DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FEDERAL UNIVERSITY OYE EKITI

DESIGN AND IMPLEMENTATION OF AUTOMATIC WATER TAP CONTROLLING SYSTEM

BY

BOLUWADE ADEKUNLE BENJAMIN
(EEE/13/1103)

FEBRUARY, 2019

DESIGN AND IMPLEMENTATION OF AUTOMATIC WATER TAP CONTROLLING SYSTEM

BY

BOLUWADE, ADEKUNLE BENJAMIN

EEE/13/1103

A PROJECT REPORT SUBMITTED TO DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING FEDERAL UNIVERSITY OYE EKITI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL AND ELECTRONICS

FEBRUARY, 2019.

DEDICATION

I dedicate this project to God Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this program and on His wings only have I soared. I also dedicate this work to my stepfather, Mr. Adelere Bhadmus and my mother, Mrs. Kemi Bhadmus.

DECLARATION OF ORIGINALITY

This project is all my own work and has not been copied in part or in whole from any other source except where duly acknowledged. As such, all use of previously published work (from books, journals, magazines, internet, etc.) has been acknowledged within the main report to an entry in the References list.

I agree that an electronic copy or hardcopy of this report may be stored and used for the purposes of plagiarism prevention and detection.

I understand that cheating and plagiarism constitute a breach of university regulations and will be dealt with accordingly

SIGNED: DATE:

OFFICIAL STAMP

CERTIFICATION

This is to certify that the project titled **"DESIGN AND IMPLEMENTATION OF AUTOMATIC WATER TAP CONTROLLING SYSTEM"** by **BOLUWADE, ADEKUNLE BENJAMIN** has been read and approved as meeting the requirements of the Department of Electrical and Electronics Engineering in the Faculty of Engineering, Federal University, Oye-Ekiti for the award of Bachelor of Engineering (B. Eng.) degree in Electrical and Electronics Engineering.

____________________	________________
Engr. Gerald K. Ijemaru (Project Supervisor)	Date
____________________	________________
Dr. J.Y. Oricha (Head of Department)	Date
____________________	________________
(External Supervisor)	Date

ACKNOWLEDGEMENT

My deepest gratitude goes to God who has provided all that was needed to complete this project and the program for which it was undertaken for. There was never lack or want. Throughout this entire study, He took care of everything that would have stopped me in my tracks and strengthened me even through my most difficult times.

My sincere gratitude, appreciation and thanks goes to my guardians Mr. & Mrs. Bhadmus for their financial and moral supports. I equally thank my brother, Segun Boluwade for standing by me and giving me the support which I needed.

My utmost appreciation also goes to my supervisor who also doubled as being the Electrical and Electronics Engineering department project coordinator, Engr. Gerald K. Ijemaru whose contribution and constructive criticism has pushed me to expend the kind of efforts I have exerted to make this work as original as it can be. Thanks to him I have experienced true research and my knowledge on the subject matter has been broadened. I will never forget you sir. I extend my immense appreciation to the dapartment Acting H.O.D, Dr. J. Y Oricha and the entire staff of the department. You all have impacted much in me. God bless you all.

Finally, my profound appreciation goes to all my friends and well-wishers especially Balogun O. Isaac and Adelaja M. Tiwatope who one way or the other have been there and have continually prayed for my success. God bless you.

ABSTRACT

Water is an essential resource in the world and currently household drinking water is an important asset to save the life due to shortage of water in the earth. This paper describes the design and implementation of an automatic water tap controlling system. This developed system helps reduce water wastage by turning off water tap automatically. The water level detector detects different specified levels of water running into the receiving-end bucket. Upon fullness of the bucket, the device turns off the water tap without the intervention of the user. The aim of this work is to implement a system for controlling water tap automatically.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVATIONS

PIC – Programmable Logic Circuit

DC - Direct Current

GSM - Global System for Mobile communication

SMS - Short Messaging Service

UHF - Ultra High Frequency

RFID - Radio Frequency Identification

IC - Integrated Circuit

PIR - Passive Infrared

LCD - Liquid Crystal Display

RTC - Real-Time Clock

IoT - Internet of Things

PLC - Programmable Logic Controller

IR - Infrared

LED - Light Emitting Diode

FET - Field Effect Transistor

SCR - Silicon Controlled Rectifier

RISC - Reduced Instruction Set Computer

ROM - Read Only Memory

SCADA - Supervisory Control and Data Acquisition

ADC - Analog-to-Digital Converter

PHCN - Power Holding Company of Nigeria

USART - Universal Synchronous/Asynchronous Receiver/Transmitter

EEPROM - Electrically Erasable Programmable Read Only Memory

SRAM - Static Read Access Memory

LIST OF APPENDICES

CHAPTER ONE

1.0 INTRODUCTION

Water supply is the provision of water by public utilities, commercial organizations, community endeavours or by individuals, usually via a system of pumps, pipes and taps. Tap water (running water, city water, town water, municipal water etc.) is water supplied through a tap (valve). Its uses include drinking, washing, cooking, and the flushing of toilets. Indoor tap water is distributed through indoor plumbing, which has existed since antiquity but was available to very few people.

In everyday life, there exists 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. Automatic systems are being used in a wide range of fields ranging from medical sciences to financial sciences, education, law, and so on. Several of them are embedded in the design of everyday devices.

Many times it happens in restaurants, malls, hotels and public boreholes, specifically at home that after fetching water we forget to switch off the tap which leads to wastage of water and flooding of premises.

The circuit described here will automatically turn off the tap when the water has gotten to the peak of the bucket/container receiving the water. This will lead to less wastage of water, reduce tendency of premises being flooded and help keep hands and germs away from tap heads.

1.1 BACKGROUND OF THE PROJECT

This project is carried out so as to provide a means of fetching water automatically from taps, reduce wastage of water and eliminate flooding of premises which may result from overfilling of the water receiving container. Automatic water tap controllers were first developed in late 1980s but were not produced for commercial use until 2000s when they first appeared to the general public at airport lavatories. Because of their assistive qualities, automatic water tap controllers are often at assistive living establishments and places where the elderly and handicapped individuals call home. Automatic water tap controllers are water saving devices, helping save 70% of the water that would otherwise swirl down the drain unused and conserve as much as 3-5% of the water used by standard household [2]. Other benefits of automatic water tap controllers are found in inhibiting the spread of germs which are known to thrive on water tap handles, as well as help prevent or mitigate incidents caused by hot water flowing out of the tap.

In the 20th century, the means of controlling water from taps exists as automatic faucets which are common in public wash-rooms, particularly in airports and hotels where they are supposed to reduce water consumption and reduce the transmission of disease causing microbes. These automatic faucets were as well found in some kitchens and in wash-rooms of some private residences. Other common places where they are found include pets or livestock rearing centres, whereby the presence of an animal allows water to flow from tap to water trough or dish.

In most recent times however, the use of PIC microcontroller for the control of water taps action has made the systematic ways of controlling water taps more sophisticated. It is now possible for users in malls, offices and homes to running taps with little or no attention. This method also brings in other advantages like cost effectiveness and much needed efficiency.

This system makes use of conductive nature of water to determine the water levels in a water receiving container and the rotary ability of DC motor to turn off or on a water tap depending on the output needed.

The inability of water tap users to control running taps especially due to their forgetfulness can bring about water wastage, flooding of premises and damage of properties that are water irresistible. With this project "automatic water tap controller", these can be avoided.

1.2 STATEMENT OF PROBLEM

One of the issues most homes, malls and food industries are having in this present time is the inability to control tap water automatically. Most times we forget to turn off taps which makes the tap to keep running endlessly. This has resulted in inefficient use of water as well as flooding of premises that are meant to be kept dry. Making use of the conductive nature of water, we designed and developed an automatic water tap controlling system.

This system is capable of turning off the tap automatically, with the help of water level detector which monitors the water levels in the container, when the water is full.

1.3 MOTIVATION

Nowadays, the need to have control over manual water taps in homes, offices, malls and industries is in high demand especially in countries like Germany, El Salvador and Guatamala where water is scarce and expensive to get. In these countries and some other ones, means of getting a precise amount of water from taps, in order to prevent water wastage and tendency of flooding the water taps environment, is in dire need. Besides, turning either on or off of taps can be a difficult task for people suffering from arthritis, kids, handicaps and aged people, hence, the reasons for embarking on this project.

1.4 SIGNIFICANCE OF THE STUDY

The significance of this work is to have automatic control for water tap which can significantly reduce water wastage and limit outflow of water to the required amount needed at a particular time. Besides, this device can eliminate cross-contamination by keeping hands and germs away from the tap knob. This project is important in places where optimum or quantified amount of water is needed for a particular purpose. Places like food industries, paint manufacturing industries and homes.

1.5 AIM AND OBJECTIVES

The aim of this project is to design and construct an electronic circuit which can control the water tap operation using PIC microcontroller (atmega-8) and the use of calibrated water level detector and water level indicator.

The Objectives of the project are:

(i). To provide a means of fetching water from tap without turning the tap knob manually.

(ii). To develop a device which will prevent wastage of water that always occurs at water taps and flooding of premises by providing a means of cutting off the water supply when the container is full.

(iii). To construct an electronic circuit that can be used to fetch a quantified amount of water.

(iv). To provide a device that will detect and display the different water levels in a container.

(v). To reduce direct contact with the tap knob in order to prevent both damage and cross-contamination by keeping hands and germs away.

1.6 SCOPE OF PROJECT

To ensure the project is heading the right direction and achieve the objectives. The project uses microcontroller and water levels detector in the development of the automatic water tap controlling system which can help reduce water wastage by monitoring different water levels up to the maximum level, prevent direct contact with water tap knobs thereby inhibiting the spread of germs from one user to another and also reduce risk of flooding premises. The detector makes use of the conducting nature of water to detect the water levels, the microcontroller controls the action of the servomotor when the container is filled and helps drive the tap to close.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Water wastage can develop from even the little unattended water wasting uncontrolled. Engineers have made great efforts in finding means of reducing the effect of water wastage with devices like the water dozer. Researchers in countries like Germany, where water is very scarce, have done a good job in trying to put stop to water wastage and in saving lives and premises from flooding. Overuse and misuse of usable water are the common problem in our daily life and also we never think about repairing dripping taps. Very often we keep water tap open to fill a bucket but we forget to close at the right time. Sometimes we go out after keeping water tap open (while absent mind and forget to close), which causes a huge water misuse. However, it is possible to minimize or overcome this problem, if the right technology can be effectively introduced and applied. This chapter states all the studies and reviews from previous projects, journals and sources that help to successfully design, build and implement the entire task during this automatic water tap base liquid control project. The studies include improvement and modification of design from previous projects.

2.1 RELATED WORKS

A number of previous related research works discussed about water level monitoring system. In general, the results from Automatic Water Tap Controlling System are in line with the previous research works.

Various researches and works have been done in the direction of this project, the very relevant ones are discussed below:

Authors in [1] developed an accurate and controlling system for monitoring of lakes and inland seas in order to prevent flooding. Level variation for lakes and reservoirs and surface-volume variations are calculated using a combination of various satellite images and radar altimetry. An operating data centre based on remote sensing and control was achieved for Global Terrestrial Network for Lakes (GTN-L) to prevent flooding.

In [2], the authors develop a flood warning system that incorporates telemetered rainfall and flow/water level data measured at various locations in the catchment area. Real-time accurate data collection is required for this use and sensor networks improve the system capabilities. It is a developed low-power and long-range communication device, so-called DatalogV1. DatalogV1 provides automatic data gathering and reliable transmission. DatalogV1 incorporates self-monitoring for adapting measurement schedules for consumption management and to capture events of interest.

In [3], Jiang et al. design a Water Environmental Monitoring System based on Wireless Sensor Networks. The system consists of three parts: data monitoring nodes, data base station and remote monitoring centre. This system is suitable for the complex and large-scale water environment monitoring such as reservoirs, lakes, rivers, swamps and shallow or deep groundwater.

Authors in [4] developed a one kind of Water Level Monitor Recording Instrument using IC comparators and the microprocessor interrupt function. The researchers developed this measuring and recording instrument using microprocessor, driver circuit, stepper motor, electric conduction metal measured line, volume line drum and water level supervised gauge head. The constructed project is measure accurately and indicate the level of water in a volume line drum.

Authors in [5] developed a Water-level Monitor for Bore-well and Water-tank Based on GSM. The project sees into the problem that there is no early warning system to monitor the tank water level when it has reached the critical level. Hence, water level monitoring system is provided in a tank as well as a bore well. . This problem is solved by using this GSM based system that will automatically make a call to the user mobile phone, when the water level in the bore-well drops below threshold or rises to the threshold level for pumping. The user can also remotely switch on or off the pump motor by sending a SMS from his mobile phone.

In [6], authors implement a New-type Sensor for Monitoring Oil-water Interface Level which is capable of monitoring, simultaneously, oil-water interface level and oil level in a single tank. A liquid level sensor was developed, suitable for determining the oil-water interface level and oil level.

