DAR-ES-SALAAM INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

BACHELOR OF ENGINEERING IN ELECTRONICS AND TELECOMMUNICATION

NTA LEVEL 8

SENIOR PROJECT TWO

PROJECT TITLE: **AUTOMATIC IRRIGATION SYSTEM**

PROJECT TYPE: **PROBLEM SOLVING**

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ADMISSION NO: **120637452681**

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CERTIFICATION

As the candidate's supervisor, I have approved this Project for submission.

Supervisor's name: Dr. G. Rugumira

Signature: ……………………………….

Date: …………………………………….

DECLARATION

I Andrew W. Uiso, declare to the best of my knowledge that the project presented here as a fulfilment of Bachelor of Engineering in electronics and telecommunication at Dar es salaam Institute of Technology is my own work. However, whatever references such as Books, Journals, Standard specifications, and report etc. on pursuing this project are clearly shown in references list

CANDIDATE NAME	**SIGNATURE**	**DATE**
ANDREW W. UISO	_______________	_____________

ABSTRACT

Due to observed problems of irrigation in many areas that are drought, different techniques have been employed to solve the problem but none of them have solved the problem effectively.

Automatic irrigation is an idea that comes into handy after observation of wastage of too much time on the manual irrigation which is currently performed by many subsistence and large scale farmers. Most of our today's systems depend on seasonal rain; therefore, introduction of improved automatic irrigation system can solve a lot of problems such as increasing more production, best time management and effective work.

The automation systems consist of different types of sensors which detect the environmental conditions and feed the data into a control unit, which then processes the data from the sensors and send signals to the output which consists of different types of actuators which perform or take action to the changes in the environment. These systems not only help to reduce the manual work for the farmers but also help to precisely regulate and control the amount of water on the farm. As a result, plants and crops can grow in the most favourable conditions and increase crop production.

To accomplish the task of designing the proposed system, study has been done in existing systems as well as existing situations. Problem caused by lack of water on the farms have been explored as well as data to justify the problem was collected. All relevant data that will be required during designing process has been collected.

Data analysis and system design was covered using data collected in the senior project one and the system design was tested using the required parameters from the implemented prototype.

After implementation, the designed system will be tested to observe its functionality and limitations. The system will be employed as a solution to solve the problems facing farmers and increase level of production.

ACKNOWLEDGEMENT

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TABLE OF CONTENTS

LIST OF ABBREVIATION

CDMA	Code Division Multiple Access
EEPROM	Electrical Erasable Programmable Read Only Memory
ETSI	European Telecommunications Standards Institute
GSM	Global Systems for Mobile Communications
PIC	Programmable Interface Controller
RAM	Random Access Memory
SMS	Short Message Service
TDMA	Time Division Multiple Access
UHF	Ultra High Frequency

TABLE OF FIGURES

LIST OF TABLES

CHAPTER ONE

1.0 INTRODUCTION

1.1 Project background

Irrigation is the artificial application of water to the soil for assisting in growing crops [1]. Water is resource that all living species need. It is therefore very precious and has to be used with moderation to be preserved for the future generations. It is known that an automation system has raised evolutions in industries due to increase in production rate and cost saving. Agriculture is an industry that uses a lot of water. Most of the time, this resource is not used efficiently and substantial amounts of water are wasted. The ones who manage this resource efficiently will be saving time and money.

Agriculture leads to the wastage of water as every time excess of water is given to the fields. There are many techniques to save water or control wastage of water from agriculture as ditch irrigation, terraced irrigation, drip irrigation, sprinkler system, rotary system and automatic irrigation techniques [2].

1.2 Problem statement

In many remote areas where agricultural activities are done there is drought, due to this reason the farmers waste a lot of time to perform irrigation activities manually which leads to wastage of time, water and low production because manual works tend to be slow as a result only small agricultural field is used to cultivate crops.

1.3 Objectives of the project

Objectives of this project can be categorized into two categories; these are general objective and the specific objectives as follows; Specific Objectives

i. To interface all sensors that will control all the process of automatic irrigation.
ii. To program the control unit so as to be able to receive the input from sensors, give output actions through actuators and send failure notifications through wireless communication technology.
iii. To interface GSM module with the whole system so as to notify the farmer about the critical conditions.
iv. To interface a solar power system that will provide power to the whole irrigation system.

1.3.1 General Objective

The general objective of this project is to design an automatic irrigation system that can maintain the land moisture and notify the farmer about the critical conditions such as high temperature, high humidity of the farm and low water level from the water tanks.

1.3.2

1.3 Significance of the project

This project intends to design an automatic irrigation system. Its completion will be of great value to the horticulture farmers. It will reduce the work done by the farmer by automatically detecting the moisture level and temperature of the soil and irrigating when the conditions necessary for irrigation are met.

1.4 Scope and Limitation of the project

The system is expected to work effectively under different atmospheric conditions such as rainy, sunny, and dull day. The system will be ineffective on severe weather conditions such as storms and floods. As the system goes off it the over rainfalls causes the amount of water on the ground to increases hence makes the system to be ineffective since the system will always sense the presence of water.

1.5 Chapter Conclusion

This chapter has discussed about introduction to irrigation, problem descriptions, objectives, significances, scope and limitation of the project. The problem addressed in this chapter is going to be solved after achieving the main objective. Methodological steps are the key procedures to be used in order to come up with the solution to the problem.

CHAPTER TWO

2.0 METHODOLOGY

2.1 Introduction

Methodology is the systematic analysis which comprises a body of principles, methods and procedures which are applied to complete and achieve the project objectives. In this project different methodologies have been used to its accomplished. A literature review on automatic irrigation system has been done; data collection with respect to design requirements of the automated irrigation system will provide important knowledge on the design requirements, analysis of data will be done on the data collected and further the circuit design, simulation and prototype implementation of the automated irrigation system.

2.2 Literature review

Literature review is an account of what has been published on a topic by accredited scholars and researches [3]. In this methodology, different books and researches about the automatic irrigation system are studied giving important information about the automation process of irrigation under different climatic conditions.

2.3 Data collection

Is the process of gathering information on variables of interest, in an established systematic way that enables one to answer stated research questions, test hypothesis and evaluate outcome. In the data collection part, different data regarding automation of irrigation system will be collected from different places. This data will provide the basic design requirements for the automation of irrigation system. The data will be collected from different ways including interview questions with the experts of irrigation system and other sources from books and the internet on automatic irrigation system.

2.4 Data analysis

Data analysis is the process of systematically applying statistical and/or logical techniques to describe, illustrate and evaluate data. In the data analysis part, the data which have been collected will be used to do the analysis for the design of automatic irrigation system. Using the data, different design procedures will be used to reach the design of the system which will be used in the design of automatic irrigation system. The data analysis leads the way to the circuit design and development and later to the prototype implementation.

2.5 Circuit design

Circuit design is the process of making the circuit based on the specifications of components and the requirements of the project as done in the data analysis part. In the circuit design the data is analysed in the data analysis process will be used to design the circuit for the project. As the project proposes there will be different systems which will be design accordingly.

2.6 Circuit simulation

Circuit simulation is the imitation of the operation of a real-world process of the circuit over time. The circuit simulation will give the clear picture about how the circuit design for the project will work. The circuit simulation will be done in different computer programs and software. One of the major computer software programs for the circuit simulation includes Proteus, National instruments multism and circuit maker and SPICE circuit design. The circuit simulation will be done after the circuit design has been completed. In circuit simulation it will be able to identify the errors made for the design and areas which need to be corrected before building of the prototype.

2.7 Prototype implementation

After the simulation of the circuit the prototype implementation follows next. In the prototype implementation the hardware prototype for the project will be built with similar functions as real environment implementation. The prototype will consist of the circuit, the sensing unit, the actuator unit and other hardware components which build up the prototype for the project.

2.8 Testing the prototype

After the design and implementation of the project the final stage is to test the prototype. The prototype will be tested and it is expected to run as it has been intended to do. The completion and testing of the prototype will mark the successfulness of the project.

2.9 Chapter Conclusion

This chapter described the steps which are going to be followed in order to solve the existing problem. In order to develop a new system to solve the existing problem, a lot of information needs to be known in order to provide the awareness on how the previous system works.

CHAPTER THREE

3.0 LITERATURE REVIEW

3.1 Introduction

In this part different sources of materials and information regarding the automation of irrigation system have been studied and below are some of the key information about the irrigation system including the environmental factors which affect plants growth and also it will cover about different wireless technologies existing today.

