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THE RFID TECHNOLOGY AND ITS APPLICATIONS: A REVIEW

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ABSTRACT

Radio Frequency Identification (RFID) is one of most exciting technologies. The purpose of this paper is to review the RFID technology and its applications. This paper gives a brief introduction to principles of RFID, classification of RFID tags and reader, frequencies used, current application, as well as advantages and limitations. This paper aims to review current development and future scope of this technology.

KEYWORDS*:* Radio Frequency Identification (RFID), RFID Components, RFID Applications

INTRODUCTION

Radio Frequency Identification (RFID) is a generic term for technologies that use radio waves to automatically identify people or objects from a distance of several inches to hundreds of feet. This is an Automatic identification (Auto-ID) technology [1] by which any object can be identified automatically. Barcode, Magnetic Strip, IC card, Optic Character Recognition (OCR), Voice Recognition, Fingerprint and Optical Strip etc are also identification technologies. RFID technology use automatic data capture system which helps in increasing system efficiency. Combination of tag and reader is used for identification purpose. A code is stored in RFID tag and this tag is attached to a physical object. Now object becomes unique identifiable. Then object transmit code from tag. In this way reader get information about object.RFID is not actually a new technology, but it is applied in new ways [2]. RFID is rapidly growing technology. RFID offers much advantage over traditional identification device like barcode. To read the barcode, the barcode scanner needs to be in line of sight with the label. It means that the manual movement of the objects or scanner is necessary [3].RFID, on the other hand can read data from tag without line of sight. Also no alignment is necessary in RFID technology. Singh et al. [4] provides a brief overview of the RFID technology.

RFID has high reading speed and this can work in presence of barrier. This technology is more effective when longer read range, fast scanning and flexible data carrying capability is required.RFID system has received more and more attention in many areas like manufacturing companies, agriculture, transportation and industries [5] etc.

Several frequencies are used in RFID applications: 125 KHz, 13.56 MHz and 860-930 MHz for passive RFID; 433MHz and 2.45GHz for active RFID. The global standardization of RFID system is an important issue. RFID has been implemented by different manufacturers in different ways. There is no global standard that can be used everywhere. Various standards or protocols are proposed for different RFID applications. These standards include hardware physics specification, tag-reader air interface specification and reader-host command specification. A number of organizations have set standards for RFID, including the International Organization for Standardization (ISO), the International Electro technical Commission (IEC) and global. A short list of RFID standards [2] follows: ISO 10374,ISO 10536,ISO 11784,ISO 14443,ISO 15693,IS0 18000,EPC global. These standards manage the communication between RFID reader and tag. These standards works on selected frequency bands (e.g. 860 – 915 MHz for UHF or 13.56 MHz for HF).This paper will provide different aspects of RFID technology. Review of RFID literature is also presented in this paper.

CLASSIFICATION METHOD

The literature review of RFID is divided into five categories: (i) RFID components, (ii) Operating frequencies, (iii) RFID principle,(iv) Advantages and limitations, (v) Application areas.

RFID Components

A combination of RFID technology and computing technology is called RFID system as shown in figure 1. A RFID system consists of following components :

1. Tag/Transponder (electronic label).
2. Antenna (medium for tag reading).
3. Reader /Interrogator (read tag information).
4. Communication infrastructure (enable reader/RFID to work through IT infrastructure).
5. Application software (user database/application/ interface).

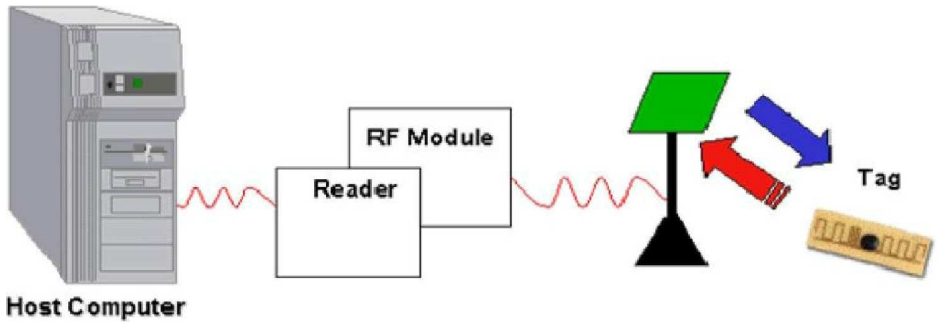
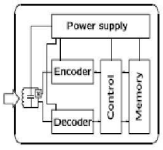
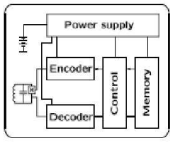
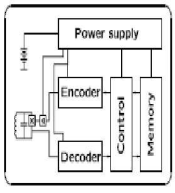


