RFID TECHNOLOGIES - RFID 101

Prepared for the American Fencing Association by:
Douglas Cram, President – Transponder and Reader Engineered Systems, Inc. doug@tresrfssolutions.com - (770) 529-1040
Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID readers, antenna and tags/transponders in the frequency range of 3 kHz to 300,000 MHz.

RFID readers (in the case of passive tags) or receivers (in the case of active tags) come in many shapes and sizes and typically process the information gathered by the antenna and output that information in specific data formats to include Wiegand, RS232, TCP/IP and/or USB. The Readers/Receivers may also be capable of other specialized functions such as data output when grounded by an activation loop, relay output functionality, read range adjustments (attenuation) and more.

RFID antennas also come in many shapes and sizes and are sometimes integrated with the readers in a single containment. There are many cases where the antenna is separate from the reader and many passive readers utilize multiple antennas connected to a single reader. The antenna is designed to pass the RFID signal being transmitted or reflected from the tag and pass it along to the reader for processing.

An RFID tag/transponder is an object that can be applied to or incorporated into a product, asset, or person for the purpose of identification and tracking using radio waves. Most RFID tags contain two primary components. One is an integrated circuit (IC) for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, and other specialized functions. The second is an antenna for receiving and transmitting the signal to the reader/receiver. There are generally two types of RFID tags: active RFID tags, which draw their transmitting power from self contained battery, and passive RFID tags, which have no battery and draw their transmitting power from the reader.
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Commonly Utilized Frequencies

**ULF** - Ultra-Low Frequency = 3 to 30 kHz – underwater radio

**LF** - Low Frequency = 30 to 300 kHz – AM radio, Proximity readers, Ultrasound (RTLS)

**MF** – Medium Frequency = 300 to 3,000 kHz Navigation beacons, AM radio

**HF** - High Frequency = 3 to 30 MHz – CB radios, smart card readers

**VHF** – Very High Frequency = 30 to 300 MHz Two way radio communications

**UHF** - Ultra-High Freq = 300 to 3,000 MHz (3 GHz) – Satellite radio, ISM Band (Industrial, Scientific, Medical) Vehicle ID & Asset/Personnel Tracking, RTLS

**SHF** - 3 to 30 GHz – Microwave

**EHF** – 30 to 300 GHz – Radio Astronomy
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Readers – Antennas

900 MHz passive reader w/integrated antenna

900 MHz passive reader w/multiple antenna

433 MHz active reader w/internal etched antenna

433 MHz external circular polarized antenna
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Readers – Antennas

- 13.56 MHz tag inlays with reader/programmer
- 125 kHz reader w/integrated antenna
- 125 kHz and 13.56 MHz multi frequency reader
- 125 kHz Prox card interior view (older style)
Read ranges (distance between the reader/receiver antenna and tags at which tag data can be effectively interrogated) can range from a few inches to thousands of feet. This read range is dependent upon a number of factors including, but not limited to: the frequency of the RFID devices, power source of the tags/transponders (batteries equal active tags, no battery equals passive tag), amount of power being applied to the reader antenna, material(s) and composition of the object being tagged, physical size of the antenna (both reader and tag), presence of EMI (electro magnetic interference) and RFI (radio frequency interference), moisture content in the air, ambient temperature, physical obstacles between the tag and reader and many additional environmental factors.

There is a commonly mistaken idea that more read range is always better, this is not always the case. In most gate control applications, 10 to 15 feet is sufficient, least the reader be reading the RF tag of the second vehicle in the lane and opening the gate for the first (and possibly unauthorized) vehicle. This is the primary reason (together with lower tag cost) that passive RFID is most commonly used for gate controls. The same is true for some asset tracking applications, it may be desirable to have a controlled read range. For these, and many other reasons, RFID readers/receivers will commonly offer the capability of adjusting read ranges.
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How Passive RFID Technology Works

▪ Reader broadcasts RF energy over an adjustable area - aka read zone. Adjustable refers to db levels controlled by power to the antenna
▪ Amount of RF energy output is regulated by the FCC
▪ Tags contain both an integrated circuit (IC) and antenna
▪ Tag antenna absorbs and accelerates RF energy from reader and then, at excite frequency, IC reflects RF signal back to the antenna, effectively using power from the reader
▪ The reflected radio waves contain the tag's ID code (facility code, ID number in case of Wiegand) and other data.
▪ Antenna relays the data to the reader
▪ Reader transmits the info to the customer's information management system (access control panel/gate operator)

