that currently require manual labor. And with multiple ways of adding RFID tags to objects, it's a technology that lends itself readily to gradual introduction. In the PCB manufacturing example, RFID technology can take the form of an applied label that includes the RFID IC and antenna, be integrated into the board design using an RFID IC and applied antenna, or integrated fully into the board using PCB traces or a slot for the tag antenna.

Integrating RFID tags within the printed circuit boards of electronic products early in the manufacturing cycle provides benefits beyond the board manufacture. It supports invisible electronic serialization (to learn more, read Section 5: *About Electronic Serialization*) and later wireless access to tag memory contents, from the manufacturing floor through shipping, distribution channels, out onto the sales floor (even when sealed in a box and not powered), and after purchase for returns and servicing.

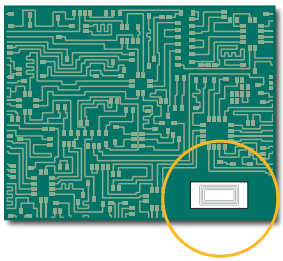
1.1 Printed circuit board manufacture

Adding RFID technology at the beginning of printed circuit board manufacture supports automation of the build process. The unique identification of each board enables a greener, more efficient, more accurate build, as well as provides the potential for downstream benefits.



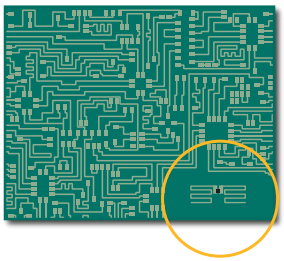
No RFID

- Based on bar codes
- Paper work order travels with boards through each stage and can be quite large
- Bar codes require line of sight for reading and only identify the board
- Board to work order connection is manual, as are test result records
- Manual systems are vulnerable to error and paper records can be lost



Using RFID labels

- Apply an RFID tag label to the first board layer on the frame periphery
- RFID chip supports individual association of board with work order in manufacturing execution system cloud
- RFID and cloud software keep records of any board failing qualification tests
- Individual failed boards are identifiable and may be pulled before they propagate further in production
- Sustainable, more secure, less costly process



Integrating RFID

- Provides additional downstream benefits
- Integrate an RFID tag into the board structure
- Some RFID tag ICs also provide a serial interface, creating a bridge between the wireless RFID and the on-board wired serial bus
- Similar process and benefits as the applied RFID label in the board manufacturing process, but with added value of supporting downstream assembly, distribution, sales, and service processes

Benefits of RFID for printed circuit assembly:

- Reduced labor costs: It obviates manual reel location/loading
- Increased accuracy: robotic arm verifies reel contents and appropriate feeder assembly without requiring visual examination
- Greater efficiency: less line stoppage, because only reels with sufficient parts get loaded
- Reduced supply cost: more accurate parts placement means less waste
- Greater product reliability: easier containment of defective part lots

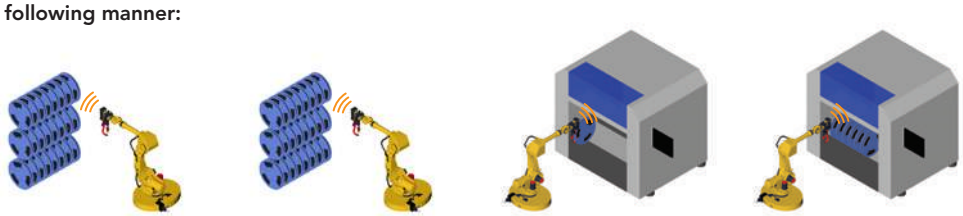
1.2 Printed circuit board assembly

A production line for printed circuit board assembly requires hundreds of component types, each sourced on its own reel. At the start of a production run, employees must locate the proper parts for the current PCA under development amongst all the similar-appearing reels in the supply racks, ensure that each reel contains enough components to complete the job at hand, and then correctly mount them, so that they feed the assembly heads from the expected feeder assembly. This manual process is labor intensive and vulnerable to error. It also provides a great case to illustrate the advantages of RFID-enabled process automation.

Automating the pick and place process requires accurate coupling of component reel to assembly head feeder. The unique, non-visual identification capability of RFID makes this process faster, more accurate, and more automated.

To begin, manufacturers uniquely identify each assembly head feeder and component reel by attaching an RFID tag. The feeder assembly tag indicates feeder location in the pick and place machine. The reel tag holds data such as the type of component, source of component, component lot, and the quantity of components remaining on the reel. Figure 1 illustrates how to use these tags for increased PCB assembly automation.