Authors in [7] teamed up to develop a system called an Automatic Liquid Level Indication and Control using Passive UHF RFID Tags. This project proposes a new perspective to the liquid level monitoring and control technique by deploying energy efficient passive UHF RFID tags as liquid level sensors.

In [8], Anjali implements a system called an Automatic Wash Basin Tap Controller using NE555 timer IC which can be used at restaurants, malls and specifically at home while brushing teeth where we forget to switch off the tap which leads to wastage of water. The circuitry of the project will automatically switch on the tap water when a hand is placed below the tap outlet and also put it off when the hand is removed.

The author in [9] talked of a project called an Automatic Public Tap Control System using PIR sensor to prevent wastage of water. The technology generally used to develop this project is PIR sensor, a microcontroller, motor driver and a DC motor. The PIR sensor will recognize the presence of a person by taking the temperature difference. An MSP430 (16-bit microcontroller) or any other microcontroller can be used to drive the DC motor to open or close the tap.

Authors in [10] developed a system called Automatic Water Tap System which is a mechanism through which water can be fetched automatically from public taps and taps at home. This system is equipped with infrared motion detector where the infrared is used to detect the movement around the water tap. By using infrared motion detector, users only need to place their hands under the water tap and after the detector detects the movement in designated area the output, which is water, will come out.

Hareendran in [11] is another researcher that worked on Automatic Water Tap (Faucet/Valve) Controller. The heart of the circuit is the Passive Infrared (PIR) module. When the PIR sensor senses motion of hands under the faucet, the solenoid valve goes to open state and water is allowed to drop off the faucet. The solenoid valve closes when the PIR sensor senses that the hands under the faucet have been removed.

Author in [12] designed and constructed an Automatic Pumping Machine for Water Supply. This project emphasizes on the construction of automatic pumping machine which in turns provide a simple logical, versatile and economical circuit which turns on the pump when water in the tank fall below the minimum level and also, off process is achieved by incorporating into the pumping system; a sensor, a responder and an actuator.

In [13], Rahman et al. work on the design of automatic controlling system for tap-water using floatless level sensor. The developed system can automatically control the water tap accordingly when the floatless level sensor senses low level of water in the tank. Also, the system has ability to activate the relay which starts solenoid valve. The system is low-cost and the result shows an autonomous plus robust monitoring system with satisfactory result which is relatively simple to install.

Authors in [14] summarized the results of a study to recommend a new tide and water level measuring system to replace the existing instrument used by the National Ocean Survey. They focused on the sensor subsystem while the companion papers address the recording subsystem and other aspects of the problem. Authors in [15] presented a multi-electrode capacitance sensor and its system used in measuring sedimentation volume, water level, ice thickness of a river or reservoir. Based on the different characteristics of the capacitor in the different mediums such as in ice, water, sediment; a multi-functional, multi-electrode and non-closed capacitance sensor is designed. That is, a multi-electrode capacitance sensor is set up around a long hollow circular drum, which can be vertically placed in a river or reservoir.

In [16], Hicks et al. present an automatic water level monitor which consists of water level sensor, comparator circuit, microcontroller, display unit, and pump. Taking advantage of the electrical conductivity property of water, they used copper conductors as the water level sensor. A Liquid Crystal Display (LCD) served as the output unit which shows the status of the system on a screen. Authors in [17] introduced the notion of water level monitoring and management within the context of electrical conductivity of the water. More specifically, they investigated the microcontroller based water level sensing and controlling in a wired and wireless environment and then proposed a web and cellular based monitoring service protocol which determines and senses water level globally.

To control water automatically for plant irrigation system, the authors in [18] used bluetooth module with vocal and text commands. The aim of the work is to simplify the method of irrigation using vocal commands through the GSM technology. The Farmer only need to open the application and utter the control commands through his phone. Authors in [19] were concerned about the pipes and pumps sizes used in order to reduce the cost of building a water saving system using numerical optimization methods which offer a powerful new technology for pump users when combined with pumping system analysis software.

In [20], Rojiha proposes a sensor network based intelligent control for power economy and efficient oil-well monitoring. His paper consists of several basic sensors such as voltage sensor, current sensor, oil pressure sensor, temperature sensor and gas sensor. These sensors are used for oil well data sensing, that is, they sense and collect data from the oil well. Authors in [21] deployed computing techniques in creating a barrier to wastage in order to not only provide more financial gains and energy saving, but also help the environment and water cycle which in turn ensures that water is saved for future. Their paper presents research in embedding a control system into an automatic water pump controller through the use of different technologies in its design, development and implementation. Authors in [22] developed a tap-control control system using smart phones and arduino boards. This system can be used to control the taps for plant watering and other taps at home, malls and restaurants through internet by sitting anywhere in the world. Arduino 2560 board with Ethernet Shield is used for this project. The arduino is coded using arduino codes and the application development is done using android programming.

In [23], Devika et al. design a plant watering system to ease the work of gardeners and also to save water. The project uses arduino board, which consists of atmega-328 microcontroller. It is programmed in such a way that it will sense the moisture level of the plants and supply the water if required. Paper [24] presents the development of an online mobile application that monitors and controls the water flow through taps whenever there is an unusual reading of the water usage at home. The authors of the work state that the primary goal of the system is to enable a user in monitoring and controlling the water flow at home via an online mobile application's graphical user interface (GUI). The authors further explain that the GUI will make the monitoring process more efficient and convenient for house owners. Authors in [25] presented the design of an automatic water level controller aimed at providing an appropriate control to pump water to an overhead tank when empty and automatically stop the pump when the tank is full. The system is said to incorporates two mains contactors which are energized to provide a direct online start of the motor, an overload relay which senses the presence of excess current and disconnect the supply and also a mercury float switch which uses the Archimedes principle of floatation to provide the electrical contact to switch ON or OFF supply to the motor when the tank is empty or full respectively. The authors opine that the system is capable of providing a seamless utilization of water at domestic and industrial level without causing spillage or flooding of premises.

In [26], Uday designs and presents an automatic water level controller. He incorporates sensors in the overhead tank and the lower level container. He stated that the sensor in the overhead tank triggers the pump to work whenever there is need for water in the lower level container. Authors in [27] proposed an embedded system for automatic control of irrigation and water saving on farm by using GSM technology. Their project has wireless sensor network for real-time sensing and controlling of an irrigation system and the system provides uniform and required level of water for the agricultural farm and it helps mitigate water wastage. In the project, microcontroller is interfaced through temperature sensor, humidity sensor and also interfacing to GSM through MAX 232. Author in [28] opined that if all the manual taps are replaced with smart ones that open and close on their own automatically not only can we save water but also have a healthier lifestyle since we do not have to operate the tap with our dirty hands. Hence, he developed a system called automatic water dispenser using arduino and a solenoid valve that can automatically dispense water when a glass cup is placed under it.

Authors in [29] described water efficiency practice and how to reduce water usage through implementation of efficient irrigation technology, effective irrigation scheduling, and soil moisture determination and retention. This practice is designed to minimize water losses from evaporation, deep percolation and run-off in agricultural practices. [30] presents the design and development of irrigation controller for water saving built around PIC16F877A microcontroller. The system consists of microcontroller, peripherals including RTC, LCD and driver circuit relay to switch on/off a motor.

In [31], R.Balathandapani et al. develop an automatic rain water and crop saving system using embedded technology. The main theme of the project is to save the crops from the heavy rain and also save the rain water. The rain sensor and soil moisture sensor are used for the working of the developed automatic roof. This system protects the crops with the help of the automatic roof which covers the whole field. This system also use emerging applications of GSM. It is used to report the conditions in the field through SMS to the mobile phone. Authors in [32] presented a project concerned with the development of water level monitoring system with an integration of GSM module to alert the person-in-charge through Short Message Service (SMS). The water level is monitored and its data sent through SMS to the intended technician mobile's phone upon reaching the critical level. The prototype was tested and functioned properly as a means to reduce the risk of unexpected shortage of water supply.

In [33], T.Jayasree et al. propose an automatic water distribution by time and water pH measurement which is also capable of detecting leakage and also tank water level measuring system using PIC microcontroller and GSM module. The authors stated that the motivation for the study, is to deploy computing techniques in creating a barrier to water wastage in order to not only provide more financial gains and energy saving, but also help the environment and water cycle which in turn ensures that we save water for future use. Authors in [34] opined that water supply with continuous monitoring makes a proper distribution so that, we can have a record of available amount of water in tanks, flow rate and abnormality in distribution line. Hence, they came up with a system that focus on continuous and real time monitoring of water supply in Internet of Things (IOT) platform. Monitoring can be done from anywhere as central office using Adafruit, as free sever data are continuously pushed on cloud so that we can see data in real-time operation. Authors of paper [35] developed a prepaid water meter; a technology which allows prepaid billing of water along with sufficient monitoring readings mechanically from an outside place without any human intervention. This system gives fast and accurate billing of water as well as prevents any abuse of it. A technique having adequate security support, for prepaid charges of water using Short Message Service (SMS) is incorporated. The prepaid water meter is used for measuring the water volume used. A sensing system is also incorporated to generate an equivalent voltage related to the amount of water used and hence, energy consumed per time can also be determined.

Authors in [36] stated that in countries like Indonesia, Mexico, Guatemala, and El Salvador, a city water authority supplies the clean water and pumps it into large ground-level storage tanks. A resident's water pump then pumps the water to a water tank on top of his/her house. When the water level in the ground-level storage tank becomes too low, the pump siphons air and shuts down, requiring a resident to manually prime the water pump to get it running again. Residents struggle to monitor the water level of the tanks effectively and keep the pump running properly. To solve this problem, the authors designed an automatic water pump controller system which monitors the water levels and controls the pump as necessary to prevent breakdown and maximize water storage without overfilling the rooftop tank and wasting water. The author in [37] designed a water outputting system as an idea of improvement to current existing touchless water faucets used in public places or at home. The system includes a hardware circuit part which is in charge of signal acquiring and processing, and a mechanical part to produce corresponding water output. It is a microcontroller-based system which incorporates infrared sensors. The author in [38] opined that lack of water is a serious problem nowadays and that, water-saving technology is a hot topic all over the world especially in agriculture. He designed an automatic precision water-saving irrigation control that is sensor based. The system incorporates soil water sensor, plant physiological meter, irrigation controller, wireless communication unit and control software. The system has high precision, good linearity and rapid response speed. Authors in [39] developed a control mechanism for controlling and monitoring water levels in a water tank which is a key component of their boiler system. For the boiler system, water level is controlled by PLC Omron C200H Sysmac using the push button panel attached to the plant or also can be controlled and monitored by PC using Wonderware InTouch 10.5. Authors in [40] limited their research work to water wastage due to overflow in overhead tanks. The solution they proffered is the use of Automatic Water Level Controller. The operation of the water level controller works upon the fact that water conducts electricity. So water can be used to open or close a circuit. As the water level rises or falls, different circuits in the controller send different signals. These signals are used to switch ON or OFF the motor pump as the authors desired.

To maintain a strategic distance from water spillage and to use out-coming water from public water-taps in a proficient way, authors in [41] designed and presented an automatic public tap control using IR sensor and water level indication using GSM. The authors accounted that most times when a compartment is filled, nobody takes consideration to close the tap hence the system constructed utilizes IR sensor and water level indicator to forestall water wastage and monitor water level respectively. Also, they proposed a future work which will utilize 8051 microcontroller and IR based programmed open tap control incorporating GSM technology which will send message to client when tank is void.

Authors in [42] presented their research in embedding a control system into an automatic water pump controller through the use of different technologies in its design, development, and implementation. The system uses microcontroller to automate the process of water pumping in an over-head tank storage system and has the ability to detect the level of water in a tank, switch on or off the pump accordingly and display the status on an LCD screen.

CHAPTER THREE

HARDWARE DESIGN METHODOLOGY

3.0 DESIGN METHODOLOGY

The hardware of this automatic water tap controlling system includes 8-bits AVR ATMEGA-8 PIC Micro-controller, 12V DC Motor for turning the tap either ON or OFF, water level detector and indicator. The system is low cost unlike other systems that serves same purpose and it is low power consuming. The water level detector is calibrated to monitor four different levels with each having its respective indicator. It can be used to fetch a precise quantity of water. The system is designed in such a way that the user will only apply little or no effort in fetching water from taps.

1. This project required an interconnection of the water level detector, a microcontroller, tap driver circuit and water level indicator as illustrated below.

2. The water level detector consists of conductive element, which in this case is, solder lead melt on a flat and long plate. It detects the water level in the final container.

3. The microcontroller board utilized is the Arduino-Uno R-3 board, which contains primarily the ATMEGA-8 chip and serial input and output terminals. The microcontroller primarily functions as an analogue to digital converter. It also stores the code which describes the sensor output behaviours and serial data output for the DC motor.

