APPROVAL FORM

The signatory below confirms that they supervised Tawanda Vincent Mugwiji on a dissertation titled: TOLLGATE COLLECTION SYSTEM USING RFID TECHNOLOGY .The dissertation was submitted in partial fulfillment of the requirements of the Bachelor of Science Honors Degree in TELECOMMUNICATIONS at Midlands State University.

…………………………………. …………………………………

SUPERVISOR DATE

DECLARATION

I Tawanda Vincent Mugwiji declare that I am the sole author of this project and I hereby grant permission to the Midlands State University Library to produce single copies of this dissertation and to lend or sell such copies for private, scholarly or scientific research purposes only. However, author maintains all other publication.

Signature ………………………… Date ………………………

DISCLAIMER

The interpretations or solid reports in this study by any way do not represent university's statements or the project supervisor and in any way are not predestined to insult anyone person, institution or organization but rather there are preordained only for academic purposes.

.

DEDICATION

To the Mugwiji family, your love and support kept me going.

ACKNOWLEDGEMENTS

First and foremost I would like to thank the LORD ALMIGHTY for his love, strength and guidance throughout the period of my project research. Secondly I would like to thank my supervisor Mr. C Mudzingwa for his exceptional and outstanding intellectual support, patience, tolerance and guidance in this research. I am also forever grateful to the Midlands State University and the MSU Physics department for offering me a chance to acquire knowledge in the field of Telecommunications. I would also want to extend my gratitude to my family and friends in particular my brother Lennon Mugwiji for the financial support he gave me to fund my education and I also want to thank Elton Dhokwani, Nyasha Mambondiani, Tapiwa Mupakati, Mr. Furusa, Rutendo Huni and others who stood by me through thick and thin. The Wonderful Lord will He richly bless them.

ABSTRACT

The toll collection system currently used in Zimbabwe is an open system whereby toll levies are collected manually by toll collectors at various tollgates across the country. This system has negative effects on both the drivers and passengers as it causes time delays and traffic congestion at tollgates especially during public holidays where traffic volumes are enormous as people will be travelling. The Tollgate Collection System using RFID Technology project will eliminate hard cash transactions by making the payment process electronic. This will also reduce time delays at tollgates and bring great conveniences to drivers as they do not have to unnecessarily carry hard cash to pay their toll levies. The system will also reduce the levels of fraud from toll collectors which will in most cases will bring great accountability for each and every toll collection made boosting the Government's revenues to be used for road construction and renovations. This project also enhances vehicle tag security in the sense that if a stolen vehicle tag approaches the tollgate the RFID reader of system will interact with this tag and a buzzer alarm will sound thereby alerting the police authorities at the tollgate. This project was effectively done and the results that were obtained indicated that this system can be implemented in real time at current tollgate bringing a broader overview of toll collection that will bring great conveniences to both toll collectors and the drivers of vehicles.

Table of Contents

Contents

List of figures

CHAPTER 1

1.1 Introduction

This project is based on the use of a tollgate collection system using RFID technology. The system will help reduce the time delays that are encountered during the payment of toll at various tollgates by making the payment process electronic.

1.2 Background

It was observed that there is a problem every time drivers and passengers travel long distances, as they are usually bored by the time delays that are encountered during the payment process of tollgate fees. In Zimbabwe the toll is collected directly from drivers passing through the highway at selected locations. The method used for toll tax collection in Zimbabwe is called an open toll system whereby vehicles stop at various tollgates along the highway to pay the toll and are given tickets. The payment process was prolonged by the fact that most drivers would produce high denominations such as $100, $50 and $20 to pay for a toll of just $2. Again this resulted in more time being spent when toll collectors had to take several minutes just to find change to give back to these drivers. This scenario resulted in long queues of vehicles waiting to pay their toll and spending several minutes to pass through the tollgate especially during public holidays where traffic volumes are very high. It was also noticed that some drivers with heavy vehicles offered bribes to some toll fees collectors causing illegal tollgate entries. This scenario motivated the student to come up with the idea of implementing the RFID based toll collection system in an effort to simplify the process and reducing the amount of time drivers spends before they pay their toll. The system will also eliminate fraud from toll collectors.

1.3 Aims of study

To design a prototype that will automate the tollgate payment process by eliminating hard cash transactions. Automatic toll collection system aims to collect tolls from the vehicle without making the vehicle stop at a tollbooth [1]. The RFID tag will be charged with denominations of choice and will be interfaced with sensors placed at the tollgate. AUTOMATED TOLL

COLLECTION SYSTEM (ATCS) is an automatic collection system based on RFID i.e. RADIO FREQUENCY IDENTIFICATION where every vehicle will have a tag (RFID) with a unique tag identification number [2].This means that the drivers have to first slow down and eventually stop when approaching the toll gates, the drivers will then swipe their passive RFID tags on to the RFID reader at the gate. The toll amount will be deducted from the passive RFID tag and the transaction will be recorded and the toll fee will be debited into the Revenue's Authority account thereby giving great accountability for each and every payment made by each vehicle passing through the tollgate and also eliminating fraud from the toll collectors. This passive RFID card will be rechargeable and the account records will be stored. The motor driver will receive input from the microcontroller and drives the motor in a forward or reverse direction that is opening or closing the Toll gate according to received command input and for the legitimate users the gate will open and for others it will remain closed. This whole payment process will take a few seconds bringing great conveniences to drivers and passengers. The system eliminates the need for motorists and toll authorities to manually perform ticket payments and toll collections, respectively.

1.4 Purpose of study

To design a prototype that will reduce the time delays that are encountered during the payment process of tollgate fee. Thus it is a more efficient toll collection by reducing traffic and eliminating possible human errors. This system allows the vehicle drivers to pass the toll booths with little stopping time at the toll booths. Movement of traffic will be much faster as users will not wait to pay their toll because the driver just have to swipe their RFID tags in-front of the card reader.

1.5 Objectives of study

- To develop a Tollgate collection system using RFID technology.
- To simplify the payment process of Toll collection.
- To reduce time delays and waiting periods at tollgates by eliminating human error.
- To reduces levels of Fraud from Revenue Collectors.
- To bring great accountability for each and every toll payment.
- To enable vehicle tracking.

- To reduce travel time during public holidays.
- To bring conveniences to drivers since they do not need to necessarily carry hard cash for toll payment.

1.6 Hypothesis

The system will automatically collect the toll fee amount from vehicles driving on the highway road with making the vehicles having little stopping time at the Tollgate booths. This system provides a broader overview for toll collection to both the toll collectors and drivers.

1.7 Problem statement

The Tollgate collection system currently used in Zimbabwe causes traffic congestions as toll fees is collected manually by toll collectors at various tollgates. This payment process has negative effects on the drivers and passengers as they have to wait several minutes just to pay a toll fee making their travelling experience boring and tiresome. Due to high levels of corruptions currently attacking Zimbabwe even the toll collectors are prone to exercise fraud and accept bribes from drivers with heavy vehicles causing illegal toll gate entries which have negative effects on the generation of Government revenues used for roads development and maintenances.

1.8 Justification

The project will simplify the payment process of tollgate fees by eliminating hard cash transactions. The implementation of an RFID based Tollgate collection system will help both the travelling drivers and the toll collectors by eliminating waiting periods just to pay a toll fee by simplifying the payment process. The implementation of this system implies that toll will be deducted from passive RFID tags that will be swiped by drivers of each vehicle passing through the tollgate with the vehicles having little stopping time thereby reducing traffic congestions. By making the toll collection process electronic this will have an effect of eliminating fraud from the toll collectors giving great accountability for each and every toll collected .The RFID antenna will detect the passive RFID tag when a driver of vehicle swipes a RFID tag through it and should deduct the toll fees in accordance to the vehicle type using the RFID technology and the verification of payment will be displayed on the LCD. In the event that the driver's RFID tags no longer have money the system has a backward compatibility with the manual toll collection that is currently employed at various tollgates in Zimbabwe thereby bringing conveniences to drivers.

1.9 Applications of RFID systems

An RFID reader will detect a tag and reads the data encoded in the tag and this data is processed on to the application that makes use of the information. Some of the application areas of RFID technology are classified as follows

1. Point -of -sale (POS) (Fast track).
2. Supply chain management.
3. Asset tracking (self-check-in and self –check-out).
4. Asset tagging and identification (inventory and shelving).
5. Access Control.
6. Authentication (counterfeit prevention).

1.10 Assumptions

- Tag users are required to stop on observing a red traffic light.
- Tag users are required to proceed only after observing green traffic light.
- All tags that arrives a tollgate are debited with a recharge amount.
- Each RFID tag is unique to only a single vehicle.

REFERENCES

[1] S. Mahajan, “Microcontroller Based Automatic Toll Collection Systems”, International Journal of Information and Computation Technology, ISSN: 0974-2239 Vol 3, pp 793-800, 2013.

[2] P. Salunke, P. Malle, K. Dartir, J. Dukale, ‘‘Automated Toll Collection System using RFID’’, IOSR Journal of Computer Engineering (IOSR-JCE), ISSN -2278-8727 Volume 9, Issue 2, pp 61 -66, 2013.

CHAPTER 2

Literature Review

2.1 Introduction

In this chapter the designer of the project gives a vivid analysis of the literature overview of all the components that were used in the designing of the Tollgate collection system using RFID technology prototype. This stage is very crucial in the designing of the prototype as the designer will have a broader understanding of each and every component that was used in developing the project. This stage also gives the designer an understanding on how best to interface these components together.

2.2 RFID components

The RFID system is made up of three components namely:

- An antenna or coil.
- A transponder (RF tag) electronically programmed with unique data.
- A transceiver (with decoder).

Each of these components is described in detail below:

2.2.1 Antenna

An antenna is a device that emits radio signals so as to active a tag and also to perform read and write operations to it. . The antenna, which is attached to the microchip, transmits information from the chip to the reader [1]. Antennas are commonly defined as conduits between the transceiver and the tag. These antennas are found in a variety of shapes and sizes. With a larger antenna on the reader and the tag the better the RFID system will work because large antennas are very efficient at transmitting and receiving radio power than are small antennas. The RFID antenna works between a reader and provide sufficient energy to the tags of which in most cases are passive tags. These devices are designed with different properties such as polarities and tags signal reading direction.

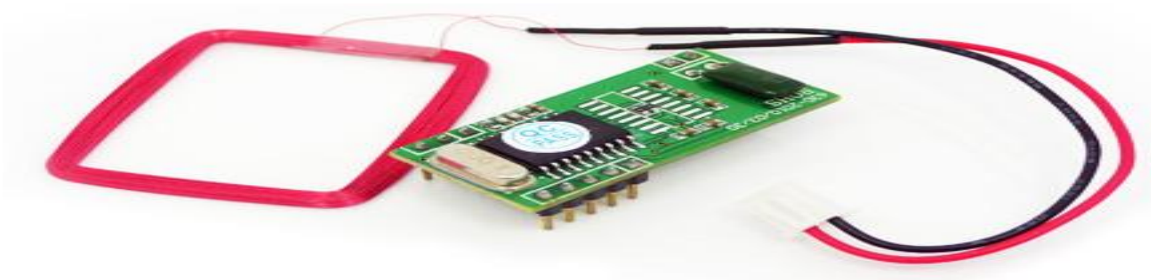

Fig 2.1 RFID reader and antenna [2]

In most cases the antenna device is packaged with the transceiver and decoder. The reader emits radio waves of different wavelengths depending on its power output and the radio frequency used. When an RFID tag passes through a zone with an electromagnetic field, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the Arduino Uno for processing [3].

2.2.2 Transponder/ RFID tag

The transponder is also known as an RFID tag, is a microchip combined with an antenna in a compact package. This microchip has logic circuits and contains memory that is used to receive and transmit data back to the reader. These tags are classified into three categories namely passive, active tags and battery assisted passive. Active tags have internal batteries that allow a longer reading range, while passive tags are powered by the signal from its reader and thus have shorter reading range [4]. A battery assisted passive (BAP) has a small battery on Board which is activated whenever the tag is in the presence of a RFID reader. These electronic tags can also be classified based on the content and format of information.

