

Declaration

I, Bornwell Mwandambira (R134288F) hereby declare that I am the sole author of this dissertation. I authorize the Midlands State University to lend this dissertation to other institutions or individuals for the purpose of scholarly research.

Signature _____ Date _____

Approval

This dissertation entitled “Design of a low cost indoor ultrasonic intruder deterrent system with GSM based SMS notification” by Bornwell Mwandambira meets the regulations governing the award of the degree of Telecommunications of the Midlands State University, and is approved for its contribution to knowledge and literal presentation.

Supervisor
Date

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ABSTRACT

Home/ Bank/ Office security has been a major issue where crime is increasing and everybody wants to take proper measures to prevent intrusion. The project is aimed at developing the security of home against Intruders. In a case of intrusion while the user is out of the house, then the device sends SMS to the emergency number provided to it and also display it on LCD connected to it. The paper consists of a background into the area At mega 2560 microcontroller, sensing elements and GSM modem, how they are interfaced to each other and AT (Attention) commands set used in communication. This system can avoid these undesirable situations of burglary and theft. Th security system has features like changing the input password of the system and a user friendly visual and audible interfaces for the user to operate on. The main goal of this research is to aid and assist in intrusion detection and avoid criminal activities which include theft and burglary. This research insured a cost effective and practical device that can be used in the student's country.

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CHAPTER ONE

1.0 Introduction

This project intends to develop and design an indoor intruder deterrent system which utilizes cost effective and readily available electronic components in the design of a redundant intruder detection and alerting system with SMS notification service. This will ensure protection of valuable property and precious, priceless human life.

1.1 Background and Justification

Unauthorised entry to premises has become an essential need in the modern-day setting, visits to the scenes of crime by the Authority are more than perfunctory, even at a time when more police officers and crime enforcing units are being recruited and the technical aid is better than before. It needs an individual to take the initiative to protect their valuable assets. In today's world both home owners and commercial businesses are becoming more concerned with security. The alarm system, which where once affordable only by large businesses are now within reach of small businesses and average households, referring to price and availability. Making burglary audibly conspicuous either by breaking the doors or windows, for this evidence is vitally important to the police and insurance companies involved.

Security alarms play an important security role in our day to day lives as we see security alarms being used, be it outdoor alarms integrated with Closed-circuit Television Surveillance (CCTV) systems which automatically start record the intruder's activities or Indoor alarms systems in houses or small offices [3]. Security alarms serve the purpose of protection of property, valuable resources and most importantly ensuring human safety from intruders and burglars. The use of ultrasonic signals to detect intruders is a remarkable scientific breakthrough as the technology proves to be redundant with accuracy in detection. The security industry is growing at a rapid rate and various video surveillance systems have been installed for monitoring of public and

private areas. However, these systems have disadvantages, an individual (usually security personnel) has to monitor the camera at all times and the area has to be properly illuminated proving costly and still very inefficient.

The reality of the matter is that conventional security systems are inadequate and ineffective to guarantee protection against the designs and devices of the present-day criminals.

1.2 Designed System

The basic concept and sole purpose illustrated by any security system alarm mechanism to detect any type of intrusion or unauthorized entry into the restricted build or space. The system will use an ultrasonic sensor mounted on a servo-motor, sweeping an area 160 degrees to detect any foreign obstacle. Upon detection, the system send a message in form of text alerting the individual of the intrusion.

Ultrasound is acoustic energy in the physical form of waves having very high frequencies and small amplitudes, the frequency is above the human audible hearing range (sonic range) which is approximately 20kilo Hertz. This range is now called the Ultrasonic range. Ultrasound is used in navigational, medical, and in security applications

Ultrasound can be used to detect and locate objects using similar principles as those used in RADAR (Radio Detection and Ranging or Radio Direction and Ranging.). High frequency, high energy acoustic waves reflect off from objects, even reflecting off the comparatively small objects due to the waves characteristic short wavelength.

An ultrasonic sensor is volumetric, meaning it floods an area within its coverage pattern. This allows it to detect persons behind partitions and other obstructions. Any moving object within its coverage area will disturb the sound wave pattern, creating a Doppler shift and altering the signal returning to the sensor. False alarm activation may also occur from vibration, air movement, high sound levels, and audible sounds having ultrasonic components. Ultrasonic sensors have sensitivity adjustments to minimize environmental effects. Reducing sensitivity will also reduce the coverage area. If ultrasonic sensors are mounted close to each other, they must operate at

different frequencies to avoid interfering with each other. [2] The system proposed here makes use of the emission of ultrasonic signal waves and the systems functions by exploiting the Doppler effect. This frequency shift between emitted and received waves is characteristic of the reflection from any object, which would indicate intrusion.

Also, another sensing element in the designed system is an electromagnetic door sensor (Reed switch), which cause a trigger in the alarm if the plates of the sensor are separated. The sensor uses electromagnetism principles to either open the switch or close it depending on how the switch is manufactured to operate.

1.3 Aims and Objectives

The purpose of this study is to:

- Provide the locale market with a low cost, reliable and effective security system.
- Improve the numbers of household and small businesses with access to electronic security systems around their premises
- Demonstrate innovative ingenuity

The other purpose of this study is to investigative and grasp an understanding of principles adopted in ultrasonic sensing equipment. The development of this system requires the application fundamental technical skills in electronic system design and implementation. The three physical principles in ultrasonic sensors investigated in this project are

- Doppler Effect
- Time of flight
- Attenuation of Sound Waves

Ultrasonic sensors are non-intrusive; this means that the don't require any physical contact with the target object, they can also detect transparent or shiny targets which are obscured to other vision based sensors.

1.4 Problem Statement

The problem being faced by the security departments of numerous institutes where security is of great priority is that security is essential around the clock for each day and for every day in a year, this becomes very costly if security personnel is hired to work in alternating shifts day in day out. Security is of huge concern these days especially due high unemployment rate being faced by Zimbabwe, robbers and burglars are finding market and profit in theft and other criminal activities in households and places of business.

Other security measures such as infrared beam and trip wire alarming systems on windows and doors can prove ineffective expensive and unreliable as they can be avoided or by-passed by the intruder.

1.5 Sub problems

The following questions were raised in order to solve them

- The interfacing of the input device i.e. the ultrasonic sensing unit to the output devices such as the Gsm module and LCD screen
- What if the sensor does to detect the intruder as it should?
- How long is the out conducts once trigger?
- Are they any loopholes which make the whole system vulnerable and susceptible to infiltration?

1.6 Hypothesis

The possible answer to the questions lies in the design of a highly accurate ultrasonic sensing security system that has a control unit that processes all the input data and in turn outputs the results in such a way that it takes the minimal time to detect intrusion and trigger the output device (notifying module) with best possible detection accuracy. The triggered output device switches off automatically after a time defined by the researchers or owner's discretion.

1.7 Aim of research

The aim of this research project is to design a low-cost household electronic security system prototype that can almost instantaneously detect intruder within the securitized perimeter or detect forceful breaking in through the door or window, upon trigger the prototype simultaneously triggers an alarm and sends an alert SMS to the owner and police.

1.8 Objectives of Research

The objectives of this research are:

- To design an electronic household security system.
- To develop the electronic security system.
- To show clearly the use of basic electronic components in the system.
- To interface the input devices of the security system such as the Sensor unit, power cables and the mechanical rotating servo- motor with the output devices such as the Gsm module, Lcd display screen, piezo buzzer and LEDs.

1.9 Assumptions

The ultrasonic sensor uses sound waves by means of short pings being transmitted by the transmitter, however sound waves lose their energy when propagating in air this results in a relatively short detection range. To avoid false detection there must be no obstacles in the perimeter facing the sweeping sensor. Notification and alert response time is governed by the speed of the SMS network operator.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses projects and respective documentations related to this project, it also introduces devices, approaches and communication technologies that have been implemented in the designed system. The related work has been reviewed carefully, this ensures an improvement in quality and reliability of this project. Analysis of previously carried out projects by other researchers gives an in depth understanding of the loosely quoted term “security”, this analysis also opens up the possibility to know what features are lacking in their projects and can assist by recommending some futuristic work that could be done to improve the same project. This chapter it will also explain some SMS (Short Message Services) based applications.

2.2 Security

In order to carry out the design and completion of this system the important objective that has to be met is to understand the concept of the broadly used term security. According to Oxford dictionary security is the state of being free from danger or threat, the state of feeling safe, stable and free from anxiety. Security can be defined objectively as the protection of an individual, building or property, organization against threats such as intrusion and criminal activities

2.3 Current Statistical Report on Burglaries in Zimbabwe

According to Zimbabwe 2016 Crime and Safety Report by the Research and Information Support Centre (RISC) [1], most criminal threats are crimes of opportunity (residential burglaries, routine thefts, smash and grab attacks at dark intersections at night. Also, as witnessed in recent political-economical demonstrations of STAY AWAYS, horrific results of multiple small businesses being raided and ransacked left the nation on high security alert for

their property and assets. Due to the economic challenges faced in 2016 which are likely to increase in 2017, crimes of opportunity that involve a low risk of arrest or apprehension and high chances of achieving hard currency or any form of marketable valuables remain key targets of criminals.

Most residential crime incidents reported to the RSO office in 2016 indicate the suspects fleeing the crime scene in a majority of the cases when the alarm is triggered and/or other robust security devices are encountered.

2.4 Why home Security Systems are Important

According to Larry Amonn from ehow contributors, [2] home security systems are reasonable inn cost (weather it is purchased or self-designed) and can be installed in virtually any household or apartment. Installing a home security ensures the users safety and guarantees security. They are several important reasons to consider getting a home security system.

i. Personal Safety

In an unfortunate event of a break in, the intruders are not likely to be concerned with personal safety of the individuals inside. If the break in is theft motivated, the thief probably might flee if caught in the act, leaving everyone physically unharmed, however some break-ins have a sole intension of hurting or even killing the intended targets inside. Home security systems date [3] and help in prevent such acts

ii. Property

In such economically constrained times being faced by Zimbabwe at the moment, thieves are more likely to be brazen about committing burglaries in households for valuables. Theft motivated break-ins can happen at any given time of the day but most incidents occur in the night when people are asleep or away under the cover of darkness. A misconception that eluded house owners is the impression that somethings are of no value so totally no security measure are adopted but in reality, thieves and criminals

actually find value in them, flagging motive to break in and take what they want forcefully.

iii. **Insurance**

In the insurance of the house, some insurance firms have lower policies for house-holds with operational security systems this will result profitable and one can saves a lot of money paying lower premiums still getting quality insurance cover. Also in some areas where there is high theft rates and criminal activities some insurance companies may suggest or mandatory require owners to install a security system in order to approve the house to be insured.

iv. **Resale Value**

Installing a home security system can prove profitable as it adds an additional selling point to the house (asset) in the retail market. A security system adds financial value to the gross price of the house when up for sale.

v. **Peace of Mind**

Installing a security system can help the owners have peace of mind and make them sleep better at night having one less thing to worry about. The system gives the owner a mindset ease knowing that if someone was to break in, an alarm will definitely be triggered alerting the owners and security enforcement personnel needed to act immediate action towards the intrusion.

2.5 Types of Existing Home Security Systems

Home security systems designed and employed to serve one sole purpose for the owner, this is to ensure that their home is well-protected from burglars, fire, flooding, earth-quakes and other unfortunate disasters which are likely to happen in his/her absence. An individual may decide upon which type of security system to purchase or install depending on various variables:

- How much security is needed

- The type of location or neighborhood where it is to be installed
- How much the owner is willing to pay for the security system
- How the system interacts with the surrounding environment (upon intrusion detection what physically mechanical action will the system take.)