Upon start of a production run, the robotic arms gather the reels necessary for the job in the following manner:



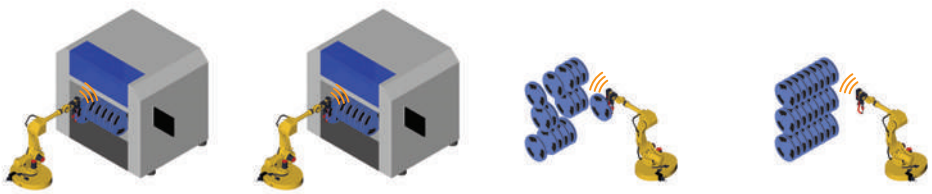
1
The backend system indicates where to locate the appropriate reels for each desired part type amongst all the bins and racks in the facility.

2
For each part type, the RFID reader built into a robotic arm goes to the indicated storage area and reads the reel tag data to verify that the reel contains approved parts from good lots, and that the reel holds enough parts to complete the production run.

3
It then reads the pick and place machine assembly head feeder tags until it finds the correct place to load the reel.

4
Repeats reel loading operation until all part types have been loaded.

After completing the production run, the robotic arm reverses the process:



1
Retrieves a reel from an assembly head feeder.

2
Accesses the backend system to determine the quantity of parts used by the assembly head from that feeder.

3
Deducts the components the production run used of that part type from the reel's part count and updates the reel tag.

4
Replaces the reel in the appropriate bin and repeats until all reels have been returned to storage.

Figure 1 Example of RFID-enabled printed circuit board assembly

Benefits of RFID for unit assembly:

- Supports real time location and status for all WIP units
- Enables more efficient work flow
- Provides better inventory control
- Reduces labor costs
- Helps to identify line choke points
- Reduces inventory because one board can support multiple products via custom configuration
- Aids in containment of defective products because RFID-enabled products are traceable
- RFID read masking or filtering capability facilitates efficient selection of product subsets

1.3 Unit assembly

For work in progress (WIP) production lines, RFID supports real time location and status for all WIP units, leading to more efficient workflow, and also contributing to better inventory control. RFID technology reduces labor costs, because RFID-enabled machinery can identify and track work-in-progress components or assemblies faster and with greater accuracy than humans. It also does not require line of sight to operate, so it works in places where barcode or machine vision systems cannot. Because RFID tags are rewritable, configuration information, quality control status, lot information and other such data may be continually added while the work progresses down the production line. And the ability to later identify and select only those products that meet particular criteria (e.g., common lot code) makes processes such as defective product containment far more efficient.

Figure 2 Unlike barcodes, RFID does not require line of sight to operate

RFID tags enable custom configuration as well, either via customized manufacturing execution system (MES) software instructions, or via specialized RFID tags that also have a microprocessor interface and can act as a bridge circuit. Both methods support the creation of multiple derivatives from one common core product, reducing inventory and saving cost.

Employing an RFID technology strategy for WIP can often result in process improvements. The real time visibility into where WIP units are in the production line provides data for time studies that can help to identify choke points where additional capability may be required.

1.3.1 Kanban

Kanban approaches can differ, but most use some sort of signaling card to track materials usage, pulling from suppliers in response to demand for product, rather than maintaining large inventories in anticipation of need. Some manufacturers use the cards to track production status and materials consumed by sending them along the production line, more of a work-in-progress (WIP) monitoring. Others use Kanban cards to indicate the need to replenish parts on the production line from a central parts inventory, the supermarket approach. RFID technology can make any Kanban production method more efficient by providing a rewritable electronic means to convey information.

For example in the supermarket approach, instead of requiring workers to manually scan barcodes on totes brought to a central location to obtain replenishment parts, RFID readers instead read the RFID-enabled cards affixed to each tote. This automation decreases errors, allows for more accurate tracking of parts inventory levels in the backend database, reduces the need for manually intensive and time-consuming stock counts, and reduces the occurrence of manufacturing shutdowns caused by parts shortages. The ability to constantly track leads to greater accuracy in supply chain management as well, because raw materials are replenished based on accurate need, reducing costly inventory levels, while ensuring adequate materials for production.

