UNDERSTANDING THE CHARACTERISTICS OF THE RFID SPECTRUM:

CHOOSING THE RIGHT RF TECHNOLOGY TO AUTOMATE YOUR BUSINESS

MOTOROLA

HOW TO CHOOSE THE RIGHT RFID TECHNOLOGY FOR YOUR IDENTIFICATION, LOCATION, TRACKING AND PAYMENT APPLICATIONS

Whether you are managing inventory in a retail store or warehouse, work-in-process (WIP) operations at a manufacturing plant, tracking medical equipment in a hospital or processing NFC cards for payment transactions, RFID can help you do it better, faster and more accurately. But RFID comes in different 'flavors' — such as Low Frequency (LF), High Frequency (HF), Ultra High Frequency (UHF) and a host of other technologies across the RF spectrum that help enterprise organizations automatically identify, locate, track and process their critical business products, assets and transactions. How can you determine which frequency or technology is most suitable for your applications?

THE UNIQUE PERFORMANCE CHARACTERISTICS OF THE DIFFERENT RFID TECHNOLOGIES

All RFID technologies basically work the same way: a fixed, handheld or mobile RFID reader wirelessly communicates with RFID tags (technically known as transceivers) on products and assets, allowing businesses and government agencies to automatically capture identification, tracking and location information. But each technology also has its own distinct set of operational and performance characteristics that affect the read, cost and deployment factors. These characteristics define the applications that are best suited for each of the various RFID technologies. Understanding these characteristics will help you easily identify which RFID technology is right for each of your RFID applications.

Questions to answer include:

- What is the minimum and maximum distance between tags and readers?

- Do you need to read one tag at a time or many tags simultaneously?

- Are you tracking items that are relatively inexpensive or high cost items?

- How much information do you need to store on tags?

- Do you need to conduct payments or other transactions with RFID-enabled devices?

- Where do you need to read tags? For example, as assets move in and out of the loading dock for receiving and shipping? As assets pass through specific areas?

- How sensitive is the data on the tag? What level of security will that data require?

PRIMARY IDENTIFICATION, LOCATION AND TRACKING TECHNOLOGIES

To help you select the right frequency candidates for your RFID application, the following is an overview of each of the predominant RFID technologies, including read ranges, unique characteristics and the most suitable applications.

Note that operating ranges cited below are average estimates only since range can be impacted by environmental conditions — including materials that are present, condition of the surface of the tag, reader power, regional operating characteristics, and interference with other RF devices in the vicinity.

125-134 KHZ LF RFID (PASSIVE)	13.56 MHZ HF RFID (PASSIVE)	433 MHZ ACTIVE RFID
READ RANGE*		
• From approximately 1 inch/2.54 cm to 1.5 ft./0.45 m	• From approximately 1 inch/2.54 cm to 3.28 ft./1 m	• From approximately 1 inch/2.54 cm to 30 ft./9.14 m • Can boost range up to a mile/1.6 km with custom system development
CHARACTERISTICS		
• Reads one tag at a time — no risk of cross talk (inadvertent reading of other tags in the vicinity) • Has a short read range and low data transfer rate • Limited memory — 96 to 2,000 bits • Penetrates most materials well, including water and body tissue, as well as metal • Easily embedded in non-metallic items, such as keyfobs, plastic cards and mobile devices • May be affected by electrical noise in an industrial environment (for example, noise generated by motors)	• Reads multiple tags simultaneously • Has a short read range • Moderate data transfer rate • Moderate memory — 256 to 16K Bytes • Penetrates most materials well, including water and body tissue • Not as effective as LF in the presence of metal • Easily embedded in non-metallic items, such as keyfobs, plastic cards and mobile devices • Not typically affected by electrical noise in an industrial environment (for example, noise generated by motors) • Orientation of tags impacts communication range — optimum range requires tag and reader to be parallel • Worldwide frequency — suitable to for deployment anywhere in the world	• Can read multiple tags simultaneously • Extended read range • Requires battery assisted tags for operation • Requires battery replacement beyond battery lifetime
TYPICAL APPLICATIONS		
• Access control, such as a contactless card that is read at the entrance or exit gate in a parking lot or building • Customer ID via key fob such as Speed Pass • Car key/ignition pairing: today's car keys have an LF RFID tag embedded that must be verified by the reader in the ignition of the car before the car will start • Individual animal tracking: from livestock such as cows to endangered species and pets • Legacy asset tracking	• Open loop contactless smart card transactions, such as MasterCard or Visa payments • Closed loop contactless payment transactions, such as ticketing for public transportation and events • Physical and logical access control — ID cards or employee badges • Identity verification — Passports and ID cards • Healthcare — patient specimen tracking, patient identification and blood/blood donor tracking • Asset tracking — from library books to machinery • Maintenance and inspections — ensure that the right asset is about to receive the right maintenance at the right time • Retail Security and Electronic Article Surveillance (EAS) for theft deterrence and detection • Self checkout counters, such as those found in libraries	• Highway toll collection • Yard management, automated vehicle identification (AVI) and private fleet tracking (in and out of facility) • Real Time Locationing System (RTLS) applications • Container tracking

