THE BEGINNER'S GUIDE to RFID SYSTEMS

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For all you RFID beginners, this white paper is for you. Whether it's RFID system basics or product information, this paper will guide you through the processes of learning about Radio Frequency Identification technology.

INTERMEDIATE Level

For all of you knee-deep in RFID, check out this white paper. After reading you will gain in-depth knowledge giving you the ability to improve your RFID systems.

ADVANCED Level

For all you RFID geniuses, this white paper will further expand your comprehension of RFID. The subject of this paper immediately delves into the high level concepts of RFID and physics behind your systems.

Table of Contents

Contents

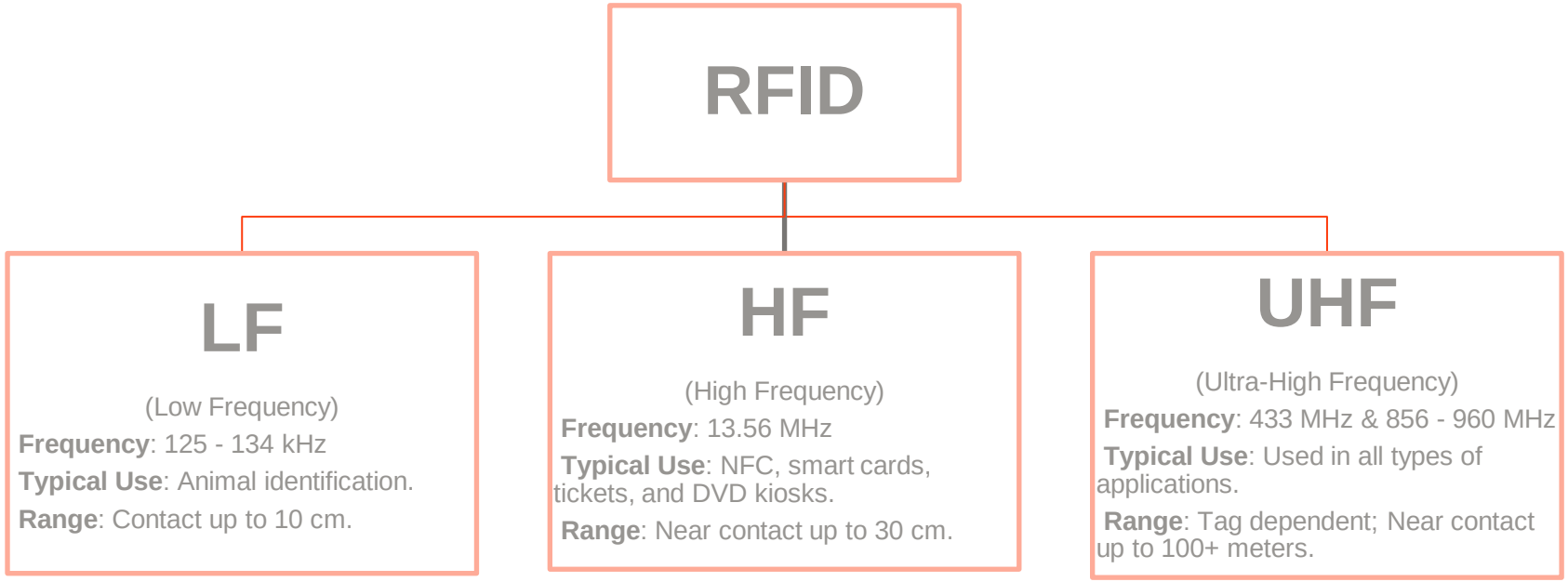
Radio Frequency Identification 3
What you need to know… 4
RFID Tags 6
RFID Antennas 8
RFID Readers 10
Development Kits 12
Cables 13
What about other equipment and accessories for RFID systems? 14
Still think RFID is right for your application? 15
Appendix A: RFID Frequency Breakdown 16

Radio Frequency Identification

RFID technology is used in hundreds of applications such as race-timing, DVD kiosks, asset tracking, and tool tracking. In order to determine if your application is ready for RFID, you need to understand the basics of RFID technology. Once you understand the benefits and limitations of RFID, you will be able to decide if RFID will improve your business.

Radio-frequency identification (RFID) is the wireless non-contact use of radio-frequency electromagnetic fields to transfer data for the purposes of automatically identifying and tracking tags attached to assets.