According to William Hynes Executive Security/Protection Services including but not limited to facility security system fall under two categories

- Unmonitored security systems
- Monitored security systems

2.5.1 Web Based Home Security System

The home controller and the Web Server are vital in a Web based security system architecture. Fig 2.1 The security company has a web server which governs the interfaced webpage which allow the user to securely login, access and control the system. Real time monitoring of the home status is done over the web browser via laptops, smart phones or any internet-enabled device. There is need for a secure internet connection via wired LAN or wireless WLAN access.

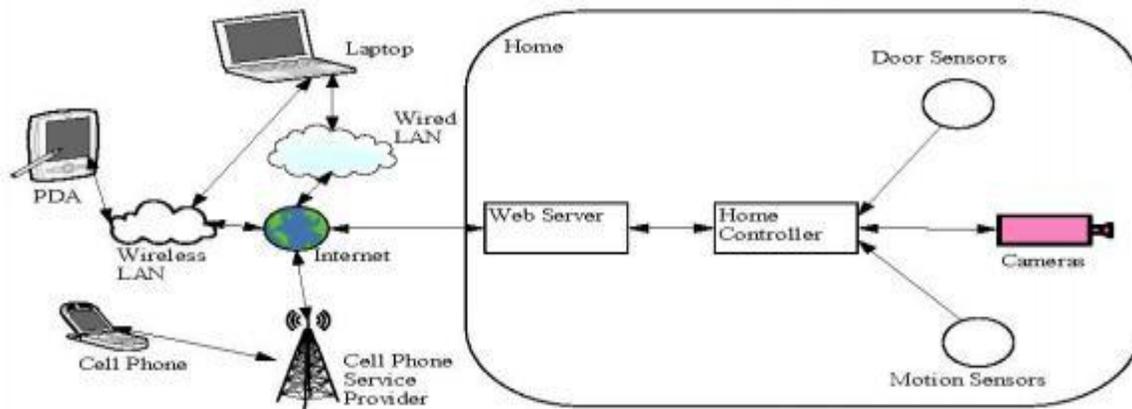


Figure 2.1 Phone based security system architecture

In a scenario where by the system sensors detect an intruder or if there is any abnormal system changes, an alert message is sent to the user via internet based alerts notifications i.e. IM message or alert webpage. The user then confirms via the active cameras installed and sensor status.

Web based security systems are generally not used these day due to a number of factors

- The user has to make a monthly payment to the security company, this proved very costly for basic need of vitally important security.
- Due to technological enhancements over the few years, security companies became a huge target for cyber security attacks and hacking. Since the system has the internet as its backbone, criminals would virtually have all the information and access they need to carry out a surgical break-in and get away with it.
- Competing security companies innovated the use of simple DIY security alarming systems which employed cost effective technology and comparably simpler architecture.

2.5.2 Phone based security systems

Phone based security system is a system incorporated into the Public Switched Telephone Network (PSTN). Fig 2.2 shows the telephone bases security system architecture. The user is to activate the alarm upon leaving the house, if the system sensor is triggered an alarm is given off through the PSTN to then notify the monitoring security company and the home owner.to get confirmation of the alarm a physical visit to the house is done by the security company personnel.

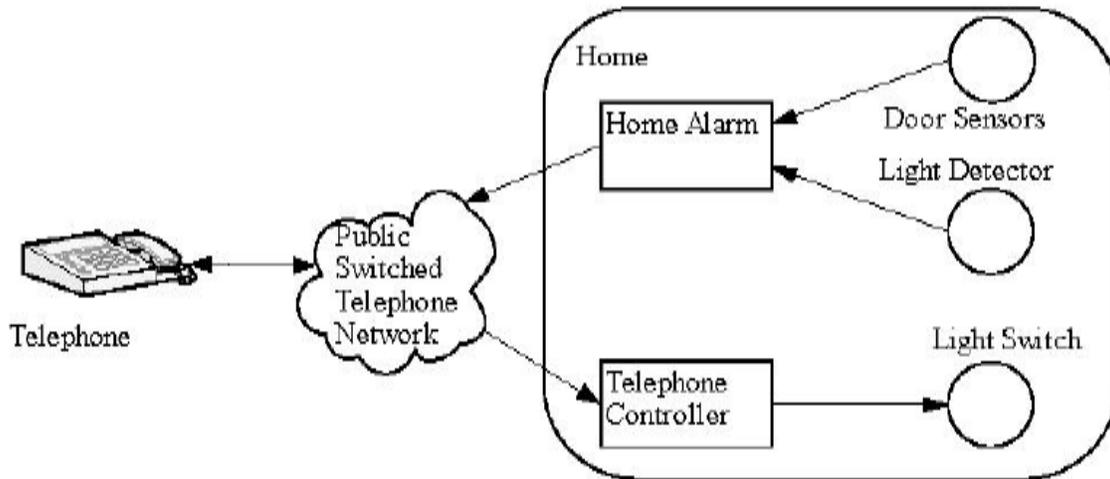


Figure 1.2 home based security system

Particularly Phone based security systems where relatively cheap to install gained immense popularity due to the fact that each and every house hold had a telephone installed. However, since it was a public network, security was a great concern to the service provides. The system was susceptible to call tap in and call scrambling.

2.5.3 Hardware based security system

In this section, there is need to discuss about the importance of hardware-based security in today's technological world. Securing hardware components proves more effectively, given that countless online threats are delivered via software or network vulnerabilities. [4] Hardware components, particularly chipsets, embedded electronic systems are often deemed as of less security importance compared to software and network security. The reason for this misconception is because hardware vendors are generally said to be trustworthy and the scope for breach is small.

According to [5] industrial security cooperation's in 2010 called upon these organizations to pay attention to all aspects of their IT environment as they were claims of chip and hardware security being overlooked all around the world. However, we can safely assume that in this region of the world security threats of that nature have never been recorded.

2.6 Communication Protocols

We are living in the IT (Information Technologies) times. The IT provides us many powerful tools that have significantly changed our way of life, work and business operations. Among all the IT advancements, Internet has the most impact in every aspect of our society for the past 20 years. In any efficient redundant security system, there is need for communication either internally within the system (remote devices sending or receiving system data and commands) or external communication (the system communicates with servers, databases or mobile internet enabled devices etc.)

Open Systems Interconnection (OSI) network architecture, developed by International Organization for Standardization, is an open standard for communication in the network across different equipment and applications by different vendors. Though not widely deployed, the OSI 7-layer model is considered the primary network architectural model for inter-computing and inter-networking communications.

2.7 OSI Network Architecture 7-layer model

The OSI model defines the communications process into 7 layers, dividing the tasks involved with moving information between networked computers into seven smaller, more manageable task groups. A task or group of tasks is then assigned to each of the seven OSI layers. Each layer is reasonably self-contained so that the tasks assigned to each layer can be implemented independently. This enables the solutions offered by one layer to be updated without adversely affecting the other layers. The 7-layer model has distinguishable features and characteristics at each layer. Ideally, layer 7 through layer 4 are mainly concerned with end to end communications between data source and destination while layers 3 to 1 deal with communication between network devices

On the other hand, the seven layers of the OSI model can be divided into two groups: upper layers (layers 7, 6 & 5) and lower layers (layers 4, 3, 2, 1). The upper layers of the OSI model deal with application issues and generally are implemented only in software. The highest layer, the application layer, is closest to the end user. The lower layers of the OSI model handle data transport issues. The physical layer and the data link layer are implemented in hardware and software.

The lowest layer, the physical layer, is closest to the physical network medium of transmission (the wires, for example) and is responsible for placing data on the medium.

Layers	Description
Layer 7	<ul style="list-style-type: none">• Defines interface to user processes for communication and data transfer in network
Application layer	<ul style="list-style-type: none">• Provides standardized services such as virtual terminal, file and job transfer and operations• Masks the differences of data formats between dissimilar systems
Layer 6	<ul style="list-style-type: none">• Specifies architecture-independent data transfer format
Presentation Layer	<ul style="list-style-type: none">• Encodes and decodes data; encrypts and decrypts data; compresses and decompresses data• Manages user sessions and dialogues
Layer 5	<ul style="list-style-type: none">• Controls establishment and termination of logic links between users
Session Layer	<ul style="list-style-type: none">• Reports upper layer errors• Manages end-to-end message delivery in network
Layer 4	<ul style="list-style-type: none">• Provides reliable and sequential packet delivery through error recovery and flow control mechanisms
Transport Layer	<ul style="list-style-type: none">• Provides connectionless oriented packet delivery

Layer 3	<ul style="list-style-type: none"> • Determines how data are transferred between network devices
Network Layer	<ul style="list-style-type: none"> • Routes packets according to unique network device addresses • Provides flow and congestion control to prevent network resource depletion • Defines procedures for operating the communication links
Layer 2	links
Data Link Layer	<ul style="list-style-type: none"> • Frames packets • Detects and corrects packets transmit errors
Layer 1	<ul style="list-style-type: none"> • Defines physical means of sending data over network devices
Physical Layer	<ul style="list-style-type: none"> • Interfaces between network medium and devices • Defines optical, electrical and mechanical characteristics
	Information

Table 2.1 OSI model hierarchy

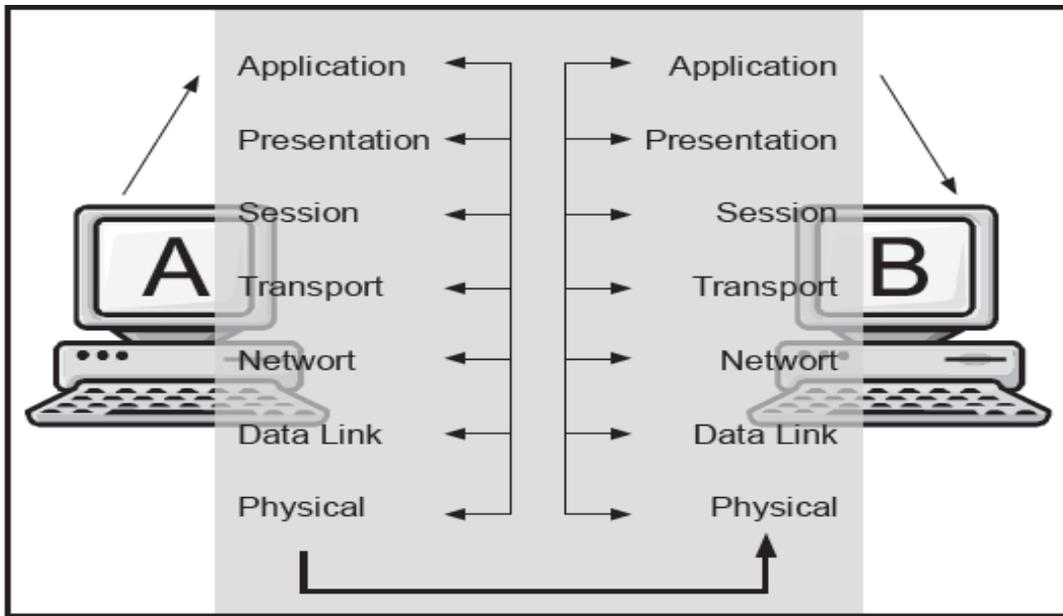


Figure 2.2 Communication between computers in a network

2.7.1 Bluetooth

Wireless communication has been around since the nineteenth century and has taken form in Radio, Infrared and more recently 802.11. Bluetooth technology is a way for devices to wirelessly communicate over relatively short distances. Bluetooth technology employs the use of radio waves, utilizing the unlicensed 2.4GHz Industrial Scientific Medical (ISM) band [7]. Bluetooth based products like a watch or head phones have microcontroller with a Bluetooth radio.

The 2.4GHz communication band is divided into 1600 timeslots of length 0.2ms. Each timeslot can encompass up to ca 620 bits. The frequency is altered for every timeslot i.e. 1600 times per second [8]. This is advantageous on the security perspective however makes it more difficult to follow Bluetooth unit communications Bluetooth communication architecture has a resounding protocol stack which enables devices to locate and establish connection. Devices can then exchange data and interact with each other through various applications.