3.2 Environmental factors and plants growth

Plants grow well in an environment with good and favourable conditions. The favourable conditions make the plant to develop from initial stage to maturity stage without some complications which may rise to hinder the plant's growth. The conditions which favour plant's growth include temperature, humidity, soil moisture, light and carbon dioxide. These environmental factors play a good role in plants development to enhance its productivity and quality. Below are some environmental effects which contribute to the better growth of plants and crops in any field.

3.2.1 Temperature effects

Temperature is an important factor during plant's growth. It influences most plant development process which includes photosynthesis, transpiration, absorption, respiration and flowering. Each plant has its own optimum range of temperature for its growth. Below that range the plant will not inhibit life and above that temperature the plant will not grow at its potential form, the enzymes will become inactive will cause the essential of life to stop.

3.2.2 Humidity effects

Humidity is another important factor for the plants growth because it controls the moisture loss from the plant. Humidity is the amount of water vapour in the atmosphere. As the plant undergoes transpiration (the process through which plants release water vapour in the atmosphere), it varies the humidity level in the atmosphere. The transpiration rates decrease proportionality to the amount of humidity in the air. This is because water diffuses from areas of higher concentration to the areas of low concentration. Due to this phenomenon plants growing in a dry environment will most likely to lose its moisture overtime. In this case plant's growth will be hindered and it may even lead to plant's death. Also high humidity hinders the plant's growth, it is under very high humidity fungal diseases are most likely to occur and spread and furthermore the air becomes saturated with the water vapour which restricts transpiration. It is important for a farmer to know the humidity of a farm so as take actions to avoid the plants from being attacked with diseases.

3.2.3 Soil moisture effects

Soil moisture content indicates the amount of water in the soil. It is commonly expressed as amount of water present in a depth of one meter of soil; it is also expressed in percentage of water in $1m^3$ of soil. Soil moisture is important for plants growth since from the soil, water is taken by root system and lost through transpiration [4]. It is necessary for the farmer to consider the soil moisture content of his/her farm. The plant needs to extract water from the soil for its development and growth. In other way if the soil moisture is too high or is flooded, the oxygen content of the plant's root substrate is reduced by higher average water content in the pores, resulting in damage to the roots. And the plants with damaged roots cannot extract water and essential nutrients from soil properly and will eventually wilt and die in period of time. Therefore, water supplied to the plant must be sufficient and optimum.

3.2.4 Light effects

Light is the most important factor for the growth of plants. It is from light the all for growth is needed. Light is very important for the plants in the manufacturing of energy through the process called photosynthesis. Without light plants cannot manufacture their own food. Apart from food production, light also influences the growth of individual organs or the entire plant in direct ways.

3.3 Wireless technologies

This project involves the use of wireless technology to create a communication link between the irrigation system in the farm and the farmer. The communication link will be used to send notifications to the farmer. There are different wireless communication technologies which are available. The following are different types of wireless technologies and their descriptions.

3.3.1 GSM (Global system for mobile communications)

GSM is a standard developed by the European telecommunication standards institute (ETSI) to describe protocols for second-generation (2G) digital cellular networks used by mobile phones. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900MHz or 1800MHz frequency band.

3.3.2 Bluetooth technology

Bluetooth is standard used in links of short scope, destined to replace wired connections between electronic devices like cellular telephones, personal digital assistants (PDA), computers and many other devices. Every device will have to be equipped with a microchip (transceiver) that transmits and receives in the frequency of 2.4GHz that is available in the whole world. Bluetooth uses a radio technology called frequency-hoping spread spectrum. The transmitted data are divided into packets and each packet is transmitted on one of the 79 designated Bluetooth channels. Each channel has a bandwidth of 1MHz. Bluetooth 4.0 uses 2MHz spacing which allows for 40 channels. The first channel starts at 2402MHz and continues up to 2480MHz in MHz steps. It usually performs 1600 hops per second, with Adaptive frequency-hoping (AFP) enabled [5].

3.4 The existing systems

Since irrigation activities have been practiced for many years, there are different techniques which are used in irrigation. The following are among those techniques:

3.4.1 Microcontroller based automatic plant irrigation system

The system supplies water only when the moisture in the soil goes below the reference. Due to the direct transfer of water to the roots water conservation takes place and also helps to maintain the moisture to soil ratio at the root zone constant to some extent. Thus the system is efficient and compatible to changing environment [6].

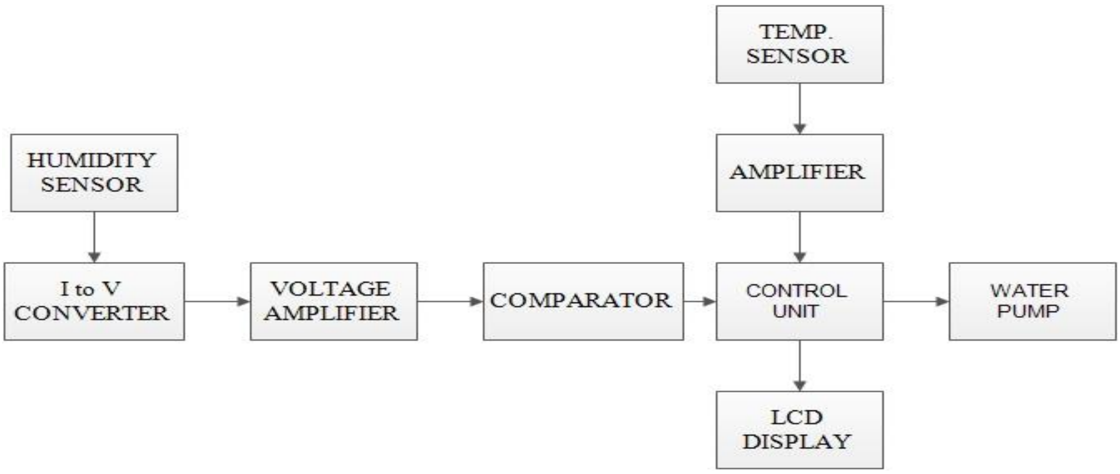

Figure 3.1 Block diagram of Microcontroller based automatic plant irrigation system

3.4.1.1 Limitations of micro controller based automatic plant irrigation system

i. Does not give out information to the farmer about the conditions of the farm.

ii. It is not water saving as since it does not have the rain sensors so it can still work while it is raining.

iii. Does not help control of fungal diseases which grow under high humid conditions

3.4.2 Water-saving irrigation system based on automatic control by using GSM technology

The system uses temperature and humidity sensors to detect the field temperature and humidity and then sensor values are sent to the base station. The base station checks the conditions for irrigation and performs automatic irrigation. Field condition is specifically monitored by the base station. Each field station is wirelessly communicating with a base station by GSM technology [7].

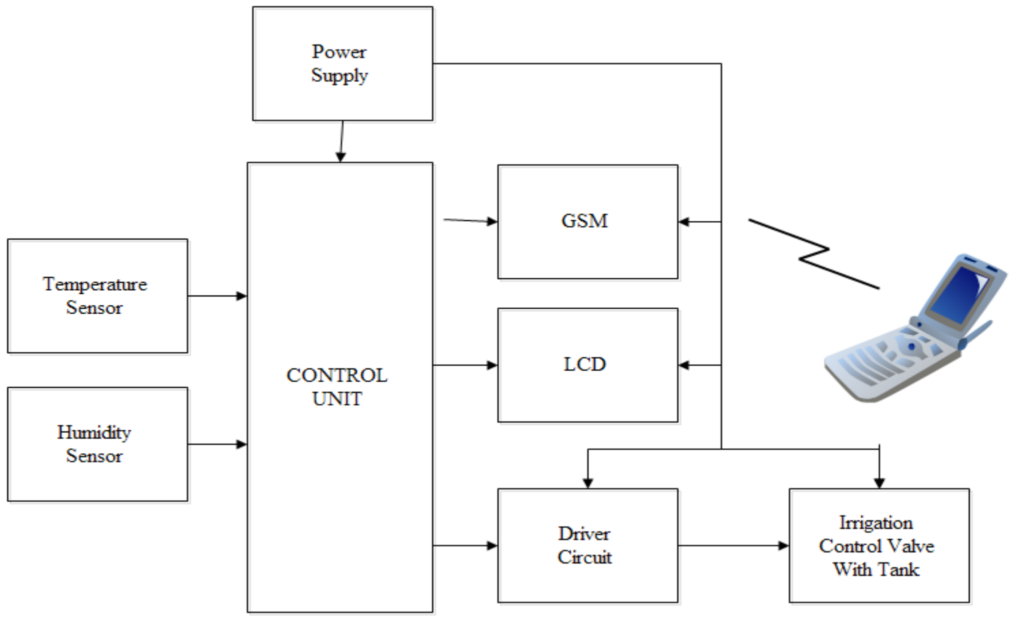

Figure 3.2 Block diagram of the water-saving irrigation system based on automatic control by using GSM technology

3.4.3 Drip Irrigation

This is known as the most water efficient method of irrigation. Water drops right near the root zone of a plant in a dripping motion. If the system is installed properly you can steadily reduce the loss of water through evaporation and runoff.