4. The DC motor is connected to the microcontroller. The appropriate size, speed and torque requirements have to be known first in order for it to be used for the sake of this project. DC motors have enough speed, peak torque and rms torque capabilities, along with optimal gearing arrangement, to meet the load arrangement, which is the tap to be driven as well as the cost objective. Equally important is selecting the size of the drive to be used. The reason why DC motor is used in this project is because it is very easy to control with the PIC microcontroller. 12VDC is required as a source to this 0.35A DC motor.

5. LEDs, which serve as indicator, are incorporated into this project in order to display various water levels in the receiving end container.

3.1 REQUIREMENTS SPECIFICATION/COMPONENTS USED

The water level detector and indicator, passive components and microcontroller used require low DC voltage, requiring between 3.3V and 5V. The DC motor is the only device that requires 12V. Below is an overall selection of the components used in design and implementation of the automatic water tap controller:

- The atmega-8 Microcontroller
- The calibrated water levels detector
- The water level indicator (LEDs)
- 0.35Amp DC Motor
- Resistors
- Capacitors
- Transistors
- Diodes
- Diac and Triac.
- ATMEGA-8 MICROCONTROLLER

The heart of the system is the atmega-8 microcontroller which has 28-pins/ports, all which are input pins by default but enabled as output pins by program.

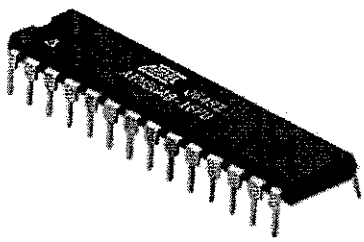


Figure 3.1: The Atmega-8 Microcontroller

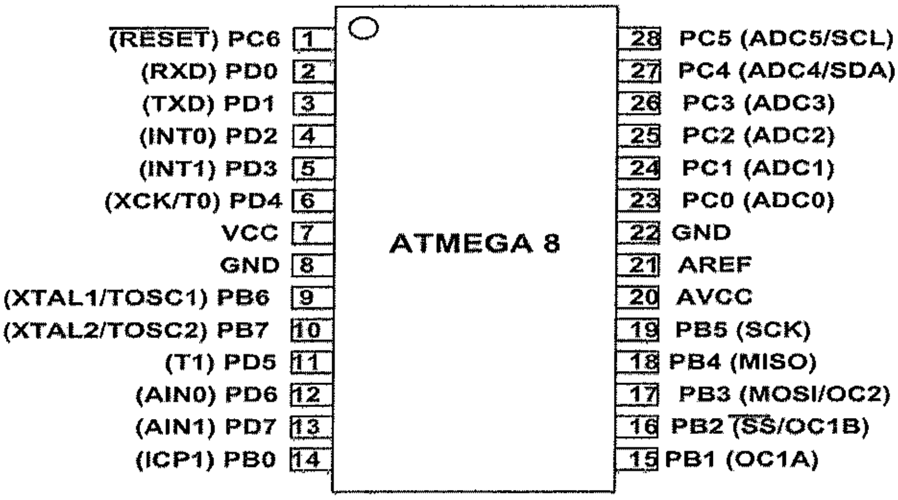


Figure 3.2: The pins of the Atmega-8 Microcontroller.

- ✓ Pin 1/PC6/Reset is the input pin on which components like resistors, diodes and capacitors are connected; 10kΩ, diode IN4007 and 1μF capacitor. These values are chosen and used as specified in the datasheet of the atmega-8 as designed by the manufacturer.
- ✓ Pins 7, 20 and 21 are positive pins
- ✓ Pins 8 and 22 are negative pins
- ✓ Pins 12 and 13 are for the servomotor driver circuit. This is used to control or drive the servomotor which in turn drives the tap to either open or close. The microcontroller has the following features:

- ❖ High-performance, Low-power Atmel AVR 8-bit Microcontroller
- ❖ Advanced RISC Architecture

  i. 130 Powerful Instructions

  ii. Most Single-clock Cycle Execution

  iii. 32 × 8 General Purpose Working Registers

  iv. Fully Static Operation

  v. Up to 16MIPS Throughput at 16MHz

  vi. On-chip 2-cycle Multiplier
- ❖ High Endurance Non-volatile Memory segments

i. 8Kbytes of In-System Self-programmable Flash program memory

ii. 512Bytes EEPROM

iii. 1Kbyte Internal SRAM

iv. Write/Erase Cycles: 10,000 Flash/100,000 EEPROM

v. Data retention: 20 years at 85°C/100 years at 25°C(1)

vi. Optional Boot Code Section with Independent Lock Bits

vii. In-System Programming by On-chip Boot Program

viii. True Read-While-Write Operation

ix. Programming Lock for Software Security

The microcontroller controls every other units of this project since it is the heart of the entire circuitry. The automatic water tap controlling system consists of a 5-water level calibrated detector which detects different water levels and a corresponding water level indicator is provided for display.

The PIC microcontroller controls the activities of the system in the following way:

On pin 12, when the first transistor BC548 (Q6) is at logic 1, that is, ON-state to the base, emitter and collector bridges (all connected together), this sets the output to zero/put it off, thus the base input to transistor, Q8 is zero and there will be a flow of voltage as well and thus transistor Q8 is put ON, this flows to transistor Q9. At transistor Q9, because of positive input which is zero/OFF state, the two terminals are opened, that is the emitter and collector, this if goes to ON state, put ON the transistor, the output of transistor Q9 goes to Q10 which put it off but because of the external power of +12V, transistor Q10 is turned ON. Its output also goes to transistor Q7, at the point transistor Q7 is turned OFF and this output goes to the servomotor. At this state, the servomotor will not roll since Q7 ends at logic 0- OFF state.

On pin 13, however at logic 0, goes through all the explanation above, the final output is logic 1- ON state. Therefore, the servomotor rolls.

The logic 0 and 1 will keep changing, in values; this makes the servo motor to roll in one direction and not roll in the other direction for the tap control.

- ✓ Pins 14 and 15 are used for manual control of the tap, thus when the button is pressed - the tap opens and when another button is pressed - the tap closes. Pins 14 and 15 represents the open and close switches on the microcontroller.

- CALIBRATED WATER LEVEL DETECTOR

The calibrated water levels detector can be said to be a calibrated rule. It detects the level in which the water running into the bucket gets to. The detector has four levels: min, ½, ¾ and max. All of this has a common ground. The detector is made with a conducting material which ,in this case, is soldered lead. Whenever water gets to any of the levels, the conducting material senses it and send the signal to the microcontroller which tells the level the water in the bucket has reached.

Figure 3.3: Calibrated water level detector

- WATER LEVEL INDICATOR

The water levels indicator consists mainly the LEDs. LED (light emitting diode) is the most widely used of all optoelectronic devices which emits a fairly narrow bandwidth of visible (usually red, orange, yellow, or green) or invisible (infrared) light when its internal diode junction is stimulated by a forward electric current. LEDs have typical power-to-light energy conversion efficiencies some 10 to 100 times greater than a simple tungsten filament lamp and have very fast response times (less than 0.1µS, compared to 10s or 100s of milliseconds for a tungsten lamp), and are thus widely used as visual indicators and as simple flashing light units. This project makes use of red LEDs to display the water level in the receiving bucket as detected by the water level detector.

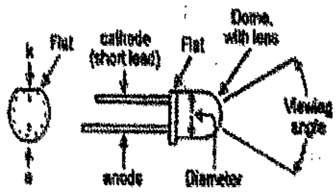


Figure 3.4: Typical physical details of a LED

- DC Motor

The tap roller consists mainly the DC motor that rotates both in clockwise and anticlockwise directions. The tap roller houses the DC motor. The disc on the DC motor is made in-phase with the roller fixed on the tap so much so that as the DC motor rotates in, say, anticlockwise direction, the roller on the tap will rotate in the clockwise direction.

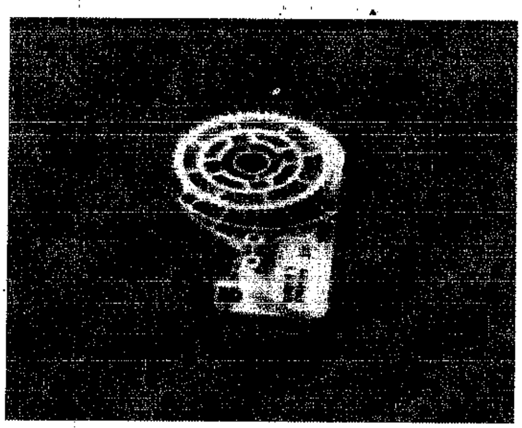


Figure 3.5: DC Motor and its disc

- AC/DC TRANSFORMER

This is an electrical device which converts alternating current which periodically reverses direction to direct current which flows in only one direction. For this automatic water tap controller, two AC/DC transformers are used. Both transformers convert 240VAC to 12VDC for use by the DC motor and PIC microcontroller. Transformer, T_1 powers the motor driver circuit while transformer, T_2 powers the control circuit unit. The two transformers turn ratio is as calculated below:

V_p = voltage induced at the primary winding

V_s = voltage induced at the secondary winding

N_s = Number of turn induced in the secondary winding

N_p = Number of turn induced in the primary winding

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{240}{12} = \frac{20}{1}$$

Therefore, the transformers have rated turn ratio of 20:1.

➢ RESISTORS

Resistors are the most commonly used of all electronic components, to the point where they are almost taken for granted. There are many different resistor types available with their principal job being to resist the flow of current through an electrical circuit, or to act as voltage droppers or voltage dividers. They are passive devices, that is they contain no source of power or amplification but only attenuate or reduce the voltage signal passing through them. When used in DC circuits the voltage drop produced is measured across their terminals as the circuit current flows through them while in AC circuits the voltage and current are both in-phase producing 0° phase shift.

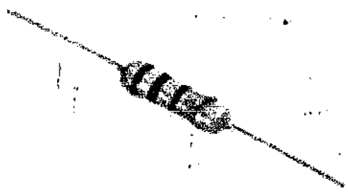


Figure 3.6: A resistor

➢ CAPACITORS

A capacitor is also a passive component which stores energy in the form of an electrostatic field which produces a potential (static voltage) across its plate. In its basic form a capacitor consists of two parallel conductive plates that are not connected but are electrically separated either by air or by an insulating material called the Dielectric.

When a voltage is applied to these plates, a current flows charging up the plates with electrons giving one plate a positive charge and the other plate an equal and opposite negative charge. This flow of electrons to the plates is known as the Charging Current and continues to flow until the voltage across the plates (and hence the capacitor) is equal to the applied voltage.

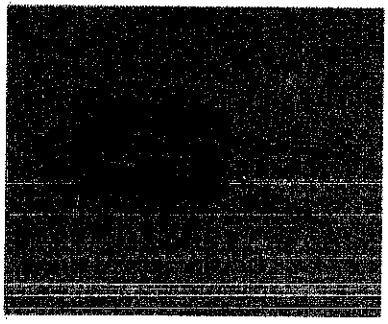


Figure 3.7: A Capacitor

- TRANSISTORS

A transistor is a miniature electronic component that can do two different jobs. It can work either as an amplifier or a switch. For this project, the transistors are used as switches. In this way, a small amount of current flowing through one part of a transistor makes a much bigger current flow through another part of it. In other words, the small amount of current the bigger one. Several transistors are used in the construction of this project's hardware. Special transistor is used for switching ON and OFF the DC motor and the transistor is called Field Effect Transistor (FET). The FET is used because it has ability to switch ON and OFF higher DC load effectively.

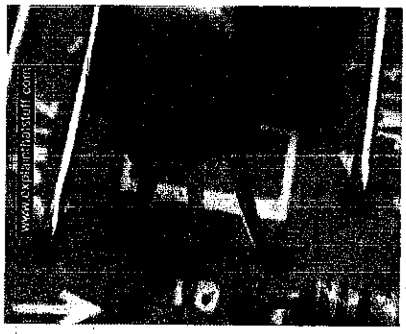


Figure 3.8: A FET

- DIACS and TRIACS

Diac is a two-terminal, four layer semiconductor device (thyristor) that can conduct current in either direction, when polarity is active. Diacs are electronic components which offer no control or amplification but act much like a bidirectional switching diode as they can conduct current from either polarity of a suitable AC voltage supply. A triac is a type of thyristor that can conduct current in both directions when the polarity is activated. The Triac is like a Diac, but with a gate terminal. Diacs are primarily used as trigger devices in phase-triggering and variable power control applications because a diac helps provide a sharper and more instant trigger pulse (as opposed to a steadily rising ramp voltage) which is used to turn ON the main switching device. The diac is commonly used as a solid state triggering device for other semiconductor switching devices, mainly SCRs and triacs. Triacs are widely used in applications such as lamp dimmers and motor speed controllers and as such the diac is used in conjunction with the triac to provide rectified full-wave control of the motor used. In this case, the triac is used as a speed controller for the DC Motor.