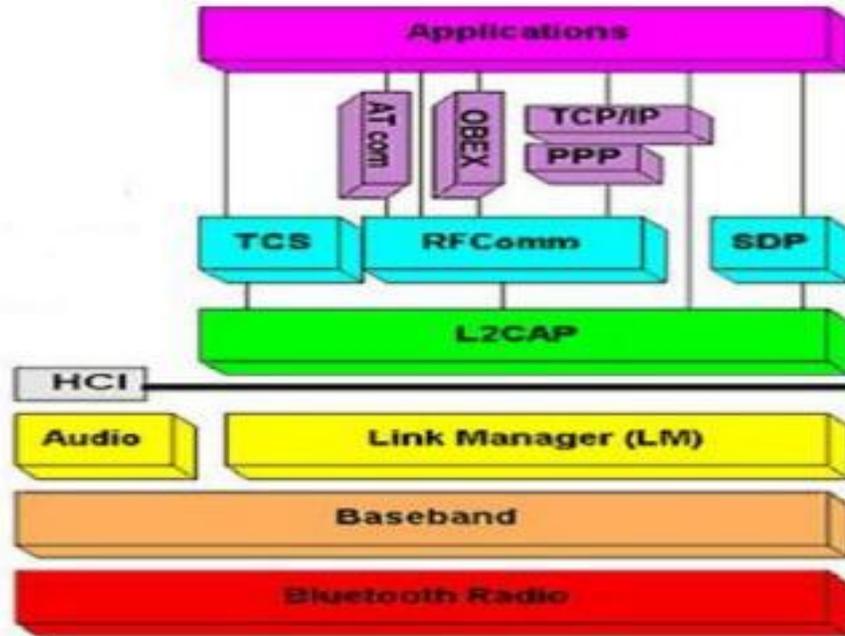


Figure 2.3 Bluetooth protocol stack

The baseband layer and the link control layer enable the physical Radio Frequency (RF) link between Bluetooth devices. The Link Manager Protocol is responsible for setting up the link between Bluetooth devices. This includes security aspects like authentication and encryption by generating, exchanging, and checking of link and encryption keys. The Logical Link Control and Adaptation Protocol (L2CAP) provides both connection-oriented and connectionless data services to the upper layer protocols. The Service Discovery Protocol (SDP) is used to get specific information about a remote device, such as available services [6]

2.7.2 Global System for Mobile Communication (GSM)

The GSM family (GSM, GPRS, EDGE) have become one of the most successful technological innovations in history [8]. Wireless local area networks WLAN have had a boom in the market, evidentially drawing market shares from GPRS and 3G infrastructure (i.e. public Wi-Fi hotspots and some coexisting UMTS home routers). GSM was designed and developed with one sole purpose in mind, Communication everywhere with everybody at any time. [6].

From the first day, the GSM technology was launched, engineers and research have been devoted to improve the development of efficient algorithms and procedures for data comprehension, security and processing of all signal types as well as the design of flexible communication protocols. Global System for Mobile communications is the most popular wireless communication system worldwide; the system has a diverse feature of not only roaming with on a particular network but also users can roam in other GSM based network architecture by implementing additional switching and administrative functions.

GSM technology was initially used exclusively for voice communication, however the Short Message Service was then developed and gained instant popularity among all GSM users. The system then expanded to data services, notably the High-Speed Circuit Switched Data (HSCSD) and General Packet Radio Services (GPRS). A driving factor for the GSM network architecture was the Wireless Application Protocol, which facilitated relatively easy wireless access to the internet.

Also, other GSM services, SMS and MMS provided very popular and successful in the architecture to date in terms of popularity at the user end as well as in terms of revenue generation at the provider side. The ability to receive or send short messages at the mobile station was supposed to be offered to the third phase E3 on all GSM networks [9]. TS21 is the point to point version of SMS permitting a single station to send a message of up to 160 characters, Conversely TS22 has been defined as an optional implementation of the capability to send short messages from a mobile station.

For SMS, the defined network operator has to establish a service center that accepts short messages from the fixed network and processes them in a store and forward mode. The corresponding interface is not particularly defined and can be DTMF signaling, fax, email etc. Message delivery can be time-shifted and is independent of the location on mobile station. Transmission of short messages uses a connectionless, protected packet-switched protocol and the reception of the message must be acknowledged by the mobile station, failure of reception leads to SMS retransmission.

2.8 Existing projects motivations

The services supplied by the current home security systems in the market prevent burglars or intruders from unlawful entry, also monitor the secured premises while the owner is absent and control some of the household control systems i.e. air conditioning, sprinklers and watering systems etc. These systems were all comprehensive, yet they still were defects and areas or improvement.

2.8.1 Laser Beams

A popular burglar deterrent system in the market is the use of lasers. Lasers generate a powerful source of coherent monochromatic light beam; the frequency of the light beam is set in order to have an invisible beam traversing the perimeter of the area to be protected. The alarm is set off provided the beam is broken by any obstacle or person moving through the beam that can travel large distances, this owing to the light beams coherent nature. Most lasers available on the retail market are semiconductor types lasers, and can be used more effectively by strategically positioning employing mirrors to form an invisible barrier around a building or valuable object

Though it sounds cheap and easy to develop a laser security system, the laser diodes are quite expensive (US\$100) for a single one, another disadvantage of using this system is the dangerous properties laser beams have towards the human eye.

2.8.2 Infrared Beams

The system consists of basically two components, the Infrared transmitter and the receiver. The transmitter transmits Infrared signal waves(beams) over a considerable distance, ranges from 30cm-300cm to the receiver. The alarm is triggered if the beam is broken or disturbed. In order to achieve optimal and maximum coverage area there is need of multiple beams and multiple infrared transceiver pairs, this results very costly.

2.8.3 Motion and Heat Sensors

Technological advancements have led to the encapsulation of motion sensing technology with heat detection schemes to result PIR (Passive Infrared) based on Motion Detector sensors, which protect the area by detecting change in infrared (heat) energy levels most probably caused by the intruder's movement.

Incorporating these sensors into a security system is very expensive and to install them will require highly skilled, highly experienced individuals.

CHAPTER THREE

3.1 Introduction

This chapter covers the research design and methodology including, the instruments and software used to collect the data, methods implemented to maintain validity and reliability of the results and data analysis. Developing a good system demands a well-planned framework for interfacing and implementation.

3.2 Structure of the system

The system consists of the following Hardware components

1. HC-SR04 Ultrasonic sensor
2. 16x2 Liquid Crystal Display
3. 4x4 Keypad
4. Reed Switch (Magnetic door/window sensor)
5. SG90 Servo motor
6. Sim900 Gsm module
7. Piezo Buzzer
8. Arduino Mega 2560
9. Light Emitting Diodes

Software components

1. Arduino IDE
2. Frequency View app

3.2.1 Interfacing the HC-SR04 to the Arduino

As Fig 3.1 illustrates for the sensor to carry out sweeping motion of 60 degrees, it is mounted directly on to the rotating lever of the servo motor. The sensor Vcc pin is connected to the +5v supply from the Arduino, the Ground Pin is connected to the system common ground and the Trig Pin and Echo Pin are connected to Arduino pins 8 and 9 respectively. The servo motor on which the sensor is mounted on draws up large current which cannot be supplied by the USB port, so there is need to have the motor's separate regulated power supply which can output a steady 5Volts with the servo control pin connected to pin on the Arduino mega board as shown.

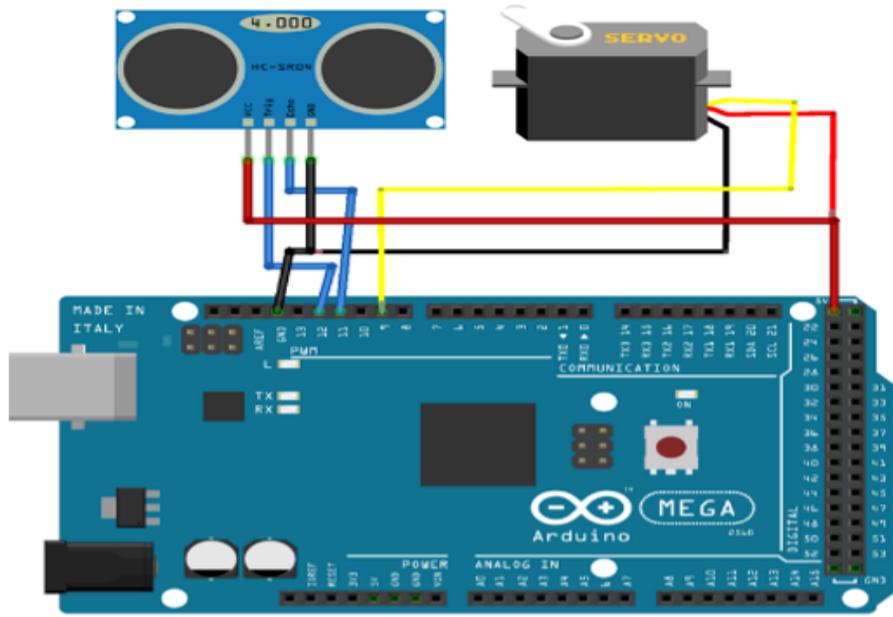


Figure 3 1 Interfacing HC-SR04 and Servo motor

3.2.2 Interfacing the Reed Switch

Also, known as a Magnetic door sensor switch, the reed switch has two leads coming out of the metallic casing, one lead is connected to the Arduino digital pin 34 and the other lead is grounded to the system common ground as shown in Fig 3.11

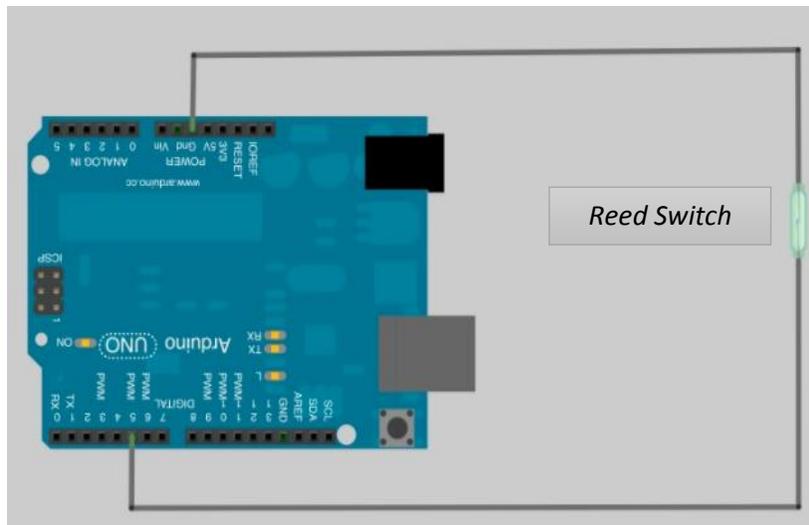


Figure 3.12 Interfacing Reed switch

3.2.3 Interfacing the 4x4 Keypad matrix

The keypad has 8 terminals as Fig 3.12 shows, the first four terminals are connected to the horizontal rows and the remaining four terminals are connected to the vertical columns. Horizontal keypad leads are connected the Arduino Mega Digital Pin 34,36,38,40 respectively and the vertical keypad leads are connected to digital Pin 42,44,46,48 of the board.

