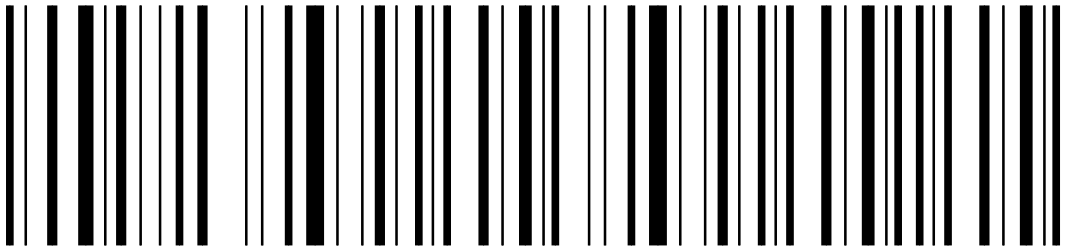
Gen 2 Implications for Smart Label Printing



APPLICATION WHITE PAPER

Zebra Technologies

Executive Summary

The long-anticipated EPCglobal Generation 2 Class 1 (Gen 2) RFID products are expected to reach markets and supply chain operations starting in the fall of 2005. Companies that ship, track, and manage materials marked with RFID tags are planning accordingly. But the arrival of Gen 2 does not signal the retirement or obsolescence of other RFID protocols. In fact, it will likely be several years before all partners in RFID-enabled supply chains are consolidated on Gen 2. Even then, other RFID protocols will also be in use in other business applications, just as numerous bar code formats are used today. Organizations that print and encode RFID smart labels, or expect to in the future, must plan for an ongoing multi-protocol RFID environment, regardless of their current RFID involvement or expected requirements.

This white paper explains the implications Gen 2 has for smart label printing. It illustrates the need to

- support multiple RFID protocols,
- cover the considerations of upgrading installed printer/encoders to support Gen 2,
- identify potential obstacles and costs to upgrading equipment and how they can be avoided, and
- explain how options and variables within the Gen 2 standard create needs for specific features in printer/encoders.

Introduction

In the interim from the ratification of Gen 2 technical specifications late last year until the first Gen 2-compliant tags are widely commercially available, millions of RFID tags built to ISO, EPCglobal Class 0, Generation 1 Class 1 (Gen 1) and proprietary protocols have been—and still are being—put into circulation. Products tagged with these RFID protocols are sitting in factories, warehouses, distribution centers, depots, and retail stores around the world, and will soon be joined by Gen 2-tagged goods. In addition, other RFID protocols are under development or used to identify returnable shipping containers, provide electronic cargo seals, and identify individual items such as prescription drugs that are packaged within cartons, cases, and pallets. While EPCglobal Gen 2 is expected to become the most widely used UHF RFID protocol, it is clear it will not be the only protocol in use.

Ironically, some of Gen 2's leading proponents are playing a key role in establishing an ongoing multi-protocol environment. While Wal-Mart and the U.S. Department of Defense (DoD) clearly require Gen 2 labels on shipments, they have each established reasonably long transition periods, where existing EPCglobal protocols will be accepted until Gen 2 tags, printer/encoders, and readers are available. For example, the DoD's policy for supplier RFID tagging allows suppliers to continue to use EPCglobal Class 0 and Gen 1 Class 1 tags for up to two years after the introduction of Gen 2 tags. This document is available at: www.acq.osd.mil/dpap/dars/dfars/changenotice/docs/20050421/2004d011.doc.

It is clear that multi-protocol environments demand readers that can process multiple protocols. The alternative is to have separate readers for each individual tag protocol that is received. This approach is not only cost-prohibitive, it would be a challenge to find physical space enough to install all the necessary hardware.

Management of these devices—especially for upgrades or new components—would also quickly spiral out of control. Some vendors support hardware upgrades to readers to allow them to handle a number of protocols; however, this approach has its drawbacks in that this is not a quick or simple fix, especially as it cannot always be anticipated which protocol will emerge as the dominant industry choice for a given application.