3.4.3.1 Advantage of drip irrigation

i. As water is applied locally and leaching is reduced, fertilizer loss is minimized [8]

3.4.3.2 Limitations drip irrigation

i. Not water saving
ii. Expensive
iii. High skills are required

3.4.4 Manual irrigation System

Manual irrigation system is time and labour intensive and requires regular attention and vigilance.

Figure 3.1 Manual irrigation system

3.4.4.1 Limitations of manual irrigation system

i. It is time consuming since it involves man power, they can't irrigate the whole farm at once they have to irrigate either in rows or columns and hence takes much time to do the job.
ii. Limited to small farms
iii. Since it involves man power, people can't do other jobs to satisfy their needs instead they have to spend most of their times in the farm.

3.5 Chapter Conclusion:

As irrigation system is becoming a major problem for farmer especially local farmers in rural areas, this system will help them to save their time also to save water and cost as it uses the energy from the sun.

CHAPTER FOUR

4.0 PROPOSED SYSTEM

4.1 Introduction

This system will comprise of the control unit to control all the actions of the system, solar power supply in order to work in places where there is no power supply from the national grid. Also will have the rain sensor in order to provide information to the PIC to stop the system from working when there is a rainfall. It also consists of wireless communication module which will also send information about the conditions of the farm.

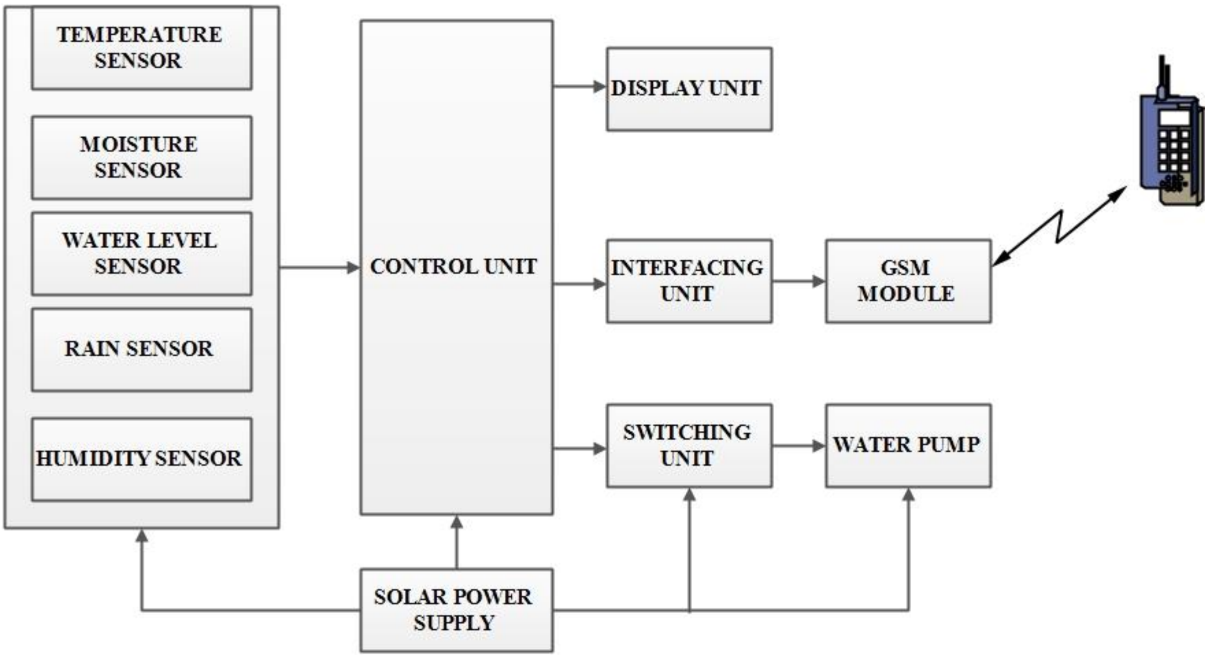

Figure 4.1 Block Diagram of an automatic irrigation system

4.3 Parts of the proposed irrigation system

4.3.1 Solar power supply

This will be used to power the whole system so as to work in rural areas where there is a lack of electricity supply from the national grid. It will consist of a solar panel and batteries**.**

4.3.2 Control unit

This consists of an integrated circuit used to manipulate different number of instructions written into it. In this project the microcontroller will be used. A microcontroller is an integrated circuit that contains memory, processing units and an input/output circuitry in a single unit.

4.3.3 Sensing unit

A sensor is a device that measures the physical quantity and converts it into a signal which can be read by an instrument. In this project the sensing unit will consist of different sensors to sense the parameters and send them to microcontroller so as it can make decisions. Sensors that are going to be used in the proposed irrigation system are rain sensor, moisture sensor, water level sensor, temperature sensor and humidity sensor.

4.3.4 Communication module

This will be used to send notifications to the farmer by using the wireless communication technology. The communication module will be receiving the string of messages from the microcontroller and send them to the farmer.

4.3.5 Water supply system

This will consist of a water pump and pipes that supplies water to the farms for irrigation purposes.

4.4 Advantages of the proposed irrigation system

i. It will reduce the work done by the farmer since the system will be automated.

ii. It will perform irrigation at a specific required period. The soil moisture sensor will be measuring the soil moisture content and the irrigation will be performed only when it is needed to be done.

iii. It can work in rural areas where there is only the power from the sun.

iv. Since it will have the rain sensor it will avoid the use of the system unnecessarily for example when the rain is falling the system has to stop working.

v. It will notify the farmer when there is a system failure or fault through SMS.

4.5 Chapter Conclusion

This chapter explained about the proposed automatic irrigation system together with its advantages and how is it going to solve the existing problem. The proposed system is expected to solve the existing problem stated in the chapter one above.

CHAPTER FIVE

5.0 DATA COLLECTION

5.1 Introduction

This chapter describes much on the data collected specifically for the blocks that make up the proposed system. Also, it gives some important data for the components and devices that are going to be used in this project. The data have been collected by considering their characteristics and the availability of the particular device.

5.2 Preliminary data

The data collected here verifies the existence of the problem and its effects to the farmers. Over 85% of irrigators in Tanzania still use buckets and watering cans [9]. The following table shows hours spent by farmers in irrigation activities:

Table 5.1 Hours spent by farmers in irrigation activities

Water lifting device	Time spent in irrigation (man-hours/ha/year)
Motorized pumps	267
Buckets, watering cans	2730
Treadle pumps	2510

The following table show the amount of money spent by farmers for diesel in generators

Table 5.2 Amount of money spent by farmers for diesel in generators

Size of the farm	Amount of oil spent (litters/day)	Cost per day	Total cost per month
¼ Acre	0.125	214.39	6431.17
½ Acre	0.25	428.78	12863.4
1 Acre	0.5	857.56	25726.8

5.3 Technical data

This part describes the specifications on the available equipment that build up the proposed system, depending on the availability of them in the market.

5.3.1 Control Unit

The control Unit includes a wide range choice of controllers. The choice of a controller depends much upon the complexity of the system design. Followings are some parameters that will be used to decide the type of control unit to be used:

Table 5.3 Parameters used to choose the type of control unit

PARAMETER	VALUE
I/O Pins	At least 16
Operating voltages	2.5-5V
RAM	At least 1.5KB
Programming memory	At least 256KB

The following are the types of control units that can be used:

5.3.1.1 Arduino

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. They are able to read inputs like light on a sensor, a finger on a button and so on so as to activate an actuator. The following are some technical specifications of an Arduino [10]:

Table 5.4 Technical specifications of an Arduino

Operating voltage	5V
Input voltage (recommended)	7-12V
Input voltage (limit)	6-20V
Digital I/O Pins	14
DC Current per I/O Pin	20mA
DC Current for 3.3V Pin	50mA
Flash Memory	32KB
SRAM	2KB
EEPROM	1KB
Clock speed	16MHz

5.3.1.2 Programmable Interface Controller (PIC)

Programmable Interface Controller (PIC) is an electronic circuit that can be programmed to carry out a vast range of tasks. Microcontrollers have traditionally been programmed using the assembly language of the target device. Microcontrollers can also be programmed using a high-level language, such as BASIC, PASCAL, or C [11].

