A Complete Framework on the Radio Frequency Identification (RFID) Devices Detection Techniques

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Abstract— This paper provides a complete survey on radio frequency identification (RFID) technology. Initially RFID tags were developed to eventually replace barcodes in supply chains. Their advantages are that they can be read wirelessly and without line of sight, contain more information than barcodes, and are more robust. This paper describes the RFID technology and its transmission system, including the frequency ranges and the type of antennas used. With the increasing ubiquity of RFID tags, however, privacy became a concern. In this paper, a novel wavelet-based detection algorithm is introduced for the detection of chip less RFID tags. The chip less RFID tag has a frequency signature which is identical to itself. Since the uses for RFID technology are so widespread and vast, there is a large interest in finding the current Trend application of RFID. The paper reviews the current progress.

Key words: Radio Frequency Identification (RFID)

I. Introduction

RFID stands for Radio Frequency Identification. RFID uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source such as a battery and may operate at hundreds of meters from the RFID reader. Unlike a barcode, the tag need not be within the line of sight of the reader, so it may be embedded in the tracked object. RFID is one method for Automatic Identification and Data Capture (AIDC).

RFID tags, or simply "tags", are small transponders that respond to queries from a reader by wirelessly transmitting a serial number or similar identifier. They are heavily used to track items in production environments and to label items in supermarkets. They are usually thought of as an advanced barcode. However, their possible area of use is much larger. This paper presents a few new applications that are possible using RFID technology such as locating lost items, tracking moving objects, and others [1].

RFID tags are expected to proliferate into the billions over the next few years and yet, they are simply treated the same way as barcodes without considering the impact that this advanced technology has on privacy. This paper presents possible exploits of RFID systems and some proposed solutions as well. RFID system components and its working is given in the section followed.

A. RFID System Components

Modern RFID system has three major components as shown in fig. 1.

- Tag –Transponder
- Reader –Transceiver
- Backend Database

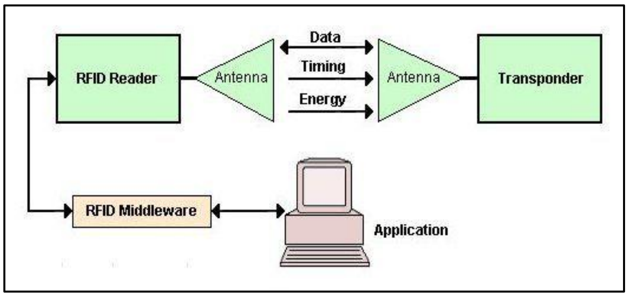

Fig. 1: RFID system components

1) Tags

Tags are typically composed of a microchip for storage and computation, and a coupling element, such as an antenna coil for communication. Tags may also contain a contact pad. Tag memory may be read-only, write-once read-many or fully rewritable.

Broadly the tags have been classified in three categories [2] shown in table I.

- Active Tag
- Passive Tag
- Semi-Passive Tag

Parameter	Passive	Semi passive	Active
Power source	None	Battery	Battery
Transmitter	Passive	Passive	Active
Max range	10m	100m	1000m

Table 1: Active, Semi-Passive and Passive Tags

2) Readers

An RFID reader is a device that is used to interrogate an RFID tag. The reader has an antenna that emits radio waves; the tag responds by sending back its data. A number of factors can affect the distance at which a tag can be read (the read range). The frequency used for identification, the antenna gain, the orientation and polarization of the reader antenna and the transponder antenna, as well as the placement of the tag on the object to be identified will all have an impact on the RFID system's read range. The RFID reader provides the connectivity between individual tags and the tracking/management system. Depending on the application and operating conditions, there may be a multiplicity of readers to fully service a specific area.

Overall, the reader provides three main functions

- Bidirectional communication with the tags.
- Initial processing of received information.
- Connection to the server that links the information into the enterprise.

3) Backend Database

Often, the RFID reader contains a networking element such as wired Ethernet or wireless Ethernet that connects a single RFID-read event to a central server. The central server runs a database application, with functions that include matching, tracking, and storage. In many applications, an "alert" function is also present (for example the re-order trigger, for supply chain and inventory management systems, or an alert to a guard, for security applications).

B. How RFID works?

RFID systems consist of three components in two combinations: a transceiver (transmitter/receiver) and antenna are usually combined as an RFID reader. A transponder (transmitter/responder) and antenna are combined to make an RFID tag [3]. An RFID tag is read when the reader emits a radio signal that activates the transponder, which sends data back to the transceiver as shown in fig. 2 below.

