Tips for RFID Smart Label Printing/Encoding

Best practices for improving performance, uptime, and encoding success with RFID smart labels

A ZEBRA **BLACK&WHITE** PAPER

Zebra

Zebra Technologies introduced the first integrated, on-demand RFID smart label printer/encoder in 2001, and since then we have worked with hundreds of customers around the world who use different RFID protocols, frequencies, inlay designs, and standards. This experience has taught us several best practices that can be applied to any smart label printing operation. Following the tips described in this white paper can help you get more from your smart label printing system by improving reliability, minimizing operator intervention, reducing wasted labels, preventing encoding and printing errors, and yielding more usable labels per media roll. These best practices are effective for all types of smart labels, including those that conform to the new EPCglobal Class 1 Generation 2 (Gen 2) standard.

Fundamentals: How Smart Labels are Produced

Smart Label printer/encoders use media that has an RFID inlay (chip and antenna combination) embedded within the label material. An RFID encoder inside the printer writes data to the tag by radio frequency transmission. The transmission is focused for the specific location of the tag within the label. Bar codes, text, and graphics are printed as usual.

Media Selection

Matching media with the printer and application is important to the success of any label printing system, but is critical for RFID smart label printing/encoding. RFID systems are designed to minimize interference, ensure data integrity, and provide maximum read range. RFID read range and data integrity depend on high-quality smart labels. The smart label must reliably transfer data in a dependable, predictable manner, and—in classic domino effect—the success or failure of the RFID system depends on getting this critical key aspect correct. Smart label material should adequately protect the inlay and not provide potential interference, which impacts range and reliability. Due diligence with regard to smart label selection will make a huge difference whether your RFID implementation goes smoothly or not.

Match the chip position to the printer/encoder

Organizations should perform testing to find the best frequency, protocol, inlay manufacturer, and design for the needs of their application. A common mistake is to place a large order for smart labels early-on in the testing phase without making sure the media is optimized for the chosen printer/encoder. In fact, smart label media may NOT be interoperable among different brands of printer/encoders that support the same RFID protocol. Therefore, the specific media must be calibrated to the specific printer/encoder model to ensure proper alignment and encoding.

Printer/encoder specifications list specific inlay manufacturers and label/tag designs that are supported. It is critical that your media provider conforms to these specifications when designing smart labels to fit your application. In order to verify that the specifications were followed, end users should obtain samples or place a small initial order for testing purposes.

Avoid foil and metal-based media

Current foil or metal-based label stocks should never be used for smart labels. Metal reflects RF signals and is a leading source of RFID interference, so it should be avoided as much as possible. Embedding an RFID inlay within a metal or foil label can prevent successful encoding and reading and can severely limit range. Foil and metal-based media are sometimes used for bar code labeling and can actually enhance bar code performance by providing more light reflection. The media provides no such benefit for RFID, which is not an optical technology.

Watch for water

Liquids are the other leading hindrance to RFID system performance. Liquids can absorb RF signals, which can severely limit range or prevent tag read/write operations altogether. Therefore, label placement on liquid products is critical in order to get successful read rates. Also, label media adhesive can be an unexpected source of liquid. Water-activated (a.k.a. dry-gum) adhesives can limit tag performance. Some current label adhesives attract moisture from the environment, which could also cause performance problems. Synthetic media and laminates that are commonly used to protect bar code labels from moisture and liquids pose no problems to smart label performance.

Media Handling

There are several things organizations can do to protect the quality of their smart label media and reduce the chances that inlays will fail to encode. Label yield (the percentage of good inlays per label roll) can be improved by media storage and handling procedures, and by the physical location of the printer/encoder relative to other RF devices.

Storage temperature

Smart label media can withstand a wide range of temperatures, so storage temperature is not usually a concern. Performance shouldn't be affected if storage temperatures are kept between -60º and +203º F (-51º and +95º C).

Limit electro-static discharge (ESD)

ESD dangers are elevated in low-humidity and high-altitude locations. This may seem like a small consideration, but failing to control for ESD can seriously affect smart label performance and lead to more cost and problems during an RFID implementation. Storing media in non-conductive bags or cartons (cardboard is sufficient) should provide sufficient protection against ESD damage. However, if ESD is a persistent problem, operators may need to wear anti-static clothing.

Printer Management

Procedures and training, optional printer/encoder settings and features, and the physical location of the printer/encoder itself all contribute to successful smart labeling. Printer/encoders that offer configurable error settings and other flexibility should be given top consideration because they can increase uptime and minimize required operator intervention.

Pick printer placement carefully

Performance can be improved by allowing some physical space between the printer/encoder and other RF products that share the same bandwidth, such as antennas, readers, or even wireless phones. Interference may result if the printer/encoder is next to or directly above or below other RF devices. Remember that the printer/encoder itself is a shield to outside RF interference. Should the integrity of the printer/encoder be compromised, there may be reduced read/write success.

