CHAPTER ONE

INTRODUCTION

1.1 Background

Water is a very essential commodity in the lives of human. It is a known fact that water provided the basis of human existence since water is used in various processes that contribute to the growth, development and maintenance of living things. The earth as a planet have seventy per cent (70%) of its surface covered with water. The human being is have water composition to his body. Where ever water flows there is life. The history of humans have always show that man from his hunting and gathering stage even up to modern era of globalisation have always relied on water for survival. In the agrarian society water was used to irrigate farms lands which when cultivated yielded the crops taken as food.

Water is used for a lot of things in the human endeavours. Water is used in cleaning, farming, health etc. The dawning of the 21st century, brought new technology as to the safe ways of treating water. This have influence the domestic usage of water around the world. Underground water serve as drinking water for a lot of homes. In Ghana, underground water is increasingly serving as source of water for many homes, Schools, factories and institutions. In recent times many underground water supply system have seen several technological advances. Among these technological advances is the mechanization of the well/bole hole water. In most rural setting a mechanical pump is attached to bole hole. These pumps draws water from underground through strokes on a level system mounted at the top of the bole hole. This type of bole holes need a lot of manual labour from the consumer and may in many cases cause undue delays to reach quality water. A typical solution to easy the consumer is the introduction of electrical pump system. The electrical pump is supplied with a source of electricity to pump underground water through pipes fixed on the well. There is always the need to control the electrical pump and the reservoir. Various form exist. The emergent of microcontroller can be used in this water supply system as a form of control module.

1.2 Problem statement

Resident students of Autonomy Hall enjoy the facility because it is can be counted as among the state of the art buildings on the University of Education, Winneba – Kumasi Campus. Recent issues on water availability is creating a major discomfort among occupants of the Hall. The Autonomy Hall water supply system is mechanised well. The system is only active when the porters are around. This situation creates water insufficiency during critical point such as nights, when there is power outage, rush hour time and when the porters are not available. Again the water content in the reservoir is not known and the system must be completely empty before the situation is known. In some situation the areas around the reservoir is flooded before the water supply system in noted to be full. All these challenges afore mentioned leads to loss in electrical energy, water and even the degradation of the concrete platform housing the reservoir. Student time is lost as a result of these frequent water shortage. Again there are often outbreak of sanitation related diseases such as cholera, nausea, candidiasis, malaria etc. because of shortage and over flows of water at the hall. Could there be a system that could effectively monitor and control the water supply system? It there a way of introducing a new control system into the old system to help minimise these very important issues?

1.3 Research Objectives

The research seeks to

1. Design the automatic control system for the water supply of autonomy hall without compromising on the performance of the existing system.

2. Implement Arduino programming as part of the design.
3. Construct the automatic control system using the design parameter.

1.4 Research Question

The following question where considered be the researcher in an attempt to reach the objective of the research.

1. What are the design parameters for an automatic control water supply system?
2. Can the Arduino microprocessor be implemented for such design?
3. Can the design be implemented by construction of the automatic control system?

1.5 Purpose of the study

In an attempt to minimise these problems which are mainly caused by the automatic control water supply system in the hall, this research seeks to design and construct an efficient water supply system for the hall using an Arduino microprocessor.

CHAPTER TWO

LITEREATURE REVIEW

2.1 Introduction

Nowadays everybody has overhead tank at their homes. But everyone who has a water tank above knows the kind of problems that they face. Firstly there is no system to track the water in the tank. Then there comes a secondary problem that is when their water pump is started they have no idea when it gets filled up and sometime there are situation where the pump keeps on pumping water to the tank and the water starts spilling out from the tank. There is wastage of energy as well as wastage of water.

2.2 Water well basics

A water well is a hole, shaft or excavation used for the purpose of extracting ground water from the subsurface. Water may flow to the surface naturally after excavation of the hole or shaft. Such a well is known as a flowing artesian well. More commonly, water must be pumped out of the well.

Most wells are vertical shafts, but they may also be horizontal or at an inclined angle. Horizontal wells are commonly used in bank filtration, where surface water is extracted via recharge through river bed sediments into horizontal wells located underneath or next to a stream. The oldest known wells, Qanats, are hand-dug horizontal shafts extending into the mountains of the Old Persian Empire in present-day Iran. Some wells are used for purposes other than obtaining ground water. Oil and gas wells are examples of this. Monitoring wells for groundwater levels and groundwater quality are other examples. Still other purposes include the investigation of subsurface conditions, shallow drainage, artificial recharge, and waste disposal (Harter, 2003).

In recent times, the focus is on vertical water-production Hydrogeology wells commonly used to supply water for domestic, municipal, and agricultural uses. It purpose is to provide readers with some basic information about water wells to help them understand principles of effective well construction when they work with a professional driller, consultant, or well servicing agency for well drilling and maintenance (Harter, 2003).

2.2.1 Determining a well water location

The location of a well is mainly determined by the well's purpose. For drinking and irrigation water-production wells, groundwater quality and long-term groundwater supply are the most important considerations. The hydrogeological assessment to determine whether and where to locate a well should always be done by a knowledgeable driller or professional consultant. The water quality criteria to use for drinking water wells are the applicable local or state drinking water quality standards. For irrigation wells, the primary chemical parameters of concern are salinity and boron and the sodium-adsorption ratio. Enough ground water must be available to meet the pumping requirements of the wells. For large municipal and agricultural production wells, pumping rate requirements range from about 500 to 4,000 gallons per minute (gpm). Small- and medium-sized community water systems may depend on water wells that produce from 100 to 500 gpm. Individual homes' domestic wells may meet their needs with as few as 1 to 5 gpm, depending on local regulations. To determine whether the desired amount of ground water is available at a particular location and whether it is of appropriate quality, drillers and groundwater consultants rely on their prior knowledge of the local groundwater system, experience in similar areas, and a diverse array of information such as land surface topography, local vegetation, rock fracturing (where applicable), local geology, groundwater chemistry, information on thickness, depth, and permeability of local aquifers from existing wells, groundwater levels, satellite or aerial photographs, and geophysical measurements. In most cases, the well location is further limited by property ownership, the need to keep surface transportation of the pumped ground water to a minimum, and access restrictions for the drilling equipment. When locating a well, one should also consider the proximity of potential sources of contamination such as fuel or chemical storage areas, nearby streams, sewer lines, and leach fields or septic tanks. The presence of a significant barrier between such potential sources and the well itself is very important for the protection of the well (Harter, Davis & Kearney, 2003).

2.2.2 Water Well Design and Installation

Once the well location has been determined, a preliminary well design is completed. For many large production wells, a test hole will be drilled before well drilling to obtain more detailed information about the depth of water-producing zones, confining beds, well production capabilities, water levels, and groundwater quality. The final design is subject to site-specific observations made in the test hole or during the well drilling.

The overall objective of the design is to create a structurally stable, long-lasting, efficient well that has enough space to house pumps or other extraction devices, allows ground water to move effortlessly and sediment-free from the aquifer into the well at the desired volume and quality, and prevents bacterial growth and material decay in the well.

A well consists of a bottom sump, well screen, and well casing (pipe) surrounded by a gravel pack and appropriate surface and borehole seals. Water enters the well through perforations or openings in the well screen. Wells can be screened continuously along the bore or at specific depth intervals. The latter is necessary when a well taps multiple aquifer zones, to ensure that screened zones match the aquifer zones from which water will be drawn. In alluvial aquifers, which commonly contain alternating sequences of coarse material (sand and gravel) and fine material, the latter construction method is much more likely to provide clean, sediment-free water and is more energy efficient than the installation of a continuous screen. Hardrock wells, on the other hand, are constructed very differently. Often, the borehole of a hardrock well will stand open and will not need to be screened or cased unless the hard rock crumbles easily.

The purpose of the screen is to keep sand and gravel from the gravel pack out of the well while providing ample water flow to enter the casing. The screen should also be designed to allow the well to be properly developed. Slotted, louvered, and bridge-slotted screens and continuous wire wrap screens are the most common types. Slotted screens provide poor open area. They are not well suited for proper well development and maintenance, and are therefore not recommended. Wire wrap screens or pipe-based wire wrap screens give the best performance. The additional cost of wire wrap screens can be offset if you only install screen sections in the most productive formations along the borehole.

2.2.3 Sanitary Protection for Wells

A properly designed and constructed well should prevent contaminants entering the well from the ground surface or from shallow soil or subsoil, and should prevent pollutants entering the aquifer from the well. This requires:

- The use of good quality materials for casing and well screen, of suitable size, carefully installed in the well to appropriate depths.
- Grouting of the well around the casing to prevent ingress of contaminated water from the ground surface or from shallow depths.