The chart below outlines the three primary frequency ranges used in RFID:



(For the extended chart, see Appendix A)

Within the UHF Frequency range of 856 – 960 MHz, there are two primary subsets:

a) The FCC (US) standard frequency range of 902-928 MHz
b) The ETSI (EU) standard frequency range of 865-868 MHz

The FCC standard is used throughout North America as well as the majority of the Caribbean and much of South America. The ETSI standard is used throughout the European Union and most countries adhering to EU standards. Various other subsets within the above ranges are used throughout the world. If you are planning on deploying RFID Equipment in a particular country, but aren't sure of that country's standards, then we can assist in providing the appropriate frequency range.

What you need to know…

- RFID is not the best fit for every application, and the technology may be expensive depending on the size of the application. The return on investment of the necessary hardware, software, and labor hours must justify the expense. Many times RFID is the right fit – other times barcodes or only a process change may be the solution.
- All RFID systems require readers, antennas, and tags in order to function (see Figure 1 below). The selection of ancillary items such as cables, mounting brackets, and GPIO devices will greatly impact the effectiveness of an RFID system.

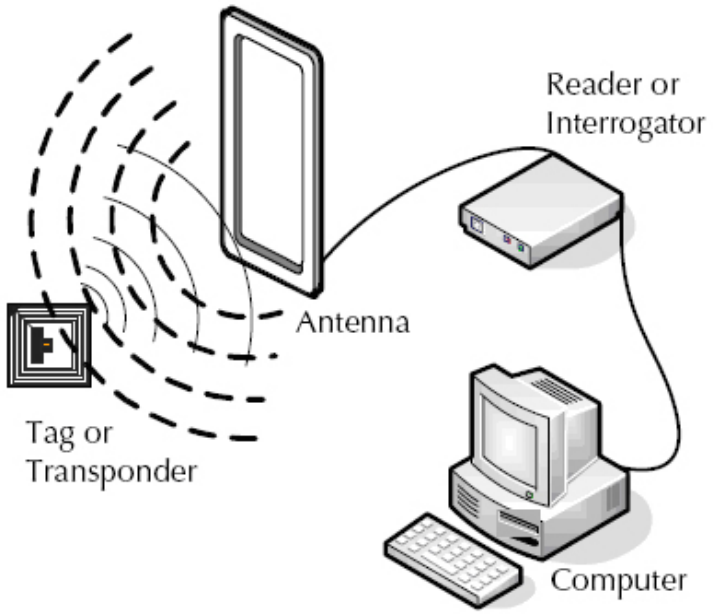


Figure 1. A simple drawing of an RFID setup.

- Keep environmental conditions in mind when selecting an RFID system. Some environments are not well-suited for certain types of RFID equipment. For example, water causes interference when reading UHF RFID tags. Steps may be taken to mitigate environmental factors, but it is important to consider all variables that may affect tag readability.
- RFID tag pricing is heavily dependent upon tag type and tag volume. Metal-mount RFID tags and rugged RFID tags are more expensive than RFID wet inlays or RFID labels. Also, pricing on 100,000 tags will be much different than pricing on 10,000, 1,000, or 100 tags. See Appendix A for general pricing ranges.

- Few "out of the box" solutions are available on the market. While certain applications such as tolling or race timing use the same infrastructure and software across a wide spectrum of locations, most RFID hardware and software deployments require specific configuration for each unique location and environment. Even within a particular manufacturing plant, for instance, different hardware and software algorithms may be needed in different locations in order to achieve desired read rates.
- Test, test, test. Reconfigure. Test some more. In order to ensure your RFID deployment is successful, you need to test a variety of RFID tags, equipment, antenna angles, and power settings. RFID development kits and RFID tag sample packs are great resources for testing a variety of readers, tags, and antennas.

RFID Tags

An RFID tag, in its most simplistic form, is comprised of two parts – an antenna for transmitting and receiving signals, and an RFID chip (or integrated circuit) which stores the tag's ID and other information.

RFID tag selection is, perhaps, the most critical component of a successful RFID system, and hundreds of tag variations are available on the market today. An RFID tag could be the perfect size and shape for your application, but be the wrong type for mounting on metal. Metal-mount RFID tags are specially designed to read well when mounted on a metallic surface, whereas RFID wet inlays or RFID labels are not

readable if applied to metal surfaces. Other specialty types include windshield RFID tags for applying to a car's windshield, laundry tags for tagging garments or linens, and RFID wet inlays for timing races. Since wet inlays are less rugged but more flexible than traditional tags, they are perfect for race-timing systems.

Primary points of consideration when selecting an RFID tag:

- What type of surface will you be tagging? On metal, plastic, wood, etc.?
- What read range do you desire?
- Size limitations (i.e. the tag can be no larger than x by y by z inches)?
- Any excessive environmental conditions to consider? Excessive heat, cold, moisture, impact, etc.?
- Method of attachment? Adhesive, epoxy, rivets/screws, cable ties, etc.?