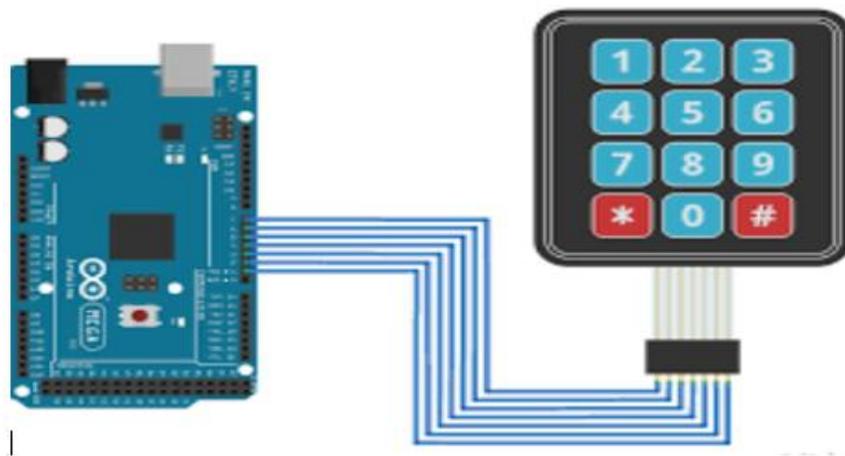


Figure 3.12 interfacing the keypad to Arduino

3.3.4 Interfacing the 16x2 Liquid crystal display

Fig 3.13 shows how the LCD module is connected to the Arduino Mega 2560 microcontroller via the connection on the breadboard. The VSS on the LCD is connected to the system common ground; the VO pin is connected to the middle leg of the 10kilo Ohm variable potentiometer with other legs grounded and connected to the +5v supply. VDD Pin is connected to the +5v power supply and for data transmission and reception through serial communication RS, Enable, D4, D5, D6, D7 Pins on the display module are connected to digital pins 2,3,4,5,6,7 on the Arduino board respectively. The backlight pin(Anode) is connected to the +5v supply and contrast pin (Kathode) is grounded.

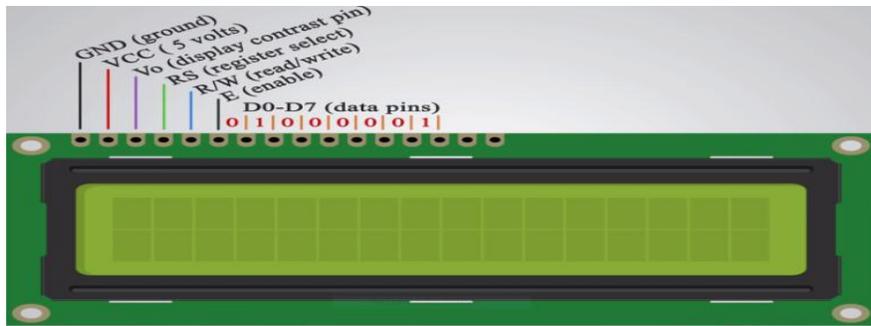


Figure 3.13 Interfacing the LCD module to Arduino

3.3.5 Interfacing the Piezo Buzzer and Light emitting diodes

The piezo electric buzzer has Positive leg connected to Arduino digital pin 10 and the ground pin connected to common ground via the breadboard. Fig 3.14

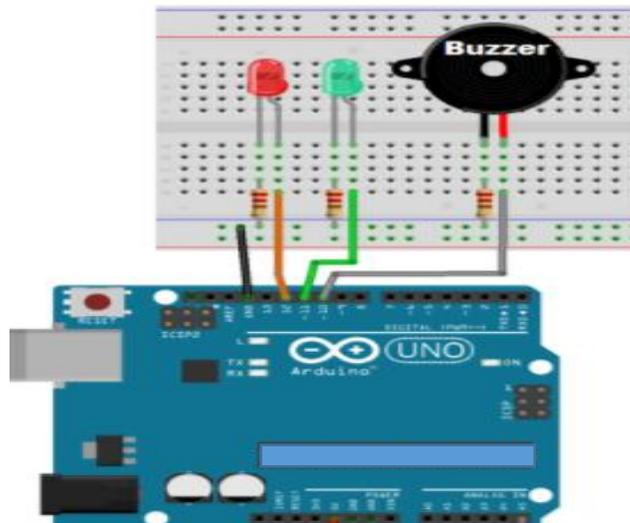


Figure 3.14 Interfacing the Output LEDs and Buzzer

The system Green and Red Light emitting diodes have positive legs connected in series with 220Ohms resistors on the breadboard and then connected to Arduino digital Pins 11 and 12 respectively, the LEDs are both connected to the system ground Fig 3.14

3.3.6 External Power Supply

There is need for an external power supply to the SG90 servo motor, as this electrical component draws large amounts of power and current from the +5v supply from the Arduino MEGA 2560 module which may damage the port communication channel or computer USB port power regulator. In this prototype the dc power source is a 12Volt battery pack, connected on the breadboard with the motors Vcc pin and system virtual Ground pin. Assumption made is that the security system can be further improved to have a rechargeable (i.e. Solar) power supply to provide for all the other smaller electrical components.

3.4 Serial Communication

Serial communication is a means of communication between the computer/CPU and the Arduino ATmega2560 microchip via the USB cable. The Rx and Tx pins on the ATmega microchip use the Universal Asynchronous Receiver/Transmitter (UART) serial Function for communication to the computer with the RS-232 Data Terminal Equipment(DTE) interface so that it can "talk" to and exchange data with modems and other serial devices .Serial communication at TTL level will always be defined in the limits of 0Volts and Vcc, often either 5Volts or 3.3Volts.A logic HIGH (1) is represented by Vcc voltage and the corresponding LOW(0) is reference 0volts. Modern boards like the one used in this project use Universal Serial Bus interface ports unlike the RS-232 interfaces used in earlier years of serial communication. [4]

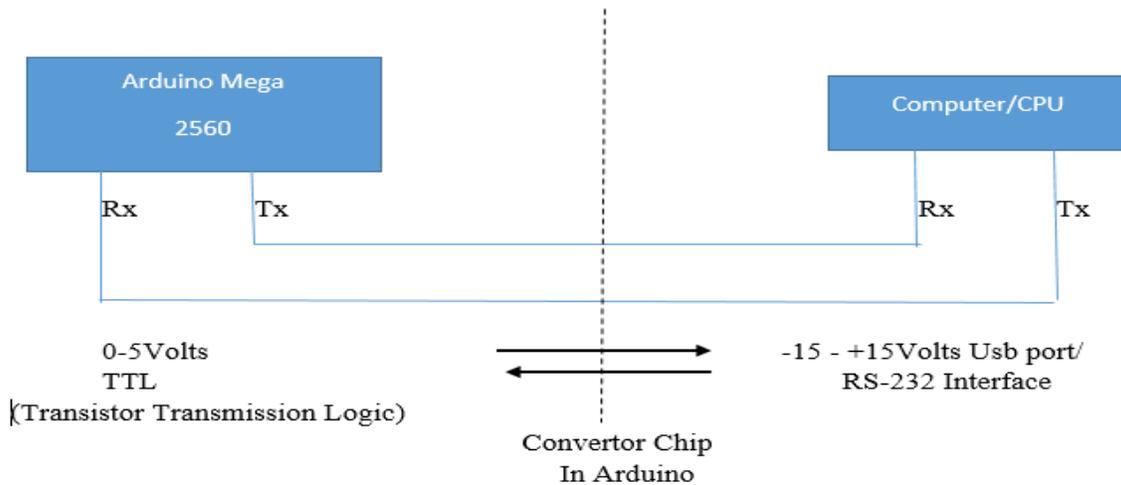


Figure 3.15 Serial Communication Block diagram

3.5 Designed System Architecture

The system will operate following a flow of inputs and corresponding outputs as the designed system is developed to generate visual and audible outputs. Visual system outputs are displayed on the liquid crystal display(Lcd) and audible keypress input is given out by the piezo buzzer. System status is given out by the system status Light Emitting Diodes(LED) and overallly the system sends an alerting message upon intrusion or obstacle detection. Fig 3.2 illustrates the security system block diagram.

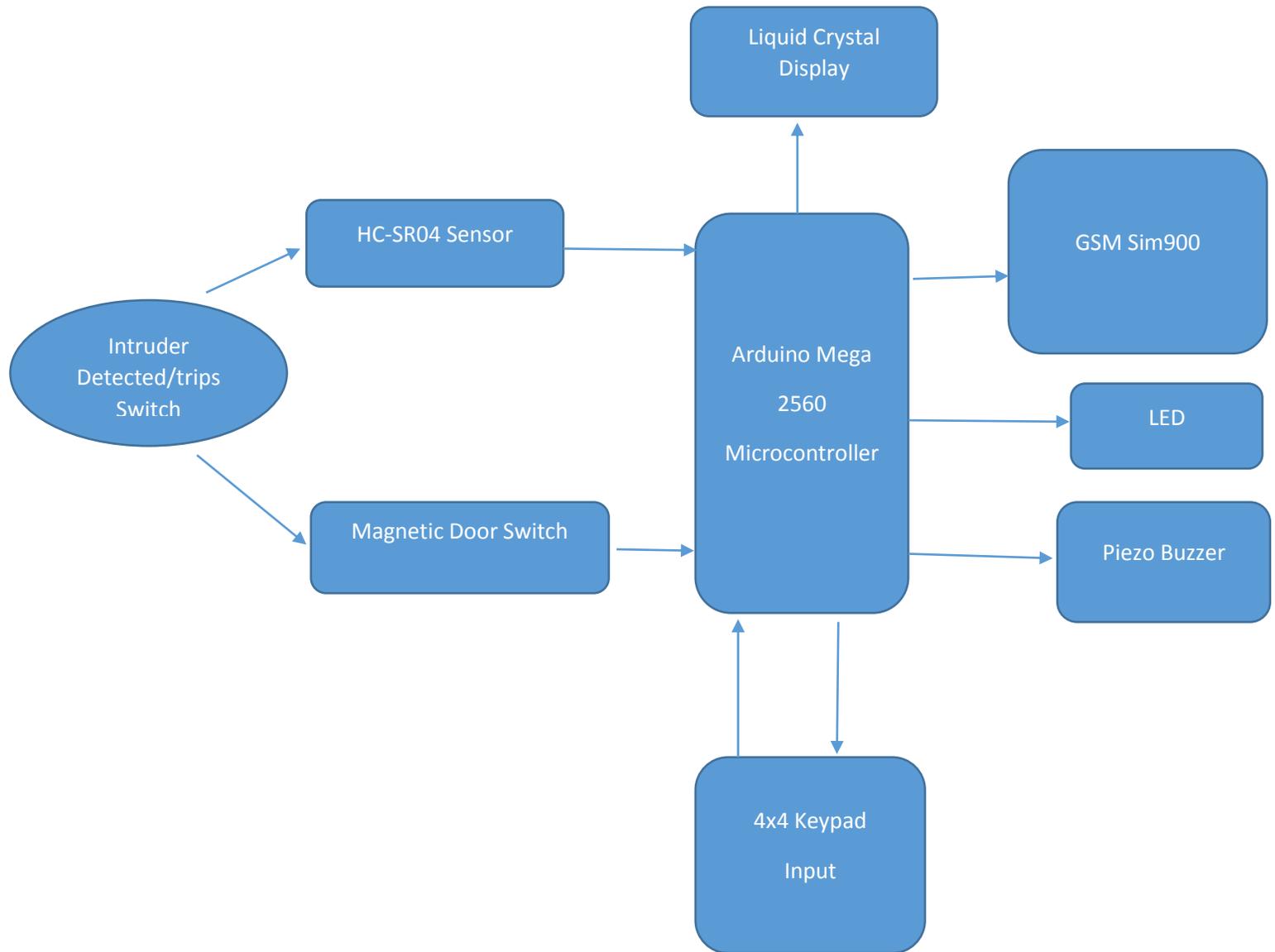


Fig 3.2 System Architecture Block Diagram

3.5.1 HC-SR04 Principle of Operation

Ultrasonic range finder units use sound waves in free space to detect and calculate the range/distance from the sensor module to the object by measuring the change in time taken by the transmitted pulse or, alternatively by measuring the change in phase frequency of the transmitted wave [1]. The ultrasonic transmitter emits an ultrasonic pulse in one direction, and a timer is started when launched. The wave propagates in the air, and would return immediately when it encountered obstacles on the way. The ultrasonic receiver stops the timer when it receives the reflected sound wave. Fig3.21