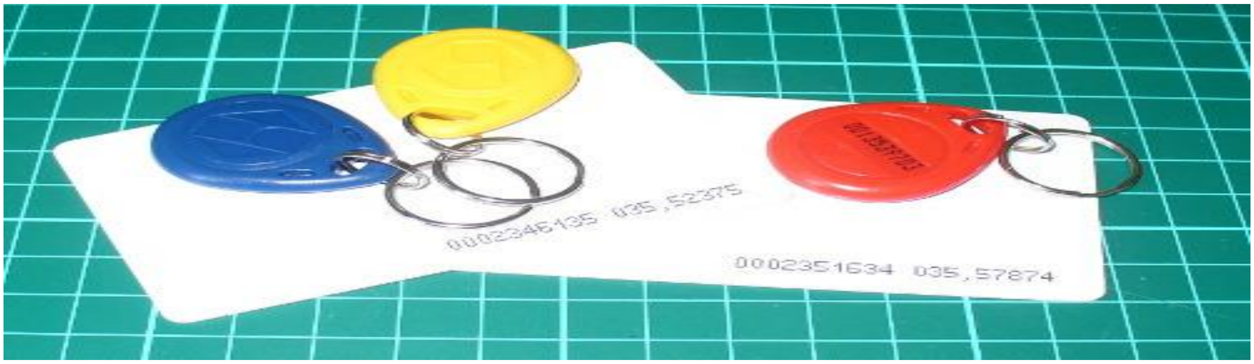

Fig 2.2: RFID tags [2]

These passive RFID tags have no source of internal power and use an external power source to operate. These tags are powered by the electromagnetic signal received from a reader. Due to an internal power source active tags can transmit information over a large distance and they are commonly used in navigational systems for both private and commercial aircrafts. Passive tags are usually smaller and cheaper because they do not have a battery on board. Cheaper, passive RFID tags are the mostly used to for consumable goods [5]. These tags are designed as either read-only, that is having a factory-assigned serial number that is used as a key into a database, or may be read/write, where object-specific data is written into the tag by the system user or designer. These RFID tags are classified into 3 categories with respect to frequency:

i. Low frequency (LF, 30 KHz to 500 KHz).
ii. Mid frequency (MF, 900 KHz to 1500MHz).
iii. High frequency (HF, 2.4GHz to 2.5GHz).

These frequency ranges mostly determine the RF ranges of these tags that are low frequency tags range from 3m to 5m, mid frequency ranges from 5m to 17m and the high frequency ranging from 5ft to 90ft. The most common frequencies used for low frequency tags are 125 - 134.2 kHz and 140 - 148.5 kHz [6]. The low frequency tags are the cheapest as compared to the other two frequency ranges of these tags. Low frequency tags are best because HF tags have high read range and are capable of reading multiple tags simultaneously which in turn leads to collisions. The major disadvantage of a low frequency that is they have the shortest reading distance.

2.2.3 RFID Reader

For an RFID system to properly function a reader is required, this device is important for reliably reading the RFID tags. The reader uses its own antenna to initialize communication with the tag. When a reader emits electromagnetic waves, all tags designed to respond to that particular frequency and that are within range will respond. A reader also has the capability to transmit and receive information from a tag without a direct line of sight, depending on the assigned radio frequency and the type of tag (active, passive, or semi passive) used. These readers also have the ability to process multiple tags at once, thereby allowing for increased read processing times. They can be mobile, such as handheld devices that scan inventory objects like cases and stationary, such as point-of-sale devices used in supermarkets. These devices are made up of a radio frequency module, a control unit and an antenna to interrogate these electronic tags through a radio frequency (RF) communication. RFID systems are commonly classified by the type of reader and its associated tag. Passive Reader Active Tag (PRAT) system has a passive reader which only receives radio signals from active tags (battery operated, transmit only) [3]. The RFID reader transmits a pulse of radio energy to the tag and detects the tag's response. When a tag detects this energy it sends back a response that contains the tag's serial number and all other relevant information as well.

2.3 RDM6300 Reader

2.3.1 Overview

The RDM6300 reader which is a 125 KHz card reader mini module and is designated for the main purpose of reading code from a 125 KHz card which is compatible with the read /write card and read-only tags. The application areas for this reader module are as follows:

1. Inventory Management.
2. Security and control applications.
3. Anti-forgery.
4. Personal Identification.
5. Animal tracking.
6. Baggage handling.

2.3.2 RDM6300 reader features

- It has a UART interface.
- Support EM4100 compatible read only or read/write tags.
- Support external antenna.
- Maximum effective distance up to 150mm.
- Less than 100ms decoding time.
- Small outline design.

2.3.3 RFID Reader Specification

- Module Type RFID.
- Frequency 125KHz.
- Weight 15.00g.
- Operation Level Digital 5V.
- Power Supply 5V.
- Board Size 3.8 x 1.8 x 1.2cm.
- Model IM120618002.
- Version 1

2.3.4 How RFID works

RFID technology from basic physics fundamentals it is simply defined as wireless link that is used to uniquely identify different kinds of objects, animals and as well as people. RFID systems only works effectively if all the RFID components are correctly interfaced with one another and as well as being compatible to each other. When a tag passes through a zone with electromagnetic waves emitted by antenna, the RFID reader interrogates the tag that is within its read zone and data is manipulated by the reader and can be transferred to different types of programmable logic controller interfaces depending on the application of the RFID system. RFID technology mainly relates to the unique identification of objects with use of electromagnetic radiation at radio frequencies. These RFID systems are commonly classified or categorized on the EM spectrum band that they operate in.

(i) Active tags are those which have an on board battery that always broadcasts or beacons its signal. These tags are the most expensive and are used for tracking containers, medical assets or for monitoring environmental conditions.

(ii) Semi passive tags also known as battery assisted passive (BAP) and they have a small battery on board that is only activated when in the presents of an RFID reader. The battery powers the internal circuitry of the tag during communication, but is not used to generate radio waves [7].

(iii) Passive tags have no battery on its circuitry; instead these tags are powered by the electromagnetic energy that is radiated by the reader. These tags are the cheapest in terms of cost but are very effective when it comes to performance.

2.3.5 Advantages of RFID

The use of RFID technology does not entirely eliminate the use of bar code in the near future; the following are benefits of adding the application of RFID for identification:

- No line-of-sight is required, tag placement is less constrained.
- RFID tags have a longer read range than, e. g., barcodes.
- Eliminates human errors from data collection.
- Reduces provisioning costs.
- Tags can have read/write memory capability, while barcodes do not.
- Many tags can be read simultaneously.
- Reduces inventory control and provisioning costs.
- Reduces warranty claim processing costs.
- An RFID tag can store large amounts of data additionally to a unique identifier.
- Tags are less sensitive to adverse conditions (dust, chemicals, physical damage etc.).
- Tag detection does not require human intervention.
- Reduces employment costs.
- Scanning speed - RFID transponders can be read at remarkable speed even in difficult conditions.
- Better lifetime and high noise immunity.

- Robust system - Transponders can be read through a whole number of substances e.g. snow, fog, ice.

2.3.6 Limitations of RFID

- Collision - The reading of many tags at the same time may result in several signal collisions and this leads to data loss. To prevent this scenario, anti-collision algorithms (most of them are patented or patent pending) can be applied at an extra cost.
- Cost -The prices of active or semi-passive tags (at least $1 per tag) are becoming more of a hindrance, thereby allowing their economic application only for scanning high-value goods over long ranges.
- Standardization -Companies developing these RFID systems are still having problems on sharing their application with others in fear of encountering conflicts as cooperating partners. These conflicts arises upon agreeing on which standards concerning communication protocols, signal modulation types, data transmission rates, data encoding and frames, and collision handling algorithms to use.

2.3.7 Toll collection system Functionality

The functioning of the toll collection system is described below.

The drivers will use an electronic RFID passive tag with account details of the vehicle to swipe at the RFID reader that will be installed at the tollgate. The RFID tag will be charged with denominations of choice and has the capability to interact with the sensors at toll gate. Every mobile vehicle will be attached with a RF tag which contains a unique ID [7]. As the vehicle reaches the tollgate the PIR motion sensor installed at the entrance will detect the vehicle, the drivers will first slow down and then eventually stop after observing the red traffic light. The RFID reader at the toll gate will interact with the tag when the driver of vehicle swipes it near the reader and reads the data embedded in the tag. The RFID Readers mounted at toll booth will read the prepaid RFID tags with vehicle information when the driver swipes the passive RFID tag and the respective amount will be automatically deducted. The reader will deduct a toll amount in accordance to the vehicle type and the information is sent to the Arduino Uno microcontroller for processing and the payment details will be displayed on an LCD. After the amount is deducted the microcontroller will send a signal to the motor driver to instruct the dc motor to either rotate forward or backward thereby opening or closing the gate .If an unknown vehicle tag or stolen vehicle tag approaches the tollgate the reader will interact with the stolen vehicle tag and the information is sent to a microcontroller for processing and a buzzer alarm will sound and the gate remains closed .If a vehicle's tag runs out of funds the manually payment will be performed since the system has a backward compatibility with the current toll payment system.

2.3.8 Features of the RFID based toll system

- Automation of the payment process of toll.
- Enhances vehicle tag security.
- Eliminates time delays at toll gates.
- Reduces traffic congestions at toll gates.

2.3.9 Range of operation of an RFID system

The range of operation simply refers to the maximum operating distance between the tag and the RFID reader. In an RFID system the frequency of operation has a large effect on the operating range. According to the analysis of RFID systems the optimum frequency of operation is between 400-500MHz. There are factors that were put into consideration to come up with this analysis. The factors that are affected by the choice of frequency are as follows:

(i) Power delivered to tag.
(ii) Tag antenna size.
(iii) Speed and cost.

Active tags get its own power from an internal battery on its circuitry, but passive tags obtain power from an antenna based on reader's signal to antenna .These passive tag's response or communication signal is based on the amount of power it gets from the antenna. When communication occurs over a short distance, relative to the wavelength of the radio wave, this scenario is said to be a near-field operation. All HF (3-30MHz) RFID systems use waves with a wavelength of around 10-100m, if the distance of the communication is much less than this then this is a near-field communication. When a directional antenna is used, its radiation pattern will also affect the reader field. The capability of the reader to power and communicate to the tag is based on the inverse square law (1/r), as will the return path of reflected signals from the tag to the reader. Operation will also be affected by environmental conditions and interference from other radio sources at the same frequency [8].

$$P_a = \frac{P_t G_t \lambda^2}{(4\pi r^2)(4\pi)} G_{tag} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.1$$

The above equation illustrates, the amount of power that will be available at an antenna ,Pa is a function of various factors including the power and gain (efficiency) of the transmitter antenna (P and G), the distance from the transmitter (r), electromagnetic wavelength (λ), and gain (efficiency) of the RFID tag's antenna (G_{tag}). What is deduced from this equation is that to improve read range (r) without increasing transmit power, one must improve the gain of the RFID antenna. As a result, characterization of RFID tags often involves significant characterization of the antenna over a wide range of frequencies.

2.4 Arduino Uno (Processing Unit)

This is a single board microcontroller based on the AT mega 328 and it has an usb port on its circuitry which is used to connect to a computer. It is powered with an AC to DC adapter or a battery in order to start using the microcontroller. The Arduino Uno microcontroller has pins where wires are connected to construct a prototype circuit with the addition of a breadboard and some connecting wires. The Arduino Uno comes with an integrated development environment (IDE) that runs on regular personal computers and it also allows users to write programs on the Arduino board using C or C++ .The Arduino Uno was mainly developed to construct circuit for prototyping purposes and also building interactive objects. Arduino board allows designers to write programs and create interface circuits which read switches and other sensors, and also to control motors and lights with very little effort. The most important feature of the Arduino Uno is that a designer can create a control code on a PC and download it onto the Arduino via an usb cable and it will run automatically.

Fig 2.3: Arduino Uno photograph [9].

2.4.1 Features

(i) It uses a high-speed micro-processing controller (ATMEGA328).

(ii) The development of language and development environment is very simple, easy to understand, very suitable for beginners to learn.

(iii) Allows simple connections with a wide range of electronic components (such as: LED light, buzzer, keypad, photo resistor, etc.), making all sorts of interesting things.

2.4.2 Special features

• Microcontroller	ATmega328.
• Input Voltage (recommended)	7-12V.
• Operating Voltage	5V.
• Input Voltage (limits)	6-20V.
• Analog Input Pins	6.
• Digital I/O Pins	14 (of which 6 provide PWM output).
• DC Current for 3.3V Pin	50 mA.
• Current per I/O Pin	40 mA.
• Flash Memory	32 KB of which 0.5 KB used by boot loader.
• SRAM	2 KB (ATmega328).