Maximize encoding success

Printer/encoders should perform two tag quality checks. The first check should be done prior to encoding to make sure the inlay is functional and can receive data. The second check should verify that data was written and stored on the chip correctly. Optimally, encoding the inlay and printing the smart label should require only a single pass through the printer/encoder. A key consideration in facilitating smooth printing/encoding operations is to ensure that the label edge is properly aligned so that the tag is in proper programmable position for encoding. The practice of manually aligning labels—common in bar coding—should be avoided. Because precise positioning is required to enable the tag to be encoded, the best practice is to adjust label location through printer/encoder commands or through label-design software.

For example, Zebra Programming Language (ZPL®) includes the "Label Home" script that can be used to adjust the top position of the label. Label design software packages also have features to adjust label layout. Some printer/encoders have programmable encoding positions that allow the encoding location to be set from the control panel or through the printer command language. Printer/encoders with a self-calibration feature—again an optimal choice—can automatically determine the best encoding position.

Limit error messages

Inlays fail to encode for a variety of reasons. It's common for inlays not to encode on the first try, so failure to do so does not necessarily indicate a problem. Therefore, it isn't practical to issue an error message or shut down the printer/encoder each time there is a failure to encode. Printers can be set to automatically retry encoding. When considering the purchase of a smart label printer/encoder, choose one that allows you to adjust the number of encoding retries to program the smart label before sending an error message. This flexibility will ensure the highest percentage of yield rates from your media.

Designate and segregate unencoded labels

Sometimes rolls of smart label media become damaged and portions of the roll will fail to encode. Processes need to be in place to prevent damaged or unprogrammable smart labels from being applied to items. Unusable labels should be clearly marked with a printed "VOID" message. Another option is to stop the printing process when an unencoded label is produced to prevent further printing until the error is resolved; however, this is recommended only in the case of persistent problems.

Use alerts for persistent problems

Halting operations should be the last step in an escalated response system. There are other options short of time-consuming system shutdowns. Most encoding failures are isolated incidents resulting from a damaged inlay. Consistent failures could indicate a larger problem. The printer/encoder should be programmed to issue an alert when a persistent problem arises. It is strongly recommended that end users incorporate a robust printer and print-server management application in their overall RFID architectures. Software-based monitoring and management of RFID printer/encoders can provide alerts and capture statistics on printer/encoder performance to flag problems before they have serious consequences.

Label Placement

Many of the principles of successful smart label printing and encoding also apply to placing the label on the cases and pallets. Proximity to metal and liquid should be avoided, care should be given to protect the label against excessive contact, and testing is required to determine the optimal position. Consideration should be given to how cases are stacked on pallets so as to keep the smart labels a sufficient distance apart. In addition, testing should be conducted to determine the optimum placement from the bottom of the pallet. If pallets are shrink wrapped, smart labels should be placed on the outside of the wrap. Bands used to hold pallets or wrappers in place should not wrap around the labels. There are a great many variables that will determine the best approach to placing labels on packages, cases, and pallets. A comprehensive guide outlining many of these considerations can be found in a document created by AIM Global's RFID Expert Group, entitled "Proposed Guidelines for the Use of RFID-Enabled Labels in Military Logistics: Recommendations for Revision of MIL-STD-129." Although designed primarily for military logistics, these guidelines have been coordinated with commercial logistics RFID practice so that conveyable goods used in military and civilian approaches can conform to a common standard as far as possible. This document can be requested from AIM Global or can be found among Zebra's RFID whitepapers on www.rfid.zebra.com.

Conclusion

The vast majority of smart labels are printed and encoded successfully. Most problems that do arise are caused by a few common conditions that can easily be resolved. Many problems can be avoided entirely by training operators on the leading causes of smart label failure, such as due diligence in selecting proper media, media handling, and manual printer calibration.

Action taken before the system is up and running can also save errors and downtime. Care taken early-on to optimize media with the specific printer/encoder will save valuable time and costs and improve long-term yields and throughput. Selecting intelligent, programmable printer/encoders helps optimize operations by letting the organization set the unit to support desired processes for error resolution and alert notification. Printer/encoders that offer programmable encoding positions and imaging adjustments make it easier to maintain calibration and uptime.

There are many other usage, environmental, and product factors that impact smart label printing/encoding performance. Contact Zebra Technologies to learn more about setting up an efficient smart labeling system for your organization. As a member of EPCglobal, and a technology sponsor of the former Auto-ID Center at MIT, Zebra plays a leading role in the development of smart label technology, standards, and applications for supply chain and business improvement programs. Zebra has provided solutions to many RFID early adopters, including suppliers in the Wal-Mart and U.S. Department of Defense (DoD) compliance programs.

Zebra Technologies Corp. (Nasdaq: ZBRA) delivers innovative and reliable on-demand printing solutions for business improvement and security applications in 90 countries around the world. More than 90 percent of Fortune 500 companies use Zebra-brand printers. A broad range of applications benefit from Zebra-brand thermal bar code, smart label, receipt, and card printers, resulting in enhanced security, increased productivity, improved quality, lower costs, and better customer service. The company has sold more than 4 million printers, including RFID printer/encoders and wireless mobile solutions, and also offers software, connectivity solutions, and printing supplies. For more information about Zebra's RFID printer/encoders, call +1 800 423 0442, or visit www.rfid.zebra.com.

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