Obviously, multi-protocol readers are a much better option and RFID readers and encoders utilizing software-defined radio (SDR) technology can be the most flexible and cost-effective multi-protocol solutions on the market. Software-defined radios use software to control the RF signal modulation and demodulation and the transfer of data. Support for frequencies, standards, and options are written into the software and are not hard-wired into the hardware. Therefore, upgrades and changes are accomplished simply by downloading new software to the device. There is no need to install new components or replace the device itself. SDRs therefore have the advantage of providing a relatively simple and expedient way to allow end users to support multiple RFID protocols as they emerge.

Companies that are implementing RFID not only need to choose multi-protocol readers, they need to choose multi-protocol printer/encoders as well. Multiple generations of Electronic Product Code™ (EPC) and ISO tag technologies are expected to coexist for years, even beyond the phased implementation timetables established in EPC compliance tagging protocols. Whole new classes of tags are under development, such as temperature sensor tags. A multi-protocol printer/encoder—again, optimally with software-defined radio architecture—provides protection for RFID investments and a cost-effective migration path to meet future requirements. As with readers, printer/encoders with SDR can be upgraded with a simple download of new protocols as they emerge.

Gen 2 Variables: Standard Doesn't Mean Homogenous

In spite of the fact that it is a standard, Gen 2 itself has a much higher potential for variation in execution by vendors than end users may expect. This is because Gen 2 is written as a robust and flexible standard that can accommodate a broad range of user needs. Gen 2 specifies a variety of basic requirements and then specifies the details of many more optional features. How these options come together in commercial products depends on the choices vendors make, which could be driven by any number of factors, including cost, performance, or speed to market. The broad scope and flexibility of the Gen 2 standard is expected to be retained as it becomes codified into the planned ISO 18000-6C RFID standard. Table 1 summarizes some of the key features and enhancements over Generation 1 tags.

Table 1 - Selected Feature Comparison Between EPCglobal Gen 1 and Gen 2 Protocols

	Gen 1	Gen 2	Notes
EPC Data	64-96 bits	96-512 bits	Pilot and pre-standard applications using 64-bit EPC Data are being phased out.
Frequency	860-930 MHz	860-960 MHz	The air interface and modulation protocols make Gen 2 compatible with most international radio requirements.
Read rate	The Gen 2 standard does not specify a minimum speed, and EPCglobal itself does not quote a required or suggested read speed. A Gen 2 tag is capable of multiple different forward and reply data rates that are commanded by the reader at the time the tag is read or written. Quoting read rates can be misleading because many factors beyond the scope of the standard specification affect the actual rate experienced in real-world operations. Many Gen 2 readers will be capable of automatically adapting to changing factors include RF interference, the number of tags and readers present and the reader power levels, the amount and type of data being exchanged, required security implementation, and other variables. In general, the Gen 2 read rate is acknowledged to be significantly faster than Gen 1 under the same conditions.		
Minimum write speed	3 tags/second	5 tags/second	Gen 2 specs enable much faster encoding speeds than 5 tags/second, depending on the amount of data written.
Write verification	Optional, conducted by encoder	Supported in air interface	Verification is supported in Gen 2 tags but is an optional feature in encoders.
Read verification	Yes	Yes	
Add/rewrite data to tag	Limited	Unlimited	
Security	8-bit password	Separate 32-bit passwords to lock or kill tags and for protecting access to different portions of tag memory; memory locks can be permanent or reversible. “Secured state” option blocks tags from communicating with non-authenticated readers and encoders.	Gen 2 surpasses Gen 1 security with a stronger password plus several additional options.

In addition to the variability that comes from tag vendors’ execution around the standard, other areas will also add to differences in RFID offerings. The chips used in Gen 2-compliant tags may vary in memory size and content, re-writability, data security, and other characteristics. Printer/encoders and readers will vary by the

features they include; how they comply with U.S., European, and other radio regulations; security support; and more. According to a feature analysis by ThingMagic, a leading developer of RFID technologies and a Zebra partner, there are several hundred possible variations of Gen 2-compliant tags, and this number does not include proprietary, custom features that chip manufacturers may add or the variations that can be introduced over time.