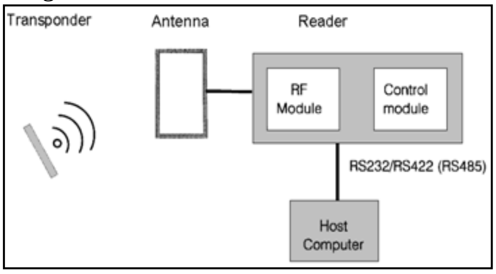

Fig. 2: Working of RFID

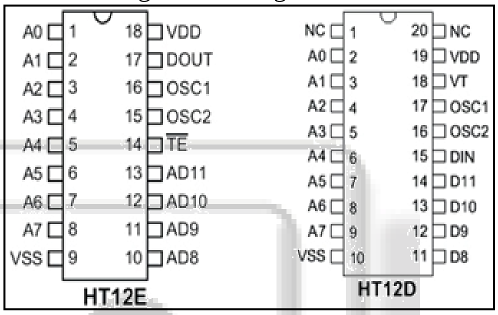

Fig. 3: Encoder and Decoder IC

RFID may also work with encoders and decoders to make them more secure [4]. RF transmitter module is assembled with encoder and the RF receiver is assembled with the Decoders. The encoders and decoders used in our paper are HT12E and HT12D as shown in fig. 3.

II. RFID TRANSMISSION SYSTEM

As an automatic identification technique without touching, RFID technology uses radio waves carrying information stored about the identified object or commands to identify object via space coupling, such as inductive coupling or electromagnetic wave propagation. As a vital device for transmitting the RF power from the radio transceiver to the open space in the form of electromagnetic wave, or receiving it from space and transferring it to the next circuit, antenna is always the key part of the RF system, and its performance greatly affects the performance of the whole system. Thus, design of antennas for the RFID system is very important. The present RFID systems are applied at LF, HF (13.56MHz), UHF and microwave bands, and the antenna design is focused on these frequency bands [5].

In fact, the system working at LF and HF bands is based on the magnetic field coupling between the tag coil and reader coil, whose operating principle is identical with that of the transformer. There is no radiation and wave transmission, and the antenna in the system is just a coil. The antenna discussed here is limited to the system that operates at UHF band, or microwave bands. Based on the different operating principles at different bands, design of the antennas in the system will be discussed at following sections.

III. ANTENNAS IN RFID SYSTEM

According to the different functions in the RFID system shown in fig. 4, the RFID antennas can be divided into two classes: the tag antenna and the reader antenna. The tag antenna not only transmits the wave carrying the information stored in the tag, but also needs to catch the wave from the reader to supply energy for the tag operation. Since the tag should be attached to the identified object, the size of the tag must be small enough, and the antenna should be small in size. In most cases, the tag antenna should have Omni-directional radiation or hemispherical coverage. Generally, the impedance of the tag chip is not 50 ohm, and the antenna should realize the conjugate match with the tag chip directly, in order to supply the maximum power to the tag chip. In common applications, the tag antenna should be low cost and easy to fabricate for mass production [6].

The reader antenna transmits the electromagnetic energy to activate or awaken the tag, realizes the data transfer and sends the instructions to the tag. Meanwhile, the reader antenna receives information from the tag. Generally, the position or the orientation of the identified object is random, and the manner for attaching the tag to the identified object is unfixed. Thus, the reader antenna should be a circularly polarized antenna, in order to avoid the polarization loss when the orientation of the identified object is changed. Meanwhile, the reader antenna should have low profile, some of which should operate at more than one band. In some special cases, multiple antenna technology for beam scanning will be employed.

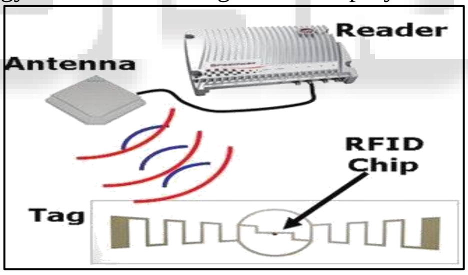

Fig. 4: Basic RFID system

A. Development of Antennas

Potential applications of the RFID technology inspired the development of various antennas for the RFID systems. Lots of antennas with high performance for various requirements have been fabricated. As an identification system with huge market and potentials, RFID system requires the RFID antenna to meet some particular specifications. Design of the RFID antennas faces many challenges, such as the antenna structure, the antenna size, the operating mode, the bandwidth, the radiation pattern, the polarization, mutual coupling between multiple antennas, and the antenna scattering. In the present RFID system, the reader antenna is designed to be a circularly polarized antenna. Patch and spiral antennas are typical reader antennas. In some special cases, linearly polarized antennas can also be used. In the tag, the eroded or printed antennas are commonly used, and the dipole is the typical tag antenna structure. Some circularly polarized antennas for the tag may be required in some special applications.