Table 5.4 PIC specifications

Feature / Name	**PIC18F252**	**PIC16F877**	**PIC16F873**
Operating frequency (MHz)	DC – 40	DC – 20	DC – 20
Program memory (kb)	32	368	192
Data EEPROM (kb)	256	256	128
Analog to Digital converter (input channels)	8	8	5
Input voltage (V)	5	-3.4 to 5.5	-3 to 7.5
Maximum input current (mA)	1000	1000	250
Timers	4	3	3

5.3.2 Sensing unit

Sensor is a device that measures the physical quantity and converts it into a signal which can be read by an instrument. There are various types of sensors but in this project, we are going to deal with the following types of sensors;

5.3.2.1 Rain sensor

There are two main applications for rain sensors. The first is a water conservation device connected to an automatic irrigation [30] system that causes the system to shut down in the event of rainfall. The second is a device used to protect the interior of an automobile from rain and to support the automatic mode of windscreen wipers. The following table shows properties of rain water that will be used during data analysis for the selection of a proper rain sensor to be used.

Table 5.5 Properties of rain water

Properties of rain water	**Range**
Temperature (^{0}C)	20 – 32
Static dielectric(E)	80.18 - 73.18
Density (kg/m^3)	998.2071 - 992.2
Surface tension (N/m)	72.8
Water level(mm)	45 – 260

A rain sensor or rain switch is a switching device activated by rainfall. The most common modern rain sensors are based on the principle of total internal reflection where by an [27] infrared light is beamed at a 45-degree angle into the windshield from the interior if the glass is wet, less light makes it back to the sensor.

The rain sensor detects the rain by using the principle of transmitting a light and observes the variation of the intensity between transmitted and received one [29].

5.3.2.2 Temperature Sensor

The following are the suitable temperature ranges for irrigation of different types of crops [12] [13]:

Table 5.6 Suitable temperature ranges for irrigation of different types of crops

Type of crops	**Temperature range (°C)**
Cool season crops	16 – 22
Warmer season crops	18 – 28

There are various ways of measuring temperature of the soil through the use of temperature sensors. There are different temperature sensors in the market. The main temperature sensors which were analysed include thermocouple, thermistors and linear IC temperature sensor (LM 35)

5.3.2.2.1 Thermocouple

A thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wires are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created [14]. There are several common types of thermocouple available, each with a characteristic sensitivity and optimal temperature measurement range. The following table shows thermocouple sensitivity and useful temperature ranges for different thermocouple types.

Table 5.7 Thermocouple sensitivity and useful temperature ranges for different thermocouple types.

Type	Sensitivity	Temperature range
Type B	5 to 10uV/°C	+250 to +1820°C
Type E	40 to 80uV/°C	-270 to +1000°C
Type J	50 to 60uV/°C	-210 to +1200°C
Type K	28 to 42uV/°C	-250 to +1200°C
Type N	24 to 38uV/°C	-250 to +1300°C
Type R	8 to 14uV/°C	-50 to +1768°C
Type S	8 to 12uV/°C	-50 to +1768°C
Type T	17 to 58uV/°C	-250 to +400°C

5.3.2.2.2 Thermistors

Thermistors are temperature sensors built with semiconductor materials which can have either positive or negative temperature coefficient. Thermistors are temperature sensitive resistors. All resistors vary with temperature, but thermistors are constructed of semiconductor material with a resistivity that is especially sensitive to temperature [15].

Advantages

i. High sensitivity to changes in temperature (having a thermal response of up to 100Ω/°C at 25°C)
ii. Fast response

5.3.2.3 Water level sensor

The following are the data requirements water tank in order to select the water level sensor for a ¼ acre

Table 5.8 Water tank requirements for 1/4 acre

Measurement	Diameter (m)	Height (m)	Volume (m^3)
Tank dimension (m)	1.784	4	10
Maximum level	1.784	3.99	9.97
Minimum level	1.784	0.01	0.02

There are various types of sensors but in this project, we are going to deal with the liquid level sensors that are capable of performing detection to the level of water changes in the storage tanks. Liquid sensors provide measurement of the height or position of a fluid surface by using a variety of different technologies and methods as follows;

i. **Air bubbler** systems involve a fixed flow of air passed through a tube with an opening below the surface level of the measured liquid.
ii. **Capacitance** sensors apply radio frequency signals to a capacitance circuit to sense materials with dielectric constants ranging from 1.1 to 88 or more.
iii. **Conductivity** or **Resistance** sensors use a low-voltage power source applied across separate electrodes. Level is interpreted based on the amount of resistance or conductance of the substance which carries the current.
iv. **Float** sensors involves the opening or closing of the mechanical switch through either direct contact or magnetic operation from a device which floats on the surface of the measured liquid.
v. **Optical** sensors detect the decrease or change in the transmission of infrared light emmited from a diode through a material.
vi. **Pressure membrane** and **differential** sensors measure the pressure or change in pressure in a vessel such as a holding or storage tank.
vii. **Ultrasonic** or **sonic** liquid level sensors measure the length of time it takes for a reflected sound wave to return to a transducer from a target surface.

5.3.2.4 Humidity sensor

The following are the Suitable humidity range for plants growth [13]:

Table 5.9 Suitable humidity range for plants growth

Type of plants	Ideal humidity levels
Vegetable plants	50% - 70%
Flowering plants	50% - 60%

5.3.2.5 Soil moisture sensor

There are different means of detecting soil moisture of the farm. The following are different temperature sensor specifications that are needed in order to select a suitable soil moisture sensor:

Table 5.10 Operating parameters for soil moisture sensor

Operational temperature		10 - 40°C
Operational voltage		3 – 5V
Soil moisture content range	**At seedling stage**	60% - 65%
	At seedling stage	70% - 75%
	At fruit developing stage	70% - 75%

5.3.3 GSM module

As discussed in the introduction section of the proposed system, the GSM module will be used to provide a means of communication between the farmer and his/her farm so as to know the conditions of his/her farm. The GSM module requirements will base in operating frequencies from different service providers in Tanzania as shown in the table below:

Table 5.11 Operating frequencies from different service providers in Tanzania

OPERATOR	**UPLINK FREQUECNY(MHz)**	**DOWNLINK FREQUENCY(MHz)**
TIGO	890-895	935-940
AIRTEL	895-900	940-945
ZANTEL	900-905	945-950
VODACOM	905-910	950-955

5.3.3.1 GSM Module

The following are different GSM Modules with their operating properties [28]

Table 5.12 Different GSM modems with their specifications

	GSM/GPRS Module SIM300	Waveform GSM/GPRS Modem Q2403	SIM900A Module	SIM900 Module
DATA TRANSMISSION (Baud rate)	1200 to 115200 bps	Baud Rate: 9600-115200bits/s	Baud Rate: 9600-115200bits/s	Baud Rate: 9600-115200bits/s
OPERATING VOLTAGE	3.6 -4.5V DC	Power Source: 5-24V DC.	Supply voltage range: 3.1-4.8V	range: 3.2 ... 4.8V
OPERATING BANDWIDTH	Support dual frequency: GSM 900/1800MHz	Support dual frequency: GSM 900/1800MHz	Dual-Band 900/ 1800 MHz	Quad-Band 850/ 900/ 1800/ 1900 MHz
PROGRAM CONTROL	standard AT commands	Control via AT Commands	SIMCOM	AT command GSM
OPERATION TEMPERATURE	-30° C to +85°C	-40° C to +85°C	-40° C to +85°C	-40°C to +85 °C
POWER CONSUMPTION	Low power consumption: 2.5mA	Low power consumption: 1.5Ma	Low power consumption: 1.5mA	Low power consumption: 1.0mA

5.3.4 Power supply system

The system uses solar power supply which will consist of solar panel, back up batteries, and an inverter. The following table shows technical requirements for the solar power supply system.

Power requirements

i. Solar panel power = 300W

ii. Battery requirements:
   - Output voltage = 24V
   - Output current = 8A

iii. Inverter requirements
   - Output voltage = 220V a.c
   - Output current = 15A (max)
   - Inverter power = 2000W

Table 5.13 General Specifications for the solar power supply system

	Minimum	Typical	Maximum
Solar panel power (W)	100	-	1200
Current range (A)	7	8.0	8.1
Solar battery voltage (V)	12	-	24

5.3.5 Display unit

The system needs a display that can display at least 16 characters. The following are different types of LCD displays that can be used in this automatic irrigation system.

