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# **RFID FAQ's - Retail Basics for Business Operations**

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*Co-authored by AIM, Inc. and the Retail Value Chain Federation (RVCF) with input from the AIM RFID Experts Group, RVCF, and several of their retailer members,*



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## Introduction

This RFID FAQ list is co-authored by AIM, Inc. and the Retail Value Chain Federation (RVCF). It is intended to convey basic terms and concepts for those in retail business operations tasked with understanding RFID and helping with its implementation, maintenance and success. RVCF worked with several retailers to identify the questions most often asked by their trading partners. Answers were provided by the AIM RFID Experts Group, RVCF, and the retailers.

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## RFID FAQ's - Retail Basics for Business Operations

In its simplest form, radio frequency identification (RFID) is a microchip which contains a unique identification number, attached to an antenna. Each chip must have a unique identifier to be singled out and “seen” by the reader which also has an antenna. Chip IDs and reader locations can be identified, which allows the system to capture and record an event (what, when, where).

In retail the unique identifier is the well-established Global Trade Item Number (GTIN) for the product and a serial number (SN) assigned by the brand owner so, for example, if there are twenty-four items with the same GTIN in a carton, because they also have a unique SN, they can each be read and counted while still in the box. RFID is currently used in retail for inventory, picking, packing, shipping and receiving.

Of course, there are many technical details and terms which need to be understood to implement RFID successfully. They include information about tags, data structures, memory locations, frequencies, readers, standards, readability issues, and business process applications. RVCF ([rvcf.com](http://rvcf.com)) and AIM, Inc. ([aimglobal.org](http://aimglobal.org)) have put together this list of frequently asked questions about RFID in Retail. Information about, and contact information for both organizations are at the end of this document.

### RFID BASICS AND COMPONENTS

#### What is RFID?

RFID (radio frequency identification), is a generic term for technologies that use radio waves to automatically identify objects. There are several methods of identification, but the most common is to store an ID number that identifies the object on a microchip attached to an antenna. The chip and the antenna together are called an RFID transponder or an RFID inlay. The antenna enables the chip to receive commands from, and transmit the identification information to a reader. In retail, currently, the data used is an EPC (Electronic Product Code – see *Data on an RFID Tag or Inlay*, below). The reader converts the radio waves reflected back from the RFID tag into digital information, creating “event information”, including what, where, and when, which is communicated to a computer system.

#### What is the difference between RFID and barcodes?

The two are different technologies with different capabilities which can overlap. A barcode is line-of-sight technology which means it has to be visually accessible, on the outside of the package or carton, to be read. RFID doesn't require line of sight; tags can be read inside a carton as long as they are within range of a reader. Both RFID tags and barcode labels can be rendered unreadable if damaged, although labels on the outside of the carton can be more easily ripped or marred. Barcodes with a Global Trade Item Number (e.g. a UPC / EAN) only contain the identifier for that product, whereas an RFID chip can uniquely identify each individual item with a serial number.

#### How does an RFID System work? What are the components?

An RFID system consists of a tag made up of a microchip with an antenna; an interrogator or reader with an antenna; and a computer system which processes the data. The reader sends out electromagnetic waves and the tag antenna is tuned to receive the waves. A passive RFID tag draws power from the reader and uses it to power the microchip's circuits. The chip then modulates the waves that the tag sends back to the reader, which converts the waves into digital data.

## **What's the difference between passive and active RFID tags?**

An active RFID tag has a transmitter and its own power source (typically a battery). The power source is used to run the microchip's circuitry and to broadcast a signal to a reader. Their read range is 300 feet / 90 meters, or more; they are more expensive and are generally reusable. Semi-passive tags use a battery to run the chip's circuitry, but communicate by drawing power from the reader. Passive tags have no battery. They draw power from the reader, which sends out electromagnetic waves that induce a current in the tag's antenna. The read range of a passive RFID tag is approximately 20 feet / 6 meters and they are considered disposable. Retail applications use passive tags.