- EEPROM 1 KB (ATmega328).
- Clock Speed 16 MHz

2.4.3 Product Information

- ATMEGA328, ARDUINO UNO, I2C, BOARD.
- Silicon Manufacturer: Arduino.
- Core Architecture: AT mega.
- Core Sub-Architecture: AVR.
- Silicon Family Name: AT mega.
- Features: Powered via USB Connection, 2KB of SRAM, and 1KB of EEPROM.
- No. of Bits: 8bit.
- Kit Contents: Board.
- Silicon Core Number: ATmega328.

2.4.4 Working principle of Arduino

Listed and explained below are the individual components that make up an Arduino Uno board and their functions.

(i) Barrel Jack. The recommended voltage range for most Arduino boards is between 6v and 12volts.The use of a power supply greater than 20v on an Arduino board will over power it and damage its circuitry.

(ii) The power USB port .This port is mainly used for powering the Arduino board and also to uploading a control code on to the Arduino Uno board. When the Arduino is powered by the usb port the maximum voltage input is a 5v.

(iii) 3.3V: This pin supplies a maximum voltage of 3.3V of power.

(iv) 5V: This pin gives a maximum voltage supply of 5V of power.

(v) GND: Which is a ground pin and there are several number of these pins on the Arduino board used for grounding circuits.

(vi) Digital pins: These pins (0 ~ 13 on the Uno Board) are used for both digital inputs and outputs. These pins are 14 that are found on the Arduino Uno board.

(vii) Analog pins: These pins are found on the Analog ln label (A0 ~A5) .These pins are 6 analog inputs. These pins are integrated with Analog to Digital convertors that is, these pins reads an analog signal from a sensor and convert it into a digital output value that is readable to human beings.

(viii) AREF: This is used as a reference voltage for analog input pins and it is used as an external reference voltage that is (between 0 to 5volts) which are upper limits input pins.

(ix) PWM: standing for (Pulse width Modulation) and these pins are with a tilde (~) next to some of the digital pins (3, 5, 6,9,10 and 11 on the Arduino Uno board) these pins are used normally as digital pins but they can also be used for Pulse Width Modulation. Pulse Width Modulation, or PWM, is a technique for getting analog results with digital means [10].

(x) Power LED indicator: Whenever an Arduino Uno board is connected to a power source this LED should light up.

(xi) Reset Button: When this button is pressed it restarts any control code that is loaded on the Arduino Uno board and it is used temporarily as a connection between the reset and ground.

(xii) Main Integrated circuit or IC: This IC is from the AT mega family line and they are developed by ATMEL Company.

(xiii) TX RX LEDs: These leds are used to indicate whenever an Arduino Uno is transmitting or receiving signals from different components that are interfaced with the microcontroller (like when loading a code to the Arduino board).TX stands for transmitter and RX stands for receiver.

(xiv) Voltage Regulator: This is used as a controller of the amount of voltage that is allowed to operate an Arduino Uno Board. It controls the amount of voltage that is let into the Arduino board [11].

2.5 Buzzer

It is simply defined as an audio signaling device. These devices are of different types that are they can be mechanical, electromechanical or piezoelectric. A buzzer is interfaced with the microcontroller so as to indicate when the RFID reader detects a tag of a stolen vehicle trying to pass through the tollgate thereby enhancing vehicle security.

Fig 2.4: Buzzer picture [12].

2.5.1 Features

Component Code: STBUZZER

- Operating Voltages   3v -5v.
- Dimensions: 22.5mm Diameter, 19mm High, 28.5mm between mounting holes.
- Kingsgate Buzzer - KPE-200.

The buzzer is also known as a sounder and in line with working principle a buzzer is split up into two major types that are a piezoelectric and electromagnetic type.

2.6 LCD Display

LCD (Liquid Crystal Display) is an electronic display screen which has a broader range of applications. It is a 2x16 LCD because it can display 16 characters per line and it has two lines. Each character is displayed in a 5x7 pixel matrix. The LCD display Module is built in a LSI controller, the controller has two 8-bit registers, an instruction register (IR) and a data register (DR) [13].The Instruction Register stores codes such as display clear and cursor shift, and it also addresses information for display data RAM (DDRAM) and the character generator (CGRAM).The Data Register is a temporarily location for storing data to be written or read from DDRAM or CGRAM. A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals [14]. Liquid crystal displays are manufactured using materials which have both properties of a liquid and also those of a crystal.

Fig 2.5: 2x16 LCD Display photograph [14].

The LCD display does not have a melting point, but rather they have a temperature range with which the molecules will be as mobile as they would be in a liquid, but these molecules are grouped together in a similar order to that of a crystal.

2.6.1 Precautions when handling LCD display

- Don’t disassemble the LCD.
- Avoid applying excessive shocks to the module or making any alterations on modifications to it since the LCD is made of glass.
- Don’t make extra holes on the printed circuit board, modify its shape or change the components of LCD module.
- Don’t operate it above the absolute maximum rating.
- Don’t drop, bend or twist LCD.
- Soldering: only to the I/O terminals.
- Soldering: only to the I/O terminals.
- Caution should be taken not to get the liquid crystal fluid in one’s mouth or hands if a panel is broken. If this occurs, immediately wash with water [15].
- All unused pins should be connected to Vcc or Ground.
- The polarizer used on the surface of display panel is easily damaged or scratched.

2.6.2 Advantages of LCD displays

- They are easily programmable.
- They are very economical.
- Have custom characters (unlike in seven segments), animations.
- Have no limitation of displaying special.

An LCD display is made of two glass panels with the liquid crystal material sand in between the glass panels, the inner surface glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.

2.7 DC motor

A dc motor mainly consists of two things that are, a stator where field flux is produced and a rotor where the armature wounding is placed. The field flux can be obtained from either a permanent magnet or rather from a field winding excitation. The field flux usually interacts with current carrying conductors the in armature to produce a torque. The Commutator in the armature circuit will ensure that the torque that is produced is always at its maximum, despite the position of the rotor. The torque that is produced is a result of the interaction of the field flux with the armature conductors and is modeled by the equation

$$T_e = K_t \phi i_a \ldots\ldots\ldots\ldots\ldots\ldots 2.2$$

Where K_t is a constant depending on motor winding and geometry. ϕ is the flux per pole due to field winding.

The direction of the torque that is produced depends on the direction of the armature current. When the armature rotates, the linking the armature winding will vary with time and in accordance to the Faraday's law, the emf that will be induced across the winding. The emf generated is known as the back emf and it depends with the speed of rotation as well as with the flux produced by the field. The polarity of the back emf depends on the motor rotation .A dc motor can be interfaced with an Arduino Uno board using a TIP 120 transistor but in this project a dc motor was interfaced with the Arduino Uno via a L293D H-bridge motor driver. A dc motor is developed to run on a dc electric power. The most common DC motor types are the brushed and brushless types, and these uses internal and external commutation respectively to reverse the current in the windings in synchronism with rotation. A permanent magnet dc motor does not have a field winding on the stator frame but rather on the permanent magnets to provide the magnet field against which the rotor field interacts to produce torque.

Fig 2.6: A dc motor with an Arduino Uno and a L293D photograph [16].

The dc motor in this project is used to open or close the gate of tollgate upon receiving a input from the Arduino Uno microcontroller via the L293D motor driver.

2.8 TIP31C Transistor

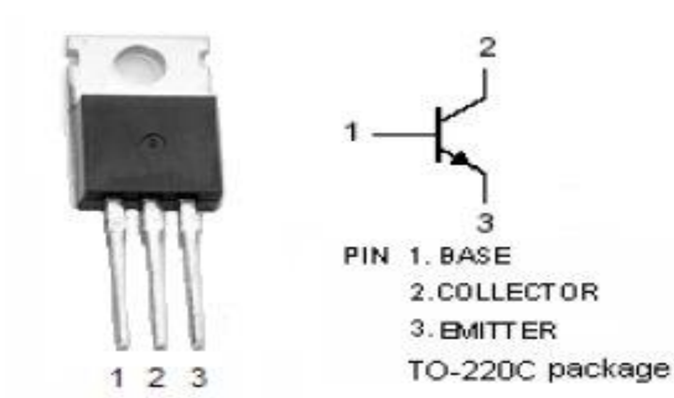

Fig 2.7: TIP 31C photograph [17].

This form of transistor is the most cheapest and versatile and can be easily interfaced with the Arduino Uno microcontroller. This device in most cases is used as a switch in most electronic systems. In this particular project this component was used to control a dc motor depending on the input that will be received from the Arduino microcontroller. The TIP31C transistor can pass up to 5 A of current at 60 V, which is more than enough to control the dc motor and it acts as a switch to turn on or off the dc motor that will rotate clockwise or anticlockwise thereby opening or closing the boom gate depending on the input received from the microcontroller. The device is called “bipolar” since its operation involves both types of mobile carriers, electrons and holes. [18]. A bipolar junction transistor is made up of two back-to-back p-n junctions, and these junctions share a common thin region with width, W_B. There is Contact made to all three regions, the two outer regions called a collector and emitter and the middle region is called the base. This electronic component is formed by joining three sections of semiconductors with different dopings. The middle pin or region (base) is narrow and the other two outside regions (emitter and collector) are heavily doped and it forms a P-N-P type.

2.9 Passive Infrared Motion Sensor

The PIR (Passive Infra-Red) Sensor is a pyro electric device that detects motion by measuring changes in the infrared levels emitted by surrounding objects [19]. The motion of objects can be detected by checking for a high signal on the single Input /Output pin. This device passively detects infrared radiation within its surrounding. They are so called passive simply because, they analysis that are transmitted from objects themselves. Unlike a radar or ultrasound sensors an active transmitter is not needed for the operation of a passive infrared sensor. It is obvious that a PIR motion detector only reacts to objects that are distinctly warmer than the surroundings, for example humans, animals or warm vehicles [20]. The working principle of the (PIR) sensor is based on infrared radiation that causes a charge transfer on a special membrane which resembles a capacitor. In order to perceive only changes in infrared radiation that is movements of an object, the dynamic states of charge of at least two equal sensor elements are analyzed, while common mode signals are compensated.

Fig 2.8 PIR sensor photograph [20].

These devices have elements made of crystalline materials that generate an electric charge whenever it is exposed to infrared radiation. The amount of infrared striking these element changes the amount of voltage generated. These devices contain a special filter called a Fresnel lens, which focuses the infrared signals onto the element. In this project the PIR sensor detects whether the vehicle has arrived at the gate so that the transaction can begin.

2.10 LED

These are distinct diodes that emit light when connected to an electric circuit. These components are commonly used as “pilot” lights in electronic circuitry to show whether there is a closed or open circuit. The LED lead negative side is indicated in two ways as shown below

- By the shorter side extending from the LED.
- By the side of the bulb which is flat.

The negative lead should be connected to the negative terminal of the power supplying source.

LED draws a current between about 10 and 40 mill amperes and operate at relative low voltages between about 1 and 4 volts.

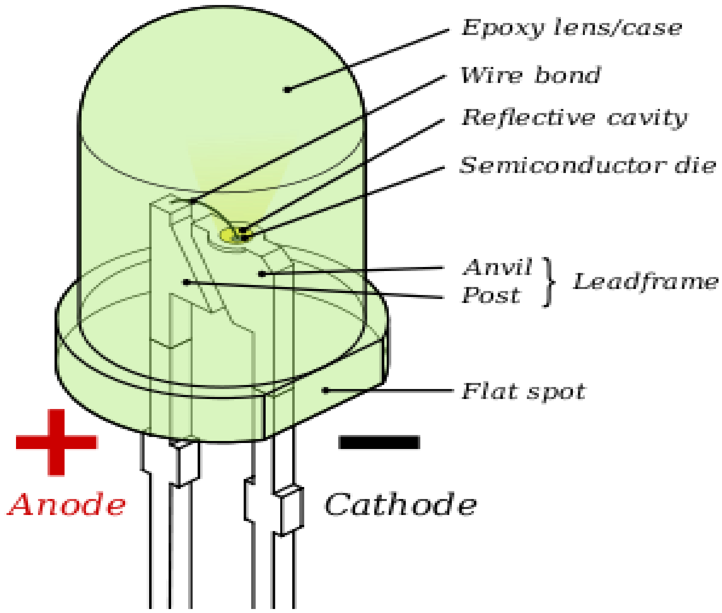

Fig 2.9 LED light emitting diode [21].

