

# UNDERSTANDING GEN 2: WHAT IT IS, HOW YOU WILL BENEFIT AND CRITERIA FOR VENDOR ASSESSMENT

WHITE PAPER

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The next generation of RFID technology – commonly referred to as Gen 2 – has finally arrived. Companies that have already implemented RFID solutions are looking to understand the benefits of Gen 2 and if upgrading is possible or even necessary. Companies that are mandated or planning to implement RFID technology are also looking to understand and quantify the business benefits of RFID. Both however, are faced with a dilemma. The Gen 2 standard has been ratified and Gen 2 products are now beginning to come to market – is it wise to implement now, or should companies wait until Gen 2 solutions are more pervasive, with proven success and interoperability?

This white paper addresses these questions, and more. In the following pages, we will examine the key new features and functionality available in Gen 2, and the benefits they can provide to organizations that look to RFID for significantly improving operational efficiency. We will provide the information you need to determine the best path of action – whether you already have RFID in place today or are preparing to implement – as well as criteria to help you evaluate different RFID products and solutions.

## WHAT IS GEN 2?

The “Gen 1” RFID standard was developed by EPCglobal, the not-for-profit, member-driven organization tasked with defining the Electronic Product Code (EPC) Network as the global standard for asset identification.

The first generation of RFID (commonly associated with the Gen 1 standard) enabled many companies, including some of the world’s largest retailers and suppliers falling under retailer mandates, to experience the business benefits that RFID offers, and realize the uncharted potential for further efficiencies. Through the lessons learned in these early adopter enterprise level implementations of Gen 1 RFID technology, several issues surfaced:

- **Standards:** Standards emerged as the single most critical issue hindering the worldwide adoption of RFID. Gen 1 offered two different air interface protocols for tag and reader technology — Class 0 and Class 1 — and only multi-protocol readers could read both classes. Companies as well as manufacturers were faced with a decision to support one or both standards for RFID solutions. This duplicity of standards also presented strategic issues — in order to achieve full benefits across a given supply chain, all the organizations in a specific supply chain needed to adopt the same set of standards, greatly magnifying the task of coordination and implementation from an IT perspective.
- **Enterprise performance:** A number of performance issues were identified to support large-scale enterprise applications, including:

- fast read rates and improved read accuracy

- reduced RF interference from the co-existence of many readers and RFID applications in the same area, such as the warehouse or dock door

Gen 2 (also known as the EPCglobal Class 1 Generation 2 UHF Air Interface Protocol) was developed to address these standards and performance issues, specifically delivering:

- A single set of global standards to facilitate and simplify global supply chain visibility
- A defined set of minimum application performance requirements, including the specification of a minimum read range (greater than five meters open air), and a variety of features designed to control interference between readers, and between multiple RFID applications running in a physical enterprise location (such as a warehouse)

## WHAT ARE THE BENEFITS OF GEN 2?

The open set of common standards defined by Gen 2 will further the development of interoperability and volume production, creating a more competitive market that will ultimately drive prices down and ensure cross-vendor compatibility, as well as provide a number of strategic business benefits for large enterprise deployment. Through a combination of performance, efficiency and capacity improvements, Gen 2 forms the foundation to deliver:

- Trouble-free operation of multiple readers and multiple RFID applications. Gen 2 provides the ability to manage interference between readers, enabling trouble-free installations of multiple readers running multiple RFID applications in close proximity (such as a fixed readers at portals or dock doors, RFID conveyor systems, vehicle-mounted RFID systems or handheld RFID readers).
- Increased operational speed. Early implementations of RFID technology often required slower business processes to ensure accurate reading of tags. But the increase in speed and accuracy of Gen 2 read rates eliminates the need to reduce the pace of a business process or operations (such as the speed of a conveyor belt) in order to ensure accurate capture of the information on all tags, eliminating impact on business momentum — or profitability.
- A platform for today and tomorrow. Currently, Gen 2 addresses simple functions and an EPC Class 1 level of functionality. However, another Gen 2 requirement was the extensibility to facilitate future features and functionality. As a result, Gen 2 also provides a platform for future growth, delivering improved investment protection and the opportunity for a higher return on investment (ROI).
- Widespread global adoption. Due to its solid foundation and expandability, Gen 2 has already been adopted by some of the largest enterprises and organizations around the world, including: Wal-Mart and other global retailers, the U.S. Department of Defense (DoD), the Food and Drug Administration (FDA), and the International Air Transport Association (IATA).<sup>1</sup>

