

RFID Packaging Innovations: From Smart Labels to Smart Packages

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Executive Summary

In the mid-1990s, flexible two-dimensional radio-frequency identification (RFID) inlays were introduced by Texas Instruments (TI) to label converting companies as the basis for manufacturing smart labels. Today, smart labels are used to track products in the supply chains of the world's largest retailers and pharmaceutical manufacturers. WalMart, Target, Tesco and numerous other companies in North America and Europe, as well as the U.S. Department of Defense, are all in the process of changing over their distribution and supply operations to include RFID.

Since the introduction of inlays less than a decade ago, RFID usage has changed considerably. In these few years, volume has grown from hundreds of thousands to hundreds of millions of units. As the industry has grown and matured, so has the need for consumer goods manufacturers and label converters to expand their product offerings. In order to provide innovative and value-added RFID solutions, RFID label design is moving from the traditional inlay model to a strap form factor to provide lower cost and greater flexibility.

This paper examines the evolution of RFID labeling beginning with inlays and smart labels, then discusses straps and the benefits of straps labeling. It addresses straps as a more flexible RFID packaging solution, allowing manufacturers to better accommodate products tracked at both the item and case-levels in the global supply chain. This paper also discusses how straps provide a tool for cost innovation with high-volume tag production in the assembly line through lower per unit and lower capital costs.

RFID Inlays

An RFID tag typically consists of a conductive metallic antenna with a low-power microchip as seen in Figure 1. When passed within range of an active RFID reader, the tag is wirelessly energized by energy transmitted by the reader, and then communicates with the reader.

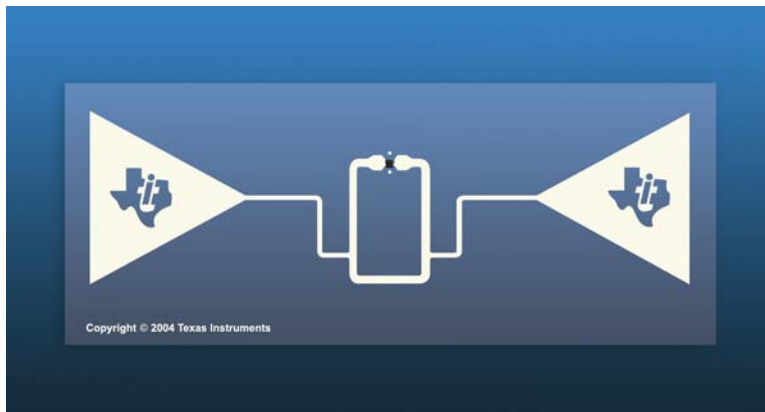


Figure 1: RFID Inlay comprising antenna and microchip

Today, RFID inlays are typically manufactured on a reel-to-reel process by directly attaching the thin microchips to a narrow web of plastic on which a series of two-dimensional antennas have been printed with conductive ink, or etched from a metal film. Figure 2 shows one typical method for creating inlays. The output of this process is a roll of fully-tested inlays.

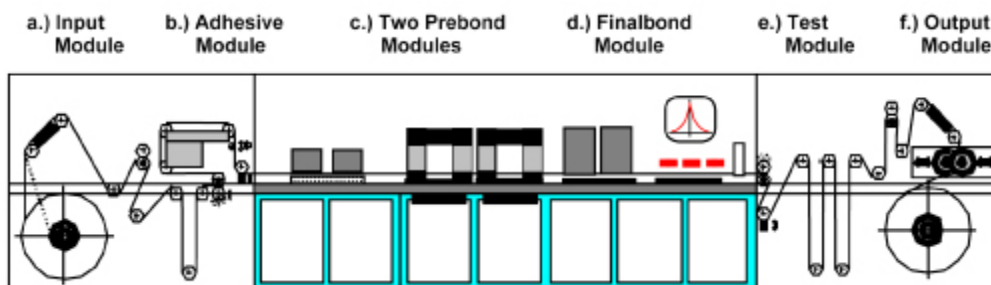


Figure 2: RFID inlays manufactured in a reel-to-reel process (courtesy Mühlbauer, AG)

