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THE USE OF ELECTRONIC CODE LOCKS FOR THE SECURITY OF HOMES AND PROPERTIES

Thesis
CENTRIA UNIVERSITY OF APPLIED SCIENCES
Information Technology
December 2016

ABSTRACT

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Degree programme Information Technology		
Name of thesis **THE USE OF ELECTRONIC CODE LOCKS FOR THE SECURITY OF HOMES AND PROPERTIES.** **CASE: Code locks of building for security and authentication**		
Instructor Johnny Vidjeskog		**Pages** 30 + 6
Supervisor Johnny Vidjeskog		

It should be noted that the rapid growth in Technology making the world a global village has gone a long way to protect lives and properties. Nevertheless, this growth in technology has brought much development as well as an increasing rate of crime, attacks by thieves, vandals and intruders. This therefore calls for the need of improving the modern security systems in homes, offices and other buildings for the protection of lives.

With a critical comparative analysis of the security systems between like Finland and Cameroon, it is noted that Finland uses code locks for the security of life and properties for most offices and homes, which has greatly reduced the rate of crime, thieves and intruders. Authentication is a very important measure that is studied today by information technology. The lower rate for the use of code locks in Cameroon explains the reason for the high crime rate compared to other countries like Finland that has a higher rate in the use of this service. The simplicity in the use and a well-structured control unit is of prime importance. Therefore, the idea of implementing this system in buildings in the less developed countries improves the security level.

This thesis takes a good look at a case study in Cameroon analyzing the disadvantages and advantages of using electronic code locks. It also looks at the different measures that can be taken to improve the use of code locks in Cameroon. Much emphasis is also made on the hardware and software systems of the code locks. The design of a simple electronic code lock is demonstrated considering all the components and their different functions and importance. The simplicity of the system on both the hardware and the software makes it easy and preferable for the security of lives and properties.

The aim of this thesis is to show how important and necessary code locks can be for the security of properties and life's. It is also aimed at showing the possibilities that can be made on improving code locks.

CONCEPT DEFINITIONS

EEPROM: Electronically Erasable Programmable Read-Only memory

MCU: Microcontroller unit

SRAM: Central Processing unit

SPI: Serial peripheral Interface Bus

USART: Serial and Universal Asynchronous receiver/transmitter

LAN: Local Area Network

USB: Universal serial Bus

Mac OSX: Macintosh Operating System

MTN: Mobile telephone Networks

CAMTEL: Cameroon Telecommunication

NEXTTLE: Next Telecommunication network

CAMTEL: Cameroon Telecommunication

ICT: Information and Communication Technology

AES SONEL: Electrical Supply Cameroon

PIDA Programme for Infrastructural Development in Africa

OECD Organization for Economic Co-operation and Development

ABSTRACT
CONCEPT DEFINITIONS
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1 INTRODUCTION

There is a rapid spread of the use of internet today making the world to become a global village. Other forms of advancements in science and technology have also contributed more in this development. It should also be noted that due to this advancements, there is an increasing rate in crime, attacks by thieves, vandals and intruders. Despite all the necessary forms of security that has been put in place for the security of information over the internet and properties at homes, more still needs to be done most especially in the security of properties and lives at homes, shops and offices. Gadgets and locks still need more attention from researchers to ensure a long lasting solution for the security of our lives and properties. This therefore calls for the necessity of ensuring the security of lives and personal belongings. In most countries that are involved with the use of mechanical locks, the crime rate has increased because these locks are easily broken. It is difficult to always identify who actually had access in to a home or apartment illegally with the mechanical locks. There is therefore the need for the use of other types of locks especially the use of electronic locks.

The advancement in science and technology has also greatly posed much danger since stronger and dangerous tools have been produced which can easily destroy the mechanical locks that are used to secure homes and properties. Publication houses have records of stories about the loss of lives and properties due to the poor security systems used in homes most especially in the third world countries. It is due to this increased rate in the crime, attacks by thieves, vandals and intruders that enhanced the need for this study based on the use of electronic code locks at homes. Therefore, the main aims of this study is to enhance a cheap and effective security systems for homes. It is also aimed at experimenting the efficiency, effectiveness and the reliability of the electronic devices as locks and also to prevent the unauthorized people from accessing homes and properties using codes. The design of a simple electronic code system will be enhanced so as to ensure a good security of homes and properties. Nevertheless, this work is greatly limited to the development of very large integrated (VLI) Circuit. Financial and time constrains is also another limitation to this project. Less complicated components are going to be used in the design of the circuit and less complicated embedded software is going to be used to develop this project.

From the above information, it can be noted that crime rate and attacks by thieves is increasing progressively as science and technology increases. Researchers are therefore faced with the problem of developing better means of protecting our homes and properties using other security methods like code

locks. “What therefore makes electronics code locks preferable for the security of our homes and properties?”

To better understand how important the security of our homes and properties are using electronic code locks, this thesis will deal with some important issues of security faced by so many countries especially African countries like Cameroon. A brief history of the electronic code locks will be introduced and then a detailed look of the of the advantages and disadvantages of the use of electronic code locks at homes after which a statistical representation of the use of electronic code locks will be presented. It is from this statistics that a clear understanding of the crime rate and attacks by thieves of different countries will be seen. For more understanding about the preferentiality of use of electronic code locks for homes, a case study will be developed on African countries especially Cameroon. This thesis also deals with the possible factors that influence the use of electronic code locks at homes in Cameroon. This piece of work is also going to be present much knowledge on the technical aspect of the electronic code locks that can possibly be used at homes for the security of lives and properties. Furthermore, this thesis goes a long way to show the design of the system (Graphical representation) and the description of the system. Possible embedded software that runs this system smoothly shall also be developed.

2 ADVANTAGES AND DISADVANTAGES OF USING ELECTRONIC CODE LOCKS AT HOMES

In order to have access into a home, there are many available options that one can use. It can either be with use of the key locks, electronic digital keypad or combination locks form. These various methods of accessibility in home ensure a different level of security for homes as it can be seen from the different price levels of the locks. Just like in every network system, there is always the need for the physical Access Control (PAC). The main objective of the physical access control is actually not to restrict access but to control it. The data security administrator should know exactly who is granted access, when then access is granted and even the reason for granting this access. In most articles, physical access control options are always discussed in terms of functions, effectiveness and cost. (Bowers 1983.)

Security has always been a source of concern to organizations and companies within the last ten years. This has caused a significant amount of capital kept for the improvement of the security system. The Door Access Control (DAC) is one of the most important part of an organization. This assures the security of a building by limiting access to the building to specific people and by keeping records of such entries. Although these locks were originally developed for use in cars with remote entry systems, they have been successfully modified for use at homes. There are a number of reasons for the use of electronic code locks at homes. However, there are also some risk involved in the use of electronic code locks at homes. It is therefore very important to consider the beginning and end before installing the code locks in homes. (Arnulola & Olaniyi, 2009.)

With all the numerous importance of the Physical Access Control and that of the Door Access Control, it is of prime importance to study the advantages and the disadvantages of using electronic code locks at homes. In order to better understand this, a brief history on the different key systems will be analyzed to ensure a proper mastery of the different qualities of the different locks use in homes. It is with knowing that the true principle of perfect security, strength, simplicity and durability should be combined in every good lock. (Chubb 1850.)

2.1 History of Electronic code locks

Before modern civilization, our ancestors developed the need to keep their belongings to themselves. This was done by the use of mechanical devices known as locks. At first, these locks were only simple knots made from rope and other materials. This was only used to determine if someone had tried to open them but with time, new technologies were developed which greatly influenced the production of locks made from wood and metal which was used all over the world. The history of ancient civilizations is unclear to whoever first created the mechanical locks by the Modern historians. It is much believing that Egyptians, Greeks and Romans developed those skills independently from each other. Nevertheless, it is good to understand the historical pespective on the development of locks since the industrial revolution. Locksmith's responsibility was to protect the public from dishonest people and also to ensure that the public pays for good locking services to protect their belongings. This was followed by a section on innovation in the lock industry , which has important issues of patenting, design registration, customer requirements, industry and lockpicking. (Butterworth-Heinemann 2007.)

PICTURE 1. Ancient Locks (adapted from Barronin 1778)

Six thousand years ago is when the history of mechanical lock started in Ancient Egypt, whereas locksmith first managed to create simple and effective pin tumbler locks made entirely from wood. During the 1st millennia BC, locks finally started improving with the technologies and designs that were introduced by Greeks and Romans. Greek locks were unsecured and this had to give rise to the Romans to improve on the innovations of the Greek and the Egyptian locks by introducing metals as their primary material. This innovation ensured that only correct key with correct shape of projections can push corresponding pins before lock could rotate and throw the bolt. The fall of the Roman Empire caused a halt in the lock innovation until the 18th century with technology advanced giving room for engineers to create small and sturdy mechanisms. Robert Barronic 1778 led the new wave of locks and Harry Soref in 1924 produced the padlocks. (Butterworth-Heinemann 2007.)

PICTURE 2. Pad Locks (adapted from Barronin 1778)

The above picture shows the pad lock makes from iron, which is still used today, but it is right to know that vandals and no authentication given can easily break this kind of locks. With all these, the ancient Romans are pioneered the earliest combination locks which was the transformation of the key from an object to an idea. In 1857, James Sargent advanced this idea by inventing the world's first key-changeable combination lock which will only open at a set time known as the time lock and time delay locks which would only open after a certain interval in 1873 and 1880 respectively. This idea of an intuitive lock that will only open for a certain person at a certain time started in the late 20th century; Tor Sornes made the first electronic keycard lock in 1975. This gave rise to a new market of programmable locks. Today, electronic locks have made great use of all kinds of authentication methods, ranging from passwords to biometric data like fingerprint. Modern technology has also made it possible to have access to a building using the facial door lock. Some companies like Yale and Schlage are leading the way towards a keyless future. In addition, an innovation from companies is opening the doors with the swipe of a smartphone or even the sound of the voice. Schlage has introduced a new electronic door lock called the sense that adds Bluetooth, which allows one to use the smart phone as a wireless door key. The picture below shows an example on the modern code lock and how easy it is to use. (Liszewski 2015.)

