

# A closer look at the Gen 2 supply chain

Sufficient visibility and cooperation among supply chain partners will drive the efficient flow of smart label production and support the EPC retail supply chain.

By Peter Bloch, Sheri Phillips and Tammy Stewart

**R**F identification (RFID) technology promises to usher in major efficiencies and enable a truly demand-driven retail supply chain based on electronic product code (EPC). Not only can inventory be managed in an automated fashion without line of sight, using wireless RFID readers, but “just in case” inventory is possible with individual items being managed at the carton, case or pallet level.

The EPC supply chain that delivers consumer goods to retailers is similar in many ways to the supply chain that delivers Gen 2 smart labels for application to their cases and pallets. Demand-driven supply chains such as these can only be efficiently managed through cooperation among all parties in the process. While the “age of the bar code” required close partnerships among retailers, consumer product goods (CPG) manufacturers and their label suppliers, the “age of EPC Gen 2” requires an even greater level of collaboration and coordination with Gen 2 technology suppliers to reap the full rewards from EPC deployments.

## Gen 2 smart label components

An EPC Gen 2 smart label consists of several key components:

- A semiconductor wafer processed into chips that have the ability to store EPC data. These chips are small in size with enough data storage capacity to satisfy EPC requirements.
- An antenna made of a conductive material that enables the chip to receive and send data to and from an RFID reader.
- A substrate on which the antenna can be printed and to which the chip can be adhered.
- A label face stock that covers the inlay and provides a readable print area.
- A release liner that serves as the bottom “sandwich” layer for the inlay. This layer allows the pressure sensitive face and inlay to be made into rolls for easy distribution. It is removed when the smart label is placed on the carton or pallet.
- An adhesive that attaches the inlay to the face stock, as well as the release liner to the inlay and face stock.

The first three components making up the inlay require 10 to 14 weeks to produce and deliver in reel form to the

label converter. The label converter receives the reel of inlays and adds the remaining components, which can require an additional one to three weeks. The smart labels are ready for distribution and use when these components are combined to make a label. Consequently, the production process can require 15 to 17 weeks lead time for production and delivery.

In terms of the supply chain, modifications to a label order can require months to implement and could potentially even delay delivery of the labels. Adjusting production to respond to large increases in demand could take months as well and lead to unplanned smart label stock-outs (Figure 1).

Management of the semiconductor manufacturing process has a significant effect on smart label availability. Consider the Gen 2 solutions from a vendor like Texas Instruments (TI). The entire processing flow for the IC consists of 20 to 30 steps to define the semiconductor elements, interconnects and overall modules. To begin with, the Gen 2-compliant IC is manufactured in state-of-art clean room facilities using 130 nm process node technologies. The finished IC is tested to ensure reliable functionality in the field. Once the ICs are ready, the next step is to manufacture the inlays.

The inlay assembly process begins with alignment of the chip bumps, typically 60  $\mu\text{m}$  to 100  $\mu\text{m}$  in diameter,

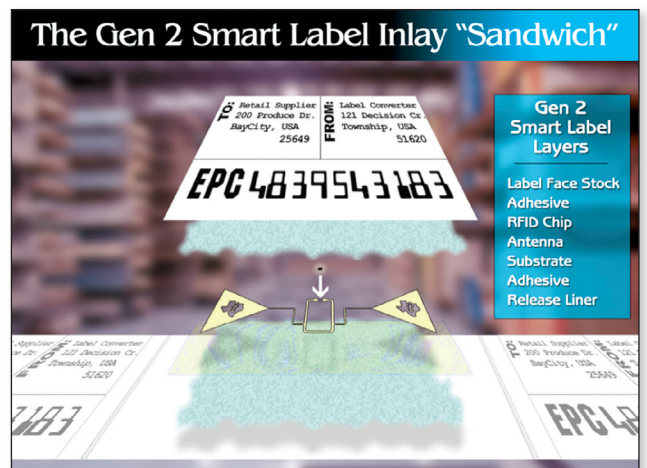


Figure 1. Unfamiliarity with the Gen 2 chip, inlay and label manufacturing process can lead to an undesirable extension of lead time.