From Inlays to Smart Labels

The rolled inlays are in an ideal format to be embedded into labels using typical reel-to-reel processing equipment, typically found in a label converting operation. The inlay is

usually placed on the bottom side of the label, next to the container, or sandwiched between layers of the label. These “smart labels” are then ready to be placed on pallets, boxes, cartons, crates and other containers in the supply chain. Figure 3 shows the creation and use of smart labels. Inlays can also be embedded in tickets, tags and other form factors. Under today’s manufacturing processes, smart labels tend to be the most straightforward, cost-effective way of affixing RFID to containers in a manufacturing environment.



Figure 3: Smart labels

In the supply chain, smart labels have proven to be a successful way to utilize RFID inlay technology, but there are some drawbacks. An extra step is required to attach the label to the container. In addition, smart labels require flat surfaces, a minimum surface area, and specific materials for attachment, which puts constraints on their use if the product to be tracked has an unusual size or shape.

The Flexible Form Factor: Strap

Straps are a new way of creating RFID tags that can reduce some of the steps needed to produce smart labels with a more cost-efficient process, helping to drive higher volume production. This new form factor and the technique of applying it also provides greater flexibility in the type of label and antenna used for packaging, as well as the type of product that can be labeled. This flexibility can also deliver advantages in item-level tracking. In general, as RFID tags become easier to use, more flexible and inexpensive, the more they can help reduce the total cost of ownership of manufactured goods.

TI has introduced its Gen 2 Strap as an improved method for creating RFID tags that greatly reduces and in some cases eliminates the need for inlays and smart labels in the high-volume manufacture of many products. The strap technique separates the two components of the RFID tag, the antenna and the chip, until they are brought together

by the user which means more control and choices for the consumer goods manufacturer.

The chips are mounted on small (4 mm × 9 mm) plastic surfaces that TI provides in thin tape rolls. Enlarged metallic contacts on both the plastic surface and the antenna simplify placement of the devices by bringing tolerances well within the normal range of automated container manufacturing.

One method of applying straps is to print the antenna, using a conductive metallic ink, directly on a container such as a cardboard box. The strap containing the chip is then attached to the printed surface which creates the complete tag. Figure 4 shows a typical RFID strap.

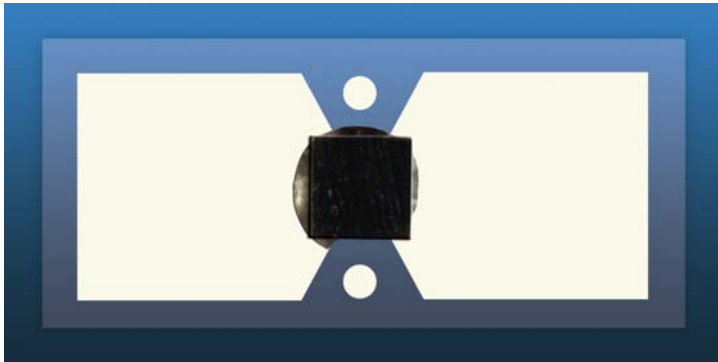


Figure 4: RFID strap

When straps are used on corrugated cartons, the RFID module is built into the cardboard so that it is not exposed, not even to the goods packed inside the container. The carton manufacturer prints the antenna on the inner liner, attaches the strap, and builds the corrugated layers over it with the module inside the corrugation. The resulting smart cartons or packages become premium products in the container manufacturer's line, offering built-in intelligence for tracking through the entire process of manufacturing, shipping and warehousing. Figure 5 shows a box with an embedded strap.