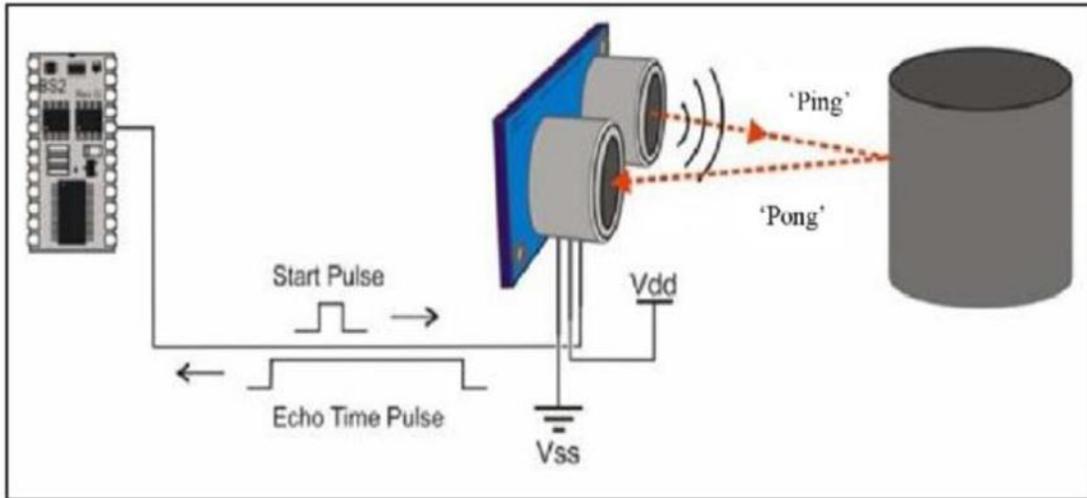


Figure3.3 Principle of operation of the HC-SR04

The ultrasound element emits a spherical wave of energy whose magnitude in any direction is a function of the angle made with respect to the direction that is normal to the face of the ultrasonic element. The peak emission always occurs along a line that is normal to the transmitting face of the ultrasonic element, and this is loosely referred to as the 'direction of travel [2]. At any angle, other than the 'normal' one, the magnitude of transmitted energy is less than the peak value. Figure 3.22 shows the characteristics of the emission for a range of ultrasonic elements.

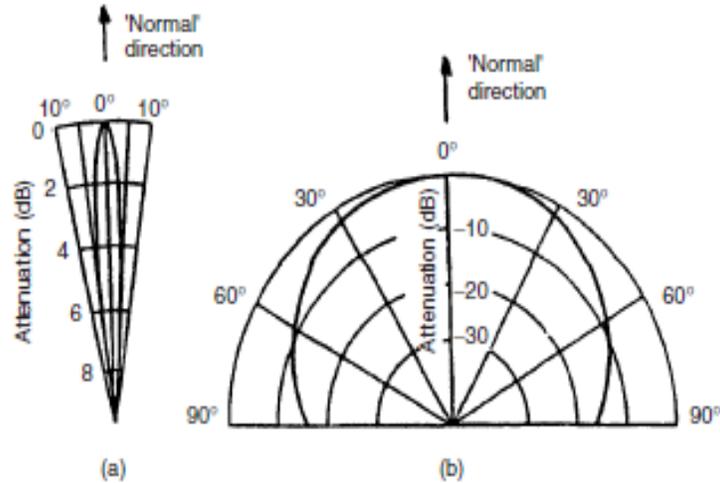


Figure 3.31 Ultrasonic emission characteristics

The average distance separation is calculated from the following equation

$$(1.0) \quad \text{Distance} = \text{Speed of sound in Air} \times \text{time interval} \quad \dots\dots\dots$$

Where

$$(1.1) \quad \text{Speed of sound in Air } (c) = 333,4 + (0,606 \times T) + (0,0124 \times H) \quad \dots\dots\dots$$

T = Temperature of the propagation medium

H = Humidity of the propagation medium

In this project the Trig and Echo pins are initially set Digital LOW, and using TTL commands at least a 10 micro second HIGH pulse is transmitted to the Trig pin, the module then send eight 40 kilo hertz square waves, simultaneously starting a timer to measure the ultrasonic wave time of flight. The timer is stopped once the Echo port detects a rising edge which is detected by the receiver. An illustration below demonstrates the principle of operation of the HC-SR04 range finder module.

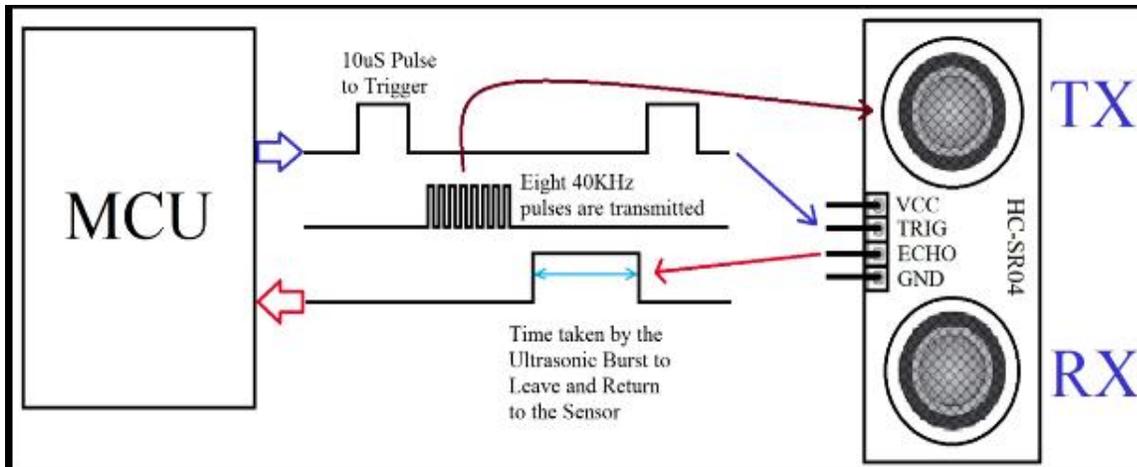


Figure 3.32 Principle of Operation of the HC-SR04

3.5.2 Reed Switch Principle of operation

A conceptual ideology of any switch, is to look at it as a drawbridge in an electric circuit and when the switch is closed the “bridge” is down and electric current can flow around the circuit, when the “bridge” is up, consequently no current flows through that junction of the circuit. The Reed switch operates in the same particular manner; the switch has two contacts made from ferromagnetic material coated with a hardwearing metal (Rhodium) to protect them from numerous switching. The contacts are sealed inside a thin glass envelope filled with an inert unreactive gas (Nitrogen) preventing dust, rusting and other reactive corrosions to the ferromagnetic material.

Typically, the contacts are made from an alloy that is highly magnetic permeable (i.e. magnetize easily) but also having low magnetic retentivity (i.e. don't stay magnetized for long). When a magnet is brought into close proximity to the switch both contacts move and magnetize to one another to make a flat, parallel area of contact closing the switch and completing the circuit.

Reed switches can operate in one of two instances

- **Normally Open**

In this instance as you bring a magnet up to the reed switch, the entire switch effectively becomes a part of a "magnetic circuit" that includes the magnet (the dotted line shows part of the magnetic field). The two contacts of the reed switch become opposite magnetic poles, which is why they attract and snap together closing the switch. Fig 3.9

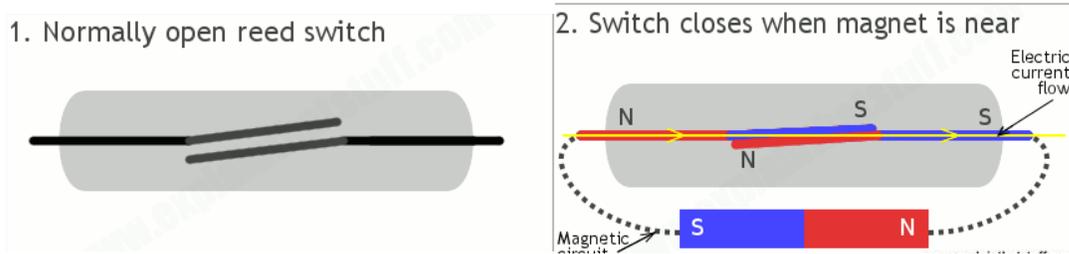


Figure 3.33 Normally Open switch

- **Normally Closed**

In this instance the reed switch work in the opposite way compared to the normally Open instance: the two contacts are normally snapped together and when you bring a magnet up to the switch, spring apart opening the switch as shown in the diagram below.

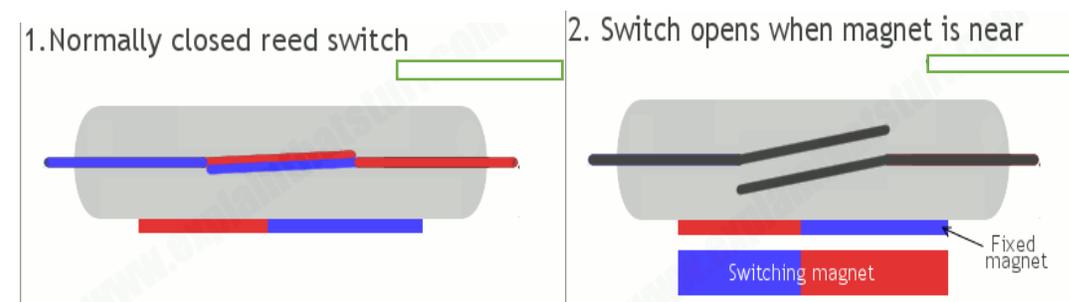


Figure 3.34 Normally closed switch

The switch uses the Electromagnetic principle, which relates the total magnetic flux induced into the immovable/fixed plate and the average distance of separation from the switching magnet, electromagnetic reed switches principle of operation obeys Faraday's law of induction.

3.5.3 Light Emitting Diode (LED)

- In this prototype LEDs are used to show the security system status, an Aluminum Gallium Phosphide (AlGaP) – green LED indicates that the system is either idle or activated while the Gallium Arsenide Phosphide (GaAsP) – red LED indicates that the system alarm has been triggered. Light emitting diode is basically a two-lead

semiconductor light source; it is special type of diode that has similar characteristics of a PN-junction diode. [2] LED composition is doped so that it emits electromagnetic radiation(light) when forward biased.