Example case: RFID-enabled manufacturing execution system for WIP

For multi-product manufacturing lines where workers perform specific steps at each workstation as a product moves down the line, the manufacturing execution system (MES) provides line operators with specific build instructions based on the product type. In past approaches, Kanban cards attached to component totes provided product information via barcodes to generate assembly instructions. But this process is not only much slower than RFID (seconds instead of the milliseconds that RFID reads require), but also more vulnerable to error.

How it works

Automated machinery or workers gather all parts required for a product build and place them in a bin fitted with a reusable RFID tag. The manufacturer enables each workstation with an RFID reader. As the bin progresses down the production line, the RFID reader accesses the bin tag to determine what product has come to its manufacturing station, allowing the MES to supply the appropriate build instructions to the worker. For products that are very similar physically, but perhaps only require custom configuration for their intended buyer, this approach makes such customization very easy.

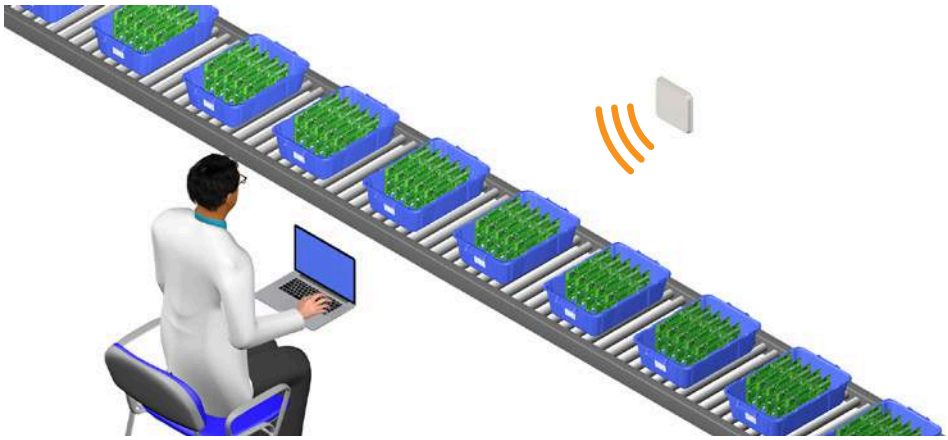


Figure 3 RFID readers at each workstation track the progress of WIP manufacturing

The backend system can identify a production run as being for a particular customer. All the components are the same, but the identification written to the bin tag at the start of the production line indicates the intended customer. No additional identification or checks are needed from then on down the production line, because the MES will read this tag and provide the appropriate instructions to the manufacturing station staff.

If the parts in the bin are also fitted with RFID tags, the reader can relay missing parts information back to the MES as well, which can instruct the worker to set that bin aside for extra attention.

Benefits

- RFID reads are much faster than barcode scans used in similar setups. For production lines with many stations, that timesaving adds up to labor reduction and cost savings.
- The RFID approach is much more accurate, resulting in less scrap
- Similar products can be easily customized for different customers
- RFID-enabled boards support custom configuration of one board type to multiple products
- No line of sight required for tag reads

1.3.2 Custom configuration

RFID tags enable custom configuration of common engine products while on the production line. One method is via manufacturing execution system (MES) software. If this software identifies a board or unit as being within a range of product serial numbers intended for a particular customer, it can create WIP instructions to custom configure the product as necessary. This approach works with the simplest of RFID tags that support item level identification. As the assembly arrives at the workstation, the MES obtains the electronic serial number via a reader positioned at the station, and generates custom configuration assembly instructions.

1.3.3 Value add

For assembly houses, having RFID capability adds another way to differentiate service above competitors. Even if the assembly house uses RFID capability in a very minor way at its own facility, providing a means of unique electronic serialization that is very difficult to duplicate is a key selling point for their customers with frequently copied high value products. These knockoffs damage brands, present a liability hazard and cause loss of revenue due to lost productivity. But with the unique electronic serialization possible via RFID, it is much easier to prove that a product is counterfeit, reducing unnecessary service costs

1.3.4 Quality assurance

After assembly, most manufacturers will visually inspect and test for proper assembly, functionality, and stress limits. Assemblies failing at any of these points must be set aside for rework. If the rework procedure requires written documentation, these steps add labor and take time, both of which contribute to higher cost. If instead, RFID-enabled assemblies flow down the line, and RFID readers located at key test points indicate to the backend system software exactly which assembly failed at any point, the process becomes much more automatic, saving labor cost and increasing accuracy at the same time.