PICTURE 3 Keypad Locks (adapted from Zhongshan Langnuo Hardware Manufacture 2013)

2.2 Advantages of using electronic code locks

It has been a problematic situation for households on the safe keep of keys. There is that worriedness of misplacing the keys. With the modern development from the history of the key locks, digital door locks also known as electronic code locks are made to reduce some of these problems. This new and modern technology has advantages. With the complexity of various electronic systems, it is a fact that the true principle of perfect security, strength, simplicity and durability should be combined in every good lock. (Chubb 1850.)

With the electronic code locks, there is an instance of a pickproof. Because there is no place for a key with the electronic code locks, the situation of break-ins is prevented because thieves are unable to pick or ‘bump’ the lock. This has reduced the rate of criminal acts on picking keys and breaking into homes. With the key system, it is always very difficult to ensure the situation of authentication. Knowing exactly who had access to an apartment or a building. With the key system, anyone in position of the keys can have access to the apartment. But with the electronic code locks, there is no fear of losing it. (Phillips 2013.)

There is no need for the change of the electronic code lock once it has been installed. An electronic user database there is no need to change locks. With those electronic code locks that uses key cards, if it ever gets lost, it can be removed from the data base and a new one can be issued. There is therefore no need to carry a large set of keys and the probability of losing is almost impossible. With the situation of landlords, resident keys are not needed or replaced if they lose them. (Phillips 2013.)

With electronic code locks, there is a high-level of security and control of homes and companies. There is the control and restriction of who goes into different sections of the building. This control can be by any resident person of an apartment or the proprietors of the apartments. They can control who can enter their rooms with one PIN code and it reduces the risk of anything getting stolen. It is easy to change the PIN code whenever needed. The ratio of the combination door locks from the Workplace Depot has over 8000 possible code combinations with just a change of the code. (Phillips 2013.)

Another advantage for electronic code lock is that authority can be given to anyone at the proprietor's discretion to have access into a home without duplicating a key to give to anyone who is to have access into a building. Authorization is done by simply giving the proper code to put into the electronic entry system to anyone who has to be given access to a building or home. With the system in place, one can tell exactly when and how people attempted to access a building. This gives a good idea on the security of homes. (Phillips 2013.)

With electronic keys, there is the reduction of the windshield and repair time. During working hours, if a technician needs extra access to handle an emergency in the field, his or her rights to access can be updated. This reduces the extra cost that a company can incur for the loss of time that the technician can take to resolve any technical problem in an apartment or a company. With this method, the technician can travel to the emergency situation without retuning to the office, reducing costly windshield time and accelerating repairs. (Phillips 2013.)

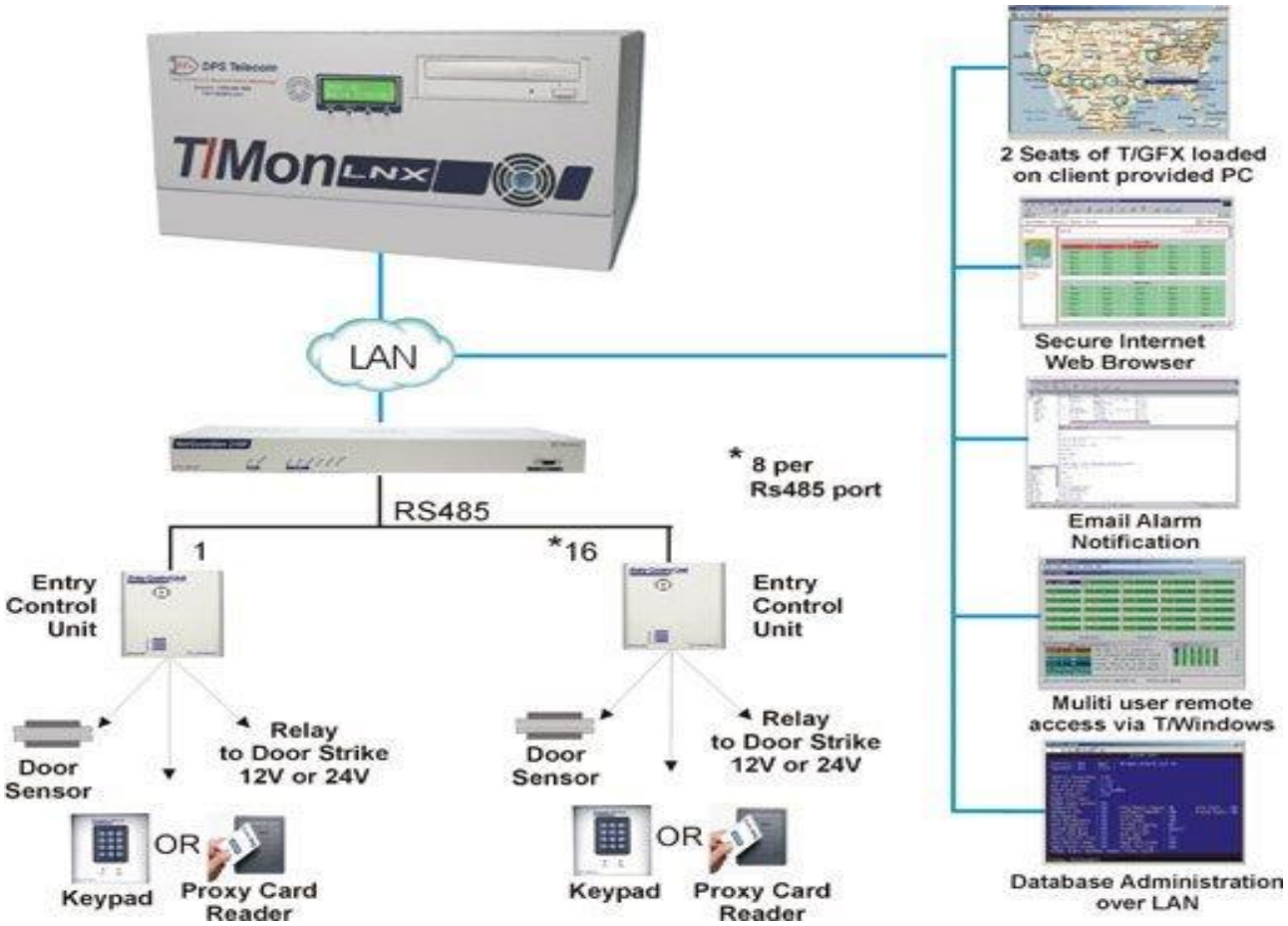
The rate of insecurity has made investment relatively slow in most African countries especially in areas were the security systems of the homes and safe guard of properties are not guaranteed. This makes life relatively hard and the rate of investors that invest in such an area is relatively low. Some areas have reduced the scale of investment. Investors prefer to invest in a small scale there by reducing the rate of employment that could have been available in such areas. The rate of insecurity has influenced a slow rate of development especially in many areas in Cameroon and most African countries. (Phillips 2013.)

The code lock electronic range provides major benefits over mechanical locks. There is a rapid programming at the keypad giving multiple codes, one-time user codes, auto alarm release and remote release options. Not requiring external power supplies, the electronic range provides a quick and cost effective solution for a wide range of applications, from lockers and cabinet to the primary lock on a

range of doors. Some of these features for door locks include; allows up to 80 user codes, 4.5 or 6 digits long. Over 1000000 code combinations are available. (Phillips 2013.)