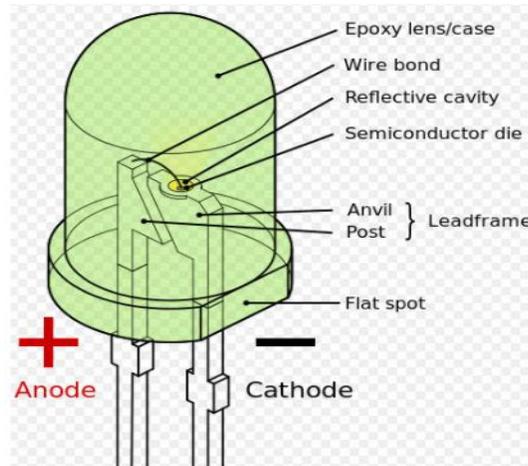


Figure 3.35 LED structure

When forward biased, the electron, hole pairs are moving across the junction to recombine(i.e.) electrons moving from the n-type region to the p-type region to combine with holes giving off energy in form of quantized photon emissions denoted by

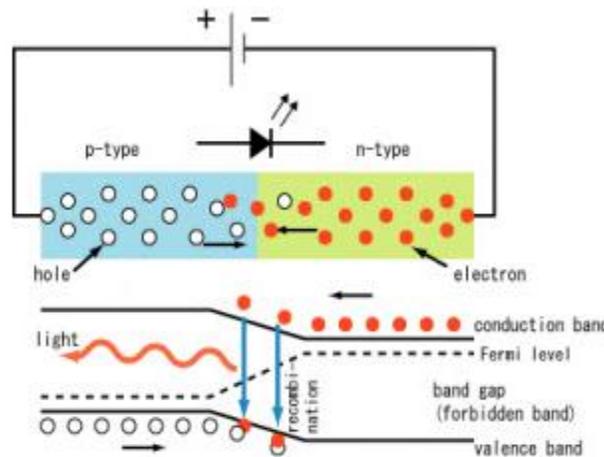


Figure 3.36 LED Principle of Operation

$$Eq = hf \dots\dots\dots (1.3)$$

h = Planck's constant
 f = frequency

of electromagnetic radiation

The corresponding wavelength (λ) of the light emitted is given by

$$E = \text{Energy}$$

Q = electric charge

$$\lambda = \frac{EQ}{he} \dots\dots\dots (1.4)$$

3.5.4 Piezo Buzzer

The name is derived from a Greek word *piezein* which means “squeeze”. Piezo buzzer or piezo transducer are based on the inverse principle of piezo electricity discovered by Jacques and Pierre Curie in 1880. [2] The Piezo electric principle is the phenomenon of generating electricity when mechanical force or pressure is applied to piezo electric materials, the reverse is true for when an alternating electric field is subject to piezo electric material they experience stretching and compressional forces hence therefore making sound in accordance with the frequency of the signal voltage.

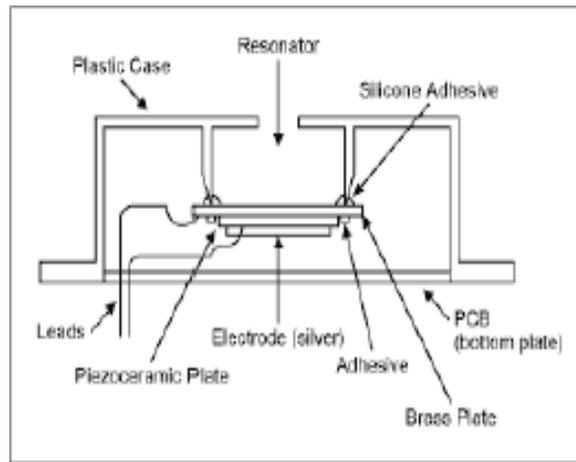


Figure 3.37 Internal structure of piezo buzzer

3.5.5 Hex keypad principle of operation

The input keyboard is basically an arrangement of sixteen push button switches in a 4x4 layout illustrated in Fig 3.28. Hex keypads have 8 connection wires (R1, R2, R3, R4, C1, C2,

C3, C4) representing the Rows and Columns respectively. Any keypress on the pad is identified by a program method called column scanning where by a particular Row is kept low without other Rows are held high. [3]

The keypad is initialized by the Keypad.h library, this library provides a simple interface for using matrix keypads. It supports multiple keypresses while maintaining backwards compatibility with the old single key library. It also supports user selectable pins and definable keymaps.

The logic status of each column line is scanned. If a particular column is found low, then that means the key that comes in between that column and row is short(pressed). Then the program registers that key being pressed. Then the same procedure is applied for the subsequent rows and the entire process is repeated.

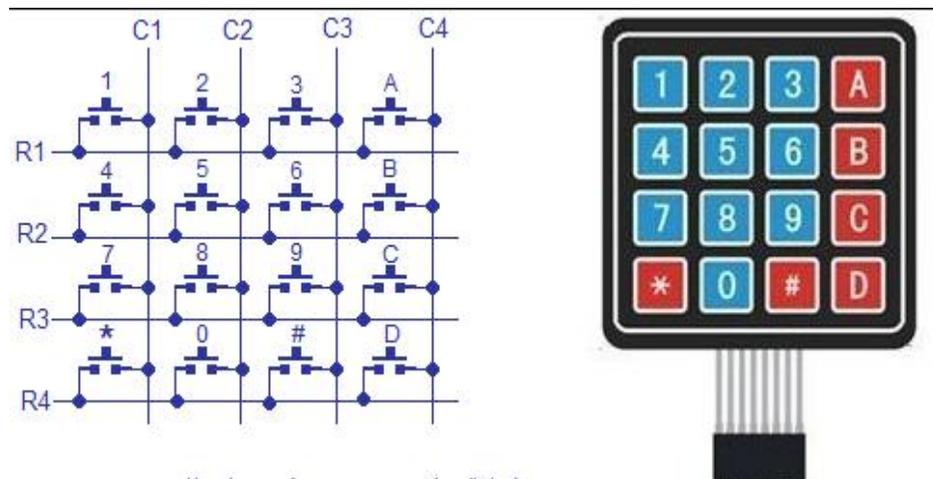


Figure 3.38 Hex keypad schematic

3.5.6 SG90 Servo motor principle of operation

This is a lightweight high power output motor which can rotate a total of displacement of 180 degrees (90 degrees in either direction).SG90 servo motors are controlled by servo hardware libraries of the Arduino Mega 2560 and has three branching cable arms as illustrated in Fig3.29



Figure 3.39 SG90 servo motor

Servo.h - Interrupt driven Servo library for Arduino using 16 bit timers- Version 2. A servo is activated by creating an instance of the Servo class passing the desired pin to the attach() method.[3] The analogWrite of Pulse Width Modulation(PWM) on pins associated with the timer are disabled when the first servo is attached. The servos are pulsed in the background using the value most recently written using the write() method.

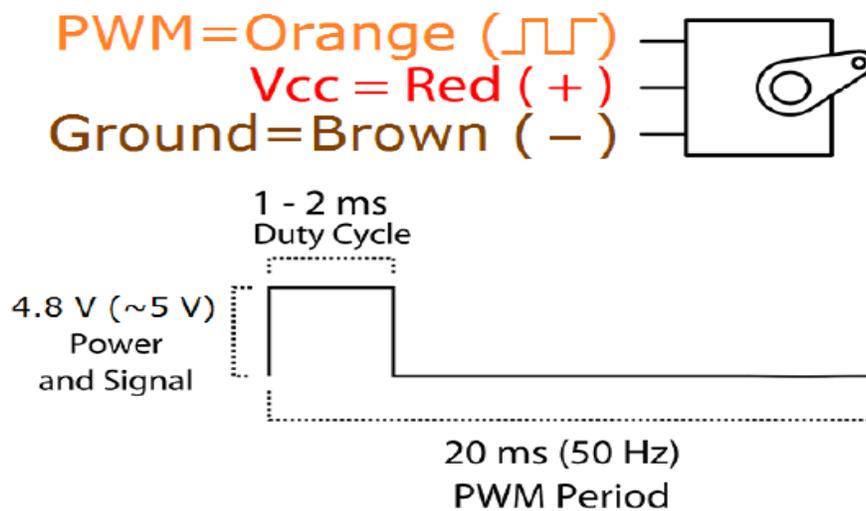


Figure 3. 4 Servo principle of operation

The mechanical and electrical specification;

- Weight 10grams
- Stall torque 1.8 kgf·cm
- Operating speed: 0.1 s/60 degree
- Operating voltage: 4.8 V (~5V)

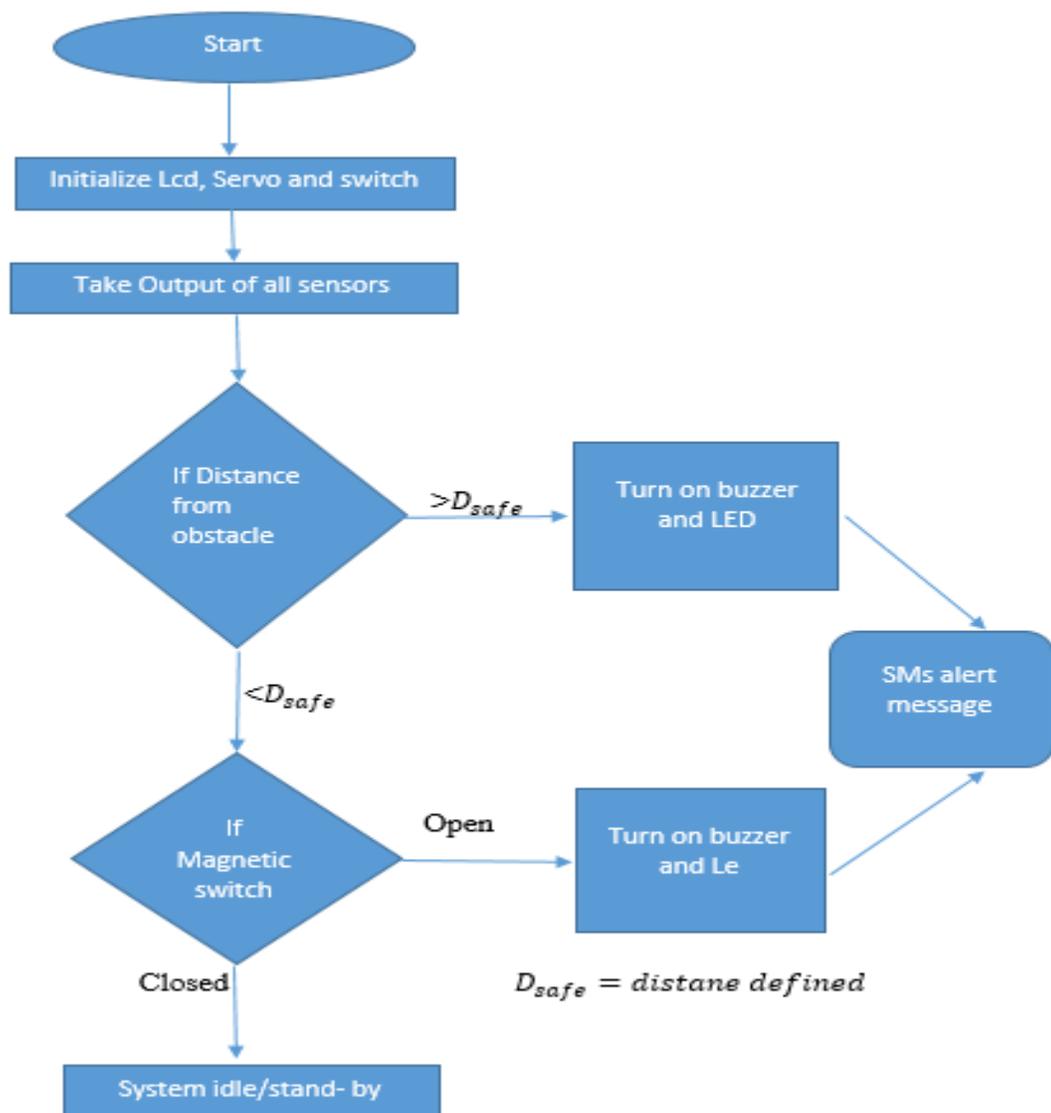
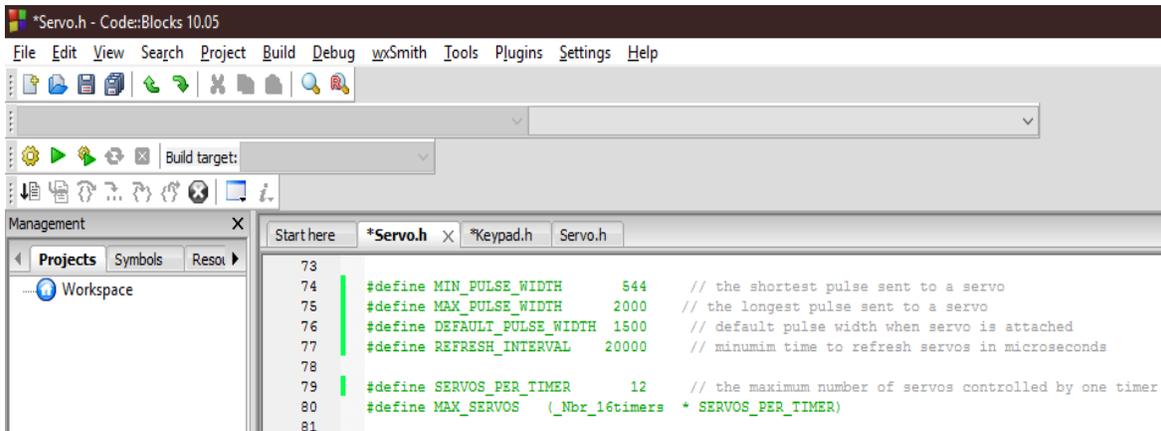


