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Identifying the Right RFID: Why Knowing the Difference Between HF and UHF is Important for Your Industrial Applications

White Paper - W1006

Industrial manufacturing is constantly adapting to meet the ever-increasing productivity and efficiency demands on the factory floor, and track and trace technologies play an important role in satisfying these goals. Radio frequency identification (RFID) has been providing manufacturers with high-quality monitoring systems to deliver unparalleled control and visibility over automated operations for increased efficiency gains and improved production.

When selecting the ideal track and trace technology, options are no longer limited to the debate between the capabilities and advantages of radio frequency identification over optical identification methods. Now, manufacturers should examine the difference in performance capacity between the various RFID frequencies in order to ensure the correct solution is implemented to meet corresponding application requirements.

With each industrial application presenting a unique set of challenges and demands, it is important to know the speed, range and number of tags individual operation requires to achieve the necessary level of control. This white paper will explain how RFID technology operates, and will further break down high-frequency and ultra-high frequency RFID. The white paper will also highlight the distinct strengths and weaknesses of each frequency, along with identifying the industries and applications that suit each technology best.

AN RFID BREAKDOWN

Unlike conventional optical identification methods, such as barcodes or the data matrix code, RFID transmits information using electromagnetic radio waves, eliminating line-of-site requirements. While printed labels attached externally to the product become unusable by the time they are exposed to high temperatures or moisture, special RFID tags and mobile reading devices make it possible to use RFID systems even under the toughest conditions.

RFID systems contain three parts: the tag, transceiver and the interface. Tags can be active (require a battery) or passive reflecting the signal back to the transceiver, which is often called a reader or antenna. The interface is the means of communicating the data from the tag a data collection device such as a computer or a programmable controller.

The transceiver is used to read the RFID tag, and an I/O device will communicate information on the tag with the enterprise or higher-level control system. RFID tags contain internal circuitry that respond to a radio frequency field that is provided by the transceiver. During operation, when the RFID tag passes through the field of the transceiver, it detects the signal from the antenna. This activates the RFID tag, signaling it to transmit or receive information on its microchip.

Originally, this technology was developed as a method to remotely gather data through tags or transceivers. However, given their data storage capacity, manufacturers have been attaching or embedding these tags into an object during production and programming them with information about the product, equipment or tool. RFID tags are designed to read and write thus users can collect and store more data than with other systems.

To accommodate various application requirements, RFID operates at diverse frequencies, including low, high and ultra-high. The frequency implemented will determine the distance in which RFID tags can be read, how many tags can be read at one time, how fast these tags are read, the actual size of the tag and how the application environment will impact its performance.

Low frequencies operate below 135 KHz and are least impacted by their surroundings. However, they are unable to read/write tags over a large distance and are limited to a single tag in the field. For this reason, low frequency is not often used in manufacturing environments. Alternatively, High Frequency RFID operates between 13.553 and 13.567 MHz and can read/write tags over longer distances, and while it can read more than one tag in the field, it is better suited for single tag applications. Further, since HF is not overly impacted by its surroundings, it offers an ideal solution for manufacturing processes, such as inventory management or work-in-progress.

Ultra-High Frequency RFID features fast speeds, which enables it to quickly identify objects in the field and offers long-range read/write capabilities. However, UHF is highly susceptible to interference from its surroundings. When looking at the different technologies for an application it is best to have an expert review your requirements and assist in selecting the correct technology for the application.

HIGH FREQUENCY VS. ULTRA-HIGH FREQUENCY

High Frequency

High-Frequency (HF) RFID is among the most commonly used track and trace technology in industrial applications, and is often implemented because of its reliable operation. HF RFID tags use inductive coupling to communicate between read/write heads and transponders. The reader emits a magnetic field, and when a transponder passes through, an electric current is created that powers the RFID tags and transmits data.

Inductive coupling creates a well-defined magnetic field that is smaller but easier to control. With high-frequency systems, the strength of the signal is dependent on the distance from the antenna. This accounts for its short-range operation, reaching up to 50 cm. HF RFID has an operating frequency of 13.56 MHz and can accommodate read-only, write-only and rewritable tags, with a memory capacity from 64 bytes to 8 kilobyte and can handle up to 20 tags at one time. Further, the amount of memory on the tag determines the amount of data that can be stored, and to accommodate various application requirements, tags are available in many different shapes, sizes and materials.