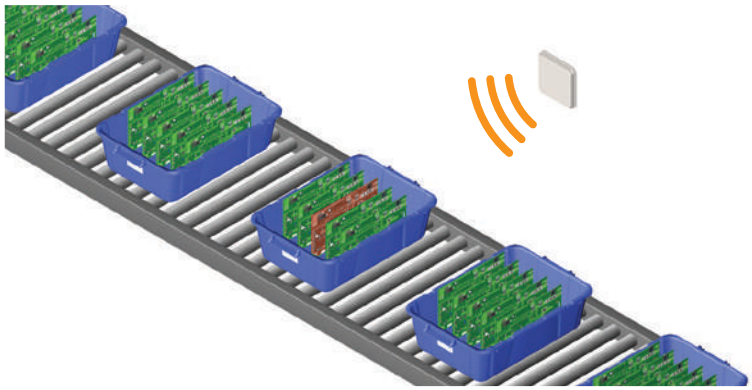


Figure 4 RFID readers check for failed assemblies along key test points

1.3.5 Containment

With tracing down to the individual item level, containment of product that includes defective parts is much easier. Backend systems know which products were made at what time, with which parts, by which crew, and where they are currently stored. Without having to disassemble any product and without even removing packaging, an RFID reader can access item level identifying information, allowing manufacturers to corral defective or otherwise unsatisfactory products before they enter the supply chain.

Figure 5 RFID readers can access item level identifying information of stored inventory

1.3.6 Masking/filtering

RFID technology supports filtering or masking based on tag memory contents. This capability is especially helpful in the case of containment. Many manufacturers obtain key parts from multiple vendors, so the internal components of their finished products may vary, even though externally they look and operate identically. And after production, it is difficult to ascertain internal product composition without disassembly. But with an RFID tag identifier, information about part component sourcing, lot codes, build date, etc., is only an RFID read away. For example, if a particular part vendor delivered defective components, a manufacturer can program an RFID reader to mask out all other vendors when assessing returns. So rather than needing to open up each product, one quick read filters the defective product from the good, a far more efficient and labor-saving process.

1.4 Pick, pack, and ship

After unit assembly, contract manufacturers generally have to gather several components as part of the overall product. For example, a computer tablet may have a country-specific battery charger and charger cord, or specific language documentation. Traditional methods for pick and place involve manual labor, or barcode-assisted solutions. But such labor-intensive solutions are vulnerable to error, and after the box is sealed, vision or barcode verification systems do not work.

Because manufacturers often re-label components entering their facilities in order to support their manufacturing execution system, a switch to RFID-enabled labels can almost be transparent. And with RFID-enabled components, execution and validation of pick-and-place package contents can occur automatically.

As the packaging moves down the conveyor system, robotic arms enabled with RFID readers select appropriate components for the work order based on the MES instructions, and place them in the box. After all components are inserted, the box is sealed. A reader deployed at the end of the pick and pack stations, and connected into the manufacturing execution system, scans the sealed box to verify proper contents. Any package that does not pass this validation check does not continue on to the finished goods area, but rather goes back for rework. This automated approach not only reduces errors, it also decreases labor and returned products costs.

Adding RFID tags to components at receiving, and the associated item-level visibility that supports, brings additional benefits, such as better and more automated inventory management, and greater insight into product flow and asset usage through a facility.

RFID operational benefits:

- Provides greater visibility into asset location
- Facilitates more accurate inventory management
- Makes inventory taking far more efficient
- Increases security because individual products are more readily traceable
- Protects against grey market diversion
- Reduces labor cost

2. RFID operational benefits for manufacturers and the supply chain

RFID tags are readable through most packaging. As long as the assembly housing is not completely metal-encased, packaged and fully functional assemblies awaiting shipment are identifiable even when powered off[1]. This capability lets manufacturers and their customers down the line, from distribution through retail and beyond, make use of all of the RFID advantages already present in the product. From automatic inventory control and asset tracking in manufacturing facilities and distribution centers, to inventory management and shrinkage control in the retail sector, to authentication and brand protection throughout the distribution and retail chains, brand owners and retailers can use RFID to their advantage. Manufacturers can also add RFID-enabled labels to item, case, and pallet packaging in a way that is transparent to the end user, yet provides the RFID benefits of increased accuracy, efficiency, visibility, and security from that point on.