## KEY FEATURES — AND WHAT THEY MEAN TO THE ENTERPRISE

Following is a review of the major new features and functionality of Gen 2, and the benefits that each delivers to the enterprise:

- Dense-reader mode – the single most critical enabler for reliable enterprise deployments where many RFID readers are required
- Fast read rates for individual readers, and fast, collective system read rates for dense reader environments – enables integration of additional RFID applications without impacting the speed of your existing business operations
- Backscatter options – provides the flexibility to maximize reader performance in ‘noisy’ environments (for example, environments with other RFID systems, non-RFID emitters, wireless LANs and fluorescent lighting)
- Improved tag memory and programmability – provides better tag security and application flexibility
- Tag data encoding / decoding standards (Q Algorithm) – enables enhanced security, reliability and interoperability with barcode systems
- Sessions and AB symmetry – eliminates interference between RFID applications by facilitating a cooperative environment for fixed and mobile readers
- More robust tag communication design – further reduces potential for ‘ghost reads’ and entry of erroneous data into the application
- More secure tag access – increased password length provides better protection against unauthorized access to tag data and functions (such as the ‘kill’ command to permanently deactivate a tag)

### Dense-reader mode: True enterprise scalability

#### What it is:

There are three different modes of operation in Gen 2 that define how the reader transmits and receives RF signals:

- Single reader mode – This mode is designed for efficient single reader use, and is very inefficient for broad deployments with multiple readers.
- Multi-reader mode – This mode is intended for smaller multi-reader environments. While it offers greater efficiencies than single reader mode, communication/interference issues can still occur that negatively impact RFID system performance.
- Dense reader mode – Designed for enterprise deployments with many readers, this mode offers specific communication functions that virtually eliminate the typical interference associated with a large number of readers concurrently communicating with their respective tag populations, resulting in maximum overall system throughput and application reliability.

In the dense-reader mode, readers communicate with tags via specifically defined communication channels, thereby minimizing interference between readers. This is accomplished through two specific functionalities that work hand-in-hand:

- Spectral allocation effectively divides the available band into reader channels and tag channels. Since tag signals are much weaker than reader signals, this functionality protects the weaker tag signals from being overpowered and lost in a reader’s transmission signal.
- Spectral containment ensures that reader transmissions remain in their designated channels, preventing stronger reader signals from overpowering weaker tag signals in adjacent channels.

<sup>1</sup> - IATA creates standards that enable approximately 256 airlines operating 94% of all international air travel to work together to deliver safe, secure and efficient air travel and services. Source: [www.iata.org](http://www.iata.org)

**What it means:**

Of the three available modes of operation, only dense-reader mode will reliably support large scale enterprise applications. As a result of its ability to enable high system throughput and reliability, the dense-reader mode is likely to become the de-facto standard for enterprise RFID solutions.

Companies need to be aware that not all Gen 2 compliant readers are capable of supporting all three modes of operation — single reader, multi-reader and dense reader modes. The EPCglobal conformance process permits manufacturers to state that readers offering only single reader mode are Gen 2 compliant. Therefore, companies that seek flexibility today or in the future should select Gen 2 readers that support and operate in the dense-reader mode to:

- Ensure optimal system performance, regardless of the number of readers you initially deploy. Dense reader mode will ensure that your RFID system can grow as your needs grow, enabling reader density to increase and applications to be added as needed, and still deliver high throughput and reliable performance.
- Provide investment protection through the ability to support the expansion of RFID technology in your enterprise, regardless of how many readers and RFID applications you may need in the future.
- Eliminate the severe reliability issues associated with multiple-reader environments.

### **Fast read rates: Seamless integration with your business processes and operations**

**What it is:**

The Gen 2 standard was designed to significantly improve the rate at which readers can read data from and write data to RFID tags. While Gen 1 supported a maximum data transfer rate of up to 140kbps, Gen 2 offers a data transfer rate of up to 640 kbps. In addition, tags must be written at a rate of 16 bits in under 20 milliseconds. The end result is the ability to achieve a read rate that is up to as much as eight times faster than Gen 1.

