Helwan University

UTIU
UNIVERSITÀ TELEMATICA INTERNAZIONALE UNINETTUNO

DOUBLE DEGREE PROGRAM IN INFORMATION AND COMMUNICATION TECHNOLOGIES ENGINEERING

GRADUATION PROJECT REPORT

TARGET DETECTION USING RFID TECHNOLOGY

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Project :

RFID Target Detection

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Preface

We would like to welcome all the readers of our paper. After two semesters of hard, well organized work, we have managed to reach the results mentioned in the paper.

We had so many ups and downs, good and bad moments, we tasted failure and success in our way to complete our graduation project to have the dual degree from Uninettuno University and Helwan University.

We would to thank everyone that helped us in this project in particular, and throughout the year in general. We are giving special thanks to Professor Dario Assante, our supervisor at Uninettuno University, and our mentor, Professor Ayman Ragab, our supervisor at Helwan Univeristy for his great support on the technical and mental sides.

In the end, we would like to dedicate our success to the martyrs of the Egyptian revolution, who devoted their lives to the freedom of our country. May their souls rest in peace.

The Team:

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Abstract

In this paper we are discussing the RFID technology as a solution to a problem in industry and other fields. This problem is detecting the position of objects with respect to a reference point. (Target detection)

In our project, we needed basic skills in programming using Visual basic at the beginning, then C#. We needed also to know how to deal with database and connect it with C# using SQL Server. We also needed to make user requirement analysis in making the graphical user interface of our project. We needed to learn about different types of motors and their different operations. We needed also basic knowledge about antennas.

We discussed the problem, the solution, the budget, and the results of our solution with all the deficiencies, and how to deal with these deficiencies.

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Chapter One:

Introduction

Preview:

In this part we will give a brief summary of the project, its objectives, and its outline.

Introduction

1.1 Introduction to the Project

Radio Frequency Identification (RFID) is one of the most exciting technologies that revolutionize the working practices by increasing efficiencies, and improving profitability. It is often presented as a replacement for today's barcodes, but the technology has much greater possibilities, such as the possibility to read the product information at a distance of several meters in addition to, RFID does not rely on the line-of-sight reading that bar code scanning requires to work.

RFID system consists of ; **Tag** chips attached to products carrying identification information, **Readers** and **Tags** communicate information between one another via radio waves and finally the **Controller** connected to the reader can use that information for various purposes.

In this project, we are using the RFID technology in target detection. The target detection is needed in a lot of industrial applications. By making some changes on the readers and tags, the RFID technology can be used in the target detection.

The target detection will be detecting the location of the tag with respect to the reader. We can consider the two perpendicular axes, the abscissa and the ordinates. The reader will be in the origin and the tag is anywhere else. The location is defined by knowing the distance between the origin and the tag, and the angle between two lines: the ordinate, and the line passing between the reader and the tag. By knowing the distance and the angle, the location is detected accurately.

In order to make the RFID reader give us the capability of detecting the location of the tags, the reader antenna should be directional, with a very small beam angle. Since the farther the tag is, the weaker the field strength it receives, therefore, the field strength can be used in measuring the distance, after applying some calibrations to get the relation between the distance and the field strength practically.

To detect the angle, the reader with its antenna will be coupled on a rotating stepper motor with known number of steps. The initial position can be assumed with no constraints. The predicable case is that on the initial position, the reader won't be able to read the tag, as the beam is not directed towards the tag. The motor will be made to rotate until the reader reads the tag. When the reader reads the tag, the interface will display the position of the detected tag.

The angle will be detected by counting the steps that the motor took from the initial position until it stops, and by knowing the angle of the step, the required angle can be calculated. The distance can be known by knowing the field strength.

In order to know the field strength, the reader should have a built-in field strength meter, or any later technology that makes the reader able to measure the distance.

The limitations of this method and the accuracy are to be put into discussion later.

Figure 1.1 Moving Monitored Boxes

1.2 Objectives of the Project

The Main objective of the project is to calculate the location of a target using the RFID technology, by measuring the distance using the received signal strength and calculating its corresponding distance value by trial and error and the angle between a Transmitter "Tag" which could be anything that we want to monitor or to track it, and the Receiver "Reader".

This could be used in many applications like vehicle tracking, indoor tracking, industrial tracking, libraries and other applications which will be discussed further on.

Figure 1.2 RFID used in Tracking and Monitoring

1.3 Main activities done in the Project

- Connecting a stepper motor to its interface card and its parallel port
- Interfacing the stepper motor to the computer, rotating it and returning it to its start or initial position.
- Connecting the RFID reader to the computer via a serial COM port
- Interfacing the RFID reader to the computer
- Recording the received data in a database and processing it
- Changing the antenna of the reader and the tags to a handmade helical antenna so the it could radiate in a semi-directional way
- Making metal cavities to make the radiation on the readers and tags directional
- Simulating the movement of the stepper motor on the computer interface
- Calibrating the value of the Received Signal Strength with distance by trial and error.
- Simulating the detected tags on the computer interface
- Creating a demo application "Shopping Cart" of another application of the RFID Technology.

1.4 Documentation of the Project

This Documentation of the project is as follows

The parts and roles of each member is:

- Introduction to RFID Technology: written by Abdelfattah Mansy
- Hardware of the System: written by Motaz Selim
- Stepper Motor: written by Sherief Mamdouh
- Software of the System: written by Sameh Mobarak
- Future developments: written by Muhammad Taimoor

By taking into consideration that the single work of each person didn't cut over the team work of the whole group.

1.5 Block Diagram of the System

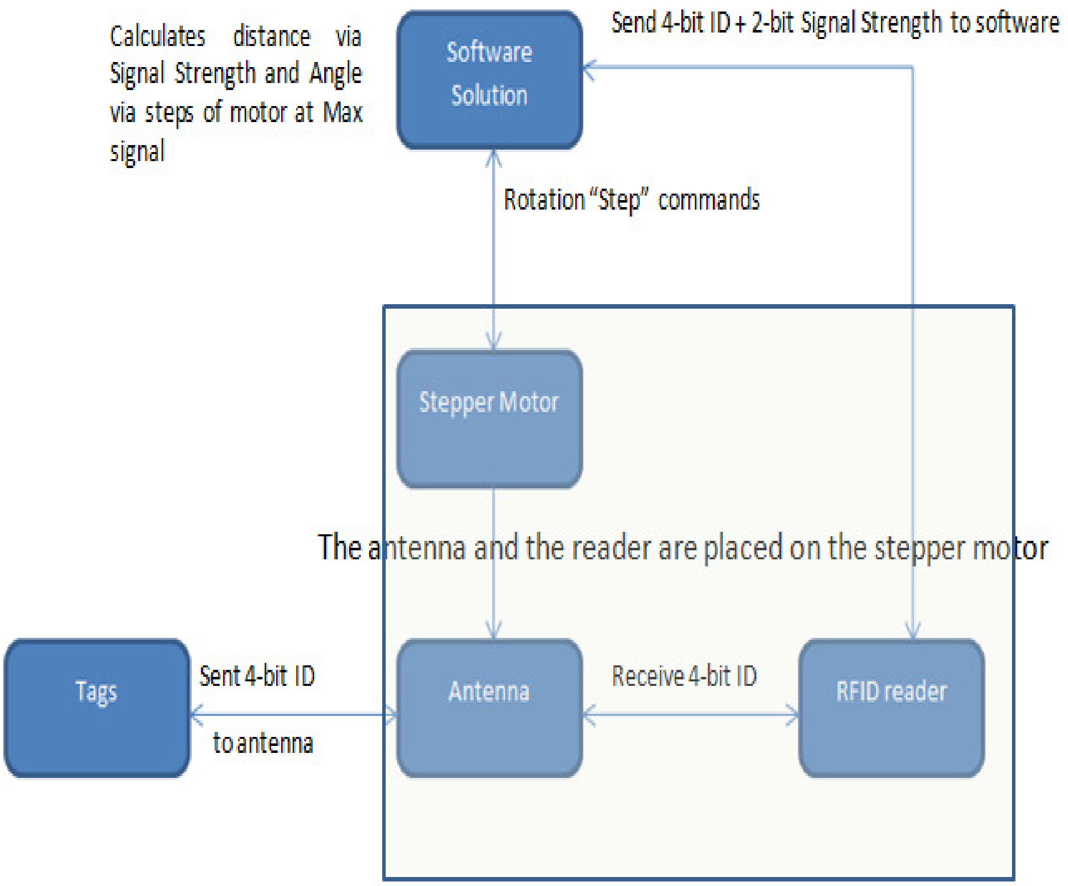


Figure 1.3 Block Diagram Illustrating the System

Chapter Two:

RFID Technology

Preview:

In this part we will help the user understand what RFID Technology is, its main components, its advantages over barcodes, and its applications.

Author: Abdelfattah Mansy

RFID Technology

2.1 What is RFID

Short for **R**adio **F**requency **Id**entification. The term RFID is used to describe various technologies that use radio waves to automatically identify people or objects. RFID technology is similar to the bar code identification systems we see in retail stores everyday; however one big difference between RFID and bar code technology is that RFID does not rely on the line-of-sight reading that bar code scanning requires to work.

Basically RFID is a wireless communication system which use RF signal to establish the communication between two ends. RFID system does this communication by using modulated RF signal which is sent between the two main components in the system; the reader and the tag.

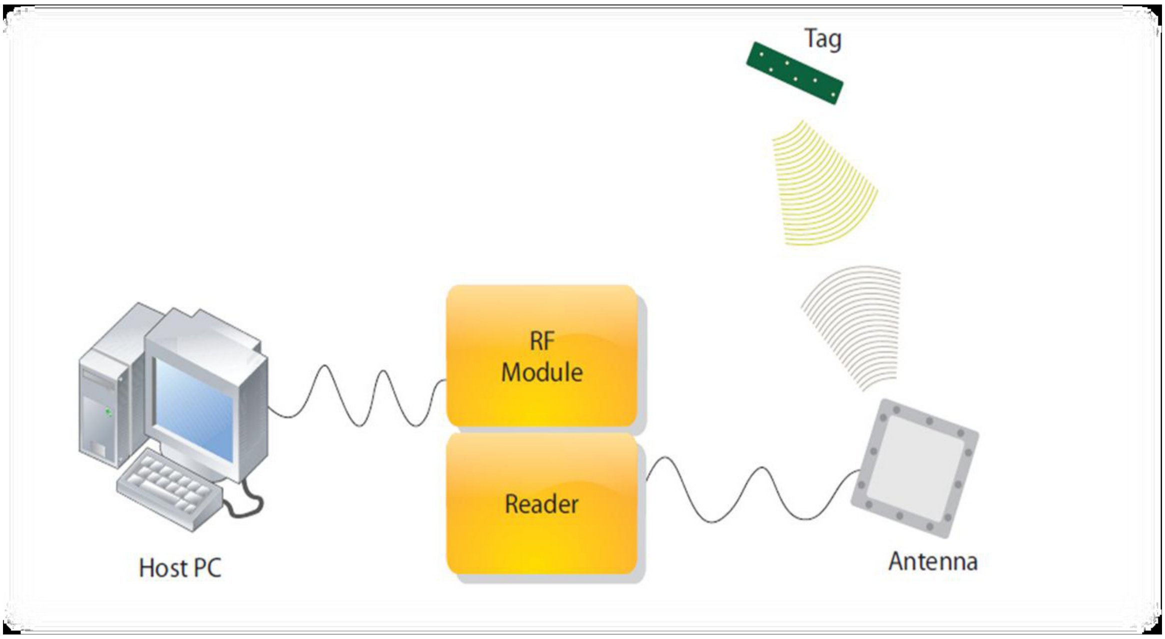


Figure 2.1 RFID System

2.2 RFID History

Radio Frequency Identification (RFID) is not a recent technology in fact it has been used years ago in many application. [1] It is believed that RFID can be traced back to World War II where the Germans, Japanese and British were using radar which has been discovered by the Scottish Physicist Robert Watson Watt. Back then those radars used radio frequency systems in order to warn of approaching planes; the problem was that those radars could only sense the approaching plane but could not identify it. It was of particular importance to be able to identify the approaching object that's why Watson Watt developed a system known as IFF Identification Friend or Foe which can differentiate between objects. The system basic concept is placing a transponder on a certain object, when this transponder is interrogated by a radio station it will respond with a code which identifies the object. Through years researches has been done to study the communication between the reader and the tag placed on the object and how can the reader communicate with a certain object. Although that the IFF system successfully demonstrated the principles of remote detection then object interrogation but the cost of the system implementation is significantly high that is why studies were done to enable this system to be used for low cost commercial application.

In the 70's, at Los Alamos National Laboratories researches have been done to implement a RFID system which can track the transportation of nuclear materials[2]. Since it was a very sensitive issue they developed a system which can keep tracking the vehicles used to transport these materials at various points along its route.By the same time further activities were done by Charles Walton a researcher who quitted IBM to start producing proximity devices. Walton's patent was using radio waves to control door locks, where radio transceiver sends a small electrical current to a tag to identify it then unlocking the door. Schlage the lock making firm bought his prototype to produce an electronic lock which can be operated using a keycard. [3]

Years later the cost of RFID component reduced, one of the first applications for RFID technology is the electronic surveillance tags used in hypermarkets, where RFID technology is used as a replacement for the European Article Number (EAN) or the Universal Product Code (UPC) which are commonly known as barcode. Barcode has been used for years to identify a certain object by placing a barcode tag closely to the barcode scanner. The barcode tag represents the product's data in terms of variation of the width and spacing of printed parallel lines. The data imprinted on a barcode tag is a fixed data and cannot be changed, while there is a certain type of RFID tags which are rewritable. Also unlike RFID, optical scanners which are known as barcode readers must be placed closely to the tag in order to identify it properly.

The 80s was the decade for full implementation of RFID technology. That's when RFID system was used for access control in different fields of life. A significant achievement in 1987 Norway was the implementation of the first successful toll collection system, this was a breakthrough product for RFID technology. That is why after few years toll systems and government toll collection agencies had spread across the United States. In the 21^{st} century RFID technology spread nearly everywhere and it is used in different life fields. The reason behind that is that the used tags can vary in shapes and sizes which make it easily to use RFID in different applications.

Since RFID technology continues to spread all over the world therefore a quantity of applications implemented using RFID in different aspects of life and each application is implemented to fulfill a unique task. This proves how flexible RFID technology is and how interesting it is to work with it. The reason why RFID technology is flexible is the variability in its components especially the RFID tag. Tags can be easily implemented in different shapes in order to fulfill different tasks. For access control systems, RFID tags are designed in the shape of cards. That is not the only form of tags; tags can also be designed as small chips so that they can be implanted in animals to keep track of their location and even their medical conditions and in some cases tags can be implanted into humans too. This is because there are certain types of RFID tags which could be rewritable. This is not the only variation in RFID technology, RFID can be operated at different frequencies depending on the application and the appropriate frequency band in each country. There are many more advantages of RFID technology that is why it is believed that within a short period of time, RFID technology will take over barcode technology.

Like any technology there are certain problems could confront RFID like inaccuracy due to reading collision. There are two types of collision, reader collision and tag collision. After many researches and many introduced anti-collision protocols RFID technology has proven its efficiency and its accuracy identifying each different tag. Another problem which can confront RFID technology is the inaccuracy occurs due to RF signals interference and in order to solve this problem the human operator should be aware of the RFID operating frequency. This is not the only problem occurred due to RF signals, another problem is the RF signal reflection due to the presence of objects. This problem is encountered only in certain RFID applications; the applied application in this paper proves that the RF reflections is a major problem.

2.3 RFID Basics

2.3.1The main components of the RFID system

The main components are:

1- RFID Reader
2- RFID Tag or transceiver

Although that physically they are separated but the reader and the tag are inseparable for any applied application. The Reader main function is to read the ID stored in the tag this is done by receiving the modulated signal from the tag. Meanwhile the tag must be placed on the object which needs to be identified like book covers and cloth price tags that is why tags comes in different shapes and sizes in order to cope with the requirements of the application. Tags at least consists of a small antenna and a small silicon chip where data can be processed and stored in. one approach of RFID is that it was build to read one particular kind of tags but recently RFID systems are implemented to read different kinds of tags. RFID readers are also classified into two classes; the first class is the fixed RFID where the reader is fixed during the identification process while the tag is moving. The second class is the mobile RFID where the reader can be moving during the identification process while the tag can be in a stationary position or even moving as well. The two classes are successfully implemented in various numbers of applications by various major electronic manufactures.

2.3.2Types of Tags

There are two differentiating factors between Tags

1. According to the on board Power Source

2. According to the Memory type

According to the on Board Power Source

There are three types of tags:

1- Active Tags
2- Passive Tags
3- Semi-Passive Tags

1. **Active Tags** contain on board power source such as battery, and it uses this power to transmit the information to the Interrogator (Reader) and this means that this tags can communicate with less powerful Interrogator, can transmit information over a larger range up to hundreds of feet and have larger memories up to 128 Kbytes, beside that it has larger size, more complicated structure and more expensive than the Passive one.

The advantages of an active tag:

- It can be read at distances of one hundred feet or more, greatly improving the utility of the device
- It may have other sensors that can use electricity for power.

The disadvantages of an active tag:

- The tag cannot function without battery power, it limits the lifetime of the tag.
- The tag is more expensive.
- The tag is physically larger, which may limit applications.
- The long-term maintenance costs for an active RFID tag can be greater than those of a passive tag if the batteries are replaced.
- Battery outages in an active tag can result in expensive misreads.

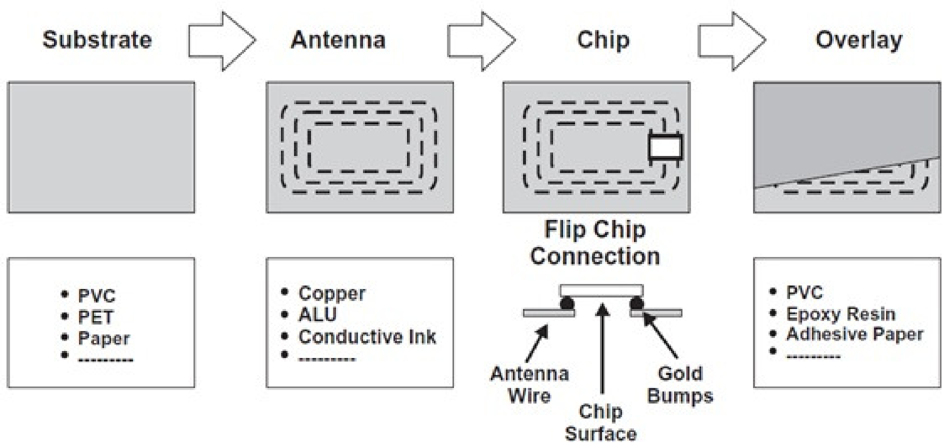


Figure 2.2 RFID Tag Components.

2. **Passive Tags** have no power source on board but drive its power to transmit data from signal sent by the Interrogator, this made Passive tags smaller and less expensive than the active tags, and however the effective range of the passive tag is shorter than the active one.

The advantages of a passive tag:

- The tag functions without a battery; and have a useful life of twenty years or more.
- The tag is typically much less expensive to manufacture.
- The tag is much smaller (some tags are the size of a grain of rice). These tags have almost unlimited applications in consumer goods and other areas.

The disadvantages of a passive tag:

- The tag can be read only at very short distances, typically a few feet at most. This greatly limits the device for certain applications.
- It may not be possible to include sensors that can use electricity for power.
- The tag remains readable for a very long time, even after the product to which the tag is attached has been sold and is no longer being tracked.

3. Semi-Passive tags are very similar to passive tags except for the addition of a small battery. This battery allows the tag IC to be constantly powered. This removes the need for the aerial to be designed to collect power from the incoming signal. Aerials can therefore be optimized for the backscattering signal. Semi-passive RFID tags are faster in response and therefore stronger in reading ratio compared to passive tags.

RFID system	Active	Semi-Passive	Passive
Tags	Tags have their own power source which is used for data transmission.	Tags have an external power source to wake up and start transmitting data. Sometimes known as BAP	Tags do not have power source. They use the emitted power from the reader to energize and transmit the data to the reader.
Communication model	Tag Talks First (TTF)	Reader Talks First (RTF)	Reader Talks First (RTF)
Reader to Tag communication	Tags can start the communication since they do not rely on the reader to operate.	Communication done depending on the RF waves sent by the reader	
Operating Frequency	UHF and Microwaves	UHF	LF, HF, UHF and Microwaves
Read range	Can exceed 100m	60m up to 80m	0.1m up to 7m
Tag size	Large ←→ Small		
Tag cost	High ←→ Low		
System complexity	High ←→ Low		

Figure 2.3 Comparison between active, passive, and semi-passive tags

According to the Memory type

There are **two main** types:

1. **Read-Only** is just that; memory that can be read only. RO tags are similar to bar codes in that they are programmed once, by a product manufacturer for instance, and from there on cannot be altered, much the way a CD-ROM cannot be altered after it's burned at the

factory. These types of tags are usually programmed with a very limited amount of data that is intended to be static, such as serial and part numbers, and are easily integrated into existing

2. **Read/Write or "Smart" Tags** Smart tags present the user with much more flexibility than RO tags. They can store large amounts of data and have an addressable memory that is easily changed. Data on an RW tag can be erased and re-written thousands of times, much the same way a floppy disk can be erased and re-written at will. Because of this, the tag can act as a "traveling" database of sorts, in which important dynamic information is carried by the tag, rather than centralized at the controller. The application possibilities for smart tags are seemingly endless. This, in addition to recent advances in smart tag technology that have driven production costs down to under $1 per tag.

In addition, some tags could contain both RO and RW memory at the same time. For example, an RFID tag attached to a pallet could be marked with a serial number for the pallet in the RO section of the memory, which would remain static for the life of the pallet. The RW section could then be used to indicate the contents of the pallet at any given time, and when a pallet is cleared and reloaded with new merchandise, the RW section of the memory could be re-written to reflect the change.

Although there are different types of tags accompanied by different operation processes, but the main difference during operation is that whether the tag will start transmitting its ID on its own (active) or whether it will wait till the reader interrogate it (passive). Regardless the type of tag used, here is a simple explanation of how RFID reading occurs using passive tag. The process starts when the RFID reader antenna sends a scanning signal, this signal will activate the tag's transponder. After receiving the scanning signal the tag sends its modulated and encoded signal over a radio carrier wave, the reader's antenna then pick up the tag's signal at this time the reader should demodulate then encode this signal in order to comprehend the tag's ID and identify the object which the tag is placed on.