The key to any RFID system is thorough testing. Some RFID tags will be a better fit for your application than others, but the only way to know for certain is by testing a variety of tags in your environment on the actual items you wish to tag. RFID tag sample packs – UHF, HF, or NFC – can be customized for your application so that you can narrow down to the tags that are right for your application.

RFID tag pricing is heavily dependent upon tag type and tag volume. Metal-mount RFID tags and rugged RFID tags are more expensive than RFID wet inlays or RFID labels. Also, the pricing on 100,000 tags will be much different than pricing on 10,000, 1,000, or 100 tags. See Appendix A for general pricing ranges.

RFID Antennas

RFID Antennas are a necessary element in any RFID system; however, they are dumb devices which use power from the reader to generate a field allowing the reader to transmit and receive signals from the RFID tags. Antennas vary in size, gain, IP rating, polarization, and connector type. The price of antennas ranges from approximately $100 to about $1,000+ depending on the type, size, and level of ruggedness. Selecting the right RFID antenna for your application is crucial to the success of your system.

As mentioned above, antennas come in many variations; however, at the base level, you should consider a few key variables:

Gain – Simply put, the higher the gain, the more powerful the antenna. A higher gain antenna will produce a larger field, thus extending read range farther than a lower gain antenna.

Polarization – Linear vs. Circular. The polarization of the antenna makes a tremendous difference when it comes to reading tags. Linear polarized antennas emit RF energy along a single plane. Typically, they have a longer range compared to similar gain circular antennas, but due to the linear nature of the field, the tags must line up with the beam in order to achieve the long read range. If the tags do not line up, then the read range is relatively short. In contrast, circular polarized antennas split the energy across two axes and "spin" the field in either a right or left hand direction

allowing the antenna to pick up tags regardless of orientation. However, due to the energy being divided, the read range is shorter versus similar gain linear antennas. To gain a more in-depth understanding on the subject, including some visual aids, please read our blog post on circular vs. linear polarization.

IP rating – A measurement of protection against dust and water ingress. In short, the higher the number, the better protected the antenna is against environmental factors. Most indoor antennas have a rating of IP 54, while a good outdoor antenna will have a rating of IP 66 or IP 67.

Primary points of consideration when selecting an RFID antenna:

- How much read range do you need?
- Is it possible to always know or control the orientation of the RFID tag relative to the antenna's position in your application?
- Any excessive environmental conditions to consider? Excessive heat, cold, moisture, impact, etc.?
- Will the antenna be mounted indoors or outdoors?
- Size limitations (i.e. the antenna can be no larger than x by y by z inches)?

While RFID antennas are needed for any basic or complex RFID system, each antenna has different strengths and fits specific types of systems. Most systems will need more than one antenna to cover all read zones and maximize efficiency.

RFID Readers

An RFID reader is the brain of the RFID system and necessary for any system to function. Readers, also called interrogators, are devices that transmit and receive radio waves in order to communicate with RFID tags. RFID readers fall into several classes – fixed RFID readers, handheld RFID readers, and integrated RFID readers. Which one you choose will depend on how and where you deploy the reader.

As you can imagine, a **fixed RFID reader** stays in one specific location when encoding and reading tags, while a **handheld RFID reader** is mobile and can be carried around while scanning various items. Fixed readers are typically two, four, or eight port readers meaning they can support up to two, four, or eight antennas, but a few can be configured to support up to 32 antennas. Fixed RFID readers are well suited for environments where you need the most flexibility in terms of antenna configuration and coverage as you have the option of adding multiple and different types of antennas. While most fixed readers require an Ethernet cable in order to send and receive data, Wi-Fi RFID readers communicate over secure wireless networks.

Handheld RFID readers are typically full mobile computing devices with the reader and antenna built into the device. Usually, they also contain barcode scanners, Bluetooth, and Wi-Fi. When you need mobility, a handheld reader is the way to go.

An **integrated RFID reader** is a reader with a built-in antenna and usually has another port to support up to one additional antenna. Integrated readers are a great fit if you are only looking for a lower cost solution and only need one or two antennas.

Another item to consider is how you will power the reader. While handheld RFID readers will use batteries, most fixed and integrated readers will have the option to power via AC power or Power-over-Ethernet (POE). POE RFID readers can provide a lower cost of deployment since you won't have to run power drops to the various reader locations, and the POE cable will simultaneously act as both the power and communication cable.

Lastly, while most RFID readers are IP-addressable, some, such as USB RFID readers, are not. USB readers are designed to be smaller, low-cost readers that interface directly with a PC. As a result, they cannot be placed on a network, but are great for short-range desktop applications.