2.2.4 Some Problems Associated with Ground Water

The major danger associated with drinking water sources is the possibility of its recent contamination by sewage or human and animal excreta (Pipes, 1981). Another problem is sitting of drinking water system (wells and boreholes) near a refuse dumpsite or landfill. Water is essential to sustain life and a satisfactory supply of drinking water must be made available to all consumers (WHO, 2006). Recently, epidemics of cholera have been reported from different parts of India, Nigeria and Zimbabwe. The outbreak was caused by Vibrio cholera 01 isolated from municipal taps and wells (Sur et al., 2006). Outbreaks of typhoid fevers and dysentery were linked to unsanitary mixing of some water supplies and sewage. It has been reported by WHO (2003) that 80% of sicknesses and deaths among children in the world are caused by unsafe drinking water. On the average, every 8s in the world, a child dies of contaminated water. The use of normal intestinal organisms as indicators of fecal pollution is universally accepted for monitoring and assessing the micro-biological safety of water supplies (Dissanayake et al., 2004). Coliform bacteria are a group of intestinal bacteria used as indicators to determine if treated water is acceptable for human consumption. Coliforms will not likely cause illnesses. However, the presence of coliforms in drinking indicates the presence of disease-causing organisms (Nwachukwu and Otokunefor, 2006).

Groundwater has been naturally very clean because of its filtering effect; however it can become polluted with nutrients and toxic chemicals when surface water carrying these substances drains into the groundwater environment (USEPA, 2001). A ground water aquifer may be as little as 30 m from the surface or as much as 300 m. Although, it costs more to pump water from deeper aquifer, the water quality in deeper ones are better than the shallow ones since contaminants which the water may be carrying are removed as the water moves through the rock (USEPA, 2001). It is essential that water be examined regularly and frequently as contamination may be intermittent and may not be detected by simple tests.

2.3 The Nature of the Existing System

Autonomy hall uses a sump (centrifugal) pump coupled with a motor to draw water from a deep well for use and some to be stored into a reservoir. The operating manual of any centrifugal pump often starts with a general statement, “the centrifugal pump will give you completely trouble free and satisfactory service only on the condition that it is installed and operated with due care and is properly maintained” (Mukesh Sahdev, 2010).

Despite all the care in operation and maintenance, engineers often face the statement “the pump has failed i.e. it can no longer be kept in service”. Inability to deliver the desired flow and head is just one of the most common conditions for taking a pump out of service.

There are other many conditions in which a pump, despite suffering no loss in flow or head, is considered to have failed and has to be pulled out of service as soon as possible. These include seal related problems (leakages, loss of flushing, cooling, quenching systems, etc), pump and motor bearings related problems (loss of lubrication, cooling, contamination of oil, abnormal noise, etc), leakages from pump casing, very high noise and vibration levels, or driver (motor or turbine) related problems (Lieberman & PennWell Books, 1991).

The list of pump failure conditions mentioned above is neither exhaustive nor are the conditions mutually exclusive. Often the root causes of failure are the same but the symptoms are different. A little care when first symptoms of a problem appear can save the pumps from permanent failures.

Thus the most important task in such situations is to find out whether the pump has failed mechanically or if there is some process deficiency, or both. Many times when the pumps are sent to the workshop, the maintenance people do not find anything wrong on disassembling it. Thus the decision to pull a pump out of service for maintenance / repair should be made after a detailed analysis of the symptoms and root causes of the pump failure. Also, in case of any mechanical failure or physical damage of pump internals, the operating engineer should be able to relate the failure to the process unit’s operating problems (Igor, 1987)

2.3.1 Working Mechanism of a Centrifugal Pump

A centrifugal pump is one of the simplest pieces of equipment in any process plant. Its purpose is to convert energy of a prime mover (an electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being pumped. The energy changes occur by virtue of two main parts of the pump, the impeller and the volute or diffuser. The impeller is the rotating part that converts driver energy into the kinetic energy (API Standard 610, 1981).

The volute or diffuser is the stationary part that converts the kinetic energy into pressure energy.

2.3.1.1 Generation of Centrifugal Force

The process liquid enters the suction nozzle and then into eye (center) of a revolving device known as an impeller. When the impeller rotates, it spins the liquid sitting in the cavities between the vanes outward and provides centrifugal acceleration.

As liquid leaves the eye of the impeller a low-pressure area is created causing more liquid to flow toward the inlet. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction by the centrifugal force. This force acting inside the pump is the same one that keeps water inside a bucket that is rotating at the end of a string. The Figure 2.1 below depicts a side cross-section of a centrifugal pump indicating the movement of the liquid (Mukesh Sahdev, 2010).

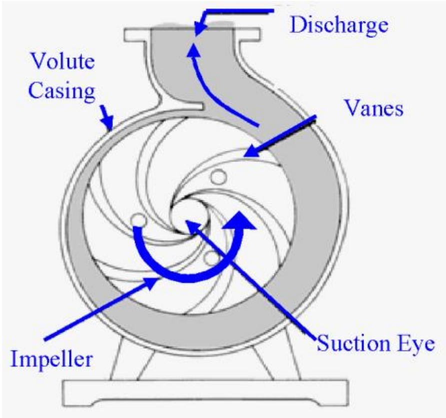

Figure 2.1: Liquid flow path inside a centrifugal pump

2.4 Water Level Indication

The simplest and oldest industrial level measuring device is, of course, the sight glass. A manual approach to measurement, sight glasses have always had a number of limitations. The material used for its transparency can suffer catastrophic failure, with ensuing environmental insult, hazardous conditions for personnel, and/or fire and explosion. Seals are prone to leak, and buildup, if present, obscures the visible level. It can be stated without reservation that conventional sight glasses are the weakest link of any installation. They are therefore being rapidly replaced by more advanced technologies.

Other level-detection devices include those based on specific gravity, the physical property most commonly used to sense the level surface. A simple float having a specific gravity between those of the process fluid and the headspace vapor will float at the surface, accurately following its rises and falls. Hydrostatic head measurements have also been widely used to infer level.

Level sensors detect the level of liquids and other fluids and fluidized solids, including slurries, granular materials, and powders that exhibit an upper free surface. Substances that flow become essentially horizontal in their containers (or other physical boundaries) because of gravity whereas most bulk solids pile at an angle of repose to a peak. The substance to be measured can be inside a container or can be in its natural form (e.g., a river or a lake). The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point. Generally the latter detect levels that are excessively high or low.

There are many physical and application variables that affect the selection of the optimal level monitoring method for industrial and commercial processes. The selection criteria include the physical: phase (liquid, solid or slurry), temperature, pressure or vacuum, chemistry, dielectric constant of medium, density (specific gravity) of medium, agitation (action), acoustical or electrical noise, vibration, mechanical shock, tank or bin size and shape. Also important are the application constraints: price, accuracy, appearance, response rate, ease of calibration or programming, physical size and mounting of the instrument, monitoring or control of continuous or discrete (point) levels. In short, level sensors are one of the very important sensors and play very important role in variety of consumer/ industrial applications. As with other type of sensors, level sensors are available or can be designed using variety of sensing principles. Selection of an appropriate type of sensor suiting to the application requirement is very important (Wikipedia, 2016).

Khaled Reza el al., (2010) introduced the notion of water level monitoring and management within the context of electrical conductivity of the water. The authors motivated by the technological affordances of mobile devices and the believe that water level management approach would help in reducing the home power consumption and as well as water overflow; investigated the microcontroller based water level sensing and controlling in a wired and wireless environment. The research result was a flexible, economical and easy configurable system designed on a low cost PIC16F84A microcontroller and finally, proposed a web and cellular based monitoring service protocol to determine and senses water level globally.

2.5 Microcontroller

A microcontroller is a circuit element that is completely self-contained, with many hardware blocks such as counters, comparators, even ADCs built in, so there is no need to wire up too much external hardware to make useful projects.

When more complex physical principles are involved, emerging technologies often use computers to perform the calculations. This requires sending data in a machine-readable format from the sensor to the control or monitoring system. Useful transducer output signal formats for computer automation are current loops, analog voltages, and digital signals. Analog voltages are simple to set up and deal with, but may have serious noise and interference issues. 4-20 mA current loops (where the loop current varies with the level measurement) are the most common output mechanism today. Current loops can carry signals over longer distances with less degradation. Digital signals coded in any of a number of protocols (e.g., Foundation Fieldbus, Hart, Honeywell DE, Profibus, and RS-232) are the most robust, but the older technologies such as RS-232 can handle only limited distances. New wireless capabilities can be found in the latest transmitters' signals, allowing them to be sent over tremendous distances with virtually no degradation (circuit today, 2016).

2.5.1 Arduino UNO Microcontroller

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino board

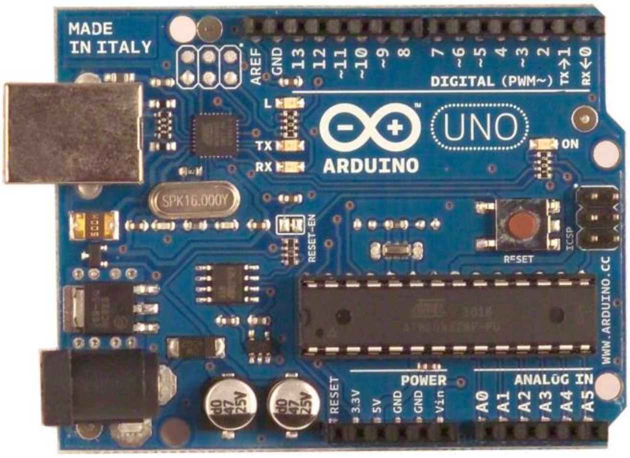

Figure 2.2 Arduino UNO

2.5.2 Technical Specification Summary of Arduino UNO

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
Clock Speed	16 MHz

2.5.3 Programming Arduino UNO

The Arduino Uno can be programmed with the Arduino software. The ATmega328 on the Arduino Uno comes pre-burned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; The ATmega8U2 firmware source code is available. The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader).