How Active RFID Technology Works

▪ Active RF tags contain their own power source (battery)
▪ Tag transmits its’ embedded information to the receiver via the antenna
▪ Tag can be “woken up” by the receiver (often a different frequency)...or
▪ Tag can be constantly transmitting (beaconing)
▪ Receiver transmits the info to the customer's information management system (access control panel/gate operator)
Active tags contain internal batteries used as a power source for transmitting data and therefore, tend to be larger than Passive tags. Passive tags absorb the RF from the reader and reflect the signal back to the reader. Pictured below are examples of an active windshield tag and its’ passive counterpart.

Passive = Unlimited tag life    Active = Limited tag life
(exception is tags with replaceable batteries)

Active = Longer Range    Passive = Limited Range

Passive = Lower cost tags    Active = More expensive tags

Active = Robust read zones    Passive = Controlled read zones

Active = Read at speeds    Passive = limited speed

Passive = Expensive Readers    Active = Inexpensive Receivers

Passive = More secure tags    Active = removable tags
RFID and FCC - Part 15 and Part 90

If The Transmitting Device Does Not Have an FCC ID Number, It Is Illegal For You To Install It – Period!

- Passive tag systems, the reader is the transmitting device.
- Active tag systems, the tag is the transmitting device

- FCC Part 15 transmitters DO NOT require a site license
- FCC Part 90 transmitters DO require a site license

Required FCC Part 15 verbiage
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LF 125 KHz - Proximity Readers

Passive Tags (Active Rarely)

• Mostly used for Proximity Reader applications
• Data Transfer Rate is Slow
• Data Transfer is One Way (rare exception)
• Read Range is Limited to 24 inches
• Commonly Used for Access Control – Buildings and Gated Entry
• Low Cost and Widely Utilized
• Common Tag Form Factors = Cards, Keytags, Hangtags, Wafers
• HID – AWID – XceedID – Far Pointe
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LF 125 KHz - Proximity Readers

Proximity Technology is Commonly Used at Gated Entrances Due to Low Cost and Market Familiarity

Leverages Existing Proximity Cards Used for Building Access

Limitations

• Read range maximum of 24 inches (passive cards)
• No simultaneous reads if multiple cards are in the field
  • Limited form factors for credentials
• Proprietary protocols still in use – compatibility limitations
• Millions of cards in circulation present security concerns
• Performance inconsistencies with switching power supplies
  • Susceptible to EMI from power sources, electric motors
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High Frequency HF 13.56 MHz

Smart Card & Tag Readers
ISO 14443A, 14443B and 15693

Passive Tags – contact and contactless

- Contact Smart Cards require physical connection between the chip and reader (older Bank and Logical Access cards).
- Contactless reads from 1 to 4 inches away – like proximity
- Smart Cards contain much more information and data
- Readers have a fast data transfer rate and can utilize secure sectors within the card – including encryption for added security
- Smart Tags (usually ISO15693) read only card serial numbers
- HSPD12 mandates FIPS201 – contactless smart cards for government employees and contractors

HSPD = Homeland Security Presidential Directive
FIPS = Federal Information Processing Standard

*Note – FIPS201 compatibility exists between the credential and reader and has nothing to do with actual controller
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Smart Card Applications

What can I do with a Smart Card?

- Biometrics
- Storing Templates
- Library Check Out
- Medical Record Storage
- Gov’t Entitlement Data
- Logical Access
- PC logon
- Time & Attendance
- Point of Sale
- Stored Value

Because Smart Cards can store large amounts of data, and Smart Card Readers can write data back to the cards, they are popular for many non-security related uses. Utilizing the Secure Sectors and Encryption features allow for higher levels of data security.

There is demand for these readers in gated entry applications so insure that you have a vendor that understands the complexities.
In the past 10 years, there has been a proliferation of multi frequency and multi protocol readers in the marketplace, initiated by XceedID and adopted by GE, IR, Far Pointe, HID and many other manufacturers/OEMs.

Multi frequency means that a Smart Card reader (13.56 MHz) can also read Proximity cards (125 kHz), and vice-versa. These readers allow for an easy migration path from one technology to another.