Voltage and current ranges slightly above these values can melt a LED chip. The LED has an important part that is the semi-conductor chip located in the center of the bulb. This chip has two regions that are separated by a junction. The n- region is dominated by negative charges and the p-region is dominated by positive charges. In the absence of a large enough electric potential difference (voltage) across the LED leads, the junction presents an electric potential barrier to the flow of electrons [21]. The junction acts as a barrier to the flow of electrons between the p and the n regions. Only when sufficient voltage is applied to the semi-conductor chip, can the current flow and the electrons cross the junction into the p region.

2.10.1 Energy Emitted by LED

The voltage required to cause electrons to flow across the p-n junction is proportional to the electric charge. The emitted light energy given by (E) thus:

$$E = qV \qquad \text{.........................2.3}$$

where q = electric charge of an electron.

V = required amount of voltage to light the LED.

The Electric energy is proportional to voltage and this is a general relationship that applies to LED's and any circuit. The electric charge constant q is of a single electron, -1.6 x 10-19 Coulomb.

The wavelength of light is related to the frequency of light. In order to examine the light from the LED the spectrometer can be used, and also to approximate the peak wavelength of the light radiated.

REFERENCES

[1] A. Kumanat, K. Chandramore, "Automatic Toll Collection System Using RFID", International Journal of Electrical and Electronics Research, Vol 2, pp. 67-72, 2014.

[2] www.tronixstuff.com (accessed on 18 March 2015).

[3] M. Kaur, M. Sandhu, N. Mohan and P.S. Sandhu, "RFID technology principles, advantages, limitations & its applications," International Journal of Computer and Electrical Engineering, Vol.3, pp. 151-157, 2011.

[4] The Basics of RFID, Veri-logic, LLC, 2003.

[5] J. Harper, 'RFID tags and privacy'', How Bar-Codes-On-Steroids Are Really a 98-Lb. Weakling, pp 1-12,2004.

[6] A.A. Agawam, "RFID based automatic shopping cart'', Control Theory and Informatics, Vol 1, pg. 39-44, 2011.

[7] A.Dhurat, P.Magal, M.Chheda, D.Ingle, "Gateless Electronic Toll Collection using RFID", IOSR Journal of Computer Engineering, Vol 16, pp73 -80, 2014.

[8] F.A .Correa, M. J. A. Gil, L.B. Redin, "RFID and health management: is it a good tool against system inefficiencies?" International Journal of Health Technology and Management Vol.8, 2007.

[9] D.Bawa, C.Y.Patil, "Fuzzy control based Solar tracker using Arduino Uno", International Journal of Engineering and Innovative Technology, Vol 2, pp 179-187, 2013.

[10] www.sainsmart.com (accessed March 2015)

[11] Bentley Born, "RFID access control using Arduino" openhardware.gridshield.net/home/RFID-access-control-using-arduino

[12] Anoop Madhusudanan, Cake robot a classic Arduino kinetic robot that

Follow www.codeproject.com/Articles/672336/ 20 (Accessed March 2015)

[13] www.winstar.com.tw(accessed March 2015)

[14] S.Hathwalia, S.C. Sankhyan, "A NOVEL APPROACH FOR DISPLAYING DATA ON LCD USING FPGA", International Journal Of Technical Research and Applications, Vol 1, pp 48-51, 2013.

[15] International Journal of Computer and Electrical Engineering, Vol.3, No.1, pp 1793-8163 February, 2011

[16] www.communityofrobots.com (accessed March 2015)

[17] www.hobbytronics.com [Accessed May 2015].

[18] B. V. Zeghbroeck, “Principles of Semiconductor Devices," Bipolar Junction Transistors, 2011.

[19] www.parallax.com (accessed March 2015)

[20] www.wilke-technology.com (accessed March 2015)

[21] LED AUTO PRODUCTS, www.ledautoproducts.com.au/product-information www.ledautoproducts.com.au (Accessed May 2015)

CHAPTER 3

Methodology

3.1 Introduction

This chapter will give a detailed analysis of each of the subsystem that leads to the proper functioning of the prototype. It gives an account on the design of all the subsystems and how these components are interfaced with each other that are the central processing unit, the software that was used in the project and how the system was properly implemented, a flow chart showing the execution of the program and also the block diagram of the overall system.

3.2 Structure of the overall system

The overall system consists of the following hardware components

- RFID reader.
- RFID tags.
- LCD.
- Buzzer.
- Passive Infrared sensor.
- DC motor.
- TIP 31C Transistor.
- Vehicle unit.
- LEDs.

This prototype consists of three main subsystems that are

(i) Vehicle detection zone.
(ii) RFID tag detection zone.
(iii) Vehicle security system.

3.3 Connections of the RDM3600 with Arduino Uno

The following are steps that were taken when connecting a RDM3600 with an Arduino Uno board.

- The RFID reader main board was connected into s solderless breadboard.
- Jumper wires are used to connect the second and third wires of the RFID board to the 5V and GND of the Arduino board respectively.
- The T_x from the RFID reader board is connected to the digital pin 2 of the Arduino Uno board.
- The Pin 2 is programmed to read.
- The digital pin 2 of the Arduino is set to read the serial connections at 9600 bps using the Soft Serial.

3.4 RFID antenna connections

3 Jumper wires are used to interface an RFID sensor to the bread board, one for the serial line communication and the other two wires are used for supplying power. The wire connections are described below.

The Pin 1 of the RFID reader is used for transmitting the detected signal to the Arduino Uno from the antenna and pin 1 was connected to the digital pin 2 of the Arduino Uno. Pin 4 is connected to the ground of the reader .Pin 5is connected to the V_{cc} (+5) the power. Pin 2 in this project is not used but it is normally used for receiving a signal from the built circuit.

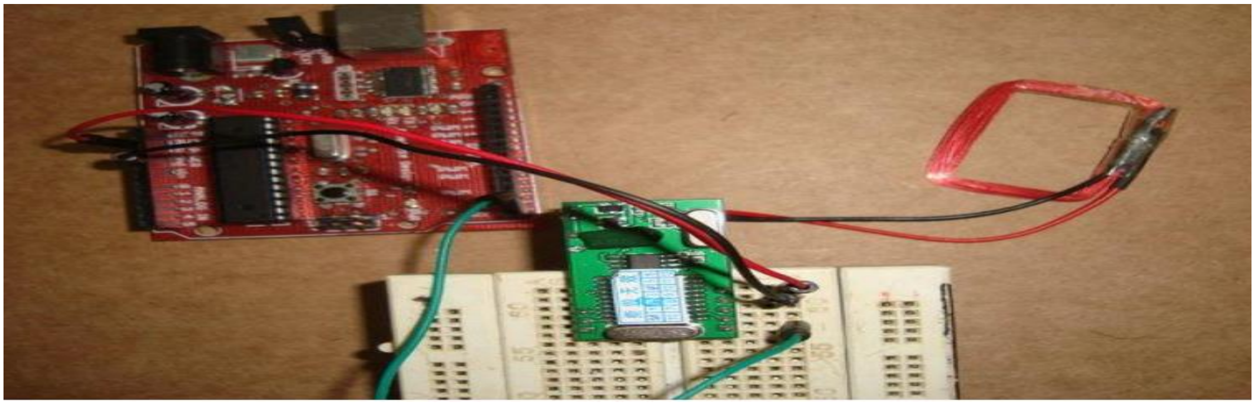

Fig 3.1 Wiring connections of the RFID reader and Arduino Uno [1].

3.5 Theoretical aspects behind the detection of tag

Fig 3.2 Interactions between RFID reader and vehicle tag [2]

The vehicle tag used in this particular project is a passive tag which is powered by the reader in order to obtain the information that is stored in the tag. As the vehicle enters the tollgate the driver swipes with an RFID tag in front of the RFID reader at the gate will detect the RFID tag and reads the account information and vehicle type information that is embedded in the vehicle tag. The reader transmits the demodulated signal from the RFID tag installed on the vehicle and this information is send to the microcontroller for processing. The RFID tags unlike bar codes do not require a line of sight for them to be read by the reader. These passive tags response signal is based on the power it gets from the reader through the antenna. There are two ways in which a passive tag obtains its power form a reader. A tag can obtain power from a reader either in the far field or near field region. In the far field a tag transmits its signal in reverse order with the antenna signal by using standard formats in order for the reader to recognize the tag's signal. Near field uses inductive coupling within the magnetic field .Far field in most applications is used for high frequency ranges and can work for longer reading ranges between tags and the reader. Near field is suitable for low frequency ranges and works in shorter ranges.

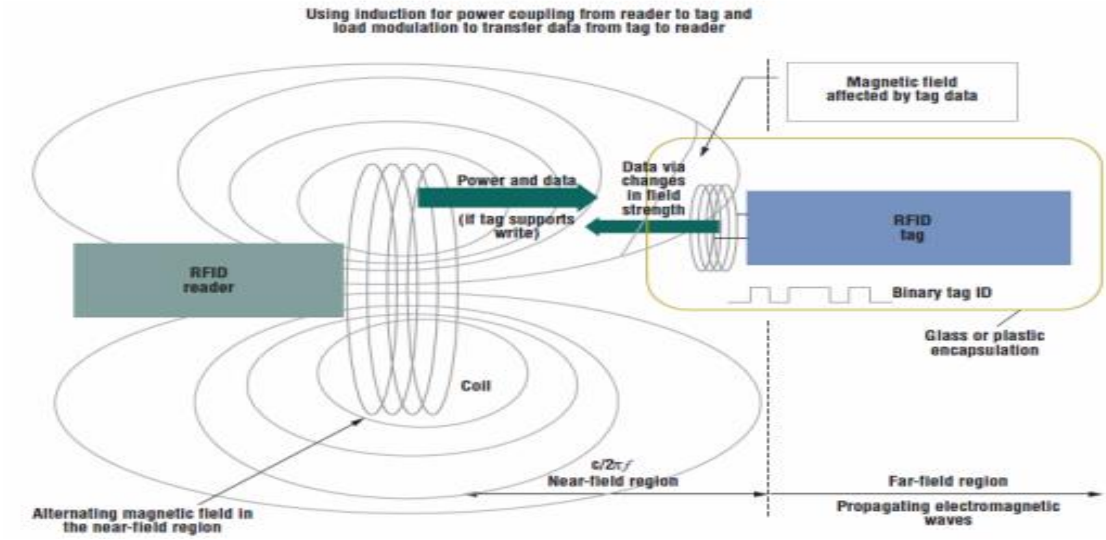

Fig 3.3 Magnetic interactions between a tag and RFID reader [1].

3.6 How to interface a LED with Arduino Uno

In order to connect a light emitting diode (led) to an Arduino board the components required are a resistor, led, connecting wires and an Arduino board. A resistor is used to limit the amount of current that passes through the led. A button can be used to turn on and off the led.

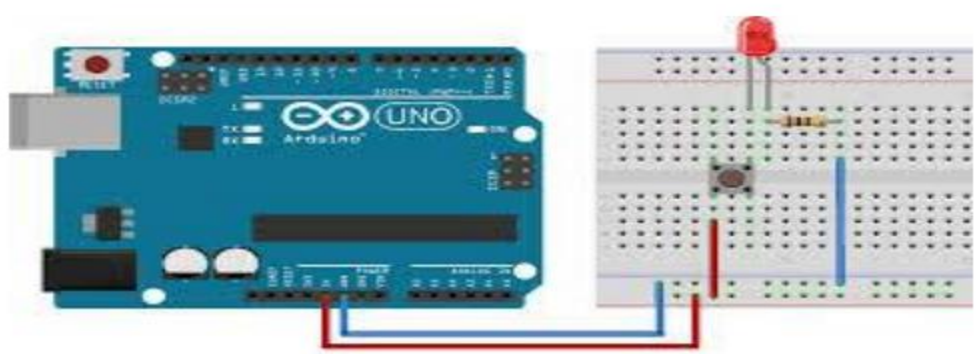

Fig 3.4 connections between Arduino and led [1]

3.7 How to connect PIR sensor with Arduino

Passive infrared (PIR) sensor is used to detect motion by measuring the exact amount of infrared light that is emitted by objects.

The PIR sensor has three pins that are 5v; output and a Ground pins respectively .The following steps are taken when connecting a PIR sensor with Arduino

(i) Connect the 5v pin to the corresponding 5v pin on the Arduino.

(ii) The ground pin of the PIR sensor is connected to one of the ground pins on the Arduino.

(iii) The output pin is connected to the digital pin 2.