2.5.4 Automatic software reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

2.5.5 USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts circuits and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

2.5.6 Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

2.6 Water Control System Using Microcontroller

Pumps are essential in the water supply field, wooden pumps existed in the 1700s and these were used to empty the bilges of ships. They were made from bored logs with wooden pistons to create suction. Metal piston type pumps, driven by steam, were developed in the early to mid-1800s but it was not until the advent of electrically driven pumps that water system expansion became feasible on a large scale. Layne Bowler developed the first vertical turbine water pumps in 1894 and Jacuzzi developed the first submersible pumps in the 1920s. These manufacturing developments provided the hardware to allow the establishment of many New Hampshire public water systems in the very late 1800s (Hicks et al., 1971).

Automatic water pump controller is a series of functions to control the Automatic Water Pump Controller Circuit in a reservoir or water storage. The water level sensor is made with a metal plate mounted on the reservoir or water tank, with a sensor in the short to create the top level and a detection sensor for detecting long again made for the lower level and ground lines connected to the bottom of reservoirs or reservoir. In everyday life, there must be some physical elements that need to be controlled in order for them to perform their expected behaviours. A control system therefore can be defined as a device, or set of devices, that manages, commands, directs or regulates the behaviour of other device(s) or system(s).

Consequently, automatic controlling involves designing a control system to function with minimal or no human interference. Intelligent systems are being used in a wide range of fields including from medical sciences to financial sciences, education, law, and so on. Several of them are embedded in the design of everyday devices (Gunturi, 2013).

A controller based automatic plant irrigation system was designed by Gunturi (2013). The main aim of the research was is to provide automatic irrigation to the plants with a system that operates with less manpower. This in turn helps to save funds and water. The researcher programmed the 8051 microcontroller as giving the interrupt signal to the sprinkler, and this was used to control the entire system. Temperature sensor and humidity sensor were connected to internal ports of the microcontroller via a comparator, and whenever there is a change in temperature and humidity of the surroundings these sensors senses the change in temperature and humidity and gives an interrupt signal to the micro-controller and thus the sprinkler is activated. It was the position of a paper by Hodgson and Walter that based on real world systems as the benchmark, using optimization software in place of traditional design techniques results in significant cost savings for both first cost and LCC. The researchers discussed the potentials of modern optimization technology to the pumping industry and presented examples of cost-saving design experiences.

Rojiha (2013) analysed this existing oil-pumping system and discovered that they have a high power-consuming process and needs more manual power. He then proposed a sensor network based intelligent control system for power economy and efficient oil well health monitoring. Several basic sensors were used for oil well data sensing, and the sensed data was given to the controller which processed the oil wells data and it was given to the oil pump control unit which controls the process accordingly. If any abnormality is detected then the maintenance manager is notified through an sms via the GSM. This system allowed oil wells to be monitored and controlled from remote places.an easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it (Rojiha, 2013).

CHAPTER THREE

METHODOLOGY

3.0 Block Diagram of Automatic control System

The figure 3.1 below show a block diagram representation of the automatic control system at the Autonomy Hall. The setup was made up of a Reservoir Block, PV Source Block, Arduino controller module block, Remote Control Block, Arduino /Hardwire level indicator interface, and Pump module. The Reservoir block represent the tanks used to storage the water from the well. The system was powered by a photo voltaic source and this is represented by the solar module on the block diagram. The Arduino controller module represented the part of the circuit that would perform the logical decisions for the system to control the water flow from the sump to the reservoir. The controller module also displayed condition of pump and level of water. As with all efficient automatic systems there was a provision for emergency switching. The remote control at the porters lodge was the block module that does the function of Emergency OFF or ON. The outputs signal of the Arduino module block could not control the pump and so an integration block was used to control the pump by amplifying the signals from the Arduino. The interfacing block module does an additional function of indicating the level of the water by a hardwired system. This helped to indicate the water level when the Arduino microcontroller fails. If such condition happened the emergency switching controls was used for various conditions.

The Block diagram representation of component

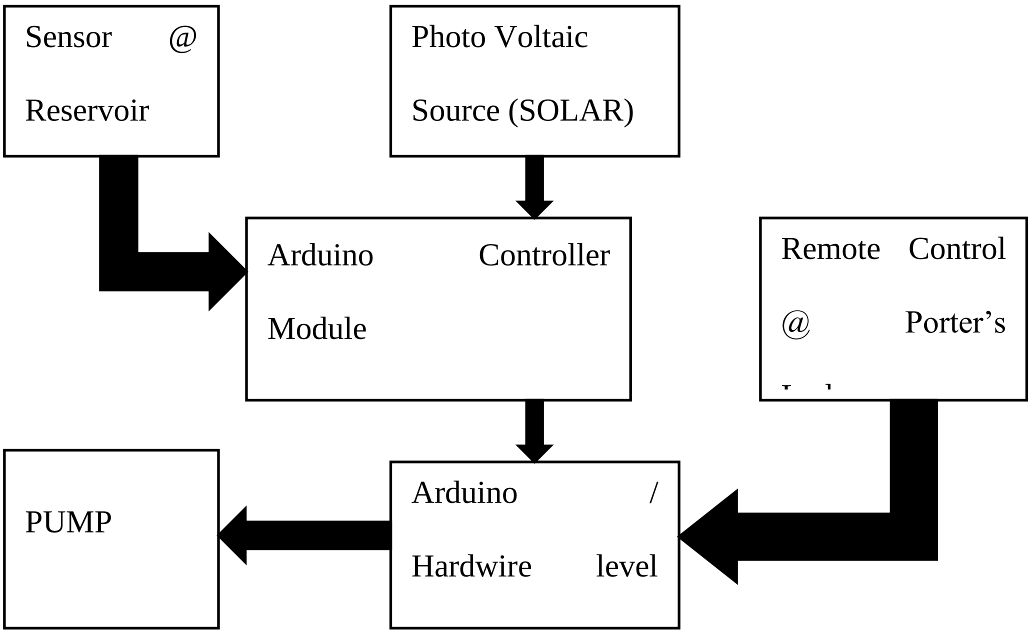

Figure 3.1: block diagram representation of the system

3.1 Design of Photo Voltaic Source

The Photo Voltaic source consisted of a 12V battery, 6V Solar panel and a 12V solar Controller Module with USB capabilities. The figure 3.2 below shows the connection for the Photo Voltaic source.

Wiring Diagram for Solar Source

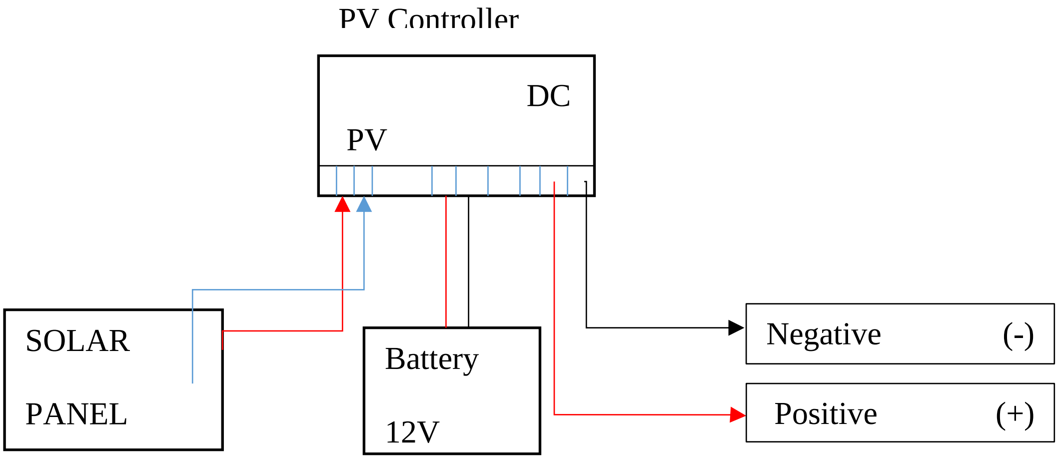

Figure 3.2 wire diagram of solar source to system

3.2 Design of Hardwired Level Indicator

The hardwired level indicator circuit is show in figure 3.3. The hardwired level indicator employed the principle of conductive method of operation. This implied that the sensors are activated by direct contact with the water in the reservoir and sump tank. The hardwired level indicator was made up of a switching IC, CD4066 and it corresponding LED outputs indicating, quarter, half, three Quarters, and Full.