Figure 6 RFID tags are readable through most packaging

2.1 Automatic inventory control and asset tracking

With unique serialized identification and because RFID has no line-of-sight requirements, RFID technology enables inventory control and asset tracking on a scale just not previously possible. For vast factories or warehouses, taking inventory manually or via bar-code readers is time-consuming, resource-intensive, and vulnerable to error. The inability to keep track of key assets can be very costly in terms of lost productivity, the need to repurchase lost or stolen material, unnecessary purchase of duplicates, and failure of quality or compliance audits.

With RFID readers placed at key choke points in storage facilities (e.g., entrance portals, loading docks, etc.), manufacturers may maintain accurate inventories of both products and assets in real time. If product goes missing, it is readily apparent when it did, which portal it passed through, and who was in the vicinity if workers badges are also RFID enabled.

1 Even if a product case is primarily metallic, with proper design, the case itself can function as an efficient omni-directional antenna. This approach eliminates the need for a separate dipole antenna. A detailed description of such an approach is beyond the scope of this paper; contact NXP for more information.

Employees with mobile RFID readers may also quickly take inventory, reading hundreds of tags simultaneously, rather than using the laborious process of individually scanning bar codes.

2.2 Transparent solution

In many cases, addition of RFID to existing operations is almost transparent, except for its impact in reducing labor requirements and increasing operational efficiency. At any location where printing a label is part of the overall process, for example, manufacturers can replace standard printers with RFID printer/encoders.

From that point on, access to information on that label no longer requires vision or barcode system line-of-sight. And even more importantly, RFID introduces the ability to read many labels in aggregate by completely automated systems. This decreased labor requirement and increased efficiency adds up to significant cost savings.

Example case: Transparent addition achieves major benefits with little impact

Most products already have labels on their individual packaging, the case packaging, and pallet shrink-wrap. By replacing existing printers with readily available RFID-enabled printer/encoders, manufacturers can switch to RFID solutions with minimal disruption, yet achieve maximum benefits.

How it works

Wherever there is a system that prints labeling information for application to the manufactured product, whether it is on individual boxes, cases, or pallet shrink-wrap, manufacturers can replace the traditional printer with an RFID printer/encoder. These machines print the standard information on the visible label, while also writing information to the nonvolatile memory of the encased RFID tag.

Individual items: Even if the assembly itself is not RFID-enabled (e.g., with RFID on the PCB or PCA itself), the packaging for a product can be. A label containing an RFID tag holds within its nonvolatile memory all the details typically printed on a package label, such as the brand name, model number, serial number, and origination location, and whatever else the manufacturer wishes to include. Other than replacing the standard printer with an RFID printer/encoder, the existing process doesn't change. After the sealed boxed are labeled, these individual products flow down the conveyor belt and are packaged into cases.

Cased products: In the cased products area, RFID-enabling the operation requires an RFID reader and again replacing a standard printer with an RFID printer/encoder. As the cased products come down the conveyor belt, the RFID reader accesses all the RFID tags for the product packages inside the case in aggregate, and writes those details to the case label tag. Because RFID readers can read many tags at once, this operation requires just seconds. Package to case aggregate information may also be stored in the manufacturing execution system cloud. RFID-enabled case labels hold a complete accounting of the case contents for further downstream processing, easily accessible and verifiable without opening any seals.

(continued)

Example case: Transparent addition achieves major benefits with little impact

Palletized products: In the palletizing area, RFID-enabling the operation again requires an RFID reader and replacement of the standard printer with an RFID printer/encoder. Cases flowing down the conveyor are loaded onto pallets. Each fully loaded pallet is then shrink-wrapped and labeled.

An RFID reader at the palletizing station reads all the cases labels (the individual products inside the case could also be accessed, but more likely would be masked out by the reader software, because this information would already be available in the MES cloud) and the printer/encoder generates a label, and perhaps an advance shipping notice (ASN). The ASN, if RFID-enabled, can provide the detailed case contents of the pallet or group of pallets in addition to its standard information.

Figure 7 By replacing standard labels with RFID-encoded labels, readers can track individual items, cased products, and palletized products.

Benefits

- Reduced labor costs, because the system may be fully automated. Validation of accurate case counts, and aggregation of product from packages to cases and pallets requires no human interaction.
- Increased efficiency, because many items are identifiable simultaneously, whether it is individual packages in their cases, or individual cases in their pallets, or individual pallets on a truck.
- Enhanced visibility into product location, because the RFID labels facilitate track and trace, which in turn also provides greater security and deters theft

2.3 Equipment maintenance

The identification of equipment via RFID technology also helps support more efficient maintenance and repair operations. Tagging manufacturing equipment provides quick access to usage and repair history logs while at the machinery site either through data on the tag itself, or via Wi-Fi connection to back-end systems that store log data.

