Kwame Nkrumah University of Science and Technology

IMPROVING GHANA'S VOTING SYSTEM BY THE USE OF PAPER DISPENSER SYSTEM.

A thesis submitted to the department of computer science in partial fulfillment of the requirements for the degree of Master of Science (Msc.)

By

MARK ROWLAND BRUCE

PG8962013

NOVEMBER, 2015

DECLARATION

I hereby declare that, apart from references made to existing literature, the internet (the internet site of the Ghana's Electoral commission and other related sites, this project work was prepared by me and it contains all the necessary materials needed for an award of master of Science (Msc).

Mark Rowland Bruce …..…….. ……..……..

Student Signature Date

Certified by

Mr. D. Asamoah ……..…….. …….

Supervisor Signature Date

Certified by

Dr. J. B Hayfron-Acquah ……..…….. ……...……..

Head of Department Signature Date

DEDICATION

This is dedicated to the Almighty God, for His infinite mercies, marvelous grace and wisdom granted to me throughout this work This thesis is also dedicated to all those who in diverse ways have contributed to the completion of this thesis especially my supervisor (Mr. D. Asamoah), Miss Monica Frema and all other friends for their support and advice I received throughout this work

May the granter of grace be gracious onto you.

ACKNOWLEDGEMENTS

My sincere thanks go to the Almighty God for this grace which He bestowed on me throughout this work. I thank Monica Frema, Nana Kudom for the help they gave me in the assembling of information for this thesis. I also thank my supervisor Mr D Asamoah and head of the department Dr. J. B Hayfron-Acquah**.** .Finally, I thank my family and friends who in diverse ways helped me throughout this research work successfully.

ABSTRACT

General Elections grant the populace the opportunity to select their president and parliamentarians and also to express their rights in how they should be governed in general.

In the recent past 2012 General election organized by the Electoral commission of Ghana (EC), there was an introduction of Biometric System which was associated with the electoral processes. It was the first of its kind ever since the introduction of democracy in Ghana. The biometric process is not just the biometric registrations of voters but also the biometric verification to ensure voter authentication and to prevent voters from multiple voting.

Although the biometric system improved the voting system in Ghana, there were a lot of problems that also came up which could have disturb the peace of the nation. The 2012 general election suffered problems of multiple voting and voting without verification which was the main problem to be solved by the biometric system. This however, resulted in the matter of a petition challenging the validity of the election of John Dramani Mahama as president of Ghana. With a critical analysis and observation, the problems that came about were from the fact that ballot papers were manually issued by the electoral officials after verification. That means, voter can get or be issue a ballot paper to cast his/her vote even if he/she has not gone through the laid down procedures. This thesis propose a design and implementation of paper dispenser system, which will secure all the ballot papers and only issued out a ballot paper if the voter has gone through laid down processes for the election. The paper dispenser system take it command or input from a biometric verification device which is rapidly processed for authentication and verification before issuing out ballot paper to voter to vote. Again the paper dispenser system output or result can be used to check for multiple voting and ballot papers that were sneaked into the ballot boxes by voters

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE

1.0 Introduction

Generally, Elections permit the public to pick out their representatives and show their franchise on who should rule them. Basically, the electoral process hinges on the fundamentals of democracy itself. The electoral system should be strong enough to withstand a variety of fraudulent behaviors and also should be understandable and clear enough that all voters and candidates can accept all out coming results of an election. It is without surprise that, we have a history of cases of elections being manipulated in order to determine their outcome. Although Ghana can boost of being successful in electing president for the state since 1992 to 2012, the outcome of the election results are not accepted by all voters and aspirants with the believe that some of the election process and results have been manipulated which have influenced the results from 1992 to 2012 general elections. The recent past 2012 General election organized by the electoral commission of Ghana suffered problems of multiple voting and voting without verification, invalid ballot paper etc. which resulted in a supreme court petition by the leading opposition party leader Nana Addo challenging the cogency of the election of John Mahama as the president of Ghana. With a careful observation the problems of multiple voting and voting without verification, invalid ballot paper came about as a result of the fact that ballot papers were manually issued by the electoral officials after voter authentication.

This research work propose a design and implementation of a paper dispenser machine, which will take its input from a biometric verification device before issuing out ballot papers to voters to vote and check issued ballot papers to identify invalid ballot papers that was sneaked into the ballot boxes by voters to solve the multiple voting and voting without verification, invalid ballot paper that came about in the 2012 General election in Ghana.

1.1 Background

In the recent past 2012 General election organized by the electoral commission of Ghana (EC), there was an introduction of Biometric system which was associated with the electoral processes in Ghana. It was the first of its kind ever since the introduction of democracy in the country. The biometric process included the biometric registrations of voters and biometric verification to ensure voters authentication and prevent multiple voting of voters. In spite of its setbacks, it was able to improve the electoral system in the country.

Although the biometric system improved the voting system in Ghana, there were a lot of problems that also came up which could have disturb the peace of the nation. The 2012 general election suffered problems of multiple voting and voting without verification which was the main problem to be solved by the biometric system. With a critical analysis and observation, the problems came about as a result of the fact that ballot papers were manually issued by the electoral official's after verification. Ghana's election need vivid Multi-factor authentication (MFA) and computerization of manual systems such as ballot paper issuing to prevent voters from multiple voting.

This research work propose a design of computerized paper dispenser machine, which will take its command or input from a biometric verification device before issuing out ballot papers to voters to vote and check issued ballot papers to identify invalid ballot papers that was sneaked into the ballot boxes by voters. This will serve as another means of authentication that will help improve the whole voting process. Voters will be issued with ballot papers only if the biometric verification is successful.

1.2 Problems Statements

The current method of conducting and monitoring election in Ghana is noted to be manually operated even with the introduction of the biometric system hence creates a room for voters and aspirants to live in a state of doubts and suspicion in times of election. Despite the fact that Ghana is still a developing country, the need for automating such systems has always been a greater motivation. The manual way of controlling and monitoring Ghana's election has resulted in the following problems:

- **The necessity to trust the election officials**: In the manual model of authentication and verification, the general public and voters are convince to have confidence in the election officials. It does not provide means to verify and affirm the authenticity of the election officials. In case, the election official is politically biased, he/she can potentially issue multiple ballots.
- **Inability to identify fake Ballots**: Fake ballot papers are difficult to be differentiated from genuine ballot papers.
- **Voting without verification**: Voters who have not passed the verification process can vote because the most important material in paper voting is the ballot sheets.
- **Cost of election:** since most all aspect of the election is done manually, more official needs to be employed which increases the overall budget of the election.

  These and other factors that may be reviewed later are the problems faced by the existing system.

1.3 General Aims of the Thesis

The general objective of the research work is to find a lasting solution to the above stated problems by introducing a paper dispenser machine to the voting process. It will also review the possible

behavior of the existing electoral system and the effect of the introduction of the Paper dispenser machine in electoral systems in Ghana. Through the use of paper Dispenser Machine for ballot paper issuing, this research work may solve the major electoral problems in Ghana such as multiple voting, voting without verification and illegal ballots

1.4 Specific Aims of the Thesis

The specific aims and objectives of this thesis is to design and implement a paper dispenser (PD) machine for Ghana's electoral process that can be:

- Interface with a biometric finger printer system
- Validate issued ballot paper and remove invalid ballot papers that was sneaked into the ballot boxes by voters
- Authenticate valid votes
- Detect and prevent multiple voting

1.5 Hypothesis

In summary of the review of problems described in the previous section yields into a one word: Automation. Most aspect of the Ghanaian voting process is done manually, aspects such as voter register checking, biometric verification, and ballot paper issuing and checking and counting of balloted papers. These are the issues that create the major problems of multiple voting, voting without verification and illegal ballots associated with Ghana's election.

I hypothesis that it is possible to create:

"An automatic system that can perform all these aspect of the Ghanaian voting process"

1.6 Benefits of this thesis

Some of the potential benefits that can be gain from this research work are:

Confidence: Human being has much trust in automatic system compared to that of manual system. The implementation of Paper Dispenser System (PDS) will boost the confidence level of both voters and aspirants by clearing their doubts and suspicion that they have about electoral officials since the system will be self-operated.

Development: Voters will now have the choice to select the right person to lead them since the PDS will prevent multiple voting, fake ballot and invalid vote which have major influence on the outcome result of an election.

Cost: With the introduction of the Paper Dispenser Machine (PD) the cost of employing electoral officials for issuing ballots and verifying votes will be reduce drastically since the (PD) Machine integrate these entire manual functionality into a one system.

Peace and stability: Since the voters vote cannot be easily rigged or manipulated, it will ensure peace and stability since the outcome of the election will reflect the true picture on the ground or will reveal the voter's choice thereby preventing rout and war after election results are declared.

1.7 Scope of Work

As a research work, the complete functionality of the system would be achieved to satisfy a wide range of user requirements. Due to financial constraint, limited time factor and other research limitations, the whole work is restricted to be applied on solving problems such as paper dispensing technology after the biometric verification and authenticating valid ballots.

1.8 Research Report Organization

Chapter 1 of the project deals with the general introduction to Paper dispenser system, statement of the problem, project objectives, Hypothesis, Benefits of this thesis**,** scope of the work and project report organization.

Chapter 2 also presents the literature review of the voting system in Ghana which first deal with a short history of elections in Ghana, the Electoral Commission of Ghana the organized body or institution responsible for election in Ghana, various elections held in Ghana, Electoral Reform Undertaken or Taking Place in Ghana's Electoral System and reviews of Voting Systems Technology such as Traditional Voting Systems and Electronic Voting Systems

Chapter 3 presents the proposed system Architecture, materials and methods used for the design and the science of the individual components for the implementation of the system. The system Hardware block Diagram and software control algorithm in a form of a flow chart is also explained in this chapter.

A chapter 4 deal with the overview of the process module based on its functionalities and explains the real design and implementation of the whole system. The results of the design based on simulation are also completed in this chapter with massive discussion.

Chapter 5 presents the summary of the work and how it relates to other works of the same idea. A brief justification of the design is highlighted and recommended in different ways.
References elaborate the sources of ideas which were used in the process of the research work.

Appendix provides the algorithm for the operation of the Voting Dispenser System.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Chapter two covers the literature review and bring on board theoretical models for improving the electoral voting system in Ghana by means of using a paper dispenser machine which will issue out printed ballot paper to voters after passing through all authentication measures put in place. A broad overview of the Ghanaian electoral voting system and various reforms are presented in this review.

2.1 Brief History of Ghana's Elections

Created from the coming together of the Togoland trust territory and the colony of British Gold Coast, in 1957 Ghana gain its independence from the British. Ghana was the first West African country to gain independence with Dr. Kwame Nkrumah as the leader. The democratic process in Ghana was several times disturbed by a number of military coups.

Ghanaians populace ballot and elects the president (head of state) on national level and a legislature. The people elect the president of the republic for a term of office for four years. The Parliament, which is made up of 275 members are also elected for a term of office for four years in every single constituencies. A presidential seat is won by getting over fifty percent (50%) of the total casted valid votes during the election. But on the parliamentary election side, a simple majority is required to win the election. Since 1992, General elections in Ghana are conducted for every four years with both the parliamentary and presidential on every 7th day of December.
(http://www.ghanaweb.com/GhanaHomePage/republic/polit_hist.php, 2015)

2.2 Ghana Electoral Commission

Ghana's Electoral Commission came into being in 1993 by parliamentary act under Ghana's constitution of 1992 as an autonomous entity with a clear Authority of supervising elections in the country. The commission has performed creditable in overseeing elections in Ghana since its establishment. The elections that have been organized by the electoral commission include, the

2012, 2008, 2004, 2000 and 1996 general elections. (http://www.ec.gov.gh/about-ec, 2015)

2.2.1 The Electoral Commission's Mission in Ghana

The sole mission of the Electoral Commission of Ghana is to advance the course of democracy and better governance to enhanced national development of the Republic of Ghana by institutionalizing transparent, free and fair electoral process that will be acceptable by all the stakeholders and political parties.

2.2.2 The Electoral Commission's Vision in Ghana

The electoral commission's vision is to attain an administration which is resourced satisfactorily, highly independent in the operation of their duties, professionally trained, highly efficient and dedicated to their responsibilities and administering of transparent, free and fair elections to enhance democracy and better governance in the Republic of Ghana. (http://www.ec.gov.gh/about-ec, 2015)

2.2.3 Functions Governing the Constitution of the Electoral Commission

The operation of Electoral Commission are enshrine in the 1992 constitution, the Electoral Commission Act 451, which was amended in 2003 by the Electoral Commission Amendment Act that state that:

- To create voters register and amend it periodically at an interval as prescribe by law;
- To oversee the conduction of all referenda and elections in the country;
- To teach the masses on the processes leading to elections and its aim;
- To create electoral boundaries for the local government and the national elections;
- To perform programs for the enlargement of voter registration exercises ; and
- To do all other responsibilities as may be prescribed by law.

2.3 Elections held in Ghana

Seven successful different General Elections have been organized which include the 2012, 2008, 2004, 2000, 1996, 1992 and the 1960 general elections. The 2008 and the 2000 elections were the top best organized as there was second round of elections on them. Ghana's Electoral Commission has been termed as the model of excellence in Africa because of its non-partisan nature and the high sense of professionalism exhibited by the staff.

2.4 Election Conflict

Despite the problems encountered in all our General elections, each election is an improvement of the previous one. There was an introduction of Biometric system in the recent past 2012 General election to detect and allow authentic voter and stop the over voting problems. In spite of all this measures put in place, the system failed to achieve its general aim, thus resulted in the Supreme Court case which was termed the "Presidential Election Petition" which resulted in the matter of a petition challenging the validity of the election of John Dramani Mahama as President of the Republic of Ghana pursuant to the presidential election held on 7th and 8th December, 2012.

Furthermore, the case was between:

1. Nana Addo Dankwa Akufo-Addo] 1st Petitioner
2. Dr. Mahamadu Bawmia] 2nd Petitioner
3. Jake Otanka Obetsebi-Lamptey] 3rd Petitioner

And

1. John Dramani Mahama] 1st Respondant
2. The Electoral Commision] 2nd Respondant
3. National Democratic Congress(NDC)] 3rd Respondant

The core grounds of their case as follows

1. Over-Voting
2. Voting without biometric verification
3. Absence of the signature of a presiding officer
4. Duplicate serial numbers on pink sheets
5. Duplicate of polling station codes
6. Unknown polling stations

(www.ghanabar.org)

Figure 2.1 Biometric verification during 2012 General Election(www.ec.gov.gh, 2012)

2.5 Reforms in Ghana's Electoral System

In an attempt to improve the clarity of Ghana's Electoral process, the Commission came out with certain changes to make the electoral process very effective. Firstly, there was compilation of credible electoral voters Register with the all political parties, participation and active collaboration.

The 1992 general election voter's register used, were alleged to be having some technical errors which was that; the number of voters in the register were more than statistically what was expected. The cause of these technical errors came about as a result of software problems, double entries due to human error, inconsistent listing of names and the commission's inability to delete the names of voter's whose registration had expired from 1987, the first year of compilation . The new voter's register which was compiled in 1995 had about 80,000 representatives from different parties as observers to erode the doubts which the unusual populaces had created in the existing register. The registration centers involve in the registration amount to a total of 20,000 and every center had four party representatives or agents which were made up of two agents from the opposition parties and the other two from the party in Government. The number of observers at the proceedings at the various poling centers were agreed upon by the electoral commission of Ghana together with the Inter Party Advisory committee (IPAC). The commission together with the IPAC realized that making the agents merely observers and not giving them the chance to take part in what they are supposed to observe will not serve any purpose. It was recommended by the commission that, on each day of registration there should be a daily report on all the registration forms which should be filled completely and counter signed by the party agents present at each registration. The evidence

of the challenge form filled, total number of the registration and the unfilled registration completed forms was to be provided by the completed daily accounting sheets: The electoral commission's own registration officials and the agents of the parties were trained together and were with them throughout the registration periods. The agents of the political parties gained massive insight in the registration process, an idea which they could share with other members of the political party. The new voter register was consequently generated and accepted by all the various political parties with no argument. The parties were given sets of the newly compiled voters register upon their request. All these initiatives were done to fulfill the requirement in the organization of free and fair elections in Ghana.

Opportunities such as challenging the applicant at the time of his/her registration was not provided during the registration process, however complains could be filed about the registration during the exhibition process. This created a lot of panic in the sense that ineligible populace could get registered. In order to forestall the confidence in the exercise, the electoral commission provided a way by which the applicant could be challenged at the time of his/her registration.

The agreement was that, the applicants whose registration had been challenged would not have their names entered into the voter register but would be allowed to go ahead with their registration and their names would be entered into the register until their challenged had been resolved. This was to help protect also the rights of the applicants.

In order to resolve the challenged applications cases related to the registration process, the Electoral Commission created the District Registration Review Committee (DRRC) comprising of up to four (4) or less legal persons who were known to be non- partisan and fair minded and members of the various political parties in the district for each district in the country.

The District Electoral Officer who happens to be the secretary in charge of the District Registration Review Committee together with the commission came out with a guideline that, the District Police and the Educational Officer and members of the traditional authority in the district should also be part of the review committee. The commission in its recommendation stated that, High Court Judge should be the supervising chief registration Review Officer for each region and evaluate the appeal of a voter aggrieved by the decision made by the District Registration Review Committee. The District Registration Review Committee figures covered from the various cases dealt with in the country concerning the voter registration exercise in 1995 showed that, of the 11,354 cases challenged brought up for hearing, as many as 6,827 applicants that were challenged were relieved and 5063 of the cases were disqualified.

Voters identity cards have the Name of the voter, the age of voter, the gender of the voter and most importantly a unique serial number of the voter were issued to voters in the year 1995 by the electoral commission. However as a result of insufficient funds of this electoral registration process, voters in only the ten regional and ten of the rural constituencies were selected which was made up of about one-third of the whole voter population had the identity cards that bear their photo with the remaining two-third voter population receiving their identity card bearing their thumb-print on the card.

Photo Identity cards were issued to all the voter population by the electoral commission during the 2000 general election in order to address the problems and complains about voter impersonation and also with the use of voter identity cards that bear the thumb print in the case of the absence of thumb-print reader to confirm.

In the previous elections the thumb-printing of the ballot paper was done in a room where the voter is not seen by anyone but in 1996 there was an introduction of the use of cardboard screen which

served as a major reform in the electoral system. Some of the main problems that were associated with this form of vote casting was that, there was the perception that voters can hide some of the ballot papers with them which they can thumb-print and fold together with the original issued ballot paper which can be placed into the ballot box and so cannot be seen. A voting screen on top of a table in the open was introduced in 1996 to make the ballot appear secretly but allow the general public to see the body of the voter while voting so that nothing can be sneak into the ballot box. The commission have also had numerous complains that ballot boxes that are opaque which was used in the past could be filled with already thumb-printed ballot papers before their arrival and even at the start of the election. As a result of these complains; transparent ballot boxes were brought on board in 1996 with donor support to stop the suspicions and allegations. Due to this innovation, voter turnout went up to 78.2% in1996 from 56.2% in1992.

To strengthen the good relationship, partnership confidence and trust between the political parties and the EC and also to improve the clarity of the EC's operations, the (IPAC) Inter- Party Advisory Committee was formed in 1994. IPAC facilitated the moves and meeting between the political parties, the commission and the donor supporters of the entire election. The preparation of the election was also dissected. The issue of confidence building measures such as the provision of ballot boxes that are transparent, photo identity cards and the organization of both presidential and parliamentary elections all on the same day was further deliberated upon.

The importance of the engagement of the political parties in almost every stage of the electoral process was also emphasized. In effect, the general election in 1996, various political parties' representative/agents were made to be present at the various printing-presses where the presidential and parliamentary ballot papers were printed. These entire moves taken by the electoral commission was to ensure that, the political parties were not left out of the election process and hence can easily

accept any outcome of the election result since they were made part of the process and for that matter; they also took it upon themselves to make the electoral activities a success.

Vote counting and the declaration of results have always been a bone of contention arousing some hunches among political parties aspirants that are contending for power. Ballot papers after the elections were countered at the constituency centers even before 1979. It was of the believe that ballot boxes were stuffed or changed on their way from the election centers to the counting centers of the constituencies.

In solving the problem a referendum in 1978 over the union Government, votes were counted at the various polls right after the polls was closed. The agents of all the political parties were given the opportunity to be present during the votes counting at the polling stations but copies of the declaration sheet was not given to them.

Contrary to the 1992 constitution Article 49 which states that after the counting of balloted votes, the total votes for each candidate at the various polling centers, would be stated on the Result declaration form which the presiding officer would append his/her signature to it and counter signed by the representatives of the candidates who witness counting of votes, and consequently releases copies of the result sheet completed and signed to the agents of the various political parties. The elections presiding officer then hand over the results form declared to the returning officer of the collation center in the constituency.

Counting of votes was done at the collation Centre unless a protest was raised at the polling station. In such a case, the challenged ballot papers from the affected polling centers would have to be recounted at the collation center in the eyes of the party representatives. Final results of the collated votes that was obtained by the candidates would be entered on a constituency's declaration result

forms which the returning officer will append his/her signature and also countersigned by all candidates agents with a copy to each of them .The Returning officer announced the results and elected candidates declared. Results copies are posted at places where everybody could see at the collation centers. The elections returning officer would send the overall results to the electoral commission head office via the Regional Director and the District Officer.

This process had remained with us till now. With the formation of Inter-party Advisory committee (IPAC), continuous communication with the political parties, electoral commission and the donor partners has yielded to new thoughts, that have enhance and brought about more confident in the electoral process which includes. (www.ec.gov.gh, 2015).