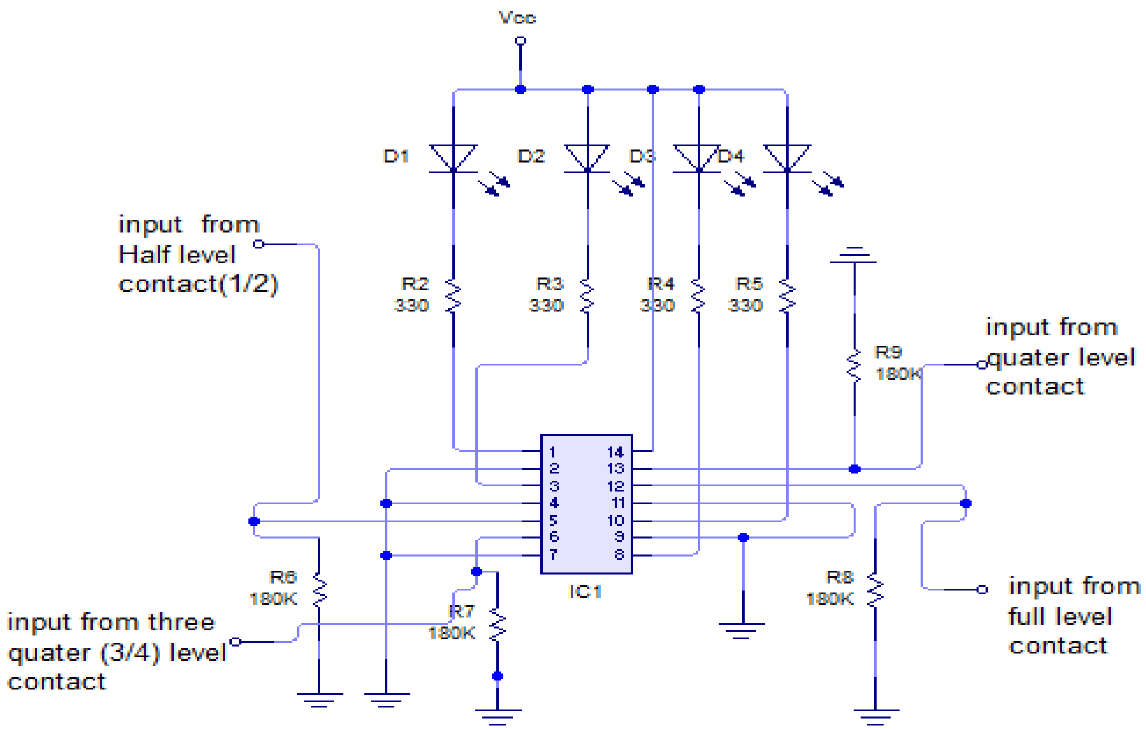

Figure 3.3 Hardwired level indicator

3.2.1 Operating Principle of the CD4066 as Level Indicator

The CD4066 that was active in the circuit is made up of four bidirectional switch with a control pin for the LED to indicate water level at various points. For CD4066 a minimum input voltage that can trigger the output voltage is 5v. This was to produce a zero potential or ground at the output pin of the IC. Since 5v was connected to the LED to the output pin of the IC any control signal applied to the control pin would allow the internal switch of the IC to close thereby making the input pin to make contact to a zero potential allowing the LED to turn ON. The figure 3.4 below shows the connection of the first switch within the IC4066. Pin 2 of the IC is connected to ground. The V_{cc} of the LED (D1) would need a zero or ground potential to switch ON. Since the whole setup was connected to pin 1 of the IC 4066 there exist an open circuit in the internal circuit of the IC 4066. A control signal at pin 13 is the only condition to short circuit pin 1 and 2 such that a potential is made to ground. If the short circuit occurs the LED would light. The same arrangement was made for the different levels of the water.

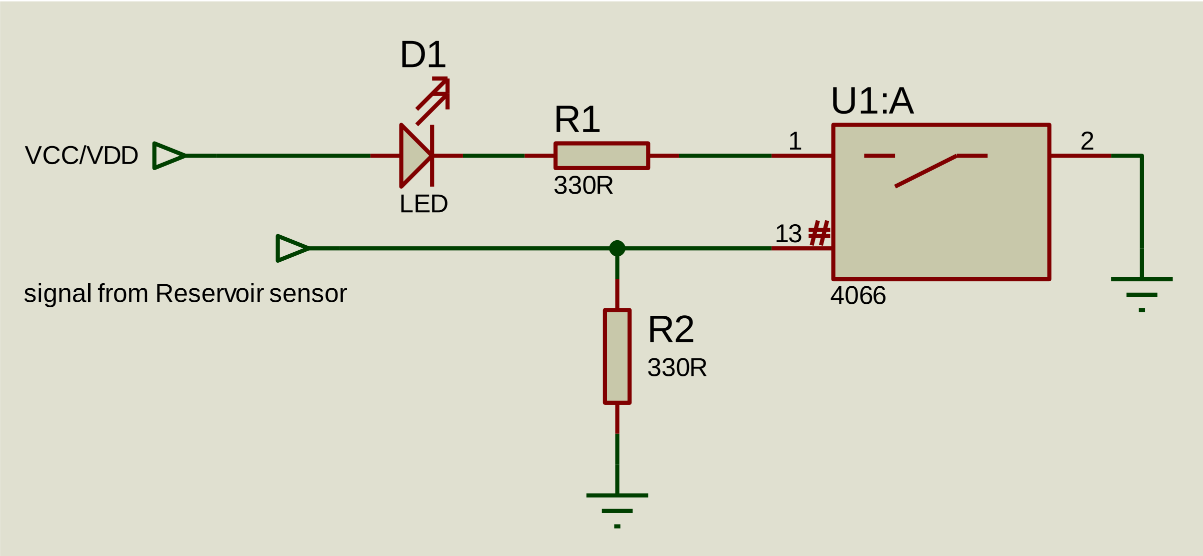

Figure 3.4 shows the internal connections of IC CD4066.

3.3 Design of Arduino module Interface and Emergency switches

The interface circuit was also going to integrate the output signals from the Arduino to the pump and buzzer. This integration circuit is used because the output current rating of the Arduino microcontroller is not capable of triggering the pump directly. Again fault resulting from feedback during the pump operation will not affect the microcontroller because of the integration circuit. In the integration circuit, an optocoupler was used to separate the two voltage levels of the circuit (i.e. the microcontroller uses 5v and the motor relay uses 12v).

The circuit Diagram for pump integration and control

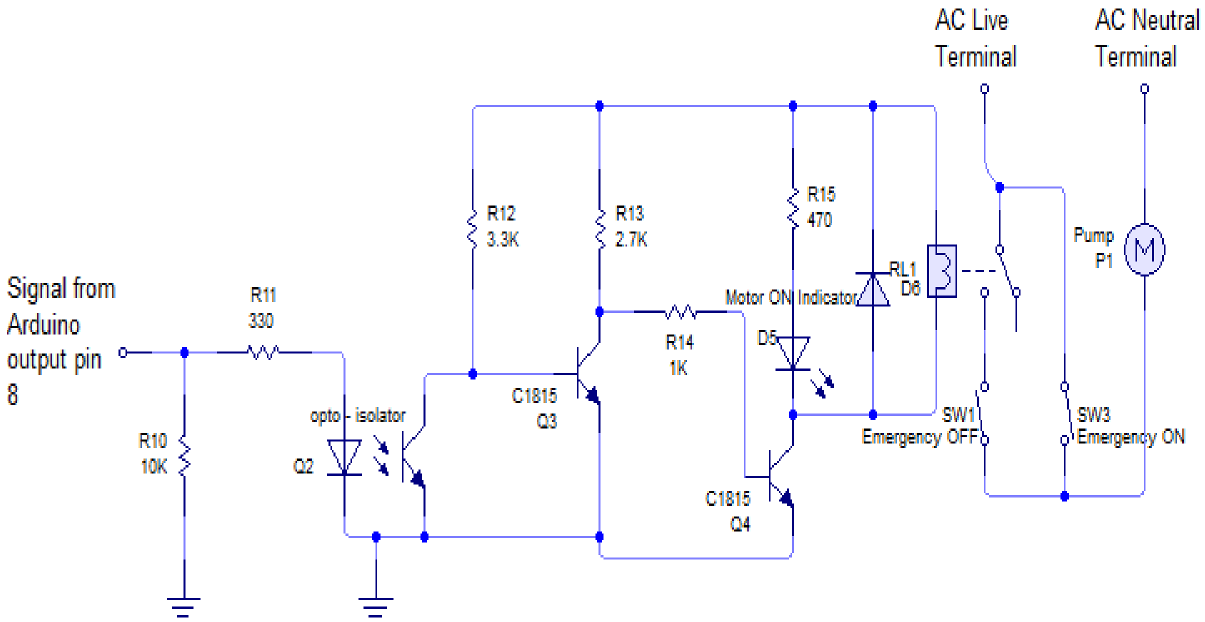

Figure 3.5 shows the pump integration circuit

3.3.1 Design Analysis of control signal to Relay

A transistor was used to control the relay in the circuit show in figure 3.6 below. The transistor is able to energise the coil of the relay so that the external load connected to it is controlled. Consider the circuit below to know the operation of a transistor to energize the relay coil. The input applied at the base drives the transistor into saturation region, which further results the circuit becomes short circuit. So the relay coil gets energized and relay contacts get operated. In inductive loads, particularly switching of the motor and inductors (Relay), sudden removal of power can keep a high potential across the coil. This high voltage can cause considerable damage to the rest circuit. Therefore, the researcher had to use the diode in parallel with inductive load to protect the circuit from induced voltages of the inductive load.