2.2.1 Building Access System (BAS) with network and alarm monitoring

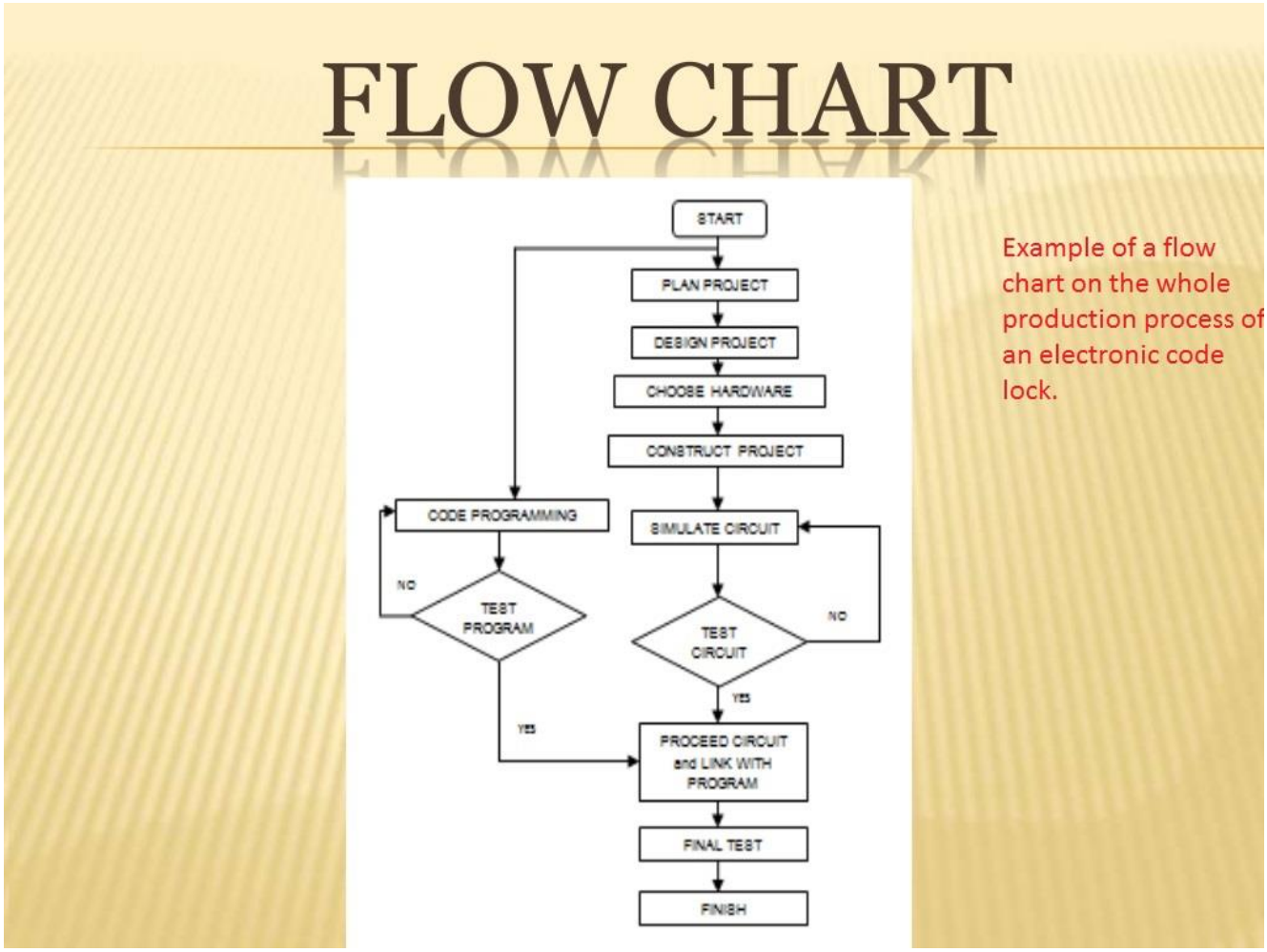
With the Building Access Control System, the network alarm managers have the capability of controlling and regulating the entry access. This has helped in the control of the sites as well as one can have a record of who was in the building. There is therefore the provision of valuable security to remote sites and deters theft, break-ins and vandalism. The graph below explains the functioning of the building access system which relates information from the door lock of keypad that goes over the internet or a network to the monitoring center. The construction of locks is a subject on which many ingenious mechanics have employed their thought and the art has had improvements from their work. (Bramah 1784).



Graph 1 Building Access System (BAS). (adapted from DPS Telecom 2016)

2.2.2 Flow chart example in engineering projects

The process flow diagrams of one company maybe different the flow that of another company even if they are involved in the production of the same goods and services. This explains why there is no universal method of the process flow chart. Nevertheless, most flows contain similar information. All the equipment is used in a project will be shown on the flow and the descriptive names of this equipment. The process streams will also be shown and identified by numbers or technical names. The basic control loops that illustrate the control strategy used to operate the process during normal operations are also clearly indicated in the flows. Graph 2 below shows the entire flow process of an engineering project like the code lock project, which encloses the managerial, and the production processes. (Addison W. 2016.)



Graph 2 Flow Chart (Adopted from www.informit.com 2016)

2.3 Disadvantages of using electronic code locks

Despite all the positive things that have been mentioned so far, electronic code locks do not fully guarantee 100% security of homes and the properties. This therefore explains why researchers have to continually research on the improvement and development of new locking technology to reduce the rate of insecurity of our homes and properties. The successful lock pickers have always been a constant impetus to improved construction, since these served to expose the weaknesses and technical deficiencies of supposed security lock. (Eras 1957.)

Forgetting the PIN code can be very easy. When one is in a rush to get into a building or when it is nighttime and dark, or when it is raining, changing the code in the middle of the night might be problematic. In addition, it might be problematic when we have children at home that need to come home in their parent's absence. They can easily forget the code or even give the code to an outsider who can have access to the home without any legal right. (Phillips 2013.)

The PIN code safe and the lock clean. This is problematic because when the locks have been used so many times, the coating may start to wipe out or mucky fingerprints may remain on the buttons. This therefore need much attentions on keeping the lock maintained and clean to stop unwanted people from finding the code. it might be an extra code on the house holds to either change the locks completely or doing some maintenance on the locks (Phillips 2013.)

Some digital door locks are powered by electricity. If in the process of using the doors, there is electricity failure, it becomes a problem for authorized persons to have access to or out of the homes. This can greatly frustrate the plan of an individual for the day. With the use of electricity, it might also be costly for households in that extra kilo watt of electricity is used to power the doors for its proper functioning. With this situation, it is preferable to buy a battery powered lock when it is faced with this problem. However, the fact remains that it is costly its maintenance. (Phillips 2013.)

Some digital door locks have a PIN code of 10 digits or more. This increases the level of insecurity in the code locks. Door locks will be much more secured when the code is only 4 digits long. There are some locks that comes with their own pin codes. Such locks are not good because people can find out the code which will give them the access into the home. It is therefore better to afford locks that the PIN code can be changed. Generally, most electronic code locks are much more expensive than the key locks. (Phillips 2013.)

Despite the numerous advantages included in the use of electronic code locks in homes, numerous drawbacks can be considered as well. There is always the problem of security. Even though the electronic code system that is very safe and is designed to alert police or other authorities if incorrect codes are entered too many times, it is possible that an intruder will be able to gain access to a home through this system by just guessing or hacking the system. (Phillips 2013.)

3 CASE STUDY ON THE USE OF ELECTRONIC CODE LOCKS IN CAMEROON

The use of electronic code locks in Cameroon is growing at a very slow rate. However, there is the use of key system, which has disadvantages as show in the previous chapter in this thesis. This is the reason why the crime rate in African countries especially Cameroon is much more than that is the western countries. This topic deals mostly with Cameroon and the use of electronic code locks. Here, a brief analysis will is conducted on the construction and the engineering expertise in Cameroon. This will then lead to the foreign trade in figure and a table for foreign trade followed with the factors that influence the use of electronic code locks in Cameroon. The various policies put in place by the government in a country determine the rate of growth of that society. The government sets the stage and the enterprises play the drama. (Wei 2002).

3.1 Construction and the engineering expertise in Cameroon

Construction in Cameroon accounts for about 3.5% of Cameroon's GDP (2008). However, the country petroleum industry has influence on the growth rate of the construction and the engineering sector in Cameroon. A lack of infrastructure has greatly affected the growth of the sectors. The main participants in the industry include subsidiaries of foreign groups like the Asquini-Encorad, KOOP Cameroon and Razel SA and local companies like Bati Service, Buns, Cacoco BTP and Scemar. The Cameroon Society of Engineers is the leading sector for engineering. However, there is no central body for the construction industry in Cameroon. Cameroon construction companies however have a slow rate of growth and the use of electronic code locks is increasing slowly. The biggest barriers to implementing regional infrastructure projects in Africa especially Cameroon are the countries themselves. (PIDA 2013).

3.2 **Foreign trade in figures**

Cameroon is one of the main African countries which is highly open to international trade. She is a member of the commonwealth, the free trade Zone and the CEMAC (Central African Economic and Monetary) and the ECCAS (Economic Community of Central African States). in 2013, Cameroons three main export partners were China (with more than 15.3% of Cameroon's export going to this country), the United States (4.2%) and European Union (54.5%). Its three main import suppliers are the European Union (33.4%), Nigeria (17.8%) and China (10.4%). The main manufactured import products in Cameroon are vehicles, machinery, electrical and electronic equipment

like the electronic code locks, which is imported in a lesser scale. In January 2009, Cameroon signed an Economic Partnership Agreement with the European Union who is the primary trade partner accounting for more than 50% of its trade. For some years now, East Asian countries especially China, Japan, India and Thailand have been reinforcing their trade ties with Cameroon. Despite all this trade activity the rate of importation of electronic code locks in Cameroon is still very low. (WTO- world trade organization; World Bank, 2015.)

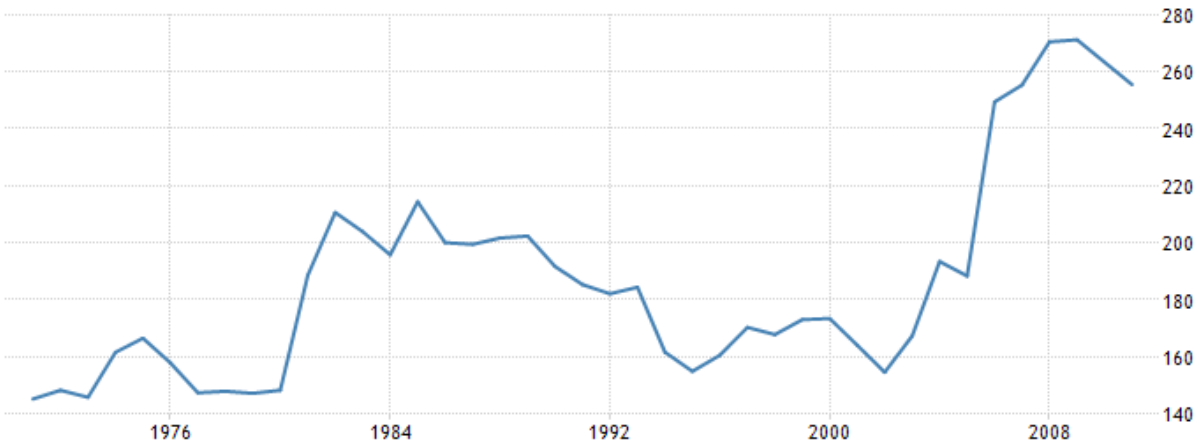
3.3 Factors that can influence the use of electronic code locks in Cameroon.