Obviously the fact that tags in numerous configurations will be circulating creates the requirement that companies using Gen 2 tags—or applying them for customers—will need to support a variety of tag types. This rule will also apply to RFID technology providers as well—particularly hardware vendors. Printer/encoders can only support features and options built into the RFID chip used in the smart label media. In Gen 2 tags, the TID (tag identification) area in the chip memory encodes the chip manufacturer and chip model number information to identify which optional features are present. Both the smart media and hardware must each support all the desired features. Additionally, the Protocol Control Bits in the UII (formerly called "EPC") memory bank may be used to specify the size and format of the data stored in the UII memory. In an EPC encoded tag, the format is defined by the EPCglobal Gen 2 Tag Data Standards.

One area to be aware of is that smart media using Gen 2 chips and printer/encoders that separately conform to the same Gen 2 standard are not necessarily physically compatible. Printer/encoders communicate data in a small and very specific physical location within the printer/encoder that corresponds to where the tag inlay must be positioned within the label media. The tightly controlled position of the inlay within the printer/encoder is in contrast to most RFID readers, which are configured to broadcast to cover the large area so that all tags in the field will be identified. Users must make sure the smart label media they use is designed to be compatible with their specific brand and model of printer/encoder.

The following sections explain variables within the Gen 2 standard and printer/encoder considerations to ensure maximum performance.

Data Content

Gen 2 requires a minimum 96-bit EPC identifier, which is a major change from the 64-bit identifiers common in early EPC tags. Even now, very few Generation 1 64-bit EPC chips are in use, and most applications will have a "sunset date" for their use.

The EPCglobal Tag Data Standards for Gen 2 tags also support much larger data structures in expanded UII memory for future applications. Gen 2 specs also allow as an option unlimited user tag memory, which organizations at any point in the supply chain can use to add proprietary supplemental data. The additional memory could be used to store lot codes or expiration dates, time and date stamps for transactions, input from temperature sensors, and other information. The presence and size of user memory available varies by the model and manufacturer of the chip used in the smart label inlay (the chip-antenna combination). So one thing to determine when choosing a printer/encoder is whether it can support these expanded data structures. For example, Zebra® printer/encoders can encode as much data as the Gen 2 chip memory supports.

Write Verification

Zebra printer/encoders have always supported the write verification feature in all classes of tags to prevent unencoded or corrupted smart labels from being put into circulation. If a chip fails to encode properly, "VOID" is printed on the label to indicate it shouldn't be used, and a new label is selected. Printer/encoders can also be set to stop and communicate an error message if encoding problems arise. Although write verification is especially important for compliance tagging applications, it should be performed for all smart label printing/encoding. The Gen 2 specifications have several new methods for verifying data written to tags, the use of which will be supported in Gen 2 Zebra printer/encoders.

Another area of consideration is that different tag inlay designs will require different power levels for optimal performance. The amount of power from the encoder required to write data to a tag is a complex function of the inlay's chip type, antenna design, and antenna size. If not enough power is applied, the chip will not be powered up or may have insufficient power for programming, and the data will fail to be encoded. Applying too much power sometimes disables the tag or causes data communication errors. Either way, the smart label will be voided. Zebra printer/encoders allow customers to adjust the encoding power level through software commands and provides optimal power settings for specific inlay designs. The power output is typically configured when the printer/encoder is first installed, but settings can be user adjusted for different tag types.

Security

The Gen 2 protocol uses an optional 32-bit password to access tag data or lock tag data or to permanently disable (kill) a tag. This is much more secure and versatile than the 8-bit password used in Gen 1. Besides the optional use of password protection, user-allocated memory can be safeguarded with flexible locking options. The "permalock" feature permanently locks the data and prevents rewriting. Gen 2 also offers a less restrictive password-protected feature that enables locking to be toggled on and off. Toggling could be used to lock the blank memory to protect it against accidental encoding and preserve it for future use. When an authorized user wants to change or append the data field, he or she would use a password command to turn off the toggle lock. Encoded data could then be protected by the toggle lock or permalock.