1. The formation of political parties' code of ethics, the conduct of political parties in an election and the regulations of relationship of inter-party.
2. The watch of the media committee was established by the commission to oversee and report all issues concerning the elections so that they can be corrected and addressed, should there be information concerning the electoral process it would be made available to the general public through the media. The idea behind this move is to maintain the integrity of the EC, so that the public can have confidence in them.
3. Refresher course for media Practitioners:-In a bit to keep media practitioners up to date with current trend of events, training was organized for media practitioners and also to make sure that reports given out by the media are very accurate.
4. Remuneration of poll workers and training review was carried out to boost the commitment level and enhance their competency.
5. Technology usage: Optical mark readers (OMR) which was brought into the registration systems of vote in relation to getting of data, enhanced the voter registration process in

1995. The register was put together early, the information level was highly accurate as compared to the past years registration exercise, the cost of labour was significantly low compared to the past years and more so. a Local Area Network (LAN) was installed by the electoral commission at the head office of the commission and was linking nearly two hundred computers (200) at their office. A wide Area Network (WAN) was also installed to liaise with the District offices and regional offices to the head office. The Local Area Network is to be deployed before 2000 general Elections. The intranet services and data transmission of the electoral commission were facilitated by the national network. The connectivity program would ease the inner and outer communications and also coordinate the activities when completed and set up. The regular flow of information from the international elections focused on organizing all, to enhance democratic process.

6. The electoral commission considered coming up with a board that seals with issue concerning voters who have been relocated by transferring them to their new polling station.

2.6 Systems of voting

Some common designed voting system for general elections has been reviewed in this section. Designing a good electoral voting system should satisfy a number of competing criteria, whether the system will be electronic base or traditional paper ballots or electromechanical devices. The anonymity of the voter's ballot must be a priority not just to ensure the safety of the voter when voting against a malevolent candidate in all the electoral system, but also to ensure that voters have no clear evidence that proves which candidates receive their votes. The existence of such a proof would result in vote buying by a candidate. The voting system must be tamper-resistant to withstand various degrees of attacks and stuffing of ballot boxes by voters.

2.6.1 Traditional Systems of voting

With the traditional system of voting, a voter can cast vote after going through the normal designated polling station and checking his identity. With this type of voting, man is directly involved and so makes the counting to be long. The traditional system of voting slow down the rate of voting since voters always must be present at the polling station. The problem that comes along with this method of voting are so many that it would be infeasible to create a comprehensive list of them. Some of them are:

- Reduce voting rate
- Multiple voting
- Fake voter
- Fake ballot paper, etc.

Figure 2. 2 Traditional Voting Systems in Ghana

2.6.2 Electronic Voting Systems

Electronic voting is a term used to describe the act of voting using electronic systems to cast and count votes.

Several studies have been conducted using computer technology to enhance elections. In these studies caution was brought to fore against the dangers of moving fast to adopt electronic voting machines due to software engineering challenges, insider threats , vulnerabilities of network and the problems encountered in the Florida 2000 presidential election, the inadequacies of commonly used punch card systems of voting have become well understood by the general public. The opposition of computer scientists has led to increasingly widespread adoption of

"direct recording election" (DRE) system of voting. Normally DRE system of voting eliminates completely ballot papers from the voting process. Similar to the traditional system of voting, voters go to their home precinct and show that they can be permitted to vote there, maybe by showing an ID card although some states permit voters to cast their votes without any form of identification at all. After this, a PIN number is given to the voter, or some offer token that permit them to approach a voting terminal, enter the token and then vote for the candidate they like. Should the voter's selection be complete, DRE system will typically show a summary of the voter's selections, giving them a final opportunity to effect changes. In effect of this, the ballot is "cast" and the voter is free to leave.

The greatest problem associated with this system of voting is that, the entire election is based on correctness, robustness and security of the software within the voting terminal. In case the code

develops security relevant flaws, then they might be exploitable either by unscrupulous voters or malicious people from inside. These malicious people include officials handling the election, developers of the voting software (VS) on which the system runs the entire election. If any of this people introduces flaws in the voting system or takes advantage of already existing flaws, then the results of the election cannot be accepted as the true will of the voters. (Thomas J. Fleischman. ,2005)

2.7 Evaluating the equipment of voting

Voting equipment which are widely used in recent years can be grouped into five various categories, namely ballot paper based, Lever voting machine, Direct Recording Electronic voting machine, Punch card and the Optical voting machine.

2.7. 1 Ballot Paper based:

In this form of voting, the voters receives blank ballot sheet. The voter uses a marker or pen to show by inscription that he/she wants to vote for a particular candidate. Counting the ballot with hands is more involving and time consuming activity, however manufacturing paper ballots is very easy, more so, the ballots paper can be kept for counting or verification any time. This is one of the most common type of voting in the world.

2.7. 2 Lever voting machine:

Voting lever machines are special equipment, and each lever correspond to a particular candidate. The voter pulls the lever to vote for his candidate. In this kind of machine, ballot is counted automatically. Its interface is not user friendly enough, for this reason; necessary training to voters will be required.

2.7.3 Direct recording electronic voting machine:

The short form of this machine is DRE. It integrates with torch screen, keyboard or buttons for the voter to press to vote. Some of them relied on voting records and counting of votes and so is very fast. There are doubts about the accuracy of some of the DRE(Direct recording electronic) that works without keeping voting records.

2.7.4 Punch card:

A hole is created on the black ballot by the voter using a metallic hole-punch. Votes are counted automatically, but the result may not be very accurate if the voter's perforation is incomplete.

2.7.5 Optical voting machine:

Voters fill a circle corresponding to their favorite candidate on the blank ballot. The machine them pick the darkest mark on each ballot for the vote and compute the total result. This kind of machine, counting of votes is done very quickly. The only challenge that will arise is when the voter fills over the circle; this will lead to an error-result of optical scan.

2. 8 Paper Dispenser System

A dispenser system is a system designed in such a way that the contents can be used in prescribed amounts. Interfacing a biometric system with the paper dispenser machine, ballot papers can only be issued out by a successful verification of voter. The design of the dispenser system consists of a mechanical and electronic part. The electronic parts consist of an embedded system with set of instructions to control a stepper motor couple to a mechanical device. With a finger print scanner attached to the paper dispenser, the output paper issuing can be controlled.

Figure 2. 3 Paper Dispenser System

2.9 Summary

Based on the conducted survey, it is obvious that the entire election procedures are manually done, from checking of voter validity to counting of casted votes. This however makes the system prone to flawed. The critical aspect of the voting system is the voter's validation and issuing of ballot papers to voters to cast their vote. By fully automating the voter validation and issuing of ballot paper, it will be difficult to manipulate and change the outcome of the election. This thesis computerized paper dispenser machine, which will take it input from a biometric finger print device before issuing out ballot paper to voter to vote and check issued ballot paper to identify invalid ballot papers that was sneaked into the ballot boxes by voters. This will serve as another means of authentication that will help improve the whole voting process. Voters will be issued with ballot papers only if the biometric verification is successful.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

In this research, a Paper dispenser machine is designed to improve the Ghanaian electoral voting system. There are several steps to be applied in designing a paper dispenser or trail machine for the voting system in Ghana. The pertinent information is gathered from the literature review from the previous chapter. This chapter presents the detail method of designing the entire paper dispenser system.

3.1 Proposed system Architecture

The proposed Paper dispenser voting machine combines the electronic equipment which involves firmware, software and documentation required to program control and support equipment and mechanical or electromechanical that is used to define the ballots; to dispense the ballot sheet to voters for casting their vote. The Paper dispenser machine or system is divided into two main parts which are integrated with a bus or cable to function as one complete system. These main parts are the microcontroller based electronic control unit which run the control software (firmware) and the electromechanical unit for the ballot paper dispensing.

The control unit is run by the control algorithm for voter authentication, verification, storing of voted records and issue a control command to control the electromechanical unit for the ballot paper dispensing. The control unit consists of Fingerprint scanner for reading voters fingerprint for authentication and verification, microcontroller (CPU) for the fingerprint data processing and storage, a display screen for outputting information to voter/users and a serial communication interface for communicating with the electromechanical unit. The electromechanical unit on the other side consists of microcontroller (CPU) for data processing, serial communication interface for communicating with the control unit, a barcode reader for reading the dispensed ballot paper serial number, a stepper motor and a coupled mechanical gearing system for dispensing the ballot paper out to the voter. Figure 3.1 shows the Proposed Paper dispenser System Block Diagram.

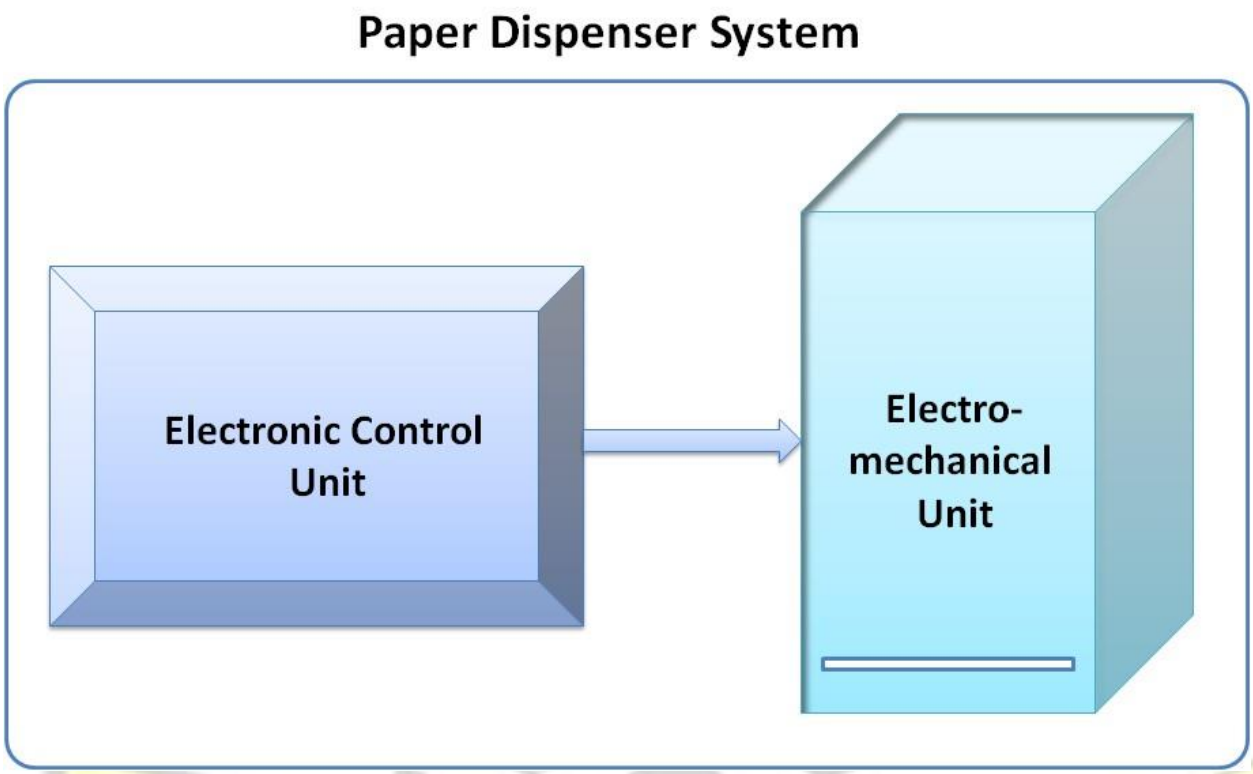


Figure 3. 1 Proposed System Block Diagram

3.2 Microcontroller based Electronic Control Unit

The designing and the implementation of the microcontroller based electronic control unit has been divided into two main parts.

- Hardware design and implementation and
- Software implementation

3.2.1 Hardware design and implementation

Hardware design and implementation covers on planning, schematic diagram drawing on a plane paper to conform with the application and simulating with Proteus ISIS simulation software, testing the diagram of the design on the breadboard with different components to find if the design meets

the desired objective, using the layout of the PCB tested diagram on a breadboard, and finally preparing the board and testing the designed hardware.

3.2.2 Software implementation

The software part covers the programming aspect of the control unit so that it can control the various operations of all the other modules or components used in the system implementation. In the research work, the writer have used the Proteus ISIS design software for PCB circuit design, the MikroC Pro for PIC integrated development environment to compile the source code which was program in C language. The JDM programmer is used to transfer the compiled HEX code from the PC to the microcontroller.

3.3 Electronic Control Unit Hardware Design

For the smooth designing of electronic control unit, the entire system is divided into blocks or modules as shown in Figure 3.2 below, and each block is implemented with the internal circuitry. The main blocks of the control unit include; Power Supply Unit, Liquid Crystal Display (LCD) unit, Finger Print module and a PIC16F887 microcontroller.

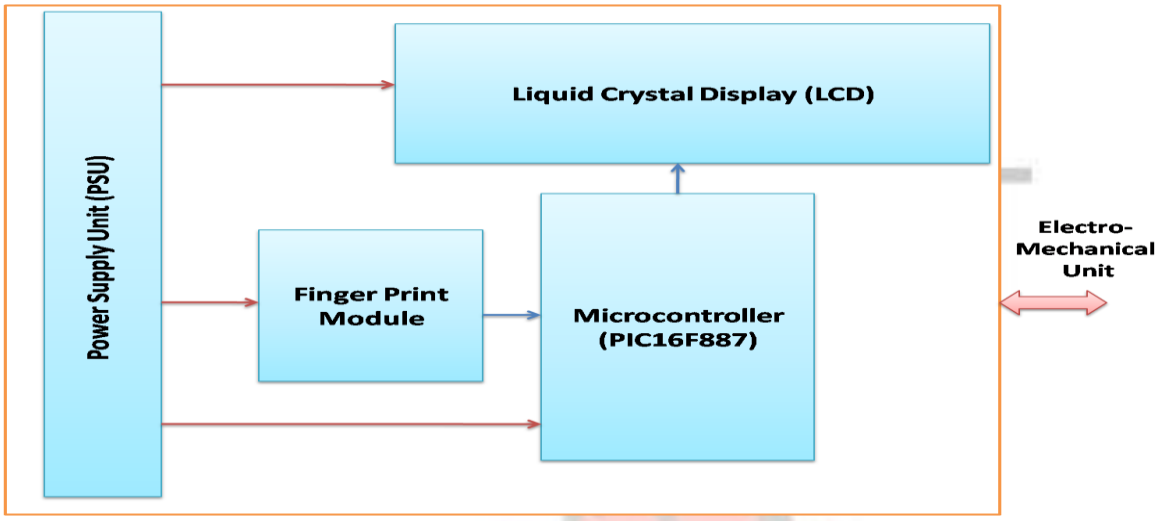


Figure 3. 2 Electronic Control Unit Block Diagram

3.3.1 Power Supply Unit (PSU)

Power supply is a reference to a source of electrical power.

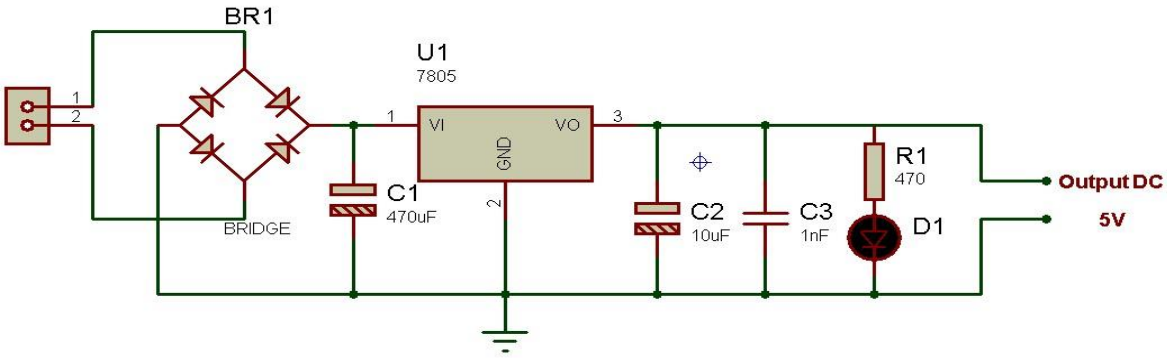


Figure 3. 3 Power Supply Unit circuit diagram

The 220V, 50HZ single phase AC supply line is step down using Step-down potential transformer to get 12V AC supply which is safer to operate with and hence provide isolation from the high voltage 220V AC source. The stepped down 12v is converted to a full wave pulsating DC voltage

using a bridge rectifier. The output of the bridge rectifier which is pulsating DC is filtered using a 470uf capacitor. The unregulated DC source is then fed into 5V linear voltage regulator (7805) integrated circuit (IC) to get stable or regulated 5v DC supply. This 5v DC supply can be used to power all the components in the circuit that requires 5V supply. To ensure ON and OFF status of the power supply, a LED indicator is connected for indication purpose.

A. Bridge Rectifier

Bridge rectifiers are used to convert AC signal to a full wave pulsating DC signal. The step down transformer output is fed as input to the bridge rectifier. It rectifies the A.C. into pulsating D.C. There are two basic types of rectifier, namely the half wave or a full wave rectifier. A full wave bridge rectifier is preferred due to its advantages such as good stability and high power output.

B. Capacitive Filter

Capacitive filter is more often utilized in most power supply circuit. Capacitor eliminates the ripples from the bridge rectifier output and makes the DC voltage smooth. Output received from this filter is fixed while the main voltage and load is also maintained fixed. However, if any of the supply voltage or connected load is varied, DC voltage received at this point changes.

Therefore a regulator is applied at the output stage.

C. Voltage regulator

As the name implies, a voltage regulator regulates the input applied to it and gives a stable output voltage. The voltage regulator is an electronic circuit designed to rapidly maintain a constant voltage level. A constant 5V Power supply is required for the Paper dispenser system to operate. In order to obtain this low voltage levels, L7805 voltage regulators is to be used. The first letter represent the manufacturer of the device in this case STMICROELECTRONICS and first two

number 78 represents positive supply and the last numbers 05 represent the required output voltage levels which is 5V.

3.3.2 Microcontroller Unit (PIC16f887)

The PIC16f887 microcontroller chip is one of Microchip special chip which is manufactured to contain many peripherals within it. The microcontroller chip contain many functionalities like EEPROM, PWM, Serial Communication, ADC, Timers and Counters, 32 Digital I/O Port, microprocessor and large number of general function registers and special function registers. Figure 3.4 shows the pictorial view of the PIC16F887A microcontroller. The PIC16F887A microcontroller is one of the main components of the proposed system and it function as the central processing unit of a computer which run the designed algorithm of the embedded system. PIC16f887 microcontroller chip has a Programming memory (ROM) size of 3Kbytes, a RAM size of 100bytes, 40 pins size DIP, a Clock frequency of up to 40MHz, A/D input, 10bit resolution of A/D converter, inbuilt EEPROM, Serial Communication etc. It also has an 8 – bit timer/counter and two 16 – bit timer/counter.(www.microchip.com).

I. Features

PIC16f887 microcontroller has many features that make it ideal for more advanced level A/D consumer applications such as industrial appliances and automotive. Some of these features are:

- ✓ Software selectable frequency range of 8 MHz to 32 kHz
- ✓ Two-Speed Start-Up mode
- ✓ Clock mode switching during operation for low-power operation
- ✓ Power- Sleep Saving mode
- ✓ Reset-on Power (POR)

- ✓ Voltage Brown-out Reset Selectable (BOR)
- ✓ Extended Timer Watchdog (WDT) with a RC oscillator chip of its own for reliable operation
- ✓ In-Circuit Serial Programming™ (ICSP™) via two pins
- ✓ In-Circuit Debug (ICD) via two pins
- ✓ 100,000 erase/write cycle enhanced Flash program memory, typical
- ✓ 1,000,000 erase/write cycle data EEPROM memory, typical
- ✓ Data EEPROM retention > 40 years
- ✓ Self-reprogrammable under software control
- ✓ Programmable code protection
- ✓ 36 I/O
- ✓ High sink/source current 25 mA
- ✓ Interrupt-on-pin change option
- ✓ TMR0: 8-bit timer/counter with 8-bit prescaler
- ✓ TMR1 enhanced: 16-bit timer/counter with prescaler, External Gate Input mode and dedicated low-power 32 kHz oscillator
- ✓ TMR2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- ✓ Capture/Compare/PWM (CCP) module
- ✓ Enhanced Capture/Compare/PWM (ECCP) module with auto-shutdown and PWM steering
- ✓ Master Synchronous Serial Port (MSSP) module SPI™ mode, I2C™ mode with address mask capability

- ✓ Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART) module:
- ✓ Supports RS-485, RS-232 and LIN compatibility
- ✓ Ultra-Low-Power Wake-up (ULPWU)
- ✓ 10-bit 14 channel Analog-to-Digital (A/D) Converter
- ✓ 2 Analog Comparator modules with:
- ✓ Programmable on-chip Voltage Reference (CVREF) module (% of VDD)

II. Pin Details

Most of the pins of the PIC16f887 microcontroller are multi-functional but can be used to perform one functionality at a time as shown in the Pin diagram figure 3.4 below. For example, the fifth pin of the microcontroller designator RA3/AN3/V_{ref}+/C1IN+ indicates that the pin has the following functions:

- RA3 Port A third digital input/output
- AN3 Third analog input
- V_{ref}+ Positive voltage reference
- C1IN+ Comparator C1 positive input

Such multi-functionality pin is very useful since it makes the microcontroller package more compact without affecting its operation. The various pin functions cannot be used simultaneously; however it can be changed at any point during operation.