2.3.3 RFID Frequencies

Much like tuning in to your favorite radio station, RFID tags and readers must be tuned into the same frequency to enable communications. RFID systems can use a variety of frequencies to communicate, but because radio waves work and act differently at different frequencies, a frequency for a specific RFID system is often dependant on its application. High frequency RFID systems (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) offer transmission ranges of more than 90 feet, although wavelengths in the 2.4 GHz range are absorbed by water, which includes the human body, and therefore has limitations

Frequency bands	LF	HF	UHF	Microwaves
Frequency range	<135kHz	13.56 MHz	860 up to 930 MHz	2.45 GHz
Wavelength	2,400 meters	22 meters	32.8 centimeters	12.5 centimeters
Tag Characteristics	Passive		Passive, Semi-Passive and Active	Passive and Active
RFID Application	Animal tagging, access control, vehicle identification and container tracking in waste management	Access control, smart cards, item tagging ticketing, document tracking, baggage control, laundries and libraries	Baggage handling, toll collection and supply chain management.	Electronic toll collection, real time goods tracking and production line tracking.

Tag Power Consumption	Low High	←→
Number of tags identified per sec.	Low High	←→
Bandwidth	Low High	←→

Figure 2.4 RFID frequencies and parameters

2.3.4 RFID vs Barcode

RFID systems are becoming widely used in the 21st century due its massive production. There are many key factors which drive the growth of RFID technology. The first key is that RFID systems have the ability to identify objects wirelessly without line of sight (LOS). Another key is the number of tags which can be identified at the same time by the RFID reader since the system can use an anti collision protocol which prevent the ID collision between two different tags. Another important key is the reading range of the RFID system which can extend to 10 meters and even more. This was a major reason why many mega stores preferred using RFID over the conventional barcode system.

	RFID	**Barcode**
Line of Site	Not required	required
Read Range	Passive RFID: - Up to 40 feet (fixed readers) - Up to 20 feet (handheld readers) Active RFID: - Up to 100's of feet or more	Several inches up to several feet
Read Rate	10's, 100's or 1000's simultaneously	Only one at a time
Identification	Can uniquely identify each item/asset tagged	tagged Can typically only identify the type of item (UPC Code) but not uniquely

Read/Write	Many RFID tags are Read/Write	Read only
Technology	RF (Radio Frequency)	Optical (Laser)
Interference	Like the TSA (Transportation Security Administration), some RFID frequencies don't like Metal and Liquids. They can cause interfere with certain RF Frequencies.	Obstructed barcodes cannot be read (dirt covering barcode, torn barcode, etc.)
Automation	Most "fixed" readers don't require human involvement to collect data (automated)	Most barcode scanners require a human to operate (labor intensive)
Cost	Expensive, but likely to cost less as more industries adopt the technology.	Cheap

Figure 2.5 Comparisons between the RFID and Bar Code

2.3.5 Advantages of RFID Systems

- Reliable system and portable database
- Easy to use and tags can be simply installed
- Easy way to read tags therefore saving time and effort
- Line of sight is not needed between the reader & the tag unlike barcode system
- Wide reading range, the reader can be up to 10 meters away from the tag
- Anti-collision Identification (multiple access techniques TDMA/SDMA/FDMA/CDMA)
- Implanted RFID tags
- RFID tags cannot be easily replicated
- RFID tags can stand to harsh environment
- RFID tags can store data up to 2KB
- RFID tags can be rewritable easily

2.3.6 Applications of RFID

- Access control in school and universities
- Airport baggage tracking
- Animal Identification and tracking
- Asset tracking
- Automatic vehicle location using RFID (AVL)
- Contactless payment (e-tolling)
- Libraries organization (replacing barcode)
- Race timing (used in Marathon)

2.4 APPLICATION STORIES

2.4.1 Animal Identification

Figure 2.6 RFID in Animal Identification

History

This is actually one of the earliest RFID applications. The concept of animal tagging is nothing new. In early days, the various cattle farms and ranches used methods like branding irons, to label the name or symbol of the ranch to which an animal belonged. A red hot branding iron, having the proprietary mark of the farmer or rancher, was used on the poor animal to etch out a mark on its hide.

Present situation

Branding gave way to physical plastic tags mounted on the animals in holes made in their ears, specifically for this purpose. Identification was still done manually though. This is the situation for cattle and other commercially raised animals. There was no system however for pets. Therefore pet owners always had problems when it came to identifying lost pets . Usually they had to rely on some birth mark or the animal's response to a name when called out, or the animals affectionate reaction to the owner—a very subjective way of identification indeed.

The RFID solution

Figure 2.7 surgical neddel used in placing tags inside animals

Injectable RFID tags are now available. They are injected to remain under the skin of the animal. Delivery is through a special syringe. The advantage is that they are less painful, also there is no outside identification mark for a malicious person to know where the tag is embedded in order to remove it or modify it. The RFID chip inside the tag is generally 'Read-Only" so that data once recorded cannot be modified.

Injectable RFID tagging system is being used for pets today. Your pet cat or dog can easily be injected by this kind of syringe which embeds an RFID tag under its skin. The tags have no side effects and have an estimated life of 25 years, which is more than the lifespan of the pet. The size of the pet is not a consideration, since the tag itself is very small, about the size of a rice grain. Hence these tags can be injected into any pet, big or small, a mouse or an elephant. Since it is injected under the skin, there is no possibility of the tag getting dirty, damaged or lost.

The reader is connected (by means of wired or wireless connections) to a remote database which correlates the unique RFID tag number on the animal with other data on the animal.

These other data fields may contain information about

a) Date of birth
b) Last vaccination done
c) Any medical history
d) Distinguishing features about the animal

Of course these fields can be many more than the four described above.

Advantages over the earlier system

a) No external tag is visible. It cannot be damaged, stolen, changed, modified or altered in any way.

b) Not painful to the animal at all

c) Visible only to an RFID reader.

d) Unique number for every tag and every animal, so no duplication, error or confusion.

e) Easily maintain electronic records of vaccination and medication, health checkups.

f) Provides audit trail traceability for food safety in case of cattle.

g) In case of pets, provides a fool proof identification system in case the pet is lost or stolen.

2.4.2 Anti-Theft Systems

Figure 2.8 RFID in Anti-Theft Systems

History

In the past, the only anti-theft systems in place at supermarkets and large shopping malls were the CCTV (Closed Circuit TV) cameras and watchful security guards. These were the only known anti-theft systems, which were effective enough in preventing shoplifting. As with any other technology, the same technology was used to prevent shoplifting in a grocery mall as well as a jewelry shop.

As expected, the grocery mall's investment did not pay off much (as the cost of the goods shoplifted were less than the cost of installing and maintaining the expensive security systems). The only place where this system gave a good ROI (Return on Investment) was in the jewelry shops, where each small item (say a diamond ring), is much more expensive than a grocery item.

Present scenario

RFID anti -theft tags and systems were introduced about a decade back. Initially again, only jewelry shops, high end designer boutiques and similar "expensive goods" shops could justify the ROI. But now, with falling prices of these systems coupled with rising costs of manpower, these systems are getting attractive and are now used in many of the large department stores, supermarkets and malls.

Their usage is growing day by day. In many supermarkets, the management relies on these systems, rather than the surveillance cameras and security guards, to actually protect their merchandise. Of course surveillance cameras are used, but mostly, they are useful only after a theft has taken place. If a theft is noticed, then after the event,

security personnel have to endure going through hours and hours of often grainy black & white camera footage from all the store cameras, trying to pick out suspicious movements and suspected thieves.
They would rather have a device which would alert them the very moment somebody tried to walk off with an item without paying for it. Is this possible? Of course, it is possible, by using RFID technology.

The RFID solution

Each item to be protected is tagged with an RFID anti-theft tag. The tag can be re-used in many cases. The tag is typically attached by a strong string or a plastic band or other means (similar to a price tag, sometimes it is the price tag), to the item (say for example an umbrella). Now once a shoplifter takes this umbrella and walks to the exit, large RFID door antennas placed near the exit detect the presence of the tag and sound an alarm. In case of a genuine shopper, if she takes the umbrella to the checkout counter, the clerk , after receiving the payment for the item, cuts the plastic band and removes the tag. The umbrella can now be carried by the shopper outside passing by the door antennas, without triggering any alarm. The store staff will then typically attach the same tag again to a new umbrella that would be now kept on the store shelf.

Alternatively, in case of a disposable tag, the checkout clerk will hold the item near a “tag killer” machine, which kills (destroys) the tag by subjecting it to a strong electromagnetic radiation. The tag, then though physically present on the item, will not trigger the alarm while passing through the door antenna field.

2.4.3 Asset Management

Figure 2.9 RFID in Asset Management

History

Asset identification has always been a major headache for corporations, especially during audit-time, when the auditor would like to physically verify the presence of an asset. Usually in the older days, asset numbers were either stenciled on the asset or painted on it, large assets like plant equipment had bolt on steel plate type tags (“boiler plate,tags”)on them, which contained details of when the asset was manufactured, when installed, capacity and so on.

Present situation

Presently many assets are still tagged by labels, steel plates or have numbers painted onto them but the confusion prevails. In the recent past many progressive companies have some sort of automatic identification systems like bar codes in place, but they may not cover all assets, or the paste-on tags themselves get lost, dirty or otherwise damaged. They cannot be read in most of these cases, leaving behind open questions from auditors and a red-faced management trying to explain, convince and cajole the auditors into not mentioning these slip ups in the annual reports. The total value of these assets is a huge figure on the balance sheets. Even if the present value of the assets is not shown to be high (because of depreciation) the actual replacement cost of these assets is substantial. It is therefore an essential task of all company managements to have a better asset identification and tracking system in place.

The RFID solution

RFID tags need not be physically present only on the exterior of an asset. They can be mounted safely in a place where they may not be visible easily to the eye, but are none the less, easily visible to an RFID reader. Therefore a company can easily tag all its assets with RFID tags. The tags need not always be pasted on, they can be located in a place from which they may not easily get damaged. Since a physical line of sight is not required, even in case of dirtying, they are still visible to the reader. For tagging assets in a manufacturing plant, industrial grade tags are available. Typically they can be attached to metal surfaces without problems. If required, they also come with safety certifications allowing them to be used in hazardous areas.

The system works like this. An asset is tagged at the time when it is dues for its next physical verification. The tag need not be the same for each asset. One can have different types of tags depending on the physical nature of the asset, its mobility, its replacement value and other such factors. For example a steel reactor which is fixed at one location would have a different type of tag than a laptop, which is a mobile asset. Also the vulnerability of the laptop to theft or malicious “vanishing” may be more than that of the steel reactor, even though its replacement cost is low.

2.4.4 Baggage Handling

Present Situation

An airline may score very high on the passenger's evaluation in terms of inflight service, pretty airhostesses, inflight entertainment systems, timely arrivals, punctual departures and courtesy at check-in counters.

However the same satisfaction levels may not exist, when it comes to passenger baggage handling. In fact lost baggage, delayed baggage arrival and other baggage problems take up a large chunk of an airline's "headache list". How much is the magnitude of the problem? By IATA 's own estimates, an amount nearing about $760 million is spent by the airlines, due to lost or misplaced baggage. So you see that it is a really big problem. Adding to this cost are the rules related to safety due to increased terror threats. Airline baggage is fixed with large stick-on barcode tags at the time of luggage check-in. The luggage then moves along various conveyors, which have bar code readers mounted on them, to scan each baggage tag that comes in its field of view. Unfortunately, the readers cannot correctly scan all bar code tags because of the following reasons:

Figure 2.10 picture of a barcode used to identify lugagge.

a) Barcode readers require a clear line of sight. If the tag is misaligned, it cannot be read.
b) Baggage articles may get bunched together because of careless loading on belt by the staff. This makes labels unreadable.
c) Tags may be dirtied, torn, wet ….. any damage makes it difficult for the readers to read the barcode automatically.

The RFID solution

Figure 2.11 RFID tag can be used instead of the bar code in luggage

Instead of the ordinary bar coded stick-on labels, we can use RFID inlay stick-on labels. These have a printed portion, as well an RFID tag inlay, which can be either a read only or a WORM (write once read many) type. This tag can be read by RFID readers mounted at various locations on the conveyor belts. The RFID readers have several advantages over the traditional bar code readers like

a) Many bags can be read at one time, not one at a time as with bar code readers. This alone speeds up baggage handling by a factor of at least three.

b) No problem of misaligned or dirty, unreadable labels. The RFID reader can read the tags even if the text label gets misaligned or dirty.

c) Retrieving bags from the hold is now easier because of the baggage handler can now have a hand held RFID reader which does not require any line of sight. It can read the multiple bag tags simultaneously and help zero-in on the suspicious bag within a matter of minutes.

Present Situation

Implementation has started or has been carried out on a pilot scale at Hong Kong's Chek Lap Kok International Airport & San Francisco International airport.

2.4.5 Blood banks

Present situation

In thousands of hospitals across the world, blood transfusion is an everyday business, but fraught with risks. This is, not only because contaminated blood may be transfused into an otherwise healthy patient, but also because he may receive the wrong type of blood altogether. This is not a rare occurrence, although we would like to believe so. Data from US hospitals show an alarming number of cases of medical negligence or mistakes, many of which are related to blood transfusion. In fact, data compiled from Year 1993 to the Year 1999 showed an increase in blood transfusion errors. Note that these errors are not in some remote third world hospitals, but are data from the US itself.

Why have the number of mistakes increased?

This because many hospitals have cut back staff due to cost pressures. The person who collects blood is not the same person who transfuses it. Typically the patient is not known personally to the nurse who administers the transfusion. The miss-identification can occur due to overwork, carelessness or any other factors.

In a typical hospital emergency room, the following situation is not unimaginable.

a) There has been an accident and large number of victims have been brought in.

b) Suddenly a large amount of blood is needed for the emergency procedures to be carried out on these patients.

c) The patient himself is either asleep, sedated or otherwise unconscious, unable to talk or communicate with the paramedics.

d) The nurse or paramedic do not know the patient personally.

One sees that the nurse or paramedic can easily pick up the wrong blood bag, get confused because of similar sounding names and hence transfuse the wrong blood. This is in most cases, fatal.

The RFID solution

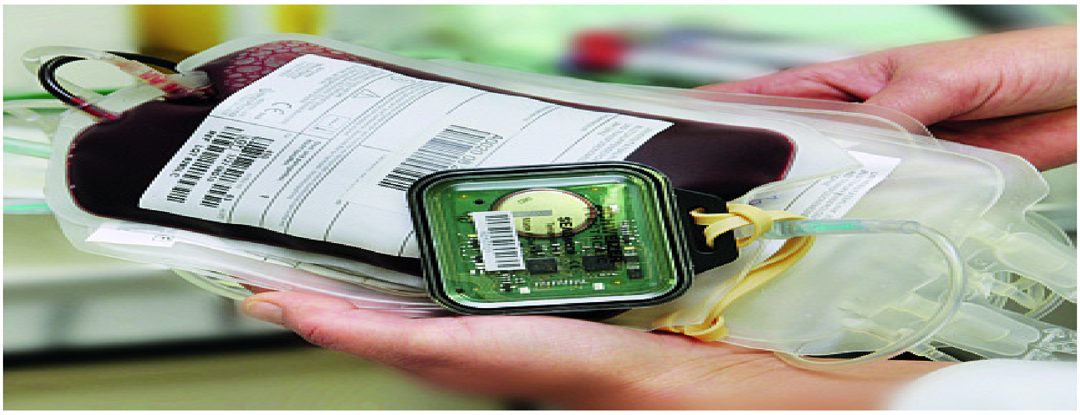


Figure 2.12 RFID Tag used in Blood Banks

The RFID solution is to embed a tag into the blood bag label itself. The paramedic who transfuses the blood can scan the bag before transferring. He typically enters the patient ID number, or in a better system, the patient also has a wrist band RFID tag which identifies him uniquely. In case the wrong blood bag is scanned, the reader can throw up a warning like this.

WARNING!!BLOOD MISMATCH!! YOUR IMMEDIATE ATTENTION IS RE QUIRED!!	
The blood bag is for patient JOHN SMTTH Patient ID JS1002453	The patient on the bed is JOHN SMTTH Patient ID JS1003453

This will save the life of Mr. John Smet (who will no doubt, be eternally grateful to the technology, if only he knew what was about to happen!)

Advantages of using RFID

a) No errors at all ,even in case of demanding and panic like situations. This itself can be said to be the ROI of an investment in such a system. Saving a few lives a year is definitely worth the cost of a few tags & readers!

b) Greatly decreases the mortality rate due to negligence.

c) Can be used for other body fluids or patient dosages too, need not get restricted to only blood. For example medicine dosages, intravenous drips, etc.

d) Offers traceability and tracking, can evaluate the actual level of patient care that is offered by the nurses, to upper management, by means of data collection. For example middleware can be used to match queries like “how much time did nurse Jensen spend between collecting the blood from the blood bank and transfusing it into Mr. Smith” and so on, which is invaluable to provide better quality of service to patients.

2.4.6 National Identification

This has been a problem plaguing countries for all time in the recent past. How to identify her own genuine nationals from those aliens (especially the illegal variety) who sneak in and manage to stay for long times.

Present situation

a) The cards are prone to illegal copying, skimming, identity theft and other ills.
b) The magnitude of this problem is huge. The resources to hunt and track down fake card holders are too less to solve the problem.

The RFID solution

Figure 2.13 RFID tags used on a passpor

A user typically has only a single card with an embedded RFID chip with a unique number. This RFID tag number then points to an online database which is accessed by a multitude of agencies. The same database can have all information related to the holder, including details like date of birth, whether allowed to drive (electronic driving permit), whether entitled to social security benefits and a multitude of other attributes. Since this common database will be accessible to all regulatory agencies, in different views, it will be difficult for any one cartel or criminal group to access it and change ALL entries related to an individual.

2.4.7 Real Time Location Tracking (RLTS)

In large factories, chemical processing plants, oil refineries, steel plants, etc there are large numbers of various kinds of people, who come in and go out during the day. These facilities operate round the clock with employees, contractors, other visitors like vendor reps entering and leaving the facility. Today, most places issue either a dumb badge with a photo to its employees and contractors or a "visitor" badge (without a photo), to all other people. These entries and exits are recorded manually. Well, they might appear "electronic" because a security guard enters it in a PC, but it is no different from a paper record, because in case of an emergency or evacuation, though one can find out how many people are inside, it is impossible to find their exact location. A typical site may be about 100 acres or more.

The RFID solution

Figure 2.14 RFID tags used for tracking

The RFID solution could be of many types. One could be just replacing the photo badges with RFID proximity cards which require to be held close to door locks or other access control devices. These access control devices would have to be networked to a central computer to collect data on which cards moved through which gates.

Advantages of the RFID solution

a) A real time picture of all employees, contractors and visitors who are in the facility.
b) One can see if a contractor has unauthorized accessed another area.
c) Visitor movement can be tracked ……. [5]

Chapter Three:

Hardware of the RFID System

Preview:

In part one we will introduce the components of the system, i.e. the reader the tags, the hardware used in the system, basics about the antenna and cavities

Author: Motaz Selim

In part two we will introduce the user to the basics of the stepper motor, its operation, and why we used it.

Author: Shereef Mamdouh

Hardware of the RFID System

3.1 Hardware Components Used in the System
Part one
3.1.1 RFID Reader

Introduction

The RF9315R active RFID 8 meters receiver module with RSSI “Received Signal Strength Indicator” , receives data sent from RF8315T modules. This low-cost receiver module requires no external power supply (some pc or notebook may require external 9V power input). Data received will be sent to RS232 com port. Standard communication software such as Hyperterninal can read the data. Custom program can read data from com port for system integration or application development.

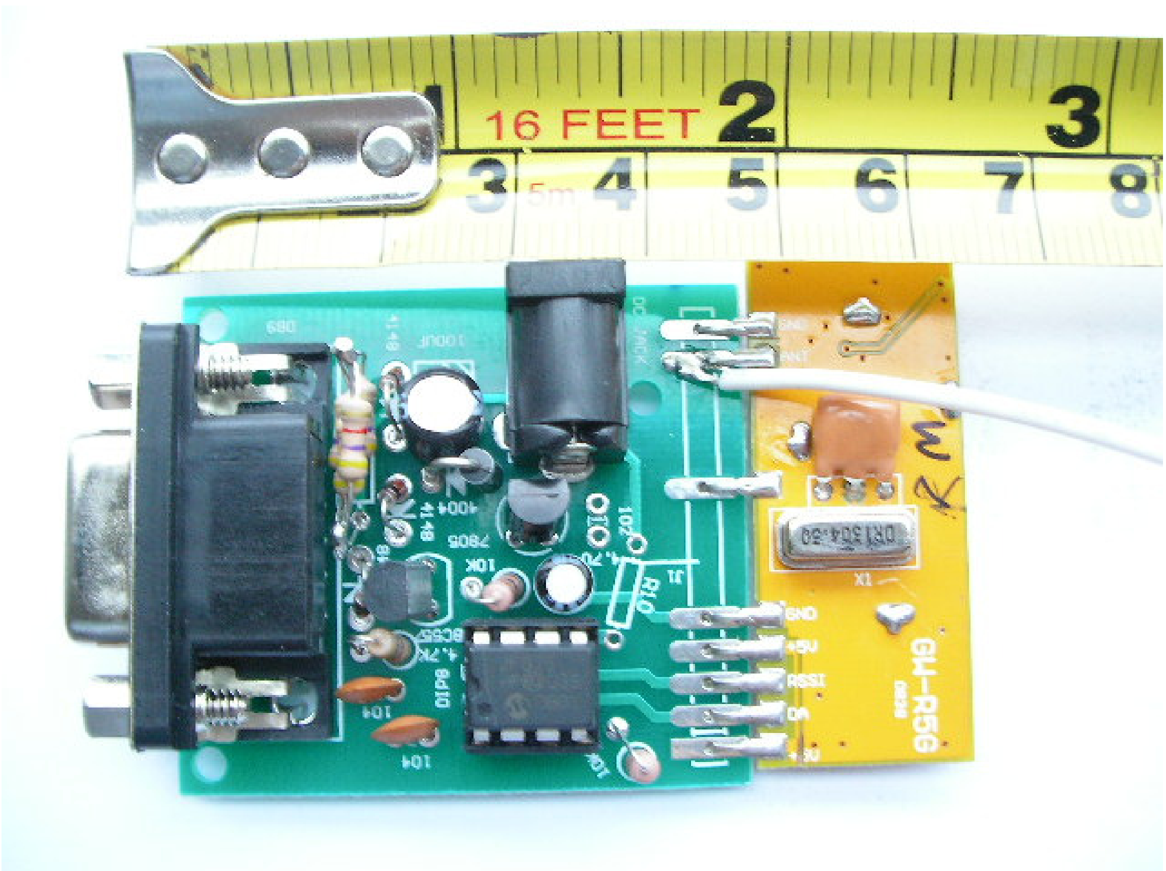


Figure 3.1 RF9315R Active RFID 8 Meters Receiver Module with RSSI

RECEIVED SIGNAL STRENGTH INDICATOR (RSSI)

The incorporated wide range RSSI which measures the strength of an incoming signal

Over a range of approximately 60dB. This allows assessment of link quality and available margin and is useful when performing range tests.