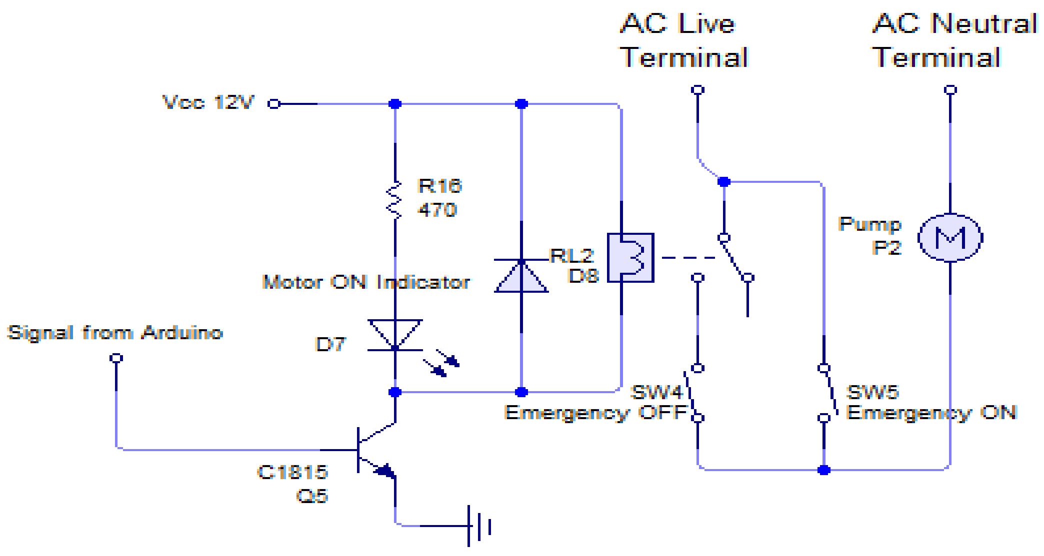

Figure 3.6 relay control circuit

3.3 Design of Alarm system

The system had a sound notification to alert porter for full condition of the reservoir, empty condition and error / fault condition of the pump. Signal produced by Arduino output was applied to the buzzer. The figure 3.7 below shows the circuit diagram of the alarm system. Base bias is used to switch the transistor (C1815) ON when signals from the Arduino is received at the base. When no signal is present at the base the buzzer would not sound any tone. Different kinds of pulsating signals is used to represent various conditions (Empty, Full, Error and Fault)

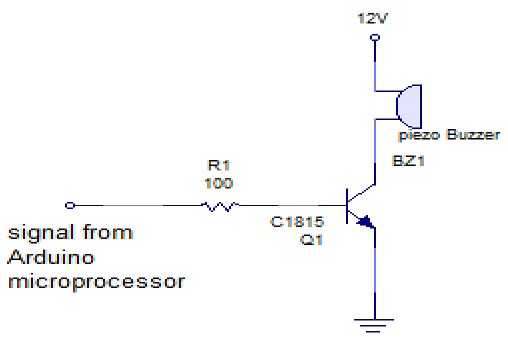

Figure 3.7 shows the buzzer circuit

3.3.1 Design calculation of Alarm system

In the design circuit the transistor C1815 was used as a switch to the buzzer. Based on the voltage applied at the base terminal of a transistor switching operation is performed. When a sufficient voltage (Vin > 0.7 V) is applied between the base and emitter, collector to emitter voltage is approximately equal to 0. Therefore, the transistor acts as a short circuit. The collector current Vcc/Rc flows through the transistor. Similarly, when no voltage or zero voltage is applied at the input, transistor operates in cutoff region and acts as an open circuit. In this type of switching connection, load (here Buzzer) is connected to the switching output with a reference point. Thus, when the transistor is switched ON, current will flow from source to ground through the load. The figure 3.8 below shows the OFF state condition of the transistor.

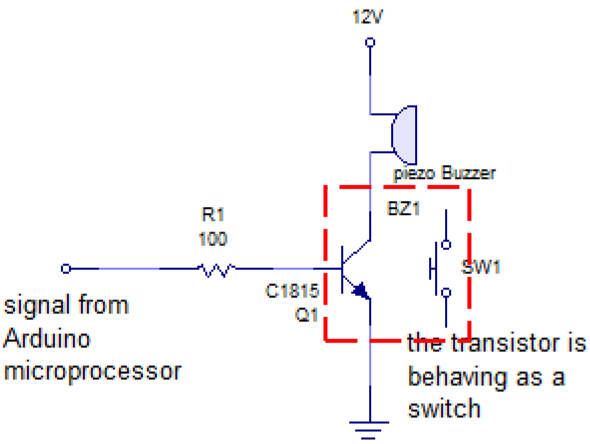

Figure 3.8 shows the OFF mode

For base resistance R1 = 100Ω, collector resistance (piezo Buzzer) Rc = 0.7k ohm, Vcc is 12V and the beta value is 130. At the base input a signal varying between 0 and 5V is given so we are going to see the output at the collector by varying the Vin at two states that is 0 and 5V as shown in figure 3.8

$I_c = V_{cc}/R_c$ when $V_{CE} = 0$

I_c = 12V/0.7k ohm

I_c = 17.142 mA

Base Current $I_b = I_c / \beta$

I_b = 17.142 mA/130

I_b = 131.861 µA

From the above calculations, the maximum or peak value of the collector current in the circuit is 17.142mA when Vce is equal to zero. And the correspond base current to which collector current flows is 131.861µA. So, it is clear that when the base current is increased beyond the 131.861 micro ampere then the transistor comes into the saturation mode.

Again Considering the ON case when zero volt is applied at the input. This causes the base current zero and as the emitter is grounded, emitter base junction is not forward biased. Therefore, the transistor is in OFF condition and the collector output voltage is equal to 12V.

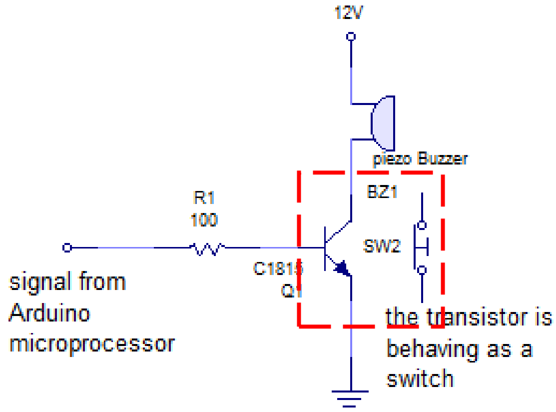

Figure 3.9 shows the ON state of the transistor.

Vin = 0V, I_{R1} = 0 and Ic =0,

$V_c = V_{cc} - (I_c R_c)$

= 12V – 0

= 12V

If the input voltage applied is 5 volts, then the base current can be determined by applying Kirchhoff's voltage law.

When $V_i = 5V$

$I_b = (V_i - V_{be}) / R_b$

For silicon transistor $V_{be} = 0.7$ V

Thus, $I_b = (5V - 0.7V)/ 100\Omega$

$= 43mA$ which is greater than 131.861 µA

Therefore the base current is greater than 131.861 micro ampere current, the transistor will be driven to saturation that is fully ON when 5V is applied at the input. Thus the output at the collector becomes approximately zero. This will allow the piezo buzzer to be ON.

3.4 Design of Arduino Microcontroller Circuit

The Arduino microcontroller was the main control unit for the automatic water control system. The inputs of the Arduino were analogue and the outputs were digital. The LCD is attached to the output to indicate various condition of the system. The conditions would be written in text and represented graphically on the display. The figure 3.10 below shows the circuit diagram representation of the circuit.

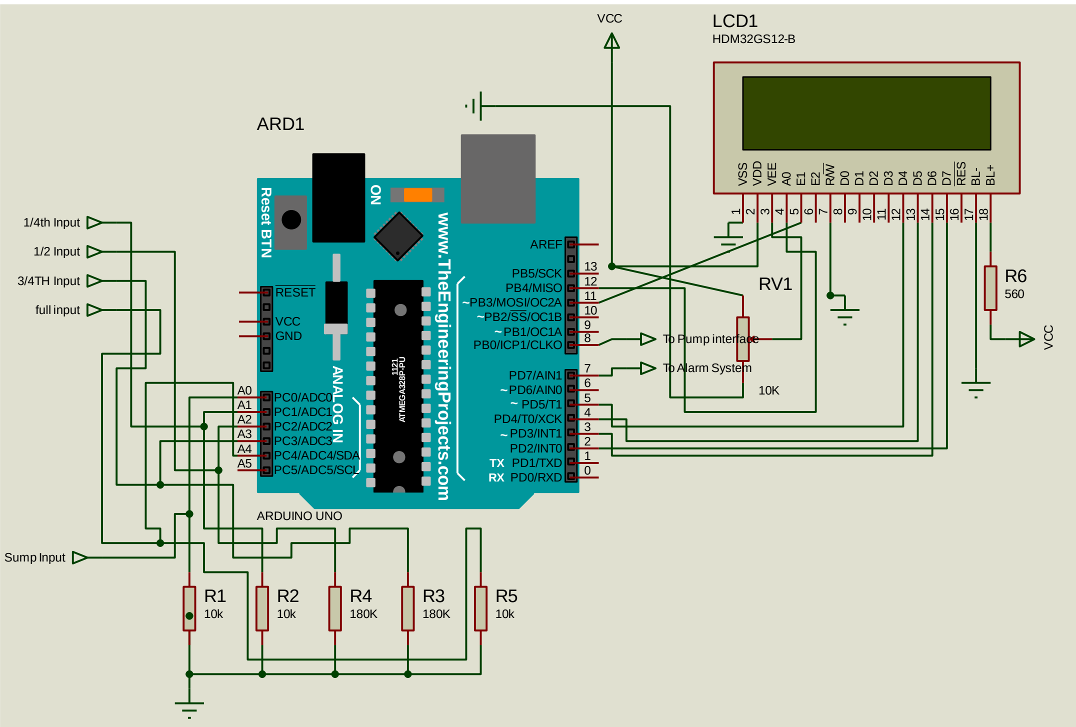

Figure 3.10 shows the circuit diagram of the Arduino control.