III. Pin diagram

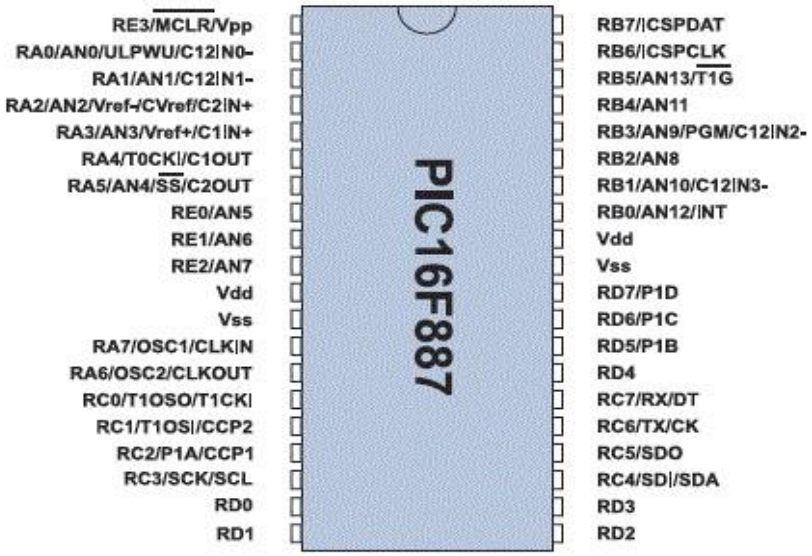


Figure 3. 4 PIC16f 887A Pin diagram (www.microchip.com)

IV. Port Details

The PIC16F887 microcontroller has five different input/output (I/O) ports. Namely Port A, Port B, Port C, Port D, and Port E.

A. Port A and TRISA Register

Port A is a bidirectional (I/O), 8-bit wide port. Bits of the registers TRISA and ANSEL control the PORTA pins. All Port A Pins act as digital Inputs/Outputs pin. Five of the Pins can be used as an analog input which is denoted as AN:

- RA0 = AN0 (set by the bit ANS0 of the ANSEL register);

- RA1 = AN1 (set by the bit ANS1 of the ANSEL register);
- RA2 = AN2 (set by the bit ANS2 of the ANSEL register);
- RA3 = AN3 (set by the bit ANS3 of the ANSEL register); and RA4 = AN4 (set by the bit ANS4 of the ANSEL register).

B. Port B and TRISB Register

Port B is a bidirectional (I/O), 8-bit wide port. Bits of the register TRISB determine the function of its pins similar to the Port A. Logic HIGH (1) in the TRISB register configures the appropriate port pin as an Input and a logic LOW (0) in the TRISB register configures the appropriate port pin as an Output. Six pins on the Port B can act as analog inputs (AN). The ANSELH register bits decide whether the pins will act as digital inputs/outputs or analog inputs.

- RB0 = AN12 (set by the bit ANS12 of the ANSELH register);
- RB1 = AN10 (set by the bit ANS10 of the ANSELH register);
- RB2 = AN8 (set by the bit ANS8 of the ANSELH register);
- RB3 = AN9 (set by the bit ANS9 of the ANSELH register);
- RB4 = AN11 (set by the bit ANS11 of the ANSELH register); and
- RB5 = AN13 (set by the bit ANS13 of the ANSELH register).

C. Port C and TRISC Register

Port C is also a bidirectional (I/O), 8-bit wide port. Bits of the register TRISC determine the function of its pins. Similar to the other ports, logic HIGH (1) in the TRISC Register configures the appropriate port pin as an input.

D. Port D and TRISD Register

Port D is an 8-bit wide, bidirectional port. Bits of the TRISD register determine the function of its pins. A logic one (1) in the TRISD register configures the appropriate port pin as input.

E. Port E and TRISE Register

Port E is a bidirectional (I/O), 4-bit wide port. The register TRISE bits determine the function of its pins. Similar to the other ports, logic HIGH in the TRISE register configures the appropriate port pin as input. The exception is the RE3 which is directional (input only) that is; it's TRIS bit is always set as HIGH. Similar to the Ports A and B, three of Port E pins can be configured as analog inputs. The register ANSELH bits determine whether a pin will act as digital input/output or analog input (AN):

- RE0 = AN5 (set by the bit ANS5 of the ANSEL register);
- RE1 = AN6 (set by the bit ANS6 of the ANSEL register); and
- RE2 = AN7 (set by the bit ANS7 of the ANSEL register).

V. Reset

A system reset initializes the PIC16F887 Microcontroller and begins program execution at program memory location 0000H. The reset input for the device is the MCLR pin (pin 1). In order to reset the device, a logic level low must be applied to the MCLR pin.

Powering up the device without a valid reset can result in the microcontroller to start it program or instruction execution from an undetermined location. Such undefined states may inadvertently corrupt the codes in the flash.(Wikipedia, 2014)

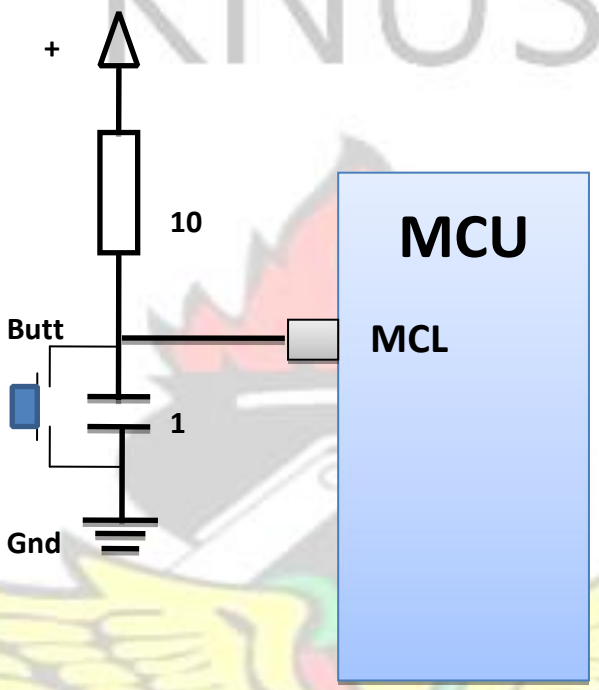


Figure 3. 5 PIC16F887 Microcontroller Reset Circuit

When power is applied to the device, the MCLR pin must be held LOW long enough for the oscillator to start up (milliseconds for a low frequency crystal), in addition to a two machine cycles for a valid power-on reset. An example of a method to extend the MCLR signal is to implement a RC circuit by connecting the MCLR pin to V_{DD} through a 10kΩ resistor and to V_{SS} through a 10µF capacitor as shown in the figure. If an RC circuit is being used, provisions need to be made to ensure the V_{DD} rise time does not exceed more than 1 millisecond and the oscillator start-up time also does not exceed 10 milliseconds.

For low frequency oscillators with slow start-up time the reset signal should be extended in order to take care of the slow start-up time. This method usually maintains the necessary relationship between MCLR and V_{DD} to avoid programming at the indeterminate location, which may cause corruption of the codes in the flash.

VI. Oscillator (Clock)

The external clock (EC) mode uses the external oscillator as clock source. The maximum frequency of PIC16F887 microcontroller clock is limited to 40MHz. The following are advantages of the external oscillator when the PIC16F887 microcontroller is configured to operate in EC mode:

- The independent external clock source is connected to the OSC1 and OSC2 input available as a general purpose I/O;
- Possible to synchronize the operation of microcontroller with the rest of the on-board electronics circuits;
- In the EC mode the microcontroller starts it operation immediately after the power is turn on. There is no time delay for the frequency stabilization; Finally
- The temporary disabling of the external clock source causes the device to stop operation, while leaving all the data intact. After restarting the external clock, the device proceeds with it normal operation as if nothing has happened.

The HS, XT and LP modes all uses external oscillator as a clock source of frequency which is determined by quartz crystal or ceramic resonators that is connected to the OSC1 and OSC2 pins. Based on the features of the component in use, one of the following modes can be used: (Nebojsa Matic, PIC microcontroller Programming in C, www.mikroelekronika.co.yu,)

- **LP mode** - (Low Power) is used for only low-frequency quartz crystal. This mode is designed to drive 32.768 kHz crystals only, usually embedded in quartz watches. It can be easily recognized by their small size and specific cylindrical shape. Their current consumption is the least among all the three modes.
- **XT mode** is used for the intermediate-frequency quartz crystals up to 8MHz. The current consumption is the less compared to the HS modes.
- **HS mode** - (High Speed) is used for very high-frequency quartz crystals of over 8MHz. its current consumption is the highest compared to the three modes.

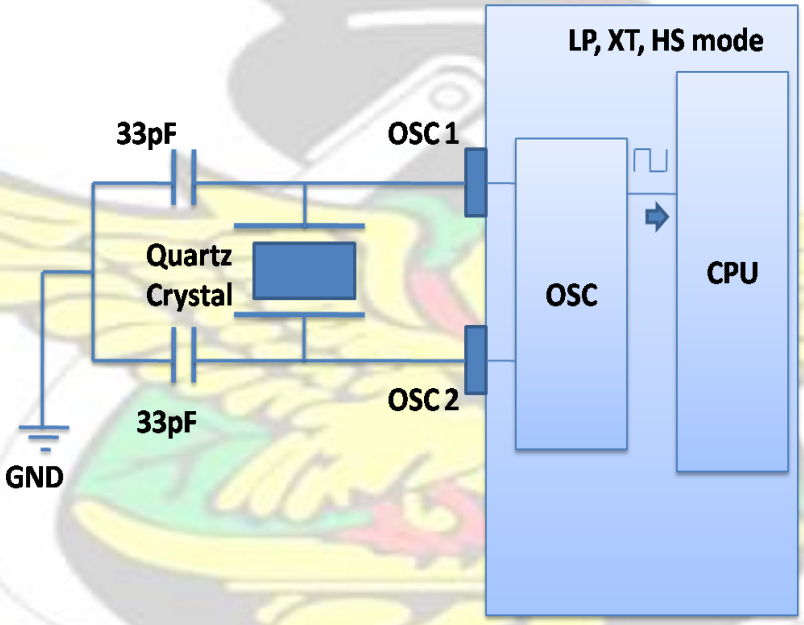


Figure 3. 6 PIC16F887 Microcontroller Oscillator Circuit

VII. Ceramic resonators in XT or HS mode

The Ceramic resonators are by their features similar to quartz crystals and are also connected in the same way as quartz crystals. But unlike quartz crystals, they are cheaper and the oscillators

contained in them have poorer characteristics. They are normally used for clock frequencies ranging from 100 kHz to 20MHz.

3.3.3 Biometrics system era

Biometrics is the art of checking the personality of a person through physiological estimations or behavioral qualities. Since biometric identifiers are related for all time with the client they are more dependable than token or information based verification techniques. In this 21st century, the utilization of biometric based frameworks has seen an exponential development. This is all as a result of gigantic advancement in this field making it conceivable to cut down their costs, ease of utilization and its enhanced utilization in ordinary life. Biometrics is turning out to be new condition of workmanship technique for security frameworks. Biometrics are utilized to anticipate unapproved access to ATM, mobile phones , portable PCs , workplaces, autos and numerous other security concerned materials. Biometric have gotten so effective that it has change the security frameworks making them more secure than some time ago, proficient and shabby.

3.3.3.1 Biometrics categories

Biometrics system can be grouped into two main categories. namely; physical and behavioral system.

a) **Physical biometrics**: The physical biometrics category involves measurement of physical characteristics of individuals. The prominent of the physical biometric used include;

- Fingerprints
- Face recognition

- Retina
- Heart bit and more

b) **Behavioral Biometrics:** The behavioral biometrics category is temporal in nature. They evolve or change during lifetime of an individual. It involves measuring the way in which an individual performs certain tasks. Behavioral biometrics include

- Signature
- Handwriting
- Gait
- Speech

3.3.3.2 Advantages of Biometrics

Biometrics offers a few focal points over customary efforts to establish safety. Some of them are introduced underneath

a) Accuracy and Security

Biometrics based security frameworks are far more secure and exact than customary secret word or token based security frameworks. For instance a password based security framework has dependably the danger of being stolen and accessed by the unauthorized person. Moreover the conventional security frameworks are constantly inclined to exaltness when contrasted with biometrics which is more accurate.

a) Multiple ID, One Individual

The problem faced by traditional security system is that, they don't give solution to the problem of a person having multiple IDs. An example is a person with many passports trying to enter a country other than his own country. A system in which a person cannot possess multiple IDs and cannot change his ID throughout his lifetime is biometric related. Everybody is identified through a unique ID biometrically throughout the entire world.

b) Multiple individual, one ID

One ID can be handled by multiple persons in a traditional system of security. An example is a case of a password based system of security in which a single password can be shared among multiple persons and they can share the resources allotted to one person. Biometric system of security cannot allow a crime such as this, since each person has a single unique ID, and so it cannot be shared with any other person.

3 4.4 Fingerprint

Fingerprints technology has been with us for some time now. As a result of the great research that has come out, this field has reached such a point where the buying of fingerprint system of security is quiet cheap. Due to this reason, fingerprint systems are becoming more popular in a variety of applications.

Fig 3.7 Illustrate an example of a finger print image.

Figure 3.7 Fingerprint Image

3.4.5 Features of Fingerprint

The pattern of a fingerprint is made up of valleys and ridges. With the fingerprint image, the valleys are the light areas between the ridges while the ridges appear as dark lines. Burns or a cut to a finger does not affect the ridge structure as the original pattern will be retained when new skin grows. Valleys and ridges normally run parallel to each other and their pattern can be showed on a global and local level.

3.4.6 Sensor finger print module (R305)

This research work used fingerprint sensor to interface with the control unit in the electronic control unit to authenticate and verify voter for the proposed voting dispenser system. The sensor fingerprint module comes with UART TTL interface which can connect directly to microcontroller UART or the PC through MAX 232/ USB – Serial adapter. The person using the instrument, can store fingerprint data in the module and can configure it in 1: N or 1:1 mode for making up the person.

A 5V or 3V3 microcontroller is interface with a module fingerprint. A level converter (like MAX 232) is required for interfacing with PC serial port figure 3.8 below show the image of the R305 fingerprint sensor module

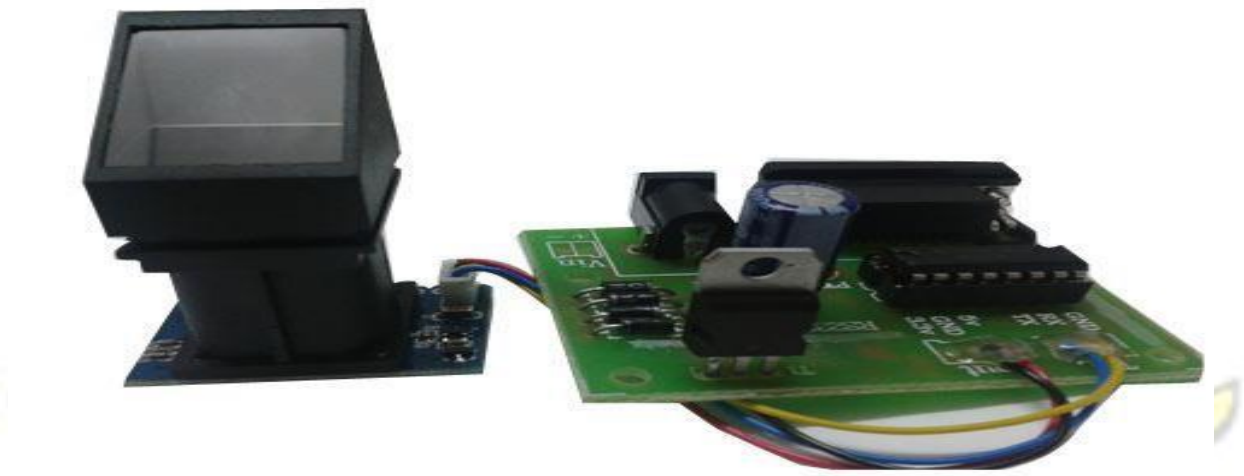


Figure 3.8 R305 Fingerprint Sensor Module(www.sunrom.com, 2015)

3.4.7 Specifications/ Features of R305 Fingerprint Sensor

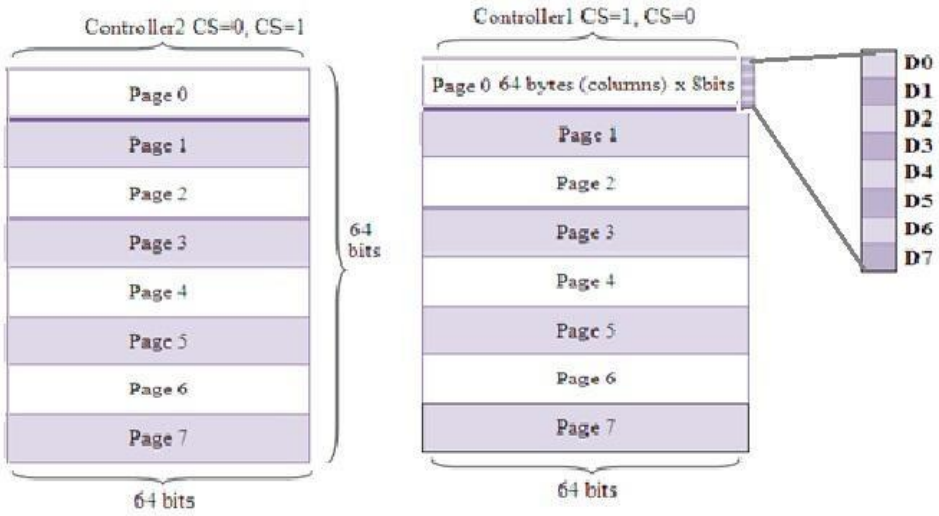
- Fingerprint sensor type: Optical
- Life Sensor :100 million times
- Static indicators: Black light of 15KVt: bright greenish
- Interface: (logical level TTL) UART/USB1.1
- RS232 communication bandwidth rate: 115200BPS ~4800BPS changeable
- Dimension: 21.5mm* 32*55
- Surface Image Capture 18-15 (mm)

- Speed Verification: 0.3 sec
- File character size: 256 bytes
- Speed of Scanning: 0.5 sec
- file Character size: 256 bytes
- size of Template: 512 bytes
- file size Character: 256 bytes
- size of Template: 512 bytes
- Temperature Operating Environment: -20 to 45° centigrade
- Method Matching: 1: N
- Current working: peak 150Ma, typical 90Ma
- Voltage: 3.5-6.0 VDC.
- Resolution 500 DPI
- Rejection False Rate (FRR): 0.1%
- Acceptance False Rate (FAR):0.0001%
- level of Security: 5 (1, 2, 3, 4, 5(highest))
- capacity of Storage: 250

3.5 Liquid crystal Display (LCD)

Liquid crystal display is purposely made for use with microcontrollers. This means that standard IC circuit cannot be used to activate it. This is used to show messages of different miniature on the LCD GLCD, which is a graphical (LCD) and gives an advanced method for showing visual messages. The LCD character can show only characters of alphanumeric, whiles the GLCD can also show messages in the form of bitmaps and drawings.

Graphical LCDs of various magnitude are in the market with all kinds of sizes. In this research work, LHD12864E Graphical LCD is been used and explained. The showing format of the LCD is 128 × 64 dots and comes with a greenish-yellow color and black light .Each one of the LCD, must be operated by a controller to exercise its internal functions. Two KS0108 controllers power the LCD.



The 128 × 64 LCD is segmented into two equal halves, with KS0108 Controller controlling each half. This LCD that uses KS0108 constitutes the whole LCD. The graphical LCD paging scheme is illustrated in the table below.

Figure 3.9 Graphical LCD paging scheme

- 64 x 128 LCD implies 128 columns and 64 rows. In total there are (64 x 128= 1024) pixels.

- 64 x 128 LCD is divided equally into two halves and is controlled by a separate controller and consists of 8 pages. The above diagram illustrate that, CS represents Select Controller.

  Each page consists of 64 columns and 8 rows. Consequently, 8 vertical pages make 64 rows (8x8) and two horizontal pages make 128 (2x64).

Figure 3.10 GLCD Pin out GLCD

3.5.1 Pin Description:

Name	**Function**	**No. of Pin**
Vss	Ground (0 V)	1
Vcc	Supply voltage; 5V	2
Vo	Contrast adjustment	3
Register select (RS)	High to display data; Low for instruction code	4
Read/Write (R/W)	Low to write to the register; High to read from the register	5
Enable (EN)	Reads data when high; Writes data at high to low transition (falling edge)	6

DB0	8-bit data pins	7
DB1		8
DB2		9
DB3		10
DB4		11
DB5		12
DB6		13
DB7		14
CS1	Chip selection for IC1; Active high	15
CS2	Chip selection for IC2; Active high	16
RST	Reset signal; Active low	17
Vout	Output voltage for LCD driving	20
LED A	Backlight V_{CC} (5V)	21
LED K	Backlight Ground (0V)	22

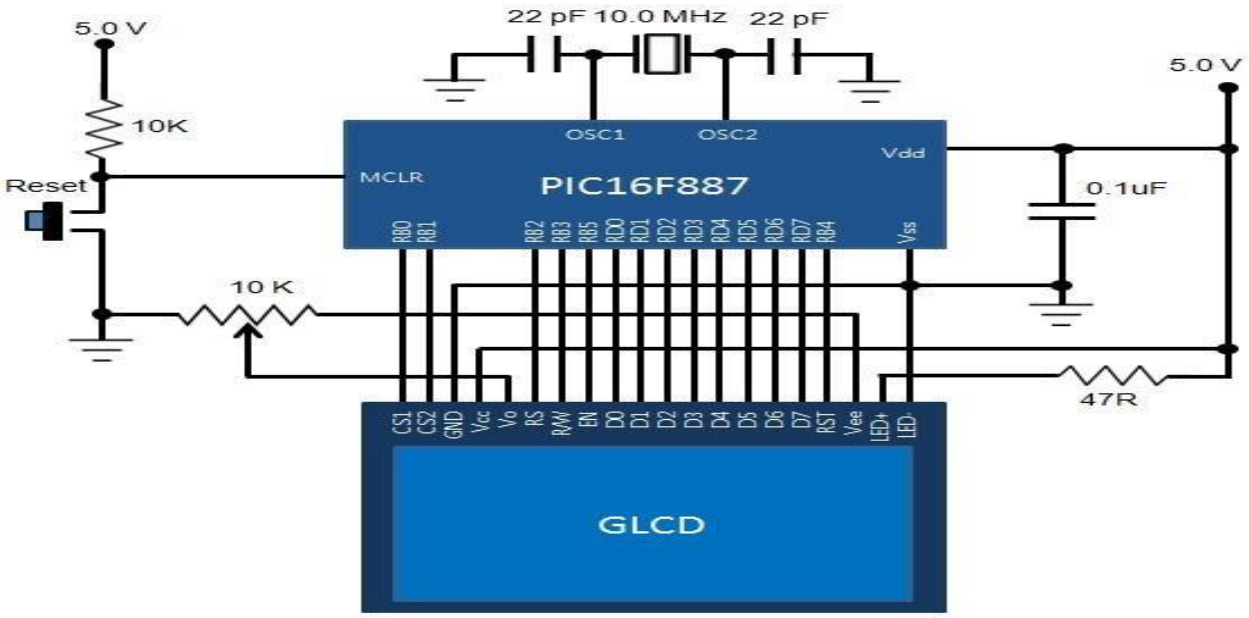


Figure 3. 11 GLCD Interfaced with PIC16F887 (www.embedded-lab.com, 2015)

3.4 Electro-Mechanical Unit

The designing implementation of the electromechanical unit is also divided in two main parts.