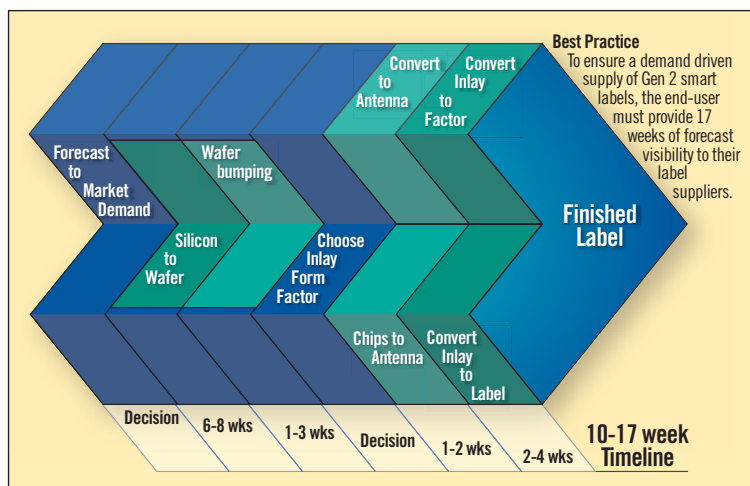


Figure 2. This graphic illustrates the Gen 2 smart label production timeline.

with the landing pads printed as part of the inlay configuration. Each bump provides a physical electrical connection to the analog and digital circuitry that make up the Gen 2-compliant IC. The bump is pressed onto the landing pads and mechanically secured with a high-strength epoxy to ensure a good conductive electrical connection. The inlays are processed in a Web format using a fast-curing epoxy to minimize processing time and to ensure that electrical testing does not bottleneck the assembly flow. Maximum test coverage minimizes the likelihood of failures in the field. Inlays that do not meet the electrical test requirement are marked so the label converter can easily remove them from the production process.

While high-volume demands are projected for this industry, it remains important to provide a reliable electronic product that can withstand the label manufacturing process and the harsh environment of a retail supply chain. Optimal process conditions must exist to overcome potential “cross-talk” or interference issues while maximizing throughput, electrical test coverage and yield.

### The effects of antenna design on the supply chain

The inlay’s antenna design is a key component of a Gen 2 smart label. Products shipped to retailers with an EPC RFID mandate are diverse in size, shape, material and density. These product variations result in corresponding variations in RF properties, which can adversely affect the performance of Gen 2 smart labels meant for products or cartons.

Designing, building and testing a Gen 2 antenna is an involved process that requires a significant amount of time to create an optimal implementation. RF engineers often use the most comprehensive antenna design and modeling software and testing procedures available to design efficient Gen 2 inlay antennas. A Gen 2 antenna can be custom-designed for any consumer product, but the time it would take to accomplish is impractical and prohibitive, given the variety of potential products that require labeling.

To address the need of CPGs and retailers implementing EPC initiatives, a company’s antenna portfolio must target a broad range of consumer product categories. This includes:

- RF-friendly: generally paper and plastic products with little or no metal or water content.
- RF semi-friendly: usually pharmaceuticals and electronics products that require careful placement of label on product casing to perform well.
- RF semi-unfriendly (UHF absorbing): including liquid products.
- RF-unfriendly (UHF reflective): including products with considerable metal content.

To manage these variables in the Gen 2 smart label supply chain, inlay providers will likely offer three or more inlays resulting in three or more part numbers. Furthermore, end-product variations require technology providers to build specific inlay and antenna designs to meet customers’ requirements.

The steps involved in manufacturing a wafer of Gen 2 chips and perfecting various antenna designs are complex. The more accurate the information that semiconductor manufacturers and label converters have about the market and end-user’s forecasted requirements, the better their ability to plan according to market demand and to roll out a more efficient supply of smart labels.

To minimize the changes in forecasted smart label requirements, forward-looking companies should prove out their processes in advance to know which labels will work on their products and how products will flow through their facilities. That is where supply chain management companies like IBM can add significant value. Working with companies to incorporate RFID requirements, it helps design, build and test RFID systems to identify optimal smart-label configurations. Armed with this information, customers can forecast demand more accurately and share this information with the label converter and semiconductor manufacturer.

### Label conversion

To create a Gen 2 smart label, a label converter like NCR takes a flexible inlay containing an IC and an etched metal or printed antenna, and inserts these components between the face sheet and liner of a label. During inlay testing the face sheet of a pressure sensitive material is split away from the liner or laminate to a transfer adhesive. Inlays that meet the appropriate testing criteria are then attached to the adhesive that covers the back of the pressure-sensitive face sheet. After insertion of the inlay, the liner is reunited with the face sheet and die-cut to the desired label dimensions. The excess material is stripped away and the label is tested one more time before being wound on a roll for use.