3.4.1 Flow chart representation of operation

The chart show the systematic operation of the Arduino module on the pump, reservoir, LCD and Buzzer.

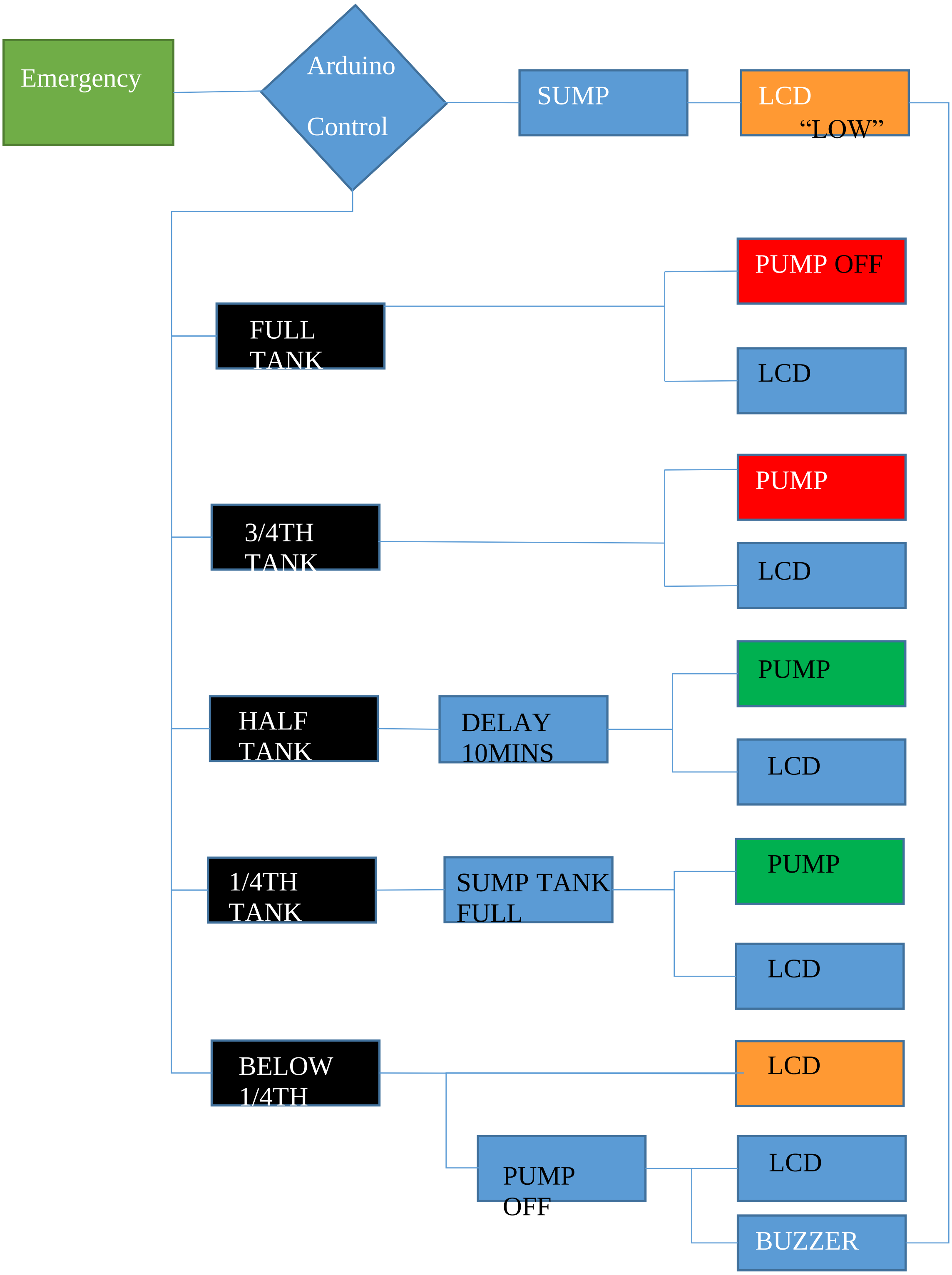

Figure 3.11 : Flow chart representation of system operation

3.4.2 Arduino Programming for automatic water supply system

The programming of the control process was written into the sketch of the Arduino 1.6.7 software. This can be found in appendix A. The program code was written for the system and its operation.

All variables were declared to represent inputs and outputs for the system. Sump represent the sump reservoir. Analogue input from reservoir are identified in A1 as quarter filled, A2 as half filled, A3 as three quarter filled, and A4 as fully filled. Pump signal pin was identified with pin 8 on the Arduino module. The Buzzer was identify with pin 7.

A command was used to identify various output variables against the input variables. This means that the buzzer and motor forms the output for the Arduino module. Pin A0, A1, A2, A3, A4 are all inputs to the Arduino model

The operation of the system was written in the command line. The "if else" command was used to demonstrate the various conditions for the LCD, pump and buzzer to operate. The system was designed such that the pump comes ON only when the water have drop to half way of the reservoir. At every level of the reservoir the LCD indicated by word and graphical representation.

The state condition for one quarter full of reservoir was such that the System delays for 10mins then switch pump ON. The Error condition occurs when pump is OFF and Water level is low. This would display ERROR on the LCD and cause the buzzer to sound.

COMPLETE CIRCUIT FOR THE DESIGN

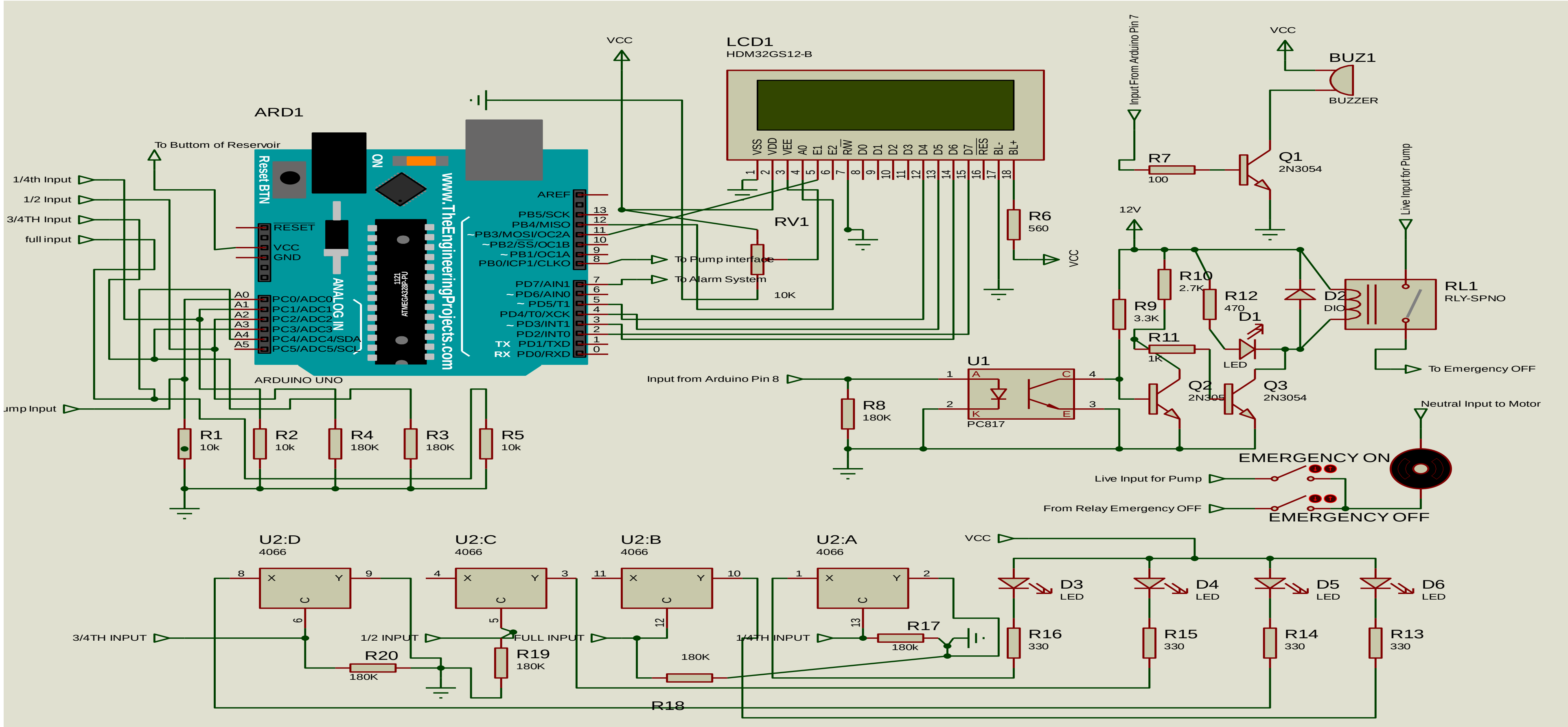

Figure 3.12: complete circuit of system

3.5 Bill of Materials for Circuit

Design Title : Design and Construction of an Automatic Water Supply System: An Upgrade to the Autonomy Hall Water Supply System.