## **RFID Tags, Labels, Stickers, and Inlays:**

### **What is an RFID Tag?**

An RFID tag consists of a chip (integrated circuit) which holds data, an antenna, and a substrate, usually paper or plastic, to hold it together. The antenna sends and receives the signal from the RFID Reader (aka interrogator). Different types of antennas can be used, depending on the application but they are all made of conductive material (metal). If the tag has a battery as the power source, it is an "active tag". If the RFID tag's power source is the reader, then it is a "passive tag." An RFID tag may also be called a transponder.

### **What is an RFID Inlay?**

An RFID Inlay is typically smaller than an RFID tag. It is designed to be embedded in an object or label, and consists of a chip and antenna.

### **What is an RFID Label / Sticker?**

An RFID label may be a printable label embedded with an RFID inlay. The label is used to add human readable information about the product and may also include a barcode. A "sticker" is an RFID label which, usually, does not contain human readable information or a barcode because those components are already on the consumer package.

### **What are the issues with RFID Labels?**

Brand owners must comply with the retailers' specifications for the inlays used within a tag, which may vary by product type. Based on demand, inlay or label availability may be a factor. Inlays can be discontinued by the manufacturer so provisions must be made to manage that possibility. Brand owners must also understand face stock and adhesive specifications mandated by each retailer. The brand owner will also make a decision on encoding the tags in-house or having a third-party service provider print and write to the tags. Evaluate the customer service capabilities and stock availability when choosing one or more RFID Tag providers.

### **Do I need to get approval for my RFID Tags?**

Testing will be governed by the retailer's RFID guidelines. Quality certification for an RFID Tag is available from Auburn University RFID Lab, which tests the inlay for things like read range including distance and variability. The tags can also be tested on the individual package and in the carton. Tag location on the package, the material makeup of the item, and the density of the item in the carton can affect read rates.

## DATA ON AN RFID INLAY OR TAG

### What is EPC?

The EPC (electronic product code) is a string of numbers and letters, consisting of a header and three sets of data partitions. The first partition identifies the brand owner. The second identifies the product type and the third is the serial number unique to the item. In other words, the EPC is a deconstructed GTIN (GS1 Company Prefix assigned to the brand owner plus an item ID number for all items of that type), plus a brand owner assigned serial number (SN) for that individual item. By separating the data into partitions, readers can search for items with a particular brand owner or product code. This is also known as an SGTIN – a serialized GTIN.

An SGTIN96 is the SGTIN written on a chip that has a 96-bit memory location for the data. A chip with up to 496 bits can be used in retail, but 96 bits is all that's needed for an SGTIN. The brand owner manages the serial numbers assigned to each GTIN to guarantee that each GTIN / SN combination is unique and not repeated.

Every RFID chip needs a unique serial number so it can be “seen” and counted by the reader. This serial number could be just the TID (“Tag ID”) built into the integrated circuit at manufacture. In retail, the serial number used is the one assigned by the brand owner. It can be used to simply count the items in a carton or the assigned SN may become part of the item master data record so the data processor can look up additional attributes about that individual product such as batch/lot, expiry date and so on. Provision must be made for either a separate, but integrated serial number manager program, or a serialization functionality built into the ERP (Enterprise Resource Manager) item master.

### What is EPC Gen 2?

Gen 2 is the shorthand name given to EPC Radio-Frequency Identify Protocols Generation-2 UHF RFID Standard. This standard describes the way passive UHF RFID tags (aka RAIN tags) communicate with RFID readers. Primarily, it enables an RFID reader to select, inventory and access tags of interest. Gen 2 was designed to work internationally and has other enhancements such as a dense reader mode of operation, which prevents readers from interfering with one another when many are used in close proximity to one another. Gen 2 has been endorsed as an ISO standard (ISO/IEC 18000-63).

### What information is stored on RFID tags?

The tags used in the supply chain and in consumer packaging contain only an Electronic Product Code. The EPC will be associated with data in online databases. Information about the item, contained in the on-line data, might be accessible to anyone, such as product name and description. At the brand owner's discretion, some data may only be available to specific entities such as trading partners. But the actual data stored on the microchip is the EPC (GTIN plus serial number).