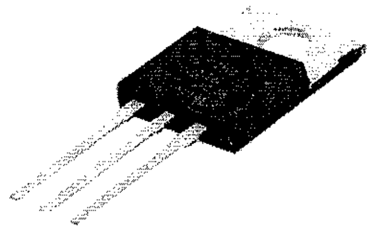


Figure 3.9: A Triac

POWER SUPPLY

The 220/240V, 50Hz input supply voltage of the automatic water ta controller is an AC source which is stepped down by two transformers, rectified and AC harmonics filtered by capacitors for use by the DC motor and control circuit. The 220/240V is stepped down and rectified to 12VDC, 500mA. Further regulation is made by the LM7805 to produce 5VDC which is made use by the control circuit.

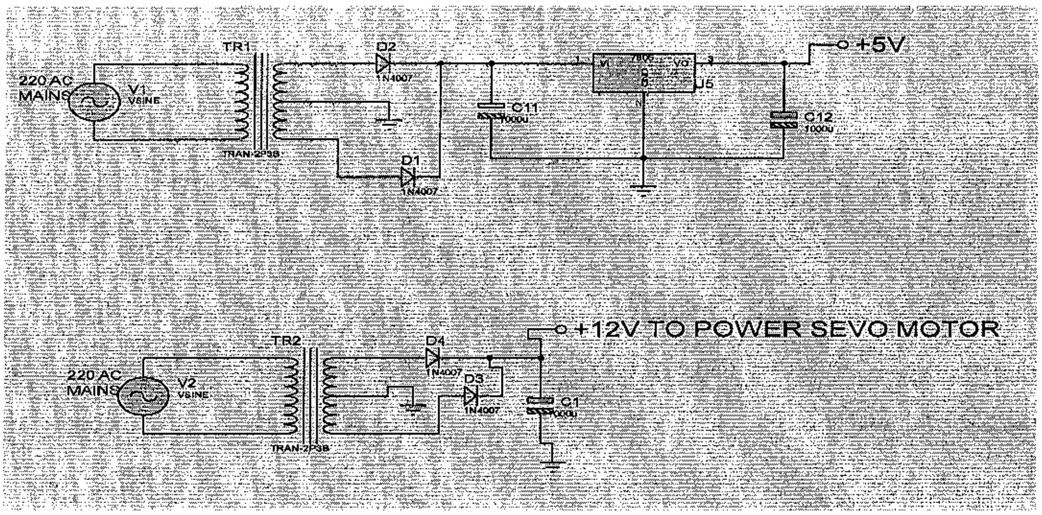


Figure 3.10: Circuit diagram of the power supply unit as drawn on Proteus

Selection, calculation and specification of the components used by this unit is explained below.

- SELECTION OF TRANSFORMER

This is an electrical device which converts alternating current which periodically reverses direction to direct current which flows in only one direction. For this automatic water tap controller, two AC/DC transformers are used. Both transformers convert 240VAC to 12VDC for use by the DC motor and PIC microcontroller. Transformer, T_1 powers the motor driver circuit while transformer, T_2 powers the control circuit unit. The two transformers turn ratio is as calculated below:

V_p = voltage induced at the primary winding

V_s = voltage induced at the secondary winding

N_s = Number of turn induced in the secondary winding

N_p = Number of turn induced in the primary winding

$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{240}{12} = \frac{20}{1}$$

Therefore, the transformers have rated turn ratio of 20:1.

- VOLTAGE REGULATION

This component provides 5V from the 12V gotten from the transformer, T_2 in order to power the control circuit of the system. The hardware component used for regulation is the LM7805 voltage regulator. This is a voltage regulator which maintains the output voltage at a constant value which in this case is 5V. The voltage regulator has three pins; the input, ground and output pins.

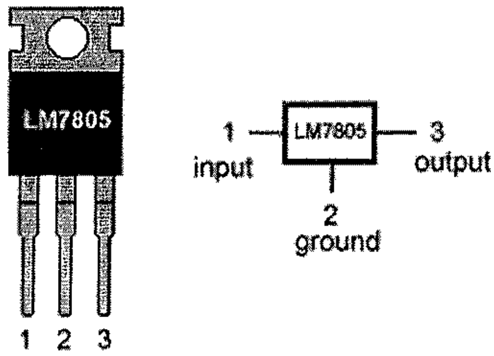


Figure 3.11: Pin Layout of the LM7805

LM7805 Voltage Regulator Ratings

Input Voltage	=	12V
Supply Current	=	1.5A (maximum)
Output Voltage	=	5V (fixed)
Operating Virtual Junction Temperature	=	0^0C – 125^0C

✧ FILTERING STAGE

In this stage, the filtering circuit consists of two diodes, IN4007 and two capacitors, 47000µF. The filtering is solely done for the DC motor whereby the two 47000µF polarized capacitors are connected alongside with the diodes IN4007 in order to filter, completely, AC harmonics going to the DC motor. The 47000µF polarized capacitors are chosen in accordance with the specified value of the capacitors to be used for the pins 12 and 13 which are meant for the servo motor driver circuit of the atmega-8 microcontroller used. The two 47000µF capacitors are filtering capacitors which are used to steady the slow changes in the voltage applied at the input of the circuit. Increasing the value of the capacitors amplify the stabilization while reducing the value of the capacitors reduce the stabilization. The rough calculation for the capacitors used in the atmega-8 datasheet is:

$$C = \frac{It}{V}$$

Where I = Maximum output current = 0.5A

V = Maximum voltage that can be discharged = 13V

And t is calculated to be 8.3ms

C = $(0.5A) \times {}^{8.3ms}/_{13V}$ = 0.32mF. However, 47000µF is chosen because it is the polarized capacitor value that is available in market. Moreover, it has stronger affinity to support the DC motor used.

3.2 DESIGN

This project provides a means of fetching a precise quantity of water from a reservoir to a smaller container without any need of having to turn ON the tap manually. The system is powered by an external AC power supply. The 220/240V, 50Hz input supply of the device is stepped down by two AC/DC transformers to deliver a secondary output of 12V, 0.3A to the motor driver circuit while the second AC/DC transformer delivers a 12V, 0.3A to the control circuit of the system. The automatic water tap controlling system consists of the hardware and software. The hardware is divided into five sections: power supply, water level detector, microcontroller, motor driver circuit for the tap and water level indicator while the software program was written in C language. The code was written in such a way that it embeds the operation of the DC motor, sensitivity of the water level detector and LEDs displaying the water level.

When the water level in the calibrated container reaches the minimum level, the sensor transistor having the pull-up and pull-down resistor bridges with the earth/ground in the container and the rate of flow of water from the tap is reduced, it goes further to the next level ¼, ½, ¾ and maximum respectively. However, at different stages minimum, ¼, average, ¾ and maximum, there is a corresponding LED (light emitting diode) that comes ON for each different level. The rate of flow of water from the tap which is accompanied by the DC motor closing the tap slowly at every interval until it gets to maximum level where the tap is finally closed, thus the tap is controlled.

In order to design this automatic water tap controlling system, there are basic structures and patterns followed. This includes:

- The circuit diagram
- Architecture of the system's PIC (Atmega-8 microcontroller)
- The block diagram and
- The flow chart

3.2.1 FUNDAMENTAL CIRCUIT DIAGRAM

The hardware of this project required simulation and interconnection of components to implement the power supply unit, water level detector, water level indicator, microcontroller and its associated device (servomotor) which it controls. The circuit diagram as drawn by Proteus software is illustrated below.

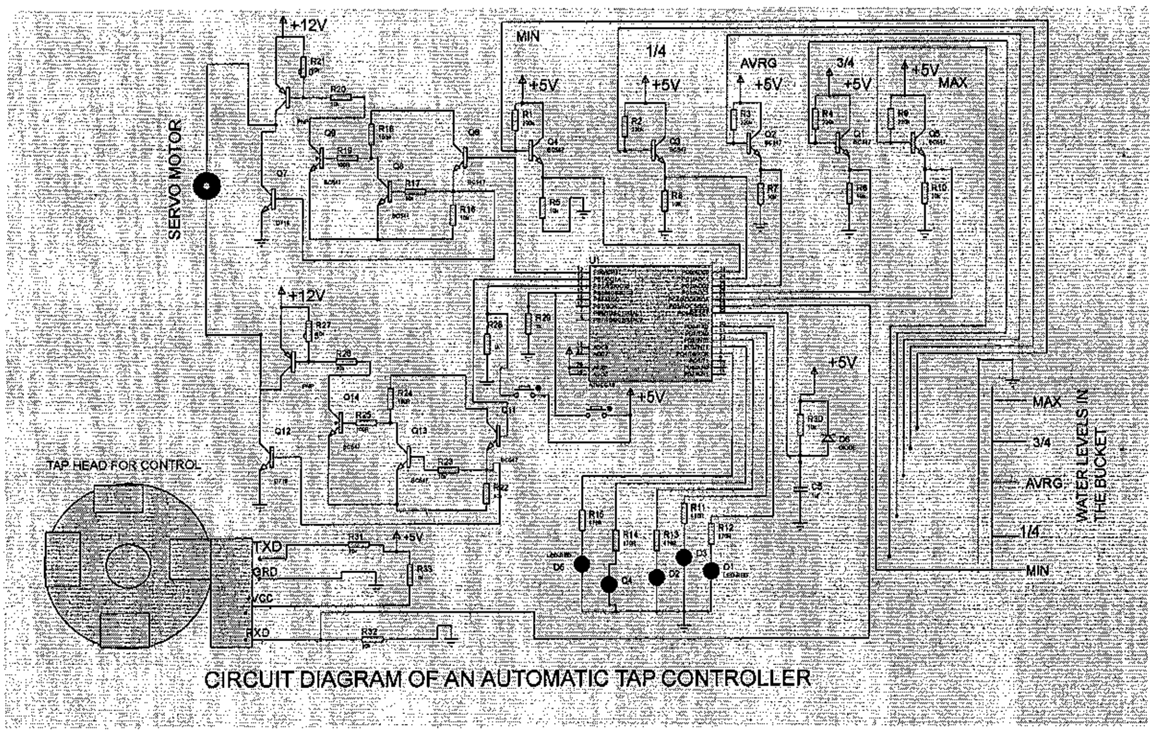


Figure 3.12: Circuit diagram of the Automatic Water Tap Controller

3.2.2 ARCHITECTURE OF THE SYSTEM'S PIC MICROCONTROLLER

The PIC, atmega-8 microcontroller, is an 8-bit CMOS built microcontroller from the AVR family and is built on the RSIC (Reduced Instruction Set Computer) architecture. Its basic advantage is it does not contain any accumulator and the result of any operation can be stored in any register, defined by the instruction [43]. The architecture consists of the program counter, SRAM, ADC Interface, Timers/Counters, Oscillators, Interrupt unit, EEPROM and USART. Each composition of this microcontroller performs its named function for effective performance of the system.

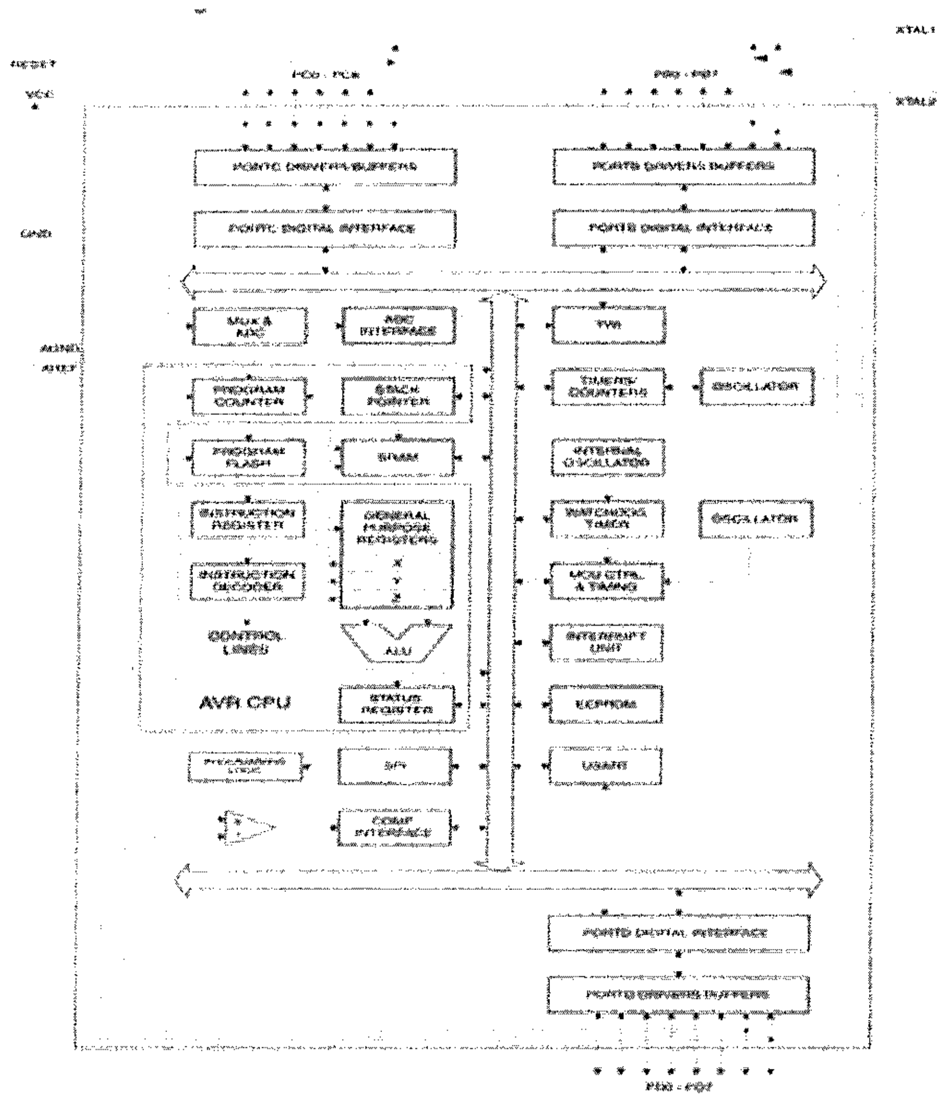


Figure 3.13: Architecture of the system's PIC microcontroller

3.2.3 FUNDAMENTAL BLOCK DIAGRAM

The block diagram includes blocks of units used in making the circuit functional. The various units used include water level detector, microcontroller, DC motor and LEDs for display.