Figure 3.5 Data flow Diagram for designed system

3.6 System Limitations

The system has one main weakness in concern which is the servo motor timer delay, this reduces the overall system responsivity by an estimated 3-4 seconds. The delay is arise from the Arduino Servo library, the library has a Pulse Width Delay for each corresponding servo interfaced on code snippet of the servo library header files is illustrated in Fig 3.41



```
73
74 #define MIN_PULSE_WIDTH      544    // the shortest pulse sent to a servo
75 #define MAX_PULSE_WIDTH     2000   // the longest pulse sent to a servo
76 #define DEFAULT_PULSE_WIDTH 1500   // default pulse width when servo is attached
77 #define REFRESH_INTERVAL    20000  // minimum time to refresh servos in microseconds
78
79 #define SERVOES_PER_TIMER    12     // the maximum number of servos controlled by one timer
80 #define MAX_SERVOS          (_Nbr_16timers + SERVOES_PER_TIMER)
81
```

Figure 3.6 Code Snippet of the servo library delay

3.7 Conclusion

The proposed methodology to design this project is with no doubt feasible, but the system will be operating with the acknowledgment of the servo motor delay of about 3 seconds. This overallly causes the response time of the system will be significantly increased. The next chapter looks at the system overall response rate and results of the sensing elements incorporated.

CHAPTER 4

4.1 Introduction

This chapter presents the research results which were obtained by carrying controlled system tests to determine how the system interacts with the environment and also the responsivity in different cases of intrusion. These results encompass how the prototype sensory electrical components respond in real time according to the uploaded system code also looking at the system status LEDs and the output of the Serial Com monitor.

4.2 System status when alarm is deactivated

The security system has stand-by status mode which outputs a user friendly visual interface on the 16x2 liquid crystal display unit and user input is done using the Hex keypad interface During stand-by mode the system prompts the user two options

- a) A - Arm/Activate system alarm
- b) C - Change System Password



Fig 4.0 System Visual Interface

4.2.1 Activating the System alarm

When the user presses the A keypad button the system initializes a countdown to arm the alarm, once the countdown reaches zero the system green LED turns on (GreenLED variable is turned

HIGH) using the digitalWrite function of the Arduino library and also the Arduino Mega micro controller executes two programs (i) a display function entitled displayMsg which displays a message on the as shown in Fig 4.1 (ii) a servo function which initializes the servo to start sweeping the perimeter at an angle defined for 80 degrees in a timed interval of 3sec. Fig 4.1

4.2.2 Changing System Password

This system mode enables the user to change the system password at any given time while the system is idle/in stand-by mode. When the C keypad button is pressed the Arduino Mega 2560 micro controller executes a changePassword function requires the user to confirm the old password first and then to confirm the new password.

The function creates a variable called tempPassword in which to stores the new password, then comparatively checks to see if the passwords match, if they do match the system declares the new password as new system password.

4.3 System status when alarm is activated

When the alarm is activated two sensors are activated, namely

- i. HC-SR04 transducer
- ii. Magnetic door sensor switch. (Reed Switch)

4.4 Results for the HC-SR04 range finder

The average range of separation between sensor and a solid surface obstacle is recorded and given out by the Arduino IDE Serial monitor as shown below

R/ KΩ	V/ V $V = \frac{R_2}{R_2 + R_1} V_{in}$	Range D/ cm	%Error for V $V = \Delta V / V \times 100$	%Error for D $D = \Delta D / D \times 100$
0.00	5.00	24.7	2	0.4
0.50	4.38	16.2	2	0.6
1.00	3.75	15.6	3	0.6
1.50	3.13	10.7	3	0.9
2.00	2.25	10.2	4	1.0
2.50	1.88	8.6	5	1.1
3.00	1.25	7.4	8	1.3
3.50	0.63	6.1	16	1.6
4.00	0.00	0.0	0	0.0

Table 4.1 Ultra sonic object detection results

potentiometer is simple a resistor wire that has a slider contact to alter the total resistance of the resistor wire at different lengths. To get voltage, we use the voltage divider rule.
53

For example, the maximum measured resistance of the potentiometer is 4KΩ and the voltage in our circuit is 5V so when the slider contact is adjusted to a certain length to get a resistance of 0.5KΩ means that we have divided the voltage into two. This can be better expressed with the formula below.

$$V = \frac{R_2}{R_2 + R_1} V_{in} \dots\dots\dots (4.1)$$

To get voltage value for the 0.5KΩ which is in the table we calculate it using the equation 4.1 and

we work it as show below.

$$V = \frac{3.75}{3.75 + 0.5} \times 5 = 4.38V \dots\dots\dots (4.2)$$

Used the same formula to calculate all the voltages for the resistances. Note that the student did not measure the voltage directly because the power supply had to be off to take the R values

without destroying the controller. To find the relationship between the voltage V and the range D of object detection, graph is plotted.

To minimize error on the graph, a centroid point for both V and D is calculated. The main slope and error slope will be connecting the centroid point. For the centroid points V_c and D_c , they are found by:

$$V_c = \frac{\sum v}{n} = \frac{22.7}{8} = 2.78 \pm 0.03V \dots\dots\dots (4.3)$$

$$D_c = \frac{\sum D}{n} = \frac{99.5}{8} = 12.44 \pm 0.08cm \dots\dots\dots (4.4)$$

Where n- is the number of values

The error on calculating the detection range D is given by the following mathematical expression

on Equation 4.4 and is used in the table to calculate error in the table.

$$Error\ in\ D = \frac{\sum D}{D} \text{ And } \%Error\ in\ D = \frac{\sum D}{D} \times 100 \dots\dots\dots (4.5)$$

$$Error\ in\ V = \frac{\sum V}{V} \text{ And } \%Error\ in\ V = \frac{V}{V} \times 100 \dots\dots\dots (4.6)$$

Where ΔD - the smallest measurement of a ruler (0.1cm)

ΔV - The smallest measurable voltage value from the instrument

The margin of error increases as we get to smaller ranges because smaller distances and voltages because smaller values are much more prone to be affected by error as opposed to longer values where the error turns to zero as the distance approaches infinity and becomes of less effective. The graph below shows the relationship between voltage (V) and ultrasonic range of object detection (D)The sensing range has a linear relationship with the voltage in the circuit from 0-5V. From Graph 1.0, there is a systematic error. The relationship is not perfect as errors are caused by the internal resistance of components, the attenuation of sound as it propagates in air. Interference from other sound waves, and noise from the system itself. There are losses space loss, system losses and other losses.

The relationship found in this research is that ultrasonic range of object detection of an HCS04 sensor is correlated to the input voltage at the trigger pin by the following mathematical expression:

$$D = 3.94V + 1.32 \quad (4.6)$$

Graph ## relationship between voltage (V) and maximum ultrasonic range of object detection

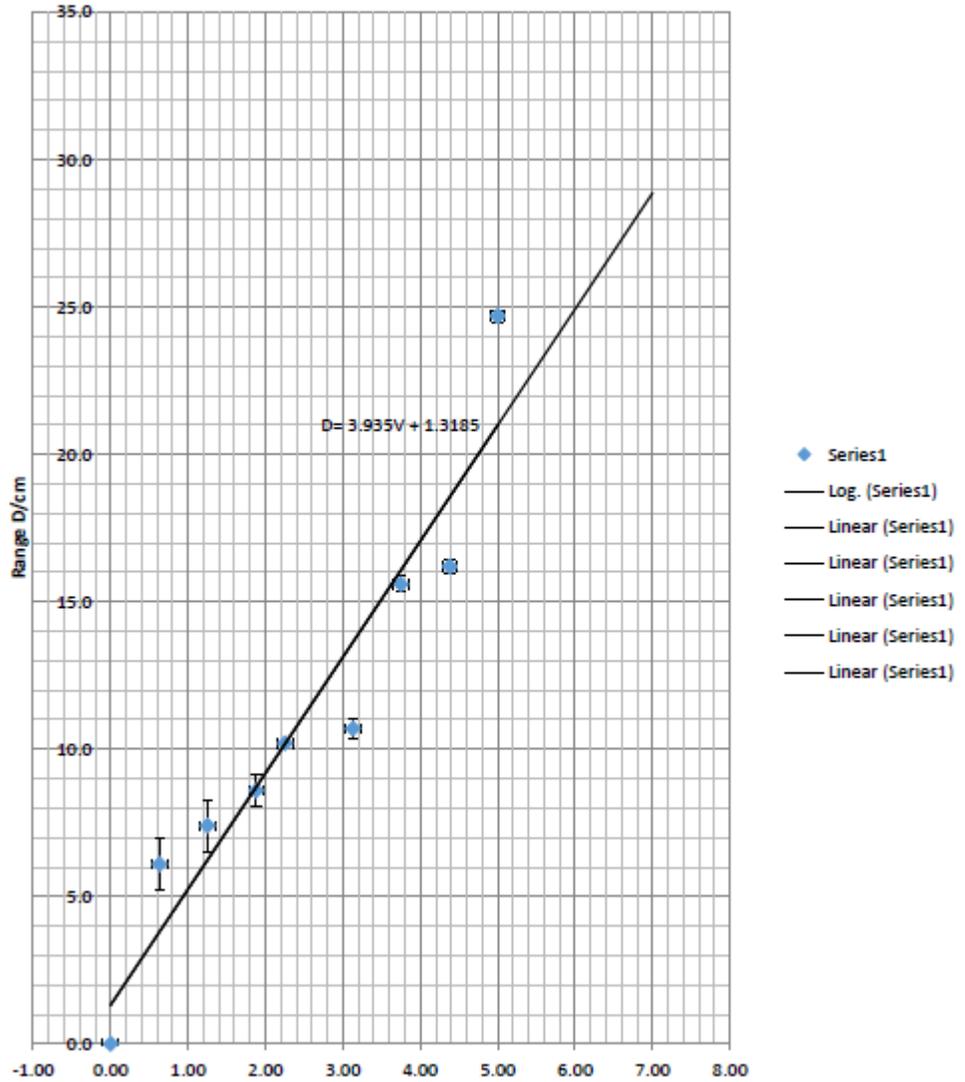


Figure 4.1 Plots showing distance and input voltage

4.5 Results for the electromagnetic door sensor (reed switch)

Results for the electromagnetic door sensor were obtained using the average separation between the fixed sensor plate and the movable plate. The separation (ΔD) was measured using standard measuring rule as shown in Fig 4.2.