Please note that the actual RSSI voltage at any given RF input level varies somewhat between units.

The RSSI facility is intended as a relative indicator only - it is not designed to be, or suitable as, an accurate and repeatable measure of absolute signal level or transmitter-receiver distance. [6]

Features of the Reader

- Plug and play. No need to send command to control the receiver
- Can read data within 8 meters with build in RF8315T antenna. If RF8315T antenna changed to 9" wire the effective radius can be 14 meters.
- RSSI data will be reported
- No power input is required for most desktop PC
- Superheterodyne design for maximum stability
- Reverse power input protection

The operating frequency of the reader is 315 MHz which is a relitively low frequency, since it is a cheap reader.

Specifications of the Reader

SPECIFICATIONS, RF9315R ACTIVE RFID 8 METERS RECEIVER MODULE WITH RSSI

Supply Voltage	9VDC via wall adaptor if necessary
Supply Current	4mA Typical
Operating Temperature	0 - 50C
Operating Frequency	315 Mhz
Data Output	ID sent by RF8315T (4 characters) plus RSSI data (0 to 255) plus 1 space
Capacity	80 ID at the same time
Build-in Watchdog	Yes. 2.3 seconds
Interface	SERIAL PORT (RS232)
Type	RS232, 9600 Baud, 8 bit words,1 stop bit,1 start bit, no parity
Dimensions	4.5cm X 6.5 cm X 1.5 cm

Figure 3.2 RFID reader specifications

RFID Reader Interface

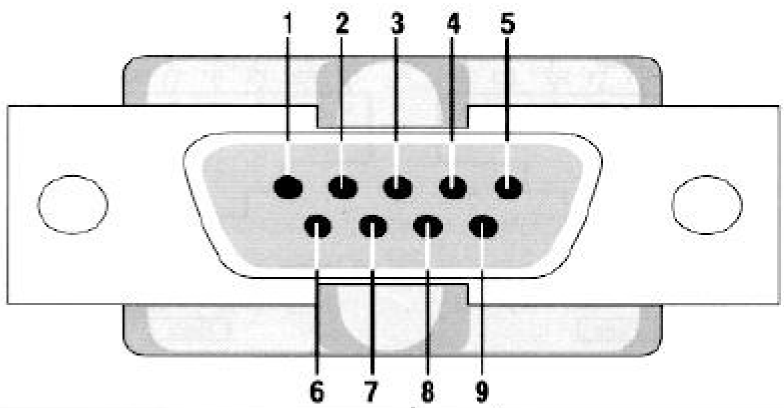
Interfacing is done between any device and a computer so that they can communicate and send and receive data and control signals between the device and the computer for user development.

The types of interfacing are wireless interfacing which is done by wireless signals "Wi-Fi, Bluetooth, GSM, etc. "between the device and the computer, and wired interfacing which is done by connecting wires between the terminals of the computer and the device.

For wired connections data can be sent by two types of connections they are:

- Parallel port interfacing: Data is sent parallel byte by byte where the port has an 8 bit data line.
- Serial port interfacing: Data is sent serially bit by bit, like the serial RS232 COM port, USB port, and the Fax modem port.

The reader that we are using is of the RS232 serial interfaced port through a Serial port to USB converter so it can communicate with laptops since they don't have RS232 Serial ports.



Pin	Signal	Pin	Signal
1	Data Carrier Detect	6	Data Set Ready
2	Received Data	7	Request to Send
3	Transmitted Data	8	Clear to Send
4	Data Terminal Ready	9	Ring Indicator
5	Signal Ground		

Figure 3.3 RS232 serial port specifications

3.1.2 RFID Tags

Introduction

The RF8315T transmitting module is and active type tag which requires a battery on board,a unique 4 characters (A-Z, a-z, 0-9) will be sent out on every 2.5 seconds plus/minus 0.5 second containing the ID of the transmitted tag. The matching receiver RF8315R can receive the ID within 8 meters although the RF power is very low. The transmitter will only turn on when ID is transmitting (< 0.01 second), as a result it will not cause data jam to other devices that are using the same frequency band.[7]

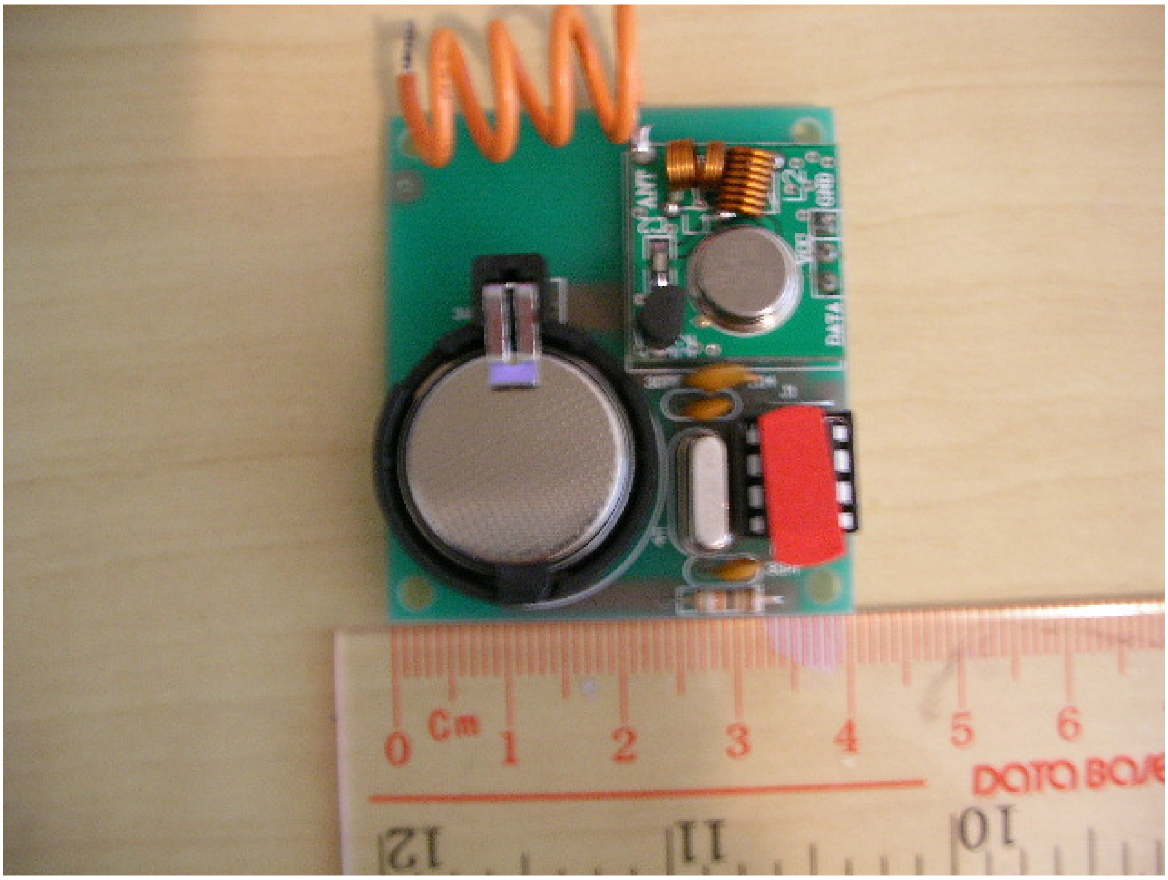


Figure 3.3 RF8315T Active RFID 8 Meters Transmitting Module

Features of the Tag

- Low power consumption (5,000 hours for CR2025, 7,000 hours for CR2032)
- Can send data up to 8 meters with included antenna. If the antenna is a 9" wire the effective radius can be 15 meters
- Small dimension
- No setup required
- Anti-collision algorithm is employed. RF8315R can handle 160 transmitters at the same time.

Specifications of the Tag

Power Supply	CR2025 / CR2032
Power Consumption	4mA when transmitting, 19uA when idle
Operating Temperature	0 - 50C
Operating Frequency	315 MHz
Data Output	4 characters (A-Z, a-z, 0-9). All transmitters carry unique ID
Effective Radius	8 meters with included antenna (8 mm diameter with 2 cm long). The radius can be 15 meters if the antenna is a 9 inches wire.
RF output power	< 2mW
Dimensions	*4 cm X 5 cm X 1.8 cm*

Figure 3.4 RF8315T Active RFID 8 Meters Transmitting Module Specifications

3.1.3 RFID Antenna

An **antenna** (or **aerial**) is an electrical device which converts electric currents into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter applies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a receiver to be amplified. An antenna can be used for both transmitting and receiving.

Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, two-way radio, communications receivers, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise.

The helical antenna:-

A **helical antenna** is an antenna consisting of a conducting wire wound in the form of a helix. In most cases, helical antennas are mounted over a ground plane. The feed line is connected between the bottom of the helix and the ground plane. Helical antennas can operate in one of two principal modes: normal mode or axial mode.

In the *normal mode* or *broadside* helix, the dimensions of the helix (the diameter and the pitch) are small compared with the wavelength. The antenna acts similarly to an electrically short dipole or monopole, and the radiation pattern, similar to these antennas is omnidirectional, with maximum radiation at right angles to the helix axis. The radiation is linearly polarized parallel to the helix axis.

In the *axial mode* or *end-fire* helix, the dimensions of the helix are comparable to a wavelength. The antenna functions as a directional antenna radiating a beam off the ends of the helix, along the antenna's axis. It radiates circularly polarized radio waves. [8]

Inorder to make the beam that is radiated by the antenna to by directional we made a helical antenna to make the radiated beam as narrow as possible to be more accurate to locate the place of the Active tags.

The wire used for making the antenna is 1.5mm wire diameter which is twisted to a number of turns to make a helical antenna.

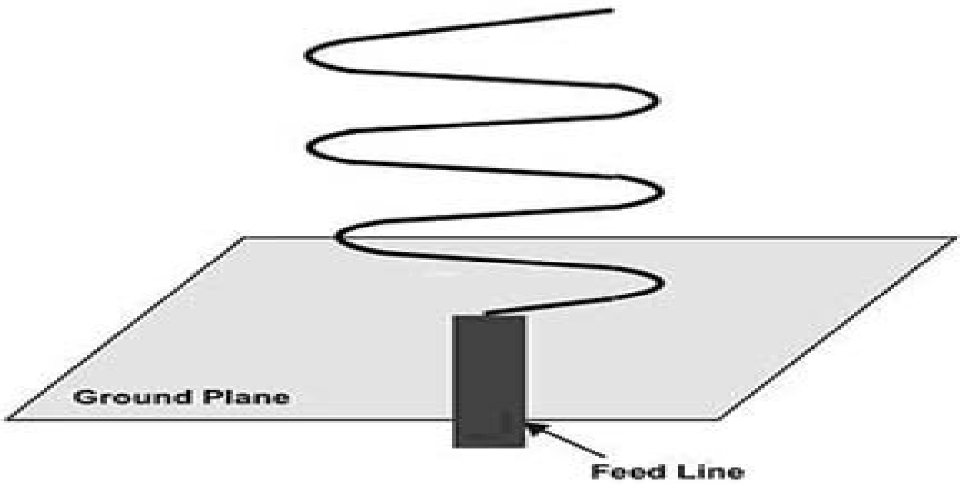


Figure 3.5 an example of a helical antenna

3.1.4 Metal Cavities

In order to make the antenna radiate in a certain direction we used metal cavities and placed the reader and the tags in the cavities, so that the direction of radiation would be in only one way.

The cavity is made by a metal material and in the shape of pyramid in the top for collecting the signal that is radiated from the antenna and making the signal directed towards the reader or the tag

The cavity of reader was made longer due to the length of the readerand it's also made with an opening at the begining to collect the received signal from the tags towards the reader in shape of directional signal and to receive the strength of the signal to calculate the place of the tag .

The cavity was isolated inside by non-conductor to make the reader safe from short circuit problems.

The cavity was hand made by us a "proto-type" in order to test its results of blocking the signals from certain directions.

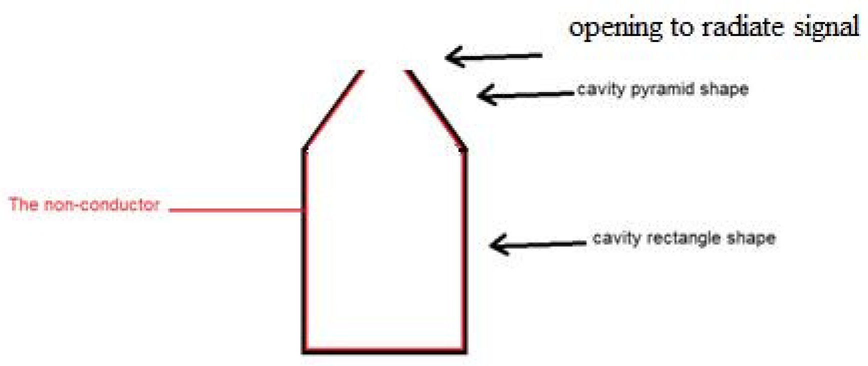


Figure 3.6 demonstration of the cavity made

Part two

3.2 Stepper Motor

3.2.1Introduction

A **stepper motor** (or **step motor**) is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application.

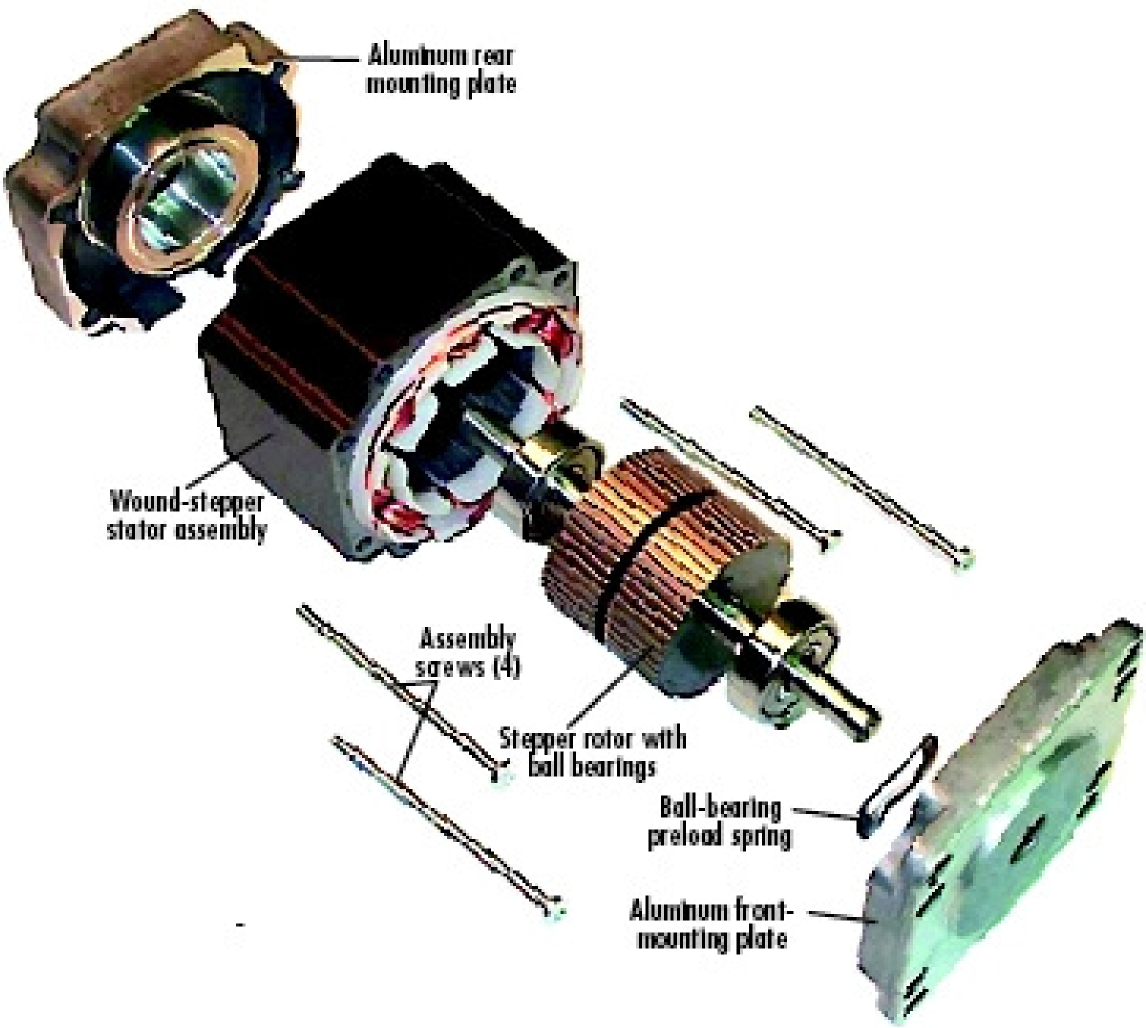


Figure 3.7 Stepper Motor Parts

3.2.2 Objectives

The objective of the stepper motor used in the System is to have the RFID reader inside the cavity placed on it so it can read the detected tags in the given direction and then to be rotated in the next direction and reads a tag until it completes a full 360 degree cycle “scan”, then the computer interface processes the detected tags and could give a demonstration of the detected tags.

We used a stepper motor in the system so we could calculate easily control the movement of the motor, and calculate the position of the tags form the number of steps the motor has rotated until the tag is detected.

3.2.3 DC motor VS Stepper motor:

1. Stepper motors are operated open loop, while most DC motors are operated closed loop.

2. Stepper motor are easily controlled with microprocessors, however logic and drive electronics are more complex.

3. Stepper motors are brushless and brushes contribute several problems.

4. DC motors have a continuous displacement and can be accurately positioned, whereas stepper motor motion is incremental and its resolution is limited to the step size.

5. Stepper motors can slip if overloaded and the error can go undetected.(A few stepper motors use closed-loop control.)

6. Feedback control with DC motors gives a much faster response time compared to stepper motors.

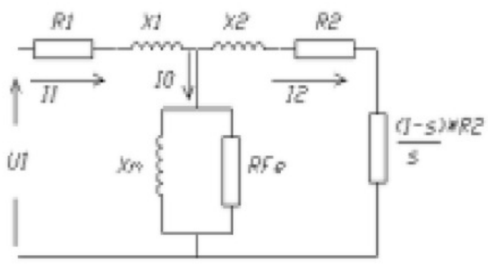
DC Motor

Stepper Motor

Figure 3.8 DC motor & stepper motor

3.3.4 Stepper motor definition & circuit:

A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied.[9]



Stepper motor equivalent circuit

Stepper motor

Figure 3.9 stepper motor, and its equivalent circuit

3.2.5 Stepper Motor Charachteristics

- Stepper motors are constant power devices.
- As motor speed increases, torque decreases. Most motors exhibit maximum torque when stationary, however the torque of a motor when stationary (holding torque) defines the ability of the motor to maintain a desired position while under external load. The torque curve may be extended by using current limiting drivers and increasing the driving voltage (sometimes referred to as a 'chopper' circuit; there are several off the shelf driver chips capable of doing this in a simple manner).
- Steppers exhibit more vibration than other motor types, as the discrete step tends to snap the rotor from one position to another (called a detent). The vibration makes stepper motors noisier than DC motors. This vibration can become very bad at some speeds and can cause the motor to lose torque or lose direction. This is because the rotor is being held in a magnetic field which behaves like a spring. On each step the rotor overshoots and bounces back

and forth, "ringing" at its resonant frequency. If the stepping frequency matches the resonant frequency then the ringing increases and the motor loses synchronism, resulting in positional error or a change in direction. At worst there is a total loss of control and holding torque so the motor is easily overcome by the load and spins almost freely. The effect can be mitigated by accelerating quickly through the problem speeds range, physically damping (frictional damping) the system, or using a micro-stepping driver. Motors with a greater number of phases also exhibit smoother operation than those with fewer phases (this can also be achieved through the use of a micro-stepping driver).

- Stepper motors with higher inductance coils provide greater torque at low speeds and lower torque at high speeds compared to stepper motors with lower inductance coils

Stepper Motor Advantages and Disadvantages

The advantages of Stepper Motor:

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at standstill (if the windings are energized).
3. Precise positioning and repeatability of movement since good stepper. Motors have an accuracy of 3 – 5% of a step and this error is non-cumulative from one step to the next.
4. Excellent response to starting, stopping, reversing.
5. Very reliable since there are no contact brushes in the motor. Therefore The life of the motor is simply dependent on the life of the bearing.

6. The motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.
7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.
8. A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

9. Stable. Can drive a wide range of frictional and inertial loads.

10. Overload safe. Motor cannot be damaged by mechanical overload.

The disadvantages of Stepper Motor :

- Resonances can occur if not properly controlled.
- Not easy to operate at extremely high speeds.

Open Loop Operation:

One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Your position is known simply by keeping track of the input step pulses.

3.2.6 Stepper Motor Types:

There are three basic stepper motor types. They are :

- Variable-reluctance
- Permanent-magnet
- Hybrid

1. Variable-reluctance (VR):

This type of stepper motor has been around for a long time. It is probably the easiest to understand from a structural point of view. Figure 1 shows a cross section of a typical V.R. stepper motor. This type of motor consists of a soft iron multi-toothed rotor and a wound stator. When the stator windings are energized with DC current the poles become magnetized. Rotation occurs when the rotor teeth are attracted to the energized stator poles.

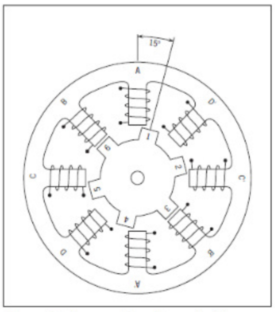


Figure 1. Cross-section of a variable-reluctance (VR) motor.

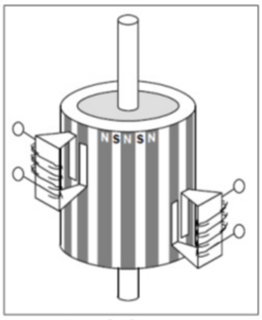


Figure 2. Principle of a PM or tin-can stepper motor.

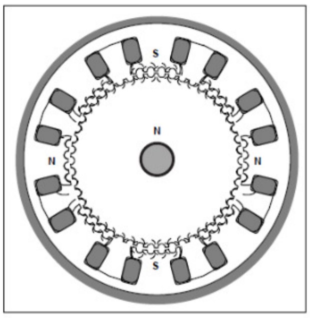


Figure 3. Cross-section of a hybrid stepper motor.