As earlier seen in this thesis, there are many advantages and disadvantages of the use of electronic code locks. One of the disadvantages mentioned is that it is costly in the use of electronic code locks. It uses electrical energy to power up the doors. Thus, disadvantageous for buildings to use this system of locking their homes since high bills are expected in the usage process. Nevertheless, the number of advantages that the electronic code locks provides far more out that of the disadvantages. With most African counties like Cameroon which has a higher level of insecurity, more of the key locking system is still been used. This case, will base on the positive and the negative factors that affects the use of electronic code locks. Possible solutions will also be given to resolve some of the negative factors that affect the use of this electronic code locks. Electronic commerce and the policies issues in various countries has been the topic of many international meetings most notably the G7 Ministerial Conference on the information Society held in Brussels in February1995 and the ministerial Conference on Global Information Networks held in Bonn in July 1997. (OECD 1997.)

3.3.1 Negative factors that affect the use of electronic code locks

The electricity supply in Cameroon is below the consumers' satisfaction as there are power shortages even in some parts of the major towns hence hindering access to information and communication technologies. Despite the efforts made by the electricity corporation (AES SONEL), some towns can be without electricity for several hours or days. Electricity remains the most readily exploited form of energy in Cameroon. Together with the Democratic Republic of Congo, it is considered to have the greatest hydroelectric potential in Africa. There are two hydroelectric stations on the Sanaga River that are responsible for the provision of electrical power. The electrical capacity of Cameroon was 810MW in 2002, for which the output for that year was 3.249 TWh. 90%

was from hydropower and the remainder from fossil fuels. However, despite Cameroon impressive waterpower resource, the national electrical line runs principally from Douala to Yaoundé and from Douala to Bafoussam. Most areas are served by diesel generated electricity or have no electrical power. The construction of dams varies from one geographical location to another and are dependent on the exact design and the way the dams operates as well as the ecological characteristics of the rivers ecosystems and the socioeconomic content. It is noted that dams modify the hydrology, water quality and temperature and sediment regimes, which affects primary productivity and morphology, which causes change at the higher tropical levels. (Posteland 2003.)



Graph 3 Power consumption in Cameroon. (Adopted from Posteland 2003).

Graph 3 above shows a fluctuating nature of the electrical consumption in Cameroon. Some times in the years, there is a rapid growth of the use of electrical energy and a fall of the consumption of electrical energy over the years from 1984 to the year 2000. There has been a drop in the use of electrical energy in Cameroon. From the years 2000 to 2008, there was then a rapid growth of the use of electrical energy. From this year to present day, there has also been a fall in the consumption of the electrical energy. This factor explains the reason why the lower use of electric power has influenced the low use of electronic code locks in Cameroon. Nevertheless, the use of electronic code locks has started increasing in a very slower rate in Cameroon.
(Posteland 2003).

The high tax rate is in Cameroon has always been a problem. Customs duties for goods imported into the country especially Cameroon are much higher especially on electronic goods. This also greatly limits the importation of electronic code locks. There is also the limitation at the level of the electronics that can store electrical energy which could ensure the storage of power that can be

used in homes for the operation of code locks. Higher taxes also limit the amount of investors who actually come into the country to invest. This causes investors to remain at a small scale and therefor do not have much reasons of worrying about the security level. (Doing business in Cameroon 2012.)

There is no proper town planning in most areas of the country. The settlement structure is just random making the identification of the homes very difficult. This is really a very big problem for the use of electronic code locks. This is because, with the electronic code locks, to ensure a maximum level of security, there has to be a system in which these homes and their alarm systems are connected to a central unit system in the security office to easily identify who is trying to have an illegal access. The process in this situation becomes difficult in using the code locks. (Posteland 2003.)

With the poor nature in the town planning, settlements in some areas are very bad which makes road networking very poor and limiting the accessibility to homes. This result to no good road mapping thereby making the security control system very difficult. The world today is becoming a global village thanks to the use of the internet. That notwithstanding, there are many areas in Cameroon that does not have the accesses to the internet. This limits also the use of electronic code locks because it can become very much difficult to use the wireless networking system to track any attempt to enter a building. (Posteland 2003).

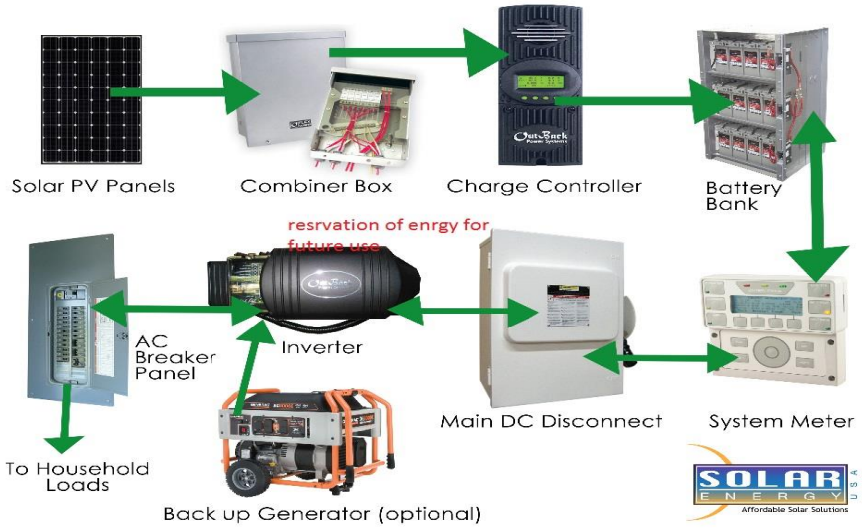
3.3.2 Possible solutions to the negative influences on the use of electronic code locks in Cameroon

Cameroon has many sources of power supply of which energy can easily generate that could be used to power homes for the use of electronic code locks but much of these resources are kept unused. Some of these power sources can be from the many waterfalls the country has, from the strong winds, the solar energy, and oil deposit. Door locks becomes even much easier when most of the code locks are manufactured using the chargeable batteries. After locking the door with the code, the battery can be removed to ensure accessibility only by the holder of the battery. Nevertheless, homes can be powered using the win miles for energy supply and the solar energy. The

picture 4 below shows how the solar panel can be used to power homes, which can help homes especially in Cameroon to use electronic code locks. (Willis 2014.)

Picture 4 Solar Panel (adapted from pixabay 2016)

There are also very good backup power systems that can be used in homes that can also ensure the constant provision of power even when there is power failure. Such a system is very good for countries like Cameroon, which has power failures. The picture 5 below shows an example of a Backup Power System. This system can be powered by the use of the solar energy. (Willis 2014.)



Picture 5 Backup Power Systems (adapted from pickering 2016)

The government's policies on the tax rate in Cameroon. There is a change on the tax rate in Cameroon. The corporate tax rate in Cameroon today stands at 33 percent. In the previous years, the Tax rate was 38.5 percent. It is important to know that the corporate tax rate in Cameroon is the tax collected from companies. The amount of tax is based on the net income companies obtained while doing their business activities, normally during one business year. This therefore gives a corporate average Tax rate of 38.04 percent from the years 2004 to 2015. The chart below shows the countries corporate tax rate. (Elsevier 2016.)

Graph 4 Cameroon cooperate tax rate (adapted from trading economics 2016)

The chart clearly shows the situation of tax in Cameroon and the reasons for the government action for reducing the take rate. It should be noted that the corporate tax is the main source of the government income. A great reduction of the tax rate from 38.5 to 33 percent is basically to encourage investors to invest in the country. Importing and investing on those goods and services that the country does not have absolute advantage over brings in development on the infrastructural, political and socio-economic affairs of the country. Therefore, the importation of code locks to secure homes and saves can be at a very low rate. This also explains why, within this few years, there has been a slow increase in the use of electronic code locks especially in most of the top ranking hotels in the country. (Elsevier 2016.)

The government of the country is making efforts in improving the infrastructure and the road-networking situation of the country. This is so that there should be a proper communication and organization in the country. Structures, which are not well constructed in most urban areas, are demolished and good road networks are constructed by the government. Most foreign countries like China and France obtain the contracts of constructing good roads and infrastructure, which gives a proper organization of the streets and infrastructure in these urban areas. The government has encouraged the construction of good roads that links cities together and even neighboring countries. There has been so many positive advantages for this. There has been a good improvement on the socio-economic activities especially in ecotourism. This is because tourism sites will be more accessible to tourists thanks to the projects. This improvement in the road network in the country has also improved the infrastructural development of the country. Most touristic homes and hotels uses the advanced method of electronic code locks to secure the hotels and touristic sides from unauthorized uses. (Elsevier 2016.)

A number of initiatives have been focused on the stimulation of the use of ICT as a development tool to eradicate poverty and other challenges. Some of these are the fact that the government has plan for an information and knowledge-based society by the ministry of scientific research and innovation. There has also been an improvement on the introduction of ICT in primary and secondary schools. The European Union with financial and technical help to update the system to manage the public service and the administrative reforms (SIGIPES) has also enhanced the use of ICT. Most importantly, there has been the computerization of the national Identity card by the Delegation of National Security. There is also the issuing of Biometric Passport by the Delegation of National Security. With the need of the higher security level at homes, much is and has to be improved on the security level on home by the use of code locks. To create an environment for the development and delivery of electronic services related to e-government and e-commerce, laws were enacted like Law No. 2010/021 of 21 December 2010 governing electronic communication; Law No. 2010/021 of 21 December 2010 related to cyber security and cybercrime. These laws will go a long way to improve the security level to track hackers who will try to get in the systems of the society without authorization. (Global investment & business center 2015.)