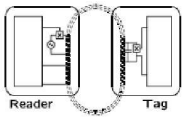
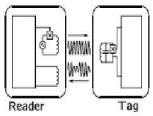
Figure 1: Basic RFID systems

Transponder (Tags)

An RFID tag is a small electronic device that is also referred to as a transponder. The tag consists of a simple silicon microchip [6] and antenna. The tag can be attached to an object, typically an item, box. Information is collected by chip and can be transmitted wirelessly. RFID tag can be active (with batteries), passive (without batteries) and semi-passive (hybrid).Tag has an identification code that can be transmitted towards reader. Classification of RFID tags is presented in table 1 [7].

Table 1: Classification of RFID Tag

Classification of RFID tags	
Passive 	• Also called „pure passive“ • Obtains operating power from reader • The reader sends electromagnetic waves that induce current in the tag‟s antenna, the tag reflects the RF signal transmitted and adds information by modulating the reflected signal
Semi-passive 	• Use a battery to maintain memory in the tag • Communicates in the same method, as the other passive tags
Active 	• Powered by an internal battery • Generally ensures a longer read range than passive tags • More expensive than passive tags • The batteries must be replaced periodically

By the tag's memory type	
Read-only	The memory is factory programmed, cannot be modified after its manufacture Its data is static Limited amount of data can be stored Cheaper than read-write tags
Read-write	Can be as well read as written into Data can be dynamically altered
By the method of wireless signal used for communication between tag and reader	
Induction 	Close proximity electromagnetic or inductive coupling-near field Use LF and HF frequency bands
Propagation 	Propagating electromagnetic waves-far field Operate on the UHF and microwave frequency bands

RFID Antenna

RFID antennas are used to collect information about any item. There are many types of RFID antenna like patch antennas, linear polarized antennas, stick antennas and adaptive antennas, gate antenna and Omni directional antennas. RFID antenna types are shown in figure 2.

Figure 2: RFID antenna types

According to the researchers, an RFID antenna should satisfy following requirement [6]: (i) Its size should be small, (ii) should have omnidirectional or hemispherical coverage, (iii) must provide maximum possible signal to the microchip, (iv) be robust and (v) be very cheap. Antenna designer firstly make a known antenna and then change its physical parameters to obtain optimum bandwidth.

In last few years, researchers have looked into the designing of circular polarized antennas.

Dual polarized antenna can be used. This antenna is suitable for passive 5.8 GHz in RFID applications. Inverted F antenna has been used in many RFID applications due to its small size and its ability to change its polarization characteristics. For ultra high frequency (1GHZ), meander line antennas (MLA) are used for reducing size of antenna Marrocco et al. (2002) first introduced the design of miniaturized meander line antennas for RFID applications. Micro-strip antennas are used for RFID These has attractive features such as lightweight, small volume, low profile and low production cost.

RFID Reader

Third component of RFID system is RFID reader. The reader sometimes called an interrogator or scanner sends and receives RF data to and from the tag via antennas. A reader may have multiple antennas that are responsible for sending and receiving radio waves. Reader informs data processing system about presence of tagged item. It consists of three main parts: control section, high frequency interface and antenna. Read range of reader is affected by number of factors. Antenna gain, frequency used, orientation of antenna will effect read range. Reader comes in four types: Read, Read/write, fixed and mobile [7] as shown in table 2. First two are based on design and technology used and last two are based on fixation of device.

Table 2: Classification of RFID reader

Classification of readers	
By design and technology used	
Read	□ Only reads data from tag □ Usually a micro-controller-based unit with a wound output coil, peak detector hardware, comparators, and firmware designed to transmit energy to a tag and read information back from it by detecting the backscatter modulation □ Different types for different protocols, frequencies and standards exists

Read/write		Reads and write data from/on the tag
By fixation of the device		
Stationary		The device is attached in a fixed way, for example at the entrance gate, respectively at the exit gate of products
Mobile		In this case the reader is handy, movable device

Operating Frequencies

Different types of RFID systems operate at different radio frequency as given in table 3. Each radio frequency has its own read distance, power requirements and performance. The choice of frequency depends on the application. Mostly four types of frequencies are used in RFID technology:

A. Low frequency (120-140 KHz) - Low frequency RFID tags operate in low frequency range. Low frequency tags are used for depositing and withdraw and controlling following with the assets.