Multi Protocol means that a Proximity reader can read HID, AWID, XceedID and Farpointe cards. A Smart Card reader can read ISO 14443A, ISO14443B and ISO 15693. This is very useful for end users with multiple brands of proprietary cards and tags
Multi Antenna units are most commonly used in Supply Chain, WIP (work in process) or File Tracking applications where there is a need for reading and writing to large quantities of tags and it is not economically feasible to install multiple readers with integrated antenna.

NOT commonly used for Gate/Lane Controls due to difficulties discriminating from lane to lane and economies of scale (why pay for 4 lanes if there is only 1 or 2?)
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UHF 902 to 928 MHz Passive

The most common 902-928 MHz Readers that we see in the Gated Entry marketplace are the integrated Antenna variety – one housing contains both the reader electronics and the antenna. These units are designed to read RF tags in one single lane. It is usually desirable for these readers offer a variety of data output formats to include Wiegand, RS232. TCP/IP for easy interfacing with multiple types of gate operators and PLC’s. Many European gate operators do not accept a Wiegand input, they are usually looking for a proprietary flavor of RS232.

It is important to know if the reader you are installing is environmentally sealed for use in outdoor environments. Because this frequency of reader is commonly used for Supply Chain/WIP applications, it may be designed for indoor use. If this is the case, be sure to mount the reader inside a NON-metallic enclosure if being mounted outdoors.
Typically, a 900 MHz passive tag reader is aimed into the traffic lane since the passive tag is usually mounted on the vehicles windshield, or the hang tag is hanging from the rear view mirror post. It is also common to have a passive “windshield style” sticker on the headlamp. This reader configuration is often used in conjunction with an activation loop which will insure that a vehicle is present before the readers’ output triggers the gate operator. Most passive tag reader manufacturers will recommend a mounting height of 6 to 9 feet for the read head so there is maximum read zone coverage in the vehicle lane and the read zone is aiming downwards to achieve a parallel surface between the read head and the tag (more on that in a couple of pages).
It is not uncommon to have a passive UHF reader mounted on the side of the lane, though care must be exercised to move the read head further back. As this illustration clearly shows, the effective read zone of the UHF readers is at it’s widest when the tags are 8 to 20 feet away. Since this reader mounting technique is used when passive tags are usually mounted on the side window in the case of passenger cars, or on the side of a truck (metal mount tag), the best results will be realized when the read head is further away from the travel lane. One of the reasons that this mounting technique might be utilized (in the case of passenger cars) is a proliferation of vehicles with metallic windshield content that inhibits the ability of a passive tag to absorb the RF and reflect it back to the reader.
Finally, that “Parallel Surfaces Rule”
If you will remember your basic RFID101 knowledge, you will recall that a passive RF tag actually gets its’ power from the reader. That is to say that, the reader is emitting RF and the tag must be able to absorb that RF, accelerate the signal and the reflect it back to the reader. Therefore, if the surface of the reader and tag are close to parallel, this principal will result in better tag reads. Below is an example of this rule not being followed:

In this instance, the fact that vehicles were turning through the read zone meant poor performance when the reader was mounted on the white post. Once the reader was moved back closer to the operator, allowing vehicles to enter the read zone straight, it worked much better!
Beware of the Customers Expectations

The single largest cause of customer dissatisfaction with AVI systems is that their expectations were not fully realized and met. Call it being oversold, but it happens very frequently and usually results in the customer being unhappy and the integrator being “gun shy” about future installs. As with any technology, the customer must be educated and their expectations must be known before the system is installed. A perfect example of this would be a gated community where many of the homeowners think that a toll tag type of system is being installed so they can fly through the entrance at high speeds. This would be an active tag system, which means big trouble if management opted for a passive tag system.

Remember your RFID101, passive tags must absorb and reflect the RF signal and therefore, can not be read at speed. Active tag systems, because the tag is transmitting, can be read at further distances and higher speeds.
Though not very common place anymore, 902-928 MHz using active (battery powered) tags used to be more commonplace. Many toll roads used this technology until drastic improvements in passive tag technology rendered these systems almost obsolete. One of the issues making this technology fall out of favor is that 900 MHz active tags are governed by FCC Part90, which requires an FCC Site License for every install. This technology is still in use for asset and personnel tracking, though the propensity for body blocking does limit those applications.
The long range capabilities with active tags (batteries) makes this the preferred technology for applications like asset tracking. Middleware is often used in conjunction with active tag receivers and tags to “zone out” a facility and provide information as to the location and movement of assets/personnel from zone to zone.
You may want longer read distance for very large vehicles such as tractor trailers or you may simply want high speed entrance capabilities for secured areas.