3.4 Positive factors affecting the use of electronic code locks in Cameroon

With the use of electronic code locks for homes and saves, the rate of crime has reduced. This is highly felt in nations that uses this code locks especially in Europe like Finland. Laws are respected and everyone is ready to work according to the laws of the country. Anyone going against these laws is pun-

ished according to the laws, which cannot be twisted to favor anyone. In countries, which are still faced with the problem of corruption, it is sometimes difficult to be certain that the laws can be fully respected and any criminal act punished according to the laws in the country. Nevertheless, Cameroon known for its efforts to resolve the problem of corruption and ensure a strict implementation of the rules and regulations governing the country as a whole. Apart from the anti-corruption groups that has been formed in the country, the government has also ensured that there is a strong and active military force that is there to maintain peace and order in the country. This has helped in reducing the crime rate of hackers, internet scammers and thieves who have access to the code lock systems to gain access into a home or building without authorization. This therefore has greatly favored the use of electronic code locks for our homes and saves. (Global investment & business center 2015.)

There is also a growth in the number of local housing companies and individuals involved in the construction of homes and commercial structures. The methods used in construction and the kind of houses constructed are better off than the ancient method. Good and solid materials are used today for the construction of homes and commercial sides which makes the buildings very strong. Some of the homes are built with the modern techniques used by most housing companies in Europe and America. The above reasons have greatly encouraged local construction companies in the use of electronic code locks. (Global investment & business center 2015.)

There has also been a greater improvement on the use of electricity by homes. The supply of electricity which is one of the key factors enhancing the use of electronic code locks has also been improved upon. The rate at which there is black out in the country has reduced. There are transformers, which can ensure the supply of higher voltages to homes, and factories, which can go a long way to power the doors with the use of these code locks. Other means for the supply of energy for homes has also been provided and made affordable for average homes and companies to ensure the constant supply of power to the doors. (Posteland 2003).

A greater improvement in the use of internet services has also enhanced the use of code locks for homes. Many companies like MTN, Nexttle, Orange and Camtel have ensured that there are internet services for our devices all over the country. This would go a long way to track hackers and none authorized persons trying to gain access into a home. It is possible to get the information if the homes, are connected to a central security system that controls the access of the homes. Some locking systems of homes are also coded in a way that information is always transfered to the main controller’s e-mail to ensure that the controller determines the access of the individual into the building. The internet

plays a vital role by ensuring that any attempted to gain access into an apartment is seen. (Cameroon radio and television 1994.)

4 HOW THE ELECTRONIC CODE LOCK SYSTEM WORKS

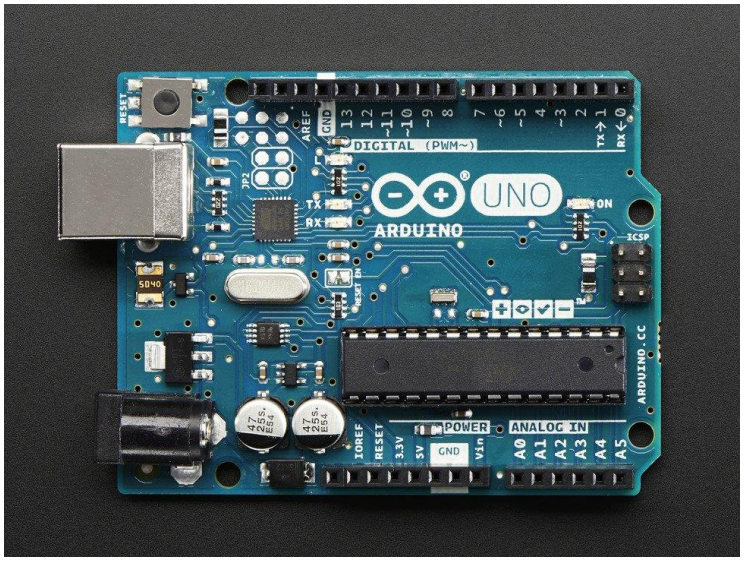
The digital key lock system is made up of two important systems, which are the hardware system and the software system. The software system is written in different languages and the run in the hard ware system, which commands the functioning of the hardware system. The hard ware has the microcontroller, which helps to assimilate the information from the code to the various hardware parts of the code lock. In this project, the Arduino Uno microcontroller will be used and the 4x4 matrix keypad. Other components needed for the hardware system are also explained in this chapter. (Prix Ars Electronica 2006.)

4.1 Arduino platform

Arduino is an open source electronic platform based on easy-to-use hardware and software. It is intended for the construction of any interactive projects. The interaction is based between the user and the hardware thanks to the help of the software. The Arduino is a simple yet sophisticated device which is based on At-Mel's AT mega microcontrollers. It is very much interesting to note that the Arduino software is supported by Windows, Macintosh OSX and Linus operating system. The software language is based on AVR C programming language and be expanded through C++ libraries. Various types of Arduino microcontroller boards are available in the market, which includes the Arduino kits and Arduino shields. (Prix Ars Electronica 2006.)

4.2 Arduino Uno Board and the ATmega328 Microcontroller

The Arduino microcontroller is of may type as earlier mentioned and of various capacities. Arduino Uno is one of the microcontroller boards manufactured by Arduino and it is a microcontroller board based on the Atmel's ATmega328 microcontroller. The Arduino Uno board has a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, a reset button, 6 analog inputs and 14 digital input/output pins (of which 6 can be used as PWM outputs). "Uno" means one in Italian and the uno board is the latest in a series of USB (Universal Serial Bus) Arduino boards which is the reference model for the Arduino platform. It uses the Atmega16U2 programmed as a USB-to serial converter instead of FTDI USB-to-serial driver chip, which was used in all the preceding boards. The board has 32 KB flash memory of which 0.5 KB is used by bootloader, 2 KB of SRAM, 1 KB of EEPROM and 16 MHz clock speed. (EETech 2016.)



Picture 6 The Arduino Uno microcontroller Board (adapted from the Arduino Board Uno 2011b)

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.The second Revision of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible with both the board that uses the AVR, which operates with 5V and with the Arduino Uno that operates with 3.3V. The second one is a not connected pin that is reserved for future purposes. (EETech 2016.)

The table below shows a summary of the Arduino Uno and the values of the input and expected memory space that the microcontroller has. The table clearly state the values of each parameters of the Arduino and the capability of the device it is used for. The capacity of the Arduino Uno has increased over the years to adapt to the need for big projects today. (Arduino 2016.)

Table 1 Summary about Arduino Uno (adapted from Arduino 2016.)

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	20 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB boot-loader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

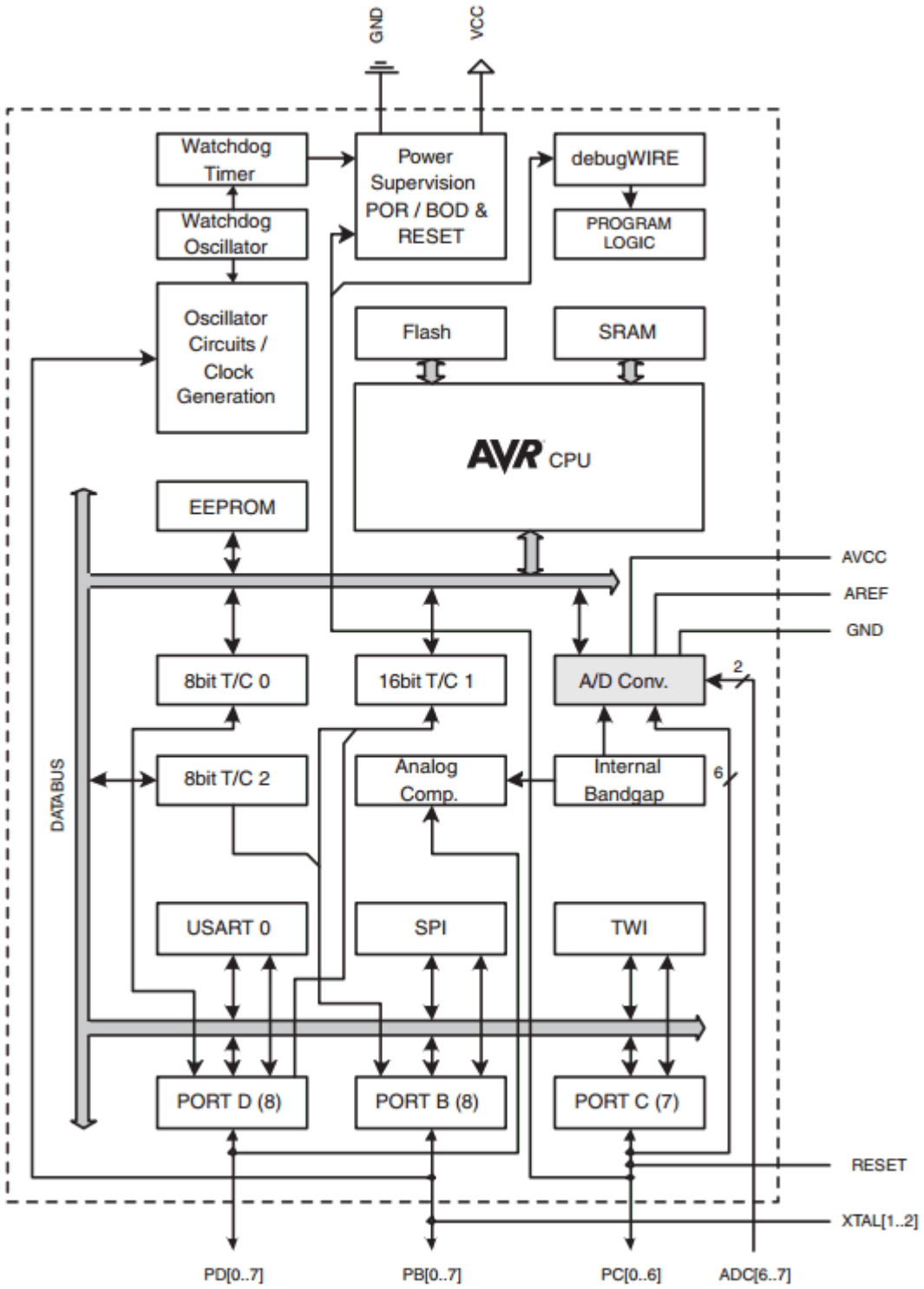
ATmega328 Microcontroller

The Atmel ATmega328P Xplained Mini evaluation kit is a hardware platform for evaluating the Atmel ATmega328P microcontroller. The microcontroller is a low-control CMOS (Complementary Metal Oxide Semiconductor) 8-bit microcontroller in light of the AVR upgraded RISC (Reduced Instruction Set PC) design. The capable execution of directions in a solitary clock cycle prompts the accomplishment of one MIPS for every MHz throughputs permitting the creator to upgrade power utilization versus handling speed. The device operates between 1.8-5.5 volts. The table 2 below shows the key parameters of the Arduino Uno and their values. (EETech 2016.)