**What it means:**

The increase in read rate reduces or eliminates operational impact by allowing enterprises to maintain the current speed of operations — for example, on your assembly line or at the shipping dock — without sacrificing accuracy. Reliability is protected, and your return on investment is maximized.

### **Backscatter options: Optimal tag transmission for any noise level**

**What it is:**

On the fly, RFID readers can opt to use one of two backscatter signal encoding methods to encode tag data transmissions: the Miller subcarrier option or FMO option. While FMO is the most rapid option, it does not work well in noisy environments and is not compatible with dense reader mode. While slower, the Miller subcarrier option is designed to optimize performance in noisy and dense reader environments through advanced techniques that separate the tag's response from general RF, backscatter interference and other reader transmissions. Miller subcarrier uses a narrow channel that is offset from the reader transmission channels, ensuring that tag signals are not transmitted in other reader occupied channels, where they might easily become overwhelmed by a strong reader signal.

**What it means:**

The Gen 2 specification provides the flexibility for RFID readers to dynamically select the tag encoding option best suited for the noise level and the environment. Whether you have areas where noise is at its peak during the day and nominal in the evening, or have certain areas in your operations that are constantly noisier or 'quieter' — backscatter encoding options help you achieve peak performance in your RFID application.

### **Improved tag memory and programmability: Increased security and application flexibility**

**What it is:**

Gen 2 specifies four memory banks (EPC number, Tag ID, Passwords, and optional user data area) that can each be independently locked with a password, either temporarily or permanently to prevent overwriting. In addition, the locking structure is protected by a 32-bit password, offering a stronger level of security than with Gen 1. The structure of a Gen 2 write operation also includes information masking from the reader. When writing data to a tag, or issuing a password to the tag, reader transmissions are scrambled to prevent easy eavesdropping.

Gen 2 also defines a standard to interpret the optional user data area. It provides the specification for interpreting this additional memory bank, allowing standardized block writes and access methods.

**What it means:**

These features combine to provide the flexibility to encode tags with an expanded set of security information to increase protection of product data against tampering, as well as expand the flexibility of your RFID business applications. For example, the optional user data field could be used by a pharmaceutical manufacturer to embed encrypted, internal product codes for increased product authentication.

**Tag data encoding / decoding standards (Q Algorithm) – enhances security, reliability and interoperability with barcode systems**

**What it is:**

In order for readers to singulate each tag to begin communication. Gen1 required the transmission of a tag’s entire 96 bit EPC code. With Gen 2’s Q algorithm, the unique identifier (EPC code) is not required to set up reader/tag communication. Instead, the tag need only send a pair of randomly generated numbers for communications to begin.

**What it means:**

The Q algorithm provides three benefits to the enterprise. First, since the tag’s unique EPC code is not broadcast until secure communication is established, security is increased — any unauthorized ‘listeners’ are unable to obtain confidential tag information, providing added protection against counterfeiting and theft. Second, the shorter exchange (a pair of numbers instead of the entire EPC) increases system reliability. The intermittent power loss often associated with the transmission of the much longer EPC data is virtually eliminated, increasing the speed and accuracy of RFID reader/tag communications. And finally, the Q algorithm enables the unique identification of tags, even if they have the same EPC code and no unique serial number — enabling the easy integration of existing bar code systems into RFID applications.

**Sessions and AB symmetry: Significant reduction of interference between multiple RFID applications**

**What it is:**

Sessions is another Gen 2 mechanism designed to enable various RFID applications to operate side-by-side without interference. For example, fixed readers on a conveyor belt or dock door portal would continue to operate at peak performance, even if a warehouse worker with an RFID handheld or RFID forklift reader is in the vicinity. There can be up to four user definable sessions, and any tags that have been read and ‘put to sleep’ by a dock door reader, for example, can ‘wake up’ for the handheld reader, without causing confusion or double reads.

This function can work hand in hand with AB symmetry, which provides the tag level support necessary to enable the sessions feature. In Gen 1, as a tag was read, the reader put the tag to sleep. But sleep mode creates major issues when multiple readers are in use. For example, a fixed reader might be halfway through performing an inventory count, with half the tags in the sleep state (already counted) and the other half ‘awake’ and waiting to be counted. But the reader on the forklift of an operator picking product in the same vicinity will wake the sleeping tags, forcing the fixed reader to begin again. With AB symmetry, tags are labeled as either A or B, eliminating the sleep state — as well as the associated issues. (A Gen 2 tag has four separate pairs of AB flags, one for each of its four sessions.)