- Hardware design and implementation and
- Software implementation

3.4.1 Electro-Mechanical Unit Hardware Design

Again for easy and smooth designing of electro-mechanical unit, the hardware unit has been divided into blocks or modules as shown in Figure 3.12 below, and each block is with the internal circuitry. The blocks include; Power Supply Unit, barcode reader module, Servo motor and Driver, Mechanical Gearing system and PIC16F887 microcontroller.

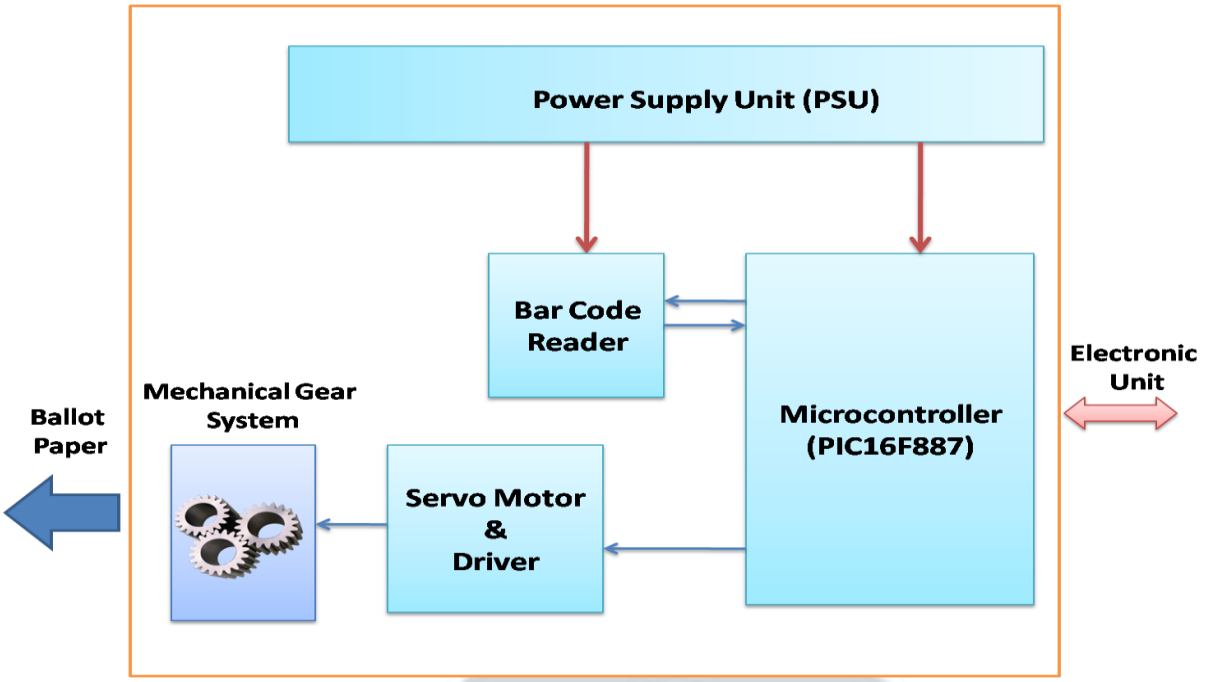


Figure 3. 12 Electro-Mechanical Unit Block Diagram

The power supply and PIC16F887 microcontroller control unit in this block is similar to that of the electronic control unit described above.

3.4.2 Barcode Reader

A barcode reader also known as point-of-sale (POS) scanner is a hand-held or stationary input device that is used to capture and read information contained in a barcode. A barcode reader consists of a scanner, a decoder (either built-in or external), and a cable used to connect the reader with a computer or microcontroller. Because a barcode reader merely captures and translates the barcode into numbers and/or letters, the data must be sent to a computer so that a software application can make sense of the data. Barcode scanners can be connected to a computer through a serial port, keyboard port, or an interface device called a wedge. A barcode reader works by directing a beam

of light across the bar code and measuring the amount of light that is reflected back. (The dark bars on a barcode reflect less light than the white spaces between them). The scanner converts the light energy into electrical energy, which is then converted into data by the decoder and forwarded to a computer or microcontroller.

Figure 3. 13 Barcode Image

3.4.3 MCR12 Barcode Scanner

The OEM scanner has a small camera inside that takes about a hundred photos per second, instead of using a scanning mirror assemble. This implies that OEM scanner is less likely to get damaged or out of alignment.

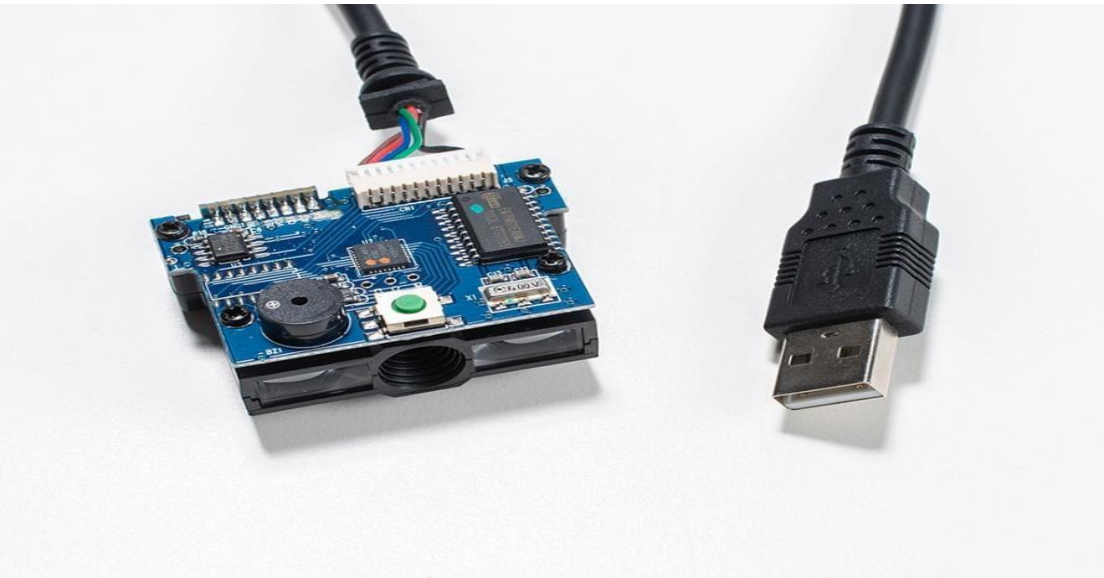


Figure 3. 14 MCR12 Barcode Scanner (www.adafruit.com, 2015)

3.4.3.1 Features

- Light Source: Visible Red light 632nm LED
- Depth Of Field: 230mm @ 20mil/0.5mm, PCS90%
- Resolution: 5mil/0.127mm, PCS90%
- Ambient Light: 5000 Lux Max
- Voltage: DC +5V ±5%
- Power Consumption: 80mA
- Reading Indicator: Beeper
- Scan Rate: 100 scans/sec ±10%
- Operating Temp: 0 oC to 50 oC (32 oF to 122 oF)
- Storage Temp: -20 oC to 70 oC (-4 oF to 158 oF)
- Relative Humidity: 20% to 95%(Non-condensing)
- Mechanical Shock: 2000G, 0.7ms, 3 axes

- Interface: USB HID Keyboard
- Cable: Straight 5 ft.
- Connector: MOLEX 11P Pitch 1.25
- Weight: Approx. 0.56 oz(17 g)(w/o cable)
- Dimension: 44 mm W x 30 mm D x 19.2 mm H
- Mounting Hole Distance: 34mm / 1.3"

3.4.4 Stepper Motor and Driver

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.

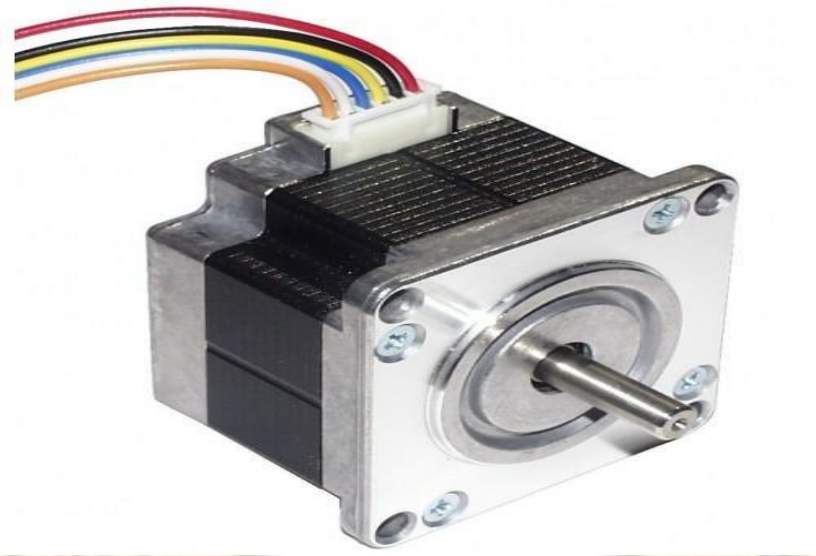


Figure 3. 15 Stepper Motor

3.5 Software Implementation

In this section simulation software, Proteus professional ISIS and MikroC Pro for PIC was used to test the performance parameters of the set up on analogue to digital conversion and the full digital processing and output of information to the window application residing on the personal computer.

3.5.1 Programming Environment

MikroC Pro for PIC is the Integrated Development Environment (IDE) used in writing the firmware for the PIC microcontroller. Visual Studio software is the integrated Development Environment and Visual C# programming language is use for writing the Graphical User Interface to be installed and run on a Personal Computer that connects to the designed hardware device. The hardware design was simulated using Proteus Professional ISIS simulation software.

3.5.2 PIC16F887 Firmware

The firmware is an operating software or system written to control the microcontroller. This is written in C language using MikroC pro for PIC compiler. The C programming language is a general-purpose programming language that provides code efficiency, elements of structured programming, and a rich set of operators. Its generality, combined with its absence of restrictions, make C a convenient and effective programming solution for a wide variety of software tasks. Many applications can be solved more easily and effectively with C than with other more specialized languages. The MikroC compiler generates HEX code from the high level language code C for the PIC microprocessor. The generated HEX code is flashed or uploaded unto the PIC16F887 with a Pic programmer through a serial COM port or USB port. A programmer or Flash software such as WinPic is required to upload the HEX file from the Personal Computer to the PIC16F887 microcontroller.

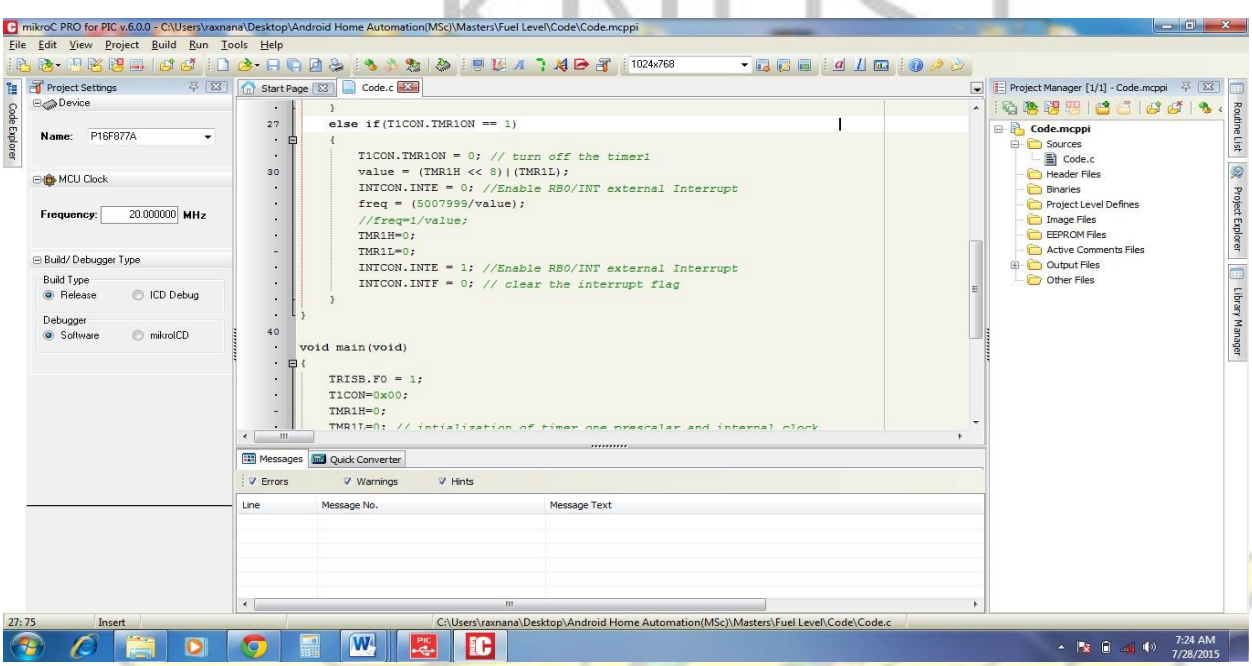


Figure 3. 16 MikroC Pro for PIC IDE

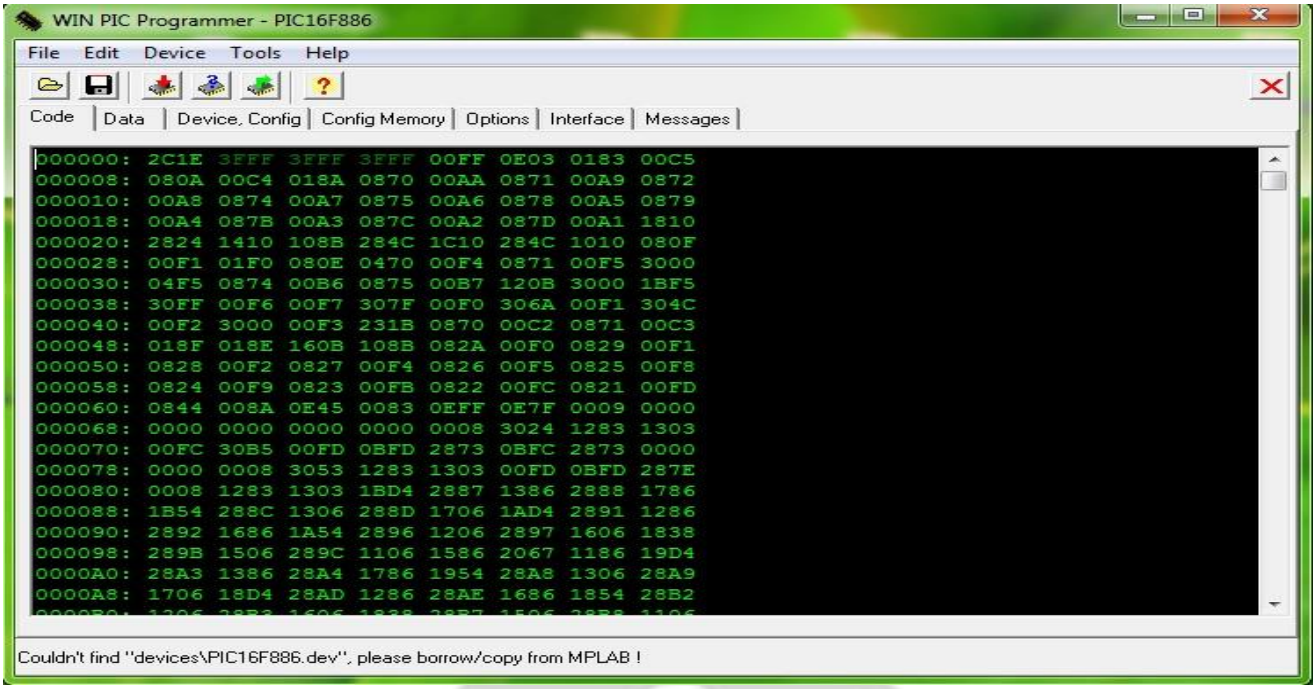


Figure 3. 17 Win Pic Programmer

3.5.3 PIC Control Algorithms

The Figure 3.23 to 3.28 represents the algorithm in flowchart for the PIC16F887 firmware for the control of the entire hardware system.

3.5.3.1 Control Unit Control Algorithm

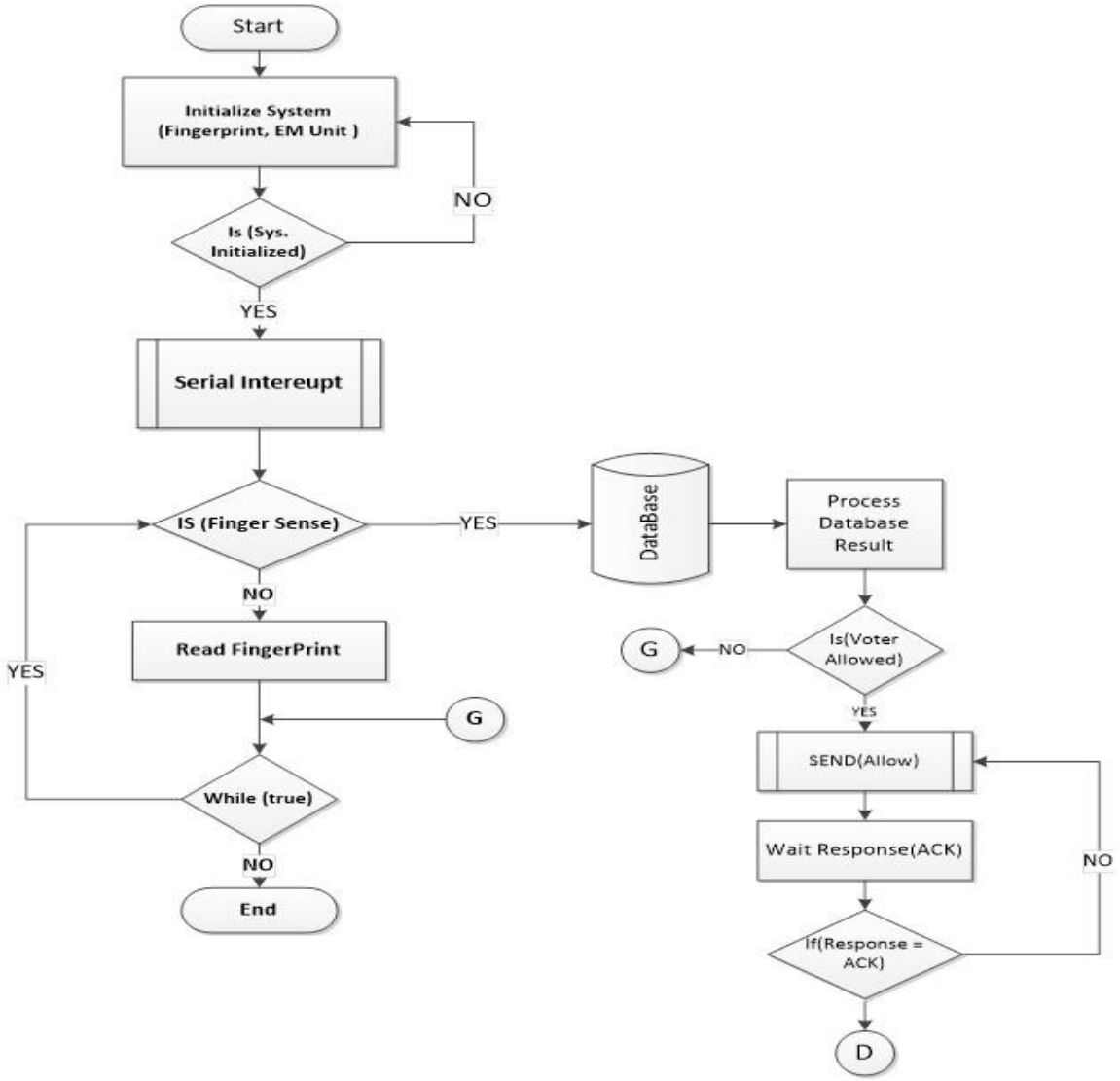


Figure 3. 18 Control Unit Flowchart (A)