Table 2 Key Parameters (adapted from EETech 2016)

Parameter	Value
Flash (kBytes):	32 kBytes
Pin Count:	32
Max. Operating Freq. (MHz):	20 MHz
CPU:	8-bit AVR
# of Touch Channels:	16
Hardware QTouch Acquisition:	No
Max I/O Pins:	23
Ext Interrupts:	24
USB Speed:	No
USB Interface:	No

Block Diagram



Graph 5 ATmega328 Microcontroller Architecture (adapted from Datasheet of ATMega328 2011)

The above graph 5 disigns the internal structure of the simple Arduino microcontroller. The inward engineering (Hardware) of the microcontroller is shown in the graph 5. The Central Processing unit (CPU) is the cerebrum of the microcontroller which controls the execution of the program. The MCU

(Microcontroller unit) comprises of 4K/8K bytes of in-framework programmable streak with read-while-compose capacities, 256/412/1K bytes EEPROM along with the 512/1K/2K bytes of SRAM. Alongside this, the MCU comprises of numerous other highlights. A byte-arranged 2-wire serial interface, SPI serial port, 6-channel 10-bit ADC (8 directs in TQFP and QFN/MLF bundles), a programmable guard dog clock with an inner oscillator and 5 programming selectable force sparing modes. Adaptable clock/counters with think about modes, interior and outside hinder also, a serial programmable USART. 23 universally useful I/O lines and 32 broadly useful working registers

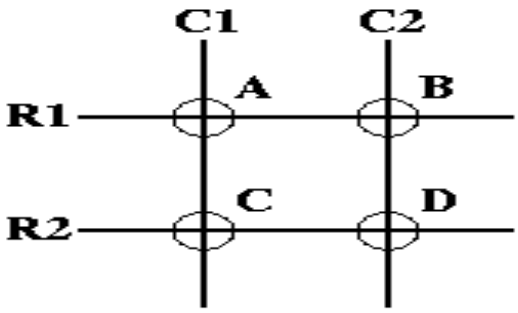
As earlier made mentioned, the CPU is the mind of the microcontroller which controls the execution of the system. Therefore, the CPU can get to the recollections, perform counts, control peripherals and handle interrupts. The AVR utilizes the Harvard engineering – with isolated recollections and transports for project and information to boost the execution and the parallelism. The idea of pre-fetching the following direction while executing the next instruction (one guideline) empowers the directions to be executed in each clock cycle and the project memory is in the System Reprogrammable Flash memory. (EETech 2016.)

4.3 Keypad

The understanding of how the keypad works is simple. The display of figures or letters on the screen of our computers depends on the key of the keypad is been pressed. Nevertheless, much understanding is also required from the technical work of switching wires with a supply current (positive +) that is grounded to the other end of the connected wires. A better understanding can be done by getting a good mastery of the Matrix of Circuit. (Giorgos L. 2010.)

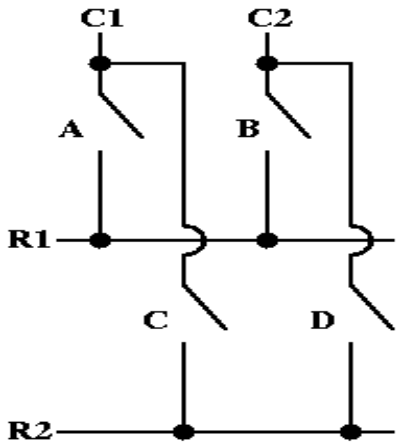
4.3.1 The Matrix of Circuit

Keypads from every indication, uses a matrix with the rows and columns made up of wires. Each key acts like a switch. When a key is pressed, a column wire makes contact with a row wire and completes a circuit. The keypad controller detects this closed circuit and registers it as a key press. (Giorgos L. 2008.)



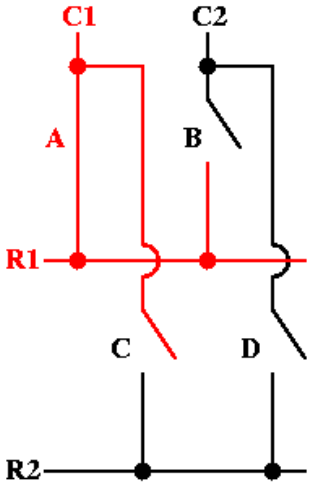
Graph 6 Conceptual Matrix Circuit (adapted from Giorgos L. 2008.)

The above graph shows a conceptual Matrix Circuit keypad, which has 4 keys: *A*, *B*, *C*, and *D*. Each key has a unique grid location, much like points on a graph. Key *A* is at node C1R1, key *B* is at node C2R1, key *C* is at node C1R2, and key *D* is at node C2R2. The electronic circuit for this matrix looks like the diagram below. In reality, this is useless which is why real keypads (keyboards) use many more rows and columns. (Giorgos L. 2008.)



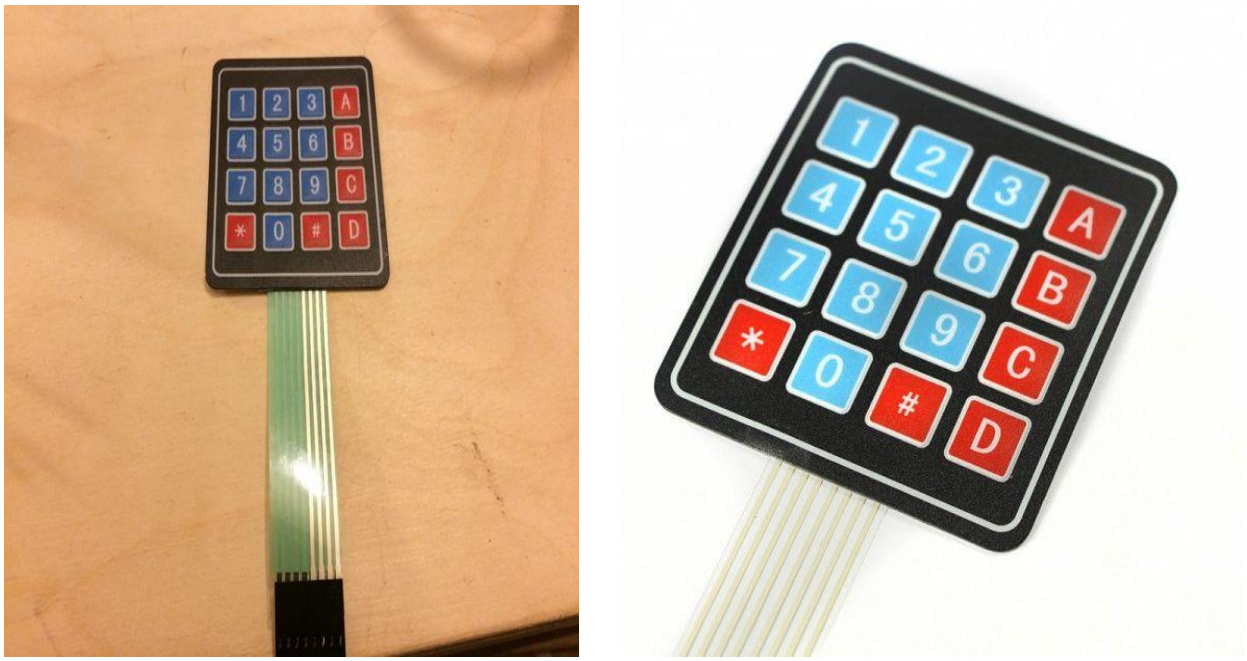
Graph 7 Switch Open (adapted from Giorgos L. 2008.)

To know which key has been pressed, the keypad controller (microcontroller) will scan all columns, activating each one by one. When a column is activated, the controller detects which rows are "activated". To step through this procedure, the controller activates column C1 and checks rows R1 and R2. The microcontroller does so with C2 and checks the rows R1 and R2 if they are connected to make a complete circuit permitting current flow. (Giorgos L. 2008.)



Graph 8 Row 1 is activated (adapted from Giorgos L. 2008.)