B. High frequency (13.56 MHz) - High frequency RFID tags operate in high frequency range. HF tags are useful for asset-tracking applications, contact-less credit cards and ID badges.

C. The ultra-high frequency (869 MHz-928 MHz)-UHF RFID tag operate in 869 MHz - 928MHz.UHF tags are used in supply chain management applications.UHF tags offers the longer reading range and are cheaper to manufacture in bulk.

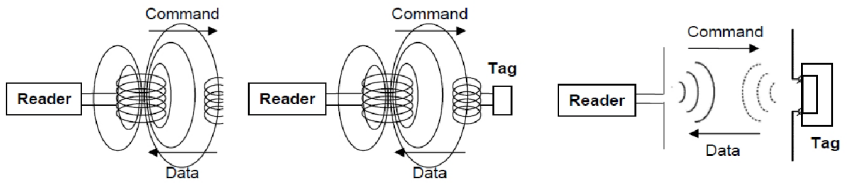
D. Microwave (2.4 GHz-2.5 GHz) - Microwave system offers higher read rate. Microwave tags are expensive than UHF tags. Microwave tags are used in electronic toll applications.

Table 3: RFID operating frequency

Frequency Range	Frequencies	Passive read distance
Low Frequency (LF)	120-140 KHZ	10-20 cm
High Frequency (HF)	13.56 MHz	10-20 cm
Ultra High Frequency (UHF)	868-928 MHz	3 meters
Microwave	2.45 & 5.8 GHz	3 meters

Operating Principle

Passive tag does not have its own power source. Chip in this tag get power from reader. Reader antenna transmit RF signal towards tag. Tag gather energy from RF signal by using inductive coupling in case of LF and HF tag and backscatter coupling in case of UHF tag . These are shown in figure 4.



a) Inductive coupling b) backscattering coupling

Figure 4: Operating principle of passive RFID system

Backscattering coupling uses electromagnetic waves and inductive coupling uses magnetic field to exchange data between tag and reader.

Inductive Coupling

An inductively coupled tag consist of an electronic data carrying device, usually a single microchip and a large area coil that functions as an antenna. These always operate passively. This means that it gets its power from reader side. For this purpose, the reader's antenna coil generates a strong electro-magnetic field, which penetrates the cross-section of the coil area and the area around the coil. A small part of the emitted field penetrates the antenna coil of the transponder. By induction, a voltage is generated in the transponder's antenna coil. This voltage is rectified and acts as the power supply for microchip. Inductively coupled systems are based upon a transformer-type coupling between the primary coil in the reader and the secondary coil in the transponder. This is true when the distance between the coils does not exceed 0.16 l, so that the transponder is located in the near field of the transmitter antenna.

Backscatter Coupling

We know from the field of RADAR technology that electromagnetic waves are reflected by objects with dimensions greater than half the wavelength of the wave. The efficiency with which an object reflects electromagnetic waves is described by its reflection cross-section. A tuned receiving antenna retransmits a portion of incident RF energy. This retransmission is known as backscattering if it is in the direction of the original transmitter. This backscattering can be detected by another antenna.

Advantages and Limitations of RFID System

The RFID technology has many advantages [6]. While having advantages this technology also has some disadvantages. Table 4 presents advantages and disadvantages of RFID.

Table 4: Advantages and disadvantages of RFID

Advantage	Disadvantage
High speed	Interference
Multipurpose and many format	High cost
Reduce man-power	Some materials may create signal problem
High accuracy	Overhead reading (fail to read)
Complex duplication	
Multiple reading	

RFID Applications

RFID technology has received more and more attention in many areas like manufacturing companies, agriculture, hospitality [8], industries, parking management [9] and transportation [10] sectors. Major applications of RFID are given below:

Healthcare Applications

RFID applications in healthcare [6] could save important resources that can further contribute to better patient care. RFID applications could reduce the number of errors by tagging medical objects in the healthcare setting such as patients‟ files and medical equipment tracking in a timely manner. RFID further improves the situation for patients‟ care by integrating medical objects involved throughout the patients‟ care. RFID based timely information about the location of objects would increase the efficiency and effectiveness of paramedical staff leading to improved patients‟ experience [11, 12].