Along with performance capabilities, it is crucial to consider the limitations of each RFID frequency, more specifically its air interface, which defines the way the tag communicates with the reader. By knowing a frequency's air interface, the tag's read range is determined and compatible readers can be identified. For HF RFID systems, the air interface size and shape are independent of the surrounding environment. High-frequency distribution fields are a homogeneous shape, which prevents communication gaps or blind spots, making it less susceptible to environmental influence. Additionally, with long wavelengths, HF RFID prevents the absorption or penetration of liquids and the radio waves will not bounce off metal and cause false reads—making it resistant to performance degradation in wet applications or metallic environments.

Ultra-High Frequency

Unlike HF RFID, Ultra-High Frequency (UHF) RFID offers both near-field and far-field read ranges. Near-field RFID operates similarly to HF RFID, where the antennas generate a magnetic field. Since the tag is closer to the antenna, near-field UHF has a narrower field of view and a shorter read range (comparable to HF RFID). For an additional performance advantage, near-field UHF features an antenna that reduces magnetic shielding, enabling it to block visibility of other tags in close proximity.

Far-field UHF uses electromagnetic waves propagating between reader and tag antennas, delivering a wider field along with an increased possibility for interference. While able to accommodate high speeds and longer read distances, far-field UHF technology technologies is more complex and performance of RFID system gradually degrades because of its absorption, refraction and reflection properties.

Using radio waves to communicate between the read/write head and the tag, UHF RFID can accommodate long-range application requirements, as the electric field features strength that extends much further than possible with high-frequency options. Capable of communicating over several meters with an operating frequency between 860 and 960 Mhz in the far-field, UHF RFID can solve fast-paced, complex applications that require multiple tags to be read simultaneously—handling as many as 200 tags at a time.

UHF RFID systems do offer multiple capabilities over high-frequency options, but they also have several limitations that may impact their ability to deliver the necessary performance capacity for industrial applications. For instance, UHF tags have lower memory capacity, only carrying between 24 to 110

bytes of data. UHF RFID is also more susceptible to the presence of various dielectric and conducting objects in the tag vicinity.

Additionally, the size and shape of air interface is highly influenced by the surrounding environment. UHF systems that use propagation coupling are harder to control because energy is sent over long distances. Further, with UHF, the field distribution tends to be inhomogeneous, resulting in blind spots, communication gaps and even overshoot areas, making the systems more susceptible to performance malfunction from surrounding environmental elements. UHF RFID is vulnerable to interference from both metal and liquids. When considering UHF technologies for industrial applications, environmental conditions need to be tested and proven as many times the bounce of the waves leaves large holes.

IN THE FIELD WITH HF AND UHF

When choosing between these two technologies, it is important to understand their individual performance capabilities, strengths, weaknesses and application suitability. By examining the various operating principles and potential environmental concerns, manufacturers can make an informed decision prior to implementing any track and trace technology.

For example, water, carbon and other materials absorb UHF energy. This means that products containing a high water or carbon content can impact the reliability of the signal. Therefore, when implementing RFID in and around liquid-bearing or carbon-composed products, high-frequency tags are better suited due to their resistance against liquid absorption. Further, when selecting RFID, understanding metal susceptibility is also important. HF tags have a shorter maximum range and are more reliable on an object made of metal. Alternatively, UHF frequencies typically offer better range and can transfer data faster than low- and high-frequencies, but use more power and are less likely to pass through materials.

Another consideration when selecting the appropriate frequency for a corresponding application is the amount of electromagnetic interference (EMI). EMI is noise that can make it more difficult to obtain a clear signal and can be caused by a wide range of machines. Motors emit EMI and may need to be shielded to prevent interference with RFID systems. Conveyors with nylon belts and robots on assembly lines also cause interference in manufacturing processes.

Also important, RFID must adhere to individual restrictions imposed by each country. For HF, the same technology is accepted worldwide, but UHF frequencies differ depending on region. For example, the read range for UHF is only achievable up to 33 cm in Europe due to current power restrictions in those countries.

CONCLUSION

RFID on the plant floor enables users to improve accuracy, provide faster production speeds and minimize errors, as well as achieve substantial cost savings from both a material and labor standpoint. In order to achieve these improvements, it is crucial that manufacturers know and understand the distinct differences between HF and UHF RFID to implement the correct capabilities and tolerances to meet specific application requirements.

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