### What is locked / unlocked RFID tagging?

The data written on an RFID chip can be overwritten unless the chip is configured to prevent it. There is a mobile app available to anyone, which can be used to overwrite data on an RFID tag. There are four lock states for data stored on a Class 1 Gen 2 RFID chip: unlocked, perma-unlocked (can never be locked), locked, and perma-locked (can never be unlocked). The tag identification number (TID), the serial number which is written into each RFID chip when manufactured, is one example of a perma-locked memory bank. If the memory location for the EPC, which contains the GTIN, is locked, it can be overwritten with a password. If the EPC is

perma-locked, then it can never be overwritten. Given the expense of password maintenance, and since the EPC will, likely, never be changed on a product, it is generally considered best business practice, and mandated by many retailers, to perma-lock the EPC. This prevents theft (overwriting the GTIN for the item with a GTIN that is less expensive), counterfeiting, and safety. Perma-locking the EPC is standard practice for pharmaceuticals. Please see the section on EPC to learn more about the GTIN encoding format in an RFID chip.

### **Are there laws governing the use of RFID?**

Since RFID in retail is currently only reading the GTIN and serial number for a product, Federal and State privacy laws are the same as scanning a UPC/EAN barcode. In the future there may be RFID specific laws aimed at preventing the covert scanning of RFID tags or their use in criminal activity. Various countries have laws that govern the frequency and power used by RFID.

### **Do we need to notify the consumer that there is an RFID tag on an item?**

The brand owner should follow the retailer guidelines for using an EPC Logo on the RFID label. The logo is used in North America and managed by GS1. The ISO RFID logo may appear on an RFID tag created outside the US.

## **FREQUENCIES**

### **What is the difference between low, high, and ultra-high frequencies?**

Just as your radio tunes in to different frequencies to hear different channels, RFID tags and readers have to be tuned to the same frequency to communicate. RFID systems use many different frequencies, but generally the most common are low-frequency (around 125 kHz), high-frequency (13.56 MHz) and ultra-high-frequency or UHF (860-930 MHz – also called RAIN RFID). Microwave (2.45 GHz) is also used in some applications. Radio waves behave differently at different frequencies, so it's important to choose the right frequency for the specific application. Retail applications generally use UHF.

### **How do I know which frequency is right for my application?**

Different frequencies have different characteristics that make them useful for different applications. For instance, low-frequency tags use less power and are better able to work in metallic environments. High-frequency tags work better on goods with a high water content. They have a maximum read range of about three feet / one meter. UHF frequencies typically offer better range and can transfer data faster than low and high frequencies. But they use more power and are less likely to pass through some materials. Because they tend to be more "directed," they require a clear path between the tag and reader. Retail has "standardized" on UHF readers and tags. This will be confirmed by your retailer's RFID guidelines.

### **Do all countries use the same frequencies?**

Different countries have allotted different parts of the radio spectrum for RFID. The industry has worked diligently to standardize three main RF bands. Most countries have assigned the 125 or 134 kHz areas of the spectrum for low-frequency systems; 13.56 MHz is used around the world for high-frequency systems (with a few exceptions); the range 860-930 MHz covers the world for UHF (the US uses 902-928 MHz).

## READERS

### What is an RFID Reader?

An RFID reader is a device that emits a radio frequency signal through an antenna. RFID tags within range and “tuned” for the same frequency, are interrogated, or read by the reader. An RFID reader also has the capability to write data to an RFID tag (see “Locked and Unlocked RFID Tagging”). The ability to write to a tag is also built into an RFID label printer. There are generally two types of readers. Fixed readers include portal readers which are installed in a location and RFID tags pass through the portal where they are read. Depending on its construction, the portal may also serve the purpose of shielding out tags not going through the portal. Fixed readers may be installed around the door from the stockroom to the selling floor, the shipping or receiving doors in a warehouse, on a shelf, or at various locations on the selling floor. Handheld readers are portable and can read tags within range, including tags in a fixed location. Handheld RFID readers may also have the ability to scan barcodes.