RFID benefits to product servicing:

- Supports long-term access to key product information, such as production date, region of production, firmware version, and lot numbers
- Provides a means to log fault codes, repair history, registration information, and warranty type with no disassembly required
- Helps validate critical internal components to combat fraudulent returns
- Alleviates grey and counterfeit market activity
- Supports more efficient warranty servicing
- Aids in electronic waste management or defective product containment

3. Service

The servicing of RFID-enabled products also becomes more efficient, less costly, greener, and more secure. From return logistics, to warranty servicing and electronic waste disposal, RFID technology provides visibility into a product's history, authenticity, and component makeup. This visibility in turn supports more efficient servicing and disposal operations, saving cost.

3.1 Return logistics efficiency

For forward and reverse logistics, RFID tags embedded into products facilitate storing of the production date, region of production, firmware versions, and lot numbers directly on the PCB with later wireless access to this information. They also provide the means to log a product's fault codes, repair history, registration information, and warranty type, so supply chain partners can access it later without disassembling products.

For service centers that process thousands of products per day, small increases in efficiency can add up to big cost savings. An RFID-enabled product identification process can facilitate huge increases in efficiency. In cases where returned electronic products are already aggregated by type, it takes workers about 30 seconds to pull each item out of a case of 60 similar items, scan the bar code on the back of the item, and replace it in its plastic wrap and package slot. Processing the entire case takes about 30 minutes. With RFID-enabled labels, the same identification process requires less than one second.

3.2 Authentication/brand management

The ability to wirelessly validate critical internal components curbs fraudulent returns, assists with warranty service status and routing, and helps to alleviate grey and counterfeit market activity. Without opening the product, or even the packaging, workers can scan the RFID chip to access key product information such as date and region of production, firmware version, lot number, repair history, registration information, warranty type, and more. They can also determine whether or not the return is authentic, which helps to alleviate grey and counterfeit market activity, as well as saves the brand owner damage to the brand and the cost of repairing a counterfeit item.

Figure 8 RFID tags embedded into products can store information that facilitates return logistics. Data can also be retrieved from inoperable devices.

Example case: RFID-enabled priority warranty routing

For consumers who purchase special warranties (e.g., high priority servicing for cell phone customers who cannot be without their device for extended periods of time), RFID tags facilitate product returns and servicing, reduce brand owner servicing costs and improve customer relations.

How it works

For an RFID-enabled cell phone, in addition to the RFID tag providing electronic serial information, it could also support the storage of warranty and registration history. And for cell phones that contain an RFID-microprocessor bridge IC (e.g., the NXP UCODE I^2C — see section 4.2), the tag memory could even store fault code information. Upon return for servicing, without even removing the cell phone from its packaging, an RFID reader at the service center can access the RFID tag information and immediately route the cell phone to high priority service workstations.

At the station, the service technician reads the tag with a fixed or mobile RFID reader, and instantly knows the type of cell phone, the warranty, the service history, the registration information, the lot codes, and possibly the fault codes (if phone contained a bridge circuit type RFID tag). All of this information serves to make the repair of the cell phone more efficient.

By prioritizing the servicing of special warranty cell phones first, customers receive their repaired merchandise more quickly, which adds to customer satisfaction and brand value. The more efficient return also saves the brand owner labor cost and potential product cost if the special warranty included a new replacement cell phone to accommodate guaranteed service windows.

Benefits

- Improved customer satisfaction
- Reduced labor costs
- Greater service efficiency
- Reduced product repair and replacement cost

3.3 Efficient electronic waste management and containment

If a product reaches its end of life or is subject to a recall, RFID tags support more efficient return of merchandise. The electronic serialization helps to identify product contents, which aids in more efficient hazardous waste disposal and defective component identification. For example, RFID tags embedded in products could contain codes to identify the presence of RoHs material, batteries requiring special handling, or other hazardous material subject to government regulations. With one scan, workers could identify products that require special attention. This efficient approach is more environmentally sound, saves labor cost, and broadens recycling capability.

RFID supply chain benefits:

- Increases security because individual products are more readily traceable
- Protects against grey market diversion
- Provides means to authenticate products and protect brands
- Reduces labor cost
- Enables method for providing value-added features post production

4. Additional supply chain benefits

In addition to the new capabilities and flexibility that embedded RFID offers during manufacturing, it also provides benefits within the distribution chain and even in the after-sales process including: provisioning of the product, verification of product authenticity, protection against grey market diversion, enabling of calibration management, and customization of products with individual customer features, such as inclusion of gift certificates with a tablet, customized wallpaper to suit the gift occasion, personalized gift messages, or pre-configured Wi-Fi credentials.