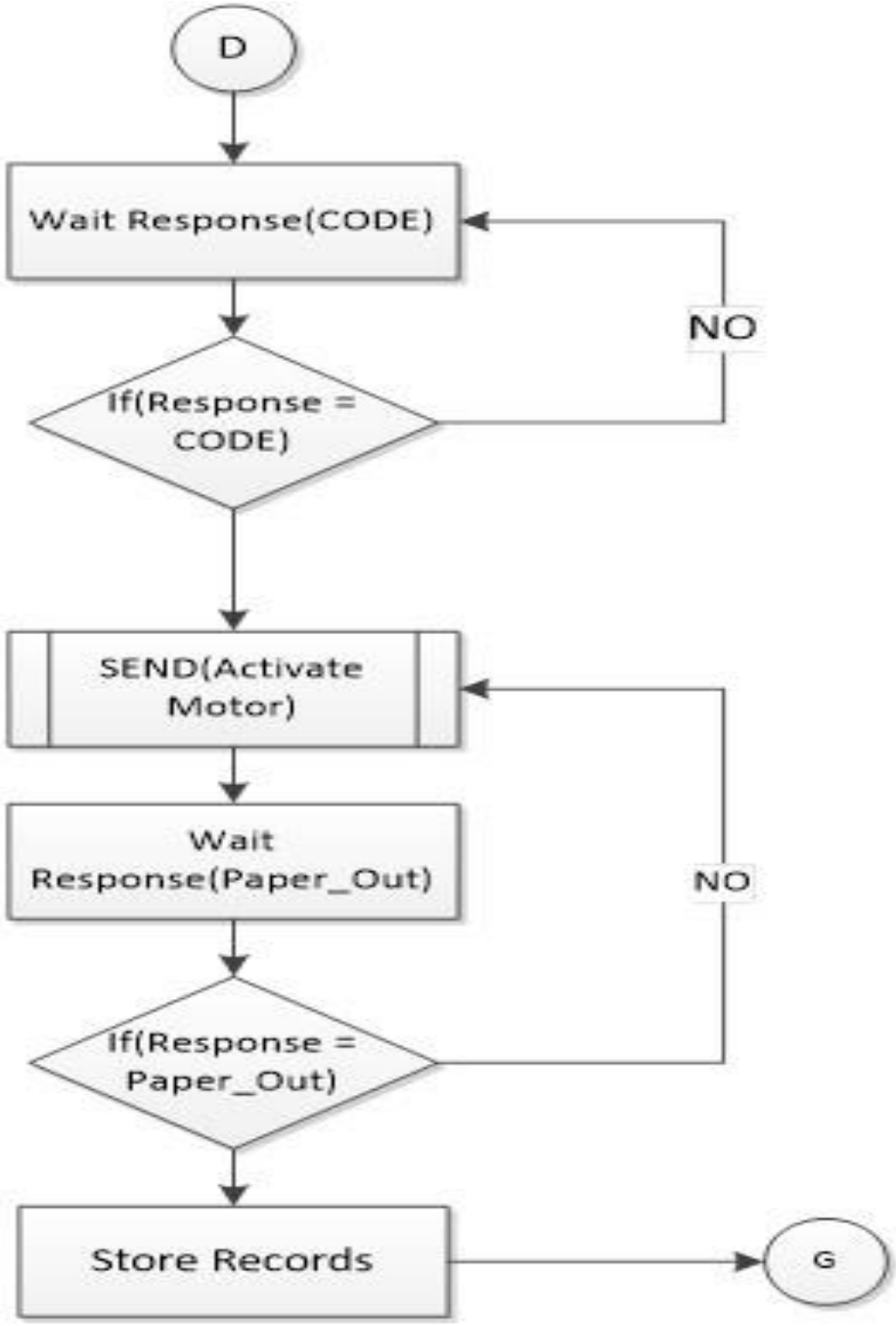


Figure 3. 19 Control Unit Flowchart (B)

3.5.3.2 Electromechanical Unit Control Algorithm

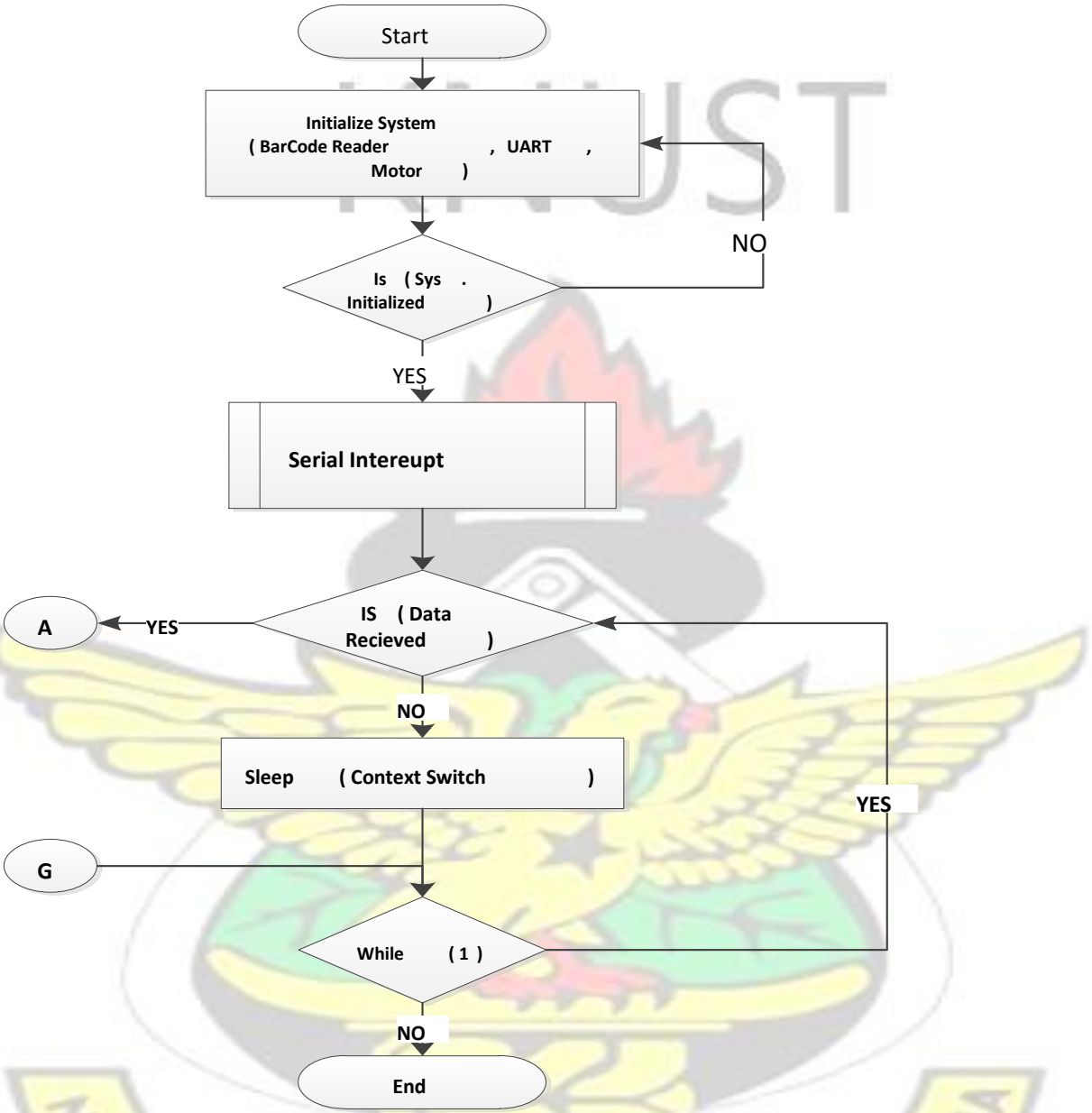


Figure 3. 20 Electromechanical Unit Flowchart -A

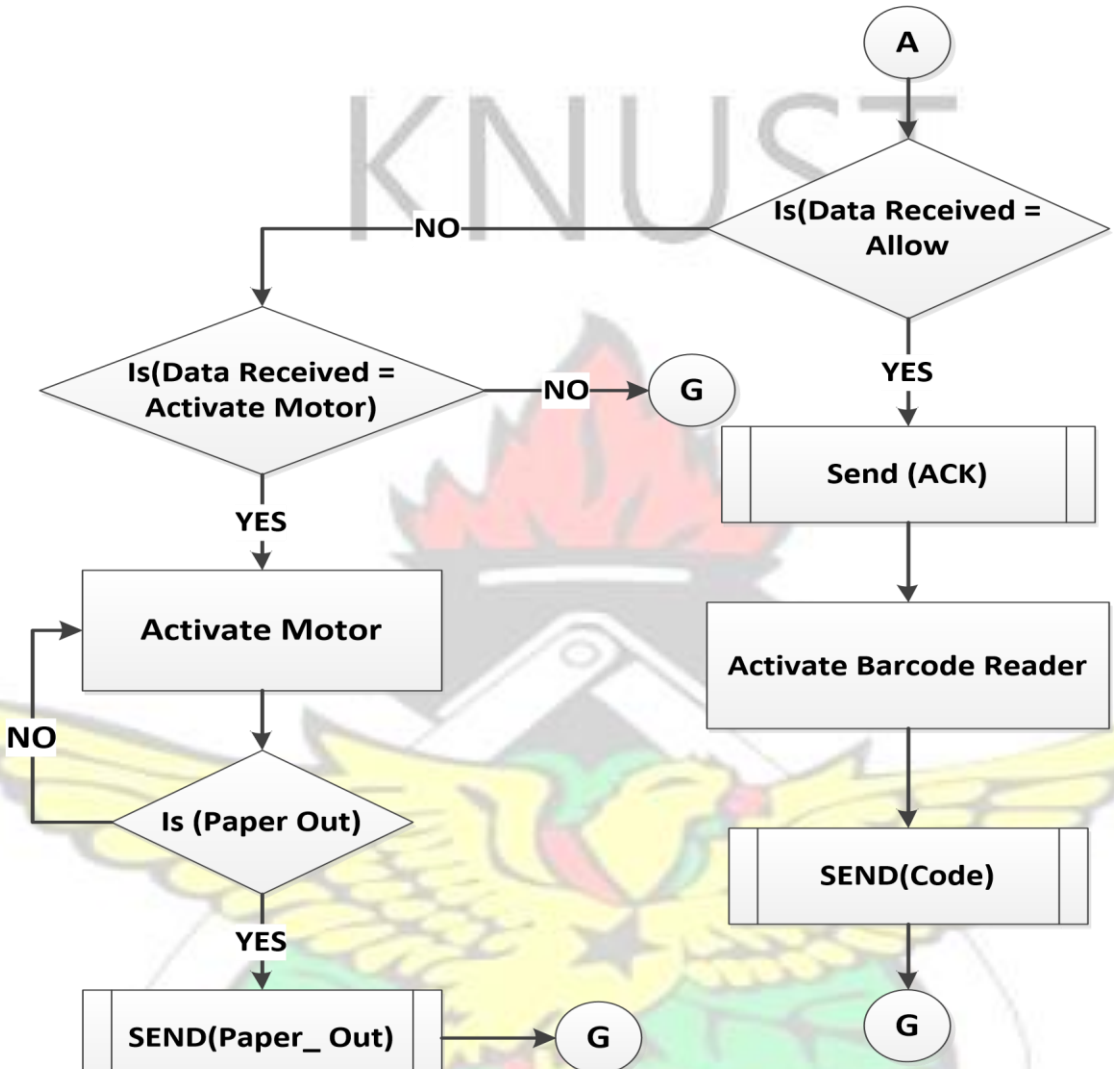


Figure 3. 21 Electromechanical Unit Flowcharts -B

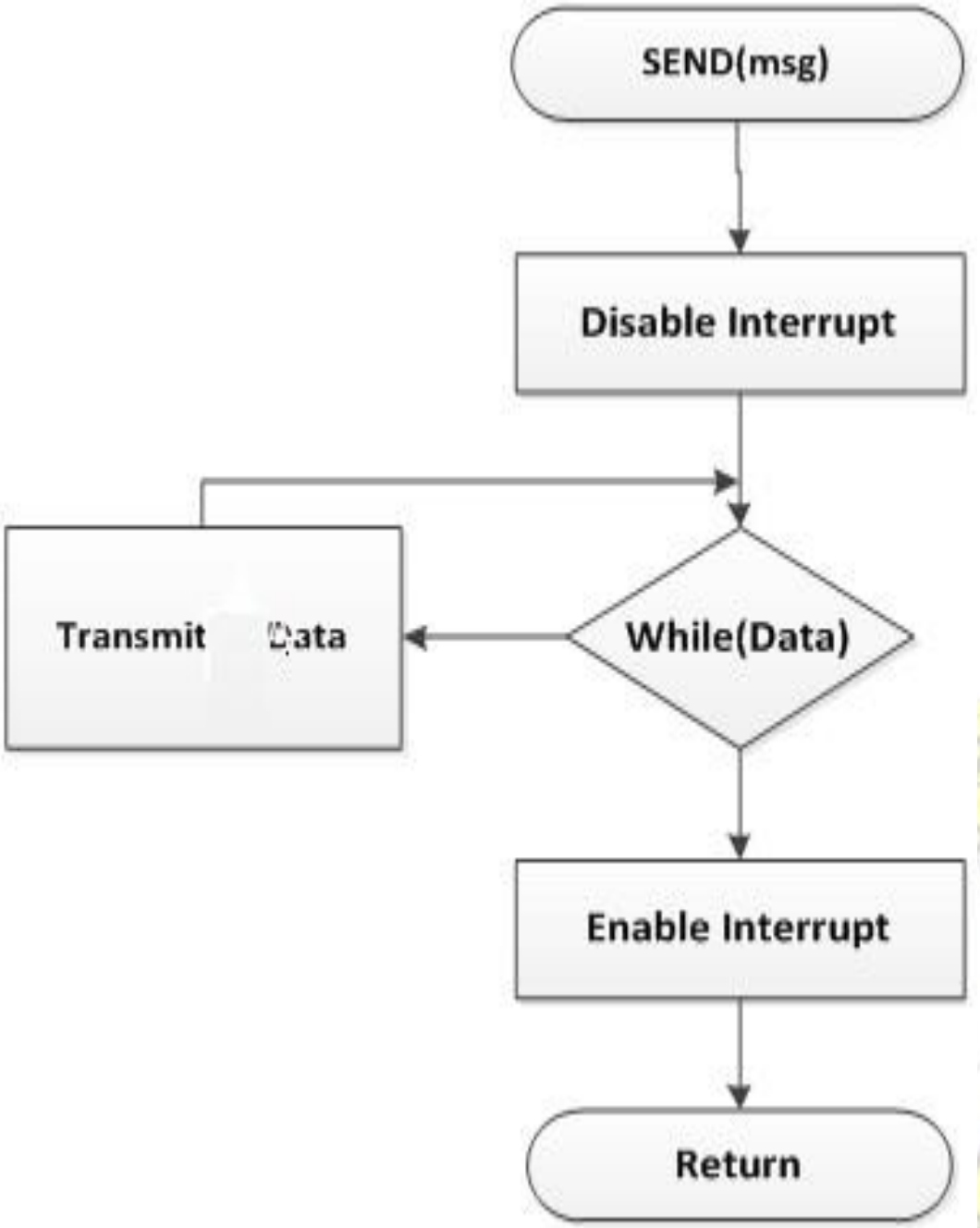


Figure 3. 22 Electromechanical Unit Flowcharts -C

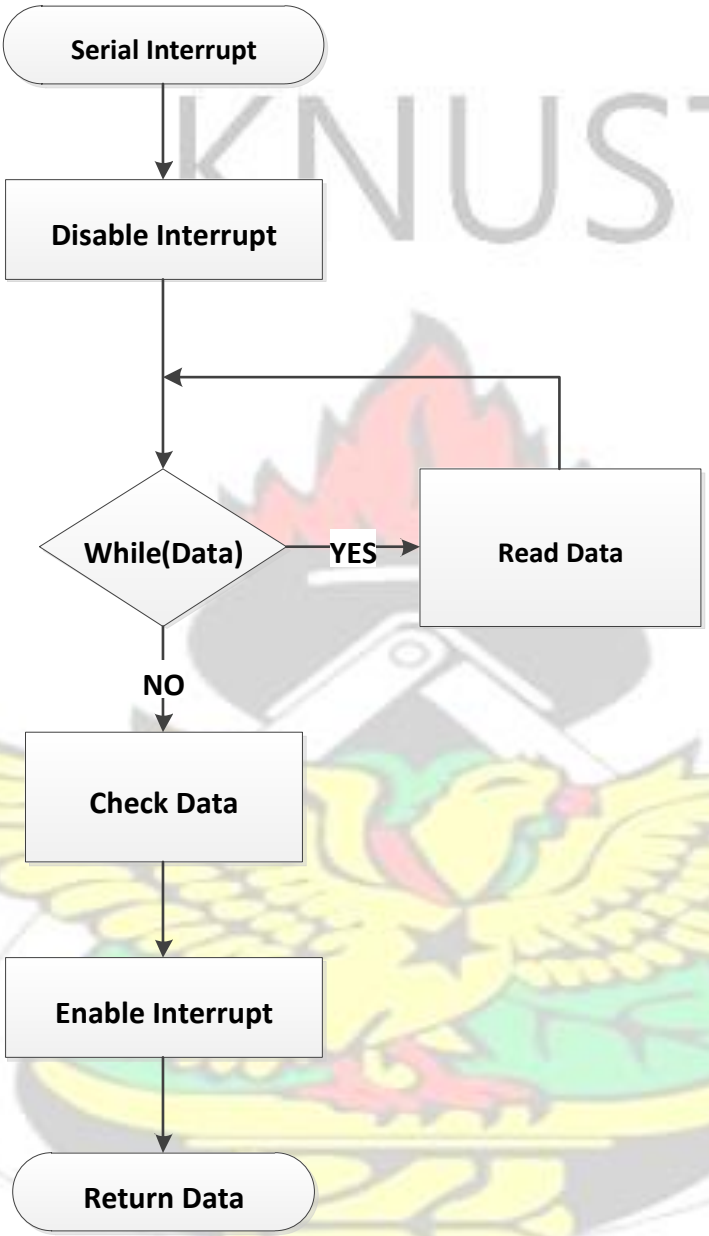


Figure 3. 23 Electromechanical Unit Flowcharts -D

3.5.4 Graphical User Interface (GUI)

The GUI is an Application written to interact with the user on the personal computer. This is written in Window Form programming language called Visual C# integrated in the Microsoft

Visual Studio IDE.