Figure 3.10 stepper motor stepper motor types

2. Permanent Magnet (PM)

Often referred to as a "tin can" or "can stock" motor the permanent magnet step motor is a low cost and low resolution type motor with typical step angles of 7.5° to 15°. (48 – 24 steps/revolution) PM motors as the name implies have permanent magnets added to the motor structure. The rotor no longer has teeth as with the VR motor. Instead the rotor is magnetized with alternating north and south poles situated in a straight line parallel to the rotor shaft. These magnetized rotor poles provide an increased magnetic flux intensity and because of this the PM motor exhibits improved torque characteristics when compared with the VR type.

3. Hybrid (HB)

The hybrid stepper motor is more expensive than the PM stepper motor but provides better performance with respect to step resolution, torque and speed. Typical step angles for the HB
stepper motor range from 3.6° to 0.9° (100 – 400 steps per revolution). The hybrid stepper motor combines the best features of both the PM and VR type stepper motors. The rotor is multi-toothed like the VR motor and contains an axially magnetized concentric magnet around its shaft. The teeth on the rotor provide an even better path which helps guide the magnetic flux to preferred locations in the air-gap. This further increases the detent, holding and dynamic torque characteristics of the motor when compared with both the VR and PM types.

The two most commonly used types of stepper motors are the permanent magnet and the hybrid types. If a designer is not sure which type will best fit his applications requirements he should first evaluate the PM type as it is normally several times

less expensive. If not then the hybrid motor may be the right choice.

Two-phase stepper motors:

There are two basic winding arrangements for the electromagnetic coils in a two phase stepper motor: bipolar and unipolar.

1) Unipolar motors:

A unipolar stepper motor has two windings per phase, one for each direction of magnetic field. Since in this arrangement a magnetic pole can be reversed without switching the direction of current, the commutation circuit can be made very simple (e.g. a single transistor) for each winding. Typically, given a phase, one end of each winding is made common: giving three leads per phase and six leads for a typical two phase motor. Often, these two phase commons are internally joined, so the motor has only five leads.

2) Bipolar motor: (the one that we used in the project):

Bipolar motors have a single winding per phase. The current in a winding needs to be reversed in order to reverse a magnetic pole, so the driving circuit must be more complicated; typically with an H-bridge arrangement (however there are several off the shelf driver chips available to make this a simple affair). There are two leads per phase, none are common.

3.2.7 The stepper motor used in the system

The type of Stepper Motor that is used in the project is a bipolar Permanent Magnet (PM) "AEG S026/48-4 Pin [P5111]":

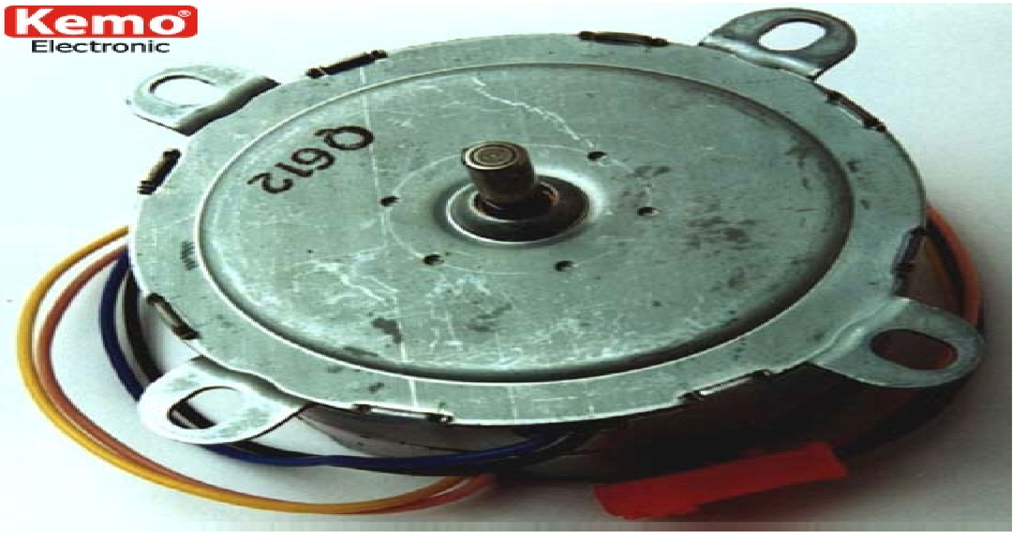


Figure 3.11 stepper motor used in the project

Specifications of the stepper motor

Technical Data	
Operating voltage	approx. 5 V/DC
Operating currrent	approx. 1 A
No. of steps	48
Dimensions without axis	Ø approx. 66 x 37 mm
Dimensions axis	Ø approx. 5 x 11 mm.

Figure 3.12 technical specifications of the stepper motor

3.2.8 The stepper motor interface card

The stepper motor interface card is used to interface the stepper motor to the computer via a parallel port at the end of the interface card.

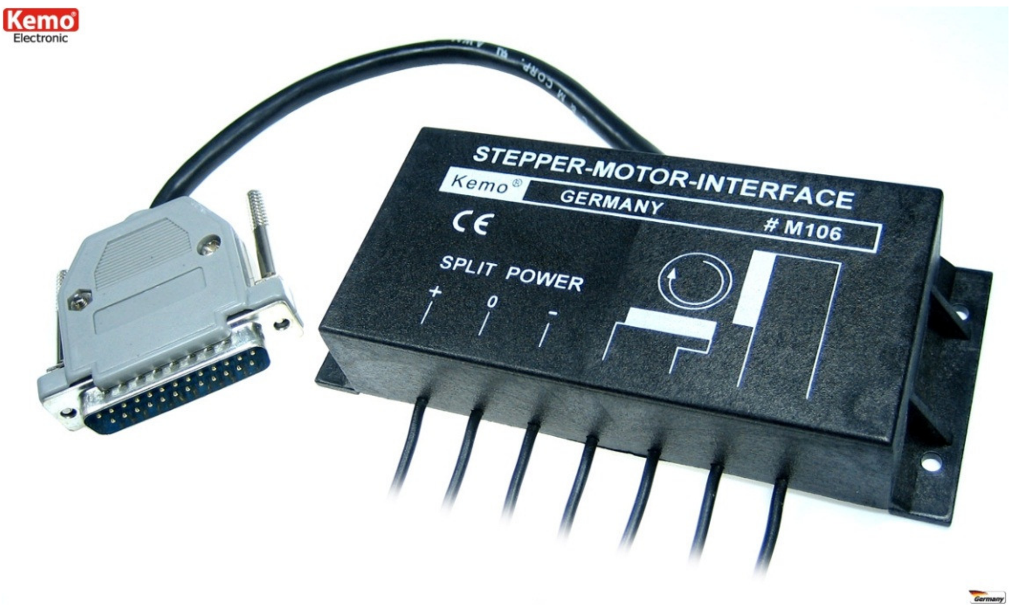


Figure 3.13 the stepper motor interface card

Specifications of the stepper motor interface card

Technical Data	
Operating voltage	4 - 18 V split power supply. Double DC voltage, dependent on the connected motor (always 1 V more than the motor requires).
Motor connection	1 bipolar stepper motor 4 connections 3 - 17 V max. 2 A
Connector	25 poles for connection to the PC printer port LPT1
Dimensions	ca. 120 x 50 x 24 mm

Figure 3.14 technical specifications of the interface card

3.2.9 The parallel port

A parallel port is a type of interface found on computers (personal and otherwise) for connecting various peripherals. In computing, a parallel port is a parallel communication physical interface. It is also known as aprinter port or Centronics port.[10]

Figure 3.15 parallel port of a computer

Pinouts for parallel port connectors.

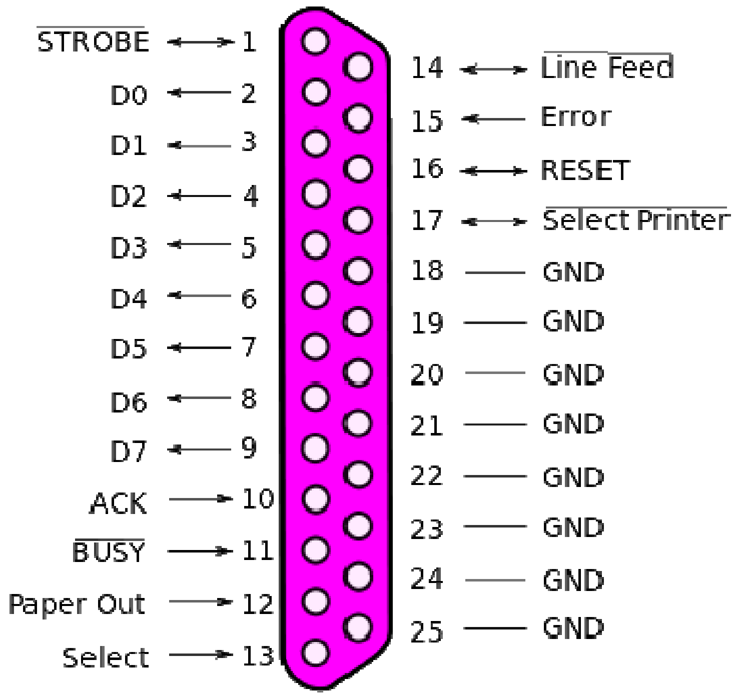


Figure 3.16 parallel port pin outs.

Chapter Four:

Software of the RFID System

Preview:

In this Chapter we Introduce & Discuss:

The Software program & Graphical User Interface

The Database

Author: Sameh Mobarak

Software of the RFID System

4.1 Software Program

The Graphical User interface was made using Microsoft C#.

4.1.1 GUI of the program

4.1.1.1 Main Form of the program

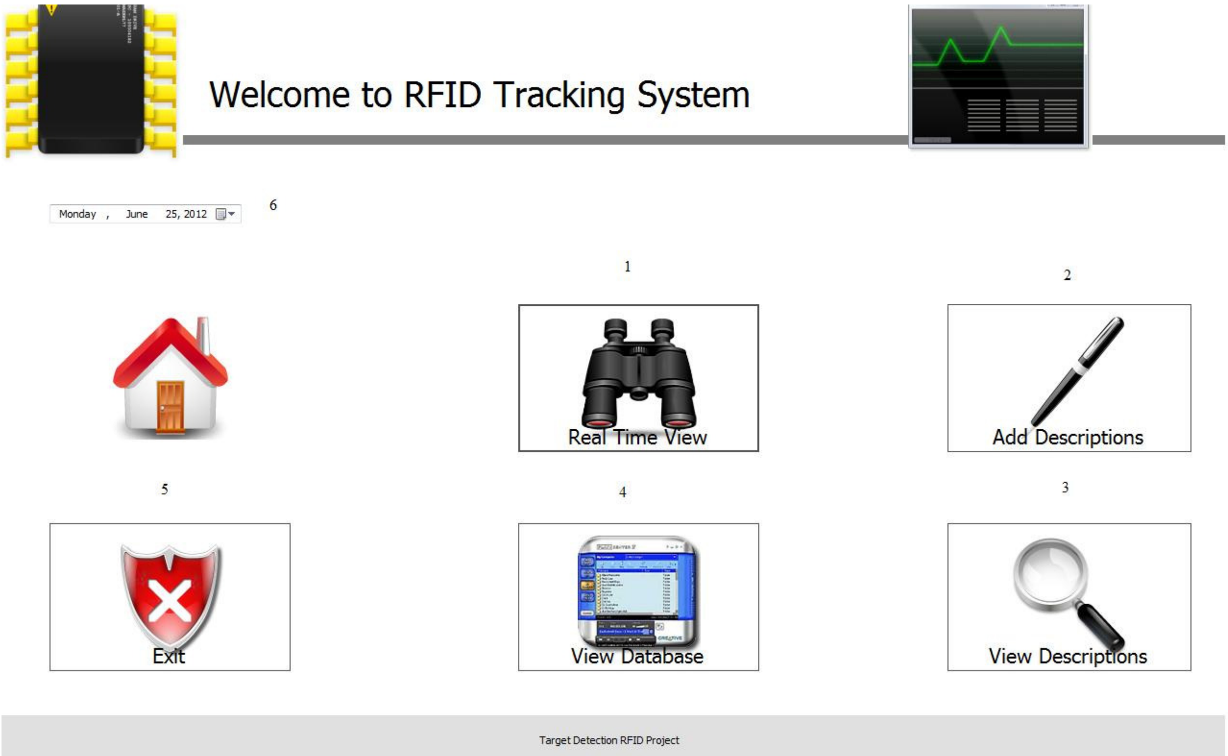


Figure 4.1 "Main Form"

The Main Form Consists of:

1- Real-Time View Button
2- Add Descriptions Button
3- View Descriptions Button
4- View Database Button
5- Exit Button
6- Calendar

The Main Form of the program can be used for:

Monitoring the System, Real-Time view of the System
Adding and Updating descriptions of Tags
Viewing the Description of Tags
Viewing the Database of the tags that were read
Viewing the Calendar of the Year

4.1.1.2 Real-Time Monitoring of the System

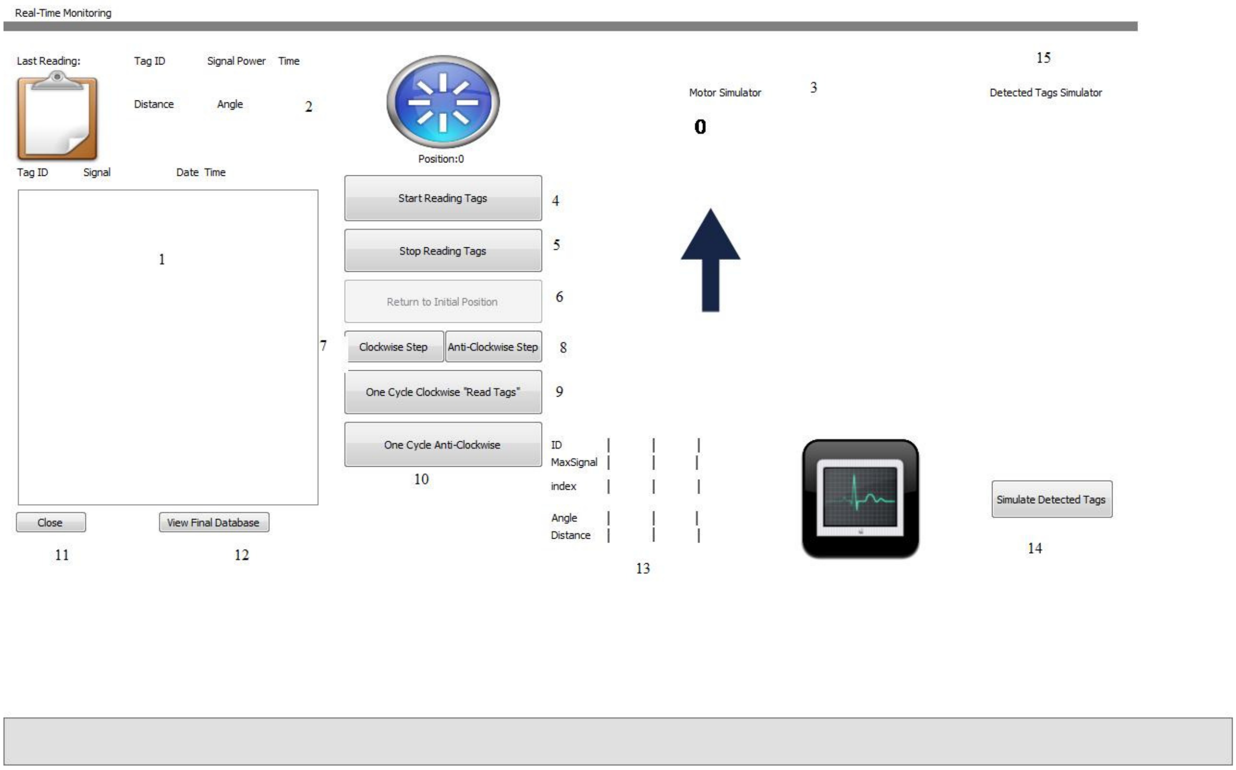


Figure 4.2 "Real-Time Monitoring"

This Window is used for Real-Time Monitoring of the System, where the user can control the reading of the tags and moving the stepper motor the required direction Clockwise or Anti-Clockwise steps or full cycles.

The user can also have a Graphic View of the System "Simulation" of what is actually happening in the system on the computer by means of the simulator.

When the user starts to read the tags the simulator prints out the ID of the tag and the signal strength of the received signal and also the angle at which the stepper motor is at.

The recorded readings of the Tags ID, Signal Strength, Date and Time of Reading, Angle, Distance, and the Description of the Tag which we can add in 4.1.1.3 is Recorded a Database called RFID using SqlServer.

<u>The Real-Time Monitoring Form consists of the following:</u>

1. List box 2.Labels 3.Motor Simulator 4.Start reading Tags 5 Stop Reading Tags

6. Return to initial position 7.Clockwise Step 8.Anti-Clockwise Step 9.One Cycle Clockwise 10.One cycle Anti-Clockwise 11.Close

12. View Final Database 13. Detected Tags Measurements

14. Simulate Detected Tags Button 15.Detected Tags Simulator

The Descriptions are:

1. List box containing the recorded Tag ID, the received signal strength, date and time of recording, angle, and distance of tag.
2. Labels containing the readings of the last recorded Tag ID and its signal strength, date and time of recording, angle, and distance of tag.
3. Simulator which shows what is actually happening in the system like the rotation of the stepper motor and the reading of tags and the angle of rotation.
4. Start reading tag button which opens the serial port for the communication with the reader so the interface can receive the data sent by the reader which is the Tag ID and the Received Signal Strength that was sent from the Tag.
5. Stop reading tag button which closes the serial port so no more data is sent to the computer and the program stops receiving data.
6. Return to initial position button returns the motor to the initial position before it started rotating.
7. Clockwise step button rotates the motor one step “7.5 degree” in clockwise direction.

8. Anti-Clockwise step button rotates the motor one step "7.5 degree" in the anti-clock wise direction.
9. One Cycle Clockwise button rotates the motor a full cycle""360 degrees" 48 steps in the clockwise direction.
10. One Cycle Anti-Clockwise button rotates the motor a full cycle"360 degrees" 48 steps in the clockwise direction.
11. Close Button closes the current window and returns to the main form

4.1.1.3 Add Description

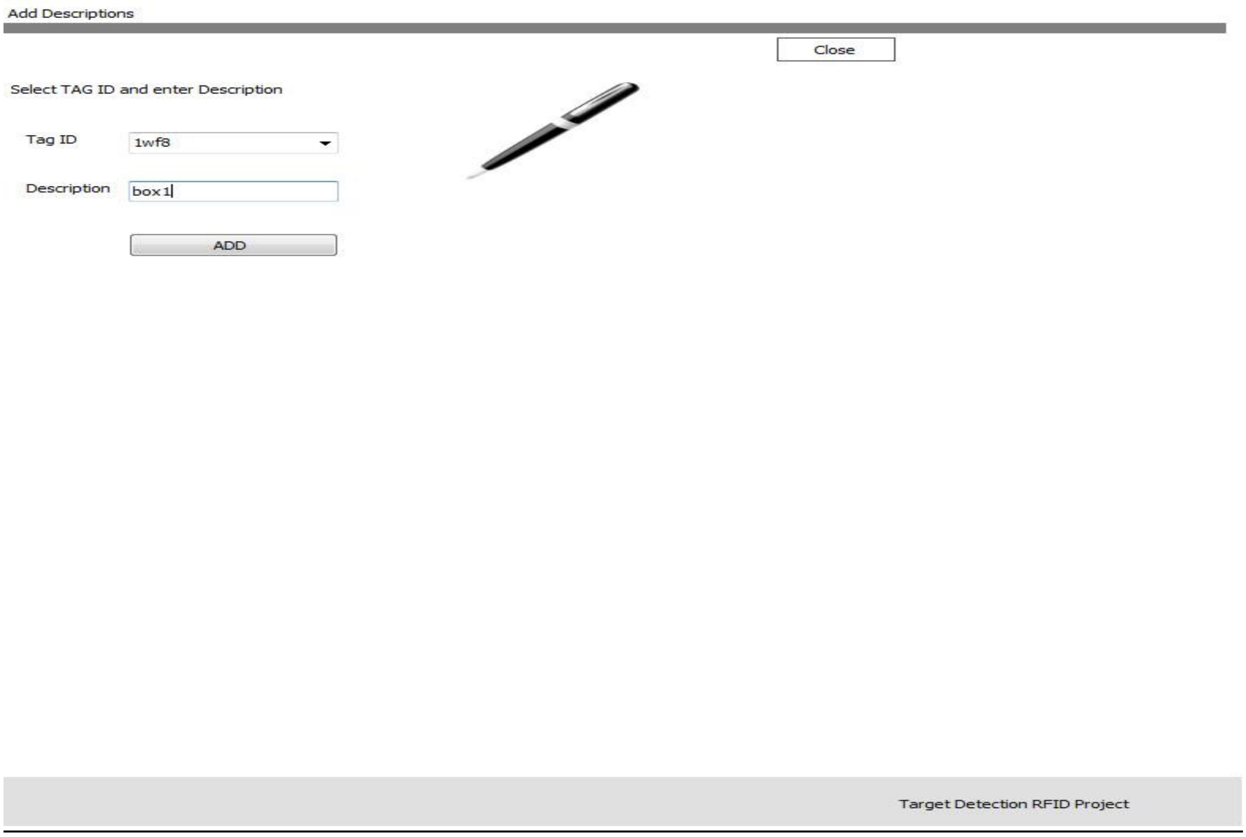


Figure 4.3 “Add Description Form”

This form is used to add descriptions of Tags for example what is the tag used to monitor or what the tag is placed in. The form checks the ID of Tags that was read and puts them in a combo box, the user selects the tag that he wants and adds the required description of the Tag.

When the user presses the add button the tag ID and the Descriptions are recorded in the database called Data which contains the Tags IDs and the corresponding descriptions.

The form can be also used to update a description of a Tag, when the Tag already has a description it is selected from the database and placed inside the textbox where the user can change it to another one.

Figure 4.3.1 "Item description added"

When the Tag ID and the Description are successfully stored in the database a message will be showed confirming the Tag ID and the added description.