Microstrip Antenna

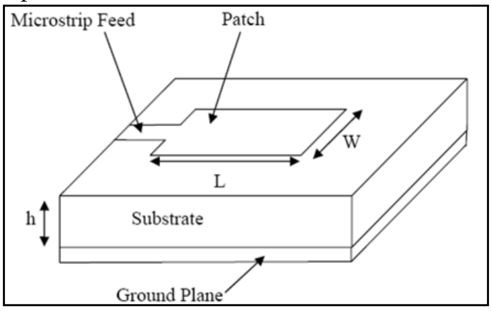

Fig. 5: Microstrip Antenna

Microstrip antennas, in recent years, have been one of the most innovative topics in antenna theory and design. The basic idea of microstrip antenna came from utilizing printed circuit technology not only for the circuit component and transmission lines but also for the radiating elements of an electronic system. They are used in wide range of modern microwave applications because of their simplicity and compatibility with printed-circuit technology. It is easy to manufacture and either as stand-alone elements or as elements of arrays. A microstrip antenna in its simplest form consists of a rectangular (or other shapes such as circular, triangular) on top of a substrate which is backed by a ground plane. Fig. 5 shows a typical microstrip patch.

B. Antenna Designing Software

Efficient numerical methods promote the antenna design. Modern antenna design becomes a manipulation of accurate computing based on relative theory and a design under the theory instruction or according to the calculated results. The antenna design method based on numerical methods has been applied to design antennas for various systems. Familiar numerical methods include Method of Moment (MoM), Finite Element Method (FEM), and Finite Difference Time Domain (FDTD). There already exist several design tools based on these methods, which are of different characteristic and are widely used. Fig. 6 shows some familiar methods and the design tools. These design tools can be chosen for different problems in designing antennas.

The MoM can be used to calculate the antenna performance quickly and accurately, especially for some large antenna structures. The FEM and FDTD methods can be used directly to analyze the antenna performance. However, the FEM method gets more accurate results than the FDTD method. Some tools such as HFSS, which are widely used to design antenna for the RFID system, add the ability of automatically meshing to facilitate the user and improve the precision.

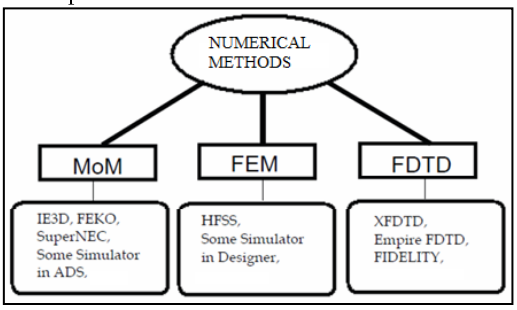

Fig. 6: Methods used for RFID antenna design

C. Simulation Design

Literature search, Analysis and designing of circularly Polarized Microstrip Antennas.

These antennas are to be simulated using Ansoft-HFSS software which is based on finite element method. The fabrication and testing of antennas is to be taken up for the validation of simulated and theoretical results.

The simulation results are to be verified by fabricating the antenna. The various parameters like return loss, input impedance, VSWR, radiation pattern, gain, directivity etc. of the antenna are to be investigated. The design is expected to give circular polarization due to different technique. The outcome of this research work will enhance the quality of existing antennas. Flowchart of simulation is shown in fig. 7 below.

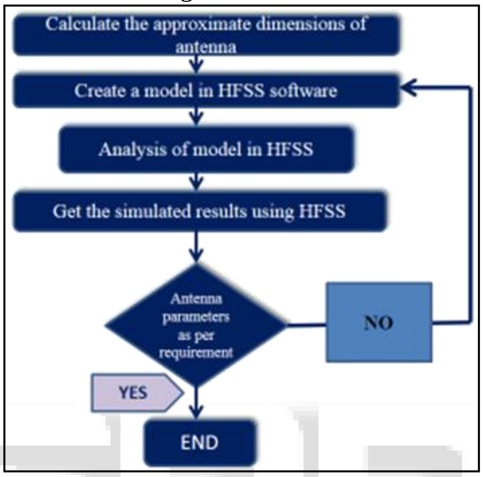

Fig. 7: Flowchart of Simulation

IV. FREQUENCY RANGES USED

RFID systems can be broken down by the frequency band within which they operate: low frequency, high frequency, and ultra-high frequency. If an RFID system operates at a lower frequency, it has a shorter read range and slower data read rate, but increased capabilities for reading near or on metal or liquid surfaces. If a system operates at a higher frequency, it generally has faster data transfer rates and longer read ranges than lower frequency systems, but more sensitivity to radio wave interference caused by liquids and metals in the environment. In our proposed work, I am designing RFID antenna operated on ultra-high frequencies range.

