Technical Review Paper Evaluation Form

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_____ / 30 Technical Content

- Current state-of-the-art and commercial products
- Underlying technology
- Implementation of the technology
- Overall quality of the technical summary

_____ / 30 Use of Technical Reference Sources

- Appropriate number of sources (at least six)
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- Appropriate citations in body of text
- Reference list in proper format

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Radio Frequency Identification Range Measurements and Applications

Introduction

This paper is a review of Radio Frequency Identification (RFID) technology, its commercial applications, and the read range limitations associated with the technology. The read range of an RFID tag is the distance from which the tag can be read, and is limited by the frequency of the radio waves, the size of the tag antenna, the power output of the reader, and whether or not the tags have a battery to broadcast a signal back to the reader. For example, an active RFID system, in which the tag broadcasts its own signal, can be read up to more than 1,500 feet away. A passive RFID system has a much shorter read range—about 2 – 80 ft.—as it harvests energy from a reader and reflects a weaker signal back [1]. Read range is essential to the application of the RFID system.

Commercial Applications Demonstrating the Range of RFID

Libraries

RFID systems provide libraries with a number of benefits: enhanced security, efficient collection management, and less repetitive motion for staff. RFID systems offered by 3M, Bibliotheca ITG, and EnvisionWare offer small, passive, ultra high frequency tags with additional hardware and software that allow the books to be read by a fixed reader about two to three feet away. The tags themselves cost between $0.25 and $0.75, but the self-check systems and kiosks can cost upwards of $8,000 [2].

HVAC

HVAC systems implement passive ultrahigh-frequency RFID technology to build a sensor network that can span the length of the entire infrastructure of a large building. The HVAC ducts act as electromagnetic waveguides, effectively decreasing attenuation and increasing communication range [3]. The read range of a 900 MHz wave can increase from 10 meters in free space to up to 4 kilometers when transmitted through a wave guide. For example, a reader sending a signal with an output power of 1 Watt could withstand 45 dB of power transmission loss and still be read by a tag with a sensitivity of -15 dBm [3].

Agriculture

Farmers can implement high frequency RFID (HF RFID) systems to monitor the feeding patterns of livestock. Older systems typically used low frequency RFID (LF RFID) in feeding stations and achieved good results. LF RFID, however, does not allow multiple tags to be read at the same time, and one LF antenna must be installed per reading place. Newer systems, such as the 13.56 MHz system

demonstrated by Hessel and Van den Weghe, use HF RFID with one antenna per feeder with multiple feeding places, making the systems much more cost effective [4].

Technology Behind RFID and its Range Limitations

RFID uses electromagnetic waves for transmitting and receiving information from a tag to and from a receiver. The operating frequency of RFID radio bands can vary from 30 kHz – 300 kHz (low frequency) up to 3 GHz – 30 GHz (super high frequency). Read range is directly proportional to frequency. For passive tags, LF tags have a read distance of 1 foot or less, whereas UHF tags have a minimum read distance of over 3 feet. Active ultrahigh frequency tags can achieve a read range of 1,500 feet [5]. The maximum read distance of the physical tag is also influenced by the RFID reader and antenna power, the integrated circuit used in the RFID tag, and the material the tag is made of and attached to.

Building Blocks for Implementing RFID Technology

Tags

All RFID systems consist of a tag and a receiver. RFID tags are typically composed of an antenna and an integrated circuit, which are situated in or on top of a substrate. The antenna is the largest part of the tag and is responsible for receiving and transmitting RF waves, as well as powering up the IC chip in passive tags. The integrated circuit is the heart of the RFID tag and is responsible for transmitting the tag's unique identifier. Lastly, the substrate can be a rigid or flexible material and is responsible for holding the tags together [6].

Receivers

The RFID receiver is responsible for communicating with RFID tags and providing an interface for RFID-application software to access tag data. The reader is made up of an antenna and a microprocessor. The antenna is engineered to a specific gain, polarization, and bandwidth to suit the environment it will be used in. The microprocessor processes the information from the tag and uses an embedded algorithm to handle cases where more than one tag is present [6].

Conclusion

Multiple parameters—both material and electric—influence the range of an RFID system. These material and electric parameters can be fine tuned according to the desired application of the RFID system. Technology and research continues to find innovative ways to increase the range and efficiency of RFID systems.

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