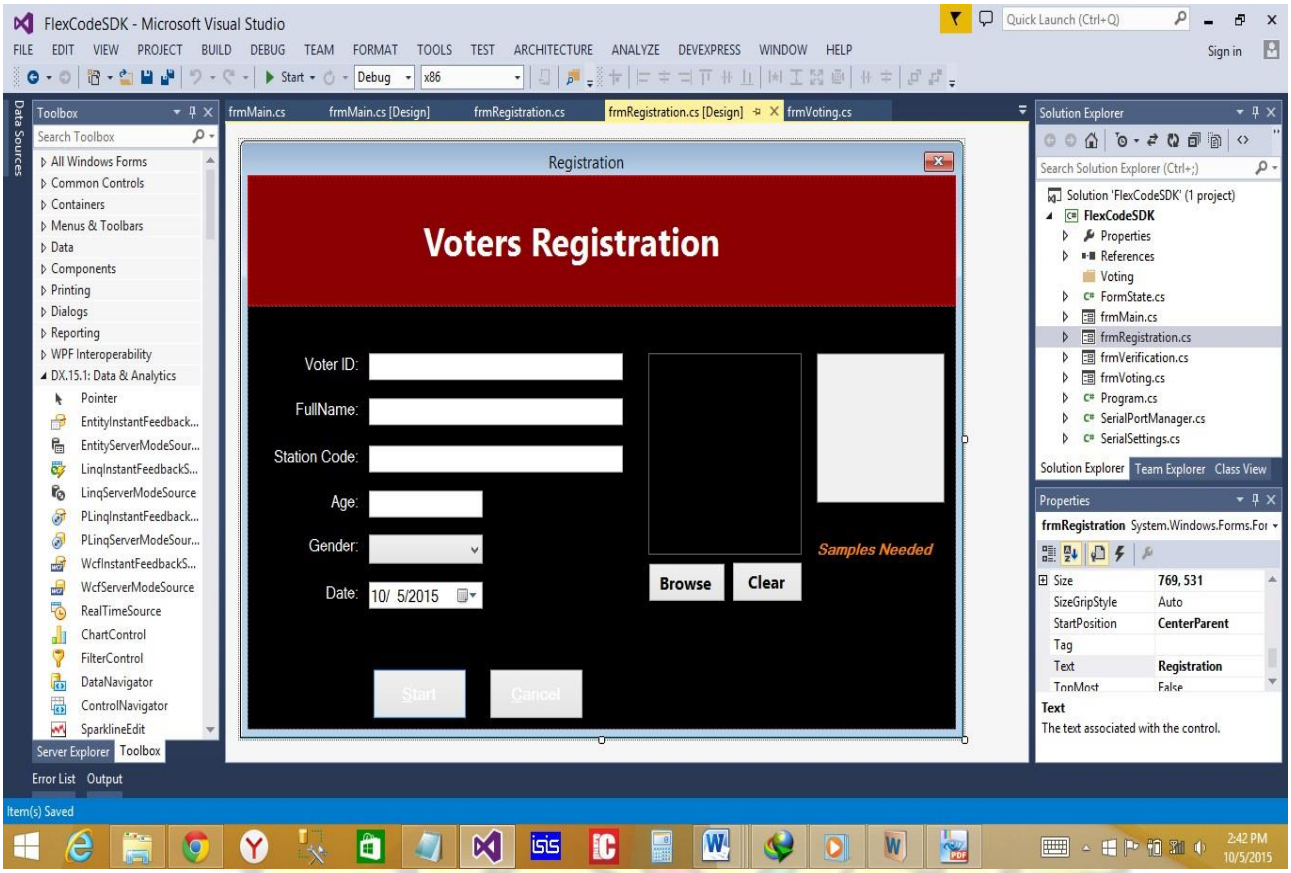


Figure 3. 24 Visual C# Design View Window

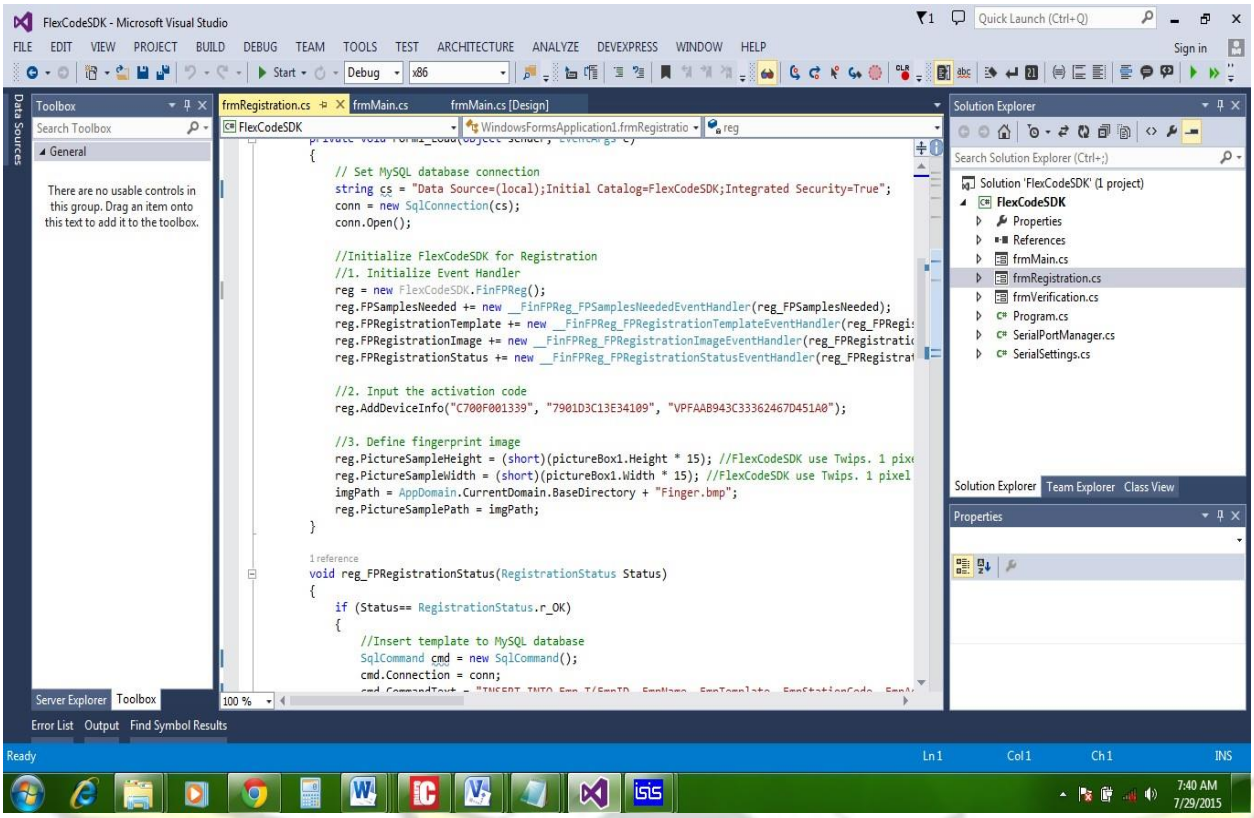


Figure 3. 25 Visual C# Code View Window

3.5.5 Simulation Software (Proteus Professional ISIS)

Proteus Professional ISIS is an industry-standard, best-in-class SPICE simulation environment from Lab Center. Proteus ISIS is used for Virtual System Modeling and circuit simulation application. The suite combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. Proteus also has the ability to simulate the interaction between software running on a microcontroller and any analog or digital electronics connected to it. It simulates Input / Output ports, interrupts, timers, USARTs and all other peripherals present on each supported processor.

The figure 3.31 below shows the simulation IDE of the Proteus Professional ISIS.

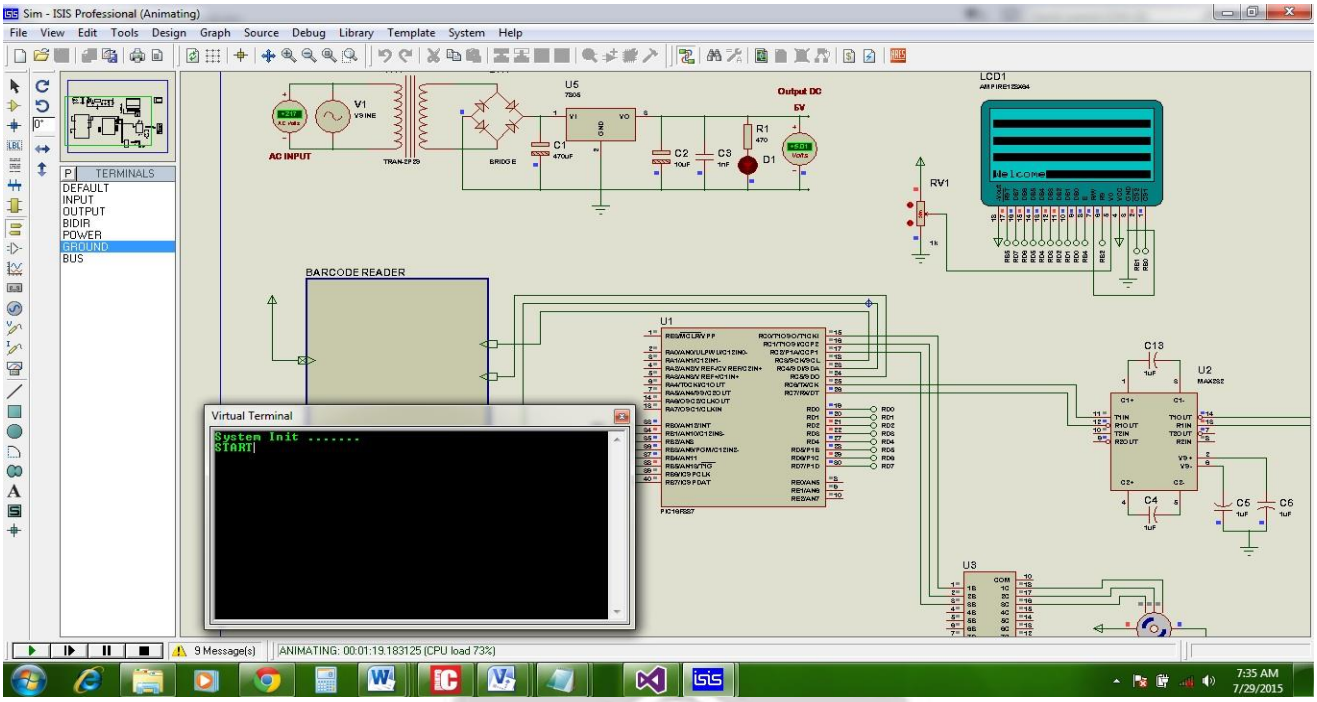


Figure 3. 26 Proteus ISIS simulation IDE

3.5.6 Circuit Diagram

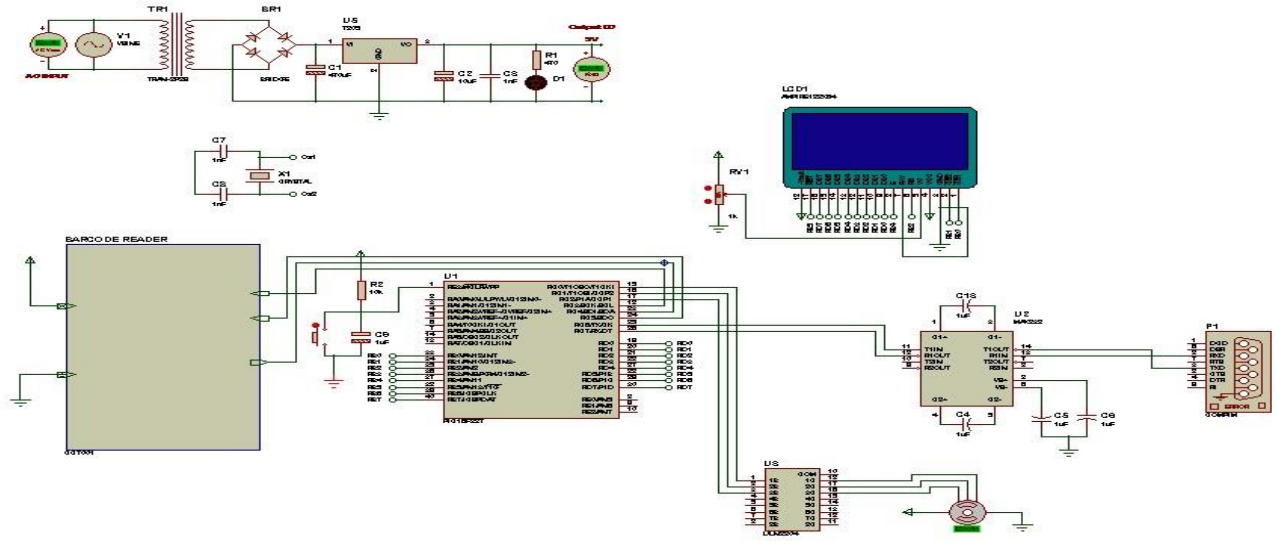


Figure 3. 27 Hardware Circuit Diagram

3.5.6.1 Circuit Description

The circuit diagrams for the Electro-Mechanical Unit system uses PIC16F887 microcontroller, Barcode reader module, Max232 serial communication, Stepper motor and motor driver and LCD Display as shown in the Figure above. The compact circuitry of Electro-Mechanical unit system is built around Microchip PIC16F887 microcontroller which, the researcher have used at an operating frequency of 40MHz. The PIC16F887 microcontroller is a low power; high performance CMOS 8-bit microcomputer with 8kB of Flash programmable and erasable read only memory (PEROM). It has 512 bytes of RAM, 32 input/output (I/O) lines, three 16-bit timers/counters, a six-vector two-level interrupt architecture, a full-duplex serial port, an on-chip oscillator and clock circuit. The system clock also plays a significant role in the operation of the microcontroller.

40MHz quartz crystal connected to pins 13 and 14 provides basic clock to the microcontroller. Power-on reset is provided by the combination of electrolytic capacitor C9 and resistor R2.

Port B pins RD0 through RD7 of the microcontroller are connected to data port pins D0 through D7 of the LCD in it 8Bit mode, respectively. Port B pins RB0, RB1, RB2 and RB4 of the microcontroller are connected to Chip selection for IC2 (CS2), Chip selection for IC1 (CS1) Register-select (RS) and enable (E) pins of the LCD, respectively. All the data is sent to the LCD in ASCII format for display. Only the commands are sent in hex form. Register-select (RS) signal is used to distinguish between data (RS=1) and command (RS=0). Preset RV1 is used to control the contrast of the LCD. Resistor 1k limits the current through the backlight of the LCD.

Port C pins RC7 (RXD) and RC6 (TXD) of the microcontroller are used to interface with the PC serial port through Max232 Logic Level Converter (LLC) through which data can be send out or received from an interfaced personal computer.

Port C Pins RC3, RC4, and RC5 of the microcontroller are used to interface with the Barcode reader through SPI. A motor driver IC ULN2804A connected to Port C pins RC0, RC1 and RC3 to control the stepper motor attached to output pin 16, 17 and 18 of the ULN2804A driver IC.

CHAPTER FOUR

RESULT AND FINDING

4.0 Introduction

This chapter presents the finding and result of the implementation of Ghana's election using paper dispensing System. The result and findings presented here are based on hardware prototyping using PIC16F887A microcontroller and stepper motor as the Electromechanical Unit and a Personal Computer system with a Graphical User Interface (GUI) as the Control Unit. The PC run the control unit algorithms implemented in the Visual C# programming environment while the PIC16F887A microcontroller runs the electromechanical algorithms implemented in MikroC pro for PIC programming environment. The two units synchronize and communicate to ensure the voter authentication and verification before a ballot paper is dispensed out to user or voter for voting.

4.1 Control Unit

The control unit of the hardware prototyping of the ballot paper dispenser system is implemented using a Personal computer for easy construction of the prototype. However it can be implemented in an embedded system. The Personal computer consist of a graphical Liquid crystal display for displaying the required message to the voter, a central processing unit for running the control unit algorithms and an interfaced DigtalPersona fingerprint reader for voter finger print scanning and processing. It however runs the SQL server Database where the voter information are kept and referenced for authentication and verification. The control unit algorithm is implemented with the Microsoft Visual C# programming language in Visual Studio

2013 which provides rich sets of controls for graphical user interface design (GUI). A third party software FlexCode Software Development kit (SDK) is used for the fingerprint reader device

(DigtalPersona) and data storage and management software SQL server 2008 is used in the database designing. Present below in figures are the various result of the control unit interface.

Figure 4.1 show the main interface which is displayed at startup of the application or the control unit. This consist of a menu bar and a navigation bar for selecting the type of operation to be performed by the control unit. The operation include Voter Registration and the Papar dispension. The voter registration is used for input/register eligible voter(s) into the voter register database while the Papar dispension is used to authenticate and verify voters before dispensing or issuing ballot to the voter by the system.

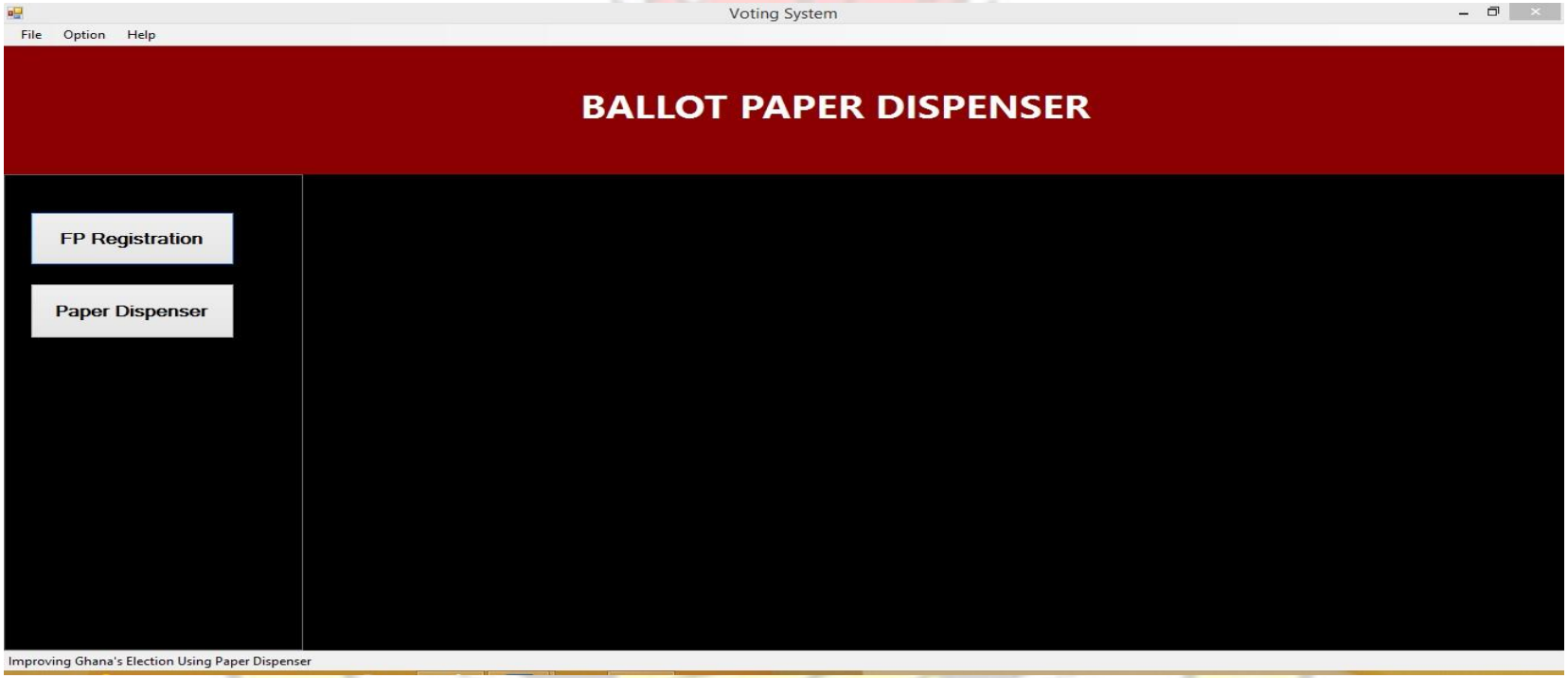


Figure 4. 1 Main Interface of Control System

Figure 4.2 show the Voter Registration form which is use to add voter(s) to the voter register Database. Detail records of the voter such as Fullname, Voter ID , Picture, Fingure print are required for the registration process.

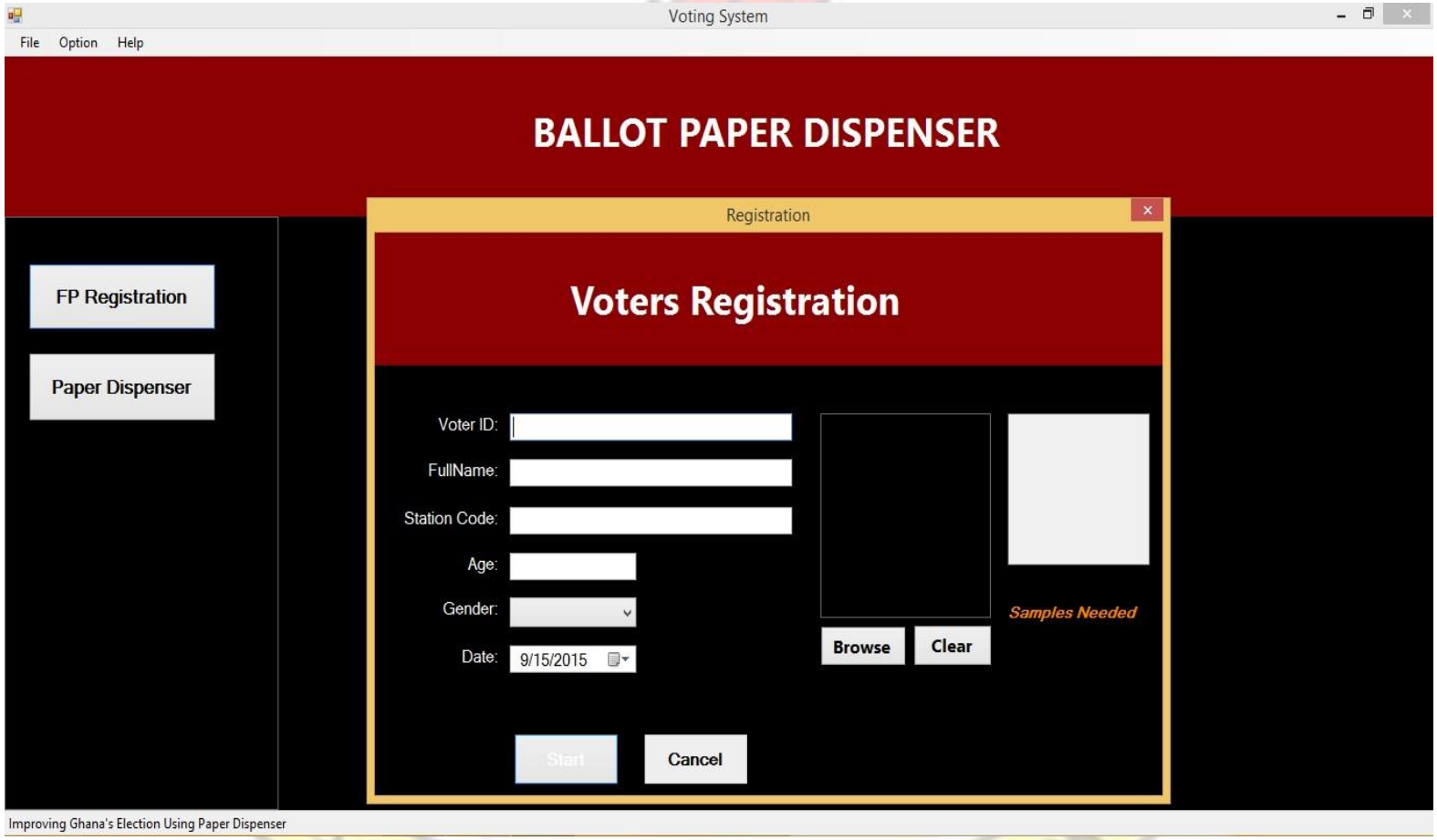


Figure 4. 2 Voter Registration Interface

Figure 4.3 show the Database Table associated with the Voter Registration Form. Records of the voters entered on the above form are stored in the database Table for future referrence of the voting process.