4.1 Authentication/brand protection to combat fraud and grey market diversion

Even the simplest of RFID tags that support unique serialization of the product provide brand owners and retailers with a way to verify product authenticity. Manufacturers can include a tag on the assembly as part of the PCA build process and optionally password-protect the device. This capability has real cost benefit to brand owners, retailers, and consumers in industries where product counterfeiting is highly prevalent. It also protects against unscrupulous customers who purchase products from unauthorized Internet or grey market channels, and then return these counterfeits to retailers as defective, fraudulently receiving a genuine version in exchange. For items that need additional features, using an RFID-to-microprocessor bridge circuit, such as the NXP UCODE I²C (see Section 4.2), supports the deactivation of the device after production with reactivation only possible at the point of sale or other brand owner-managed location. This approach provides another effective and cost efficient means to deter counterfeiting and theft.

Figure 9 With embedded RFID bridge circuits, products can be deactivated after production, then activated at the point of sale to deter fraud and theft.

4.2 Custom configuration

Some RFID ICs, such as the NXP UCODE I²C RFID chip, combine RFID technology with a hardwired microprocessor interface to provide additional configuration options. The I²C-bus supported by this chip is an industry standard, ubiquitous two-wire serial interface commonly available on most microprocessors. In the case of the UCODE I²C tag chip, its built in I²C-bus interface supports a hardwired microprocessor connection via the two-wire I²C-bus traces, allowing it to act as a bridge between the wireless, passive RFID communication and the onboard microprocessor. Embedded RFID adds new capabilities and flexibility during manufacturing, within the supply chain and even in the after-sales process including:

- Ability to provide firmware patches anywhere in production and distribution
- Support for fast reaction to market demands for new features and functions by using one design for products with many customized derivatives, and then selectively enabling features wirelessly
- Means to provide calibration profiles
- Post production activation of the device as a theft deterrence approach
- Customization of products with individual customer features
- Method of storing error logs for later service

Example case: RFID-enabled product customization

With products that include RFID to microprocessor bridge capability (such as that provided by the NXP UCODE I²C chip), brand owners and retailers in the distribution or retail space can very readily customize a product for an individual customer without even opening the box. This capability provides the brand owner with extra flexibility and the potential for more revenue, while increasing customer satisfaction.

How it works

If a manufacturer uses an RFID bridge IC for the RFID tag inside an electronic product, there is a permanent connection between the product's microprocessor and the wireless RFID interface. While the device is powered off and packaged, the retailer can use the RFID interface to store configuration information to the RFID IC's non-volatile memory. Upon power-up, the microprocessor is able to retrieve this information via the hard-wired I²C-bus. Thus at the point of sale, retailers can add additional features, such as personalized gift messages or cards.

For a video example of this feature, see http://nxp-rfid.com/applications/embedded-electronics.

Figure 10 Using embedded RFID bridge ICs, retailers can access products within sealed packages to add additional features such as personalized messages or gift cards

Benefits

- Custom product configuration without powering the device and while in packaging
- Improved customer satisfaction
- Greater flexibility and revenue for the seller

RFID electronic serialization benefits:

- Supports wireless production line tracking
- Deters theft
- Tamper-resistant
- No unattractive external markings
- Does not require line of sight to read
- Enables more efficient and accurate WIP, inventory management, and quality control
- May be accessed post assembly, even when inside packaging and sealed products

5. About electronic serialization

Because RFID tag chips contain read/writeable memory, when placed onto a PCB early in the production cycle, they immediately support electronic serialization of that board. This serial number integrated into the product has no unattractive external markings, does not need line-of-sight for reading, and may even be accessed later, when inside sealed product cases or packaging.

Early on in the manufacturing process, an integrated electronic serial number offers a means to wirelessly and without power to the tag itself, monitor and track a PCB as it moves down the production line. For later assembly processes, this individualized identification enables WIP, custom configuration, better and more efficient quality control, inventory management, theft deterrence, and more.

The memory structure for a UHF tag chip helps illustrate how to provide secure RFID item level identification. The UHF tag chip memory according to Gen 2 specifications[2], has three banks: Tag Identifier (TID), Electronic Product Code (EPC) and a User memory. These three banks can be compared to an automobile Vehicle Identification Number (VIN), license plate number, and optional security system (see Figure 11).