5.3.5.1 LCD Display

A liquid-crystal display (LCD) is a flat-panel display or other electronic visual display that uses the light-modulating properties of liquid crystals [16]. Liquid crystals do not emit light directly. The display unit that is going to be used will be selected from the LCD types below

5.3.5.1.1 Alphanumeric LCD Displays

The table below shows properties of alphanumerical LCD displays

Table 5.14 Properties of alphanumerical LCD displays

DEVICE MODEL	OPERATING VOLTAGE (v)	RESOLUTION
LM016L	5	16x2
LM017L	5	32x2
LM018L	5	40x2
LM020L	5	16x1
LM032L	5	20x2
LM041L	5	16x4
LM044L	5	20x4

5.3.5.1.2 LCD Graphical displays

The table below shows properties of graphical LCD displays

Table 5.15 Properties of graphical LCD displays

DEVICE MODEL	OPERATING VOLTAGE (v)	RESOLUTION
LM3228	5	128x64
LM3229	5	240x128
LM3267	5	240x64
LM3283	5	240x64
LM3287	5	240x64
LM4229	5	240x128
LM4265	5	128x128

5.3.5.1.3 Electrical properties of different LCDs displays

The table below shows electrical properties of different LDC displays

Table 5.16 Electrical properties of different LDC displays

ELECTRICAL PARAMETER	16x2 LCD (016M002B)	16x4 LCD DISPLAY (016M004)
Operating voltage	4.7v to 53v	4.7v to 5.3v
Operating current	12mA to 3mA	12mA to 3mA
Physical Dimension	80mm x 36mm	87mm x 60mm
Operating temperature	0^oC to 70^oC	-20^oC to 70^oC

5.3.6 Interfacing unit

5.3.6.1 Max232

Max232 is designed by Maxim integrated products. This IC is widely used in RS232 communication systems in which the conversion of voltage level is required to make TTL devices to be compatible with PC serial port and vice versa. This chip contains charge pumps which pumps the voltage to the designed level. It can be powered by a single +5-volt power supply and its output can reach +7.5 volts. Max232 comes in 16pin dip and many other packages and it contains dual drivers [17]. There are many GSM modems available in the market and most of them are on TTL logic but some of them use RS232 standards and again it becomes a problem to communicate with GSM modem by using micro controller, Arduino or any other TTL platform. Max232 is used to solve this problem. Max232 requires minimum 4 external capacitors. Their value can range from 1uF to 10uF and 16volts or more rating.

5.3.7 Water supply system

This water supply system consists of water pump to pump water from a tank that is at least 5meters from the farm, sprinklers and pipes that can supply water to the plants in the farm. The following are different types of water pumps and sprinklers available.

5.3.7.1 Water pumps

The most appropriate pumps to move water from a shallow water source to a small application area are the centrifugal, jet, and sump pumps [18].

5.3.7.1.1 Centrifugal pump

Centrifugal pumps sometimes called sprinkler or lawn pumps, are best used when you want to move water from a shallow water source to a small system with high volume required. The shallow water source can be a pond, ditch, reservoir, etc. that is 25 feet deep or less. The small system can be a lawn sprinkler system with many sprinkler heads.

Figure 5.1 Centrifugal pump

5.3.7.1.2 Jet Pumps

Jet pumps are best used when you want to move water from a shallow water source to a small system with low volume required. The shallow water source again can be a pond, ditch, reservoir, etc. that is 25 feet deep or less. The small system can be a lawn sprinkler system with few sprinkler heads [18].

Figure 5.2 Jet Pump

5.3.7.1.3 Submersible Sump Pumps

Submersible (underwater) sump pumps are best used when you want to take water from a shallow water source to a single outlet with high volume. The shallow water source, can be a pond, ditch, reservoir, etc. that is 20 feet deep or less [18]. The single outlet is typically a garden hose. The common use for the sump pump would be to water a small garden with a hose. (It's most common use however is to pump water out of flooded basements.)

Figure 5.3 Submersible Sump Pump

Table 5.17 Most appropriate pumps to move water from a shallow water source to a small application area

Pump Type	Common Use	Distance (ft)	Pump Pressure (PSI)	Pump Flow Rate (GPM)	Pump Power (HP)
Centrifugal/ Sprinkler/ Lawn Pump	Move water from one source to many sprinkler heads along one line (low pressure, high volume)	0 – 100	30 – 50	15 – 45	1– 1.5
		100 – 200	30 – 50	25 – 55	1 – 1.5
		200+	30 – 50	35 – 60	1.5 – 2
(Shallow Well) Jet Pump	Move water from one source to very few sprinkler heads along one line (high pressure, low volume)	0 – 100	30 – 60	5 – 10	0.25 – 0.5
		100 – 200	30 – 60	10 – 20	0.5 – 0.75
		200+	30 – 65	10 – 25	0.5 – 1.5
Submersible Sump Pump	Drops into water and attaches straight to garden hose (low pressure, high volume)	0 – 150	30 – 60	25 – 80	0.25 – 1

5.3.7.2 Small-scale sprinkler systems

5.3.7.2.1 Mini Gun

Mini gun sprinkler systems are best used when you want to irrigate a small area by moving a portable sprinkler with a wide application area. Mini gun systems come with a sprinkler attached to a water reel. The reel is connected to a hose which supplies it water. Because the reel is set on wheels, it is very easy to move [18]. Once you have placed the reel, you pull out the sprinkler and then the reel pulls it back in automatically, irrigating as it goes.

5.3.7.2.2 Solid Set

Solid set sprinkler systems come in two basic forms, portable and permanent. These systems may have a variety of sprinkler heads attached to them, depending on your needs. The solid set system is made up of sprinkler risers (vertical pipe) spaced evenly along the length of a horizontal pipe running on the ground [18]. This system can be permanent or portable. These systems are labor intensive.

5.3.7.2.3 K-Line – 5 Pod 2 Acre Kit

K-Line sprinkler systems are highly mobile. If you are interested in irrigating more than a couple of acres, it is easy to expand by simply buying more of the K-Line sprinkler kits. The kits include the sprinklers, the tubing, and the rest of the system (without the pump). The sprinkler sits in a black pod which looks like a tire [18]. The pods are connected along a line of hose, generally 5 pods to a hose. They are very easy to move and are grazing animal - friendly. They perform well on flat or hilly ground.

Table 5.18 Sprinkler System Selection Matrix

Sprinkler System Type	**Features**	**Application Area (acre)**	**Optimal Pressure (PSI)**	**Flow Rate (GPM)**
Mini Gun	Portable. Grazing animal friendly. Easily automated. Can be used on irregularly shaped areas.	0.2 – 2*	45 – 150*	4 – 80*
Solid Set	Easily automated. More maintenance labor required. Expandable to more areas.	As desired	25 – 65	1 – 8 (per sprinkler head)
K-Line (5 pod 2-acre kit)	Portable. Expandable to more acres if more kits are purchased. Grazing animal friendly. Can be used on flat and hilly ground, as well as irregularly shaped areas.	2	40 – 50	12 – 24

5.4 Chapter Conclusion

In this chapter, data from different sources have been collected in order to show the existence of the problem. Also data which are going to be used in the design of the system have been collected in order to solve the existing problem.

CHAPTER SIX

6.0 DATA ANALYSIS AND DESIGN

6.1 Introduction

This chapter contains the analysis of data collected and their related calculations which are going to be used during implementation of our project. Also the expected input to the circuit is going to be explained and analysed so as to achieve the project objectives.

6.2 Sensing unit

The control unit consists of different sensors that will read environmental conditions and send signal to the microcontroller to process them. The sensors used are as follows:

6.2.1 Soil Moisture sensor

The required soil moisture sensor is supposed to be operating at temperature between 16 – 28 degrees Celsius, its operating voltage of about 5V, its output voltage should not exceed 5V so as to be able to send the signal to the microcontroller.

Qualitative analysis

Table 6.1 Types of soil moisture sensors

SENSOR	AVAILABITY	SENSITIVITY	COST
Frequency Domain Reflectometry(FDR)	High	Good	Cheap
Time Domain Reflectometry(TDR)	Moderate	average	Expensive
Gypsum Blocks	Moderate	Good	Average

The selected soil moisture sensor is a frequency domain reflectometry moisture sensor which is VH400 manufactured by the Vegetronix industry.

[25] The sensor requires input voltage range between 3.3V to 20V and output voltage range between 0V to 5V in relation to the soil moisture content in the soil. It measures the dielectric constant of the soil using transmission line technique and its output voltage is proportional to the moisture content in the soil. The relationship between sensor output voltage and the moisture content in the soil can be expressed using the equation below:

$$SM\ (\%) = (V_{out} \times 21.186) - 10.381$$

Where:

- SM – The soil moisture content in Percentage
- V_{out} – The output voltage of a sensor

From the data of soil moisture, the required range of moisture is between 60% and 75% soil moisture content,

For 60% moisture content:

$$V_{out} = (SM + 10.381)/21.186 \text{ ……………...Equation (i)}$$

$$V_{out} = (60 + 10.381)/21.186$$

$$V_{out} = 3.3V$$

For 75% moisture content:

$$V_{out} = (75 + 10.381)/21.186$$

$$V_{out} = 4.03V$$

Therefore, the output voltage will be within the input range of the microcontroller so the selected sensor is suitable for moisture content measurement.