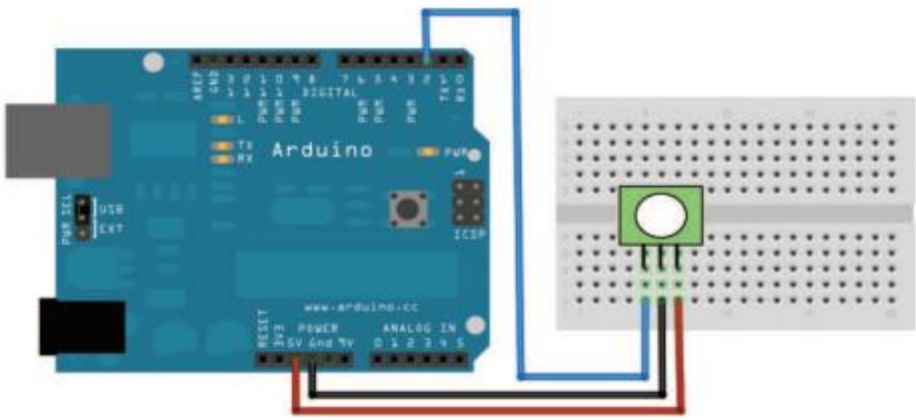

Fig 3.5 connects between a PIR sensor and Arduino [3].

3.8 System Architecture

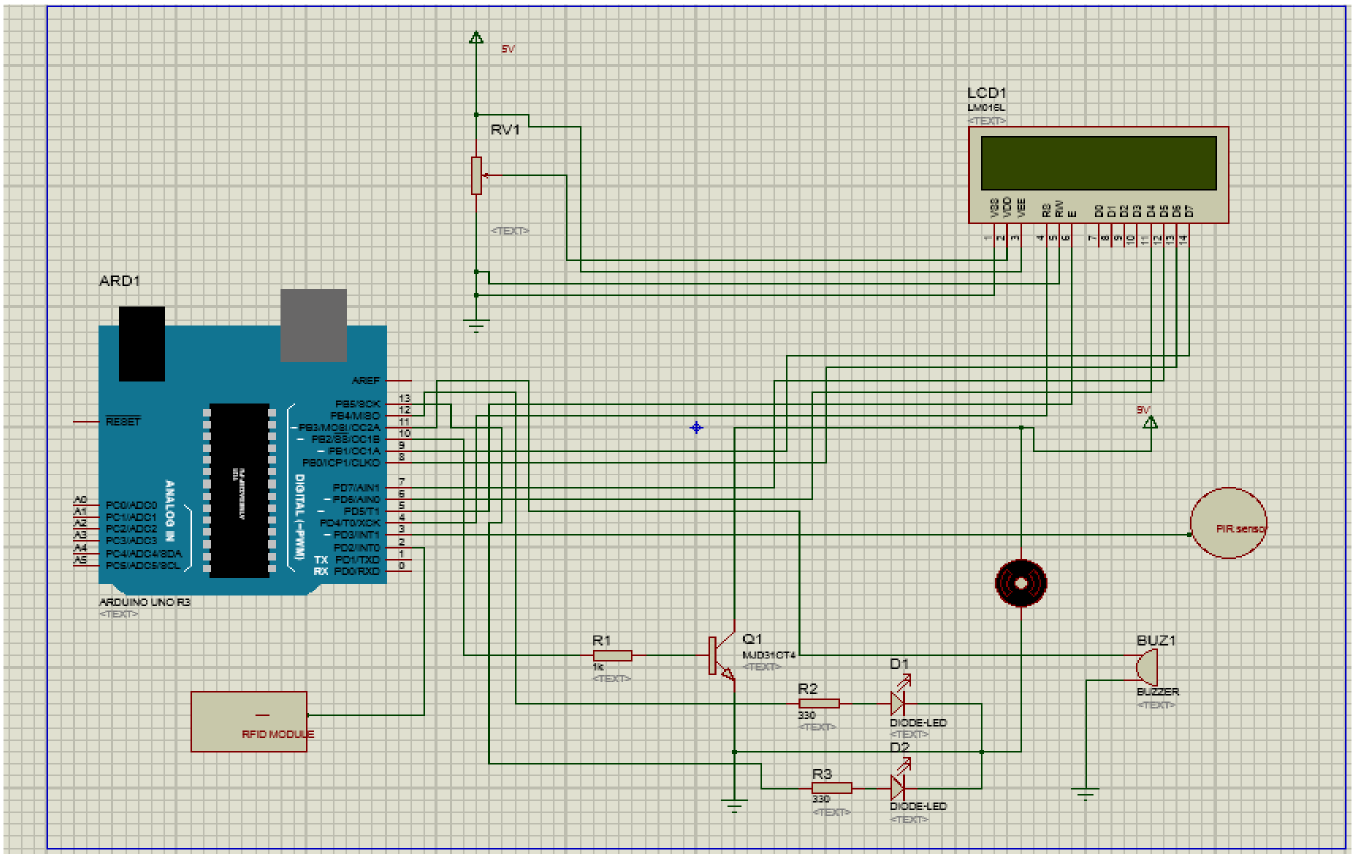

Fig 3.6 System Architecture.

The pin connections between a LCD, TIP 31C transistor, dc motor, buzzer, leds and Arduino Uno board are as follows:

- Pin 2 of the Arduino connected to RFID T_x.
- Pin 3 of the Arduino is connected to the PIR sensor.
- Pin 4 of the Arduino is connected to RS pin of the LCD.
- Pin 5 of the Arduino is connected to E pin of LCD.
- Pin 6 of the Arduino is connected to D4 of the LCD.
- Pin 7 of the Arduino is connected is connected to D5 of LCD.
- Pin 8 is connected to D6 of the LCD.
- Pin 9 is connected of the Arduino is connected to D7 of the LCD.

- Pin 10 of the Arduino is connected to the DC motor via a transistor.
- Pin 11 of Arduino is connected to a buzzer.
- Pin 12 of Arduino is connected to a red led.
- Pin 13 is connected to a green led.
- Ground pin of Arduino is connected V_{ss} of LCD.
- Ground pin of Arduino is connected RW of the LCD.
- +5v of the Arduino is connected to V_{DD} of the LCD.
- +9v of external power is connected to a dc motor

3.9 Software descriptions

The Arduino Uno microcontroller is coded using the embedded C programming language. The hardware of the RFID also uses embedded C programming language for communication between the RFID reader that will be installed at the tollgate and the passive tag that will installed on the vehicle with the relevant information about the vehicle type and vehicle's owner account details. The RFID reader detects a vehicle tag and demodulates important information about the vehicle and maps it to the amount to be deducted in accordance to the vehicle type. All these programs will be written in embedded C programming language.

3.10 Block diagram of system

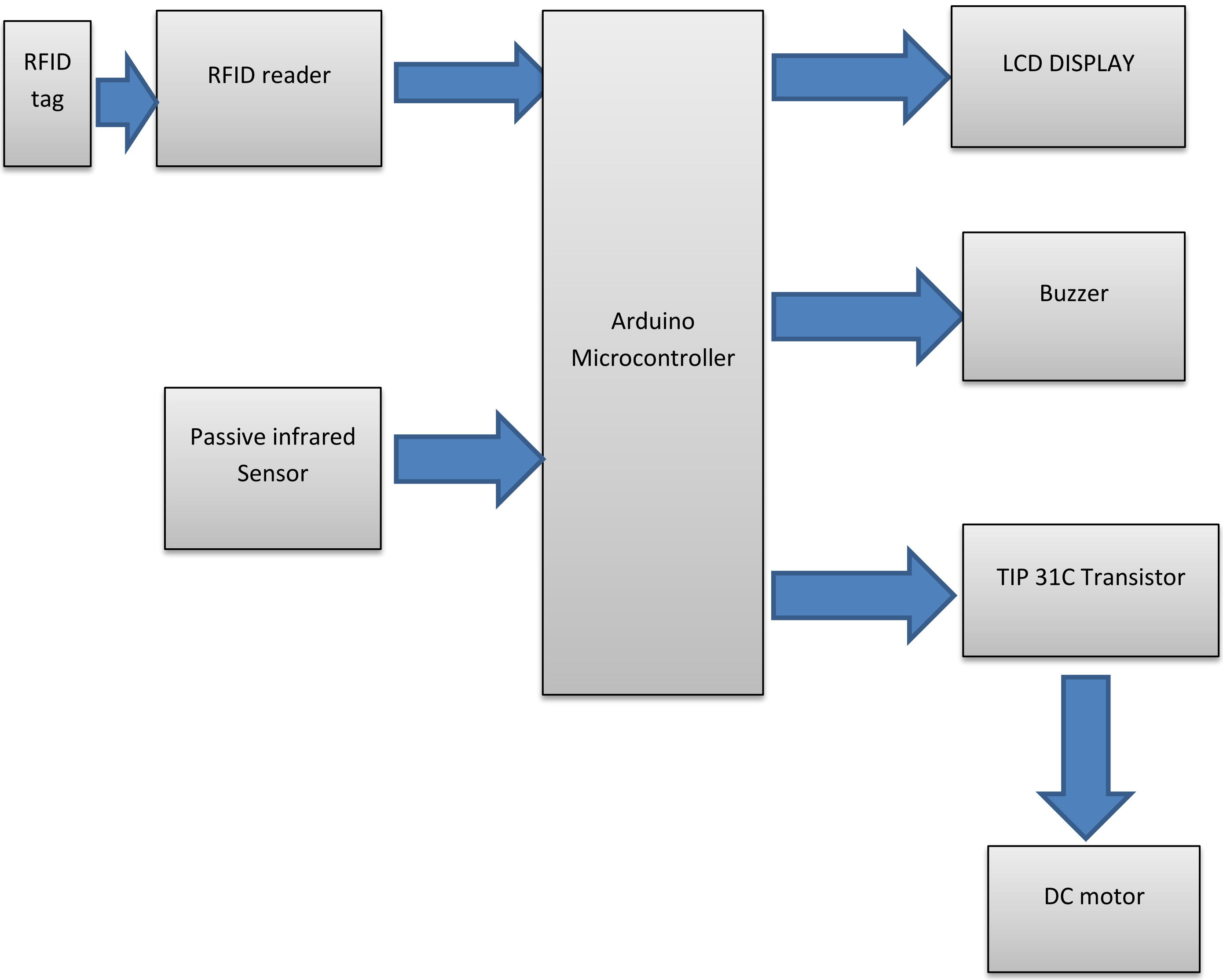

Fig 3.7: Block diagram of the overall system.

The above block diagram shows the architecture of the overall tollgate collection system. When a vehicle reaches the tollgate the passive infrared sensor will detect motion of vehicle and transmit this information to the Arduino Uno microcontroller thereby indicating to vehicles to stop with the use of traffic lights. The RFID reader will then detect the vehicle tag when the driver of vehicle swipes it in front of reader and demodulate the information that will be embedded in the tag and an amount for toll will be deducted in accordance to the vehicle type.

When the amount is deducted the microcontroller will send a command to the motor driver to either open or close the gate at the same time indicating a green traffic light instructing vehicles to proceed with their journey. When a stolen vehicle tag reaches tollgate the RFID reader will interact with this tag when the driver swipes and sends a signal to the microcontroller and the microcontroller will send command to the buzzer to sound its alarm thereby notifying the police at tollgate, this will enhance vehicle tag security. When a vehicle with no tag reaches tollgate a manual payment of toll will be done through the using the current manual payment already existing.