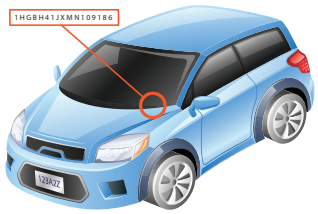
		
TID	**EPC**	**USER**
Like an automobile VIN number, the TID is a factory pre-programmed unique serial number that is permanent and unalterable.	The EPC is similar to a vehicle license plate. It contains product-specific identification and serialization that is added post-production.	User Memory is optional. It offers additional security to those that wish to implement an even more tamper-resistant system. It can be thought of as similar to what an automobile key fob might offer in added security to an automobile owner.

Figure 11 Gen 2 memory structure illustrated

The permanently locked and unalterable TID may optionally contain a pre-programmed individual serial number. Because this number is factory programmed by the IC manufacturer, upon placement onto the PCB, that PCB immediately carries an exclusive electronic serial number.

2 UHF Class-1 Generation-2 air interface protocol V1.2.0 that defines the physical and logical requirements for a passive-backscatter, Interrogator-talks-first (ITF), radio-frequency identification (RFID) system operating in the 860 MHz - 960 MHz frequency range.

The electronic product code (EPC) is similar to a universal product code (UPC) bar code, but with an additional Unique Identification Number (UID) or serial number (see Figure 12).

The User memory further supports unique product identification and security via password controlled and private areas. For further information, contact NXP.

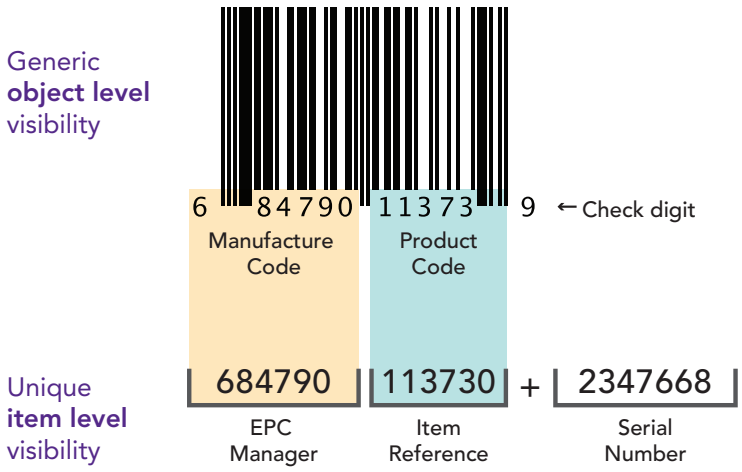


Figure 12 Electronic Product Code (EPC) (for illustrative purposes only).

Example case: RFID-enabled electronic serial number

For some applications, such as automobile electronics, the printed circuit boards are extremely small (an inch or so on a side). Adding a serial number to tiny, densely populated, two-sided boards poses a challenge. Lack of board area means no printed label space. Adding a barcode label on top of the components is not always feasible. And attempting to access the microprocessor via small connectors in order to record an electronic serial number uses board space for a connector, adds cost to the bill of materials for the connector, and labor cost to remove the board from the line, connect to it, program it, and replace it. A low cost RFID tag solves all of these issues.

How it works

Adding an RFID tag to the circuit design takes very little board area. During the manufacture of the rest of the circuit board, the assembly heads place an RFID tag IC along with the other components. Because these boards are so small, they are typically manufactured in an array to take advantage of fixed panel sizes. So at the end of the manufacturing line, one panel will contain an array of identical boards. The final step in the process is to write a unique serial number to the RFID tag on each board in the array. This step makes the previously identical boards all uniquely traceable.

Benefits

- Reduced labor costs
- Reduced bill of materials expense because RFID cost is more than offset by removing the connector cost
- Greater line efficiency
- Better security, as the serial number is not easily changed or duplicated
- Greater accuracy in product identification

About NXP Semiconductors

NXP Semiconductors (NASDAQ: NXPI), a global semiconductor company with operations in more than 25 countries, is a key supplier of LF, HF, NFC and UHF RFID solutions, as well as a provider of High Performance Mixed Signal products.

For more information visit www.nxp-rfid.com,
or to contact NXP, see www.nxp-rfid.com/contact

www.nxp-rfid.com

Date of release: August 2013
Published in the USA