Many “exclusive” gated communities and higher end homes want the gates opening while the vehicle is approaching – not necessarily good for security, but sometimes convenience matters more.
When using an active tag system, it is often necessary to use a circular polarized antenna to make your read zone “directional.” The diagram above shows the read characteristics of the tres433 active tag receiver with internal etched antenna. Imagine this receiver was installed in the chassis of a typical gate operator. Depending on the lane design, this could easily be reading the active tags of exiting vehicles as well as the tags of any vehicles parked immediately behind the gates/barriers. This is a common problem with active tag RFID.

This proprietary diagram is used with the permission of Transponder and Reader Engineered Systems, Inc.
When using an active tag system, it is often necessary to use a circular polarized antenna to make your read zone “directional.” The diagram above shows the read characteristics of the tres433 active tag receiver with a circular polarized (directional) antenna. In many lane control applications, this read range is far too long and can easily be adjusted by the TRES, Inc. exclusive auto-tune procedure. The auto-tune is normally accomplished directly in the front of the reader meaning there is a proportionate decrease in read range at all angles. This is imperative when you have side by side lanes or when you need to be cautious of reading tags of following vehicles.

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A.V.I. (Automated Vehicle Identification) Readers – this frequency is most common among European manufacturers – operates in a similar manner to the 433 MHz products as regards read ranges and functionality. Prices tend to be much higher.

This is the same frequency as wireless access points/WiFi data networks utilize. Usually seen in conjunction with European gate access or revenue control systems.

RTLS (Real Time Locator Systems) - This same frequency is used in many hospitals for Asset Tracking – they are leveraging the existing WiFi networks and hotspots already installed and tracking active 2.4 GHz tags attached to assets or even patients.
Data that is programmed into a proximity/AVI card or tag consists of a site/facility code and ID number in most cases.

Site/Facility code – usually verified by the system controller before the card ID number is read – one verified, controller then looks at the ID number to ascertain access level, time zone, etc. (is that card number allowed access at this gate on this day at this time) and if access is granted, gate/lock relay opens/closes to allow access and entry is logged in database.

Common data output formats used in the Gated Entry/Parking Controls industries are Wiegand and Serial:

Most common is Wiegand Data, 26 bit

Higher Bit Count = Higher Security (more number combinations)

174 01045 is a 26 bit format example

256 possible site codes - 65,535 possible ID numbers

256 X 65,535 = 16,776,960 possible number combinations

024 12347629 34 bit format example

256 site codes – 16,776,960 ID numbers (4,294,901,760 combos)

Many Gate Operator Manufacturers (primarily European) will utilize a serial format (RS232) – often proprietary. These formats may or may not include the same data as described above. Smart cards (13.56 MHz) may utilize just a serial number (CSN) or more, possible encrypted.
The biggest mistakes that I seen made in the last fifteen years of RFID and Gate Controls installation:

• These devices are nothing but longer range Proximity Readers and I have installed a million of those! Being arrogant and rushing is not professional

• Customer Expectations not in alignment with reality
  Take time to discuss the realities and limitations of the technology with your customer – don’t be afraid to say NO!

• Failure to listen to the manufacturers recommendations regarding power supplies and mounting consideration
  Just like any electrical appliance, there is a right way and a wrong way to install it – read and learn before installing

• Allowing the end user to install their own tags without proper training
  I always use the example of a gated community – if you have 1,000 residents, you will fine 999 ways NOT to install an AVI tag.

• Improper grounding of the AVI Readers
  • AVI readers are usually outdoors on a metal pole connected to an electronic access controller – need we say more?
Feel free to contact us with any questions that you may have regarding this presentation.

You are welcome to join us for any of our webinars, call or email for more information.

Prepared for the American Fencing Association by:
Douglas Cram, President – Transponder and Reader Engineered Systems, Inc. doug@tresrfsolutions.com - (770) 529-1040