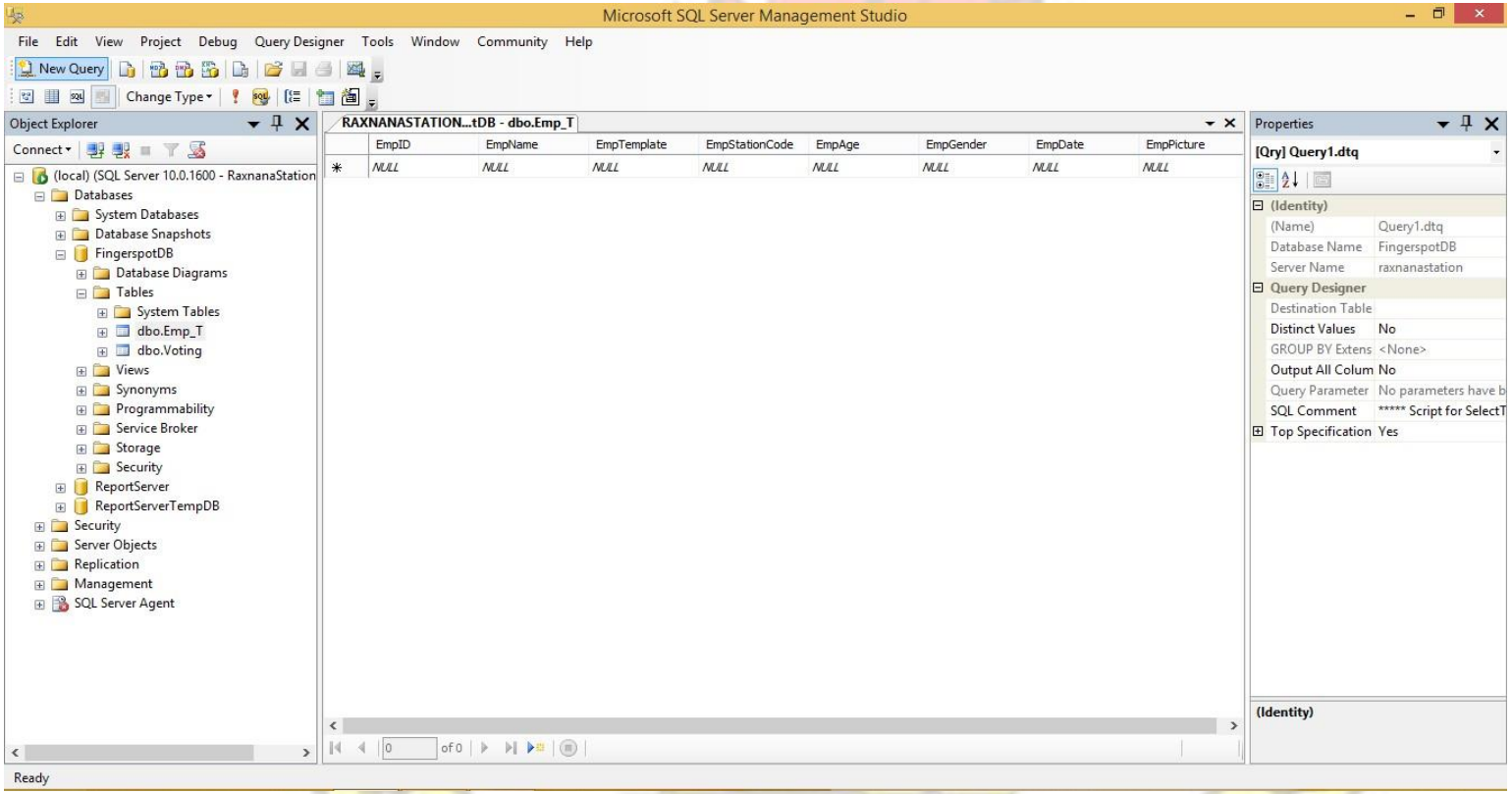


Figure 4. 3 Voter Registration Database Table

Figure 4.4 show the Voter Registration form with detail record of an eligible voter filled. All the provided fields are validated to ensure that the correct information of the voter are entered. Four samples of the voter Finger print are collected before saving the records to prevent fingerprint mismatch during the voting process.

Figure 4. 4 Voter Registration Form

Figure 4.5 show data saving information after required details of the voter is entered and validated.

Figure 4. 5 Data Saving of Voter Registration

Figure 4.6 show the voter registration information or records save into the database table.

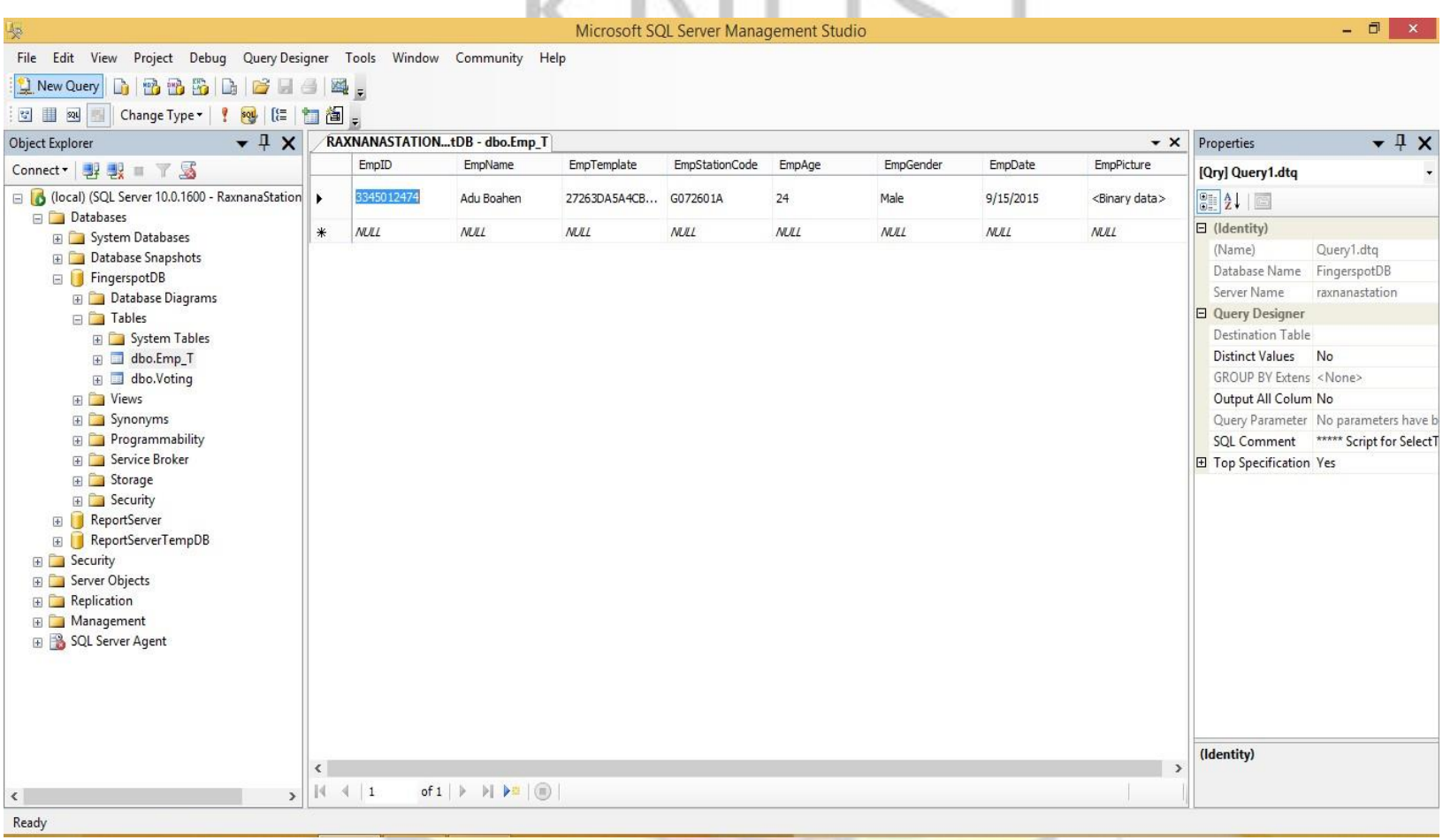


Figure 4. 6 Data Saved Records in Database Table

Figure 4.7 show the Paper Dispening Interface or the voting interface of the Control unit. This interface ensure the authentication and verification of the voting process. Voter(s) are required to placed the finger on the fingerprint scanner for authentication and verification

before issuing or dispensing of ballot paper for voting. This interface connect and communicate with the electromechanical unit after authentication and verification process to dispense the ballot paper.

Figure 4. 7 Paper Dispensing Interface of Control Unit

Figure 4.8 shows an empty table records before the voting process.

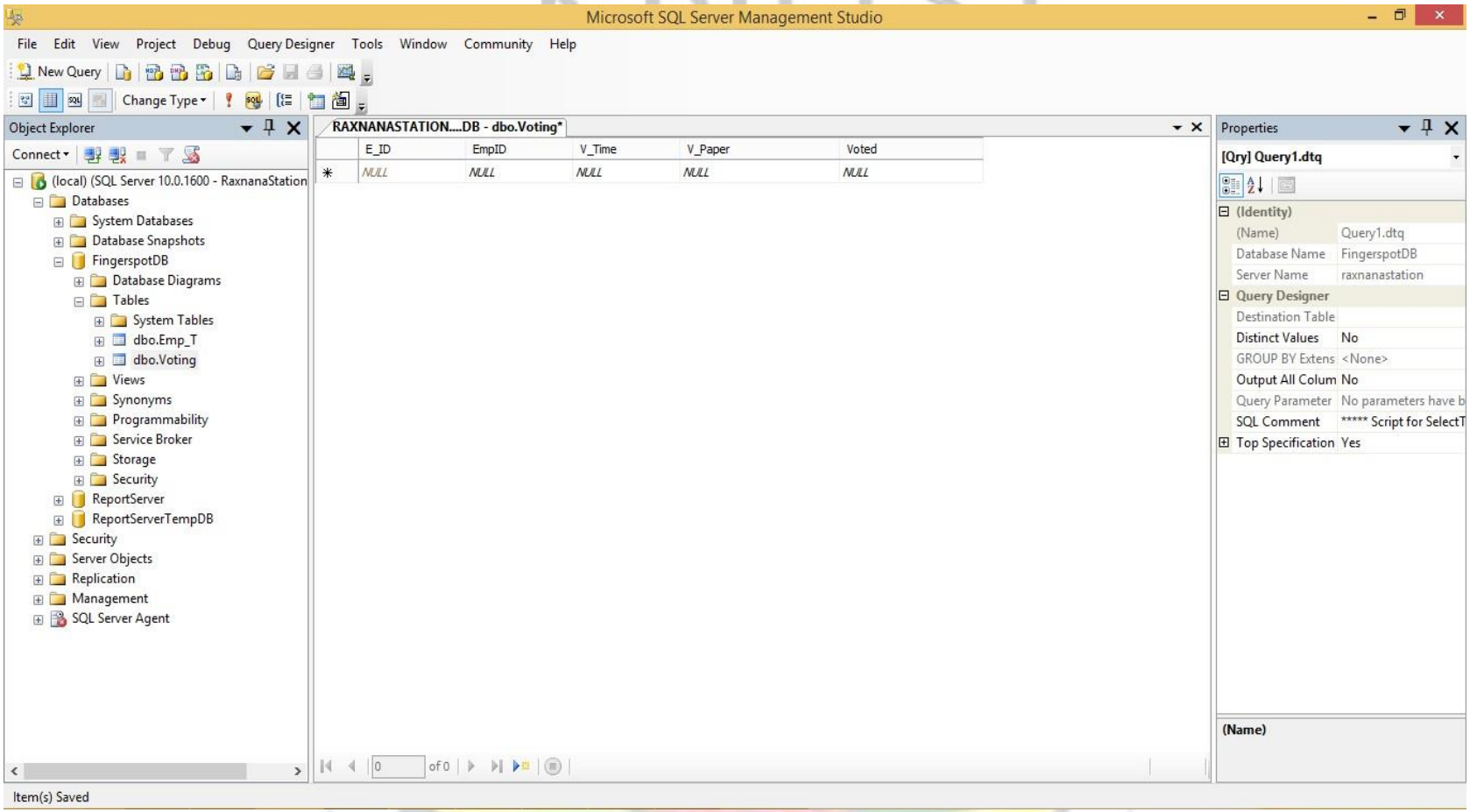


Figure 4. 8 Empty Database Table for voting process

Figure 4.9 shows an error message in the initialization process if the electromechanical unit is not connected to the control unit.the error will persist until the electromechanical unit is connected to the control unit.

Figure 4. 9 Control Unit Serial Communication Error

Figure 4.10 shows the connection sucessful message in the initialization process if the electromechanical unit is connected and responding to the control unit. The system at this stage is ready for the authentication, verification and dispensing of the ballot papers to voter(s) for the voting process.

Figure 4. 10 Control Unit and Electromechanical Unit Serial Communication Successfully

Figure 4.11 shows an error communication message in the initialization process if the electromechanical unit is connected but not responding to the control unit.

Figure 4. 11 Control Unit and Electromechanical Unit No Serial Communication

Figure 4.12 shows the authentication and verification passed successefully by the voter. The control unit at this stage send a command message to the electromechanical unit for issuing or dispensing of balllot paper. Ballot paper is dispensed within 500ms by the electromechanical unit with the Serial number of the ballot sheet noted and send back to the control unit.

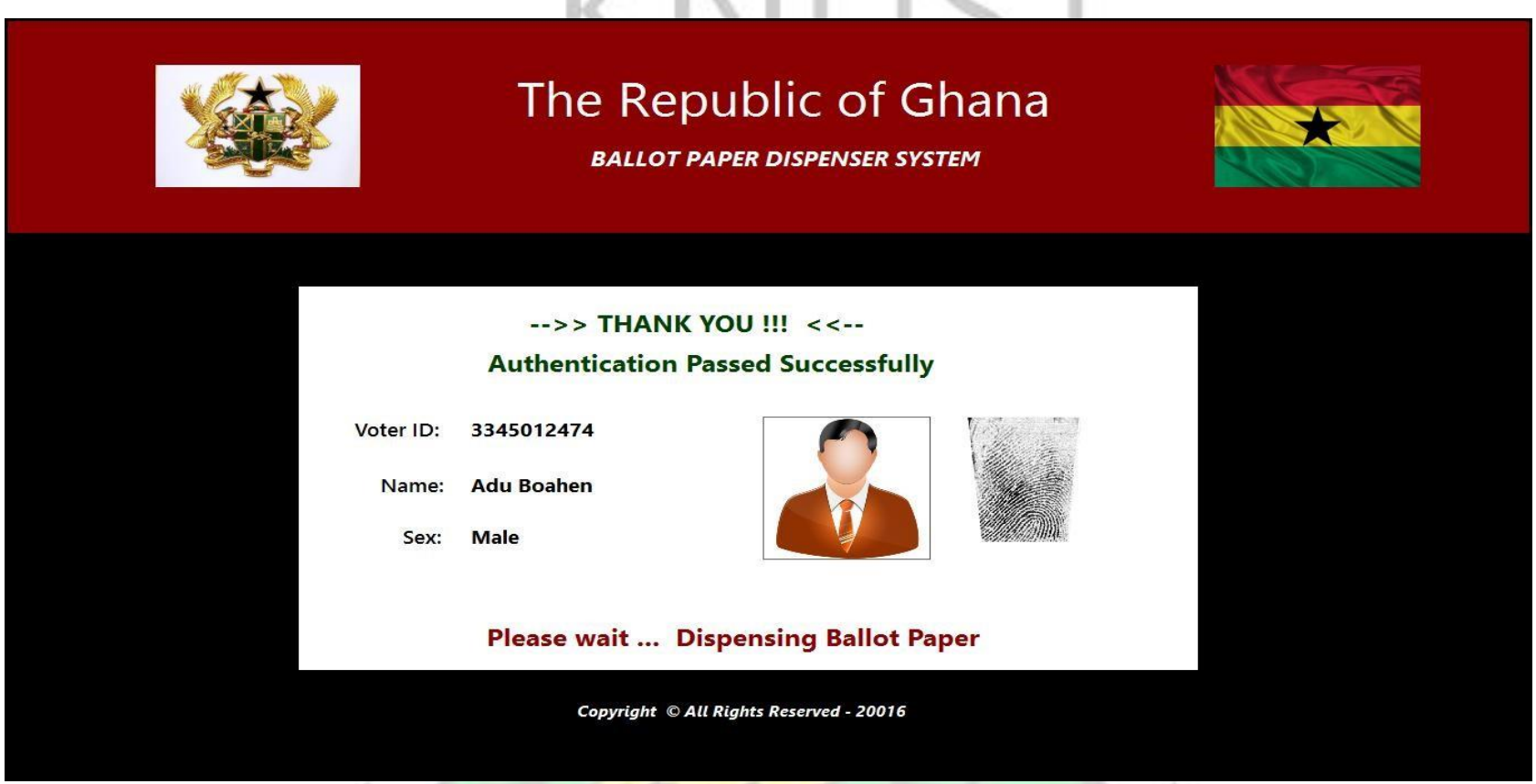


Figure 4. 12 Authentication and Verification passed by Voter

Figure 4.13 shows the saved records of a passed authentication and verification of voter. The ballot serial number together with time and voter details are saved by the control uint after authentication and verification of voter to avoid double or over voting.

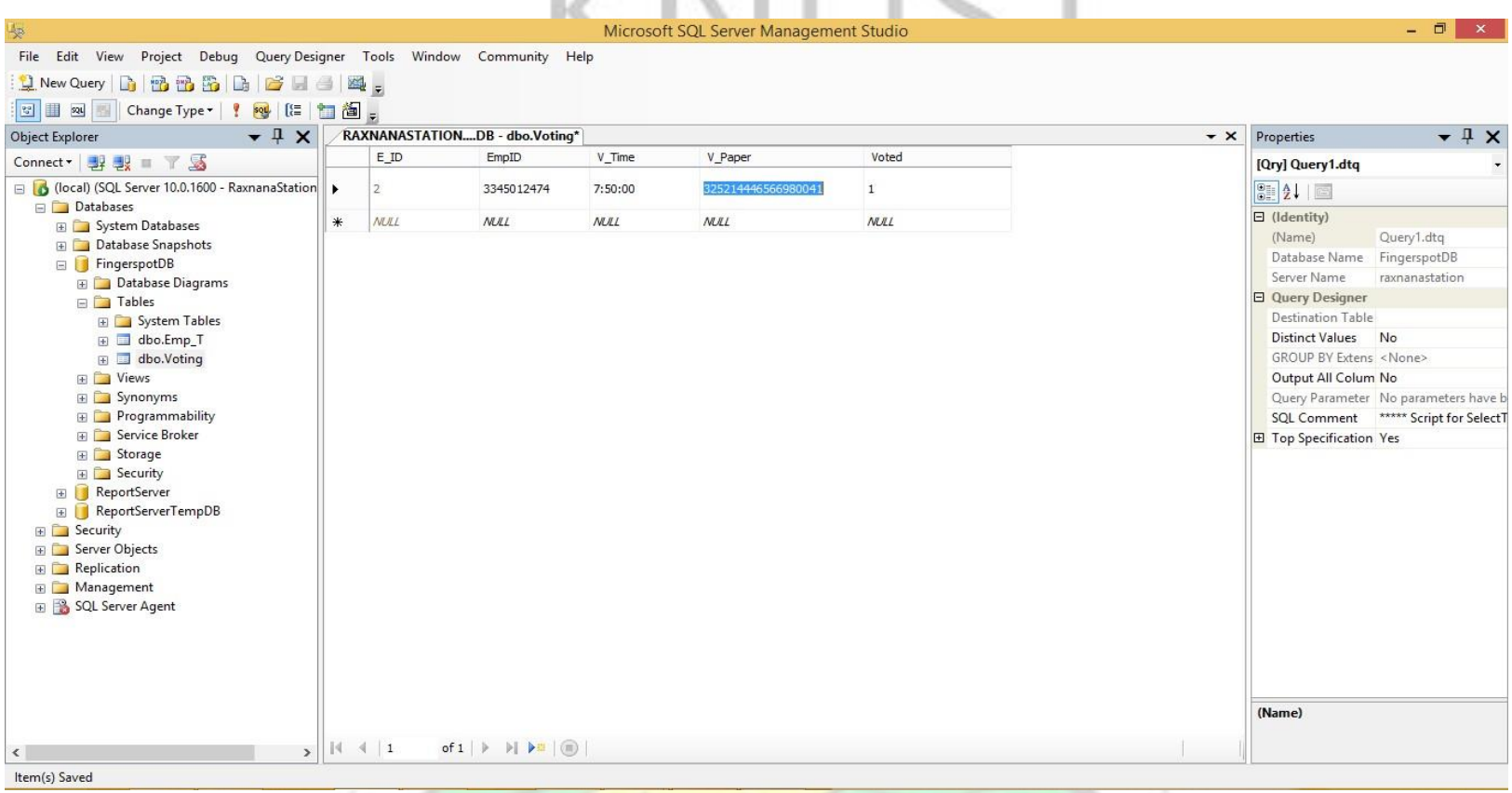


Figure 4. 13 Saved records of voted voter

Figure 4.14 shows an error message of double voting.

Figure 4. 14 Double Voting Error Message

Figure 4.15 shows an error message of an unregistered voter trying to vote.

Figure 4. 15 Unregistered Voter Error Message

4.2 Electromechanical Unit

The electromechanical unit of the hardware prototyping of the ballot paper dispenser system is implemented using a PIC16F887 microcontroller interface with a stepper motor to control a mechanical gearing system to dispense paper out of the system and a barcode

reader for capturing the barcode number of the ballot paper. The electromechanical unit takes it command from the control unit for dispensing of ballot paper. Figure 4.16 shows a dispensed paper from the system after authentication and verification process has gone through successfully and the control unit issued a command “ALLOW” to the electromechanical unit.

Figure 4.16 Dispensed Ballot paper

4.3 Conclusion

The testing and result of the prototype shown in the various figures above implement the ballot paper dispensing system proposed in the research work. The system is capable of preventing over-voting, voting without verification and detecting duplicate or illegal ballot paper sneaked into the ballot box. Implementing this system in any electoral process will avoid the process of over-voting, voting without verification, illegal voter and duplicate or illegal ballot paper sneaked into the ballot box.

CHAPTER FIVE

ANALYSIS OF RESULT AND CONCLUSION

5.0 Introduction

This chapter presents the analysis of result based on the chapter four and finally presents the conclusion and recommendation of this research work implementation of Ghana's election using paper dispensing system.

5.1 Analysis of result

The paper dispenser system is design to take it command or input from a fingerprint scanner attached to the control unit of the system. Upon placing your finger on the fingerprint scanner, the system captures the fingerprint and connects to a voter register database to search for a match of the captured finger print. When the captured finger print does not match any voter in the voter register database, an error message "Warning: YOU ARE NOT ALLOWED, PLEASE KEEP OFF" is displayed to the user with a sound as shown in Figure 4.15 in chapter four. Hence registered voters only are allowed to vote by issuing ballot paper to them by the system. The entire system however strictly ensures that no verification no voting as the main concern rose by the political parties during the 2012 general election. With the find of a search match, the system again makes a search through the voted list database to verify whether the searched match has voted or not. When the captured finger print is found in the voted list database, an error message "Warning: YOU HAVE ALREADY VOTED, KEEP OFF" is displayed to the user with a sound as shown in Figure 4.14 in chapter four. This however prevent double or multiple voting by not issuing ballot paper to the voter. The entire system again strictly prevents multiple voting which was a big issue with all the general elections organized by the electoral commission of Ghana.