Author : Kingsford Tibu Darko & Prempeh Isaac

Design Created: 31 March 2017

Design Last Modified: 16 April 2017

Total Parts In Design: 38

20 Resistors				
Quantity	References	Value	Stock Code	Unit Cost
3	R1-R2,R5	10K	M10K	0.30
6	R3-R4,R8,R18-R20	180K	Digikey 311-180KLTR-ND	0.30
1	R6	560	Digikey 311-10.0KCCT-ND	0.30
1	R7	100	Digikey 311-180KLTR-ND	0.30
1	R9	3.3K	Digikey 311-180KLTR-ND	0.30
1	R10	2.7K	Digikey 311-180KLTR-ND	0.30
1	R11	1K	Digikey 311-180KLTR-ND	0.30
1	R12	470	Digikey 311-180KLTR-ND	0.30
4	R13-R16	330	Digikey 311-180KLTR-ND	0.30
1	R17	180K	M10K	0.30
SUBTOTAL				6.0

Table 3.1 : part list and cost of resistors

Integrated Circuit				
Quantity	**References**	**Value**	**Stock Code**	**Unit Cost**
1	U1	PC817		5

Integrated Circuit				
Quantity	**References**	**Value**	**Stock Code**	**Unit Cost**
1	U2	4066		5
SUBTOTAL				10

Table 3.2 : part list and cost of Integrated circuits

Transistors				
Quantity	References	Value	Stock Code	Unit Cost
3	Q1-Q3	2N3054		0.50
SUBTOTAL				1.5

Table 3.3 : part list and cost of Transistors

Diode				
Quantity	References	Value	Stock Code	Unit Cost
5	D1,D3-D6	LED		0.50
1	D2	DIODE		0.50
SUBTOTAL				3.00

Table 3.4 : part list and cost of Diodes

Miscellaneous				
Quantity	**References**	**Value**	**Stock Code**	**Unit Cost**
1	ARD1	ARDUINO UNO		250
1	BUZ1	BUZZER		2
2	Emergency Off, Emergency On	SWITCHES		1
1	LCD1	HDM32GS12-B		-

Miscellaneous				
Quantity	**References**	**Value**	**Stock Code**	**Unit Cost**
1	RL1	RLY-SPNO		3
1	RV1	10K	Digikey 3005P-103-ND	3
SUBTOTAL				260

Table 3.5 : part list and cost of Miscellaneous Devices

Total cost of Design Circuit: **293.50 cedis**

3.6 Construction of the Design Circuit

The system was constructed in the electronic Laboratory at the Kumasi Technical University.

CHAPTER FOUR

4.1 IMPLEMENTATION, TESTING AND INTEGRATION

The complete system as constructed was made up of the Arduino microcontroller hardware, the integration circuit, remote control and the hardwired level indicator. The hardwired level indicator shows the level of the water in the reservoir by indicating LED lights. The Arduino microcontroller also shows pump condition and level of water by an LCD display. At various conditions as programmed in the controller the relay to the pump is operated. The motor pump starts and begin evacuating or releasing the water from the sump tank whenever the water goes beyond half of the reservoir. The system is designed in such a way there is no over flow at the reservoir and it is not totally empty. The remote switches can be used to override automatic control when the need be (i.e. in situations where the reservoir needs to be cleaned or failure of the automatic control by the Arduino). In situation of pump failure the LCD would display the condition of the pump.

4.2 Component Test

Similar component like resistor were packed together. The other component include capacitors, switches, transformers, Diodes (rectifier), LED, and transistor were tested before the construction of the system. Each component was tested and the value read and recorded.

4.3 System Test

The system was powered and operated upon using several condition states. This conditions include making sure that the pump only start when the water level has gone below half of the reservoir, and stops when the water level has reach maximum. The LCD display was also tested to make sure correct level was display on the LED indication. The LCD display screen was also monitored in the testing process to display state condition of the system as during the operation of the system. A continuity test was conducted on the probes from the reservoirs to the system.

4.3.1 Water sample conductivity test

The system was tested with samples of water from different sources. These sources include Autonomy well water (sample A), Rain water (sample B), pipe borne water (sample C), well water from Kumasi Technical University (KsTU) (sample D) and filtered water (sample F) thus for temperatures below ten degree Celsius and at room temperature. The table below shows the condition of the system for various sources of water.

Table 4.1 Test on state condition of the system as against various source of water.

System component/Part	**System condition for various sample**					
	SAMPLE A	**SAMPLE B**	**SAMPLE C**	**SAMPLE D**	**SAMPLE F**	
					Below 10^oc	@ 25^oC
Hardwired indicator	Active	Active for ¼ and ½ full	Active	Active	Active for ¼ and ½ full	Active for ¼ full
Arduino Controller	Active	Active	Active	Active	Active	Active
LCD	Active	Active	Active	Active	Active	Active

Table 4.1 shows the state condition of the system as against various source of water.

The system was operational in all the sample of water that was used to test the system. In effect the water was conductive for all sources of water.

4.3.3 Continuity test of Reservoir Probes

The probes that transmit the signals from the reservoir to the system was tested using a multimeter. All probes from the reservoir showed conductivity and was continuous through to the system input intake.

4.3.3 Probes length effect test on system

In an attempt to analysis system operation for various reservoirs, various length of probes were considered for the operation of the system. Probes for signals to the microcontroller was increased in length. The test results are indicated in the table 4.2 below.

Table 4.2 showing the probe length test of the system

Probe Length(meters)	System Condition
20	Active and Work perfectly
15	Active and Work perfectly
10	Active and Work perfectly
5	Active and Work perfectly

Table 4.2 probe length effect on the system

4.4. Power rating of the system

An ammeter and a volt meter was used in measure the condition of the system as they operated.

Max voltage: 12V;

Power consumption: 4.8W (~400 mA assuming 12V)

4.5 Discussion

This system will be more sensitive and efficient to check the presence of water and prevent any problem resulting from overflows of water tanks at the autonomy hall. It uses an extended sensing device that may be conveniently disposed in the form of strips in areas of reservoir where water would be expected to accumulate. More particularly, the system operate on the principle of water detection through a resistive conductivity sensing system for detecting water in the low, quarter ,half ,three quarters and full condition by the use of the probe contacts which sends signals in the form of electricity to the Arduino microcontroller module and hardwired level indicator.

Throughout the testing we realize that changing the length of the probe up to maximum of twenty meters 20m has no significant change to the conduction of the system and thus works perfectly. The Arduino was able to detect change in length and work accordingly, LED and LCD also functioned as expected.

Also the test conducted on different samples of water showed some interesting results. The LED and LCD function correctly on some samples and others the motor will run without stopping even if it meets the condition coded for it in the programing. Some samples too shows no sign of failure or all conditions works perfectly from hardwire level indicator, LCD, LED, Arduino Microcontroller (programming) to the running of the motor. The results on each water sample is discussed below:

4.5.1 Sample A (Autonomy Well Water)

The test conducted on a sample of autonomy well water which happened to be the main focus the project turned to be a success since all conditions were met. The hardwire level indication was conductive at every level, LED displayed correct colours at every level, LCD ensured that the situation is monitored and no error functioning. When LCD indicated half full, relay opened the motor started to pump water back into the system as indicated in the programming. The same conditions was achieved for the change in length of the probe to a maximum of 20m.

4.5.2 Sample B (Rain Water)

When the test was conducted on rainwater, the system was active for ¼ and ½ full. Anything above ½ full was not displayed on the LCD. The LED light was on for ¼ and ½ full but was inactive for ¾ and full. The motor which is set to be active when the level of water in the reservoir is ½ and below full was now active and running and continued to ran since the other conditions ¾ and full couldn’t be detected and the LCD indicated for this condition.

4.5.3 Sample C (Pipe Borne Water)

The test conducted on pipe borne water was also a complete success. The system and its parameters work accurately with changes in length of the probe. LCD displayed each level of water in the reservoirs correctly, LEDs were on pertaining their correct level, motor started to run when the water reached ½ full and Arduino microcontroller also worked perfectly.

4.5.4 Sample D (The Well Water at KsTU)

The test conducted on the sample of well water collected from KsTU shows no difference from the sample from autonomy, LCD, LED, Arduino Microcontroller Module and the motor worked actively as programmed. Also change in length of probe to a maximum of 20m also works perfectly with the system.

4.5.5 Sample F (Filtered Water)

A. AT TEMPERATURE LESS THAN TEN DEGREES CELSIUS

When the test was conducted on filtered water with temperature below ten degree celcius, LCD display showed for ¼ and ½ full conditions and above such conditions the LCD showed error. The motor keeps running since the other conditions such as ¾ and full condition couldn't be detected by the system. LED displayed the correct corrects assigned for ¼ 1nd ½ full but showed none for ¾ and full conditions with the subsequent changes in length of probe up to 20m maximum.