Baggage Applications

Airline industries, package and delivery service lose a lot of money on lost or late delivery of baggage/packages [6]. Handling large amount of packages from many places to various destinations on different routes can be very complex. In this scenario RFID application provide best resource management, effective operation and efficient transfer of packages. RFID helps to identify the packages, and provide records that can advice the industry on possible areas that may require some improvements. It also keeps customers informed about their packages.

Toll Road Applications

RFID applications make the toll collection/charging better with improved traffic flow, as cars/vehicles cannot pass through toll stations without stopping for payment. RFID is used to automatically identify the account holder and make faster transactions [6]. This application helps to keep

good traffic flow and to identify traffic patterns using data mining techniques that can inform the administration or decision support systems. For example, the information can be used to report the traffic conditions or to extend and develop future policies [13].

Asset Tracking and Locating Objects

RFID can be used to prevent misplacement of items, or to locate items. An asset is tagged with RFID chip for its physical verification. A database is used to keep track of item movements.

Libraries of RFID Labels

RFID can be use in library for management of the books. For this management RFID use many components like tag, reader, self check-out/in, book drop reader, middleware etc.With the help of these components it manage the process of borrowing and return the book. RFID remembers to be already borrowed books while borrowing the book and already returned book while returning the book.

Animal Identification

This is one of earliest RFID application. RFID tag can be injected to remain under skin of animal [1]. This process is less painful and there is no identification mark with the help of which tag can be removing or modify. RFID chip inside tag is „Read-only‟ so data cannot be modified. This chip contain many information like date of birth, last vaccination done, any medical history and distinguishing features about the animal.

Anti-Theft System

Any item can be protected by using RFID anti-theft tag [1] tag is attached by a strong string or a plastic band to the item. If anyone walks to the exit with this item, RFID door antennas placed near exit will detect the presence of tag and sound an alarm.

Waste Management

RFID can be used for waste management [1] also. RFID tag is attached to each waste bin and every garbage truck has RFID reader attached to it. When waste bin is emptied into truck then reader read tag and transmits data to truck driver‟s cabin wirelessly. At end of route data is transmitted to central server. This data include waste bin number, collected at what time, who was waste collector.

National Identification

National identification has been a biggest problem for all the countries. For identification RFID technology can be used [1]. A user has only a single card with embedded RFID chip. This RFID tag number then points to an online database which is accessed by multiple agencies. A single ID card needs to be issued for identification.

Researchers [14, 15] have also focused on improving the traffic control systems using RFID technology.

The RFID tag can be attached to animals, plants and in particular human body. The technology is capable of preventing medical accidents in the health industry. RFID tag system is able to obtain and store blood pressure and body temperature. RFID sensors have found application in health care. RFID sensors have been used to monitor the heart-rates of cardiac patients [16], to identify patients for surgery [17], and to monitor the life of dental retainers [18]. Lin et al. [19] propose a RFID-based information management system for wirelessly monitoring the missile assembly process. Torrent et al. [20] use a combination of global positioning systems and RFID-tags to monitor the components arriving at a construction site. Other applications include an efficient paper roll management system [21] and improved asset management and accountability [22].

FUTURE SCOPE

RFID technology uses radio waves to automatically identify people or objects. After sixty years of development RFID is being used in many fields. There are some problems needed to overcome before RFID technology becomes widespread in the world. One major problem is the high costs, the other is privacy issue. After avoiding problems, the RFID technology will be a big help to human. Price of RFID tags are expected to decrease. RFID tags will only become cheaper and more powerful with improving technology and design experience .Some standards for RFID system are under development. Also there is improvement in tag life expectancy and durability in past few years. The RFID technology brings new opportunities as well as challenges to the AIDC infrastructure. Although RFID suffers from many limitation but still Demand for RFID systems is increasing day by day. RFID tags can combine with sensors of different kinds. This would allow the tag to report not simply the same information over and over, but identifying information along with current data picked up by sensors. Over times, the proportion of “scan-it-yourself” will increase. RFID technology does not replace barcode. This technology improves barcode by adding functions which existing barcode technology fail to achieve.

CONCLUSIONS

The paper gave an overview of current state and trends of RFID technology. RFID technology will open new doors to make organizations, companies more secure, reliable, and accurate. The first part of this paper has explained and described the RFID technology and its components, and the second part has discussed the RFID technology in terms of advantages and limitations. The last part explores RFID technology applications. The paper considers RFID technology as a means to provide new capabilities and efficient methods for several applications.

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