### What is an agile reader?

An agile reader is one that can read tags operating at different frequencies or using different methods of communication between the tags and readers.

### How far away can a typical RFID tag be read?

The distance from which a tag can be read is called its read range. Read range depends on a number of factors, including the frequency of the radio waves used for tag-reader communication, the size of the tag antenna, the power output of the reader, and whether the tags have a battery to broadcast a signal or gather energy from a reader or merely reflect a weak signal back to the reader. Battery-powered (active) tags typically have a read range of 300 feet /100 meters. These are the kinds of tags often used in toll collection systems. High-frequency tags, which are often used in smart cards, have a read range of three feet / one meter or less. UHF tags - the kind used on pallets, cases and individual items in the supply chain - have a read range of 20 - 30 feet / 6 – 20 meters under ideal conditions. If the tags are attached to products with water or metal, the read range can be significantly less. If the size of the UHF antenna is reduced, that will also dramatically reduce the read range. Increasing the power output could increase the range, but most governments restrict the output of readers so that they don't interfere with other RF devices.

### **I've heard that RFID doesn't work around different materials, for example metal and water. Does that mean I can't use it to track cans or liquid products?**

Radio waves bounce off metal and are absorbed by water at ultrahigh frequencies. That makes tracking metal products, or those with high water content, difficult. However, good system design and engineering are overcoming this. Low and high-frequency tags work better on products with water and metal. In fact, there are applications in which low-frequency RFID tags are embedded in metal auto parts to track them.

## RFID STANDARDS

### Who maintains RFID Standards?

International standards bodies include GS1, the International Electrotechnical Commission (IEC), the International Standards Organization (ISO), and the Joint Technical Committee (JTC 1), a committee formed by ISO and IEC. Regional entities that regulate the use of RFID frequency bands include the Federal Communication Commission (FCC), which oversees the United States,

and the European Telecommunications Standards Institute (ETSI), which operates in Europe. Other regions have their own regulatory entities.

AIM, Inc. (Automatic Identification and Mobility) is the International Registration Authority (RA) for the ISO/IEC 15961 Standard which is the *Information Technology Data Protocol for RFID for Item Management*. AIM, Inc. is responsible for maintaining the Data Construct Register, overseeing the procedures and applications to request new Data Constructs and allocating Application Family Identifiers (AFI) related to ISO/IEC 15961.

### **Why are RFID standards important?**

RFID standards help ensure that products are interoperable, regardless of the vendor or user. Standards provide guidelines by which companies can develop products, such as tags, readers, software, and accessories. Additionally, standards help broaden markets and increase competition within the industry, which brings the prices of standardized RFID products down. RFID standards also help increase widespread confidence in the technology.

### **What is RAIN RFID?**

RAIN RFID (rainrfid.org) is both a technology and an organization. RAIN RFID is a wireless technology that connects everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate, and engage each item. RAIN RFID is also a global alliance promoting the universal adoption of UHF RFID using the GS1 UHF Gen2 protocol (ISO/IEC standard 18000-63). The word RAIN (an acronym derived from RADio frequency IdentificationN), covers conventions used to link UHF RFID and the cloud, where RFID-based data can be stored, managed and shared via the Internet. A RAIN RFID solution uses a reader (which may be built into a label printer), to read and write a tagged item, manage the data and take action.

### **What is an ARC RFID Spec?**

An RFID Spec is a designation that covers a specific RF performance requirement. Auburn University's RFID Lab conducts testing on RFID inlays and tags to ensure they meet the requirements needed for both performance and quality, based on specific product and read environment characteristics. Testing is a part of the ARC program. Specs are identified with names such as "Spec R" or "Spec F" and are driven by the performance needs of end users such as retailers.