The above graph, it shows that row R1 is activated. So the microcontroller now knows that node C1R1 is pressed. Since C1R1 corresponds to the *A* key, the microcontroller knows that the *A* key is pressed. When the microcontroller activates column C2, neither row R1 nor R2 are activated. Both switches B and D are open. The images of the keypads bellow show the most common keypads that are been used in projects. Nevertheless, the matrix of such a keypad follows the same logical matrix like the above explanation of a keypad matrix and the determination of which key is pressed. (Giorgos L. 2008.)



Picture 7 keypad for projects (adapted from Dieudonne 2015)

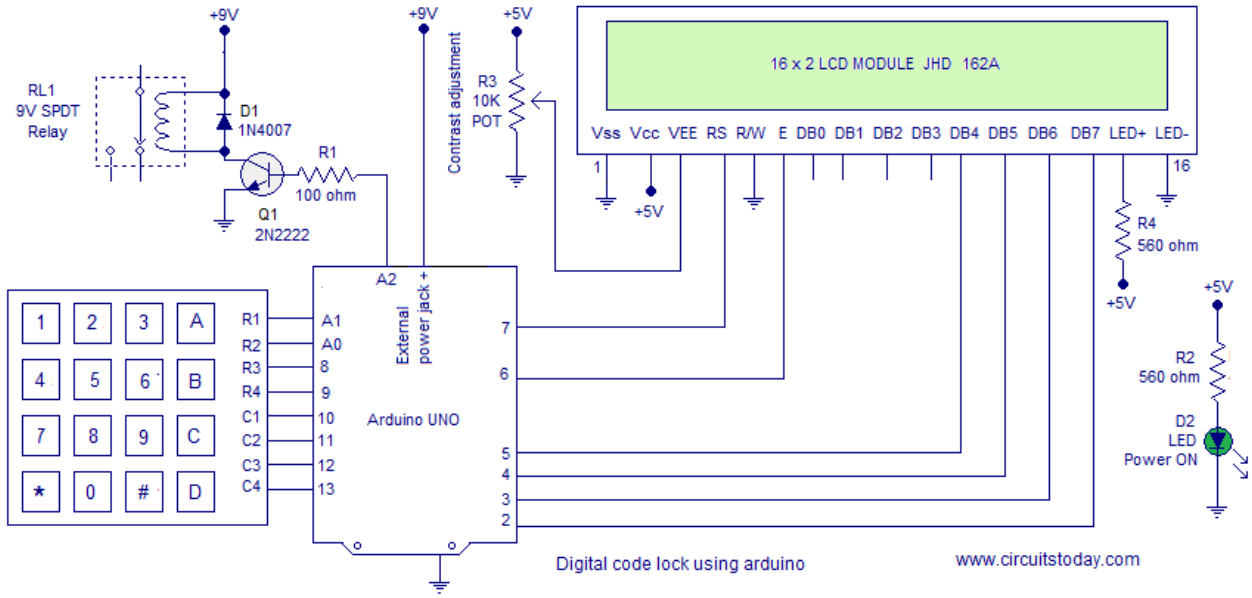
There are 8 pins on this keypad. It works by 4 pins being connected to the rows and 4 pins to the columns. There are a few uses for this keypad. A door lock, controlling lights, password for a laptop. These are all the components that is needed. Arduino Uno or Mega, 8 x Arduino Connection Wire (Male-Male), 4x4 matrix keypad. (Dieudonne 2015.)

4.3.2 How to connect and read a key with an Arduino

The main objective of this project is knowing how to intergrate microcontrollers with any key pad. This is so because key pads are used in almost all electrical divices such as phones, ovens, door locks, microwaves, fax machines. A good understanding of this connection is of much importance because it helps in the innovation of new electronical prducts. This project uses the matrix keypad. This type of keypad follows an encoding method having less output pins than there are keys. Using the keypad having 16 keys (0-9, A-D, *. #), only 8 pins are needed. With this, they have less wiring. When the keypad is facing an individual, the first four pins from left to right are rows and the last four pins are column. When connecting the pins to the Arduino board, it is done on the digital output pins from D9-D2. Pin 1 from D9 and then continue to the right to D2 that ends with pin 8. (Dieudonne 2015.)

4.4 Design and Development of the system (Graphical representation)

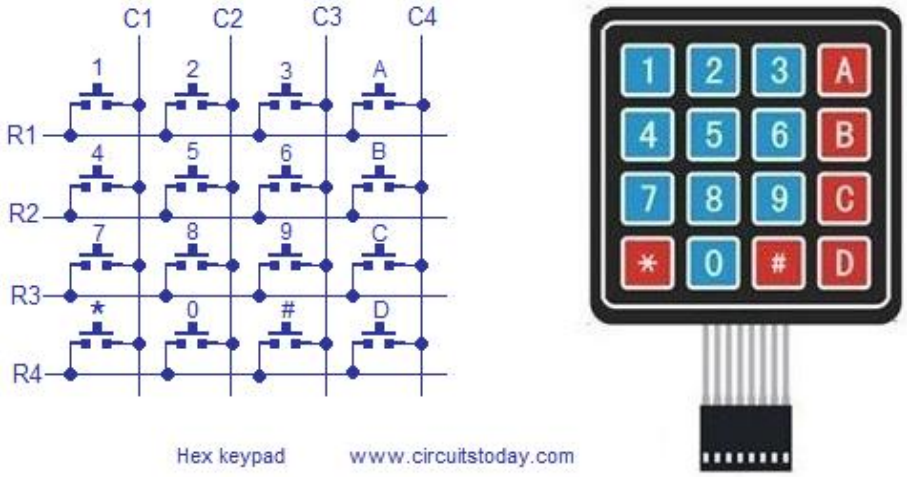
From the above descriptions of the Arduino Uno and the keypad, much technical skills on the hardware and the software are still needed to enhance a smooth functioning of the code system as a whole. With this system, the user will be promoted to set a password at installation. Nevertheless, the password which is set at installation will continue to serve the lock until the password is changed. Users of this lock can continue to change the password with a single key press. The software program will check for the correct password and allow the user to change the password only if the current password is inputted correctly. The graph on the next page shows an example of the different components and how they are connected. This project is not principally on this design but for the sake for demonstration of how components are connected, this is used. (Dieudonne 2015.)



Graph 8 digital code locks circuit using Arduino Uno (adapted from circuits today 2015)

4.5 Description of the digital code locks circuit

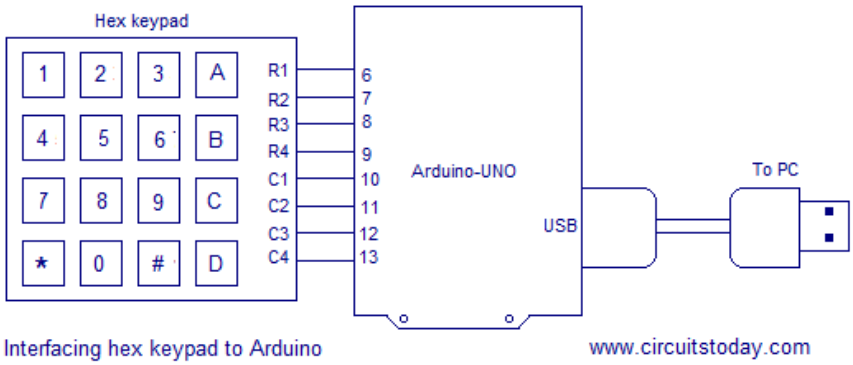
For a better understanding of this project and the circuit design, much knowledge is required on two important concepts. The very first one is based on the interface hex keypad with Arduino and the second one is on the interface LCD with Arduino. With the understanding of this above concepts, it will then require a few lines of code to build the Code Lock. It should be noted that the Hex key pad is a very important component in embedded systems and most of the typical applications in which the hex keypad is been used are the code locks, calculators and automation systems. The hex keypad has an arrangement of a 4x4-matrix form. On the Hex keypad, there is the following numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and letters A, B, C, D, *, #. The Hex keypad will therefore have 8 connecting wires namely R1, R2, R3, R4 and C1, C2, C3, C4 representing the rows and columns respectively. A simple example of a Hex diagram and the picture is shown on the next page. (Murtala 2013.)



.

Graph 9 hex diagram (adapted from circuits today 2015)

The project distinguishes the pressed key by a technique called segment filtering. In this strategy, a specific row is kept low and different rows are held high. The rationale status of every column line is examined. if a specific column is discovered low, then that implies the key that comes in the middle of that row and column is short(pressed). At that point the project enlists that key being pressed. At that point the same strategy is connected for the other lines and the whole process is repeated. For instance, if line 1 is kept low and segment 1 is discovered low amid examining, then that implies key"1″ is pressed. The diagram below shows the connecting interface between the hex keypad and the Arduino-Uno. (Murtala 2013.)



Graph 10 interfacing hex keypad to Arduino (adapted from circuits today 2016)

Rows R1, R2, R3 and R4 are interfaced to digital pins 6, 7, 8 and 9 pins of the Arduino respectively. Columns C1, C2, C3 and C4 are interfaced to the digital pins 10, 11, 12, 13 of the Arduino. The Arduino is connected to PC through the USB port. The circuit is powered from the USB itself and no external power supply is needed. (Murtala 2013.)