* Read ranges indicated are common and typical, and are dependent on the specific RFID tag, environmental and operational characteristics.

860-960 MHZ UHF RFID (PASSIVE)	2.4 GHZ WI-FI RTLS

READ RANGE*

• From approximately 1 inch/2.54 cm to 10-20 ft./3.0-6.1 m	• From 1 inch/2.54 cm to 30 ft./9.14 m

CHARACTERISTICS

• Can read multiple tags simultaneously	• Can read multiple tags simultaneously
• Has a relatively long read range for the tag size and cost	• Has a long read range (dependent on Wi-Fi infrastructure)
• Provides a fast data transfer rate	• Requires battery assisted tags for operation
• Moderate memory — minimum 96 bits for EPC data and 512 bits to Kilobytes for user data	• Requires battery replacement beyond predetermined lifetime
• Supports the EPC standard	• Provides fast read rates
• Provides a worldwide frequency — suitable for worldwide deployment	• Does not easily penetrate water or metal
	• Basic installations can use existing Wi-Fi infrastructure, such as Wi-Fi access points (additional infrastructure is typically required)

TYPICAL APPLICATIONS

• Retail and supply chain inventory management: pallet/carton/item level tracking in a manufacturing plant, warehouse, store room, distribution chain, retail back room and sales floor	• Real Time Locationing System applications
• Inventory and cycle counting	• Healthcare asset management of higher valued equipment and supplies that need the increased granular location information that a larger, battery powered RFID tag can provide
• Manufacturing work-in-process (WIP)	
• Asset tracking (mass assets): airline baggage, tools, returnable transport items (RTI's), equipment, evidence and supplies	
• Track and trace — food, cold chain and pharmaceutical tracking	
• Healthcare — tracking of equipment, supplies and patients	
• Maintenance and inspections — ensure that the right asset is about to receive the right maintenance at the right time	

* Read ranges indicated are common and typical, and are dependent on the specific RFID tag, environmental and operational characteristics.

OTHER TECHNOLOGIES INCLUDE:

• Ultra Wide Band (UWB) — a 6.4 GHz technology that provides a longer read range for niche applications

• Active UHF — a battery-assist solution for UHF that can boost the read range up to 328 ft./ 100 m), though tag cost is increased and tag life is reduced

For more information about how RFID works and how you can benefit from RFID in your organization, please visit www.motorola.com/rfid, www.motorolasolutions.com/mc75AHF or access our global directory at www.motorola.com/enterprise/contactus

TYPICAL HF AND UHF RFID APPLICATIONS

RFID is a mature technology that has been in existence for decades. As a result, a few major applications have already standardized on a specific frequency and technology. This standardization furthers the innovation and adoption of RFID technology, helping to strenghten benefits for customer and enterprise alike.

HF RFID FOR NFC APPLICATIONS AND SECURE TRANSACTIONS

HF RFID tags are read every day, on passports at security checkpoints; on tickets for everything from commuter trains and buses to sporting events; on gift cards; and even on credit cards. These HF tags are either physical cards, fobs or tokens with an embedded HF tag, or a 'virtual' credit card that utilizes near-field communications (NFC) with smart devices. While HF RFID supports a wide variety of applications, a predominant application in the HF spectrum is payment-based transactions — both closed and open loop.