B. AT ROOM TEMPERATURE

The test on filtered water at room temperature indicated ¼ full in the LCD even when the hardwire level indicator makes contact with all the levels. The LED designated for ¼ full is the only one which was activated and the motor wasn't active and running.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 Conclusion

The device is expected to be working effectively and efficiently provided the parameters discussed in chapter four is maintained constant. Nowadays, electronic components which are imported are very costly; hence this device (automatic water level indicator with activated alarm) must be kept in good condition to last longer.

There is therefore the need to abide by the precaution outlined under recommendation to prevent unnecessary failure of the device to ensure proper operation and save cost owning to lack of care.

5.1. Recommendation

Extensive growth of population development and technology has leads to the need of proper utilization of the natural resources especially water. Thus our proposed system and the review of all the possible implementation of technology is the first step toward prevention and proper utilization of water.

The system can be used in wide range of application, from repeater stations of water distribution, domestics use, elevator pit, agriculture purposes, processing industries and others. In fact anywhere undetected leak or overflow can occur with the water distribution or supply.

For its effective work the following must be considered.

a. The device must be kept away from heat source.

b. Must not be immersed in water.

c. Water drop on the device must be avoided.

d. The power supply to the device must be monitored.

With the above points stated so far, the device will be able to operate properly to solve any problem resulting from overflow, pump failures, well drying and leakages of water in our everyday life as far as the storage of water is concerned.

Finally, we recommended that this device should be introduce to more people.

Future works on this automatic control system may include but not limited to:

- Tasks such as water level detection and intimation of more volume of water in main tanks and reservoirs which are gathered from other tanks located in different places.
- GSM module can be used for status updates on mobile phone and related devices.
- In future this system can be modified as, it will detect the exact location of pressure drop and this system can also be applied to other remaining water distribution systems.
- A future review of automated water distribution system with the various controllers and parameters focuses on the entities such as proper supply, red alarm popups, filtration, flow control, supervision using various protocols can concluded with the future aspects of real time implementation in the municipal corporations where scarcity of water is the huge issue.
- Use the microcontroller automatic system to overcome the problem of the water theft, vandalism in water distribution system can be successfully implemented.

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Appendix A

Arduino Programming for automatic water supply system

Below is the programming source code for the Arduino microprocessor operation.

/* This is a program source code for the Design And Construction Of An Efficient Automatic Water Supply System: An Upgrade To The Autonomy Water Supply System. The system is made up of the Arduino module, Pump, integration circuit, and the buzzer. */

```
#include <LiquidCrystal.h>              //header file for using LCD functions
```

/* declaration of variables that would be used as inputs and outputs for the system. Sump represent the sump reservoir. Analogue input from reservoir are identified in A1 as quarter filled, A2 as half filled, A3 as three quarter filled, and A4 as fully filled. Pump signal pin is identified with pin 8 on the Arduino module. The Buzzer is identify with pin 7. */

```
int sump=A0; int qut=A1; int hlf=A2; int thf=A3; int ful=A4; int motor=8; int buz=7; int s;
int q; int h; int t; int f;
int i; //motor status flag          int v=100; //comparison variable(needs some adjustment)
int b=0;   //buzzer flag            int m=0;   //pump flag            int c=0;   //sump flag
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);  // declaration of LCD functional pins from Arduino.
```

/* this command is used to identify various output variables against the input variables. This means that the buzzer and motor forms the output for the Arduino module. Pin A0, A1, A2, A3, A4 are all inputs to the Arduino model*/

```
void setup()
{pinMode(qut,INPUT); pinMode(hlf,INPUT); pinMode(qut,INPUT); pinMode(ful,INPUT);
pinMode(sump,INPUT); pinMode(motor,OUTPUT); pinMode(buz,OUTPUT); lcd.begin(16,
2); digitalWrite(buz,LOW);}
```

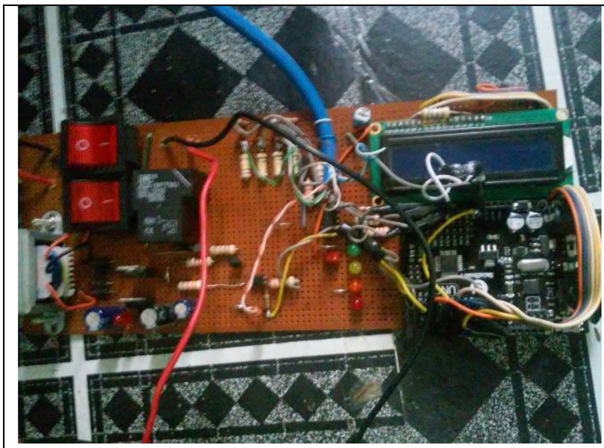
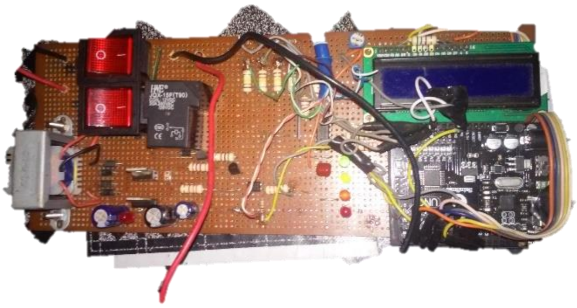
/*The operation of the system is written in this command line. The “if else” command is used to demonstrate the various conditions for the LCD, pump and buzzer to operate. The system

```
is such that the pump will come ON only when the water have drop to half way of the
reservoir. At every level of the reservoir the LCD will indicate word and graphical
representation.*/
void loop()
{//identify state condition for inputs and outputs
i=digitalRead(motor);s=analogRead(sump);
        q=analogRead(qut);h=analogRead(hlf);t=analogRead(thf);f=analogRead(ful);
lcd.clear(); if(f>v && t>v && h>v && q>v ) // state condition for full reservoir or filled
{lcd.setCursor(0,0); lcd.print(char(219)); lcd.print(char(219)); lcd.print(char(219));
lcd.print(char(219)); lcd.setCursor(5,0); lcd.print("FULL"); m=0; b=0;} else{if(f<v && t>v
&& h>v && q>v) //state condition for three quarter full of reservoir
{lcd.setCursor(0,0); lcd.print(char(219)); lcd.print(char(219)); lcd.print(char(219));
lcd.print("_"); lcd.setCursor(5,0); lcd.print("3/4th"); b=0;} else { if(f<v && t<v && h>v &&
q>v) //state condition for half full of reservoir {lcd.setCursor(0,0); lcd.print(char(219));
lcd.print(char(219)); lcd.print("_"); lcd.print("_"); lcd.setCursor(5,0); lcd.print("HALF");
m=1; b=0;
} else if(f<v && t<v && h<v && q>v)
/*state condition for one quarter full of reservoir. System delays for 10mins then switch pump
ON */
{ lcd.setCursor(0,0); lcd.print(char(219)); lcd.print("_"); lcd.print("_"); lcd.print("_");
lcd.setCursor(5,0); lcd.print("1/4th"); delay(600000); m=1; b=0;} else { if(f<v && t<v &&
h<v && q<v)  //state condition for below quarter level or empty { lcd.setCursor(0,0);
lcd.print("_"); lcd.print("_"); lcd.print("_"); lcd.print("_"); lcd.setCursor(5,0);
lcd.print("LOW"); b=0;} else{ /*Error condition occurs when pump when pump is OFF and
Water level is low. This would display ERROR on the LCD and cause the buzzer to sound*/
```

```
digitalWrite(motor,LOW); lcd.setCursor(0,0); lcd.print("ERROR!"); b=1;}}}}
if(i==HIGH) // state condition for the operation of motor to be displayed on LCD
{lcd.setCursor(0,1); lcd.print("Motor ON");}
else { lcd.setCursor(0,1); lcd.print("Motor OFF");} if(s>v && m==1)
{digitalWrite(motor,HIGH);} if(s<v) // Sump condition to trigger reservoir pump. Pump is
ON only if sump is full { digitalWrite(motor,LOW); lcd.setCursor(11,0); lcd.print("Low");
lcd.setCursor(11,1); lcd.print("Sump"); c=1;} if(s>v) {c=0;} if(m==0)
{digitalWrite(motor,LOW);}
if(b==1 || c==1) // state condition of buzzer for ERROR state of pump {
digitalWrite(buz,HIGH); delay(500); digitalWrite(buz,LOW);} else
{digitalWrite(buz,LOW);} delay(100); lcd.clear
```

Appendix B

Gallery

	
Constructed system	**Constructed system**
	
Probes(CAT 6 cable) and System	

Appendix C

Project time line

Activity	Time line																											
	`November ,2016				December, 2016				January 2017				February ,2017				March ,2017				April ,2017				May, 2017			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Arduino training									x	x	X	x	x	X	x													
System modelling				x	x	X																						
Acquiring components												x	x	X														
Design of system											x	x	x	X	x	x	x	x	X									
construction															x	x	x	x	X									
Write up							X	x	x	x	x	x	x	X	x	x	x	x	X	x	x	x	x	x	x	X		
Testing and evaluation																	x	x	X	x	x	x						