Fig 4.2 Reed switch distance measurement

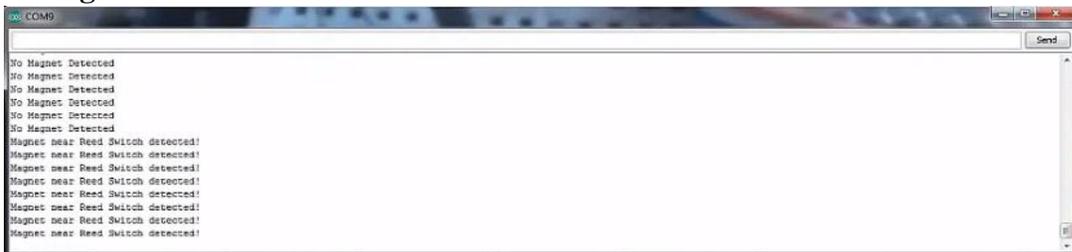


Fig 4.3 Results from the Serial monitor

The switch state is displayed on the Arduino Mega 2560 serial monitor and recorded against the corresponding separation (ΔD) as shown in the table of results below

Separation (ΔD)/ <i>cm</i>	Switch state	System alarm state(Boolean)
2	Normally closed	False
4	Normally closed	False
6	Open	True
8	Open	True

Table 4.2 Results from the reed switch sensor

4.6 Rate of response of the Overall detecting system

The response rate is governed by the processing speed of the At mega 2560 microcontroller, and the GSM network strength and speed. Table 4.3 shows the response rate of the alarm going off and average time taken for the alerting message to reach the recipient.

Trigger Distance/cm	Time taken to trigger alarm/s	Time taken for Notifying alert/s
30	≅ 1	≅ 5
40	≅ 1	≅ 4
50	≅ 1	≅ 5

Table 4.3 Results for the system response time

4.7 Discussion

From the above results, the proposed project is a cost effective, interactively user friendly security system with acceptable and accurate response rates for intruder detection. All the designed functions were implemented and were fully operational within the acceptable standards. The ultrasonic object detection experimental results are covered in section 4.4 and from them, it is seen that the ultrasonic sensor maximum range of object detection is correlated to the VCC supply.

4.8 Conclusion

This chapter covered the results and considerable analysis of the student's prototype, results obtained concludes that the HC-SR04 ultrasonic range finder module can detect any obstacle with in a range of 200m with high accuracy as discussed in section 4.3. The secondary sensing element which is the reed switch can detect the opening of a door or window effectively with minimal delay.

The notification function from the students results show that there is some delay in delivering the SMS which can be tolerated to a lesser extent but overally acceptable. In conclusion, the

experimental results show that the Ultrasonic based security system is indeed feasible with no doubt can ensure human and property safety and security.

CHAPTER FIVE

5.1 Conclusion

Basically, in a nutshell, the Intruder deterrent system works very well exceeding all expectations given that the terrain and environment is stable and not changing. All of the sensing elements namely the HC-SR04 ultrasonic range finding module, electromagnetic door sensor (Reed Switch) and the communicating notifying GSM Sim900 module were operational. The security system can be installed in households or in workplaces, where the owner just simply activates the system upon leaving and locking the premises.

5.2 Limitations

The indoor security system has only a few limitations and flaws, whereby we see the delays caused by the rotating servo motor and the Gsm module, however these delays are acceptable and do not affect the system overall performance. Another limitation is the maximum accurate ranging distance of the sensor, which is approximately 100m-150m, if this range were to be increased the application of the security system can be taken outside to be an outdoor system.

5.3 Further Studies

Further studies can be carried out to improve the ranging and response time for detection. Passive Infrared sensors can be employed for better range sensing. Also, using the PIC microcontroller can result in more faster processing and better storage capabilities. Object detection is still one area that really needs to be researched on especially if complex DSP and remote sensing algorithms are implemented to really detect what the actual object detected really is for example when pushed to the limits, the system must know how to differentiate between people and other objects by maybe the infrared that they emit.

5.3 Recommendations

The student recommends that scholars at Midlands State University to take up on practicals of embedded systems and instrumentation alike, this refines student technical ability by a large scale and overall produces better well designed and well researched projects from the faculty of Applied Physics

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APPENDIX

6.1 Program Code

```
#include <LiquidCrystal.h> // includes the LiquidCrystal Library
#include <SoftwareSerial.h> // include the SoftwareSerial Library
#include <Keypad.h> //include the Keypad Library
#include <Servo.h> //include the Servo Library
#define RedLed 11 //define System status red LED Pin
#define GreenLed 12 //define System status green LED Pin
#define buzzer 10 //define System Buzzer Pin
#define trigPin 9 //defines sensor trigPin
#define echoPin 8 //defines sensor echoPin
#define reedsensor 34 //defines reedswiych Pin

long duration; //Declaring variables
int state; //reed
int distance, initialDistance, currentDistance, i;
int screenOffMsg = 0;
int pos = 0; // variable to store the servo position
String password = "1234";
String tempPassword;
boolean activated = false; // State of the alarm
boolean isActivated;
boolean activateAlarm = false;
boolean alarmActivated = false;
boolean enteredPassword; // State of the entered password to stop the alarm
boolean passChangeMode = false;
boolean passChanged = false;
const byte ROWS = 4; //four rows
```

```

const byte COLS = 4; //four columns
char keypressed;
//define the symbols on the buttons of the keypads
char keyMap[ROWS][COLS] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8','9','C'},
  {'*','0','#','D'}
};
byte rowPins[ROWS] = {44,42,40,38}; //Row pinouts of the keypad
byte colPins[COLS] = {52,50,48,46}; //Column pinouts of the keypad

Servo myservo; // create servo object to control a servo

Keypad myKeypad = Keypad( makeKeymap(keyMap), rowPins, colPins, ROWS, COLS);

LiquidCrystal lcd(2,3,4,5,6,7); // Creates an LC object. Parameters: (rs, enable, d4, d5, d6, d7)

void setup() {
  lcd.begin(16,2);
  pinMode(buzzer, OUTPUT); // Set buzzer as an output
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  pinMode(RedLed,OUTPUT);//sets the Led as an Output
  pinMode(GreenLed,OUTPUT);
  myservo.attach(36); // attaches the servo on pin 9 to the servo object
  pinMode(reedsensor,INPUT_PULLUP);
}

```

```

void loop() {
  if (activateAlarm) {
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print("Alarm will be");
    lcd.setCursor(0,1);
    lcd.print("activated in");

    int countdown = 3; //seconds count down before activating the alarm
    while (countdown != 0) {
      lcd.setCursor(13,1);
      lcd.print(countdown);
      countdown--;
      tone(buzzer, 700, 100);
      delay(1000);
    }
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print("Alarm Activated!");
    activateAlarm = false;
    alarmActivated = true;
    digitalWrite(GreenLed,HIGH);
  }

  if (alarmActivated == true){
    currentDistance = getDistance(); //Calculate the distance from sensor
    if ( currentDistance < 100) {

```

```

    tone(buzzer, 1000); // Send 1KHz sound signal
    lcd.clear();
    enterPassword();

    Serial.print(currentDistance);
  }
}

if(alarmActivated == true){
  if (Serial.available())
    switch(Serial.read())
    {
      SendTextMessage();
      break;
    }
  if (Sim900Serial.available())
    Serial.write(Sim900Serial.read());
}

if(alarmActivated == true){
  state =digitalRead(reedsensor);

  if (state == HIGH){
    tone(buzzer,400);
    enterPassword();
  }
else{
  noTone(buzzer);
}

```

```
}  
delay(200);  
}
```

```
if (!alarmActivated) {  
  if (screenOffMsg == 0){  
    lcd.clear();  
    lcd.setCursor(0,0);  
    lcd.print("A - Activate");  
    lcd.setCursor(0,1);  
    lcd.print("C - Change Pass");  
    screenOffMsg = 1;  
    digitalWrite(GreenLed,LOW);  
    digitalWrite(RedLed,LOW);  
  }  
  keypressed = myKeypad.getKey();  
  if (keypressed == 'A'){ //If A is pressed, activate the alarm  
    tone(buzzer, 1000, 200);  
    activateAlarm = true;  
  }  
  else if (keypressed == 'C') {  
    lcd.clear();  
    int i=1;  
    tone(buzzer, 2000, 100);  
    tempPassword = "";  
    lcd.setCursor(0,0);  
    lcd.print("Current Password");
```

```

lcd.setCursor(0,1);
lcd.print(">");
passChangeMode = true;
passChanged = true;
while(passChanged) {
keypressed = myKeypad.getKey();
if (keypressed != NO_KEY){
  if (keypressed == '0' || keypressed == '1' || keypressed == '2' || keypressed == '3' ||
    keypressed == '4' || keypressed == '5' || keypressed == '6' || keypressed == '7' ||
    keypressed == '8' || keypressed == '9' ) {
    tempPassword += keypressed;
    lcd.setCursor(i,1);
    lcd.print("*");
    i++;
    tone(buzzer, 2000, 100);
  }
}
if (i > 5 || keypressed == '#') {
  tempPassword = "";
  i=1;
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Current Password");
  lcd.setCursor(0,1);
  lcd.print(">");
}
if ( keypressed == '*') {
  i=1;

```

```

tone(buzzer, 2000, 100);
if (password == tempPassword) {
  tempPassword="";
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Set New Password");
  lcd.setCursor(0,1);
  lcd.print(">");
  while(passChangeMode) {
    keypressed = myKeypad.getKey();
    if (keypressed != NO_KEY){
      if (keypressed == '0' || keypressed == '1' || keypressed == '2' || keypressed == '3' ||
        keypressed == '4' || keypressed == '5' || keypressed == '6' || keypressed == '7' ||
        keypressed == '8' || keypressed == '9' ) {
        tempPassword += keypressed;
        lcd.setCursor(i,1);
        lcd.print("*");
        i++;
        tone(buzzer, 2000, 100);
      }
    }
  }
  if (i > 5 || keypressed == '#') {
    tempPassword = "";
    i=1;
    tone(buzzer, 2000, 100);
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print("Set New Password");
  }
}

```



```

digitalWrite(RedLed,HIGH);
while(activated) {
  keypressed = myKeypad.getKey();
  if (keypressed != NO_KEY){
    if (keypressed == '0' || keypressed == '1' || keypressed == '2' || keypressed == '3' ||
        keypressed == '4' || keypressed == '5' || keypressed == '6' || keypressed == '7' ||
        keypressed == '8' || keypressed == '9' ) {
      tempPassword += keypressed;
      lcd.setCursor(k,1);
      lcd.print("*");
      k++;
    }
  }
  if (k > 9 || keypressed == '#') {
    tempPassword = "";
    k=5;
    lcd.clear();
    lcd.setCursor(0,0);
    lcd.print(" *** ALARM *** ");
    lcd.setCursor(0,1);
    lcd.print("Pass>");
  }
  if ( keypressed == '*') {
    if ( tempPassword == password ) {
      activated = false;
      alarmActivated = false;
      noTone(buzzer);
      screenOffMsg = 0;
    }
  }
}

```

```

    }
    else if (tempPassword != password) {
        lcd.setCursor(0,1);
        lcd.print("Wrong! Try Again");
        delay(2000);
        lcd.clear();
        lcd.setCursor(0,0);
        lcd.print(" *** ALARM *** ");
        lcd.setCursor(0,1);
        lcd.print("Pass>");

    }
}
}
}
}

// Custom function for the Ultrasonic sensor
long getDistance(){
    //int i=10;

    //while( i<=10 ) {

    digitalWrite(trigPin, LOW); // Clears the trigPin
    delayMicroseconds(2);

    digitalWrite(trigPin, HIGH); // Sets the trigPin on HIGH state for 10 micro seconds
    delayMicroseconds(10);
    digitalWrite(trigPin, LOW);

```

```
duration = pulseIn(echoPin, HIGH); // Reads the echoPin, returns the sound wave travel time in microseconds
```

```
distance = duration*0.034/2; // Calculating the distance
```

```
//sumDistance += distance;
```

```
//}
```

```
//int averageDistance= sumDistance/10;
```

```
return distance;
```

```
}
```