3.11 Data flow of the tollgate collection system

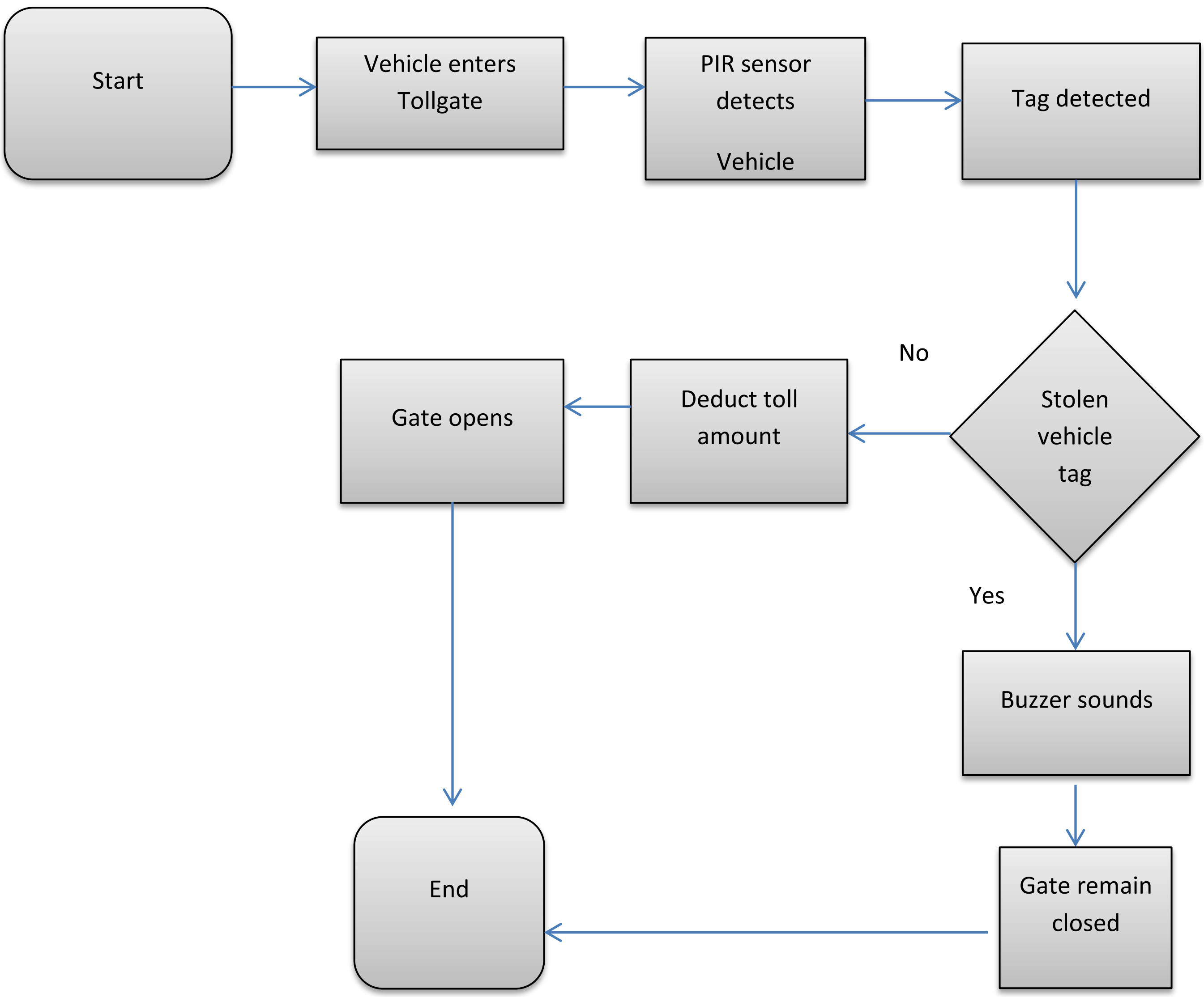

Fig 3.8: Data flow diagram of system.

The data flow diagram above shows the procedure that occurs during the tollgate collection payment process .The vehicle with an RFID tag first enters tollgate and the passive infrared sensors at the entry point of tollgate detects a vehicle and controls a traffic light instructing vehicles to stop. The RFID reader then detects the vehicle tag when the driver swipes the tag in front of reader and verify its status whether it's a stolen vehicle tag or not .If the vehicle is detected as stolen tag a buzzer alarm with sound notifying the police officers at the tollgate and the gate remain closed thereby enhancing vehicle tag security .If the vehicle tag is not stolen a toll amount will be deducted and the gate will open for vehicle to pass through.

REFERENCES

[1] R.Kumar1, K.Gopalakrishma2, K.Ramesha3, “Intelligent Shopping Cart”, International Journal of Engineering Science and Innovative Technology, Vol 2, pp 499-507,2013.

[2] A.Win, C.MyatNwe, KyawZinhatt, “RFID Based Automate Toll Plaza System”, International Journal of Scientific and Research Publications, Vol 4, pp 2250 -3153, 2014.

[3] M.Schmidt, “Arduino A Quick-Start Guide”, Pragmatic Bookshelf, LLC, 2011

CHAPTER 4

Results and Analysis

4.1 Introduction

In this chapter the results that were obtained from the project are analyzed in vivid detail. The results that were obtained from the circuit design and from the functional prototype are presented in tabular form as well as in graphical presentation.

4.2 Power measurements

The voltage across an RFID antenna was measured using a loop antenna. The voltage readings across the RFID antenna were measured at various distances between an RFID tag and the loop antenna. The voltage readings that were obtained were averaged to get accurate readings. The voltage measurements were obtained by vertically and horizontally orientating the loop antenna and different readings were obtained. The relationship between voltage and distance is shown in the graphs below. Power was calculated when the voltage readings were obtained using the formula generalized as follows:

$$P = V^2/I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.1$$

Where P is Power.

V is the Voltage.

I is the Current.

A fluke multimeter was used to measure the resistance of the loop antenna of the RFID reader. Accurate measurement of the power inductively transferred to the tag is impossible using bond wires or probes, because both would introduce severe distortions of the electromagnetic field [1].

Fig 4.1 below shows a picture of voltage measurements that were obtained in order to calculate the power induced into the tag by the loop antenna.

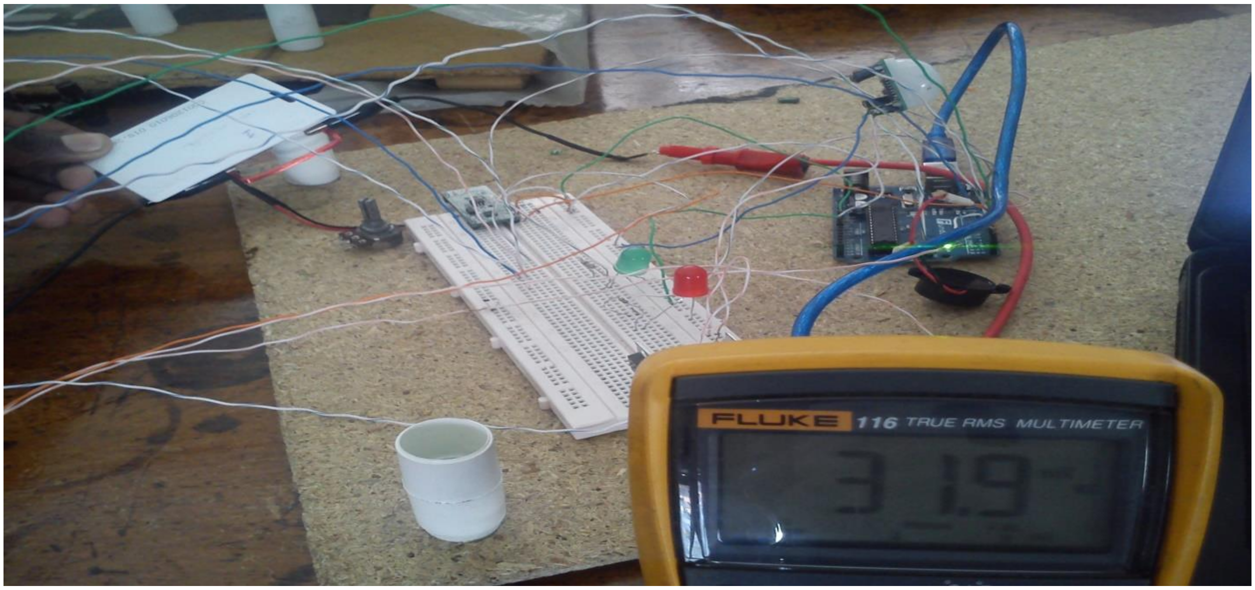

Fig 4.1 Power measurements photograph.

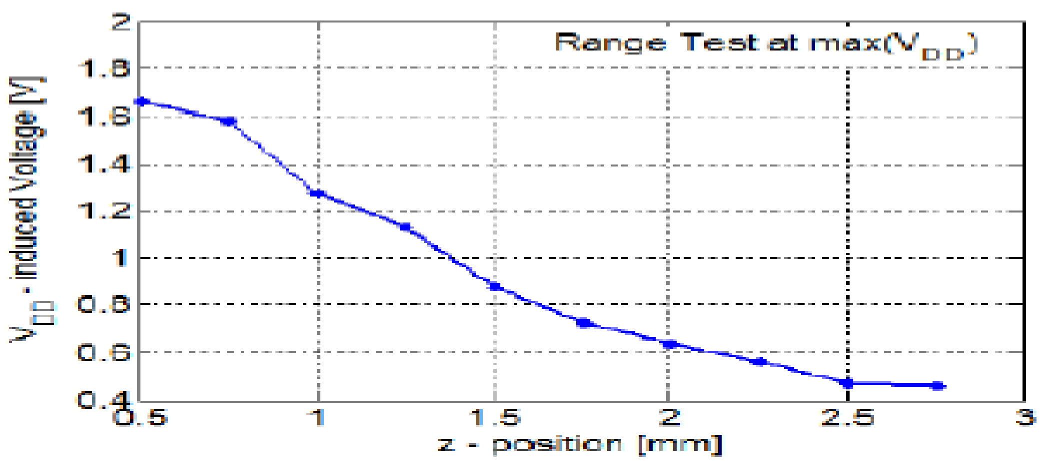

Fig 4.2 Relationship between voltage and distance [1].

The above graph shows the theoretical relationship between voltage and distance of an RFID tag from a loop antenna. The induced voltage *VDD* decreases with distance in *z*-direction as expected [1]. The graph shows that the induced voltage is inversely proportional to the distance between a tag and the loop antenna. These passive tags are read by the reader in the near field, but as the frequency of operation increases, the distance over which near-field coupling can operate decreases. The magnetic field drops off at a factor of $1/r^3$, where r is the separation of the tag and reader.

4.3 Tollgate collection System Prototype

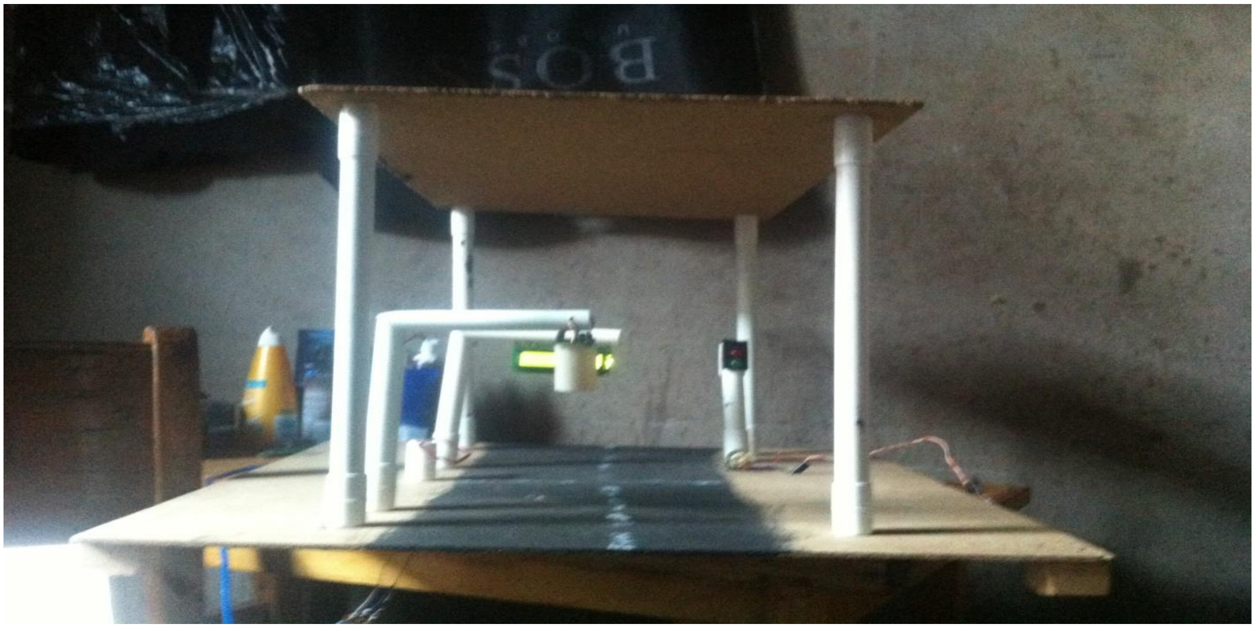

Fig 4.3 Tollgate System prototype image.

Fig 4.4 LCD display image.

The prototype shown from fig 4.3 was built using an LCD display for showing various messages to the drivers; these messages includes the vehicle type information, account balance information after the payment transaction. It also comprises of a dc motor which is used as input for closing and opening the gate. A PIR sensor is used to detect vehicles that approaches tollgate and the traffic lights were designed using LEDs to control traffic at tollgate.