But when no match is found in the voted list database then it means that the search captured fingerprint has not been issued with a ballot sheet before so the system goes ahead to display an authentication and verification passed successeful message with a sound and the voter information including Name, Sex and Picture as shown in Figure 4.12, and issue a command to the electromechanical unit to despense a ballot sheet to the voter. After dispensing ballot sheet out of the system to the voter by the electromechanical unit, an acknowledgment message is passed back to the control unit by the electromechanical unit. The control unit then save the captured fingerprint

in the voted list database with the serial number of the dispensed ballot sheet for future reference. This however makes the system intelligent in preventing multiple voting and checking out for unique ballot sheet issued out by the system in case some fake or duplicate ballot papers were sneaked into the ballot box causing over voting. All duplicate ballot papers and fake ballot papers can be removed since the system can present to us the serial numbers of all the original ballot papers dispensed by the system.

5.2 Conclusion

The theory and concept of implementing Ghana's election using paper dispensing system is based on the fact that, the manual way of issuing ballot paper to voter is one of the main causes of electoral fraud in Ghana's general elections. Since ballot paper can be given to fake or ineligible voter, already voted voter or more than one ballot paper can be given to a voter and even fake ballot paper can be sneaked into the ballot box which will result in over-voting in elections. Implementing the paper dispensing technique presented here in this thesis will eliminate completely the problem of over voting, no verification no vote as been the major concern associated with the voting system in Ghana is shown in the designed and build prototype. The entire system is compact and power efficient which make it feasible to be implemented in all part of the country.

5.2 Recommendation

Implementing Ghana election using paper dispensing system is a practical solution to the problem faced by Ghana's general election organized by the electoral commission of Ghana. This thesis presents the solution of this election problem. I recommend the system to the electoral commission of Ghana to critically observe and scrutinize it for the implementation of the system in their

subsequent General elections to be conducted. Other researchers of this area of concern can use this thesis as a base to improve upon their work to make the entire general elections organized in Ghana by the electoral commission of Ghana transparent, free and fair as recommended by the 1992 constitution of Ghana.

REFERENCE

Adafruit (2015) "BARCODE READER/SCANNER MODULE-CCD CAMER- USB INTERFACE"
https://www.adafruit.com/products/1203 Accessed at : 10 April 2015

Africa World Press, 2000): pp. 23-29 - Africa in the Nineteenth Century Volumes I- VIII.

A. M. Keller, A. Dechert, K. Auerbach, D. Mertz, A. Pearl, and J. L. Hall, "A PC-based OpenSource Voting Machine with an Accessible Voter-Verifiable Paper Ballot," *Proceedings of the USENIX Annual Technical Conference*, U.S.A., 2005, p.52.

C. A. Gaston, "A Better Way to Vote," *Proceedings of the 38th Annual Hawaii International Conference on System Sciences*, 2005, p.117c.

C. A. Gaston, *SAVIOC Voting Systems*, [Online], Available: http://www.savioc.com/, 2007.

C. H. Yang, *Network Security: Theory and Practice*, Key Hold Information Inc., Taipei, Taiwan, 2006 (in Chinese).

Compuware Corporation, "Direct Recording Electronic (DRE) Technical Security Assessment Report," *Ohio Secretary of State*, 2003.

EC (2015) "ELECTORAL COMMISSION OF GHANA" http://www.ec.gov.gh/about-ec/

EC(2015) "Electoral Reform" http://www.ec.gov.gh/electoral-reforms-intro-of-the-biometricsystem/

Engineering Projects (2015)"Fingerprint Based Security System and door lock"
http://www.engineerprojects.info/electronics-projects/fingerprint-based-security-system-anddoor-lock/ Accessed at: 20 March 2015.

Embedded – Lab (2015) " Interfacing a KS0108 based Graphics LCD " http://embedded-lab.com/blog/?p = 2398 Accessed at : 19 March 2015.

Embed Journal (2015) "Stepper Motors – Introduction and Working Principle" http://embedjournal.com/stepper-motors-introduction-and-working-principle/

Ghana Bar Association (2013) "ELECTION PETITION 2012" http://www.ghanabar.org/election-petition-2012/ Accessed at: 20 January 2015.

Ghana web (1994) "Political History" http://www.ghanaweb.com/GhanaHomePage/republic/polit_hist.php Accessed at: 20 January 2015.

Institute Policy Institute, "Report of the National Workshop on Internet Voting: Issues and Research Agenda," *Proceedings of the 2000 Annual National Conference on Digital Government Research*, 2000, pp.1-59.

KARTHIKEYAN .M (2014)"GRAPHIC LCD EMBEDDED PROJECT" http://www.embededprojects.com/2015/09/graphic-lcd.html Accessed at : 27 March 2015

Microchip (1994) "PIC16F887 - 8-bit PIC® Microcontrollers" http://www.microchip.com/wwwproducts/Devices.aspx?product=PIC16F887 Accessed at: 20 January 2015.

Microchip Technology Inc. "28/40/44-Pin, Enhanced Flash-Based 8-Bit CMOS Microcontrollers with Nano Watt Technology" PIC16F882/883/884/886/887 Data Sheet, 2007 U.S.A. DS41291Dpage 6.

Nebojsa Matic, PIC microcontroller Programming in C [E-book] Available: http://www.mikroelekronika.co.yu/english/product/books/PICbook/0_Uvod.htm Accessed at: 20 March 2015.

R. Mercuri, "A Better Ballot Box?" *IEEE Spectrum*, Vol.39, No.10, 2002, pp.46-50.

Sunrom Electronic Technologies (2015) "Finger Print Sensor (R305)" http://www.sunrom.com/p/finger-print-sensor-r305 Accessed at : 27 March 2015

T. Kohno, A. Stubblefield, A. D. Ribin, and D. S. Wallach, "Analysis of an Electronic Voting System," *IEEE Computer Society*, 2004, pp.27-40.

Thomas J. Fleischman(2005) "System for secure and accurate electronic voting" International Business Machines Corporation, US20060273169 A1.

Wikipedia (2014) "Power-on reset" Available at https://en.wikipedia.org/wiki/Power-on_reset Accessed at : 27 March 2015.

APPENDIX

1.0 CODE

1.0.1 Registration Interface (FORM) CODE

```
public partial class frmRegistration : Form
 {
 FlexCodeSDK.FinFPReg reg = null;
String template = "";  string imgPath
= "";
 SqlConnection conn = null;
 SqlCommand cmd = new SqlCommand();  SqlParameter picture = null;  string cs = "Data
Source=(local);Initial Catalog=FingerspotDB;Integrated Security=True";   public
frmRegistration()
 {
 InitializeComponent();
 }


 private void Form1_Load(object sender, EventArgs e)
```

```
{
// Set MySQL database connection
conn = new SqlConnection(cs);
cmd.Connection = conn;
picture = new SqlParameter("@EmpPicture", SqlDbType.Image);

//Initialize FlexCodeSDK for Registration
//1. Initialize Event Handler  reg =
new FlexCodeSDK.FinFPReg();
reg.FPSamplesNeeded+=new
__FinFPReg_FPSamplesNeededEventHandler(reg_FPSamplesNeeded);
reg.FPRegistrationTemplate+=new
__FinFPReg_FPRegistrationTemplateEventHandler(reg_FPRegistrationTemplate);
reg.FPRegistrationImage+=new
__FinFPReg_FPRegistrationImageEventHandler(reg_FPRegistrationImage);
reg.FPRegistrationStatus+=new
__FinFPReg_FPRegistrationStatusEventHandler(reg_FPRegistrationStatus);

//2. Input the activation code  reg.AddDeviceInfo("C700F001339","7901D3C13E34109",
"VPFAAB943C33362467D451A0");
```

```
//3. Define fingerprint image  reg.PictureSampleHeight = (short)(pictureBox1.Height * 15);
//FlexCodeSDK use Twips. 1 pixel = 15 twips  reg.PictureSampleWidth =
(short)(pictureBox1.Width * 15); //FlexCodeSDK use Twips. 1 pixel = 15 twips

imgPath = AppDomain.CurrentDomain.BaseDirectory + "Finger.bmp";
reg.PictureSamplePath = imgPath;
}

void reg_FPRegistrationStatus(RegistrationStatus Status)
{ if (Status==
RegistrationStatus.r_OK)
{
//Insert template to MySQL database

MemoryStream ms = new MemoryStream();
pbPicture.Image.Save(ms, pbPicture.Image.RawFormat);
byte[] a = ms.GetBuffer();  ms.Close();
cmd.Parameters.Clear();
cmd.Parameters.AddWithValue("@EmpPicture", a);
cmd.CommandText = "INSERT INTO Emp_T(EmpID, EmpName, EmpTemplate,
EmpStationCode, EmpAge, EmpGender, EmpDate, EmpPicture) VALUES('" + txtVoterID.Text
+ "','" + txtName.Text + "','" + template + "', '" + txtStationCode.Text + "', '" + txtAge.Text + "',
'" + cbGender.Text + "', '" + dtRegistrationDate.Value.ToShortDateString() + "',
```

```
@EmpPicture)";//
 conn.Open();
 cmd.ExecuteNonQuery();
 conn.Close();


 MessageBox.Show("Data Save Successfully","Saving Info");
txtVoterID.Text = "";  txtName.Text = "";  template = "";
txtStationCode.Text = "";  txtAge.Text = "";  cbGender.Text
= "";  pbPicture.Image = null;  pictureBox1.Image = null;
dtRegistrationDate.Value = DateTime.Now;   label1.Text =
"Samples Needed : ";  btStart.Enabled = true;
btCancel.Enabled = false;
 }
 }


 void reg_FPRegistrationImage()
 {
 pictureBox1.Load(imgPath);          if          (imgPath          ==
 AppDomain.CurrentDomain.BaseDirectory + "Finger.bmp")
{
imgPath = AppDomain.CurrentDomain.BaseDirectory + "Finger2.bmp";
} else
```

```
{       imgPath = AppDomain.CurrentDomain.BaseDirectory +
"Finger.bmp";
}
reg.PictureSamplePath = imgPath;
}

void reg_FPRegistrationTemplate(string FPTemplate)
{
template = FPTemplate;
}

void reg_FPSamplesNeeded(short Samples)
{
label1.Text = "Samples Needed : " + Convert.ToString(Samples);
}

private void button1_Click(object sender, EventArgs e)
{ if (txtVoterID.Text == "" || txtVoterID.Text == "" || pbPicture.Image == null)
{
MessageBox.Show("Please Fill in all imformation !!!","Warning");
} else
{  btStart.Enabled = false;  btCancel.Enabled = true;
reg.FPRegistrationStart("MySecretKey" + txtVoterID.Text);
```

```
}
}

private void button2_Click(object sender, EventArgs e)
{
MessageBox.Show("Data Registration Canceled !!!", "Information");
txtVoterID.Text = "";  txtName.Text = "";  template = "";
txtStationCode.Text = "";  txtAge.Text = "";  cbGender.Text = "";
pbPicture.Image = null;  pictureBox1.Image = null;
dtRegistrationDate.Value = DateTime.Now;  label1.Text = "Samples
Needed : ";
btStart.Enabled = true; btCancel.Enabled
= false;
} private void button1_Click_1(object sender, EventArgs
e)
{
try
{
OpenFileDialog of = new OpenFileDialog();  of.InitialDirectory
= "C:/Pictures/";  of.Filter = "ALL
File|*.*|JPEGs|*.jpg|Bitmaps|*.bmp|GIFs|*.gif";  of.FilterIndex =
2;  if (of.ShowDialog() == DialogResult.OK)
{
```

```
pbPicture.Image = Image.FromFile(of.FileName);
// pictureBox2.SizeMode = PictureBoxSizeMode.StretchImage;
// pictureBox2.BorderStyle = BorderStyle.Fixed3D;
} }
catch {}
}

private void button2_Click_1(object sender, EventArgs e)
{
pbPicture.Image = null;
}
}
```

1.0.2 Voting Interface (FORM) CODE

```
public partial class frmVoting : Form
{
FinFPVer ver = null;
String empid = "";
SqlConnection conn = null;
string imgPath = "";
```

```
FormState formState = new FormState();  string cs = "Data Source=(local);Initial
Catalog=FingerspotDB;Integrated Security=True;";  SerialPort myPort = null;  public
frmVoting()
{
InitializeComponent();
// UserInitialization();
}

bool exit = true;  string
data_rx = string.Empty;
private void
Form3_Load(object sender,
EventArgs e)

{
Cursor.Hide();
formState.Maximize(this);  myPort
= new SerialPort();
myPort.BaudRate = 9600;
myPort.PortName = "COM7";

try
{
```

```
 myPort.Open();
while (exit)
 {
 lbMsg.Text = "No Communication";
lbMsg.Visible = true;
lbMsg.BackColor = Color.Red;
string data_rx = myPort.ReadLine();
if (data_rx != string.Empty)  exit =
false;
 }

lbMsg.Text = "Communication Successfully"; lbMsg.Visible
= true;

lbMsg.BackColor = Color.Green;
}                catch
(Exception)
 {
myPort.Close();
 MessageBox.Show("Serial Commonication Error!!!", "Warning");
Cursor.Show();  this.Close();
 }
myPort.Close();
 VerifyFingerPrint();
```

```
}                    void
VerifyFingerPrint()
{
 //Initialize FlexCodeSDK for Verification
 //1. Initialize Event Handler  ver = new
FlexCodeSDK.FinFPVer();
 ver.FPVerificationID                    +=                    new
__FinFPVer_FPVerificationIDEventHandler(ver_FPVerificationID);
 ver.FPVerificationImage                    +=                    new
__FinFPVer_FPVerificationImageEventHandler(ver_FPVerificationImage);
 ver.FPVerificationStatus                    +=                    new
__FinFPVer_FPVerificationStatusEventHandler(ver_FPVerificationStatus);
//2. Input the activation code
ver.AddDeviceInfo("C700F001339",                    "7901D3C13E34109",
"VPFAAB943C33362467D451A0");

 //3. Define fingerprint image  ver.PictureSampleHeight = (short)(pictureBox1.Height * 15);
//FlexCodeSDK use Twips. 1 pixel = 15 twips  ver.PictureSampleWidth =
(short)(pictureBox1.Width * 15); //FlexCodeSDK use Twips. 1 pixel
= 15 twips  imgPath = AppDomain.CurrentDomain.BaseDirectory +
"Finger.bmp";  ver.PictureSamplePath = imgPath;

 //4. Load templates from database to FlexCodeSDK
```

```
conn = new SqlConnection(cs);  conn.Open();  string sql = "SELECT
EmpID, EmpTemplate, EmpName FROM Emp_T";
SqlCommand cmd = new SqlCommand(sql, conn);
SqlDataReader rdr = cmd.ExecuteReader();  while
(rdr.Read())
{ ver.FPLoad(rdr.GetString(0), 0, rdr.GetString(1), "MySecretKey" +
rdr.GetString(0)); }
rdr.Close(); conn.Close();
//5. Set FlexCodeSDK to still working even the application not get focus.
//ver.WorkingInBackground(true); This feature need administrator accesss (Run As Admin)
ver.WorkingInBackground(false);

//6. Start verification process  ver.FPVerificationStart();
}       void    ver_FPVerificationStatus(VerificationStatus
Status)
{
//ver.FPVerificationStop();    if  (Status
== VerificationStatus.v_OK)
{
lbVoterID.Text = empid;
ReadDetails(empid);
```

```
tmVote.Enabled = true;
tmPicture.Enabled = false;
 //HARDWARE SERIAL COMMUNICATION HERE
 }                else        if        (Status        ==
VerificationStatus.v_NotMatch)
{
plWelcome.Visible = true;
plVoterInfo.Visible = false;
lbMsg.Text = "WARNING: YOU ARE NOT ALLOWED, PLEASE KEEP OFF!";
lbMsg.Visible = true; lbMsg.BackColor
= Color.Red;
 }
 }

 void ver_FPVerificationImage()
 {
 pictureBox1.Load(imgPath);                    if        (imgPath        ==
AppDomain.CurrentDomain.BaseDirectory + "Finger.bmp")
 {
 imgPath = AppDomain.CurrentDomain.BaseDirectory + "Finger2.bmp";
 }
else
 {
```

```
 imgPath = AppDomain.CurrentDomain.BaseDirectory + "Finger.bmp";
 }
 ver.PictureSamplePath = imgPath;
 }

void ver_FPVerificationID(string ID, FingerNumber FingerNr)
{
empid = ID; }

void ReadDetails(string id)
 {
 conn = new SqlConnection(cs);  conn.Open();  string sql = "SELECT *
FROM Emp_T WHERE EmpID = '" + id +"'";
 SqlCommand cmd = new SqlCommand(sql, conn);
SqlDataReader rdr = cmd.ExecuteReader();  byte[]
ap = null;  while (rdr.Read())
 {
 lbName.Text = rdr["EmpName"].ToString();
lbGender.Text = rdr["EmpGender"].ToString();  ap
= (byte[])(rdr["EmpPicture"]);
 }
 MemoryStream ms = new MemoryStream(ap);
pbPicture.Image = Image.FromStream(ms);
```

```
ms.Close();  rdr.Close(); conn.Close();

plWelcome.Visible = false;

plVoterInfo.Visible = true;


} private void frmVoting_KeyDown(object sender, KeyEventArgs

e)

 {

 if (e.KeyCode == Keys.Escape)

 {

formState.Restore(this);

 Cursor.Show();

 }  }  int countfor = 0;  private void

timer1_Tick(object sender, EventArgs e)

 {    if  (pictureBox5.Visible  ==

true)

 {  pictureBox5.Visible =

false;  pictureBox4.Visible =

true;

 }    else  if  (pictureBox4.Visible  ==

true)

 { pictureBox4.Visible =

 false; pictureBox5.Visible =

 true;
```

```
}     if(lbMsg.Visible   ==
true)
 { countfor++;  if
(countfor == 5)
 {  lbMsg.Visible =
false;  countfor = 0;
 }
 }
 }

 private void tmVote_Tick(object sender, EventArgs e)
 {
 myPort.Open();
myPort.WriteLine("200");
myPort.Close();
tmVote.Enabled = false;
tmPicture.Enabled = true;
plWelcome.Visible = true;
plVoterInfo.Visible = false;
lbMsg.Visible = false;
ver.FPVerificationStart();
}
}
```

1.0.3 Main Form Code

```
public partial class frmMain : Form
{
public frmMain()
{
InitializeComponent();
}  private void button1_Click(object sender, EventArgs
e)
{  frmRegistration aform = new
frmRegistration();  aform.ShowDialog();
}  private void button2_Click(object sender, EventArgs
e)
{
frmVoting aform = new frmVoting();  aform.ShowDialog();
}
private void fPRegistrationToolStripMenuItem_Click(object sender, EventArgs e)
{  frmRegistration aform = new
frmRegistration(); aform.ShowDialog();

} private void fPVerificationToolStripMenuItem_Click(object sender, EventArgs
e)
{
```

```
frmVoting aform = new frmVoting();  aform.ShowDialog();

}

private void exitToolStripMenuItem_Click(object sender, EventArgs e)

{

Application.Exit();

}

}
```

2.0 Cost Estimate

QTY	COMPONENT	UNIT PRICE (GH¢)	TOTAL PRICE (GH¢)
1	PIC16F877A Microcontroller	30	30
1	ULN 2003 Relay Buffer	5	5
1	Fingerprint Scanner (Digitalpersona)	700	700
1	Max232	20	20
4	Stepper Motor	3	12
3	Step down transformer 12v	30	90
1	20x4 LCD	60	60
2	1N4007 diode	.1	50
10	10kΩ resistor	.5	50

10	100kΩ resistor	.5	50
2	1kΩ resistor	.1	50
1	L7805 Voltage regulator	5	5
5	Electrolytic capacitor	2	10
1	Quartz Crystal	10	10
2	Button Switch	2	5
5	Ceramic capacitor	.5	50
4	LED	.2	50
1	Female Header connect	5	5
1	Male Header pins	5	5
1	Package Case	100	100
2	12v Relay	5	10
	TOTAL		**1086**

3.0 GLOSSARY

DRRC - District Registration Review Committee

IPAC - Inter Party Advisory Committee

EC - Electoral Commission

NPP - New Patriotic Party

NDC - National Democratic Party

DRE - Direct Recording Electronic

LAN - Local Area Network

WAN - Wide Area Network

OMR - Optical Mark Readers

DRRC - District Registration Review Committee

PIN - Personal Identification Number

MFA - Multi-factor authentication (MFA)

PDS - Paper dispenser system

ID - IDentification

PIC - Peripheral Interface Controller,

ICT - Information Communication Technology

PDS - Paper Dispenser System

CPU – Central Processing Unit

ROM – Read Only Memory

RAM – Random Access Memory

IDE – Integrated Development Environment

IC - integrated circuits

MCU - Microcontroller Unit

PSU - Power supply unit

PCB – Printed Circuit Board

SPDT - Single Pole Double Throw

LCD - Liquid Crystal Display

RISC - Reduced Instruction Set Computer

I/O – Input/Output

HEX – Hexadecimal

AC – Alternating Current

DC – Direct Current

EEPROM – Electrically Erasable Programmable Read Only Memory

MIPS - million instructions per second

SRAM – Static random access memory

PWM – Pulse-width modulation

USART – Universal Synchronous/Asynchronous Receiver/Transmitter

SPI – serial peripheral interface

LP – Low Power

HS – High Speed

CMOS - complementary metal oxide semiconductor

PMOS - Positive channel metal oxide semiconductor

PC = Personal Computer

TTL – Transistor – Transistor Logic