Additional data encoded on Gen 2 tags does not necessarily have the same security protection as the tag ID in the TID memory and EPC memory. The Gen 2 standard also supports optional security implementations, including a separate 32-bit password to access the memory block reserved for users. Different security levels can be applied to different portions of tag memory. Password protection, lockable fields, and other security features for optional data may be supported in the tag, encoder, and reader.

Effectively Meeting Multiple Needs

As you can see from the preceding pages, data content, write verification, and security represent some leading areas of variability within the Gen 2 standard. It is most likely that the various chip manufacturers will produce a range of Gen 2 chips that have different functionality and features, all of which are Gen 2-compliant but not necessarily identical to each other in terms of optional features. As a result, it will be even more important to match smart label media to the specific make and model of printer/encoder used. Smart label media should not be considered an interchangeable commodity.

The best strategy for managing the complexity in a multiple protocol environment is to develop a flexible, configurable, and upgradeable RFID infrastructure. Products with limited feature support or upgrade options will require more frequent replacement and raise the total cost of ownership. Organizations simply can't afford to replace or add equipment every time requirements change. When evaluating printer/encoder and reader products, determine if they meet three key criteria to support a flexible and cost-effective RFID architecture:

1. Provide simultaneous support for multiple RFID protocols (e.g., Gen 1, Gen 2, ISO, etc.)

2. Meet the user's current needs for protocols, options, and features

3. Provide a clear and efficient upgrade path to add new features and protocol support

All vendors will say they offer an upgrade path, so these claims must be investigated more carefully. Issues to consider include:

- Who will pay for future upgrades?
- If new options and supports are made available for "free," is installation and support also free?
- How much time and effort will be required to perform the upgrade? Is it simply a firmware upgrade, easily available through the Internet or over the company LAN, or does it require hardware upgrades and on-site or back-to-factory service?
- Can the printer/encoder be adjusted or optimized to support new inlay designs?
- Is adding support for future protocols an "either/or" proposition? That is, if a printer/encoder is "upgraded" to process a new standard, will it lose its ability to encode tags that support different protocols?
- Can the protocol "mix" supported in the company's printers be configured to support all the tag types and chip options in use?

Multi-protocol requirements force users to look beyond initial considerations to determine what costs will be associated with maintaining and upgrading the RFID system. The answers to those questions do more than differentiate vendors—they determine the total cost of ownership for the system and the amount of protection the organization has for its RFID investments.

Zebra Printer/Encoders

Zebra's UHF multi-protocol smart label printer/encoders use software-defined radios (SDR) to support multiple protocols. Zebra also offers "RFID Ready" bar code label printers that can be upgraded to perform smart label encoding any time in the future.

Here's how a Zebra printer/encoder with an SDR can handle the upgrade to support Gen 2. Assume a printer/encoder is currently being used to produce EPCglobal Gen 1 Class 0 and Class 1 smart labels. To add support for Gen 2 or future Gen 2 options, the user organization must obtain the firmware from the printer vendor. The firmware can be downloaded from a Web site or provided on a CD. Uploading the firmware to printers requires considerably less time than removing and installing radio modules or replacing printer/encoders altogether, thereby providing time, labor, and support savings. A printer management system such as ZebraNet™ Bridge Enterprise can remotely upload the firmware directly to printer/encoders through a network connection, with no need to physically handle each device. If grouping and profiling features are provided, every Zebra printer/encoder could be upgraded in the same amount of time it would take to upgrade one, thereby multiplying the administrative time-savings.

The following section answers frequently asked questions about Zebra RFID smart label printer/encoders.

Is multi-protocol support an option for Zebra printer/encoders?

Zebra's latest RFID printer/encoders support multiple protocols.

Which protocols does Zebra support?