6.2.2 Temperature sensor

In this project the temperature sensor required to be able to measure the temperature in the range of 16 – 28 degrees Celsius also its operating voltage should be between 0 – 5V.

Qualitative analysis

Table 6.2 Types of temperature sensors available

SENSOR	AVAILABITY	SENSITIVITY	COST	RANGE OF MEASUREMENT(°C)
Thermocouple	High	Good	Cheap	-270 to 1260
Thermistor	Moderate	average	Inexpensive	0 to 100
Linear IC Temperature sensor(LM35)	Moderate	Good	Average	-55 to 150

The selected temperature sensor which will be suitable for these conditions is LM35. [23] The LM35 has a linear scale factor of 10mV/°C, and hence it is governed by the equation (ii) below:

$$\text{Temperature}(°C) = V_{out}(100°C/V) \text{ ……………………Equation (ii)}$$

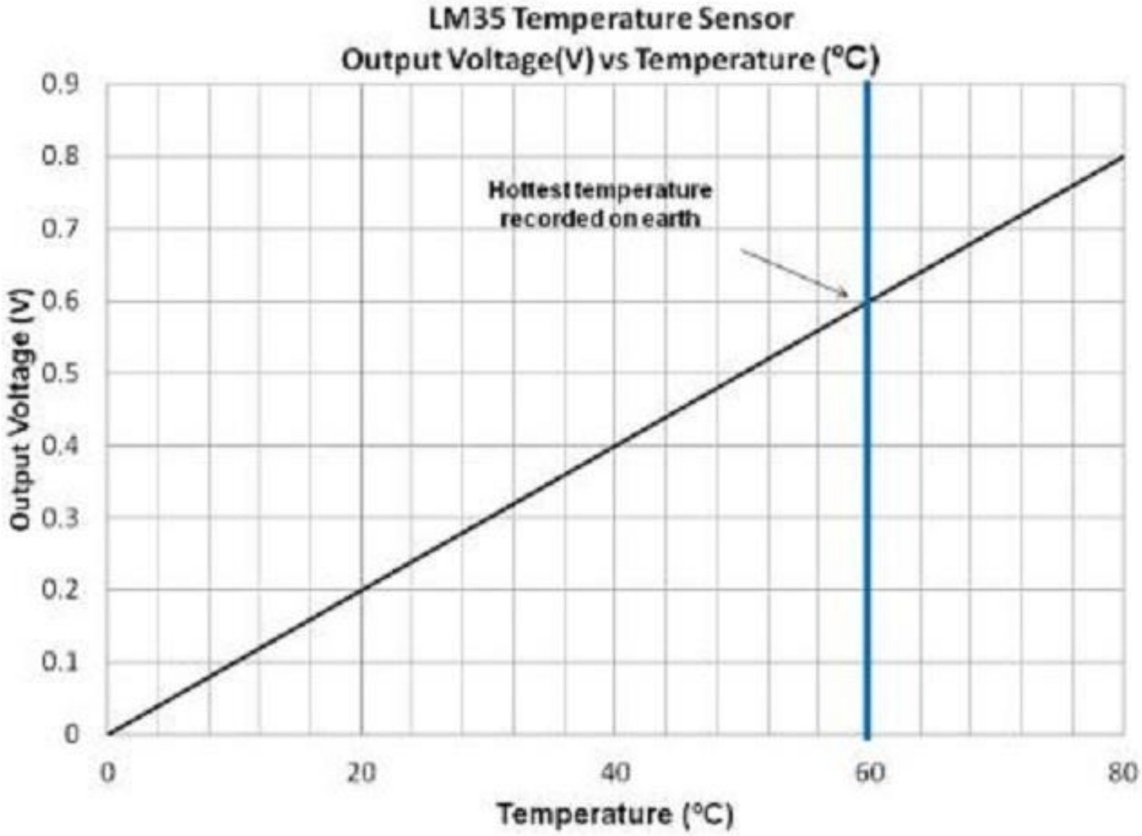

Figure 6.1 Graph of LM35 output voltage vs Temperature

For the temperature range of the soil as from the data collected earlier in the data collection chapter, the temperature sensor should work in the required temperature range of 16 – 28 degrees Celsius, the respective output voltages that are fed to the microcontroller is computed from the sensor's equation as shown below:

$$V_{out} = \frac{\boldsymbol{Temperature}}{(\mathbf{100°C/V})} \text{ ....Equation (iii)}$$

For the temperature of 24°C:

$$V_{out} = \frac{16°C}{(100°C/V)}$$

$$V_{out} = 160\text{mV}$$

For the temperature of 16°C:

$$V_{out} = \frac{28°C}{100°C/V}$$

$$V_{out} = 280\text{mV}$$

From the results above, the output voltage from the sensor can be detected by the microcontroller without any other external circuit.

6.2.3 Humidity Sensor

The humidity level required to be measured in this project is about 50% - 70%

Qualitative analysis

Table 6.3 Types of humidity sensors available

SENSOR	AVAILABITY	SENSITIVITY	COST	RANGE (%)
DHT 11	Moderate	Good	Cheap	20 – 90
DHT 22	High	Average	Average	0 – 100
HS1101 sensor	Moderate	Good	Average	0 – 100

The selected humidity sensor is the capacitive humidity sensors (HS1101 sensor) which gives output in capacitive form. [22] They change their capacitance with respect to change in sensing parameter which is the amount of water vapours in air. Its relationship between relative humidity and voltage is as shown below:

$$\boldsymbol{V_{out} = V_{cc} \times (0.00474 \times \%RH + 0.2354)} \text{…………….. Equation (iv)}$$

Where by when RH = 50%

$$V_{out} = V_{cc} \times (0.00474 \times 50 + 0.2354)$$

$$V_{out} = 2.36V$$

When RH = 70%

$$V_{out} = V_{cc} \times (0.00474 \times 70 + 0.2354)$$

$$V_{out} = 2.83V$$

6.2.4 Rain Sensor

Basic requirements

The rain sensor is used to switch off the irrigation system when rain is encountered by the system. The rain sensor required in the designed system needs to have the following features:

- The sensing module of low power supply requirement (typically 5V) is needed in order to save the power consumption in the system
- The sensor should provide a digital output when a rain is detected by the system

Qualitative analysis

Table 6.4 Types of rain sensors available

MODEL/TYPE	COMMUNICATION	COST	OUTPUT
Arduino module	Wire	Cheap	Analog/Digital
Kemo M152 12V Rain Detector	Wire	Expensive	Analog/Digital
Hunter RAIN-CLIK	Wireless/wire	Expensive	Digital

The Arduino rain sensing module is selected to be used in the system because it is cheap and also it meets all specified requirement stated. The outputs of interest are HIGH (5V) and LOW(0V).

The sensitivity of the rain sensor is of no interest since the rain sensor is used to switch off the system when rain is detected.

6.2.5 Water level sensor

Basic requirements

The system requires a water level sensor that will be able to detect the depth of water up to 4m deep, so as it can send a signal.

Qualitative analysis

Table 6.5 Types of water level sensors available

MODEL/TYPE	COMMUNICATION	COST	OUTPUT
Arduino module	Wire	Cheap	Analog/Digital
Kemo M152 12V Rain Detector	Wire	Expensive	Analog/Digital
Ultrasonic sensor (HC-SR04)	Wireless	Cheap	Digital

The selected sensor is the ultrasonic sensor (HC-SR04) since it meets the required conditions. Its operation is as follows:

[24] The timing diagram of HC-SR04 is shown. To start measurement, Trig of SR04 must receive a pulse of high (5V) for at least 10us, this will initiate the sensor will transmit out 8 cycle of ultrasonic burst at 40kHz and wait for the reflected ultrasonic burst. When the sensor detected ultrasonic from receiver, it will set the Echo pin to high (5V) and delay for a period (width) which proportion to distance. To obtain the distance, measure the width (Ton) of Echo pin.