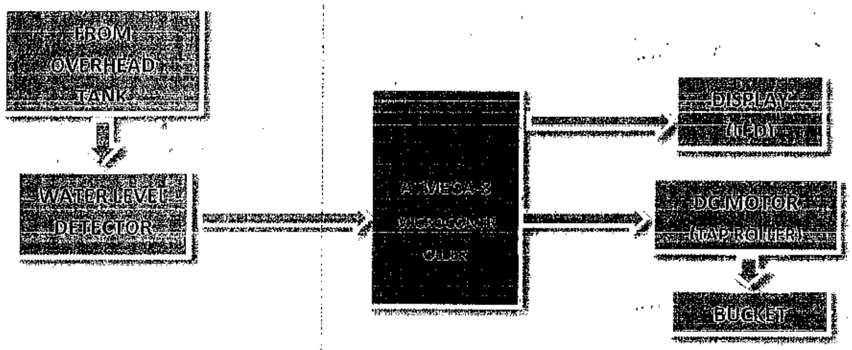


Figure 3.14: Basic block diagram of the system

3.2.4 FUNDAMENTAL FLOW CHART

The operation of the system is shown the figure below. The figure represents the flow chart of the automatic water level controller.

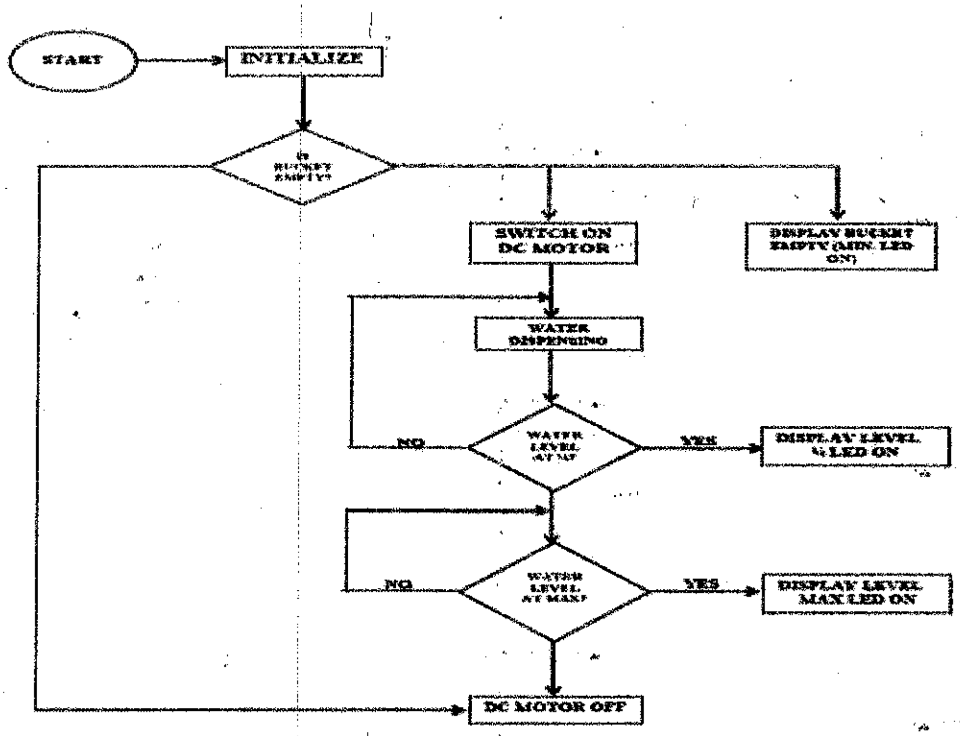


Figure 3.15: Schematic Flow chart of the Automatic Water Tap Controller

CHAPTER FOUR

4.0 TESTING, ANALYSIS OF RESULTS AND DISCUSSION

Design and implementation processes and steps taken to construct the hardware of this project is basically explained and analysed in the following subheadings.

4.0.1 PRE-IMPLEMENTATION TESTING AND TOOLS USED

The implementation of this project requires electronic components coupled to build units which are then soldered on veroboard. However, before these units were permanently soldered on the veroboard, each components making up a unit were laid out on the breadboard and tested in order to ensure that the units to be finally made would work.

The following are some of the simple hand tools used in implementation and testing:

1. Multimeter- for taking values of resistors, capacitors, testing for continuity in the hardware circuitry and measurements of voltage, current and so on.

2. Laptop computer- for accessing software application, programming microcontroller and running simulation.

3. Set of screw drivers- for tightening and loosening screws.

4. Soldering Iron- for heat joining wires and circuit hardware.

4.0.2 SYSTEM IMPLEMENTATION

The proposed circuit diagram is implemented by making the passive, active and all other components needed into different units. Examples are the power supply unit, motor driver circuit, tap roller circuit, water level detector circuit, water level indicator and so on. These units are then put together in order to construct the project as a whole.

In implementation of the system, some steps are taken in order to achieve the aim and objectives of the system. The steps taken are but not limited to:

- Hardware circuit design and simulation
- Microcontroller programming
- Hardware implementation
- Soldering of components into units
- Casing of the project.

4.0.2.1 HARDWARE CIRCUIT DESIGN AND SIMULATION

The hardware circuit design and simulation are done using a software package called Proteus. The components making up this system are selected and interconnected using this software. Below is the figure of the circuit designed, simulated and run:

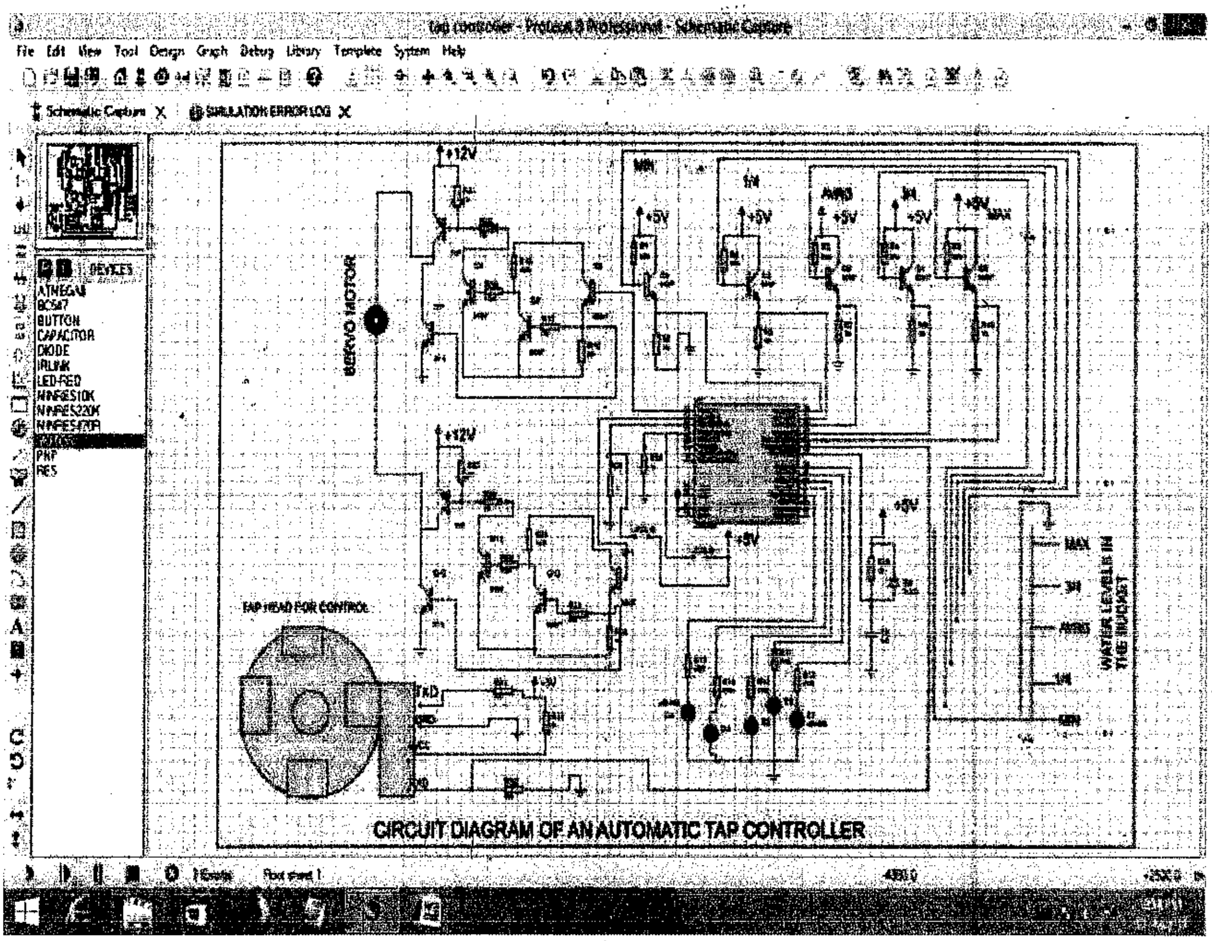


Figure 4.1: Hardware circuit design and simulation using Proteus

4.0.2.2 MICROCONTROLLER PROGRAMMING

The written program in C language is written for the atmega-8 microcontroller used. The program is used to alter the basic function performed by the pins. All the 28 pins of the microcontroller are input pins by default but with the help the written program, they are enabled as output pins.

4.0.2.3 SOLDERING OF COMPONENTS INTO UNITS

The components making up each unit are carefully soldered on veroboard to avoid being burnt using 60W/220V rated soldering iron and sucker. The sucker was used to extract excess molten lead from the veroboard. Each soldered joint of the components to the veroboard was ensured to be firm in order with small mechanical stress.

4.0.2.4 HARDWARE IMPLEMENTATION

The designed and simulated circuit outlined in figure 4.1 was realized by making the passive, active and all other components needed into different units. Examples are the power supply unit, motor driver circuit, tap roller unit, water level detector, water level indicator and so on. These units are then individually tested and put together in order to construct the project as a whole.The uncased hardware was then entirely tested before it was cased. Brief explanation of some of these units is done below:

a. Power supply unit: This consists, mainly, the two AC/DC transformers and LM7805 voltage regulator for limiting the 12VDC output of transformer, T_2 to 5V used by the control circuit. After this unit is constructed, the output supply is tested using multimeter in order to ensure that only the required voltages which are 12VDC and 5VDC are achieved.

b. Motor driver circuit: It is for controlling the DC motor. It is also the buffer circuit for the motor. It consists of the FET for switching on/off the servomotor.

c. Tap roller unit: It consists mainly the DC motor itself and the roller attached on the tap head.

d. Water level detector: It is a flat rectangular plate with melted solder on it. The melted solder acts a conductive material and is used to calibrate the detector in order to detect four water levels. However, the levels have a common ground.

e. Water level indicator: It indicates the level as detected by the detector.

The units are coupled in the right order and tested. The figure shows the demonstration of the uncased hardware with the pipes and buckets needed for the automatic water tap controller:

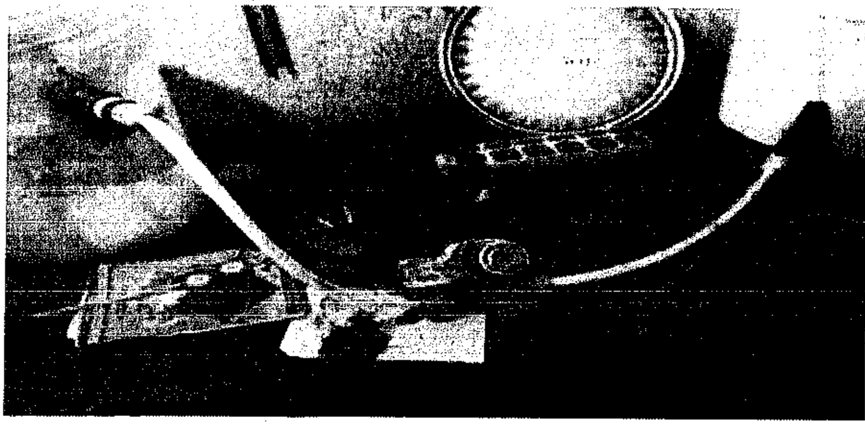


Figure 4.2: Hardware implementation

4.0.2.5 CASING OF THE PROJECT

The casing was constructed putting the size of the circuit board, transformers, all other components and units and ventilation for the circuit into consideration.The casing was made of transparent plastic material which cannot rust and permit easy accessibility of units making up the hardware.