Zebra printer/encoders support numerous standard and proprietary high frequency (13.56 MHz) or UHF (860-960 MHz) RFID protocols including EPCglobal Gen 1 Class 0, Class 1, Symbol/Matrics Class 0+, Impinj Class 0+, ISO 18000-6A, 18000-6B, ISO 15693, Philips UCODE 1.19 and I•Code, Texas Instruments Tag-it®, Inside Contactless PicoTag®, E-M Marin 4223 and more. While all Zebra printer/encoders support multiple protocols, they are applications-targeted products, which means that a single product line may not support a full or identical set of protocols.

Does Zebra support Gen 2?

Zebra was the first thermal printer company to demonstrate support for Gen 2 technology using its standard and readily available printer/encoders. Zebra plans to release its Gen 2 firmware upgrade as soon as Gen 2 smart label media is commercially available. Zebra, as a member of the EPCglobal Hardware Action Group, was a leading contributor to the development of the Gen 2 standard.

How are upgrades handled?

Upgrades to support new RFID protocols and features are made through firmware, easily downloaded from www.zebra.com. Zebra smart label printer/encoders use software-defined radios and do not need hardware changes to be upgraded. Zebra also offers the ZebraNet Bridge Enterprise device management system, which enables upgrades and configurations to be done remotely by a single administrator. ZebraNet Bridge Enterprise supports one-to-many configurations, which enables an upgrade or configuration change to be uploaded to groups of printers simultaneously, eliminating the need to configure each unit individually.

If I upgrade to Gen 2, can I still encode Gen 1 and Class 0 tags?

Yes. Multi-protocol support means customers don't need to choose which protocols their printer/encoders can encode, or purchase specific printer/encoders to support specific protocols.

Does legacy labeling software support Gen 2, or does it need to be upgraded too?

Label design software must specifically support Gen 2, so most legacy packages will need to be upgraded. Contact your label design supplier for information on their Gen 2 support plans.

Where can I get more information?

Visit www.rfid.zebra.com to access dozens more Frequently Asked Questions (FAQs) about Gen 2 and other RFID technologies, implementation issues, other RFID topics, and Zebra printer/encoder product information. The FAQs are updated as new questions, features, products, and issues emerge. ThingMagic provides an excellent white paper with a detailed explanation of software-defined radios and the value they will provide as Gen 2 adoption grows. The paper, "Gen 2: A User Guide," is available at www.thingmagic.com.

Conclusion

Although Gen 2 will bring many much-needed improvements in the performance of RFID systems, there will still be a long period in which Gen 2 technology coexists with other standards in the real world. Not only is Gen 2 unlikely to completely displace other RFID technologies, many chip feature variations allowed by the standard itself assures there will be diversity within the Gen 2 user community. In addition, Gen 2 as an emerging standard will experience transitions during the adoption period, until it has matured. Organizations that currently use or will use smart labels need to recognize this diverse RFID environment and plan accordingly. Planning includes developing an understanding of Gen 2 features and variables, and the implications for making equipment purchases. It is important to look beyond the current spec sheets and evaluate vendors and products on their ability to accommodate changes and meet future needs. If equipment is installed that can't simultaneously support Gen 2 and other protocols, or can't support Gen 2 optional features or future upgrades, organizations then are at risk for costly and premature equipment replacement.

Multi-protocol equipment and software-defined radios (SDR) provide the flexibility and investment protection users need in the current RFID environment. Printer/encoders built with multi-protocol software-defined radios must be designed to accommodate support of all the intended Gen 2 smart label media and have a vendor support infrastructure to enable efficient upgrading to new options. The answers to these questions do more than differentiate vendors—they determine the total cost of ownership for the system and the amount of protection the organization has for its RFID investments.

Zebra is playing 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 compliance programs. Zebra, as a member of the EPCglobal Hardware Action Group, was also a leading contributor to the development of the Gen 2 standard.

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 Technologies Corp. (Nasdaq: ZBRA) delivers innovative and reliable on-demand printing solutions for business improvement and security applications in 100 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. Information about Zebra products can be found at www.zebra.com. For more information about Zebra's RFID printer/encoders, call +1 800 423 0442, or visit www.rfid.zebra.com.

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GSA#: GS-35F-0268N

13918L (9/05)