### **What is the ARC program?**

The purpose of the ARC program is to ensure that RFID tags are able to meet or exceed the levels of performance and quality necessary to provide benefit to the end user in a consistent and cost effective manner. Auburn maintains a database of inlay specifications. When an inlay manufacturer sends a new tag for testing, ARC tests the performance and, if it meets the criteria, it is assigned the appropriate Spec. ARC has worked with close to thirty retail product categories. The ARC testing process is open and has been established through industry collaboration. <http://info.rfid.auburn.edu/contact-us>

### **Is it possible for different retailers to ask for a different Spec on the same product type?**

Yes. Retailers may have different performance requirements based on the reading environment. For example warehouses ( longer read distance, metal shelving, boxed product, RF interference) versus stores (shorter read range, unboxed products., etc.). The ultimate goal is to follow the product from supplier through consumer, so Spec requirements that focus on one specific environment might limit the use of RFID in retail.

## RFID SYSTEMS AND START UP

### Do I need to make changes to my item master software for RFID?

One system change for RFID is the need for the brand owner to assign individual serial numbers to each product as part of the SGTIN encoded in the EPC. There are serial number manager programs. Remember, serial numbers can simply be used to count the number of individuals in a carton, or they can be used to track the individual items. If they are used for tracking, then they must be integrated into or associated with data in the item master. Creating this additional level of data, of course, increases data storage and processing. RAIN RFID advocates for communicating and storing RFID data in the cloud, so provision must be made for data security and managed-access to the data by both personnel and computer programs/processes.

### What's New with RFID?

Industry publications, such as RFID Journal (<https://www.rfidjournal.com/>) and NRF (<https://nrf.com/tag/rfid>) provide information on current trends and RFID news.

### How is RFID used in Retail?

Companies are interested in using RFID in the supply chain to track event data for a product. The vision is to create near-perfect supply chain visibility—the ability to track every item anywhere in the supply chain securely and in real time. RFID can dramatically reduce human error such as shipping and receiving partial or mixed cases of goods; managing markdowns; and receiving, if there is an incorrect or missing EDI 856 Ship Notice. Instead of typing information into a database or scanning the wrong barcode, RFID-tagged goods will communicate directly with inventory systems. Readers installed in factories, distribution centers, stock rooms and on store shelves will automatically record the movement of goods (event data) from the production line to Point of Sale (POS).

This event data may include goods arriving at a warehouse or store, going from the backroom to the store shelf, or used at POS. The goal, as always in retail, is to have the product available to the consumer. Readers in stores can “take inventory” for all tagged items on the floor or can be used to find items for store pickup. RFID is used in the store / backroom / warehouse for inventory cycle counts (correctly counting partial cases and finding misplaced items), notifying personnel when the shelf is empty and if there is replacement product in the stock room. Some RFID applications are used for theft prevention by alerting store personnel when an unusually large number of shrink-prone items are taken at once by a customer. For high ticket items, it is possible to identify counterfeit products when the unique serial number assigned by the brand owner does not match the tagged counterfeit item. Expired and recalled product can be found and removed from the shelves.

### How do we get started?

A good place to start with RFID is the selection of equipment and tag solution providers. You may want to start with your current label supplier and printer manufacturer. RVCF provides RFID and Retailer / Supplier Open Forums where you can ask for ideas and recommendations from your peers.

Following is a list of other organizations that offer information and guidance.

Auburn University RFID Lab	<a href="https://rfid.auburn.edu/">https://rfid.auburn.edu/</a>
AIM, Inc. / North America	<a href="https://www.aim-na.org/">https://www.aim-na.org/</a>
AIM, Inc. / Global	<a href="https://www.aimglobal.org/">https://www.aimglobal.org/</a>
GS1 US	<a href="https://www.gs1us.org/">https://www.gs1us.org/</a>
GS1 Global	<a href="https://www.gs1.org">https://www.gs1.org</a>
RAIN RFID	<a href="https://rainrfid.org/">https://rainrfid.org/</a>
RVCF	<a href="https://www.rvcf.com/">https://www.rvcf.com/</a>