4.1.1.4 View Descriptions

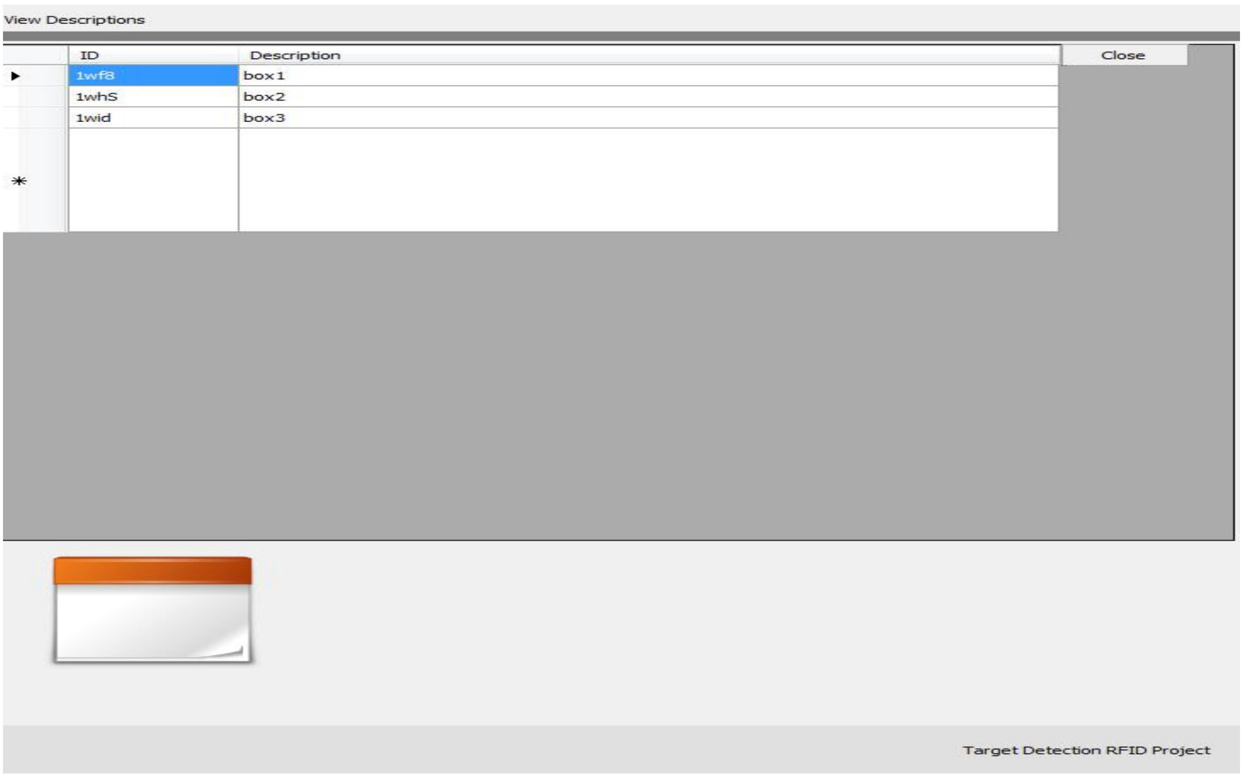
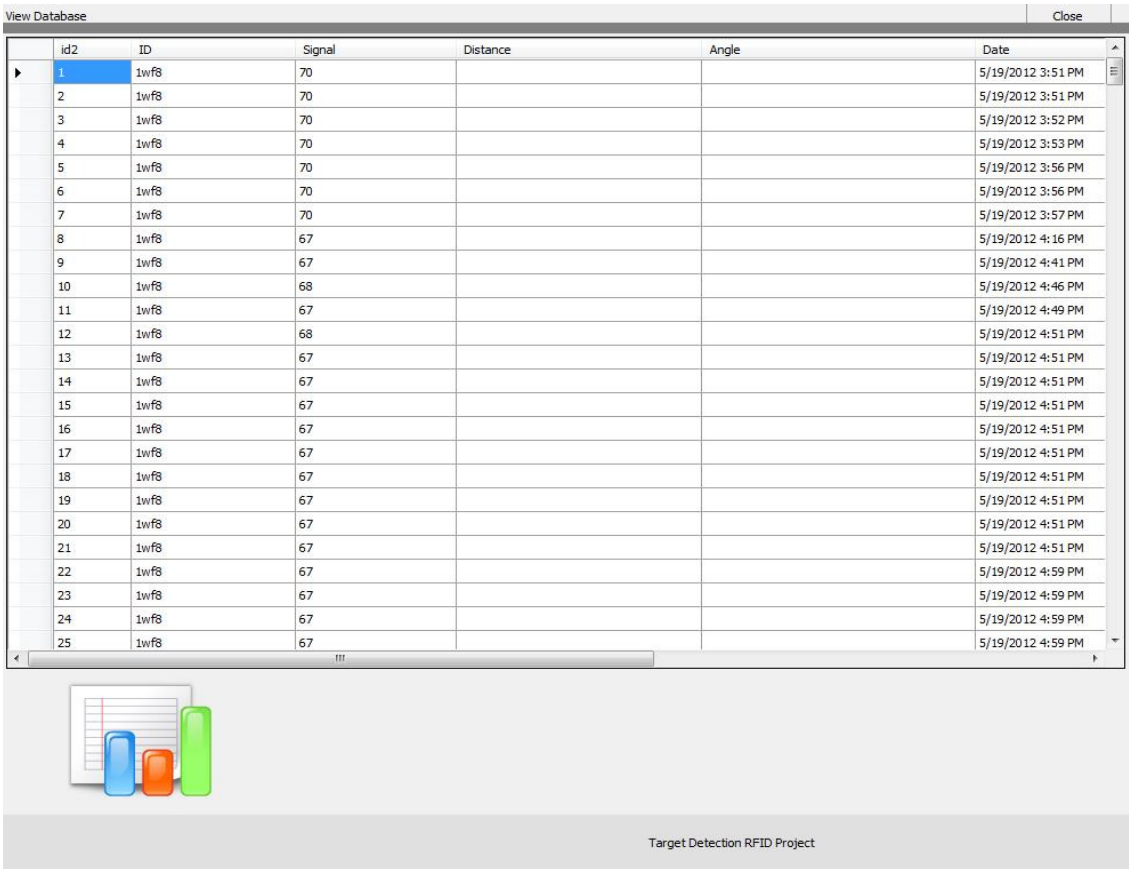


Figure 4.4 "View Descriptions Form"

This form is used to view the descriptions of the Tags ID; it uses the database that contains the Tags ID and its descriptions.

4.1.1.5 View Database



id2	ID	Signal	Distance	Angle	Date
1	1wf8	70			5/19/2012 3:51 PM
2	1wf8	70			5/19/2012 3:51 PM
3	1wf8	70			5/19/2012 3:52 PM
4	1wf8	70			5/19/2012 3:53 PM
5	1wf8	70			5/19/2012 3:56 PM
6	1wf8	70			5/19/2012 3:56 PM
7	1wf8	70			5/19/2012 3:57 PM
8	1wf8	67			5/19/2012 4:16 PM
9	1wf8	67			5/19/2012 4:41 PM
10	1wf8	68			5/19/2012 4:46 PM
11	1wf8	67			5/19/2012 4:49 PM
12	1wf8	68			5/19/2012 4:51 PM
13	1wf8	67			5/19/2012 4:51 PM
14	1wf8	67			5/19/2012 4:51 PM
15	1wf8	67			5/19/2012 4:51 PM
16	1wf8	67			5/19/2012 4:51 PM
17	1wf8	67			5/19/2012 4:51 PM
18	1wf8	67			5/19/2012 4:51 PM
19	1wf8	67			5/19/2012 4:51 PM
20	1wf8	67			5/19/2012 4:51 PM
21	1wf8	67			5/19/2012 4:51 PM
22	1wf8	67			5/19/2012 4:59 PM
23	1wf8	67			5/19/2012 4:59 PM
24	1wf8	67			5/19/2012 4:59 PM
25	1wf8	67			5/19/2012 4:59 PM

Figure 4.5 “View Database Form”

This form is used to view the database of the recorded tags reading it displays the operation number “id2”, the ID of the recorded Tag, the received signal strength of the Tag, the calculated angle, distance, and the Date and time of recording.

4.1.2 Programming of the Serial Port

4.1.2.1 Configuration of the Serial Port

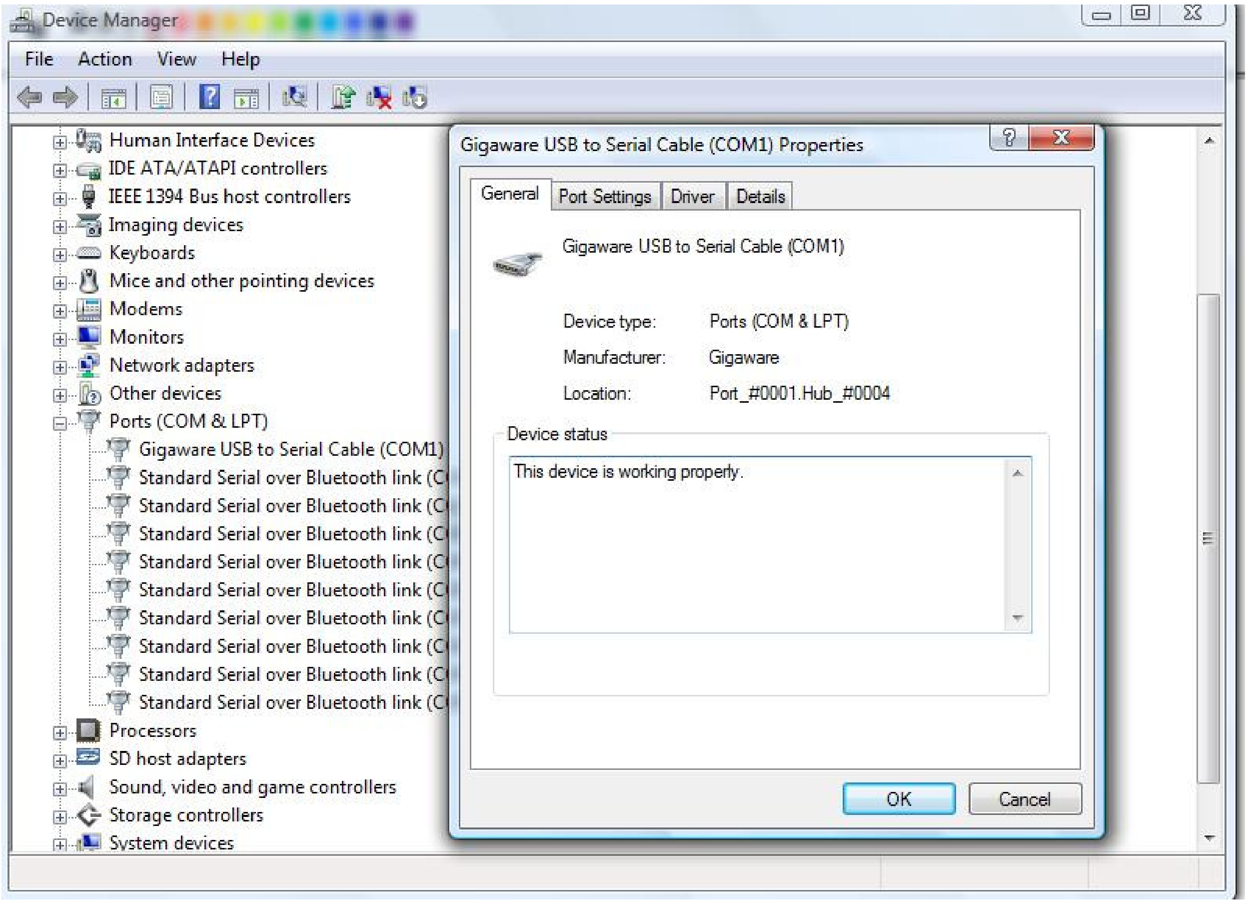


Figure 4.6 "Serial Port Properties"

The serial port must be configured in order to work properly with the interface, using the device manager the serial port must be configured to the following:

The COM port must be Port1: COM1

The Bits per Seconds Rate must be: 9600

The Data Bits must be: 8 bits

The Stop Bits must be: 1 bit

The Flow Control must be: None

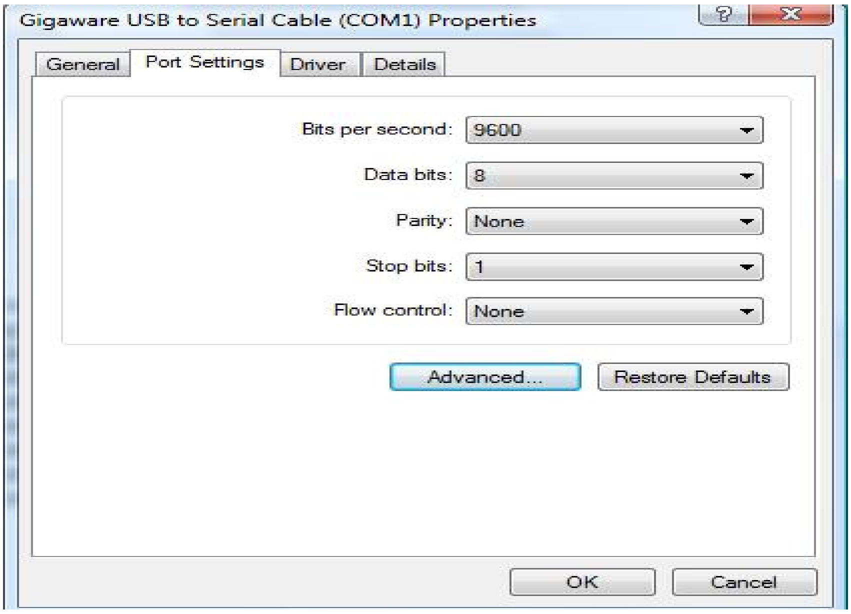


Figure 4.7 "Serial Port Configuration"

4.1.2.2 Opening the Serial Port

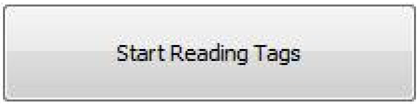


Figure 4.8 "Start Reading Tags Button i.e. opens serial port"

Open serial port C# code:

```
int x = 1;
            if (axrfidAX1.OpenPort(ref x) == true)
            {
                MessageBox.Show("Starting Reading Tags, COM1 port
opened");
            }
            else
            {
                MessageBox.Show("Error opening port COM1");
            }
```

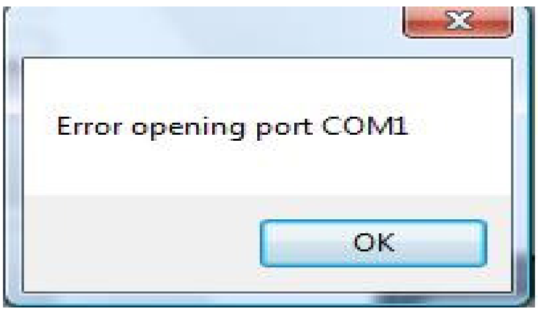


Figure 4.9 "COM1 port error message"

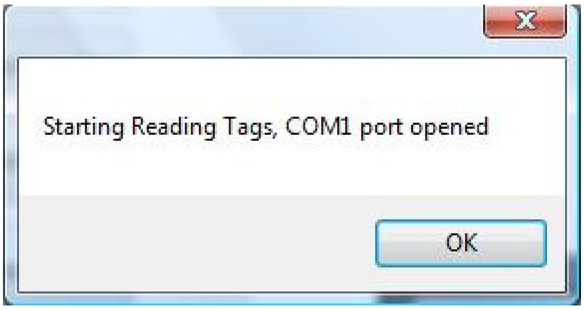


Figure 4.10 "COM1 port opened message"

4.1.2.3 Closing the Serial Port

Figure 4.11 "Stop Reading Tags Button i.e. closes serial port"

Close serial port C# code:

```
if (axrfidAX1.ClosePort() == true)
            {
                MessageBox.Show("Stopping Reading Tags, COM1 port closed");
            }
```

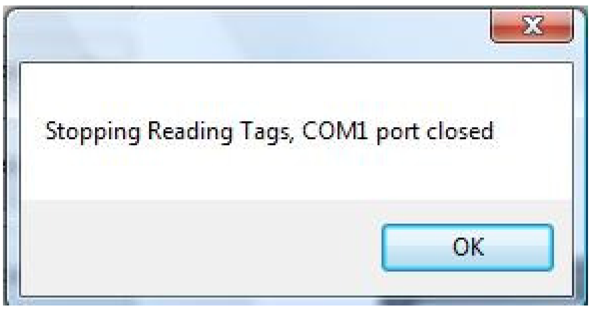


Figure 4.12 "COM1 port closed message"

4.1.3 Reading the RFID Tags

The tags send its 4 bit unique ID every 2.5 seconds along with the 2 bit received signal strength indication, the reader reads there 6 bit characters and when the serial port is open it sends them to the interface where we divide the first 4 bits which are the unique tag ID and store them in a variable "string" called n1, and the other 2 bits which represent the received signal strength indication is stored in another variable "string" called n2.

The tag ID and the received signal strength along with the date and time of reading the tag are displayed in a list box.

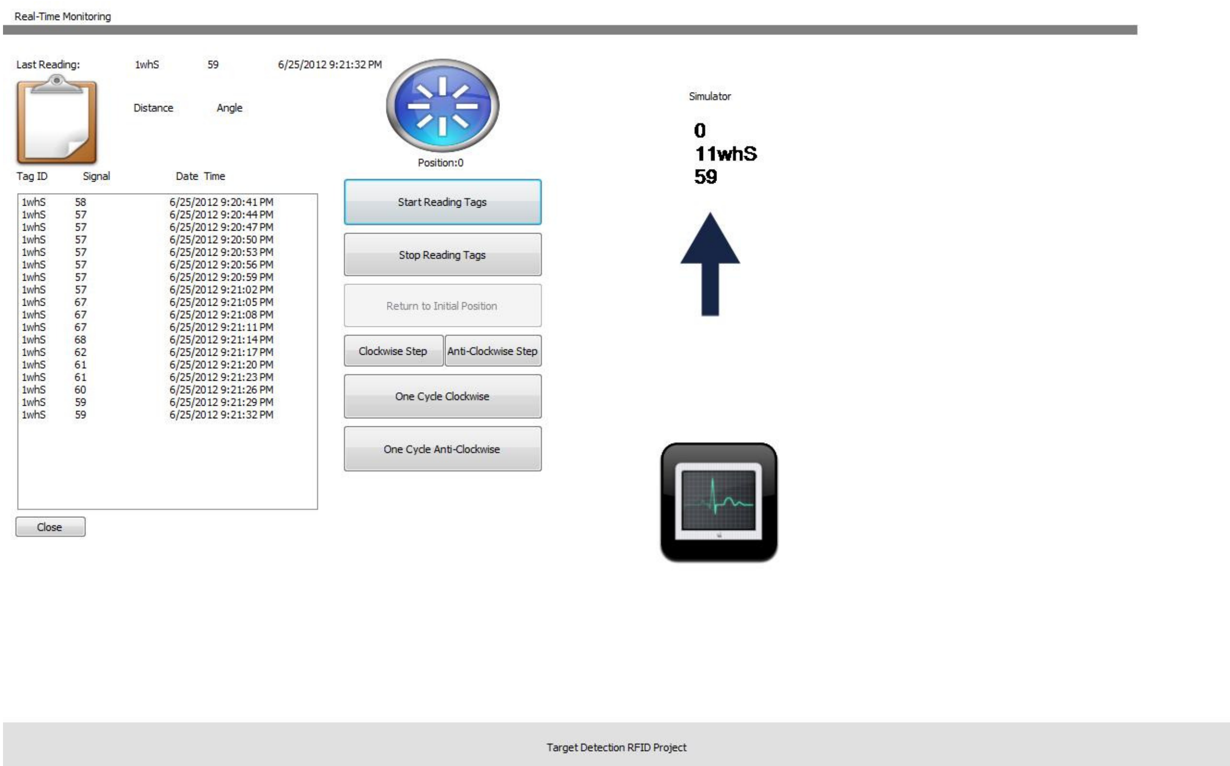


Figure 4.13 "Monitoring Form displaying Tags and its Signal in a List box"

Code for dividing the 6 bit characters to tag ID and Signal Strength and storing them in a List box:

```
       string n1 ;
       string n2 ;
public void axrfidAX1_rfidData(object
sender,AxRFIDX.__rfidAX_rfidDataEvent e)
        {
             n1 = e.sID.Substring(0, 4);
             n2 = e.sID.Substring(4, 2);
            listBox1.Items.Add(n1 + "     " + n2 + "       " +
e.dDataTime);

            label4.Text = n1;
            label5.Text = n2;
            label6.Text = e.dDataTime.ToString();
        }
```

4.1.4 Running the Stepper Motor

4.1.4.1 Parallel Port connection

The stepper motor is connected to the computer via a parallel port.

Accessing the parallel port is done so we can send data to the stepper motor, the data which is sent to the stepper motor is used to rotate the stepper motor to the desired direction depending on the data sent for the computer.

A class called PortAccess is created in order to communicate with the parallel port; also a file called input inpout32.dll must be placed in the System32 folder in Windows folder.

The code of the PortAccess Class:

```
private class PortAccess
        {
            [DllImport("inpout32.dll", EntryPoint = "Out32")]
            public static extern void Output(int address, int value);
        }
```

4.1.4.2 Rotating the stepper motor

4.1.4.2.1 Rotating the stepper motor one step clockwise

The stepper motor has a step size of 7.5 degree.

To rotate the stepper motor in the clockwise direction we send data to the interface of the stepper motor via the parallel port to excite the coils in order to rotate it in clockwise direction we send data as follows 3,9,12,6.

The method for doing so is called clockwisestep() its code is:

```
    static int output;
    static double x = 0;
public static void clockwisestep()
{
     if (output == 3) output = 9;
     else if (output == 9) output = 12;
     else if (output == 12) output = 6;
     else if (output == 9) output = 3;
     else output = 3;
     PortAccess.Output(888, output);
     System.Threading.Thread.Sleep(50);

}
```

By clicking on the Clockwise Step Button the stepper motor rotates one step in the clockwise direction, by calling the method clockwisestep() and incrementing the value of x which is the angle of rotation of the motor, when the angle is equal to 360 or -360 or 0 degrees the motor is in its initial position so the Return to Initial position button is deactivated, else the button is activated.

Figure 4.14"Clockwise Step Button"

The code for rotating the stepper motor in a clock wise direction:

```
private void button3_Click(object sender, EventArgs e)
        {

            clockwisestep();
            x += 7.5;
            if (x != 0 && x != 360 && x != -360)
                button7.Enabled = true;
            else
                button7.Enabled = false;
            if (x == 360 || x == -360)

                x = 0;
            label7.Text = "Position:" + x + "°";
         }
```

4.1.4.2.2 Rotating the stepper motor one step anti-clockwise

To rotate the stepper motor in the anti-clockwise direction we send data to the interface of the stepper motor via the parallel port to excite the coils in order to rotate it in clockwise direction we send data as follows 6,12,9,3.