**What it means:**

Sessions and AB symmetry work hand-in-hand to enable enterprises to eliminate interference issues associated with the deployment of multiple RFID applications. Since tags always appear as autonomous to a given reader, multiple RFID readers can read the same tag at the same time, without any confusion or impact on performance.

**Improved tag verification: Virtual elimination of ghost reads**

**What it is:**

Ghost reads occur when an RFID reader gathers information from a noisy environment and reports on a tag that does not exist. Statistically, there is always a chance of a ghost read, however, Gen 2 was specifically designed to address and minimize the occurrence of ghost reads. Statistics reveal that roughly one ghost read occurs per thousand tags. Gen 2 virtually eliminates the potential for these phantom reads, even in a noisy environment, by providing five sequential mechanisms that serve as checks for a tag’s validity:

- 1.) Tag response time. Tags must respond to a reader within a very short defined time frame. If the tag response is not timed exactly from the beginning of a response to the end of the response, the probability that the tag is a phantom is high, so the reader will ignore the tag. The reader may try to re-read the tag at a later time, possibly under different conditions.
- 2.) Preamble. For each and every response, tags first send a signal called a preamble. When a reader receives a valid preamble, it knows the signal is valid (from a real tag), and not simply noise. If the preamble is not valid, the reader discontinues communication and moves on to the next tag signal.

- 3.) EPC format check. If the preamble is validated, the reader then examines the bit stream transmission to ensure it is in a valid EPC format. If the EPC format is validated, communication between tag and reader continues. If the EPC format is not validated, the reader begins communication with another tag.
- 4.) 'Bit' match. The reader then compares the number of bits (units of computer information) the Gen 2 tag reported it would be sending to the number of bits received – if it is not a match, the information is discarded.
- 5.) Cyclic redundancy check (CRC). Finally, the CRC checks for bit errors in transmission by comparing the number of bits the tag 'stated' it would send with the number of bits actually sent. If the correct number of bits were received, the transmission is verified as accurate. If the correct number of bits are not received, the data is rejected and the reader moves on to begin communication with the next tag.

Only tags that pass all five tests are designated as valid tag reads and entered into your system.

**What it means:**

Reporting of phantom tags consumes processing and network time that may impact system reliability and performance. This new system of tag validation checks helps protect your system against the reporting of erroneous data — and its impact. All EPC Gen 2 readers perform these types of intensive validation – to ensure proper reads and protect against ghost reads, be sure your readers are fully compliant EPC Gen 2 readers.

**Improved Data Selection Capability: Maximizing your RFID data**

**What it is:**

Gen 2 increases the flexibility to query your tags, enabling the selection of a specific subset of tags. Where Gen 1 can search for a single specific piece of information, such as a specific product code, Gen 2 expands the selection function to enable a search for multiple and complex pieces of non-contiguous information contained in any combination of the tag's four memory banks.

**What it means:**

The expansion of the selection capability enables enterprises to search for groups of product using any tag criteria at any time. For example, a warehouse could quickly locate all car parts received from a specific manufacturer or shipping location on a specific date in the event of a product recall. Or a consumer packaged goods distribution warehouse could easily inventory and locate all products that will expire within five days and place them on sale to avoid a loss.

Today, this feature is important in applications that are reading large tag populations, enabling, for example, the small number of pallet tags to be accurately captured without activating the thousands of item level tags within each pallet. Tomorrow, this function will ensure that reliability and performance are not affected as Gen 2 tags become integrated into more products and materials, and the number of RFID tags flowing through an area is increased exponentially.

**Increased security: Stronger password protection**

**What it is:**

Passwords are required to lock and unlock the EPC number and user-defined memory, as well as deactivate a tag (known as a kill code). Gen 2 provides over four billion password possibilities through the mandate of a 32-bit password, where Gen 1 security provided a maximum of 16 million unique passwords. In addition, Gen 2 also mandates that the passwords are written in a manner that is more difficult to eavesdrop. The use of a cover code is negotiated with each tag for every request to write or use the passwords, providing a high level of assurance that the password implementation process is not compromised.

