White Paper

Questions & Answers – RFID Tag Encoding

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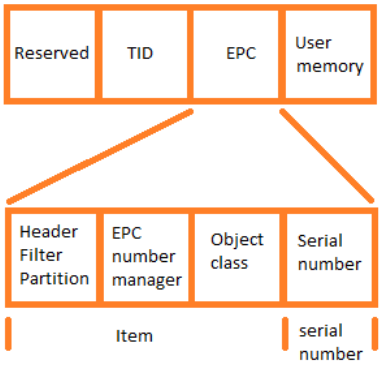
1 What is the RAIN RFID tag's memory?

RFID tag's memory has four parts (in most cases).

- EPC memory is the part accessed in RFID inventory. EPC memory includes the essential information about the item where the tag is attached. This is the main memory area needed in encoding the tags.
- Another memory area is used for storing the Tag ID (TID). This is a unique serial number of the chip. The TID code is added to the chip when the chip is manufactured and cannot be altered. Code tells for example manufacturer of the chip and model of the chip.
- Yet another memory area is used for passwords – reserved memory. The chip can be for example locked with password so that it cannot be re-written.
- Last part is user memory. User memory area can be used for any additional information.

2 So, EPC memory is the key. What should be coded to a RAIN RFID tag's EPC memory?



In general, the EPC code includes two parts:

- The first part identifies the type and model of the item where the tag will be attached – such as a can of diet cola by a soda company. Same cola on a different size can would be a different model and needs a different code. Different soda in similar can would again be a different product model and has its own code. If same cola is in a can of same size but can printing changes, a manufacturer decides, if the model is same or a new one. In trade items this part of the code corresponds with GTIN/UPC/EAN/JPN barcodes used in retail stores. The code tells to Point of Sale (POS) which item is scanned, and what the price is.
- Second part of the EPC code is serial number. This makes soda cans unique, even if they would have same contents, look the same and in any way be similar to each other physically.

Details of the coding are described in Tag Data standard: *https://www.gs1.org/epcrfid-epcis-id-keys/epc-rfid-tds/1-11*. This standard is the key document when coding is designed.

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3 Why does the standard matter?

Avoiding duplicate codes is important for every RAIN RFID system to work properly. The worst case alternative: every RFID user codes the tags with consequent numbers starting with"1". It is easy to see the problem. With 10 million RFID users there are soon 10 million duplicate codes of everything. When a tag is read, it is no longer known what actually was read. The same way: vehicle license plates would be meaningless if every license plate would have just 001 on them.

Best way to avoid duplicate codes is to always follow commonly accepted coding rules. Those rules are described in the Tag Data Standard (TDS).

4 In Tag Data Standard (TDS) there are several code types; which one should I use?

The different code types are intended for different use (different type of item). In many cases the name of the code guides the selection well. Below table summarizes the codes and items into which they are designed. Just choose which of the below matches the item you are tagging. Note that in several systems different code types may be used in parallel.

Code	**Type of item**
SGTIN Serialized Global Trade Item Number	Trade item is any item that is sold and bought. For example, every item that is scanned at a retail store POS, or any item that can be bought online can be equipped with SGTIN codes.
SSCC Serialized Shipping Container Code	SSCC codes are used in logistics. SSCC identifies a container such as a box or pallet. When a box is loaded with trade items the SGTIN codes are associated with SSCC code of the box. When the SSCC code is read in the logistics chain, it is known by association which trade items passed the reading point. SSCC label is usually outside of the box or pallet and can be read even if individual SGTIN codes are unreadable for some reason.
SGLN Global Location Number	SGLN identifies a location. Location may be for example a shelf position in a warehouse or a room in a hospital. As an example: If you do an inventory count in a warehouse you may find SGTIN codes, SSCC codes and SGLN codes. SGTIN codes that are seen at a same time with an SGLN code indicate those items being stored in that location.