4.0.3 FINAL COUPLING AND OVERALL PERFORMANCE EVALUATION

4.0.3.1 FINAL COUPLING

The main veroboard on which the units and other devices like the DC motor are placed on is first screwed to the hardwood laid at the bottom of the project casing for support. This is done in order to prevent unwanted repositioning of the units placed on the main veroboard. Excessive vibration and movement of electromechanical devices like the DC motor used can cause them to malfunction and misbehave over time.

4.0.3.2 OVERALL PERFORMANCE EVALUATION

The performance of the system is evaluated here in order to ensure, it is performing optimally well and that the aim and objectives of the constructing the automatic water tap controller are fully achieved. The sequence of operation of this control system can be briefly outlined as follow:

- ✓ The water level detector detects the fullness of water in the receiving bucket.
- ✓ The detector communicates this to the microcontroller which triggers the DC motor into action.
- ✓ The motor, with the help of the roller attached to the tap head, drives the tap to close in order to prevent water wastage and/or flooding of premises.

❖ EXPECTED PERFORMANCE UNDER NORMAL WATER FETCHING CONDITION

At this condition, the tap keeps running and water is being dispensed the reservoir to the receiving bucket without any spillage. Once the water level detector detects the fullness of the receiving bucket, it sends signal to the microcontroller that the maximum level has been reached.

❖ EXPECTED PERFORMANCE UNDER TAP CONTROL CONDITION

When the fullness of the receiving bucket is detected by the level detector, it sends signal to the microcontroller which triggers the servomotor and the tap roller into action. The motor starts rotating in anticlockwise direction setting the tap roller to rotate in the other direction, that is clockwise. In this manner, the tap is able to be driven to close thereby preventing water spillage, wastage and most importantly, flooding of water tap premises. Hence, the aim and objectives of constructing this project are achieved.

4.1 TESTING

The testing of the designed and constructed project was carried out. The water level detector detects the corresponding level of the water in the receiving bucket and it communicates with the microcontroller which controls the action of the DC motor to close the tap when the water in the receiving bucket reaches the level marked maximum on the water level detector. For easier reading, the water level indicator displays the corresponding water level as detected by the level detector. All of this is tested and confirmed to be working perfectly for the constructed system to achieve its aim and objectives. However, the units making up the entire system are individually tested before being coupled. The basic units making up this project are the ones decided to be tested since they are major units required for this project to function effectively.

4.1.1 TESTING OF POWER SUPPLY UNIT

The components making up this unit consist of two 240VAC/12VDC transformers and a voltage regulator, LM7805 coupled with one of the transformers to provide a rectified and regulated 5VDC used by the microcontroller and the control circuit as a whole. The components were individually tested and then made into two power supply units on two veroboards. After the construction of each power supply unit, a test was properly carried out to ensure that the voltages (12VDC and 5VDC) delivered by the power supply units were within the specified range of values needed for the project. The voltmeter section of a digital multi-meter was used to read out and confirm the two voltages.

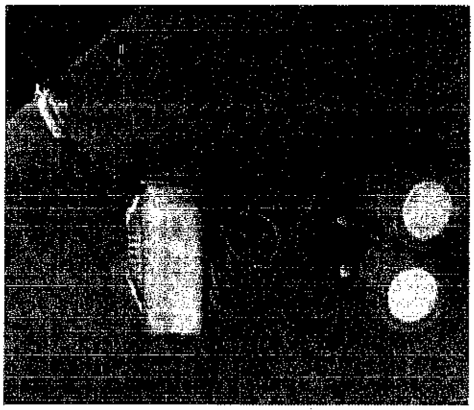


Figure 4.3: Rectified 12VDC power supply unit

4.1.2 TESTING OF MOTOR DRIVER CIRCUIT

The motor driver circuit consists of the switching components, that is; components capable of switching on and off the servomotor. This unit consists of FETs, capacitors and resistors. The FET is specifically used for handling high DC load which is the motor used in this case. These components are soldered on veroboard and tested for effectiveness.

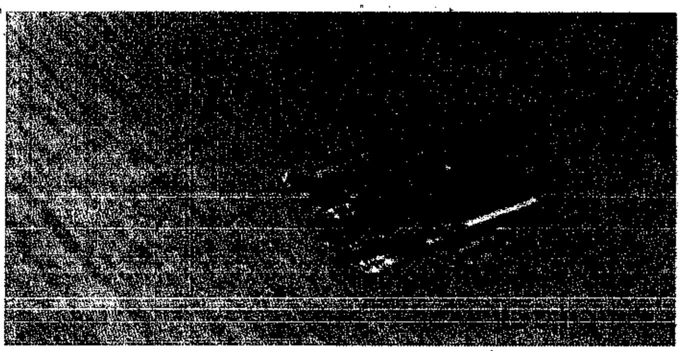


Figure 4.4: Motor driver circuit

4.1.3 TESTING OF DC MOTOR

The motor was tested to ensure that it was working perfectly well and rotating in both clockwise and anticlockwise directions. The motor was coupled to the motor driver circuit and it was discovered that it works well in both directions. Coupling it to the motor driver circuit was done so as to ensure the required rectified 12V gets to the motor and not damage it with over-voltage.

4.1.4 TESTING OF WATER LEVEL DETECTOR

The flat rectangular calibrated water level detector was tested to be in good condition. It was placed in the water receiving bucket and was confirmed to be functioning well. It reads each water level appropriately from minimum, 1/4, average, 3/4 and then maximum.

4.1.5 TESTING OF WATER LEVEL INDICATOR

The main components used for the level indicator are the LEDs. The LEDs were tested to ascertain that they are still working. Continuity test was done for each LEDs using digital multimeter that buzzes when continuity on the component is established.

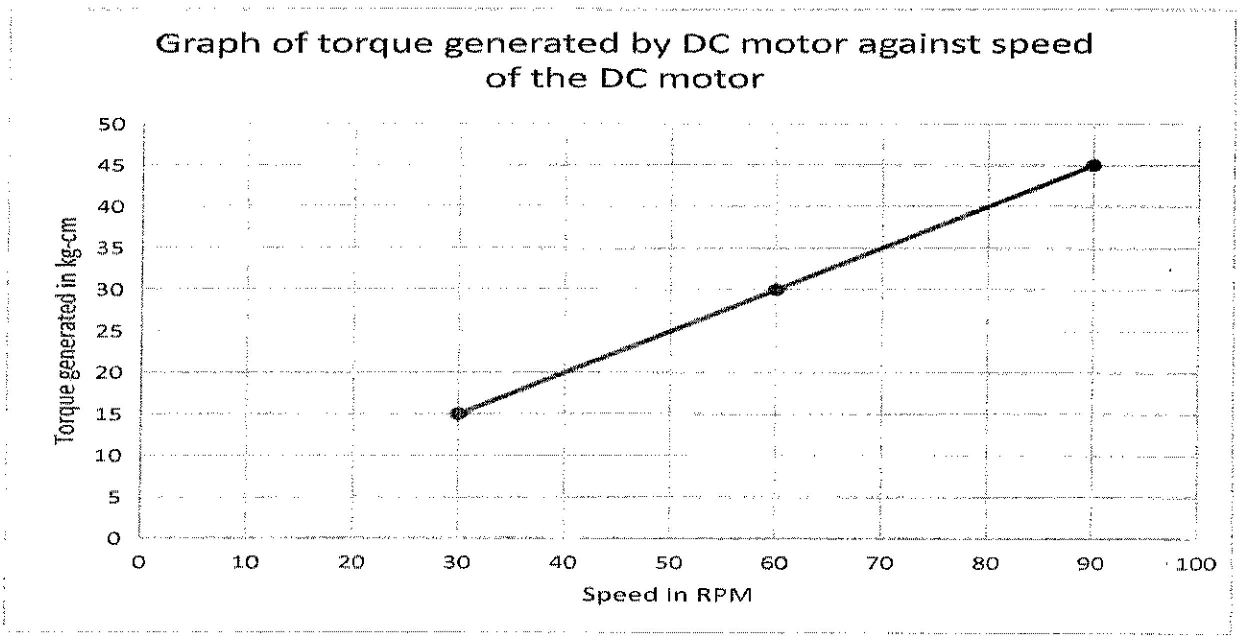
4.2 ANALYSIS

In this work, the microcontroller for the automatic water level monitor, having passed the necessary tests with the other components interfaced to it, is presented. With this implemented system, it is possible to monitor the water level in the receiving bucket, switch OFF the DC motor when the bucket is full without any need for human intervention. By so doing, the incidence of water wastage is eliminated.

As already stated that the atmega-8 microcontroller is the heart of this project work, as all the control signals pass through and are processed by the microcontroller. The water level detector and indicator were interfaced to the microcontroller in order to monitor and display the status of the system as it operates. The display unit is interfaced to the microcontroller through a port and via this port, the microcontroller is able to send information to the level detector and also read information from the level detector. The microcontroller then processes the data received and uses it to control the DC motor based on the written flow or control algorithm stored in its ROM. The simulated software algorithm began with flowchart and finally the c-language program is written to the microcontroller's internal ROM for the appropriate controlling of the device. The written program was loaded into a virtual atmega-8 microcontroller and then simulated. The output of the simulation was followed for the implementation of the hardware. After construction, tests were carried out to ensure that the tap controller is functioning according to the design specifications. After a successful testing, the prototype design of the automatic water level controller was designed. All the units were combined together with the microcontroller to obtain the model of the design.

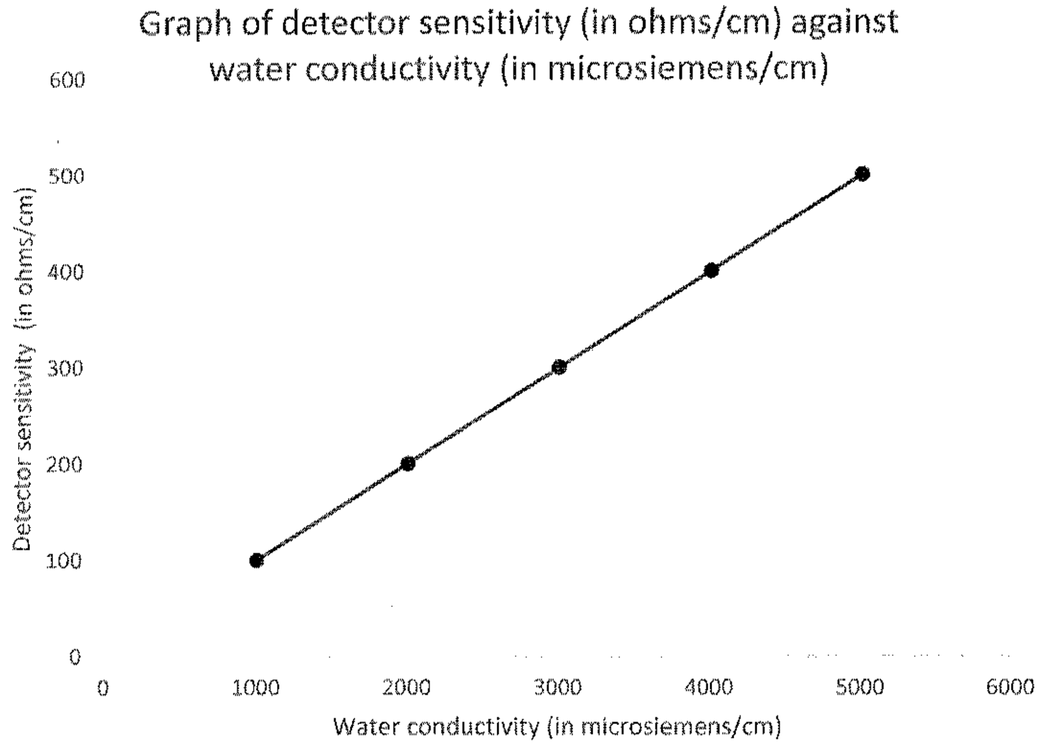
4.2.1 ANALYSIS OF THE DC MOTOR

The DC motor works on the principle that whenever a current carrying conductor (coil) is placed in a magnetic field, it experiences a mechanical force. The motor converts the electrical energy into motion which can physically start and stop the water flow. The speed of the motor depends directly on torque generated. The higher the torque, the higher the speed of the motor. The torque is plotted against speed below:



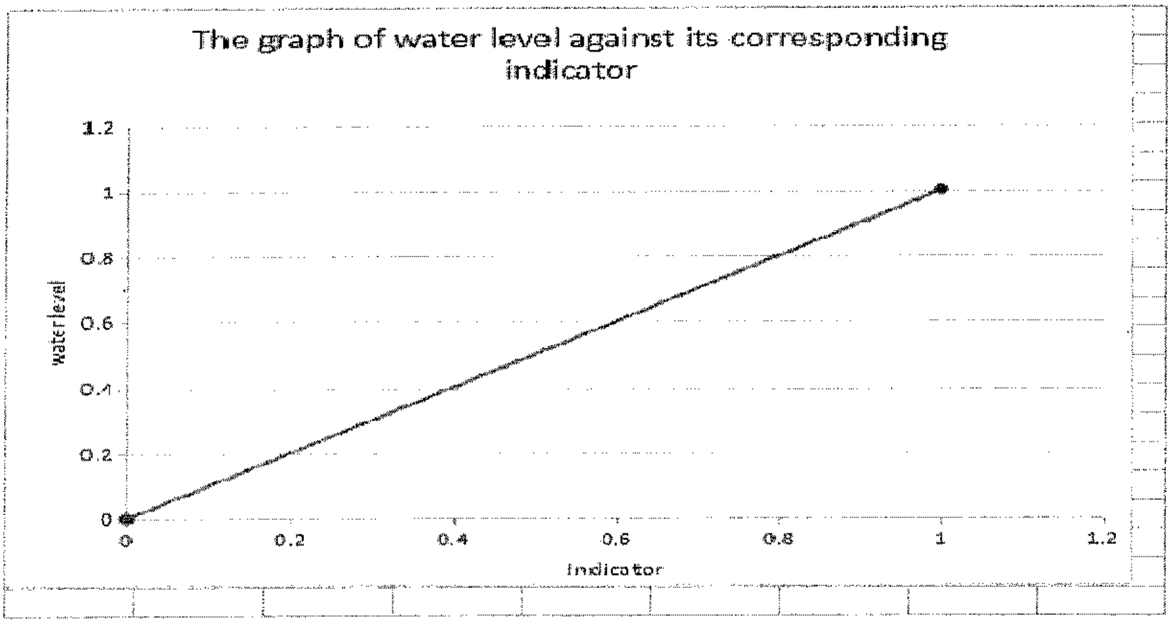
4.2.2 ANALYSIS OF THE WATER LEVEL DETECTOR

The water level detector is made by melting solder lead on a flat plate, this is done in five different levels with the minimum used as a common for all the other levels. The melted solder acts like electrodes which help to make conducting paths. The conductivity of the water used is very important here. Less conductive water e.g chemically treated water and distilled water brings about low sensitivity by the level detector. Hence, the higher the conductivity of the water, the higher the sensitivity of the detector and vice versa. The graph below shows this better:



4.2.3 ANALYSIS OF THE WATER LEVEL DETECTOR AND ITS INDICATOR

The graph plotted below shows the relationship between a water level and its corresponding indicator. When the water in the receiving-end bucket is at a level, say 1, the corresponding LED indicator for the water level 1 comes on. This shows the observer/user that the water in the receiving-end bucket has reached level 1.



4.3 PROJECT MANAGEMENT

The project management includes the work breakdown structures; like the Gantt chart, risk identification and management not excluding the literature reviews taken to arrive at the Gantt chart drawn.

4.3.1 PROJECT SCHEDULE

This can best be analysed using a Gantt chart which shows the time when a particular task starts and ends.

4.3.1.1 GANTT CHART

A Gantt chart is a useful graphical tool which shows activities/tasks performed against time. It is a visual presentation of a project where the tasks are broken down and displayed on a chart which makes it easy to understand and interpret. Gantt is a very popular and important tool in project management as it helps track project schedules.

The chart contains the tasks taken for the achievement of the project aim and objectives. Literature review is part of the tasks involved.

The following are few literatures reviewed for the construction of this project's Gantt chart:

In [44], Tamble works on implementation of automatic water distribution with RTC using 89S52 microcontroller. In achieving his proposed aim and objectives which is to reduce water wastage and to achieve safe distribution of water, Gantt chart is used to analyse his project work and keep tracks of the scheduled project.

Authors in [45] opined that to implement an automatic water faucet control system using PIC controller, the project activities must be scheduled using a Gantt chart which they followed in order to achieve their aim and objectives. Here, the authors made use of a Gantt chart in their project work to build a system which turns on a solenoid valve with the help of water conductor (copper electrode) level sensor used.

In [46], Ashok proposes a water anti-theft and quality monitoring system using SCADA and PLC. He made use of the Gantt chart in his project management and scheduling to achieve the aim of his project which is atomization of the water distribution system to avoid the wastage of water due to vandalism. To keep an eye on the vandal, the SCADA unit initiated red alarm pop-ups.

Authors in [47] opined that with ever increasing population of people in the world, an automated water supply with performance system is needed to reduce water wastage and keep theft away at the same. Their work made use of various applications applied through the embedded system. For proper project management, scheduling and achievement of objectives a Gantt chart is made use of.

The fundamental Gantt chart of the automatic water tap controlling system is drawn below:

	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12	WK 13	WK 14	WK 15	WK 16	WK 17	WK 18
LT. RVW																		
Task 1																		
Task 2																		
Task 3																		
Task 4																		
Task 5																		
Task 6																		
Task 7																		

WK- Week LT. RVW- Literature Review

Task 1- Preparation of materials for project execution.

Task 2- Design of project circuit diagram using Proteus.

Task 3- Program code writing for the ATMEGA-8 microcontroller.

Task 4- Acquisition of components for project hardware implementation.

Task 5- Construction of project into units, soldering and testing.

Task 6- Coupling of units and testing.

Task 7- Casing and final testing of the constructed hardware.

- Power failure
- Backstabbed wires and electric shock.

The above listed challenges were mitigated in this respective order:

- Enough components for construction of the hardware were made available.
- Alternative power supply was made available in order to meet the project scheduled time.
- Tight connection and soldering were ensured. Sagging of connecting wires was eliminated.

4.3.3 SOCIAL, LEGAL, ETHICAL AND PROFESSIONAL CONSIDERATION

Before this project is embarked on, findings were made to be sure that related projects constructed were socially and legally acceptable by the society. As an engineer-to-be, I ensure this project conform to the required standard of Institute of Electrical and Electronics Engineers (IEEE). Issues regarding this project which will tarnish my image were duly and wholly avoided.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

There is huge demand for the usable water in the whole world and thus monitoring water level to reduce the water wastage is often a key requirement in the water stress countries. To make the constructed project affordable for purchasers; very simple, easy to get and low cost components and instruments are used to develop the system.

Conclusively, automatic water tap controlling system employs the use of different technologies in its design, development, implementation and testing. The implemented system uses microcontroller to automate the process of water dispensing from a reservoir to a receiving bucket and has the ability to detect the level of water in the receiving bucket, switch on/off the DC motor accordingly and display the status using LEDs as indicator. This research has successfully provided an improvement on existing water level controllers by its use of calibrated circuit to detect different water levels and use of DC instead of AC power thereby eliminating risk of electrocution within the system circuitry. The overall performance of the developed system was evaluated and the resulting data were verified, hence, the stated aim and objectives of the project is achieved.

5.1 CONTRIBUTION TO KNOWLEDGE

During the design and implementation of this project and even upon completion, I have acquired more theoretical and practical knowledge within and outside the scope of my disciplinary study. I have been able to learn more about the use of software applications like Proteus and Multism for electrical and electronics project designing and simulation. Also, I learnt how to fabricate electronic components into units. Lastly, the report writing of this project has really helped me to make researches in diverse fields of engineering and courses and this in one way or the other shed more light to what I have been taught in courses taken in class.

5.2 LIMITATIONS

The following are some of the limitations of the project:

1. If there is no AC power supply, the project cannot be powered and hence, cannot be used.

2. Buzzer alarm to notify the occupants that the desired water level has been reached is not incorporated into this work.

3. Notification in form of call or message using mobile GSM-Based technology is not incorporated into this project.

4. The project hardware only works for conductive liquids. Hence, non-conductive liquids such as petrol, diesel, vegetable oil e.t.c cannot be controlled since the level detector only work amidst conductive liquids.

5.3 FUTURE WORKS

The future importance of this project; especially in countries like Germany, El Salvador and Guatamala where water is scarce; cannot be overemphasized. Therefore, it is suggested that more research be carried out towards the improvement of the project. However, the following are few suggestions which I can proffer:

1. Future research work can be directed at the development of more sophisticated and latest technology (such as GSM) which will overcome one of the current limitations.

2. Notification in form of buzzer alarm can be incorporated to this system.

3. The system can be connected to a solar panel to provide constant supply of electricity when there is PHCN power failure. This will make the system functional at all times and in turn increase availability and reliability of the system.

5.4 CRITICAL APPRAISAL

The inability to have automatic control over water taps from running endlessly in the past few decades has been a major concern in homes, offices, restaurants and even food industries. This project is designed and constructed to avert water wastage which often times leads to flooding of premises where water tap is being sited. With the help of simulation and some electronic components put together, a control mechanism is developed; capable of controlling water taps automatically. Thereby, making users of water taps less bothered about the detrimental havoc which leaving water taps running endlessly and unattended to can pose.

The control system is developed using simple, low cost and less power consumption components and devices. This makes the system developed affordable for users.
The implemented system consists of water level detector for detecting different levels of water up till the maximum level. When maximum level is reached, the detector communicates this to the microcontroller which activates the servomotor driver circuit and hence, the motor itself and it drives the tap to close. In this simple way, the water tap is automatically controlled.

REFERENCES

[1] J.F. Cretaux, W. Jelinski, S. Calmant, A. Kouraev, V. Vuglinski and M. Berge-Nguyen, "SOLS: A lake database to monitor in the Near Real Time water level and storage variations from remote sensing data" *Advances in Space Research*, vol. 47, no. 3, pp. 1497-1507, 2011.

[2] R. Marin-Perez, J. Garcia-Pintado and A. S. Gomez, "A Real-time Measurement System for Long-life Flood Monitoring and Warning Applications" *Sensors (Basel, Switzerland)*, vol. 12, no. 6, pp. 4213, 2012.

[3] P. Jiang and X. Sung, "Design of a Water Environment Monitoring System Based on Wireless Sensor Networks", *Institute of Information and Control & Environmental Science Research & Design Institute*, vol. 9, no. 8, pp. 6411-6434, 2009.

[4] P. Xuange, L. Peipei, and H. Chunying, "One Kind of Water Level Monitor Recording Instrument", *Industrial Electronics and Applications (ICIEA) 3rd IEEE Conference*, vol.1, no. 5 pp. 24-25, 2008

[5] R. Ramani, S. Selvaraju, S. Valarmathy, R. Thangam and B. Rajasekaran, "Water-Level Monitor for Bore-well and Water Tank Based on GSM", *International Journal of Engineering, Science and Technology (IJEST)*, vol. 2, no. 7, pp. 0975-5462, 2012.

[6] G. Lu, H. Hu, B. He and S. Che,, "A New-Type Sensor for Monitoring Oil-Water Interface Level and Oil Level", *Electronic Measurement & Instruments International Conference*, no. 9, pp. 2981-2983, 2009.

[7] A. Atojoko, R. A. Abd-Alhameed, Y. Tu, F. Elmegri, C. H. See and M. B. Child, "Automatic Liquid Level Indication and Control using Passive UHF RFID Tags" *Loughborough Antennas and Propagation Conference (LAPC)*, IEEE Catalog Number: CFP1469B-POD, pp. 136-140, 2014.

[8] S. Anjali, "Automatic Wash Basin Tap Controller", *Proceedings of India Science and Technology Information*, vol. 12, no. 19, pp. 773-779, 2012.

[9] S. Khan, "Automatic Public Tap control system using PIR sensor", *International Journal of Electrical and Electronics*, pp. 224-229, 2013.

[10] D. K. Wood, "Automatic Water Tap System", *International Conference on Computers and Information Technology,* vol. 6, no. 12, pp. 492-496, 2015.

[11] T. K. Hareendran, "Automatic Water Tap (Faucet/Valve)", Issues in *Informing Science and Information Technology*, vol. 9, no. 16, pp. 887-894, 2018.

[12] B. Adewale, "Automatic Pumping Machine for Water Supply", *International Journal of Innovative Research in Computer and Communication Engineering,* vol. 3, no. 6, pp. 186-195, 2015.

[13] M. M. Rahman, M. Abdullah, N. U. Ahamed, M. S. Ali and M. M. Islam, "Design of Automatic Controlling System for Water-tap using Floatless Level Sensor", *IEEE International Symposium on Robotics and Manufacturing Automation,* vol. 1, no. 3, pp. 16-21, 2015.

[14] C. Beckers, R. Franklin, and T. Smith, "Sensor Subsystem for the next Generation Tide and Water Level Measurement System," *Information Forum for OCEANS*, vol. 5, no. 3, pp. 1100-1105, 2010.