Gen 2 also implements a permanent locking scheme so that information that is to be permanent cannot be overwritten even with the correct password. Similarly, the kill function can also be permanently disabled so that tags cannot be killed even using a compromised password.

**What it means:**

This enterprise-level robust security scheme will help incent the widespread enterprise use of RFID technology by drastically reducing the ability for unauthorized personnel to compromise the information in RFID tags.

**IMPLEMENTING RFID TODAY: CRITERIA FOR SUCCESS**

Today, RFID technology is shifting from emerging technology toward more widespread and rapid adoption, driven heavily by industry mandates with strict timelines. This presents a number of challenges and real-world issues, from meeting enterprise performance requirements to leveraging existing systems and integrating your RFID solution with other components of your supply chain. What criteria should you use to help identify and evaluate the RFID products and solutions that will deliver the most benefit to your organization?

Look for:

- EPCglobal Gen 2 compliant readers – with dense-reader mode capability. Investing in a Gen 2 compliant reader with dense-reader mode capability ensures that your enterprise can take full advantage of the enterprise-level features and functionality it offers. If you are considering implementing Gen 1 upgradeable readers, be sure to assess the cost of upgrading to Gen 2 with dense reader mode. Can the upgrade be performed easily and cost-effectively via firmware only, or is a more costly and complex change of hardware required?
- Flexible standards-based product design. Just as standards are migrating from Gen 1 to Gen 2 right now, there will be future standards. To ensure maximum investment protection, look for vendors that offer standards-based products, proven design flexibility, the ability to upgrade, a demonstrated commitment to multi-protocol products (which support all standards) and a commitment to auto ID data capture (AIDC) products and technologies.
- Technology innovation. Gen 2 defines a set of standards, a minimum level of requirements that must be met in order to achieve Gen 2 compliance. However, how those standards are implemented can vary. Gen 2 allows for a framework for vendors to improve above and beyond the specifications. Look for RFID solution providers that offer proven technology and innovation — such as patents, design and manufacturing investment, and participation in industry standards boards — that consistently exceed standards, delivering expanded functionality to better meet real-world performance and ROI requirements.
- A complete offering of RFID products, technology and services. Complete solution providers eliminate the need, complexity, costs and headaches of working with multiple vendors to design and implement your RFID solution. Look for a vendor who offers complete solutions, including:
  - Readers, antennas and tags
  - Packaged solutions as well as point products
  - Flexible deployment options that enable multiple reader form factors to best meet business needs, including portals for dock doors, RFID conveyor readers, vehicle-mounted RFID readers and RFID handheld devices
  - End-to-end services to ensure a smooth implementation and maximum ROI, with demonstrated experience in your industry — from design and deployment to training, on-going maintenance and support

- Partner ecosystem — ensure that the vendor you select has a robust network of partners to deliver the applications and systems integration necessary to achieve your return on investment and total cost of ownership goals

Also look for demonstrated expertise in your industry through successful implementations, and vendors who are on the leading edge, ensuring that your RFID solution incorporates the latest technologies.

- Full suite of tags. Tags are at the heart of your RFID system — look for vendors who really understand tag technology. Vendors who offer both readers and tags may have additional technology expertise in understanding both sides of the critical tag to reader negotiation process. Make sure your vendor can provide tags designed to work with your surfaces as well as your environment, and who offers pre-manufactured tags as well as the ability to custom design application-specific inlays and tags to meet special needs today — and tomorrow.

Today, tags are separate labels on the box. In the future, tags may be integrated directly into your actual products. This set of criteria will ensure that you select a vendor that can meet your solution requirements today, with the capability to design and provide integrated tags in the future.
- Advances in manufacturing. To date, one of the major deterrents to widespread implementation of RFID solutions has been the cost of the tags. Look for a vendor with forward-thinking manufacturing processes and programs that do not affect tag performance and pave the way to address your volume requirements and associated price point in a major enterprise-scale RFID implementation.
- Demonstrated expertise in implementing RFID solutions in your industry. Just as you would ask a doctor how many times he or she has performed a surgery to evaluate their expertise, be sure to ask potential RFID vendors how many successful EPCglobal RFID enterprise solutions they have completed in your industry. Look for solution providers with a systems approach. Those vendors who take a system approach focus on achieving high system read rates rather than only high reader read rates. A systems approach factors in all elements — including application software, your business processes and existing technology — to achieve maximum visibility for your product across your supply chain, maximum benefits, and a maximum return on investment. Contact references that have implemented RFID solutions of an equivalent scope to those you are seeking to implement, and ask how large the deployments are — are they truly enterprise-size? Many companies today claim leadership in this emerging technology arena, yet offer limited customer deployments and limited deployment expertise.