If the labels are going to be run through an EPC-enabled variable thermal printer, placement of the inlays is critical and is defined by the specification set by the printer

## Packaging best practices

The following are best practices for packaging inlays and shipping to label converters:

1. Do not wind inlay reels too tightly or the tension will cause damage to the chips.
2. Carefully calculate the quantity of inlays per reel so that the weight of the outer inlays does not damage the inner ones.
3. To prevent potential shipping damage, use outer packaging with cushioning at the various pressure points. One reel per protective box is recommended.

manufacturer. Tolerances for inlay placement are in millimeters, so even a slight deviation in the placement of the inlay can cause a thermal printer to “miss” the inlay during encoding and mark a fully functional label as void or failed (see “Packaging Best Practices”).

There are generally two ways to convert an inlay into a carton or pallet smart label. The first is pre-conversion editing, which tests and edits (i.e. replaces) defective inlays before they are inserted into final label constructions. The pre-conversion method typically cuts a stream of continuous inlays into individual units. In this method a parametric test is done on the inlays before they are placed into label construction to measure the quality and viability of the inlay and to determine its reflective strength.

The second approach is post-conversion editing, which employs many of the same steps except it does not test the inlays before they are converted into labels. Inlays can be aligned with the face sheet in an “on pitch” or one-to-one ratio. After the liner is reunited with the face sheet and die cut, labels are processed onto finished rolls. These labels are then tested off-line via a separate test station where nonworking labels are manually edited and replaced with working labels.

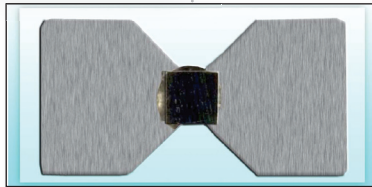
There are limitations associated with the post-converting testing method. Because post-conversion uses manual placement of labels and is not exact, printing/encoding failures may result further in the process. The release value of the label adhesive is also altered with label replacements, potentially leading to pre-dispensing issues and equipment jams. Pre-conversion editing is preferred over manual editing because manual editing will not scale in the long term as Gen 2 smart label volumes increase.

### On-time delivery

The final stage in the Gen 2 smart label supply chain is the appropriate placement of the inlay in the label (Figure 2). Placement is important because it determines the type of printer the end users will need to print their labels. Because CPGs and other manufacturers have a variety of products to tag, they will likely require different types of labels. Most will use EPC-enabled printers in their

packaging or shipping processes, and inlay positioning within the adhesive label may be different between printer models and manufacturers.

The ordering, manufacturing and inventory of Gen 2 smart labels are more complex than for standard, bar code-printable adhesive labels. Label converters make a wide variety of labels available across a diverse customer base. The challenge is to manage in-stock supplies efficiently. It is essential that a label converter have an intimate understanding of its customers’ Gen 2 smart label requirements



*Figure 3. The Texas Instruments Gen 2 Strap 8 is composed of RFID silicon with two conducting paths that make it easy to attach the chip to an antenna. These straps will also be shipped to the label converter on a reel. Forty thousand straps can fit on a reel vs. only 10,000 to 12,000 inlays. This will enable semiconductor companies to ship more straps per package than with inlays and, therefore, meet high volume demands.*

so that it can procure the appropriate materials and schedule manufacturing, testing and shipping to reduce and prevent any negative impact or delay on the supply chain. Today, many label converters provide testing facilities and services to end users to ensure that Gen 2 smart labels will be determined and appropriately matched for use with their stock keeping units (SKUs).

The Gen 2 smart label supply chain promises to become even more efficient as label converter companies assume part of the inlay production process, bringing

production closer to the end customer in the demand-driven supply chain (Figure 3).

Any supply chain like Gen 2 smart label production that carries long lead times becomes more dependent on the demand insight from all the customers in the chain. Sufficient visibility and cooperation among supply chain partners can help drive the efficient flow of smart label production and support the EPC retail supply chain. With the level of variation and complexity in the Gen 2 smart label supply chain, it is not realistic or sufficient for companies to only focus on individual improvements. The demand-driven supply chain requires intentional, informed, and innovative process development among all its members. The more that the semiconductor manufacturer, the label converter, and the end customer can communicate true demand signals to drive production, the more successful each player can be in the quest to meet customer’s needs cost-effectively and efficiently. **EWT**

*Peter Bloch is the global RFID program director of the Systemedia division for NCR. Bloch is responsible for the development and delivery of program elements that make up NCR’s RFID labeling offer.*

*Sheri Phillips is an associate partner within IBM’s Supply Chain Management Practice. She has more than 20 years business experience and 15 years in changing the way organizations execute their business.*

*Tammy Stewart is an EPC business development specialist for EPC UHF solutions at Texas Instruments RFid Systems, a business unit of Texas Instruments Inc. based in Plano, Texas. She is responsible for developing strategic partner relationships with label converters that provide EPC products to end-users.*