The method for doing so is called anticlockwisestep() its code is:

```
           static int output;
           static double x = 0;
        public static void clockwisestep()
        {
            if (output == 3) output = 6;
            else if (output == 6) output = 12;
            else if (output == 12) output = 9;
            else if (output == 9) output = 3;
            else output = 3;
            PortAccess.Output(888, output);
            System.Threading.Thread.Sleep(50);

        }
```

By clicking on the Anti-Clockwise Step Button the stepper motor rotates one step in the clockwise direction, by calling the method anticlockwisestep() and incrementing the value of x which is the angle of rotation of the motor, when the angle is equal to 360 or -360 or 0 degrees the motor is in its initial position so the Return to Initial position button is deactivated, else the button is activated.

Figure 4.15"Anti-Clockwise Step Button"

The code for rotating the stepper motor in an anti-clock wise direction:

```
private void button4_Click(object sender, EventArgs e)
        {
            anticlockwisestep();
            x -= 7.5;
            if (x != 0 && x != 360 && x != -360)
                button7.Enabled = true;
            else
                button7.Enabled = false;
            if (x == 360 || x == -360)
                x = 0;

            label7.Text = "Position:" + x + "°";

        }
```

4.1.4.2.3 Rotating the stepper motor one cycle in the clockwise direction

In order to rotate the stepper motor a full cycle 360 degrees we need to rotate the stepper motor 48 single steps to have a full cycle "since 360 degrees of a full cycle divided by 7.5 degrees of a single step gives us 48 steps for a full cycle"

So by a loop of 48 iterations and a stopping condition of iterations greater than 48, we can rotate the stepper motor a full cycle.

Figure 4.16"One Cycle Clockwise Button"

The code for rotating the stepper motor one cycle in clock wise direction:

```
private void button5_Click(object sender, EventArgs e)
        {
            int i;
            for (i = 1; i <= 48; i++)
            {
                double f = 7.5 * i;
                clockwisestep();


             }

        }
```

4.1.4.2.4 Rotating the stepper motor one cycle in the Anti-clockwise direction

In order to rotate the stepper motor a full cycle 360 degrees we need to rotate the stepper motor 48 single steps to have a full cycle "since 360 degrees of a full cycle divided by 7.5 degrees of a single step gives us 48 steps for a full cycle"

So by a loop of 48 iterations and a stopping condition of iterations greater than 48, we can rotate the stepper motor a full cycle.

Figure 4.17"One Cycle Anti-Clockwise Button"

The code for rotating the stepper motor one cycle in Anti-clock wise direction:

```
private void button5_Click(object sender, EventArgs e)
        {
            int i;
            for (i = 1; i <= 48; i++)
            {
                double f = -7.5 * i;
                anticlockwisestep();


             }

        }
```

4.1.4.3 Returning the stepper motor to its initial position

To return the stepper motor to its initial position the motor must have already rotated, and we must find the direction of rotation, so we check the variable x which determines if the rotation was in the clock wise direction if x has a positive value and the rotation was in the anti-clock wise direction is x has a negative value.

Figure 4.18"Return to Initial Position Button Activated"

So if the value of x was positive then it was in the clock wise direction, in order to return it to its initial position in the shortest way we must check if the angle of rotation was less than or greater than 180 degrees; if the angle of rotation is less than 180 degrees, we rotate the motor in the opposite direction "anti-clock wise" until the angle of rotation equals zero which means that it is in the initial position, if the angle of rotation is greater than or equal to 180 degrees we rotate the motor in the same direction ”clock wise” so it has a shorter distance to the initial position, until the angle of rotation equals 360 degrees.

Similarly if x has a negative value then the rotation was in the anti-clock wise direction, also we must check if the value of x is greater than or less -180 degrees, if the angle of rotation is greater than 180 degrees so it is better and shorter to rotate it in the same direction “anti-clock wise” until the angle of rotation equals to - 360 degrees, which means that the motor is at its initial position. And if the angle of rotation is less than -180 degrees we rotate the motor in the opposite direction “clock wise” until the angle of rotation becomes zero which means that the motor is at its initial position.

When the motor is at its initial position which is either at zero degrees or 360 degrees or -360 degrees we set the position to zero and make the Return to Initial Position Button Deactivated.

Figure 4.19”Return to Initial Position Button Deactivated”

4.2 Database in the program

A database is an organized collection of data, today typically in digital form. The data are typically organized to model relevant aspects of reality (for example, the availability of rooms in hotels), in a way that supports processes requiring this information (for example, finding a hotel with vacancies).

The term *database* is correctly applied to the data and their supporting data structures, and not to the database management system (DBMS). The database data collection with DBMS is called a database system.

The term *database system* implies that the data is managed to some level of quality (measured in terms of accuracy, availability, usability, and resilience) and this in turn often implies the use of a general-purpose database management system (DBMS).[1] A general-purpose DBMS is typically a complex software system that meets many usage requirements, and the databases that it maintains are often large and complex. The utilization of databases is now so widespread that virtually every technology and product relies on databases and DBMSs for its development and commercialization, or even may have such software embedded in it. Also, organizations and companies, from small to large, depend heavily on databases for their operations.

Well known DBMSs include Oracle, IBM DB2, Microsoft SQL Server, Microsoft Access, PostgreSQL, MySQL, and SQLite. A database is not generally portable across different DBMS, but different DBMSs can inter-operate to some degree by using standards like SQL and ODBC together to support a single application. A DBMS also needs to provide effective run-time execution to properly support (e.g., in terms of performance, availability, and security) as many end-users as needed.

A way to classify databases involves the type of their contents, for example: bibliographic, document-text, statistical, or multimedia objects. Another way is by their application area, for example: accounting, music compositions, movies, banking, manufacturing, or insurance.

The term *database* may be narrowed to specify particular aspects of organized collection of data and may refer to the logical database, to the physical database as data content in computer data storage or to many other database sub-definitions. [11]

The Language used to manage and manipulate data in the program is SQL "Structured Query Language", and the Database Management System is Microsoft SQL Server 2005.

To store the data we want we created a database called RFID containing the tables we needed to store in order to manipulate the data easily.

One of the tables is called RFID it contains the following columns:

Id2, ID, Signal, Distance, Angle, Date, and Description.

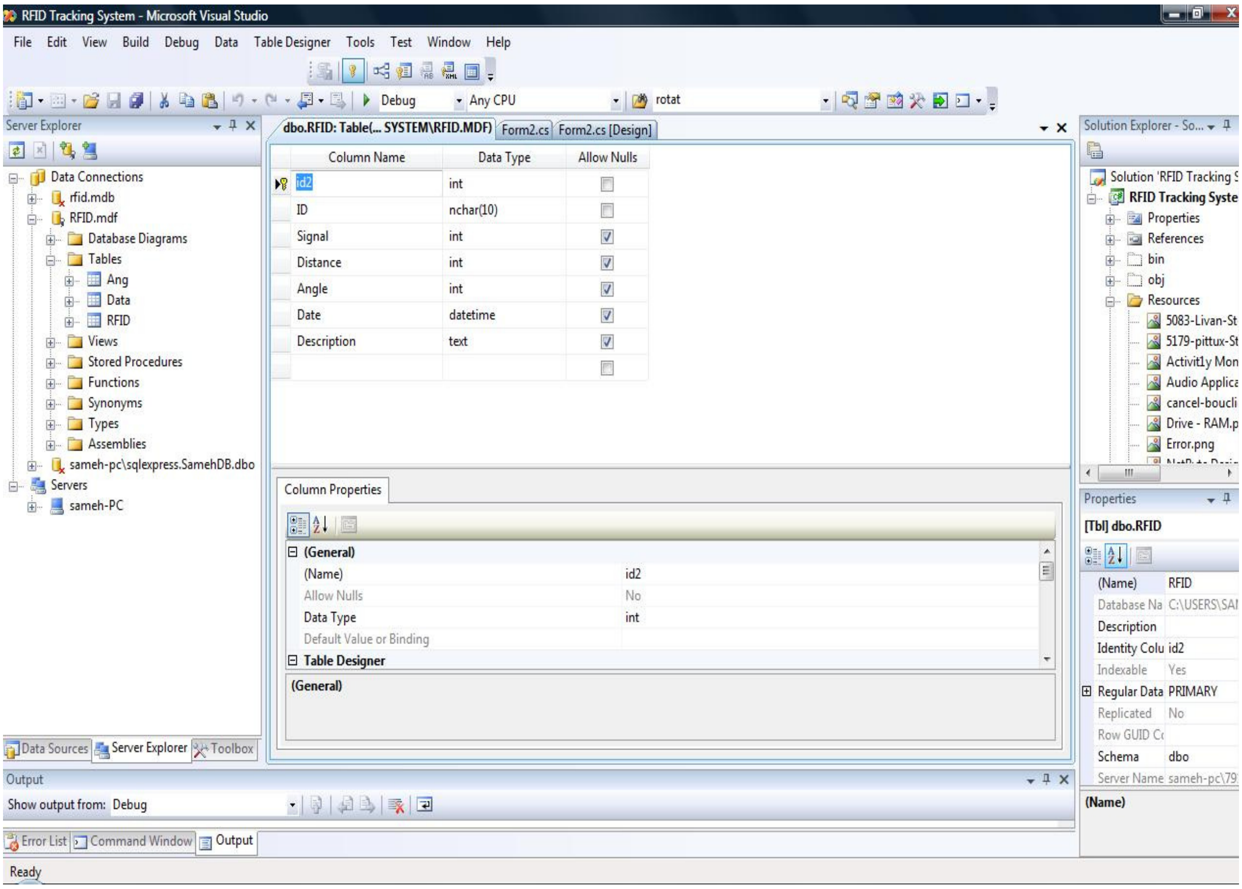


Figure 4.20"Table1 RFID"

4.2.1 Inserting values in a Table

The following table can be used to insert the values of the tag like its ID, Signal Strength indication, received time, calculated angle and distance.

The code for inserting these data in the database is:

```
SqlConnection Con = new SqlConnection("Data
Source=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sameh\\Documents\\Visu
al Studio 2008\\Projects\\RFID Tracking System\\RFID.mdf\";Integrated
Security=True;Connect Timeout=30;User Instance=True");


Con.Open();

SqlCommand Cmd = new SqlCommand("insert into RFID (ID, Signal , [Date])
values('"+label4.Text+"',"+label5.Text+",'"+label6.Text+"')", Con);
```

```
Cmd.ExecuteNonQuery();

Con.Close();
```

Another table in the database is called Data which contains the description of the Tags.

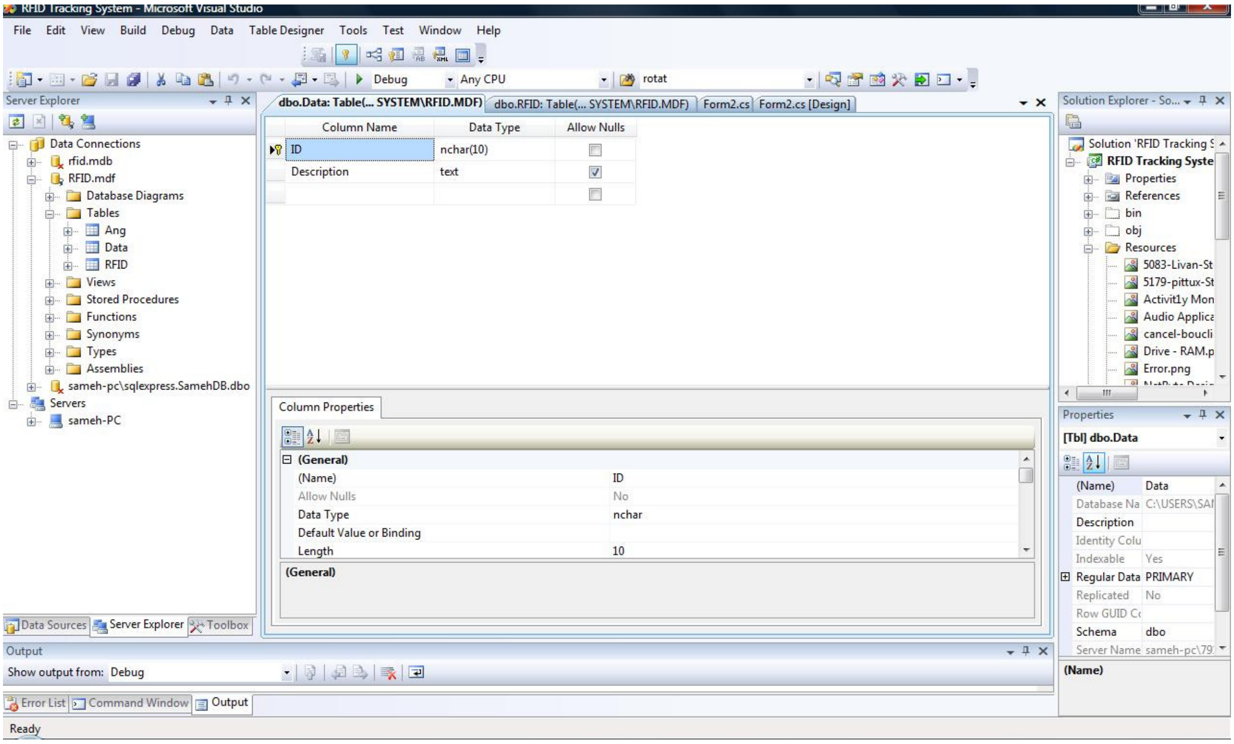


Figure 4.21"Table2 Data"

To insert a description of a Tag, the tag ID is first selected from the Table RFID of the database, and it is then put in a combo box so the user can select the tag he wants to add a description to; then the user can add the description he wants in the text box.

By pressing the add button the values of the Tag ID and the description are stored in the Table Data in the database.

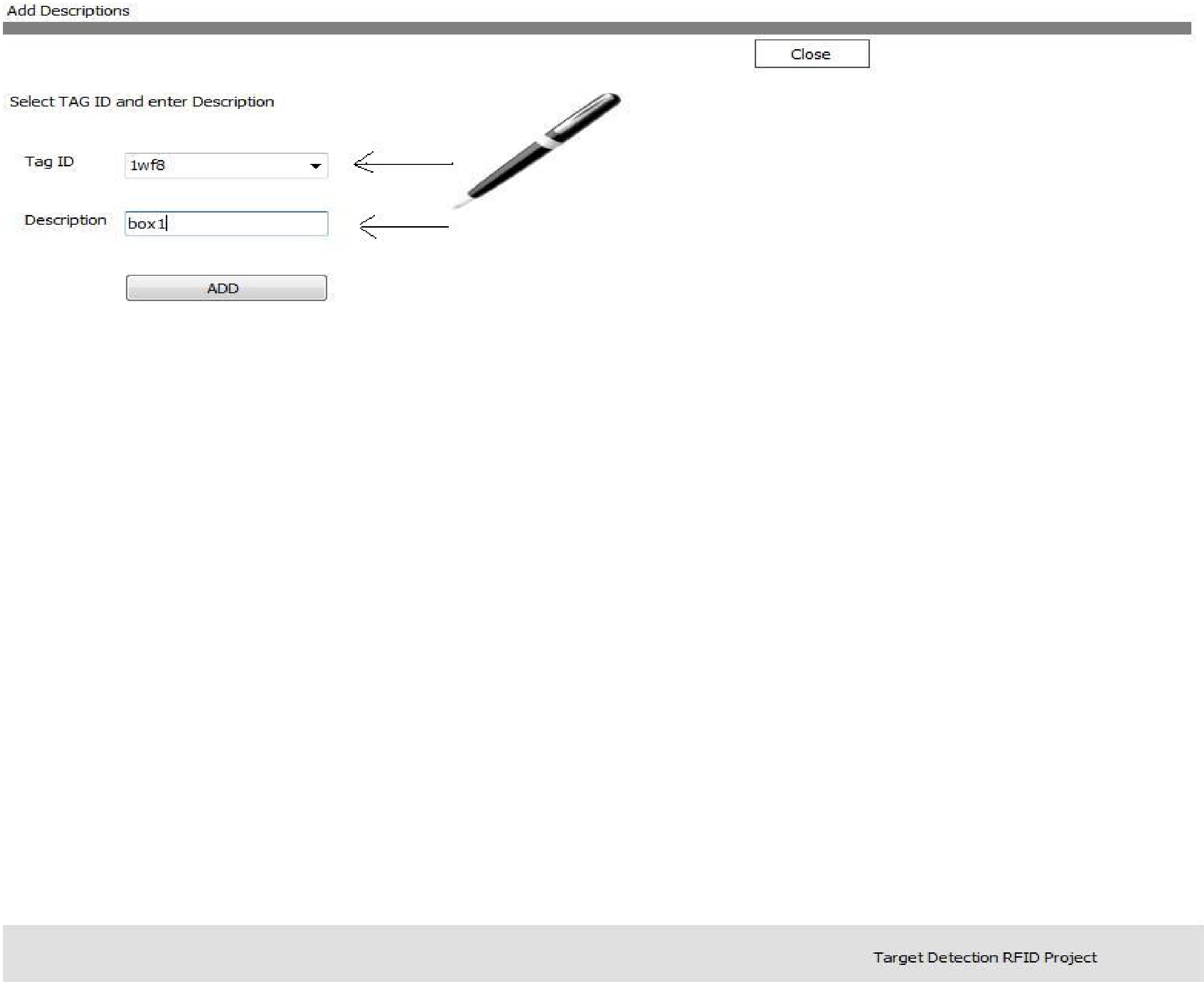


Figure 4.22"Inserting Descriptions in the Data Table"

4.2.2 Selecting values from a Table

We try to select the first value of the description, so it helps if the user wants to update so he can see the last stored value of the description.

If there is no description stored before the textbox where the user puts the description is set to be empty.

If there is a description that was stored before the last description is returned and put in the textbox.

The code for selecting descriptions from the Database Table Data is:

```
      private void comboBox1_SelectedIndexChanged(object sender,
EventArgs e)
        {

SqlConnection Con = new SqlConnection("Data
Source=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sameh\\Documents\\Visu
al Studio 2008\\Projects\\RFID Tracking System\\RFID.mdf\";Integrated
Security=True;Connect Timeout=30;User Instance=True");

            Con.Open();

SqlCommand Cmd = new SqlCommand("Select description from Data where
id='"+comboBox1.Text+"'", Con);

try
            {

                textBox2.Text = Cmd.ExecuteScalar().ToString();

            }
catch
            {

                textBox2.Text = "";

            }

            Con.Close();

        }
```

And when the form loads it selects the values of Tag IDs from the table RFID and puts it in the combo box for the user to select the required Tag ID so he can add the description.

The code for selecting the Tags ID is:

```
private void Form3_Load(object sender, EventArgs e)
        {

            SqlConnection Con = new SqlConnection("Data
Source=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sameh\\Documents\\Visu
al Studio 2008\\Projects\\RFID Tracking System\\RFID.mdf\";Integrated
Security=True;Connect Timeout=30;User Instance=True");


            Con.Open();

            SqlDataAdapter AD1 = new SqlDataAdapter("Select DISTINCT
RFID.ID from RFID", Con);

            DataTable T1 = new DataTable();

            AD1.Fill(T1);

            comboBox1.DataSource = T1;

            comboBox1.DisplayMember = "ID";

            comboBox1.ValueMember = "ID";

            Con.Close();
        }
```

4.2.3 Inserting and Updating values in a Table

And by clicking on the Add button the values are either inserted if there was no description before or updated if there was a description before, so we first try to update the data if it is not updated we check if there was nothing added before so it there was nothing added before we insert the values in the database.

The code for Updating or Inserting:

```
private void button1_Click(object sender, EventArgs e)
        {
            SqlConnection Con = new SqlConnection("Data
Source=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sameh\\Documents\\Visu
al Studio 2008\\Projects\\RFID Tracking System\\RFID.mdf\";Integrated
Security=True;Connect Timeout=30;User Instance=True");
            //SqlConnection Con = new SqlConnection("Data Source=SAMEH-
PC\\sqlexpress;Initial Catalog=SamehDB;Integrated
Security=True;Pooling=False");
            Con.Open();
            SqlCommand Cmd = new SqlCommand("update Data set description
='"+textBox2.Text+"' where id='"+comboBox1.Text+"'", Con);
            int j = Cmd.ExecuteNonQuery();
            if (j == 0)
            {
                Cmd = new SqlCommand("insert into Data
values('"+comboBox1.Text+"','"+textBox2.Text+"')", Con);
                j = Cmd.ExecuteNonQuery();
            }
                Con.Close();

            {
                MessageBox.Show("Tag ID:"   + comboBox1.Text +    "
Description:"  + textBox2.Text +  "\nItem Description Added");

            }
            this.Close();
        }
```

4.2.4 Selecting Descriptions from Data Table

Here we select the values of the Tags ID and the descriptions added

The code:

```
private void Form4_Load(object sender, EventArgs e)
        {
            SqlConnection Con = new SqlConnection("Data
Source=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sameh\\Documents\\Visu
al Studio 2008\\Projects\\RFID Tracking System\\RFID.mdf\";Integrated
Security=True;Connect Timeout=30;User Instance=True");
            Con.Open();
            SqlDataAdapter AD = new SqlDataAdapter("SELECT * FROM Data ",
Con);
            DataTable T = new DataTable();
            AD.Fill(T);
            dataGridView1.DataSource = T;
            Con.Close();
        }
```

4.2.5 Selecting All Data from RFID Table

Here we select all the stored data in the RFID table.

The code:

```
private void Form5_Load(object sender, EventArgs e)
        {
            SqlConnection Con = new SqlConnection("Data
Source=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sameh\\Documents\\Visu
al Studio 2008\\Projects\\RFID Tracking System\\RFID.mdf\";Integrated
Security=True;Connect Timeout=30;User Instance=True");
            Con.Open();
            SqlDataAdapter AD = new SqlDataAdapter("SELECT * FROM RFID ",
Con);
            DataTable T = new DataTable();
            AD.Fill(T);
            dataGridView1.DataSource = T;
            Con.Close();

        }
```

4.3 Angle Calculation

The angle of the detected Tag is calculated by continuously reading the data transmitted by the tags in each of the 48 steps of the cycle of the stepper motor, and selecting the maximum received signal, and by determining the index of the maximum signal and multiplying it by 7.5 degrees, we could be able to find the angle of the Tag.

By storing the values of these readings in a table in the database we could find the index of the maximum signal, but we must take into consideration that the table must be reset every one cycle in order to correctly find the angle.

The angle is not 100% accurate since the Tags transmit its ID and the Signal Strength every 2.5 seconds ± 0.5 seconds, which could affect the calculated signal.

In order to keep the angle that we calculated before deleting the table and resetting the index counter we store it in a table which contains the final calculated angle and distance called Final table.

The SQL code for selecting the Max signal:

The following code is saved in a View Called dbo.Vw.Ang

```
SELECT       ID, MAX(Signal) AS Signal
FROM          dbo.Ang
GROUP BY ID
```

Where dbo.Ang is the Table of recorded readings in one cycle.