Time = Width of Echo pulse, in uS (micro second)

i. Distance in centimeters = Time / 58
ii. Distance in inches = Time / 148
iii. Or you can utilize the speed of sound, which is 340m/s

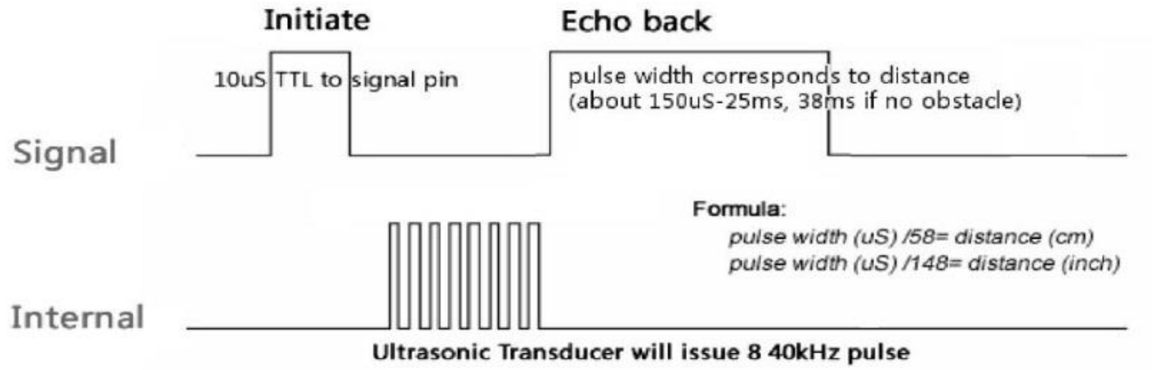

Figure 6.2 Ultrasonic sensor output signal pulses

6.3 Control unit

In this project the microcontroller that is needed should have the following characteristics:

i. It should have the UART terminals for communication purpose
ii. It must have a built in analog to digital converter
iii. Low power consumption
iv. It must have enough processing speed
v. It should be easily available in the market

Qualitative analysis

The following are different control units and their qualities from which one has to be chosen

Table 6.6 Types of PICs available

MODELS	AVAILABITY	MEMORY	COST	OPERATING VOLTAGE(V)
PIC6F887	High	Enough	Average	2 to 5.5
PIC16F877	High	Enough	Average	2 to 5.5
PIC 16F877A	High	Good	Average	2 to 5.5

Figure 6.3 PIC16F887

From the required features the selected microcontroller is from PIC16 family which is PIC16F887. The control unit will be responsible to read the sensors values and make decisions on accordance with the environmental conditions. The PIC16F887 is interfaced with external oscillator and for controlling how fast the controller work. The external oscillator chosen is 8MHz

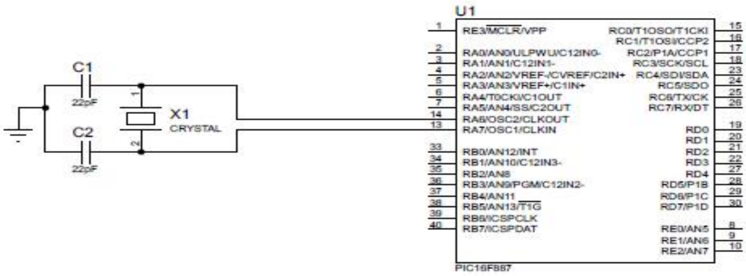

Figure 6.4 PIC Connection with crystal oscillator

6.3.1 Programming the control unit

When programming the control unit, the following flowchart will be followed

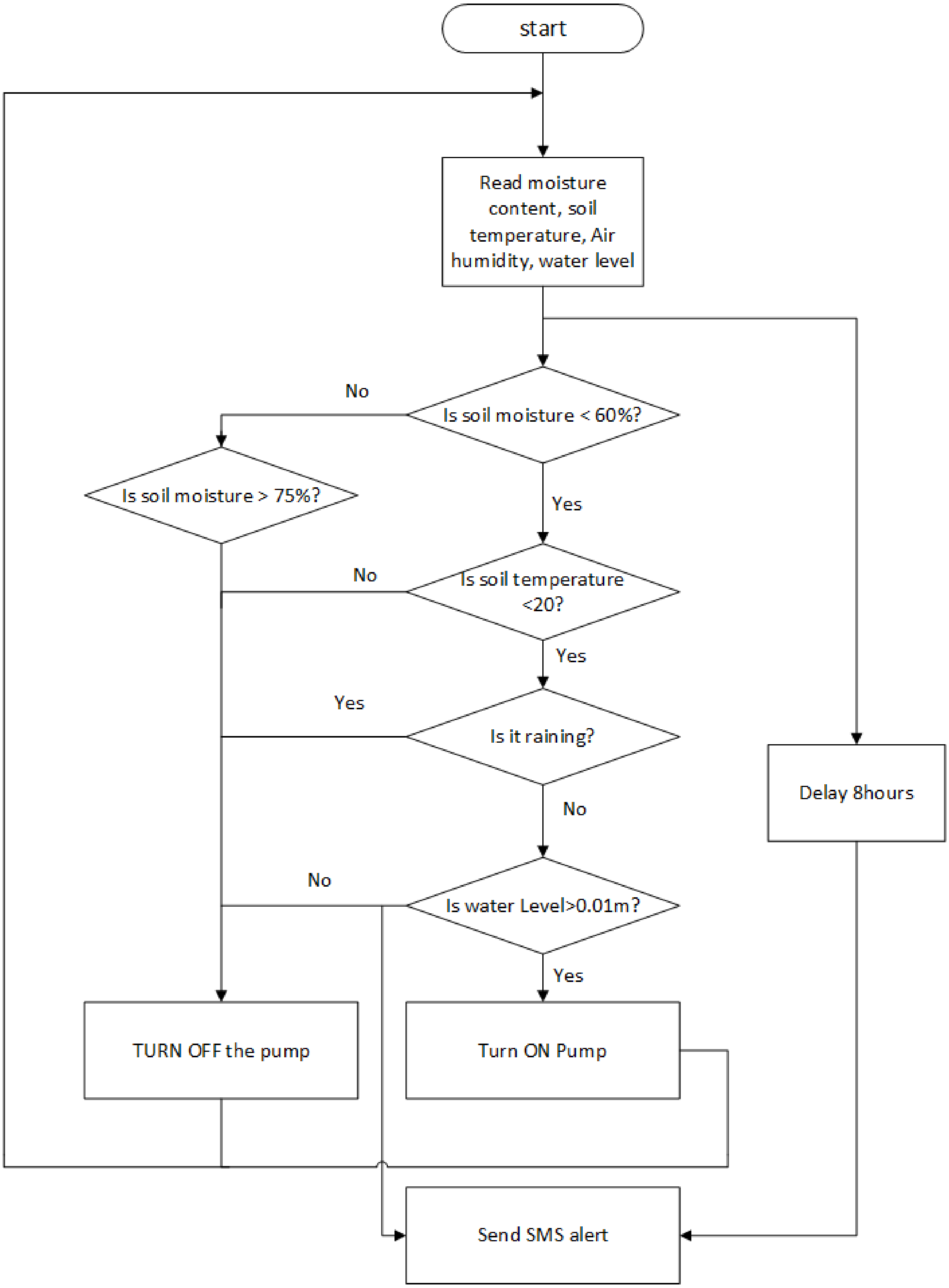

Figure 6.5 Flowchart for programming the microcontroller

6.4 Water supply system

The water supply system will consist of switching unit that includes a transistor and a relay for switching the pump ON and OFF when needed. Also a system will consist a water pump in order to supply water from the tank to the farm.

6.4.1 Switching unit

The switching unit consists of switching transistor and a relay

6.4.1.1 Switching Transistor

A transistor is used as a current-controlled switch since its collector current is proportionally limited by its base current. Transistors may be used as switching elements to control DC power to a load. The controlled current goes between emitter and collector, the controlling current goes between emitter and base. The transistor used in this switching unit is [26] BC548 because it has high gain of 110 and has a maximum collector current of 100mA which will allow connection of load devices of load devices like relay.

6.4.1.2 Relay

The relay switch opens and closes the control of another electric circuit. The selected relay's maximum coil current should not be greater than the collector current of the transistor and it should be a 12V relay in order to run a pump. The first thing to consider when connecting a relay is to know the coil resistance of the relay so as to know the current flow through the relay. The selected relay has a coil resistance of 400Ohms.