## RFID SOLUTIONS – THE SYMBOL DIFFERENCE

Whether you are faced with mandatory compliance or are seeking to achieve the benefits of product visibility in your supply chain, Symbol offers the technology and expertise you need to achieve a successful RFID implementation that delivers maximum value to your enterprise.

Symbol offers a hallmark of true leadership – over 30 years of experience delivering full-service integrated enterprise mobility solutions to help companies of all sizes, across industries capture real-time business information and achieve higher levels of operational efficiency.

The worldwide leader in bar code technology, Symbol has leveraged its RFID experience with its legacy of deploying over 7 million bar code scanners and mobile computers worldwide and over 30 years experience developing and delivering enterprise mobility solutions. Symbol was one of the first companies to market and deploy EPC-based RFID applications — including fixed readers, handheld RFID readers and RFID portal systems. Symbol was also the first to successfully deploy EPC RFID in multiple, operational dense reader environments, such as in supply chain distribution centers and in airports for baggage tracking, where hundreds of readers negotiated efficient RFID communications.

Symbol is committed to developing flexible RFID technology to meet the needs of today and tomorrow, as exemplified by our unprecedented level of reader design innovation. Symbol's XR400 fixed reader is Gen 2 dense-reader mode, certified by EPCglobal. Additionally, our original Gen 1 AR400 readers are fully upgradeable to dense reader mode via firmware — without any change to hardware, major cost, disruption in business, or impact on degradation or performance. This was achieved despite development prior to the Gen 2 specification and the industry claims that any Gen 1 reader would require an expensive hardware swap or new hardware platform to upgrade to Gen 2.

But perhaps the biggest testimony to Symbol's success in RFID came from a 2005 AMR Research survey, which asked the question, "Which vendor would you turn to as a primary RFID provider?" The number one answer was Symbol — for technology innovation, the ability to provide complete solutions, and proven success through major deployment in major corporations.

You can count on Symbol for flexible, high-performance RFID solutions that meet enterprise-level requirements, as attested to by the 10,000 deployed EPC RFID readers and over 60 million manufactured RFID tags and inlays, delivered globally to the world's largest retailers and manufacturers.

## SUMMARY

Gen 2 is no longer the future – it is here today. If you have deployed Gen 1 RFID solutions in your organization, contact your vendor today to determine if there is an upgrade path to Gen 2, and if so, what is entailed, and what is the cost. Also – be sure the upgrade is to EPC-compliant Gen 2 with dense-reader mode enabled to ensure support for enterprise solutions.

If you are looking to deploy RFID, or need to deploy RFID to meet a mandate, deploy EPC-compliant Gen 2 solutions or Gen 2 upgradeable EPC-compliant solutions, complete with dense-reader mode. Only dense-reader mode will accommodate the performance and scalability requirements of the enterprise. And while RFID pilots and tests can be easily performed with Gen 1 readers, be sure your investment is protected through a proven upgrade path to Gen 2 EPC compliance.

For more information on RFID solutions, and how RFID can benefit your enterprise, contact Symbol today at 866.416.8545 or visit us on the web at [www.symbol.com/rfid](http://www.symbol.com/rfid)

## About Symbol Technologies

Symbol Technologies, Inc., The Enterprise Mobility Company™, manufactures and services enterprise mobility systems, delivering products and solutions that capture, move and manage information in real time to and from the point of business activity. Symbol enterprise mobility solutions integrate advanced data capture products, radio frequency identification technology, mobile computing platforms, wireless infrastructure, mobility software and services programs under the Symbol Enterprise Mobility Services brand. Symbol enterprise mobility products and solutions are designed to increase workforce productivity, reduce operating costs, drive operational efficiencies and realize competitive advantages for the world's leading companies.



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