Closed loop transactions. Closed loop transactions can be processed completely inside the enterprise infrastructure and do not require integration with any other organization. In addition, these typically debit-based transactions eliminate credit card processing fees. Many cities, municipalities and businesses are implementing a closed loop RFID ticketing solution to simplify their transportation ticket management process. Passengers purchase paper tickets or pre-paid cards that have an embedded RFID tag or an electronic RFID-enabled ticket that is stored on an NFC-enabled mobile phone. Then, tickets are read automatically, either by a conductor utilizing a handheld RFID reader or a fixed reader at a boarding gate. Since cards are pre-loaded and tickets are paid in full at the time of purchase, there is no need to interact with any type of outside organization for real-time payment processing.

Open loop transactions. Open loop transactions require interaction with other financial institutions (for example, charges to a credit card) and typically subscribe to the credit-based EMV or Europay, MasterCard and Visa processing system. The proliferation and growing adoption of smart devices will expand the usage of the HF-based NFC technology in ticketing and other enterprise and consumer-based applications.

Why is HF RFID the technology of choice for payments?

Because of its short read range and adoption of the ISO14443 security standard, governments, enterprises and regulatory groups such as the Payment Card Industry (PCI) have adopted HF RFID technology as a world-wide standard for contactless payment card transactions. These features combine to provide a secure infrastructure for transactions that contain highly sensitive data, such as credit card and access card information.

HF RFID FOR IDENTIFICATION AND AUTHENTICATION APPLICATIONS

HF RFID technology is also typically used to identify and verify credentials. Confidential information can be stored in a secure area on the tag that can only be read with the right keys from the issuing agency. Because it is so secure, this technology has been embraced by governments around the world. Half of all the passports issued worldwide contain an HF RFID tag to ensure document authenticity, enable rapid document processing and reduce wait times at border crossings. In addition, many government issued ID cards, including Control Access Cards (CACs), also use HF RFID technology.

UHF RFID FOR PRODUCT AND ASSET TRACKING

UHF has emerged as the frequency of choice for two major business processes: the tracking of goods on the retail floor and as they move throughout the supply chain; and the tracking of the capital assets inside the enterprise that are required to conduct business. Retail inventory and supply chain applications include:

- Frequent inventory counts of goods on a retail sales floor

- RFID tagging of case, pallet and item level goods throughout the supply chain

Today's retailers around the world are using UHF to track inventory at the item level on the retail floor, providing the real time visibility into inventory and customer trends. And in manufacturing plants, distribution centers and warehouses, mass shipments are automatically tracked as they move in, out and through facilities, providing the visibility required to streamline the supply chain and reduce the cost of doing business.

Asset tracking applications include:

- Tracking a wide variety of assets, from enterprise tools and returnable transport items to wheelchairs in a hospital

- Tracking and monitoring the location of IT assets that contain sensitive company information, such as servers, hard drives, backup tapes and mobile computers

Why have these types of transactions standardized on UHF RFID? Three characteristics have made it the ideal choice:

- UHF allows for the bulk data capture capabilities required to read many RFID tags simultaneously

- UHF has a longer read range, providing the flexibility to read items that are a few inches away or stored on the upper shelves of a warehouse

- UHF offers a low cost per RFID tag, making it financially feasible to tag large quantities of assets and whole store inventories or product lines

ABOUT MOTOROLA

Motorola helps businesses gain increased visibility and automation through wireless technologies like HF and UHF RFID. A Fortune 100 company with global presence, Motorola extends the value of your RFID solution with a portfolio that includes wireless infrastructure, advanced data capture and mobile computing products. Our comprehensive offering simplifies deployment, lowers costs and maximizes return on investment. Inspired by our vision of transforming the enterprise, Motorola is committed to helping you seamlessly connect to the people and information that drive your business.

When you choose Motorola, you get leading edge RFID technology. And when it comes to experience, Motorola is unsurpassed. We've spent decades deploying some of the world's largest and most successful RFID implementations in some of the world's largest companies.

We offer:

• The industry's broadest portfolio of RFID readers

• Tested and field proven best-in-class solutions

• A long history of innovative technology, industry firsts and a wealth of real-world experience in your industry

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