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GRAI Global Returnable Asset Identifier	GRAI identifies a returnable asset, for example many transportation pallets and totes belong to returnable asset systems. A returnable pallet may have two codes on them: GRAI identifies the pallet (who owns the pallet), GRAI code may be stored to a tag that is embedded to the pallet. SSCC identifies the pallet as a collection goods (which items are on the pallet), SSCC code is typically on a label attached to wrapping around a pallet. If GRAI code is found in inventory scan, there may be an item belonging to someone else, somewhere someone is waiting for an item to be returned to them, and possibly rent is paid as long as the GRAI item is not returned.
GIAI Global Individual Asset Identifier	GIAI is used for identifying assets that are activated to an organization's balance sheet. GIAI assets are for example machines. Note that when a piece of machine is bought it may have SGTIN code. When it is taken to use it may be relabeled as GIAI asset. Benefit of separate GIAI codes are seen in inventory counts. If we scan an office space there would be several SGTIN codes in pens, cola cans and other small items – these are not interesting from accounting point of view. Any found GIAI item indicates something that has value in the balance sheet.
GSRN Global Service relation Number – Recipient	GSRN identifies a recipient of a service. For example, patient in a hospital may be identified with a bracelet coded with GSRN code. And member of a gold club can be identified with a membership card with GSRN code. One use for the GSRN codes is access control. Patient or club member can enter some rooms, but cannot open RFID equipped smart locks to other areas. Other typical use is in invoicing: A cruise customer can purchase food and drinks by showing bracelet with GSRN code. Consumed services are then charged from customers' credit card.
GSRNP Global Service relation Number – Provider	GSRNP is the pair of GSRN in a service relation. For example, nurses and doctors in hospital may have ID batches with GSRNP codes. Access control and activity tracking are typical uses for these codes. Nurse can enter storages forbidden from patients. Personnel participating in a procedure is identified with GSRNP codes, at the background the system can for example check that require skill set is available when a task is started.

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GDTI Global Document Type Identifier	GDTI identifies a document. As an example, a document may need to be tracked because of confidential information. With GDTI codes it is for example possible to create alerts when a document is seen at a building's exit door.
CPI Component / Part Identifier	CPI codes are used in identifying components and parts in technical manufacturing. For example, parts used in car assembly are identified with CPI codes. CPI codes can be used in tracking value of work in process, and in managing just in time processes.
SGCN Serialized Global Coupon Number	SGCN identifies a coupon. For example, in a fully automated retail store checkout sold items and the prices are identified with SGTIN codes. The price may be then adjusted if SGCN codes are seen in the same checkout process.
GINC Global Identification Number for Consignment	Consignments are used when logistics provider combines several shipments into one. For example, one freight container may include several SSCC (and SGTIN) codes. When the GINC code is read, the logistics provider knows by association which SSCC codes have passed the reading point.
GSIN Global Shipment Identification Number	GSIN identifies a shipment that is transported under one bill of lading. GSIN may include several SSCC codes and several SGTIN codes. Difference to GINC is that GSIN is assigned by the owner of transported goods (one bill of lading), whereas GINC is assigned by the logistics service provider.
ITIP Individual Trade Item Piece	ITIP is used for identifying a part of a trade item. For example, a piece of furniture is one trade item, but may be delivered in several parts. These individual parts may be identified with ITIP code. As an example: think of a piece of Ikea furniture (SGTIN) in several flat boxes (ITIP).
GID General Identifier	If none of the other item descriptions match the items you are tagging, GID can always be used. It is the miscellaneous of EPC codes.
DOD US Department of Defense Identifier	DOD codes are used exclusively by US Department of Defense. If you supply to DOD they may request DOD codes, and would provide the details.
ADI Aerospace and Defense Identifier	ADI codes are used for identifying parts and items that belong into an airplane. These items include safety vests, fire extinguishers, radio cards etc. The code is used for example in safety checks of airplanes.

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BIC BIC Container Code	BIC codes are used to identify freight containers (sea containers transported with container ships) and their owners. BIC is in away a special case of GRAI – applicable to the freight containers.
LGTIN GTIN + Batch/Lot	LGTIN is used for identifying trade items by a lot instead of individual serial numbers. For some items it is relevant to know into which production lot it belongs, even if individual serial numbers are not relevant.

5 There are lots of code alternatives. Why can't I just use TID on everything? Or SGTIN?

Reading TID is slower than reading EPC memory. But that is not the main reason.

Using different codes in different item types makes RAIN RFID systems efficient. Different actions can be filtered out by code types. Using different code types the systems can handle most data at the edge of the system (for example inside a reader), and only relevant information is transferred to and handled in the cloud. Couple of examples:

In a hospital there can be millions of items – patients, assets, trade items (medicine bottles, office supplies, etc.), documents, returnable assets (medicine totes, uniforms), and so on. A reader at a hospital department's entrance door would see all of these RAIN RFID tags when they pass the door. If all of the data is transferred to database (cloud) a lot of information is transferred and stored – most of it would be irrelevant. With different codes the reader can make decisions and only relevant information generates actions. For example – when a patient or a nurse passes the door, a timestamp and code is stored; system checks the codes and alerts if the patient is not allowed to leave the department. When a document passes the door, the information is stored and alert is sound if the document should not leave the department. Personnel, uniforms, trade items and assets can move freely between departments and are ignored by the reader. Filtering the data by code types enables optimization of the system and avoiding excess data handling. There are billions of RFID tags in use and billions are taken to use every year. Filtering keeps the amount of data lower.