The UHF frequency band covers the range from 300 MHz to 3 GHz. Systems complying with the UHF Gen2 standard for RFID use the 860 to 960 MHz band [7]. While there is some variance in frequency from region to region, UHF Gen2 RFID systems in most countries operate between 900 and 915 MHz. The read range of passive UHF systems can be as long as 12 m, and UHF RFID has a faster data transfer rate than LF or HF. UHF RFID is the most sensitive to interference, but many UHF product manufacturers have found ways of designing tags, antennas, and readers to keep performance high even in difficult environments. Passive UHF tags are easier and cheaper to manufacture than LF and HF tags.

UHF RFID is used in a wide variety of applications, ranging from retail inventory management, to pharmaceutical anti-counterfeiting, to wireless device configuration. The bulk of new RFID projects are using UHF opposed to LF or HF, making UHF the fastest growing segment of the RFID market.

V. DETECTION ALGORITHM FOR CHIPLESS RFID SYSTEM

The chipless RFID reader extracts the backscattered signal and decodes the tag ID. This is an ongoing challenge, as the detection procedure for a chipless RFID tag has more complexities compared to a conventional RFID tag. The signal collides with other scatters or tags which give a 'clutter' signal with interference. A number of detection techniques have been applied to achieve an accurate result of its tag ID.

The basic detection technique is based on comparing the received data with threshold values obtained by calibration. It is, therefore, a basic approach and it does not possess the flexibility and adaptability required in the detection process to address errors due to a dynamic environment [8]. Different types of detection algorithms and decoding techniques have been revealed in the past few years.

As many of the above algorithms are highly complexes in implementing in the chipless RFID reader. Also, most of them have the limitation in the number of bits that can be detected. In this paper, we have developed a novel wavelet which suits the chipless RFID received signal to detect the frequency ID of the chipless RFID tag [9].

A. *Flowchart for Detection Algorithm*

The flowchart given in Fig. 8 shows the steps of the developed algorithm and how it is applied to the received signal.

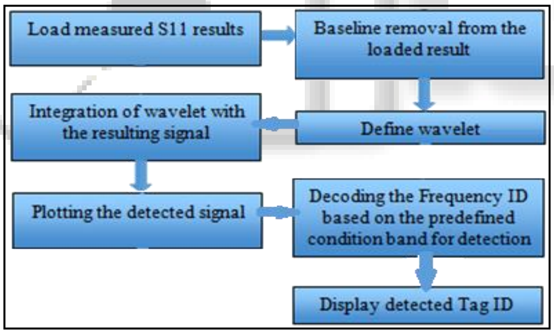

Fig. 8: Flowchart for Algorithm

First the measured results using VNA are loaded into MATLAB. The post processing is performed using MATLAB programming software. The program can be directly downloaded to the microcontroller of the frequency domain reader developed by the research group which will be implemented in the next step of this research. A baseline removal is performed on the first results to remove the nulls of the antenna S11. Then the wavelet is defined and is integrated with the resulting signal. The tag ID is decoded based on the condition band defined for the detection. Experiments have been performed under different indoor dynamic environments such as placing clutter objects above the chipless RFID tag.

In addition to retail adoption, mature RFID applications (fig. 9) account for broad adoption to monitor access control and in the banking and transit sectors [10].

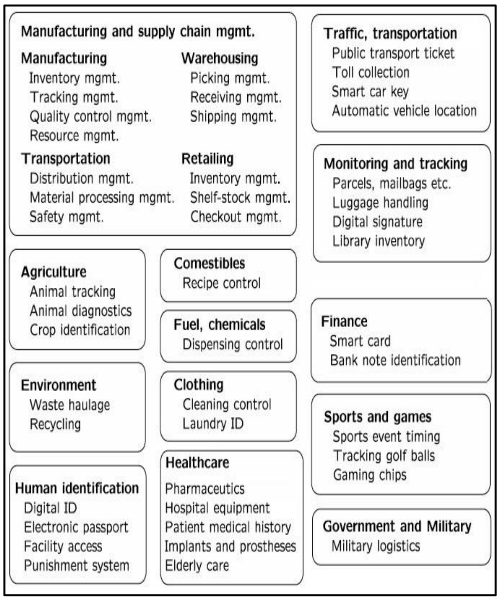

Fig. 9: Applications of RFID

VI. CONCLUSION

From these Discussions, it is concluded that RFID has very vast area of utilization. In this paper, I have analyzed the factors affecting the RFID devices and their detection techniques. Now we know the whole operation of RFID with the microstrip antenna. By knowing the frequency ranges used nowadays and current trends of RFID in our society, one can use RFID technology in the best way as per his requirements. Proposed method of detection is verified for the RFID transponder detections. Analysis of this paper results into a more accurate system which is sufficient for successful tag detection.

VII. FUTURE SCOPE

The antenna requirements for the RFID are explained in brief in this paper; in the future one can design a more effective and efficient microstrip patch antenna which makes a Novel System for RFID Transmission by using the results of this paper.

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