Table 1 Table of results showing the voltages across an antenna loop oriented horizontally with the corresponding distance and the average voltage

Distance(mm)	**Voltage Reading1 (mV)**	**voltage Reading2(mV)**	**voltage Reading3(mV)**	**Average Reading(mV)**
0.1	64.2	67.2	65.5	65.6
0.5	38.0	42.2	53.4	44.5
1.0	22.6	31.6	34.8	29.7
1.5	19.2	20.8	24.6	21.5
2.0	13.3	16.8	15.4	15.2
2.5	11.2	11.6	12.2	11.7
3.0	8.6	8.9	8.8	8.8
3.5	6.8	6.7	7.3	6.9
4.0	5.4	5.2	6.0	5.5
4.5	4.8	4.3	4.5	4.5
5.0	3.7	3.6	4.2	3.8
5.5	3.4	3.7	3.8	3.6
6.0	3.1	2.8	3.2	3.0
6.5	2.7	2.5	2.8	2.7
7.0	2.5	2.6	2.4	2.5
7.5	2.3	2.4	2.6	2.4
8.0	2.1	2.2	2.2	2.2

The table 1 above shows the voltage readings that were obtained in correspondence to the different distances between the loop antenna and the RFID tag. These voltage readings were obtained when a loop antenna was orientated horizontally .The differences between the obtained voltage readings was due to the changes of the electromagnetic fields therefore by taking many readings and averaging them was in an effort to reduce the degree of errors. As shown from the table above the highest voltage reading was 65.6 millivolts and was obtained when the tag was very closest to the loop antenna at a distance of 0.1mm. These results showed that distance and voltage between a tag and a loop antenna varies inversely proportional which is in agreement with the theory of electromagnetic waves.

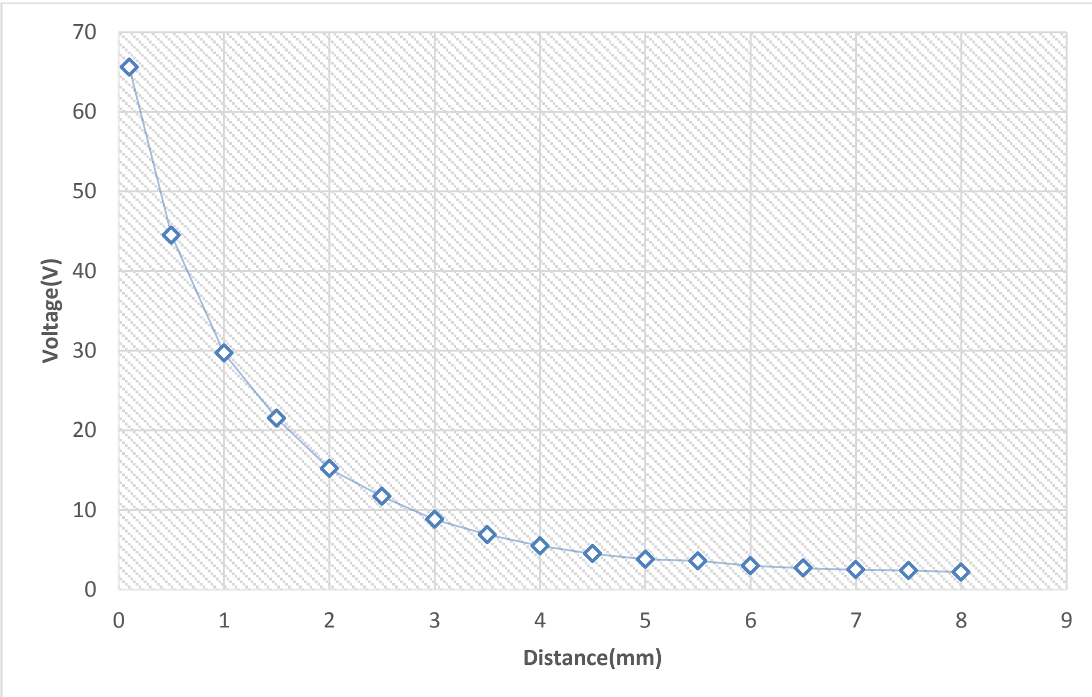

Fig 4.5: variation of voltage and distance of a loop antenna horizontally orientated.

The graph on fig 4.2 indicates the variation of voltage and distance which tend to vary inversely from the results obtained. High voltage readings were obtained in the read range zone close to the RFID antenna. The results obtained indicated that voltage and distance vary inversely to each other. That is when the distance between tag and reader increases the voltage obtained decreases and vice versa.

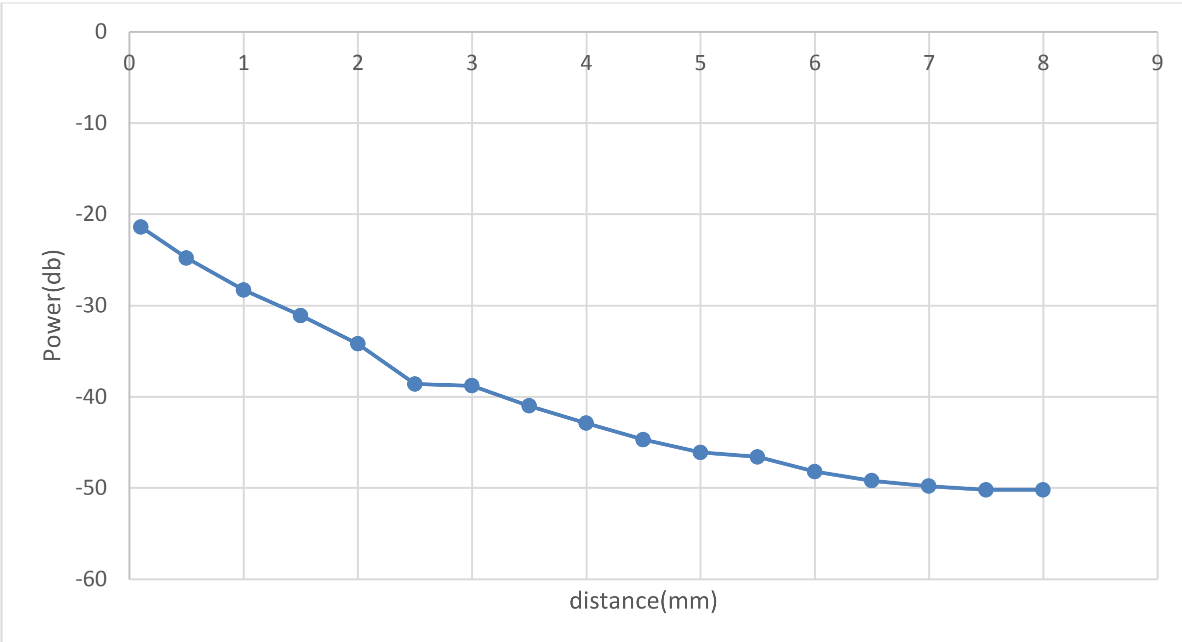

Fig 4.6: Variation of power and distance obtained from the average horizontal voltage.

By using the voltage readings that were obtained power was calculated by using the relationship between voltage and resistance indicated from equation 4.1 above .The resistance of the loop antenna was 0.6ohms .The relationship of the variation of power and distance of tag from reader was obtained as shown by the graph in fig 4.3 above. The graph showed that the induced power varied inversely with the distance. The power is at its maximum when the tag is close to the antenna and it decreases as the tags are moved away from the read range zone.

Table 2: Table of results showing the voltages across an antenna loop oriented vertically with the corresponding distance and the average voltage.

Distance (mm)	**voltage Reading1 (mV)**	**voltage Reading2 (mV)**	**Voltage Reading3 (mV)**	**Average Reading (mV)**
0.1	54.8	53.2	57.5	56.5
0.5	35.2	33.7	40.8	36.6
1.0	24.0	23.8	30.8	26.2
1.5	18.9	18.6	23.4	20.4
2.0	13.4	13.2	17.8	14.8
2.5	11.1	10.9	12.9	11.6
3.0	8.6	7.8	10.0	8.8
3.5	7.3	6.8	7.5	7.2
4.0	5.7	5.4	5.2	5.4
4.5	4.8	4.5	4.8	4.7
5.0	4.2	3.6	4.2	4.0
5.5	3.7	3.5	3.3	3.5
6.0	3.0	2.6	3.1	2.9
6.5	2.6	2.9	2.8	2.8
7.0	2.3	2.4	2.5	2.4
7.5	2.5	2.3	2.4	2.4
8.0	2.0	2.0	2.0	2.0
8.5	0.1	2.0	0.1	0.73

The table 2 above shows the voltage readings that were obtained at various distances between an RFID tag and the loop antenna of an RFID reader. These voltage readings were obtained with loop antenna orientated vertically .Three readings of the same value were obtained at the same length measurement. Due to the changes of EM fields different readings were obtained for the same distance between a tag and the reader. Many voltage readings were taken and they were averaged so as to reduce the level of error.

The maximum voltage reading when the loop antenna was orientated vertically was 56.5 millivolts at a distance of 0.1mm between the tag and the loop antenna as shown from the table 2 above. By comparing the maximum voltage readings between that of a loop antenna vertically orientated and that of it being horizontally orientated, it is observed that when loop antenna is horizontally orientated a higher voltage reading is obtained than when it is vertically orientated. This is due to the fact that horizontally orientation of the loop antenna provides more surface area. The obtained results when a loop antenna is orientated vertically shows an inverse relationship between voltage and the distance between a tag and loop antenna.

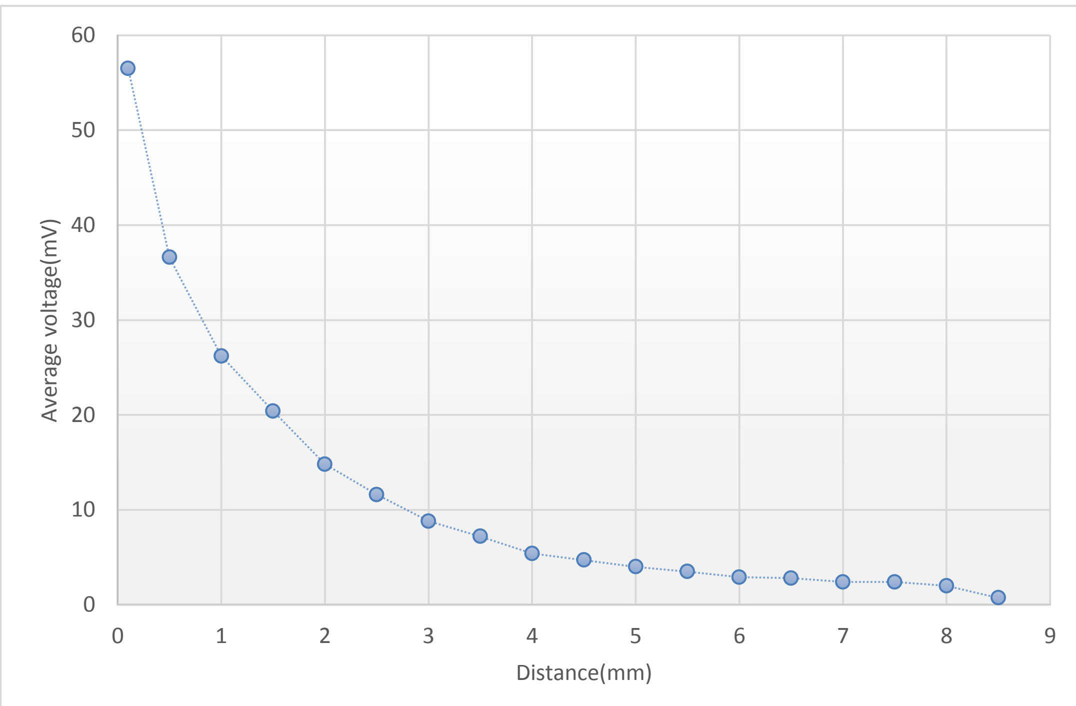

Fig 4.7: Variation of voltage with distance for a loop antenna oriented vertical

The graph on fig 4.5 shows the variation of voltage and distance which varies inversely from the results obtained as expected from the theoretical graph above in fig 4.2. High voltage readings are obtained in the read range zone close to the RFID antenna. The obtained results showed that the voltage and distance varies inversely to each other. As one parameter is increased the other is decreased. The voltages obtained in the vertical form showed that were a bit lower as compared to the ones obtained in the horizontal format and this is due to the increased surface area for a loop antenna which is horizontally orientated.