To select the id "the index" of the detected tag we might face a problem which is that the maximum signal is the same for many indexes so we select the first index of the angle.

The Final SQL code for finding the maximum angle and its index:

```
SELECT        MIN(dbo.Ang.id3) AS id3, dbo.Ang.ID, dbo.Ang.Signal
FROM           dbo.Ang INNER JOIN
                          dbo.VwAng ON dbo.Ang.ID = dbo.VwAng.ID AND
dbo.Ang.Signal = dbo.VwAng.Signal
GROUP BY dbo.Ang.ID, dbo.Ang.Signal
```

Where dbo.VwAng is the pervious view.

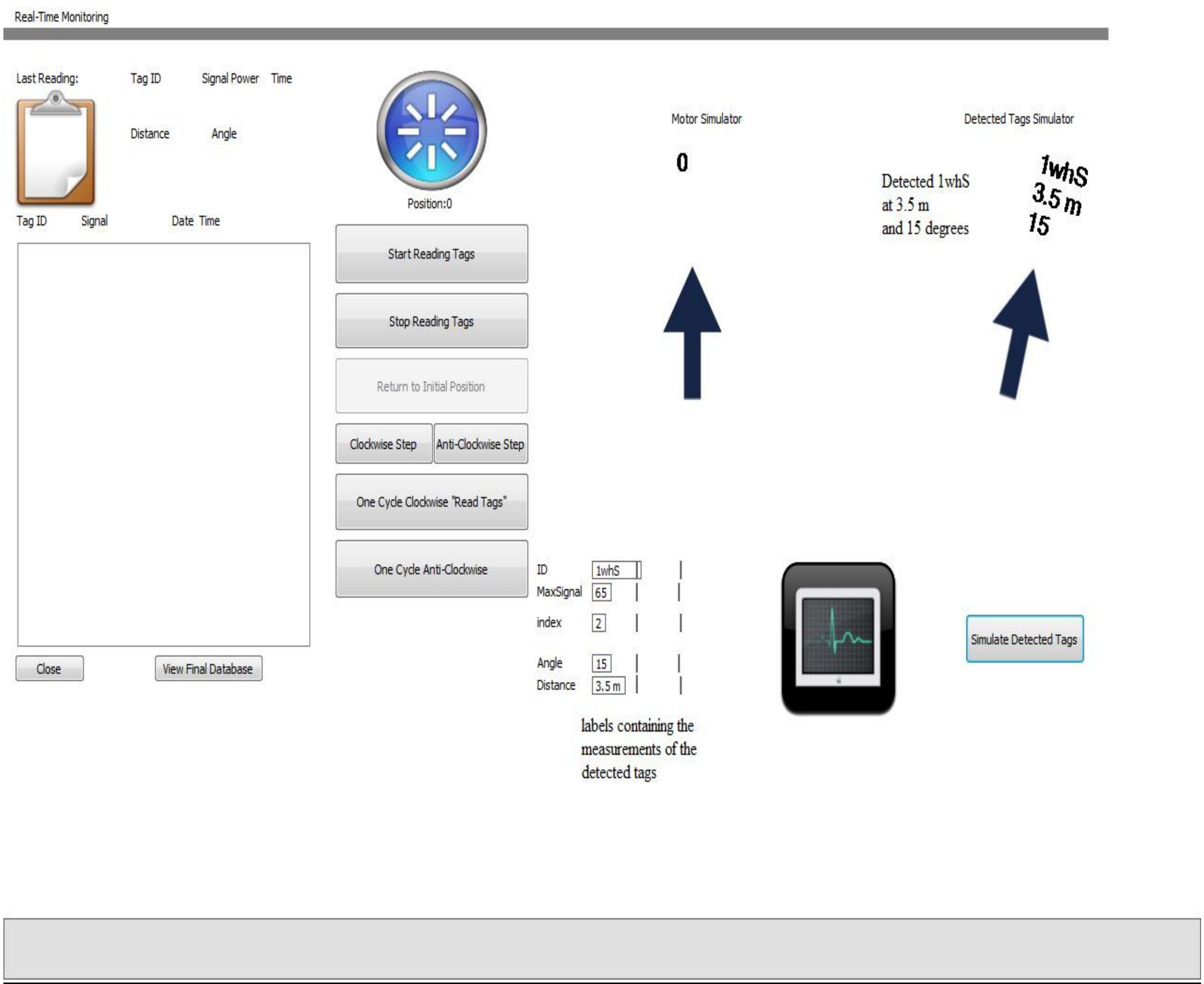


Figure 4.23"Detected Tag and its measurements"

4.4 Distance Calculation

Distance calculation is done by finding the corresponding value of the received signal practically, by means of trial and error.

So for example if the range of the received signal is from 30 to 40 means that the distance is 0.5 meters for example.

And if the range of the received signal is from 20 to 30 means that the distance is 1 meter for example…. And so on.

So we first select the maximum received signal from the database and then check the range of this signal and then we could determine the distance.

The code for determining the distance corresponding to a given signal:

```
SqlCommand Cmddd = new SqlCommand("SELECT * FROM VwAngFinal", Con);
SqlDataReader Dr = Cmddd.ExecuteReader();
Dr.Read();
label15.Text = Dr["Signal"].ToString();
label16.Text = Dr["id3"].ToString();
label32.Text = Dr["ID"].ToString();
Double res = Double.Parse(label16.Text);
res = res * 7.5;
label26.Text = res.ToString();
if (Double.Parse(label15.Text) >= 0 && Double.Parse(label15.Text) <= 10)
                {
                label28.Text = "2.5 m";
                }
else if (Double.Parse(label15.Text) > 10 && Double.Parse(label15.Text) <=
20)
                {label28.Text = "2 m";
                }
else if (Double.Parse(label15.Text) > 20 && Double.Parse(label15.Text) <=
30)
                {
                    label28.Text = "1.5 m";
                }
else if (Double.Parse(label15.Text) > 30 && Double.Parse(label15.Text) <=
40)
                {
                    label28.Text = "1 m";
                }
else if (Double.Parse(label15.Text) > 40 && Double.Parse(label15.Text) <=
50)
                {
                    label28.Text = "0.75 m";
                }
```

```
else if (Double.Parse(label15.Text) > 50 && Double.Parse(label15.Text) <=
60)
                {
                    label28.Text = "0.5 m";
                }
else if (Double.Parse(label15.Text) > 60 && Double.Parse(label15.Text) <=
70)
                {
                    label28.Text = "0.25 m";
                }
```

4.5 Simulation

4.5.1 Introduction

Simulation is done to make the user visualize what is actually happening in the system and to help the user monitor the system easily.

We have done the simulation using an imported class called Utilities.cs which helps us rotate and draw and write required values.

4.5.2 Motor Simulation

Motor simulation is done so that what is happening in the motor system can be visualized on the interface; if the motor is rotating a full cycle in the Anti-Clock wise direction for example the Motor Simulator also rotates in the same direction as the motor is rotating.

The Motor Simulator also gives the angle, at which the motor is actually standing at, also when the motor is ordered to return to its first or initial position the motor simulator moves to the initial position and the angle becomes 0.

Figure 4.24"Motor Simulator"

4.5.2.1 Motor Simulation Motor Step Clockwise

When the motor rotates in the clock wise direction when pressing the once step clockwise button the motor rotates in the clockwise direction and also the simulator rotates in the clock wise direction indicating the corresponding angle at which the motor is at.

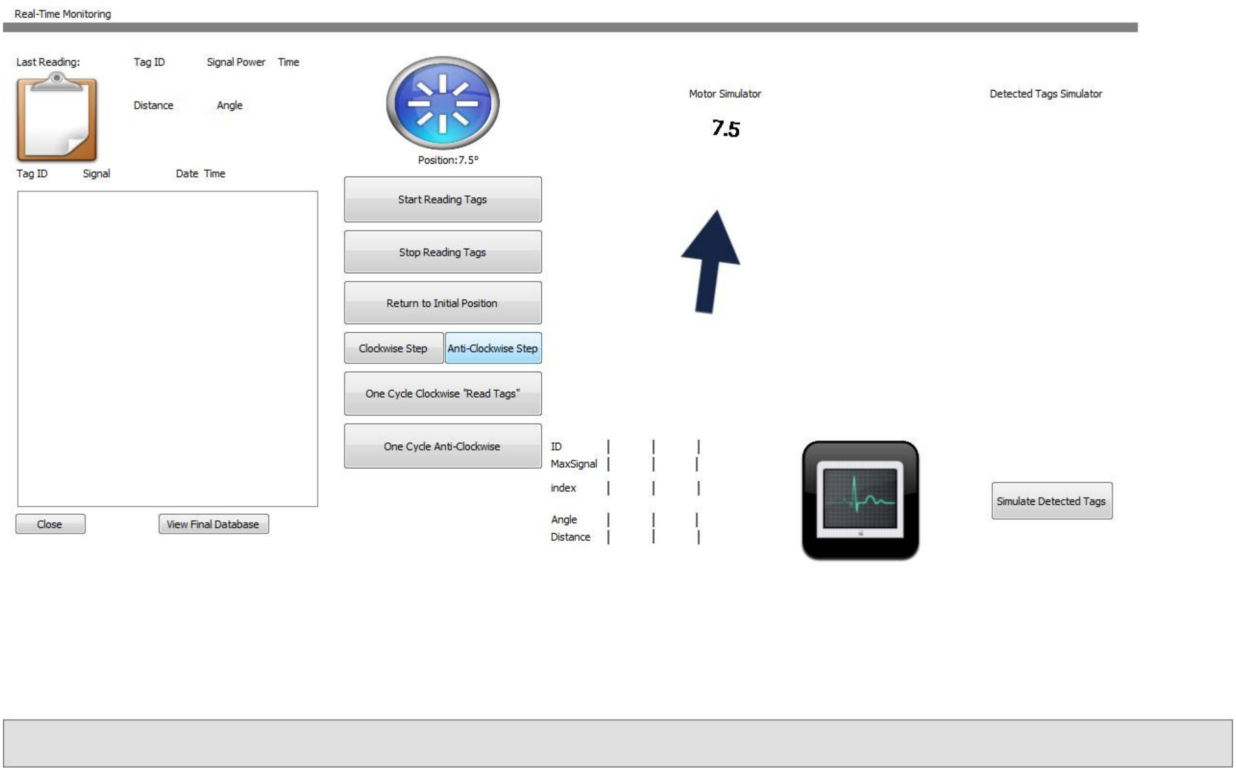


Figure 4.25"Motor Simulator after pressing clockwise step button"

The code for rotating the arrow of the Motor simulator when pressing the clockwise step button:

```
RotateImage(x.ToString(), pictureBox1, image, (float)x);
```

Where x is the angle of the rotation of the motor,x having a positice value.

4.5.2.2 Motor Simulation Motor Step Anti-Clockwise

When the motor rotates in the anti-clock wise direction when pressing the once step anti-clockwise button the motor rotates in the anti-clockwise direction and also the simulator rotates in the anti-clock wise direction indicating the corresponding angle at which the motor is at.

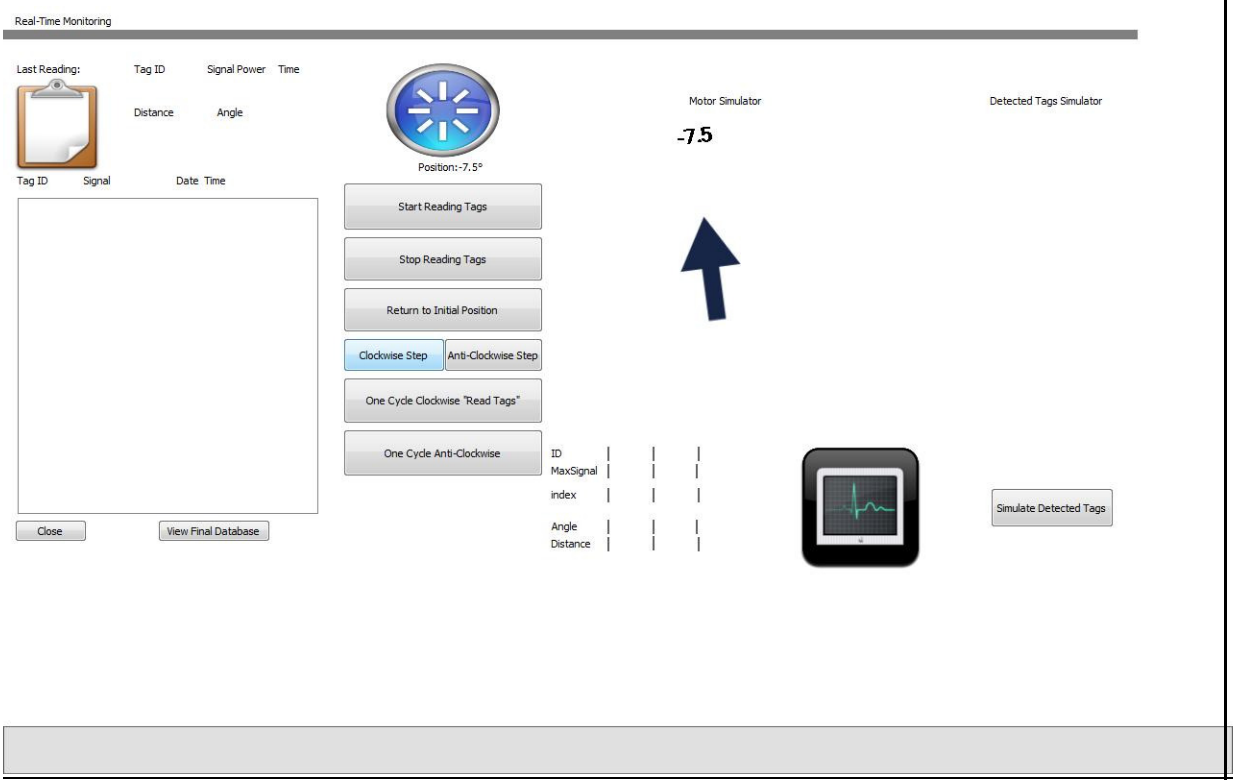


Figure 4.26"Motor Simulator after pressing Anti-clockwise step button"

The code for rotating the arrow of the Motor simulator when pressing the Anti-clockwise step button:

```
RotateImage(x.ToString(), pictureBox1, image, (float)x);
```

Where x is the angle of the rotation of the motor, knowing that x has a negative value, since it is in the anti-clockwise direction.

4.5.2.3 Motor Simulation Motor Step One Cycle Clock wise

When the Motor rotates a full cycle the simulator also rotates in the same direction as the motor.

The code for rotating the motor one cycle in the clock wise direction:

```
int i;
            for (i = 1; i <= 48; i++)
            {
                double f = 7.5 * i;
                clockwisestep();


                RotateImage(((x + f) % 360).ToString(), pictureBox1,
                image, (float)((x + f) % 360));
                Application.DoEvents();


            }
RotateImage(x.ToString(), pictureBox1, image, (float)x);
```

4.5.2.4 Motor Simulation Motor Step One Anti-Cycle Clock wise

When the Motor rotates a full cycle the simulator also rotates in the same direction as the motor.

The code for rotating the motor one cycle in the anti-clock wise direction:

```
int i;

            for (i = 1; i <= 48; i++)
            {
                double f = -7.5 * i;
                anticlockwisestep();
            RotateImage(((x + f) % 360).ToString(), pictureBox1, image,
            (float)((x + f) % 360));
                Application.DoEvents();

            }
            RotateImage(x.ToString(), pictureBox1, image, (float)x);
```

4.5.2.5 Motor Simulation Motor Returning to first position

To return the Simulator Motor arrow to its initial position we first check the value of the angle of the motor “x” if it has a positive value then the motor rotation was in the clock wise direction, then we check the value of “x” if it is less than 180 degrees we rotate the motor in the opposite direction “anti-clock wise” and decrease the angle by 7.5 degrees until the value of x equals zero which means that it is at the initial position while we do that we use the method RotateImage to rotate the image of the simulator until it is at its initial position.

On the other hand if the angle “x” is at a value greater than 180 degrees we rotate the motor in the same direction and increase the value of x by 7.5 degrees until it is equal to 360 degrees. We also use the same method RotateImage to rotate the motor using the value of x until the arrow is at the initial position.

But if the angle of rotation of the motor “x” has a negative value this means that the motor has rotated in an anti-clock wise direction and also we check the value of “x” again if it has a value less than negative 180 degrees the rotate the motor in the opposite direction and decrease the value of "x" by negative 7.5 degrees until the value of "x" is equal to -360 degrees, and if the value of x is positive we rotate the motor arrow in the same direction and increase the value of x by 7.5 degrees until the value of x becomes zero.

The code for rotating the motor simulator arrow to its initial position:

```
if (x > 0)
            {
                if (x < 180)
                {
                    do
                    {
                        anticlockwisestep();
                        x -= 7.5;
                        RotateImage(x.ToString(), pictureBox1, image,
(float)x);
                        Application.DoEvents();
                    } while (x != 0);
                }
                else if (x >= 180)
                {
                    do
                    {
                        clockwisestep();
                        x += 7.5;
                        RotateImage(x.ToString(), pictureBox1, image,
(float)x);
                        Application.DoEvents();
                    } while (x != 360);
                }
            }
            else if (x < 0)
            {
                if (x < -180)
                {
                    do
                    {
                        anticlockwisestep();
                        x -= 7.5;
                        RotateImage(x.ToString(), pictureBox1, image,
(float)x);
                        Application.DoEvents();
                    } while (x != -360);
                }
                else if (x >= -180)
                {
                    do
                    {
                        clockwisestep();
                        x += 7.5;
                        RotateImage(x.ToString(), pictureBox1, image,
(float)x);
                        Application.DoEvents();
                    } while (x != 0);
                }
            }
```

```
button7.Enabled = false;
if (x == 360 || x == -360)
    x = 0;
label7.Text = "Position:" + x+"°";


RotateImage(x.ToString(), pictureBox1, image, (float)x);
```

4.5.3 Detected Tags Simulation

The Simulate Detected Tags Button Simulates the Measurements and data of the detected tags, using the Detected Tags Simulator.

When the motor rotates a full clockwise cycle the values of the detected tags that are found are passed to the Simulate Detected Tags Button and by pressing it simulates the location of the detected tag, and by pressing on the button again it checks if there is another tag that was detected and also simulates its location and measurements.

It is accurate within the quarter of the coordinates.

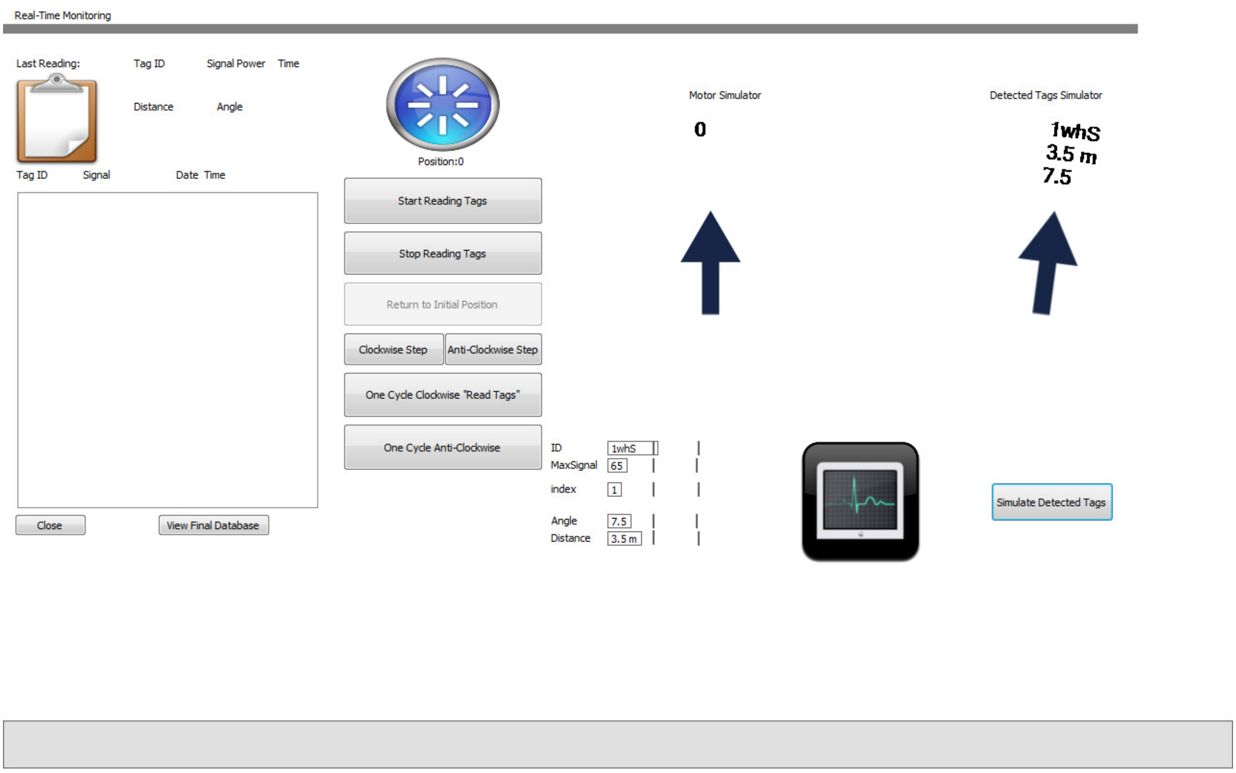


Figure 4.27"Detected Tags Simulator after pressing Simulate Detected button"

The code for Simulating detected Tags:

```
int CurArrow = 0;
Bitmap image1 = new Bitmap(Application.StartupPath + "\\arrow.png");
            pictureBox5.Image = new Bitmap(Application.StartupPath +
"\\arrow.png");
            if (CurArrow == 0)
            {
                try
                {
                    RotateImage(label33.Text.ToString() + "\n" +
label29.Text.ToString() + "\n" + label24.Text.ToString(), pictureBox5,
image1, float.Parse(label24.Text));
                    //
                }
                catch
                {
                }
            }
            else if (CurArrow == 1)
            {
                try
                {
                    RotateImage(label32.Text.ToString() + "\n" +
label28.Text.ToString() + "\n" + label26.Text.ToString(), pictureBox5,
image1, float.Parse(label26.Text));

                }
                catch
                {
                }
            }
            else if (CurArrow == 2)
            {
                try
                {
                    RotateImage(label34.Text.ToString() + "\n" +
label30.Text.ToString() + "\n" + label25.Text.ToString(), pictureBox5,
image1, float.Parse(label25.Text));

                }
                catch
                {
                }
            }
            else if (CurArrow == 3)
            {
                RotateImage("", pictureBox5, image1, (float)0);

            }
            CurArrow = (CurArrow + 1) % 4;
```

4.6 Extra Application Using RFID Technology "Smart Shopping Cart"

4.6.1 Introduction

The Smart Shopping Cart is a new application made using the RFID technology, is has many advantages such as speeding up the process of buying goods and products, instead of the regular way of buying products, placing them in the cart and going to the cashier.... taking the items off the cart identfiying them and putting them back on the cart again; this new techniques uses cheap tags and palced on the items, products or goods. When the customer wants to purchase these goods he goes to a gate where an RFID reader is placed and reads the tags on the products and calculates the total price of the goods that was purchased.