[15] Y. Dou, J. Qin, and X. Chang, "The Study of a Capacitance Sensor and its System used in Measuring Ice Thickness, Sedimentation and Water Level of a Reservoir," *Information Technology and Applications (IFITA)*, vol. 2, no. 6, pp. 616-619, 2009.

[16] F. Hicks, G. Tyler and T. W. Edwards, "Pump Application Engineering," McGraw-Hill Book Company, New York, 2013.

[17] S. M. K. Reza, S. Ahsanuzzaman, M. Tariq and S. M. M. Reza, "Microcontroller Based Automated Water Level Sensing and Controlling: Design and Implementation Issue", *Proceedings of the World Congress on Engineering and Computer Science*, no. 7, pp 220-224, 2010.

[18] N. Venkata and R. Gunturi, "Micro Controller Based Automatic Plant Irrigation System", *International Journal of Advancements in Research & Technology*, vol. 2, no. 4, pp. 236-242, 2013.

[19] J. Hodgson and T. Walters, "Optimizing Pumping Systems To Minimize First Or Life-Cycle Cost", *Proceedings of the International Pump Users Symposium,* no. 19, pp 1-8, 2002.

[20] C. Rojiha, "Sensor Network Based Automatic Control System for Oil Pumping Unit Management," *International Journal of Scientific and Research Publications*, vol. 3, no. 3. pp. 1-4, 2013.

[21] L. Somnath and P. Sanjay, "Microcontroller Based Automatic Water Level Control System", *International Research Journal of Multidisciplinary Studies*, vol. 2, no. 1, pp. 36-43, 2016.

[22] K. S. Vani and P. C. Shrinidhi, "Automatic Tap Control System in the Smart Home using Android and Arduino", *International Journal of Computer Applications,* vol. 127, no. 16, pp. 0975 – 8887, 2015.

[23] S. V. Devika and K. S. Kapoor, "Arduino Based Automatic Plant Watering System", *International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE)*, vol. 4, no. 10, pp. 449-456, 2014.

[24] K. J. Kumar and M. A. Mahmoud, "Monitoring and Controlling Tap Water Flow at Homes using Android Mobile Application", *American Journal of Software Engineering and Applications,* vol. 6, no. 6, pp. 128-136, 2017.

[25] E. J. Band and F. I. Anyasi, "Design of an Automatic Water Level Controller using Mercury Float Switch", *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE),* vol. 9, no. 2, pp. 16-21, 2014.

[26] P. P. Uday, *B. Tech- Final Year Electrical Engineering*, a Major Project on "Water Level Automatic Pump Controller", 2017.

[27] K. S. Prasad and M. P. Sanjay., "Water-Saving Irrigation System Based on Automatic Control by Using GSM Technology," *Middle-East Journal of Scientific Research,* vol. 12, no. 12, pp. 1824-1827, 2012.

[28] A. Raj, "Automatic Water Dispenser using Arduino", *International Journal of Engineering, Science and Technology*, vol. 4, no. 7, pp. 46-52, 2018.

[29] P. T. Bhosale and D. B. Salunke, "Agricultural Water Saving Irrigation Controller," *International Journal of Emerging Trends in Science and Technology*, vol. 03, no. 03, pages 3647-3657, March 2016.

[30] V. V. Dixit, "Water Saving-Irrigation Automatic Agricultural Controller," *International Journal of Scientific & Technology*, vol. 1, no. 11, pp. 345-352, 2012.

[31] R. Balathandapani and K. Quazeem, "Automatic Rain Water and Crop Saving System using Embedded Technology," *International Journal of Science, Engineering and Technology Research (IJSETR),* vol. 4, no. 3, pp. 739-747, March 2015.

[32] A. Johari, P. Pandeev and T. Medvedev, "Tank Water Level Monitoring System using GSM Network," *International Journal of Computer Science and Information Technologies (IJCSIT),* vol. 2, no. 3, pp. 1114-1120, 2011.

[33] T. Jayasree, and M. Abdullah, "Automatic Water Distribution Management System using PIC Controller and GSM Module", *International Journal for Research & Development in Technology*, vol. 7, no. 4, pp. 2349-2355, 2018.

[34] A. T. Jaiad and H. S. Ghayyib, "Controlling and Monitoring of Automation Water Supply System based on IoT with Theft Identification", *International Journal of Research - Granthaalayah*, vol. 5, no. 5, pp. 320-325, 2017.

[35] M. K. Sangole, M. Bauskar, A. Mahajan and A. Nankar, "GSM based Prepaid Water Control Circuit System for Water Meter," *International Journal of Current Research*, vol. 8, no. 02, pp. 26609-26612, 2016.

[36] A. D. S. Gonzalez and K. R. Marquez, "Automatic Water Pump Controller," *International Journal of Electronics and Control Engineering*, vol. 3, no. 5, pp. 187-192, 2016.

[37] X. Chen, "Touchless Faucet with Automatic Temperature Control," *Middle-East Journal of Scientific Research,* vol. 1, no. 4, pp. 16-21, 2015.

[38] Y. Zhao, "The Automatic Precision Water-Saving Irrigation Control System," *International Journal of Engineering, Scientific and Technology (IJEST)*, vol. 9, no. 13, pp. 1225-1231, 2014.

[39] I. Saputra and L. Hakim, "Perancangan Water Level Control using PLC Omron Sysmac C200H and Software SCADA Wonderware InTouch 10.5," *Information Journal for Electro-technical Research*, vol. 1, no. 3, pp. 23-29, 2013.

[40] I. C. Murmu and L. K. Yadav, "Low Cost Automatic Water Level Control for Domestic Application," *Department of Electrical Engineering, National Institute of Technology Rourkela, Odisha,* India-769008, 2013.

[41] D. P. Tibe, P. C. Ghodke, I. J. Pawara, A. U. Gupte and S. K. Mahindrakar, "Automatic Public Tap Control using IR Sensor and Water-Level Indication using GSM", *International Journal of Advance Engineering and Research Development,* vol. 3, no. 5, pp. 1-6, 2016.

[42] E. V. Ejiakor and O. F. Oladipo, "Microcontroller based Automatic Water level Control System," *International Journal of Innovative Research in Computer and Communication Engineering*, vol. 1, no. 6, pp 1-6, 2013.

[43] ElProCus, "AVR Atmega 8 Microcontroller Architecture and Its Applications," Retrieved February 17, 2019, from www.elprocus.com/avr-atmega8-microcontroller-architecture-applications

[44] S. A. Tamble, "Automatic Water Distribution System with RTC using 89S52 Microcontroller", *International Conference on Mechanic Automation and Control Engineering (MACE),* vol. 3, no. 5, pp. 453-458, 2008

[45] M. V. Pavankumar and A. P. Kumbhar, "Automatic Water Faucet Control System using PIC Controller", *International Journal of Engineering, Automation and Technology (IJEAT)*, vol. 2, no. 4, pp. 132-134, 2014.

[46] G. S. Ashok, "Water Anti-Theft and Quality Monitoring System using SCADA and PLC", *International Journal of Electrical and Electronics,* vol. 1, no. 1, pp. 1-5, 2015.

[47] N. B. Bhawarkar, D. P. Pande, R. S. Sonone, M. M. Aaquib, P. A. Pandit and P. D. Patil, "Automated Water Supply with Monitoring the Performance System", *International Journal of Current Engineering and Technology,* vol. 4, no. 5, pp. 3328-3331, 2014.

APPENDIX A: BILL OF ENGINEERING MEASUREMENT AND EVALUATION

S/N	DESCRIPTION	UNIT PRICE (Naira)	QUANTITY	AMOUNT (Naira)
1	ATmega 8 Microcontroller with Programmer	3000	1	3000
2	Transformer	1000	3	3000
3	DC Motor (035A)	500	1	500
4	Voltage regulator (LM7805)	400	3	1200
5	Capacitors	150	5	750
6	Transistors	20	15	300
7	Resistors	10	30	300
8	Diode	20	5	100
9	Diacs	50	5	250
10	Triac	150	4	600
11	Connecting Hose	300	2	600
12	Cable Plug	150	1	150
13	Connecting Wires	-	-	500
14	LED	20	10	200
15	Veroboard	500	1	500
16	Casing	1000	1	1000
17	Tap	250	2	500
18	Bucket	700	2	1400
19	Miscellaneous	2000	1	2000
	Total			**16,850**

APPENDIX B: CONFIGURATION SUMMARY FOR ATMEGA 8

FEATURES	ATMEGA 8
Pin Count	28/32
Flash (Bytes)	32K
SRAM (Bytes)	2K
EEPROM (Bytes)	1K
General Purpose I/O Lines	23
SPI	2
TW1 (I_2C)	1
USART	1
ADC 10-bit	15Ksps
ADC Channels	8
8-bit Timer/Counters	2
16-bit Timer/Counters	1

APPENDIX C: PROGRAMMING CODE

The following code was uploaded to the Atmega 8 microcontroller chip.

```
.EQU    PORTB = 0X18

.EQU    DDRB = 0X17

.EQU    PINB = 0X16

.EQU    PORTC = 0X15

.EQU    DDRC = 0X14

.EQU    PINC    = 0X13

.EQU    PORTD = 0X12

.EQU    DDRD   = 0X11

.EQU    PIND    = 0X10

.EQU    SPH             = 0X3E

.EQU    SPL             = 0X3D

.EQU    UBRRH = 0X20

.EQU    UCSRC = 0X20

.EQU    UBRRL = 0X09

.EQU    UCSRB = 0X0A

.EQU    UCSRA = 0X0B

.EQU    UDR    = 0X0C

.EQU    ADMUX           = 0X07

.EQU    ADCSRA          = 0X06

.EQU    ADCH   = 0X05

.EQU    ADCL   = 0X04

.EQU    TCCR0  = 0X33
```

```
.EQU	TCNT0 =		0X32
.EQU	TIMSK = 0X39
.EQU	TIFR	= 0X38
.EQU	SREG	= 0X3F
.EQU	TCCR1A		= 0X2F
.EQU	TCCR1B		= 0X2E
.EQU	TCNT1H		= 0X2D
.EQU	TCNT1L		= 0X2C
.EQU	OCR1AH		= 0X2B
.EQU	OCR1AL		= 0X2A
.EQU	OCR1BH		= 0X29
.EQU	OCR1BL		= 0X28
.EQU	SFIOR	= 0X30
.EQU	TCCR2	= 0X25
.EQU	TCNT2	= 0X24
.EQU	GICR	= 0X3B
.EQU	MCUCR		= 0X35
.EQU	ASSR	= 0X22
.EQU	EEARH = 0X1F
.EQU	EEARL = 0X1E
.EQU	EEDR	= 0X1D
.EQU	EECR	= 0X1C
.EQU	OSCCAL		=	0X31
.ORG	0X00
```

```
START:

        LDI     R17,0XA8
        OUT     OSCCAL,R17

        LDI     R17,0X5F
        OUT     SPL,R17

        LDI     R17,0X04
        OUT     SPH,R17

        CLR     R17

        OUT     PORTB,R17
        OUT     PORTC,R17
        OUT     PORTD,R17

        LDI     R17,0XF3
        OUT     DDRB,R17

        CLR     R17
        OUT     DDRC,R17

        LDI     R17,0XFF
        OUT     DDRD,R17
```

```
LDI     R17,0X04
OUT     SFIOR,R17

LDI     R17,0X01
OUT     PORTB,R17

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
```

```
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1
```

```
LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
LDI     R17,0X00
OUT     PORTD,R17
RCALL SEC1

LDI     R17,0X0F
OUT     PORTD,R17
RCALL SEC1
```

```
        LDI     R17,0X00
        OUT     PORTD,R17
        RCALL SEC1

        LDI     R17,0X00
        OUT     PORTB,R17

        CLR     R18
        CLR     R19
        CLR     R20

REDO:
        RCALL BUTTON1
        RCALL BUTTON2

        RCALL DISPLAY

        RJMP    REDO

DISPLAY:
        SBIC    PINC,3
        RJMP    DISPLAY2

        SBIC    PINC,2
```

```
RJMP   DISPLAY2B


SBIC   PINC,1

RJMP   DISPLAY2C


SBIC   PINC,0

RJMP   DISPLAY2D


LDI    R17,0X0F

OUT    PORTD,R17


SBRC   R18,0

RET

SBRC   R19,4

RET


SBRS   R20,0

RJMP   ADJ1


LDI    R17,0X01

OUT    PORTB,R17


RCALL SEC5

RCALL SEC1
```

```
        LDI     R17,0X00
        OUT     PORTB,R17

        ORI     R19,0X10
        ANDI    R19,0XFE

        LDI     R20,0X01

        RET

ADJ1:

        RET

ADJ2:
        LDI     R17,0X02
        OUT     PORTB,R17

        RCALL SEC5
        RCALL SEC5
        RCALL SEC5

        LDI     R17,0X00
        OUT     PORTB,R17
```