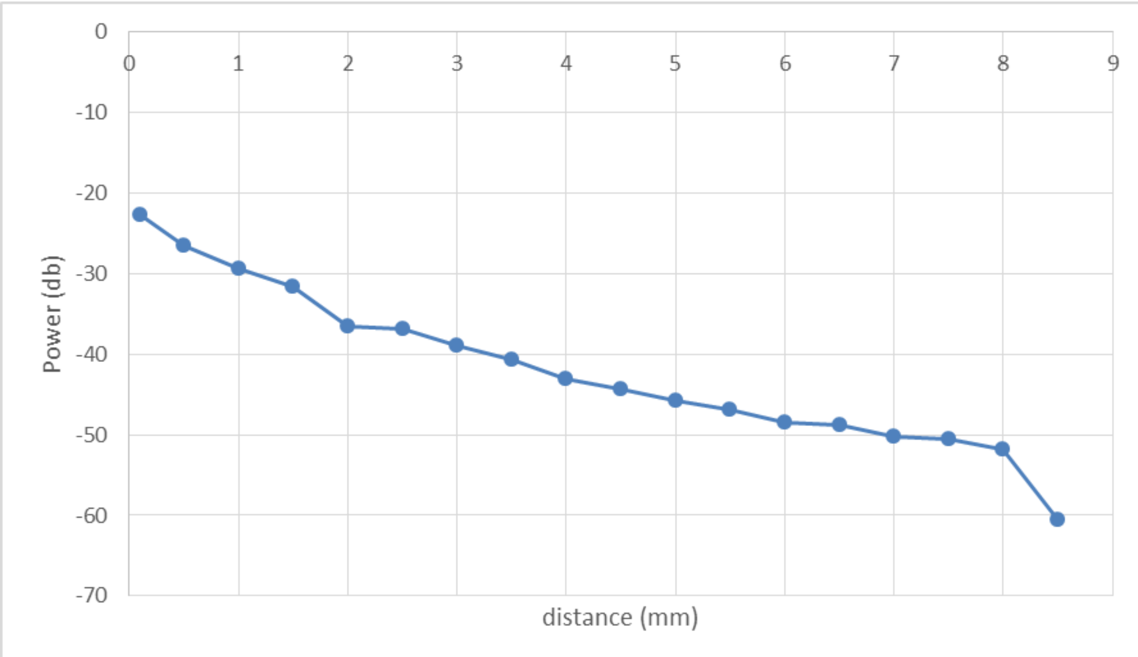

Fig 4.8: Variation of power and distance obtained from the average vertical voltage

The induced power is calculated using the obtained voltage reading and the variation of power with the distance is obtained. The loop antenna used had a resistance of 0.5 ohms. The graph showed that it power varied inversely with the distance. The power is greater close to the antenna and it decreases as the tags are moved away from the read range zone.

4.4 Analysis

- The system proved to automate the payment process of toll and the process takes a few seconds thereby reducing time delays tollgate.
- When a stolen vehicle tag approaches a tollgate a buzzer alarm sounds and the dc motor remains turned off thereby enhancing vehicle security.
- The system also eliminates hard cash transactions as well as reduces levels of fraud.
- The RFID reader used in this system reads tags at a distance of 6.6cm and below.

- The antenna does not allow multiple reading of tags therefore one tag is detected at a time.
- The antenna radiates the same constant power all the time the signal strength depends on the distance at which the vehicle is from the detection zone.
- The horizontal part proved to measure much power due to a large surface area as compared to the vertical part which had a small surface area.
- The project showed positive results as it produced the correct relationship between the antenna power and distance. The graphs showed to be decaying exponential.
- Part of the details about the system was not clearly shown on the LCD since the 16*2 LCD type proved to be small for the task.
- The LCD proved to be clear as the information was read easily.
- The system is user friendly and brings convenience to drivers as they do not have to unnecessarily carry cash.
- The system has a backward compatibility with current manual payment system.
- The antenna cannot read vehicles at high speed so drivers need to slow down and eventually stop upon reaching the tollgate.

REFERENCES

[1] K.Phillipp, Gentner, G.Hofer, L.Arpad and C.F.Mecklenbranker, "Accurate Measurement of Power Transfer to an RFID Tag with On-chip Antenna", PIERS Proceedings, Russia, 2012.

CHAPTER 5

5.1 Introduction

The tollgate collection system using an RFID technology was successful and thereby broadening the designer's intellectual skills as he managed to integrate the gap between practical and theory in the Telecommunication field of study. From the results and analysis obtained the tollgate collection system using RFID technology can be implemented at the current tollgate systems.

5.2 Recommendations

- A GSM module can be integrated into the system for sending verification messages of payment to the drivers and transaction details giving great transparency.
- This system can be integrated with Ecocash whereby drivers can easily transfer money from their Ecocash accounts into the vehicle tag for toll payment.
- An active RFID tag can be used and installed on the vehicle windscreen which allows larger reading distance between a tag and a reader.
- A servo motor can be used for a boom gate as it offers greater compatibility with an Arduino Uno microcontroller in terms of angles of rotation when opening and closing the gate in comparison with a simple dc motor.

5.3 Further recommendations

- This project can be implemented in real time so as to eliminate hard cash transactions and as well as to automate the payment process at the current tollgates in Zimbabwe ,this system will enhance vehicle security as stolen vehicles will be detected at tollgates. This system would also reduce levels of fraud and eliminate illegal tollgate entries.
- This system can also be Implemented at large car parks where drivers pay money for the safe keeping of their vehicles and stolen vehicle will be easy detected if they arrive at the car park facilities.

5.4 Conclusion

The planned aims and objectives of the system were achieved wonderfully and the prototype model functioned very well as expected by the designer. The writer learnt that this system can be strongly implemented at current tollgates in the country and will effectively combat against fraud and corruption that is currently attacking Zimbabwe due to the elimination of hard cash transactions and will also reduce the level of theft of vehicle tags as they will be easily detected at various tollgates around the country. This system will also bring great convinces to drivers as they no longer have to wait long queues at tollgates just to pay their toll and it also eliminates waiting periods by drivers that would have produced high denominations such as $50 and $100 just to pay for a toll of $2. It also brings great accountability for each and every toll collection as the money paid by drivers will directly be debited into the Zimbabwe Revenues accounts just the moment drivers swipes their tags in front of the RFID reader. This project effectively simplified the payment process of toll as this process take a few seconds to perform.

APPENDIX A

Software algorithm

```
#include <LiquidCrystal.h>

#include <SoftwareSerial.h>

SoftwareSerial.h RFID (2, 3); // RX and TX

int data1 = 0;

int ok = -1;

int yes = 13;

int no = 12;

int buzzer =11;

int dcmotor =10;

int pirsensor =3;

 int tag1[14] = {2,55,52,48,48,49,50,54,54,70,65,70,65,3};

int tag2[14] = {2,55,52,48,48,49,50,54,49,67,53,67,50,3};

int new tag[14] = { 0,0,0,0,0,0,0,0,0,0,0,0,0,0}; // used for read comparisons

int balance_tag1=20;

 int balance_tag2 =100;

 int current_balance1;

 int current_balance2;

 int new_balance1=balance_tag1;

 int new_balance2;

 Liquid Crystal lcd (4, 5, 6, 7, 8, 9); // pins for RS, E, DB4, DB5, DB6, DB7

void setup ()
```

```
{
  pinMode (yes, OUTPUT); // for status LEDs
  pinMode (no, OUTPUT);
pinMode (dcmotor, OUTPUT);
  pinMode (pirsensor, INPUT); // declare pirsensor as input
  RFID.begin (9600);    // start serial to RFID reader
  Serial.begin (9600);  // start serial to PC
 lcd.begin (16, 2);
  lcd.setCursor (0, 0);
  lcd.println ("Welcome To");
  lcd.setCursor (1, 1);
  lcd.println ("e-Tollgate");
  delay (5000);
  lcd.clear ();
  lcd.clear ();
}
 boolean comparetag (int aa [14], int bb[14])
{
  boolean ff = false;
  int fg = 0;
  for (int cc = 0; cc < 14; cc++)
  {
    if (aa [cc] == bb [cc])
```

```
    {
      fg++;
    }
  }
  if (fg == 14)
  {
    ff = true;
  }
  return ff;
}
 void checkmytags () // compares each tag against the tag just read
{
  ok = 0; // this variable helps decision-making,
  // if it is 1 we have a match, zero is a read but no match,
  // -1 is no read attempt made
  if (comparetag (newtag, tag1) == true && balance_tag1 >= 2)
  {
    ok++;
    lcd.setCursor (0, 0);
    lcd.println ("Light vehicle");
    delay (2000);
    lcd.clear ();
    lcd.setCursor (0, 0);
```

```
  lcd.println ("bal left is");
  lcd.setCursor (1, 1);
  lcd.print ("$");
  lcd.println (balance_tag1-2);
  delay (2000);
  current_balance1 = balance_tag1 -2;
  balance_tag1=-2;
    lcd.clear ();
    lcd.clear ();
}}
if (comparetag (newtag, tag2) == true && balance_tag2 >= 10)
{
  ok++;
  lcd.setCursor (0, 0);
  lcd.println ("Heavy Vehicle");
  delay (2000);
  lcd.clear ();
  lcd.setCursor (0, 0);
  lcd.println ("bal left is");
  lcd.setCursor (1, 1);
  lcd.print ("$");
  lcd.println (balance_tag2-10);
  delay (2000);
```

```
    current_balance2 = balance_tag2 -10;
    balance_tag2=-10;
    lcd.clear ();
    lcd.clear ();
  }
}
void readTags ()
{
  ok = -1;
 if (RFID.available () > 0)
  {
    // read tag numbers
    delay (1000); // needed to allow time for the data to come in from the serial
buffer.
   for (int z = 0; z < 14; z++) // read the rest of the tag
    {
      data1 = RFID.read ();
      newtag[z] = data1;
    }
    RFID.flush (); // stops multiple reads
 // do the tags match up?
    checkmytags ();
  }
```

```
 // now do something based on tag type
 If (ok > 0) // if we had a match
 {
   lcd.setCursor (0, 0);
   lcd.println ("Transaction done");
   delay (1000);
   digitalWrite (yes, HIGH);
   delay (1000);
digitalWrite (dcmotor, HIGH);
delay (1000);
   digitalWrite (yes, LOW);
delay (1000);
   lcd.clear ();
 ok = -1;
 }
 else if (ok == 0) // if we didn't have a match
 {
   lcd.setCursor (0, 0);
   lcd.println ("Stolen vehicle");
   digitalWrite (no, HIGH);
   digitalWrite (buzzer, HIGH);
   delay (1000);
   digitalWrite (no, LOW);
```

```
    delay (1000);
digitalWrite (dcmotor, Low);
delay (1000);
    digitalWrite (buzzer, LOW);
  ok = -1;
  }
}
 void loop ()
{
  readTags ();
  int val = digitalRead (pirsensor); //read input value
  if (val ==HIGH)
  {
    lcd.setCursor (0, 0);
    lcd.println ("stop to swipe");
    delay (5000);
    lcd.clear ();
    digitalWrite  (no, HIGH);
    delay (5000);
    digitalWrite (no, LOW);
  }
}
```

APPENDIX B

1. Table 1 Table of results showing the voltages across an antenna loop oriented horizontally with the corresponding distance and the average voltage.

2. Table 2 Table of results showing the voltages across an antenna loop oriented vertically with the corresponding distance and the average voltage.

APPENDIX C

List of Abbreviations

AC - Alternating Current.

BAP - Battery Assisted Passive.

DC - Direct Current.

IC - Integrated Circuit.

IDE - Integrated development Environment.

HF - High Frequency.

LED - Light Emitting Diode.

LCD - Liquid Crystal Display.

LF - Low Frequency.

MF - Mid Frequency.

RFID - Radio Frequency Identification.

.PIR - Passive Infrared.

PRAT -Passive Reader Active Tag.

POS - Point Of Sale.

T_x and R_x -Transmit and Receive

APPENDIX D

List of components

Component	Voltage value	Quantity
RFID reader	5V	1
Arduino Uno	5V-12V	1
RFID Antenna	5V	1
Buzzer	3V-5V	1
DC motor	9V	1
L293D	9V	1
2x16 LCD Display	5V	1
LED(green and red)	…………..	2
Resistors	330ohms and 1k ohms	3
PIR motion sensor	5V	1
RFID tags	…………….	3
Connecting wires	……………..	1
Potentiometer	10kΩ	1