4.6.2 Smart Shopping Cart Main Interface

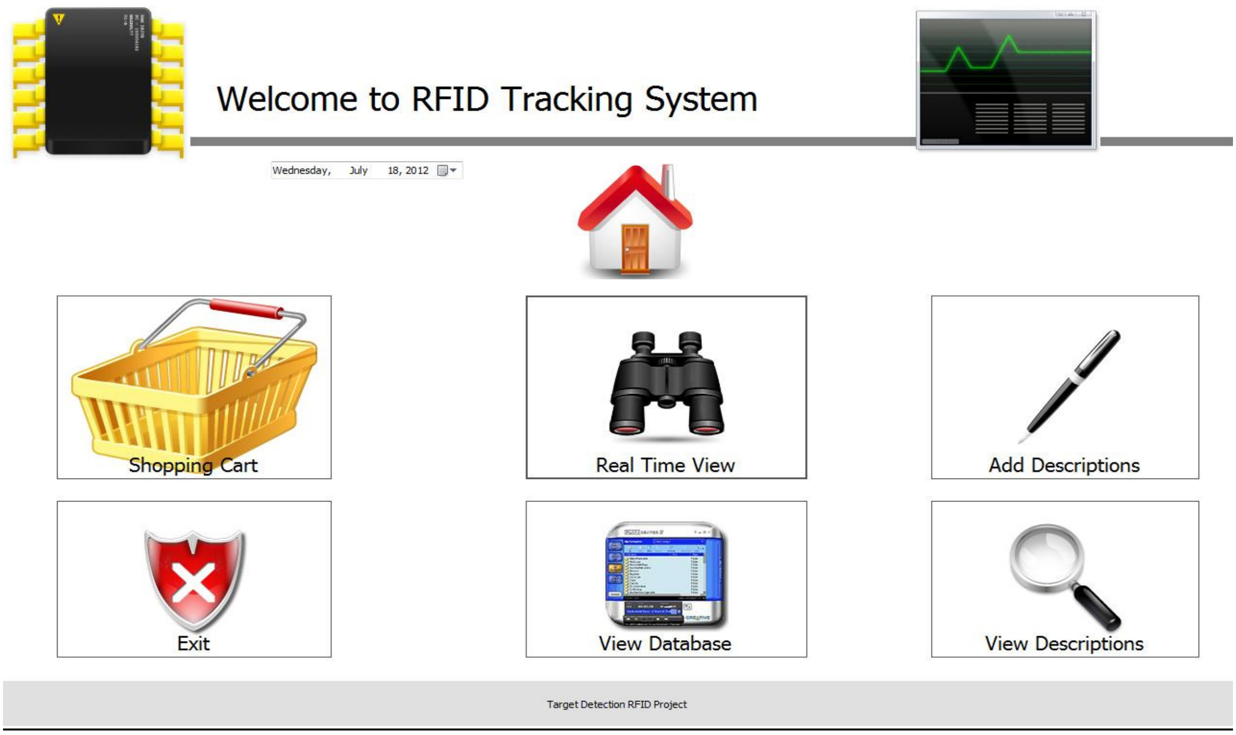


Figure 4.28 "Main Interface with the Smart Shopping Cart"

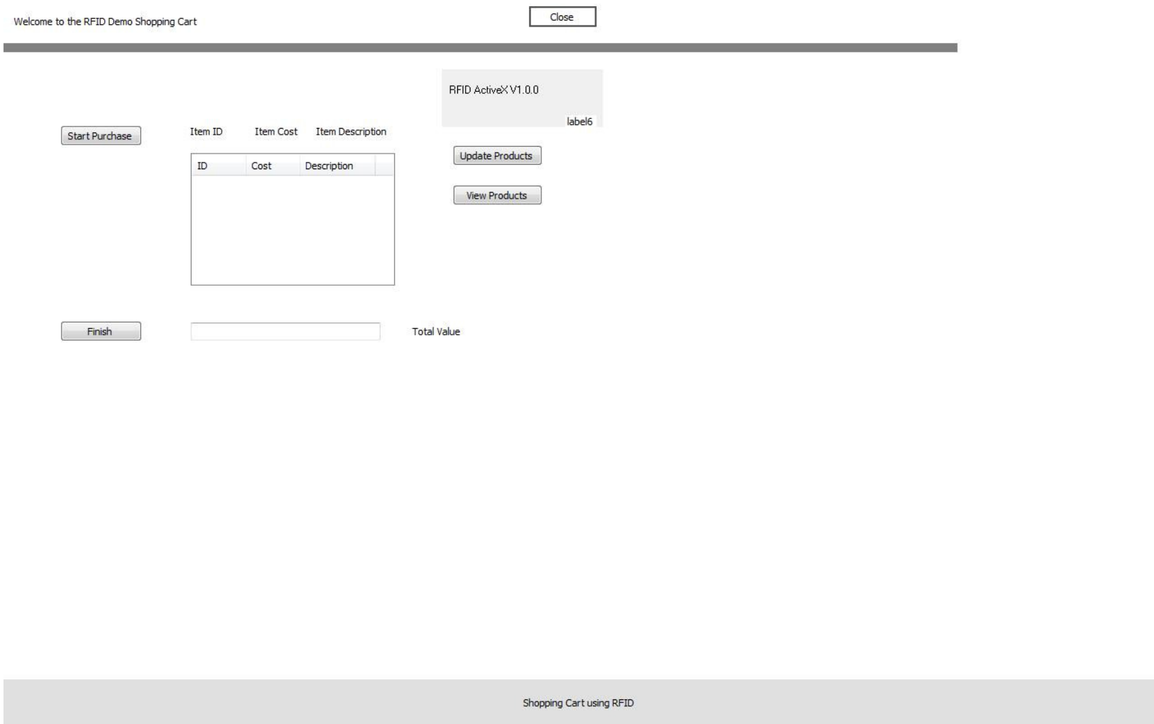


Figure 4.29"Interface of the Smart Shopping Cart"

The interface of the Smart Shopping Cart checks the ID of the Tag and from the database finds its description and cost form a table called Shop. The interface automatically calculates the summation of the costs and displays it in the total values textbox.

The Start purchase button opens the serial port so that the ID of the Tag can be transmitted.

The Finish purchase button closes the serial port and to close the system.

We faced a problem in this application which is that the tag transmits its ID along with the Received Signal Strength which the reader detects, so we don't need the Received Signal Strength in this application, so we only used the first 4 charachters that the tag transmits i.e. its unique ID.

But the tag transmits its ID every 2.5 seconds so the ID would be read continuously and we don't wan't that; so we made a condition in the programing that the ID is read once and then ignored. We checked if the ID transmited has been transmitted before or not, if it wasn't transmitted before then display the ID and select the other values "the cost and the description" also, if the tag ID is transmitted before then ignore it, so it is already displayed.

This is done in the Event of Reading the Tags Called axrfidAX1_rfidData

After that the sum of the Cost column is calculated and the total value is displayed.

The code for doing so is:

```
string ss = "";
        private void axrfidAX1_rfidData(object sender,
AxRFIDX.__rfidAX_rfidDataEvent e)
        {
            ss = e.sID.Substring(0, 4);

            label6.Text = ss;

            bool Fond = false;

            for (int IFond = 0; IFond < listView1.Items.Count; IFond++)
            {

     if (label6.Text == listView1.Items[IFond].SubItems[0].Text)
                {

                    Fond = true;
                }

}
            if (Fond == false)
            {

SqlConnection Con = new
SqlConnection("DataSource=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sam
eh\\Documents\\Visual Studio 2008\\Projects\\RFID Tracking
System\\RFID.mdf\";Integrated Security=True;Connect Timeout=30;User
Instance=True");

                Con.Open();

SqlCommand Cmdd = new SqlCommand("insert into Reading values('" +
label6.Text + "')", Con);

                Cmdd.ExecuteNonQuery();
```

```
                Cmdd = new SqlCommand("SELECT * FROM shop where id='" +
label6.Text + "'", Con);

                SqlDataReader Dr = Cmdd.ExecuteReader();

                Dr.Read();

                listView1.Items.Add(new ListViewItem(new string[] {
Dr["ID"].ToString(), Dr["Cost"].ToString(), Dr["Description"].ToString()
}));


                Con.Close();

                int Sum =0;

                for (int ISum = 0; ISum < listView1.Items.Count; ISum++)

                {
                   Sum+=
int.Parse(listView1.Items[ISum].SubItems[1].Text);


              }

                textBox1.Text = Sum.ToString();



            }
```

4.6.3 Updating the Descriptions and Costs of the Product

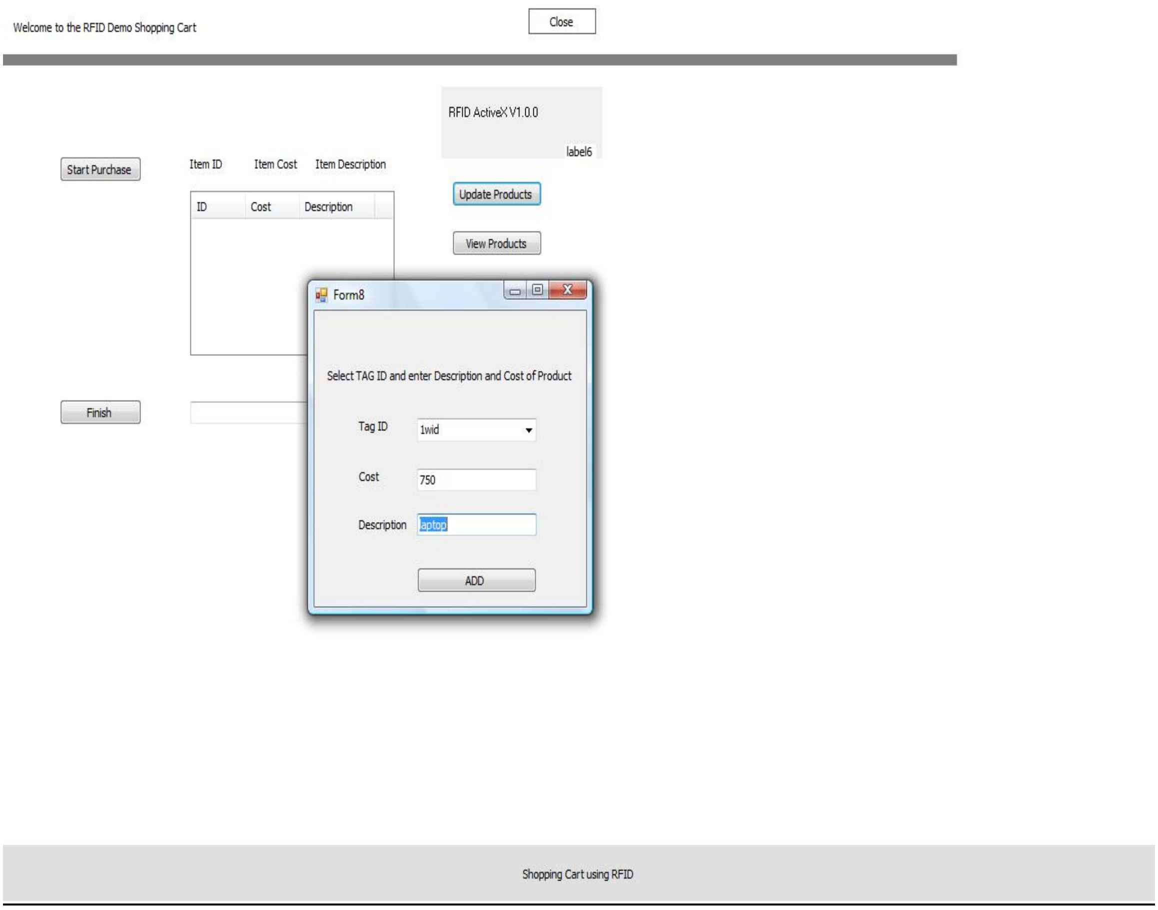


Figure 4.30 "Updating the Costs and Descriptions of the Tags in the Smart Shopping Cart"

Using the previous window we can update the values of the Cost and the Description of the ID of the Tag, so we can change the description of a product, change or update the cost of a product.

When we press the ADD button these changes are updated in the database.

4.6.4 Viewing the Descriptions and Costs of the Product

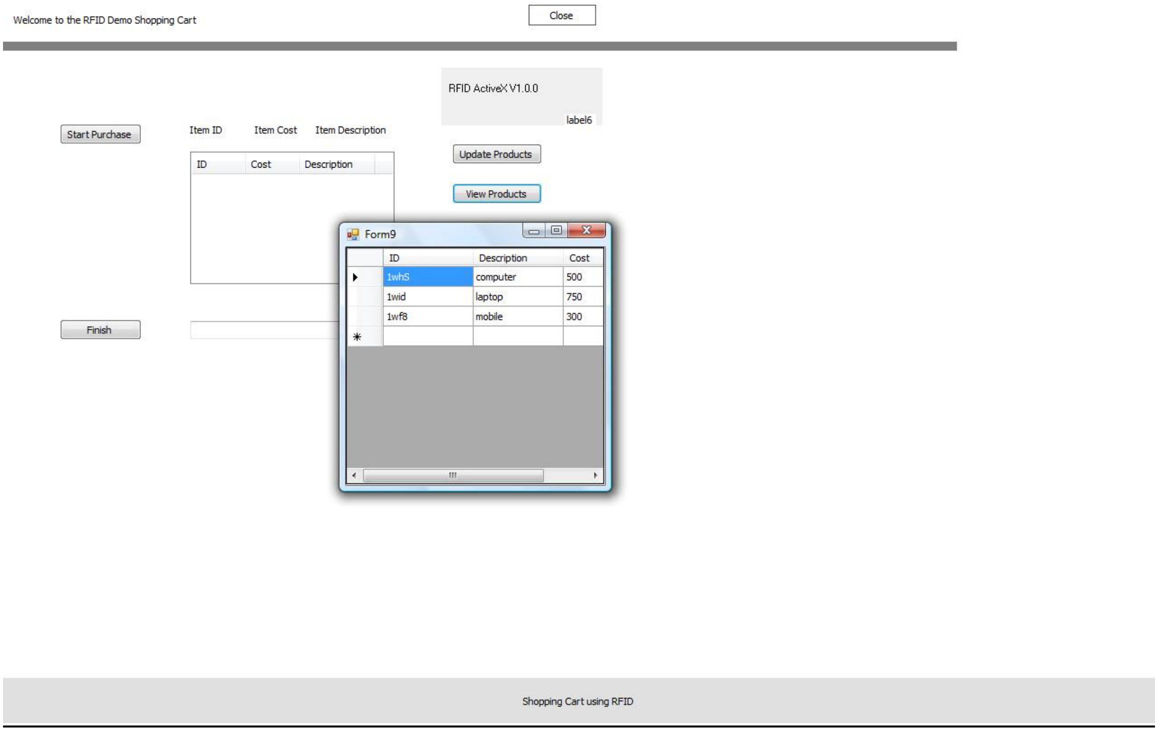


Figure 4.31 "Viewing the Costs and Descriptions of the Tags in the Smart Shopping Cart"

After pressing the View Products button, the following window will appear selecting the descriptions and costs of the Tag from the database.

The code for viewing the products is:

```
SqlConnection Con = new SqlConnection("Data Source=.\\SQLEXPRESS;AttachDbFilename=\"C:\\Users\\sameh\\Documents\\Visual Studio 2008\\Projects\\RFID Tracking System\\RFID.mdf\";Integrated Security=True;Connect Timeout=30;User Instance=True");

            Con.Open();

 SqlDataAdapter AD = new SqlDataAdapter("SELECT * FROM Shop ", Con);

            DataTable T = new DataTable();

            AD.Fill(T);

            dataGridView1.DataSource = T;

            Con.Close();
```

4.7 Illustration of the Tracking system

Figure 4.32 "Hardware of the Assembled System "

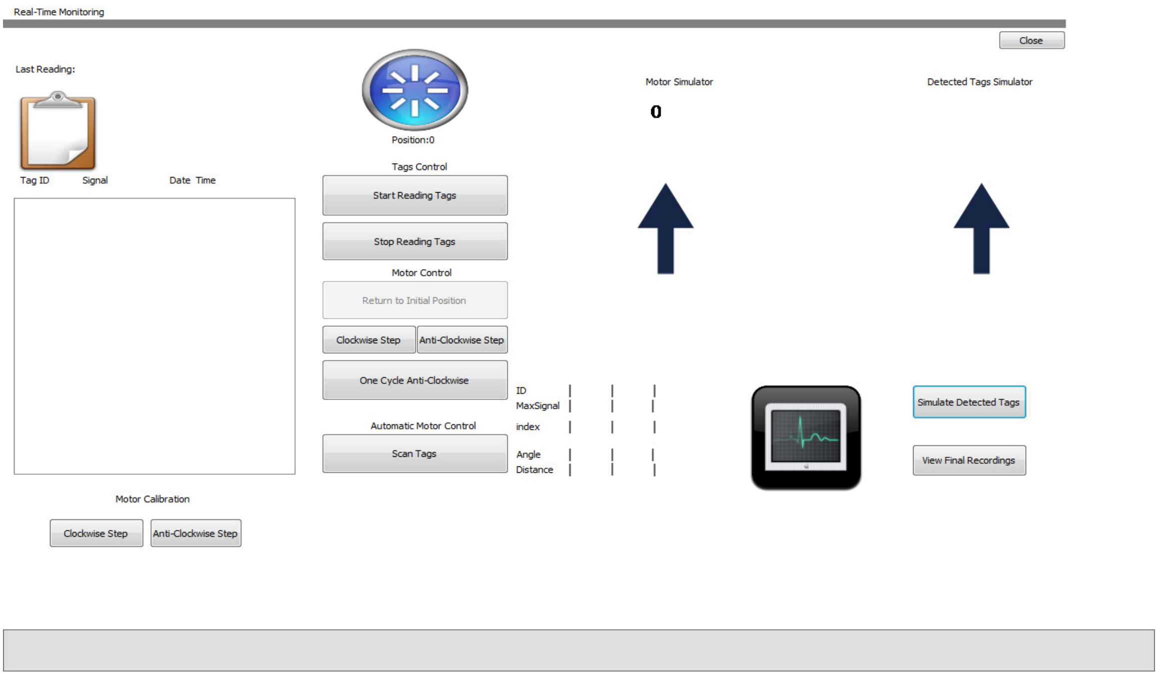


Figure 4.33 "Monitoring Control Interface "

Chapter Five:

Conclusion, Budget and Future Ideas

Preview:

In this Chapter we discuss the Conclusion, Results,and the future ideas that can be used to develop the system

Author: Muhammed Taimoor

Conclusion and Future Ideas

5.1 Conclusion

After a year of well organized work, we reached the following progresses:

1-An interface between the PC and the stepper motor, and a program that enables us to operate on the motor with the required rotating angle, and the required delay.

2-Simulation to the rotation of the motor in both directions: clockwise and anticlockwise.

3-An interface between the RFID reader and the PC and recording the reading results in a database.

4-Simulation of approximated results in detecting the target of the objects, which are the tags, according to the distance and the angle.

5-A demo application of the readers and tags, besides target detection, which can be used in markets (Shopping carts).

The RFID can be used as an indicator of objects and can be used in tracking, but not in a fully exact way, and needs development of upto date technology in order to reach full accurate results.

5.2 Results

After working on the target detection using the RFID technology, with all the possible materials available for us as students, for sure the results won't be very accurate, as well as the operation itself. The results were fair, but the rate of error had well known reasons:

1- The antenna of the reader should have special properties, as it should be directional with very small beam width, and getting such an antenna for a reader working at such low operating frequency (315 MHZ) with high directionality will make it have large size, which is inconvenient for the motor. So it was replaced by the cavity.

2- The stepper motor itself has a large step (7.5 degrees) beside the tolerance in the industry itself.

3- The transceiving tags send signals every 2.5 – 3 seconds, which makes the motor stay at each step for 3 seconds to guarantee receiving the signal from the tag if it exists.

4- The field strength meter itself is not very accurate and have a wide range of error, which had an effect on detecting the distance.

5- The material of the cavity and the cavity shape had an effect on the wave coming out from the antennas of the reader and tags.

5.3 Recommendations

From the previous problems, the results from our demo project for the idea weren't giving satisfying results for the industrial field. If the previous problems had a good industrial solution, the RFID technology can be used very well in target detection.
So in order to solve the previous problems, the following steps should be carried out:

1-A directional antenna with small beam width, with small size and non effective side lobes, with high gain should be used to increase the accuracy in measuring the angle.

2-A stepper motor with a step angle equals to the beam width of the antenna should be used.

3-The tags and readers should be made in industry with faster operation than 2.5 seconds in order to get the results faster.

4-The RFID should use accurate field strength meter, or any later technology which is better in measuring the distance.

5-In case of finding the required antenna, there will be no need for the cavity.

5.4 Budget of the Project

The project has a relativily low budget.

The project approximate cost are as follows:

RFID Reader Module	40$
Three RFID Active Tags	3x30$=90$
Stepper Motor with Parallel port interface card	50$
Accessories "COM port to USB converter, Cavities, Wires"	70$
Approximated Total Budget	250$.

5.5 Possible Future Applications

Smart robot:

The clearest application that can be used in target detection is the robot. For an automatically controlled robot, a robot can be used to carry or lift boxes and move them somewhere else.

Our exact demo version of the project can be used for the robot, after treating the problems in our demo project. The motor will be placed on the robot, with the antenna connected to it. The tags will be stuck into the objects (target). With this target detection method, the robot can detect the target automatically without any human interference.

Shopping Cart:

In big markets, the cashiers suffer in congestion when the customers have so many products to buy, so they take time to remove the items from the cart to the cashier to read its bar code, and then reload again in the cart.

The RFID technology can save this effort and time, also it can help the customers to know the total value of their items on every added item.

The idea is like that: there will be an RFID reader inside the cart, with a small range of sending the field so that it can't read the tags except when they're inside the cart. The items and their values are stored in a database, so that the reader of the cart will access the database to get this value and add it to the values of all the items in the cart and display it on an LCD or a 7-segment screen.

By this method, when the customer goes to the cashier for payment, he won't have to remove the items from the cart. He'll only pay the value displayed on the screen and the queue congestion will be less.

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