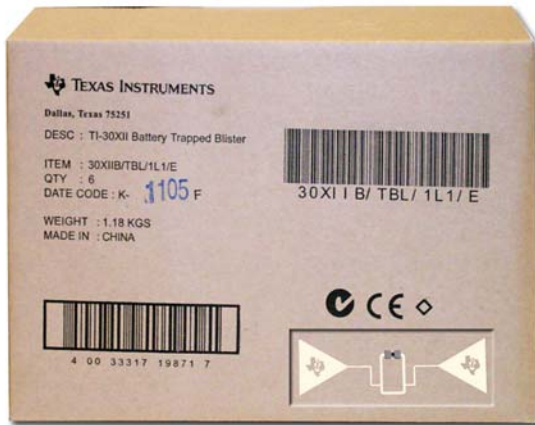


Figure 5. Smart package with embedded straps (courtesy Smurfit)

Meeting Needs with Flexibility

The greater flexibility inherent in straps enables them to be adapted to a wider range of label and packaging forms. Most importantly, straps also offer more choices in terms of antenna design and placement. Label and box manufacturers can use one strap as the basis for a wide variety of finished products, such as labels, hang tags, embedded tags and smart packages. Strap attach equipment is intended to support this wide variety of form factors based on a single strap format. This reduces the cost of the capital associated with starting an RFID tagging operation required for inlays.

Straps can be attached or embedded at the beginning of the container manufacturing process to create smart packages that bring greater intelligence to every stage of the supply chain. For manufacturers of the end products that go into corrugated containers, cartons with embedded RFID straps relieve the problem of attaching RFID altogether. All the manufacturers have to do is write their identifying codes into the tags using RFID readers. This task does not have to take place on the product assembly line, but at any point or points that are appropriate and convenient. Distributors and retailers can continue the tracking process, as they already are doing with RFID, by reading the manufacturer's information and, if desired, adding their own.

In the case of strap modules that are attached to individual product items, improved inventory management continues all the way to the retail store shelf and check-out counter. Portable readers can count items on the shelf, check the items individually for information such as expiration dates, and update pricing. Reordering becomes faster and more cost-efficient, and shrinkage is easier to control. At purchase time, merchants can more readily update their inventory and customer loyalty databases.

Conclusion

There are many benefits that consumer goods and label manufacturers can realize by using RFID straps.

First, straps enable efficient, high volume production that can meet demands in the millions of units and beyond. Second, the strap attach equipment can be compact and versatile, thus lowering capital costs. Third, this new format offers more choices in the type of label being used with antenna design for dry and wet goods.

All of these benefits combine to make a compelling case for straps, which offer a more flexible RFID packaging solution enabling manufacturers to better track products with RFID at both the item and case-levels for efficient movement through the global supply chain.

About the Authors

Prashant Upreti is responsible for developing and managing TI's radio frequency identification (RFID) product portfolio for the retail supply chain. Previously, Prashant was a RFID design engineer with TI where he designed and developed RFID transponders and readers.

Within the TI-RFid group, Prashant works with equipment manufacturers to accelerate adoption of straps technology. He also works with label converters and consumer package groups to design TI's products for the retail supply chain.

Prashant holds a BSEE in electrical engineering from Louisiana State University in Baton Rouge.

Tony Sabetti is the director of UHF Retail Supply Chain solutions for the TI-RFid System's group in Plano, Texas. He is responsible for TI's RFID initiatives in the emerging supply chain management applications. In this role, Tony is currently leading the development and launch activities of TI's UHF EPC compliant products. Tony has over 15 years experience in the RFID industry the areas of marketing, product development and global manufacturing operations, and is active in several RFID industry associations, including EPCglobal.

Tony began his career as a design engineer for Texas Instruments and has since held positions as an applications manager, marketing strategy manager, and operations and engineering manager. He worked with Ford Electronics to establish the first mass-production use of RFID transponders in a vehicle immobilizer system and has been granted several U.S. patents.

Tony earned a B.S. degree in electrical engineering from the University of Rhode Island and an MBA in management from Bryant College.

About Texas Instruments RFid Systems

Texas Instruments is the world's largest integrated manufacturer of radio frequency identification (RFID) transponders and reader systems. Capitalizing on its competencies in high-volume semiconductor manufacturing and microelectronics packaging, TI is a visionary leader and at the forefront of establishing new markets and international standards for RFID applications.

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