Another example: Inventory scan of a factory shows several SGTIN codes, CPI codes, GRAI codes and GIAI codes. GIAI codes can be used to check assets on balance sheet (accounting), CPI codes can be used to define value of work in process, GRAI codes can be used to identifying assets that maybe should be returned – there may be a rent fee running on these. Different users and business processes have different interest on the scan results; using different code types enables everyone to get the information that is relevant to them.

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6 If I have chosen SGTIN as the code type, what next?

Almost all codes start with Company Prefix (DOD, ADI GID are exceptions), and BIC has company information in different format. Company Prefix is a part of code identifying company that owns the code. In SGTIN codes the code owner is the brand owner. Company Prefix codes are assigned by GS1, GS1 ensures that each company code is unique. So, at first you need the company prefix from GS1.

Second part of the code is Item Identifier. The company (owner of the code – company prefix) defines which item identifiers are used on which items. There are some rules though, for example length of item identifier is set in the TDS standard.

The two first parts are also found in barcodes used in retail (GTIN/UPC/EAN/JPN). In an easiest situation the item you are tagging already has UPC/EAN/JPN/GTIN) barcode. This is the starting point for the EPC code.

Third part is serial number, this is again controlled by the Company, following rules of the TDS standard.

7 Ok, I have the 13 digit long EAN code of the item. Do I just write the same code to the EPC memory?

Unfortunately, it is not so simple. Data content will be the same, but some transformation is needed. Codes in RFID tags are binary and EAN code uses decimal digits (0-9). When creating EPC from EAN a “formula” must be used. The details are again in TDS standard, here is the principle:

- First bits of the EPC code tell the code type and other information of the code type (header, filter and partition)
- Second part is company prefix: Partition value tells how many digits of the EAN code belong to company prefix, and how many to Item identifier. The decimal value of company prefix is turned into binary
- And the decimal value of item reference is turned into binary.
- in the process the check digit of barcode is cleaned out, and additional zeros are added for making the company prefix and item reference 14 decimal digits long
- And final part is to add the serial number, zeroes on front to achieve correct length
- EPC code is then all of the above parts in a one binary string, 96 bit or 128 bit long depending on how long SGTIN is used.

Good news is that if you use systems like Voyantic personalization for encoding the tags, you don’t have to worry about the formula and how to transfer codes to others. That is all embedded to the Voyantic system and done automatically.

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8 How to choose which serial number to use in which item?

There are not a lot of rules on how to do this. One method is to start with 1 and keep increasing the serial number. Another method utilizes unique TID codes in RFID chips; the serial number part of the TID is transferred to serial number. Important is not to mix methods between same Item identifier, that could lead into duplicate codes.

9 In barcode there was a check digit, but not in the EPC. Can I use one anyway?

The EPC standard does not include check digit. There are some other ways to partially tackle possible misreads. There are couple of ways you can use to include check digit if needed, but note the caveats.

- You can calculate check digit of part of the EPC code and use it at the end of the code. Note that this method decreases the space for serial number since part of the serial number space is now used for check digit.
- Some chips include also user memory in addition to the EPC memory. In these chips the check digits can be stored to user memory.

In both cases the check digit is not automatically used when reading the tag. Adding a check digit reading requires additional effort; and can only be used in reading points where the check is implemented. Since this is non-standard method, all code users would not utilize the check digit, even if you design a fancy check digit system.

10 Is there anything else I should take into account when selecting the codes?

It is good to plan ahead for the serial number management. For example, in case of SGTIN. If the same model is manufactured at different plants, how is it ensured that there are no duplicate codes. And how are returned items serialized.

Another point to consider is the locking and passwords: should the code be open for anyone to alter, should it be permanently locked or locked and protected with a password.

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11 I have now selected the codes and planned the serialization and passwords. How do I actually get the codes to the tags?

This is the easy part. Once the coding scheme is designed, the Voyantic personalization system takes care of the rest. When you have defined what needs to be coded and have the data in correct format, the system takes care of the encoding (programming the tags) and printing. The system ensures that there are no wasted codes or duplicates. The system makes sure that the EPC code and printed codes match each other. The system also collects log files on what was coded to the tags.