Primary points of consideration when selecting an RFID reader:

- How much read range do you require for your application?
- Any excessive environmental conditions to consider? Excessive heat, cold, moisture, impact, etc.?
- Will you be adding the reader to a network?
- Where will the reader be placed? Fixed location? Vehicle? Does the reader need to be mobile?
- How many read points/read zones will you need?
- How many tags might need to be read at one time?

- How quickly will the tags be moving through the read zone? For example, is this a slow moving conveyor belt or a fast moving race?

UHF RFID Readers range in price from about $450 - $4,000 or more depending on the type and functionality required. If you need more information on a specific reader, please let us know.

Development Kits

RFID development kits include all the basic RFID equipment needed in order to set-up and test an RFID system. Most RFID development kits come with a reader, one or more antennas, some sample tags, a sample program for reading, encoding, and testing RFID tags, as well as access to the reader's SDK (software development kit – documentation, API access, and code samples).

Development kits range in price from around $900 to $2,900 or more. If you are just getting started with RFID, a development kit is the way to go.

Cables

In order for the reader to transmit and receive data, it must be connected to an antenna via an RFID antenna cable. Choosing the correct type of cable is important because it must connect properly to the reader and antenna, and you want to minimize the amount of loss across the length of the cable.

Connector options for cables are determined by the connector types on the reader and the antenna. Also, the insulation rating of the cable (i.e. the thickness of the cable) will be determined by the length needed as well as the read range desired. RFID cables are available at three different insulation ratings – LMR195, LMR240, and LMR400. The longer the length of the cable, the better insulated the cable needs to be in order to maximize efficiency and reduce the amount of loss along the length of the cable. Of note, as the insulation rating increases, the cable will be thicker and more rigid. The LMR400 cable, while highly efficient, will be more difficult to bend and work with when turning corners or running through a conduit.

Primary points of consideration when choosing an RFID antenna cable:

- How long do you need the cable to be?
- What is the read range desired for your system?
- Which connector type does your reader have?
- Which connector type does your antenna have?

To read more, check out our blog post on getting the highest performance possible from your RFID antenna cables.

What about other equipment and accessories for RFID systems?

Like all electronics, a variety of accessories and equipment have been designed to enhance your RFID system. For example, RFID printers, RFID portals, GPIO adapters, and antenna mounting brackets will all supplement or augment your system. While adding components to an RFID system also adds to its complexity, when used appropriately, they may greatly increase your systems efficiency.

Still think RFID is right for your application?

Now that you have an idea of the basic items needed and general costs, if you still think RFID is a good fit for you, then please contact us with any other questions you may have.

For more information on RFID, check out our blog RFIDinsider and our website atlasRFIDstore.com.

We are here to help you!

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Appendix A: RFID Frequency Breakdown

RFID

(Radio Frequency IDentification)

LF

(Low Frequency)

Frequency: 125 - 134 kHz

Cost Range: $0.50 - $5

Read Range: contact - 10 cm

Examples: Animal tracking, Access Control, Car Key-Fob, Applications with high volumes of liquids and metals

Pros: work well around liquids and metals, global standards

Cons: very short read range, limited quantity of memory, low data transmission rate (read very few tags at one one), high production cost

HF

(High Frequency)

Frequency: 13.56 MHz

Cost Range: $0.23 - $10

Read Range: contact - 30 cm

Examples: DVD Kiosks, Library Books, Personal ID cards, Poker/Gaming Chips

Pros: NFC protocol, larger memory, global standards

Cons: short read range, low data transmission rate (read fewer tags at one time)

UHF

(Ultra-High Frequency)

Active

(Battery Powered)

Frequency: 433 & 856- 960 MHz

Cost Range: $25 - $100+

Read Range: 30 - 100+ meters

Examples: Auto dealerships, Auto Manufacturing, Mining, Construction

Pros: very long read range, lower cost readers, write extensive amounts of data, high data transmission rates (read more tags at one time)

Cons: very high tag cost, cannot be shipped via air transport (if tags are actively beaconing), complex software may be necessary, high amount of interference from metal and liquids, no global standards

Passive

(Powerd by RF Energy)

Frequency: 856- 960 MHz

Cost Range: $0.13 - $25

Read Range: near contact - 25+ meters

Examples: Supply Chain, High-volume Manufacturing, Pharamceuticals, Electronic tolls, Item Tracking, Race Timing, Asset Tracking

Pros: longer read range, lower cost per tag, wide range of tag sizes and types, global standards, high data transmission rates (read more tags at one time)

Cons: typically higher associated infrastructure cost, write small amounts of data, high amount of interference from metal and liquids