4.6 Description of the software for the interfacing keypad with Arduino

The design for the interface between the keypad and the Arduino is shown on graph 10. The smooth functioning of the software is mainly based on the correct declaration of variables and a proper setting of the PIN mode as it is rightly connected to the hardware. The keypad matrix is a 4x4 matrix and is expected to have 16 PINS but it has been compressed to 8 PINS working in a matrix and a circuit form. The hexa-keypad matrix is shown below in the example of lines of codes. The above lines of code codes simple initializes the variables that we have in our project to make it function well. It also shows the matrix form of the keypad. The variables are mostly integers declared in a simple form.

```
const byte ROWS = 4; //four rows
const byte COLS = 4; //four columns

//the design of the keypad
// a 4x4 metrix keypad

char hexaKeys[ROWS][COLS] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8','9','C'},
  {'*','0','#','D'}
};
```

The voip setup loop simply explains the declarations on the state of the pins when pressed. Nevertheless, when a button is pressed the pin Mode is activated. The password for this code lock is “1245”. When it is typed correctly, the door lock opens and when it is wrong, LED on the pin 6 of the Arduino turns on indicating a wrong password. The codes below just shows some decelerations in the void setup() loop in this project. They simply declare the pinMode of the Output and the Inputs. This function is called in the mian loop when a command is given.

```
// setting the pinMode for the rows and columns of the keypad
void setup()
{
// example of the void set decleration
  pinMode(r1,OUTPUT);
```

```
  pinMode(r2,OUTPUT);
  pinMode(c1,INPUT);
  pinMode(lock,OUTPUT);

  Serial.begin(9600);

  digitalWrite(c1,HIGH);


// giving the password for the code lock
  p[0]=1;
  p[1]=2;
  p[2]=4;
  p[3]=5;
}
```

The lines of code in the void loop() below mainly describe the connection between the keypad and the Arduino. With the variables declared, when a button is pressed, for example 1 as in the code below, the digital write r1 is low and the other values are kept high. If column 1, which is equal to LOW the serial print will then print the value one as the output value on the device that is used. This goes the same as to all the values that are pressed on the keypad.

```
Void loop()
{

  digitalWrite(r1,LOW);
  digitalWrite(r2,HIGH);


  colm1=digitalRead(c1);
  colm2=digitalRead(c2);


  //setting the pins connected to the arduino
```

```
 if(colm1==LOW)
 { n=1;
  a=1;
  Serial.println("1"); // printing out the figure as typed
 delay(100);}
 else
 {
  if(colm2==LOW)
  { n=2;
    a=1;
    Serial.println("2"); // printing out the figure as typed
   delay(100);}

}}
```

In this section of the code, if column 4 is LOW and the password is given correctly, the digital write for the lock becomes high and the serial print command prints the “UNLOCKED” on the monitor displaying the output as in the case of the values pressed on the keypad. The LED connected in PIN 13, which starts to blink and delays for about half a second and then returns back to the lock state. If a wrong password is given, then the LED connected to PIN 13 does not blink and it is displayed on the monitor "WRONG PASSWORD".

```
  if(colm4==LOW)
  {
   if(c[0]==p[0]&&c[1]==p[1]&&c[2]==p[2]&&c[3]==p[3]) // giving the password correctly
   {digitalWrite(lock,HIGH);
   Serial.println("UNLOCKED");



 digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
 delay(500);                        // wait for a second
 digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
 delay(500);                        // wait for a second

   c[5]=9;}
   else
```

```
{Serial.println("WRONG PASSWORD");

digitalWrite(r1, HIGH);    // turn the LED off by making the voltage HIGH
delay(500);
digitalWrite(r1, LOW);    // turn the LED off by making the voltage LOW
delay(500);                    // wait for a second

}
delay(100);}
}}}
```

When these lines of codes are debugged in the hardware of the code lock, it works perfectly. Nevertheless, the code lock was just for simplicity. It can really be made complicated and with many futures like the change of the password and the use of other complicated hardware system, that requires more complicated lines of code. Usually as explained above, the matrix codes for the keypad are designed facilitating the interface between the Arduino and the keypad. What is then required is to include the lines of codes to the other interface that relates the Arduino and the LED interfacing part of the hardware.

4.7 Limitation of the study

Just like every other research work in technology, it is always very interesting but has some limited constrains. This project has been theoretical and a practically based. This gave the means to carry out a quantitative and qualitative analysis. Nevertheless, it was quite a success to actually go to the field in Cameroon to make some findings about the number of homes or offices that uses this electronic code looks. In the few places that are reached, it is discovered that there were relatively very few homes and offices with such systems of locks. However, the research was limited with the amount of time to be spent to stay there to make many findings in many towns. Finance also was another imitational factor that influenced the fewer visitations to many towns. There was also the problem of bad roads limiting movement from one place to another. It was also difficult to get statistical information from some offices because of some confidential secrets about their own security system.

5 CONCLUSION

This research work on the use of electronic code lock was based providing answers to the research question “What therefore makes electronics code locks preferable for our homes for the security of our homes?” in answering this question, various steps were taken and then resulted to some major conclusions. Nevertheless, the history of locks was analyzed and saw how researchers acknowledged the importance of security in our homes and made great and numerous improvement from the use of the mechanical locks to the use of the electronic code locks. In this process, a case study of Cameroon was taken and then looked at the factors that might hinder the use of the electronic code locks. There was also the motivated to provide possible measures that can be used to ensure that the use of these locks becomes possible and highly effective. Analyzing the advantages of the use of the electronic code locks were not also left out. The technical work of knowing the hardware system and the software was also of prime importance. The development of the software showed how good and secured it is for use electronic code locks. If a home or office using this code lock system for security is connected to a central unit for security that checks illegal entry into an apartment with the help of all the modern security measures, then the rate for theft and illegal access into an apartment reduces to almost zero. Analyses can be made by comparing Finland and Cameroon. The rate of insecurity in Cameroon is much higher than that of Finland because of the systems put in place by the people and the government. This system includes the security system of our homes and properties. Finland is known to be one of the leading countries in the world in Information Technology and one can truly confirm this from the security system they put in place both over the internet and in homes and offices. With this, recommending the use of electronic code locks to individuals, groups or the government of any society will be something with little or no doubt that it will greatly reduce illegal movement into apartments and the loss of properties. There all homes and offices are advised to implement the use of electronic code locks for a safe and secure system of protecting lives and properties.

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```
// declaring variables
int n;
int a=0;
int i=0;
int lock=3;
int p[4];
int c[4];

const byte ROWS = 4; //four rows
const byte COLS = 4; //four columns

//the design of the keypad
// a 4x4 metrix keypad

char hexaKeys[ROWS][COLS] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8','9','C'},
  {'*','0','#','D'}
};
//byte cPins[COLS] = {4, 5, 6, 7}; //connect to the column pinouts of the keypad
//byte rPins[ROWS] = {3, 2, 1, 0}; //connect to the row pinouts of the keypad

int r1=6;
int r2=7;
int r3=8;
int r4=9;

int colm1;
int colm2;
int colm3;
```

```
int colm4;

int c1=10;
int c2=11;
int c3=12;
int c4=13;

// setting the pinMode for the rows and columns of the keypad
void setup()
{
  pinMode(r1,OUTPUT);
  pinMode(r2,OUTPUT);
  pinMode(r3,OUTPUT);
  pinMode(r4,OUTPUT);

  pinMode(c1,INPUT);
  pinMode(c2,INPUT);
  pinMode(c3,INPUT);
  pinMode(c4,INPUT);

  pinMode(lock,OUTPUT);

  Serial.begin(9600);

  digitalWrite(c1,HIGH);
  digitalWrite(c2,HIGH);
  digitalWrite(c3,HIGH);
  digitalWrite(c4,HIGH);
  digitalWrite(lock,LOW);

// giving the password for the code lock
  p[0]=1;
  p[1]=2;
  p[2]=4;
```

```
 p[3]=5;
 }

Void loop()
{

 digitalWrite(r1,LOW);
 digitalWrite(r2,HIGH);
 digitalWrite(r3,HIGH);
 digitalWrite(r4,HIGH);

 colm1=digitalRead(c1);
 colm2=digitalRead(c2);
 colm3=digitalRead(c3);
 colm4=digitalRead(c4);

 //setting the pins connected to the arduino
 if(colm1==LOW)
 { n=1;
  a=1;
  Serial.println("1"); // printing out the figure as typed
 delay(100);}
 else
 {
  if(colm2==LOW)
  { n=2;
    a=1;
    Serial.println("2"); // printing out the figure as typed
   delay(100);}

   else
  {
  if(colm3==LOW)
  {Serial.println("3"); // printing out the figure as typed
```

```
   n=3;
   a=1;
 delay(100);}

 else
 {
 if(colm4==LOW)
 {Serial.println("LOCKED");
  digitalWrite(lock,LOW);  //locks
  i=0;
  delay(200);}
 }}}

digitalWrite(r1,HIGH);
digitalWrite(r2,LOW);
digitalWrite(r3,HIGH);
digitalWrite(r4,HIGH);
colm1=digitalRead(c1);
colm2=digitalRead(c2);
colm3=digitalRead(c3);
colm4=digitalRead(c4);
if(colm1==LOW)
{Serial.println("4");
 n=4;
 a=1;
delay(100);}
else
{
 if(colm2==LOW)
 {Serial.println("5");
  n=5;
  a=1;
delay(100);}
 else
```

```
{
if(colm3==LOW)
{Serial.println("6");
  n=6;
  a=1;
 delay(100);}
else
{
if(colm4==LOW)
{
 if(c[0]==p[0]&&c[1]==p[1]&&c[2]==p[2]&&c[3]==p[3]) // giving the password correctly
 {digitalWrite(lock,HIGH);
 Serial.println("UNLOCKED");


digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
delay(500);                        // wait for a second
digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
delay(500);                        // wait for a second

 c[5]=9;}
 else
{Serial.println("WRONG PASSWORD");

 digitalWrite(r1, HIGH);    // turn the LED off by making the voltage HIGH
 delay(500);
 digitalWrite(r1, LOW);    // turn the LED off by making the voltage LOW
 delay(500);                // wait for a second

 }
 delay(100);}
 }}}
 if(a==1)
 {
```

```
c[i]=n;
i=i+1;
a=0;}
}
```