The current through the relay is calculated from ohm's law

$$V = IR \quad \text{………………… Equation (v)}$$

$$\text{where } I = V/R$$

$$I = \frac{12V}{400\Omega}$$

$$I = 30mV$$

From the transistor BC548 data sheet the maximum collector current is 100mA, h_{fe} = 110

From the formula: $h_{fe} = \boldsymbol{Ic}/\boldsymbol{I_B}$……………………. Equation (vi)

Where $I_B = {I_C}/{I_{fe}}$

$$I_B = {30mA}/{110}$$

$$I_B = 0.27\text{mA}$$

To calculate the Base resistance R_B:

$$R_B = \frac{V_1 - V_{BE}}{I_B}$$

$$R_B = \frac{(5-0.7)V}{0.27mA}$$

$$R_B = 15K\Omega$$

6.4.2 Water Pump

Basic requirements:

The theoretical power needed for pumping water is called **water horsepower** (WHP) and is calculated by [20]:

$$\boldsymbol{WPH = \frac{GPM\ x\ TDH}{3960}} \text{ ……………………………….. Equation (vii)}$$

Where: GPM = Pumping rate in Gallons per minute

TDH = Total dynamic head (feet)

Also TDH = (static head) + (friction loss) + (operating pressure) + (elevation change) …………………………………………………………Equation (viii)

But elevation change can be ignored since the system is used for irrigation in a flat levelled field. Therefore,

TDH = (static head) + (friction loss) + (operating pressure)

Where: Static head = 13.12ft (4m)

[21] Friction loss: $H_L/100' = 0.2083 \text{ X } (100/C)^{1.85} \text{ X } (Q^{1.85}/D^{4.8655})$

$H_L/100'$ = Head loss per 100 feet of pipe

C = Correction factor to account for pipe roughness (C = 100, assume a worst case scenario)

Q = 10GPM (Liquid flow rate in GPM)

D = (2 inches) Inside pipe diameter

Therefore, friction loss $H_L/100' = 0.2083 \text{ X } (100/100)^{1.85} \text{ X } (10^{1.85}/2^{4.8655})$

$$H_L/100' = 0.506ft$$

Operating pressure = 184.48ft (80psi)

TDH = 13.12 + 0.506 + 184.48

TDH = 198.11ft

Therefore,

$$WPH = \frac{10\ x\ 198.11}{3960}$$

WHP = 0.5hp

Qualitative analysis

Table 6.7 Types of water pump for irrigation

Pump Type	**Distance (ft)**	**Pump Pressure (PSI)**	**Pump Flow Rate (GPM)**	**Pump Power (HP)**
Centrifugal/ Sprinkler/ Lawn Pump	0 – 100	30 – 50	15 – 45	1– 1.5
	100 – 200	30 – 50	25 – 55	1 – 1.5
	200+	30 – 50	35 – 60	1.5 – 2
(Shallow Well) Jet Pump	0 – 100	30 – 60	5 – 10	0.25 – 0.5
	100 – 200	30 – 60	10 – 20	0.5 – 0.75
	200+	30 – 65	10 – 25	0.5 – 1.5
Submersible Sump Pump	0 – 150	30 – 60	25 – 80	0.25 – 1

Therefore, the selected water pump is a jet pump since it meets the required conditions

6.5 GSM Module

GSM module required in this project is supposed to operate at a voltage supply which is not greater than 5V and should be operating at frequency band that is used by the mobile service providers in Tanzania. Different mobile service providers available in Tanzania with their operating frequencies are as shown in the table below:

Table 6.8 Operating frequencies for network operators in Tanzania

OPERATOR	**UPLINK FREQUECNY(MHz)**	**DOWNLINK FREQUENCY(MHz)**
TIGO	890-895	935-940
AIRTEL	895-900	940-945
ZANTEL	900-905	945-950
VODACOM	905-910	950-955

Qualitative analysis

Table 6.9 Types of GSM module available

	GSM/GPRS Module SIM300	Waveform GSM/GPRS Modem Q2403	SIM900A Module	SIM900 Module
DATA TRANSMISSION (Baud rate)	1200 to 115200 bps	Baud Rate: 9600-115200bits/s	Baud Rate: 9600 - 115200bits/s	Baud Rate: 9600-115200bits/s
OPERATING VOLTAGE	3.6 -4.5V DC	Power Source: 5-24V DC.	Supply voltage range: 3.1-4.8V	Range: 3.2 - 5V
OPERATING BANDWIDTH	Support dual frequency: GSM 900/1800MHz	Support dual frequency: GSM 900/1800MHz	Dual-Band 900/ 1800 MHz	Quad-Band 850/ 900/ 1800/ 1900 MHz
PROGRAM CONTROL	standard AT commands	Control via AT Commands	SIMCOM	AT command GSM
OPERATING TEMPERATURE	-30° C to +85°C	-40° C to +85°C.	-40° C to +85°C	-40°C to +85 °C

The selected GSM module is SIM900 module since it meets all the required characteristics.

6.6 Circuit design:

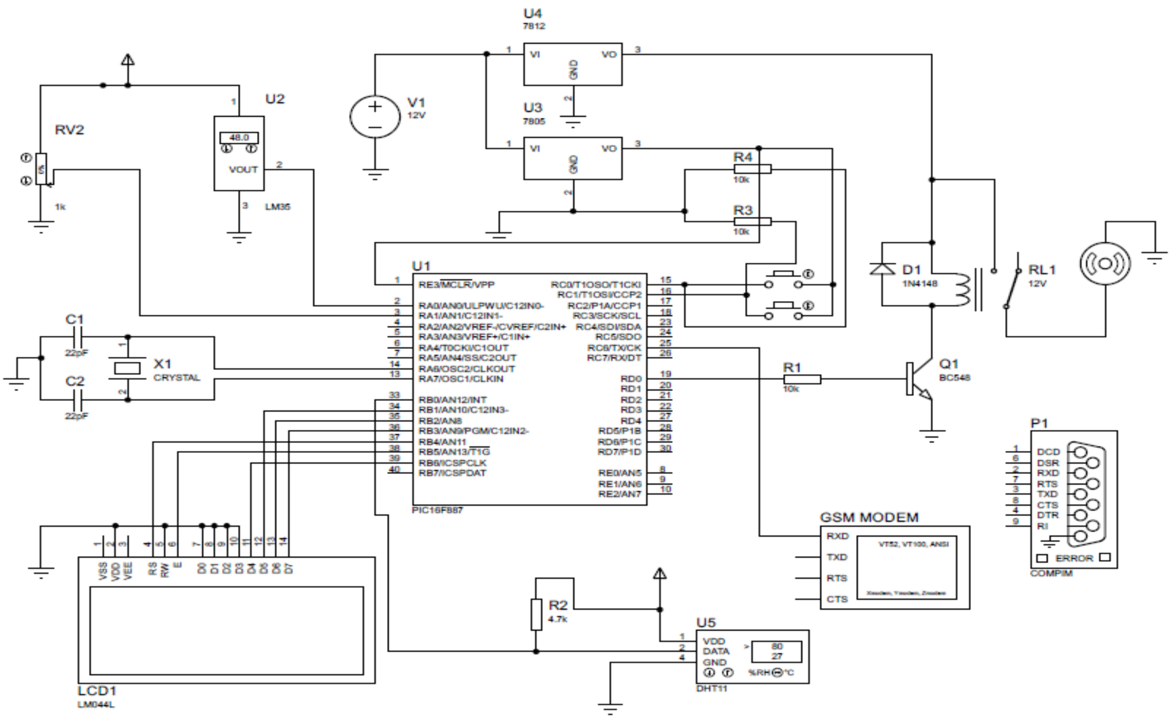

Figure 6.6 Circuit design of the system

6.7 Chapter Conclusion

Different data have been analysed in this chapter to the completion of the circuit design. The circuit design will be used in the simulation software to test different parameters to observe if they correlate with the calculations made in this chapter.

CHAPTER SEVEN

7.0 SIMULATION AND RESULTS

7.1 Introduction

In this chapter a series of simulations were done using the simulation software. The simulation software contains different simulation model for different components and results were recorded. The results are recorded to show if the circuit operates as required and if it can be implemented to the designing of prototype.

7.2 Simulation Setup

The simulation of the circuit is done using Proteus software installed in the computer. The software has different simulation models and components which simulate the real working environment for the component. The available simulation devices include:

i. PIC16F887
ii. Transistor BC548
iii. Relays
iv. Resistors
v. Motor which acts as a water pump
vi. Power and ground terminals
vii. Display
viii. Crystal oscillator
ix. Virtual terminal used as a mobile terminal/phone
x. Temperature sensor (LM35) simulation model
xi. Push buttons
xii. COMPORT act as a GSM Modem

In the simulation software some of the components like the soil moisture sensor does not have a simulation model therefore variable resistors were used to vary the voltage which would be given out by the moisture sensor.

The rain sensor and water level sensor are simulated by using push buttons because they provide a digital output. The binary input is selected because the rain sensing module is not available in the proteus components library

The simulation circuit was setup in proteus software as shown in the figure below:

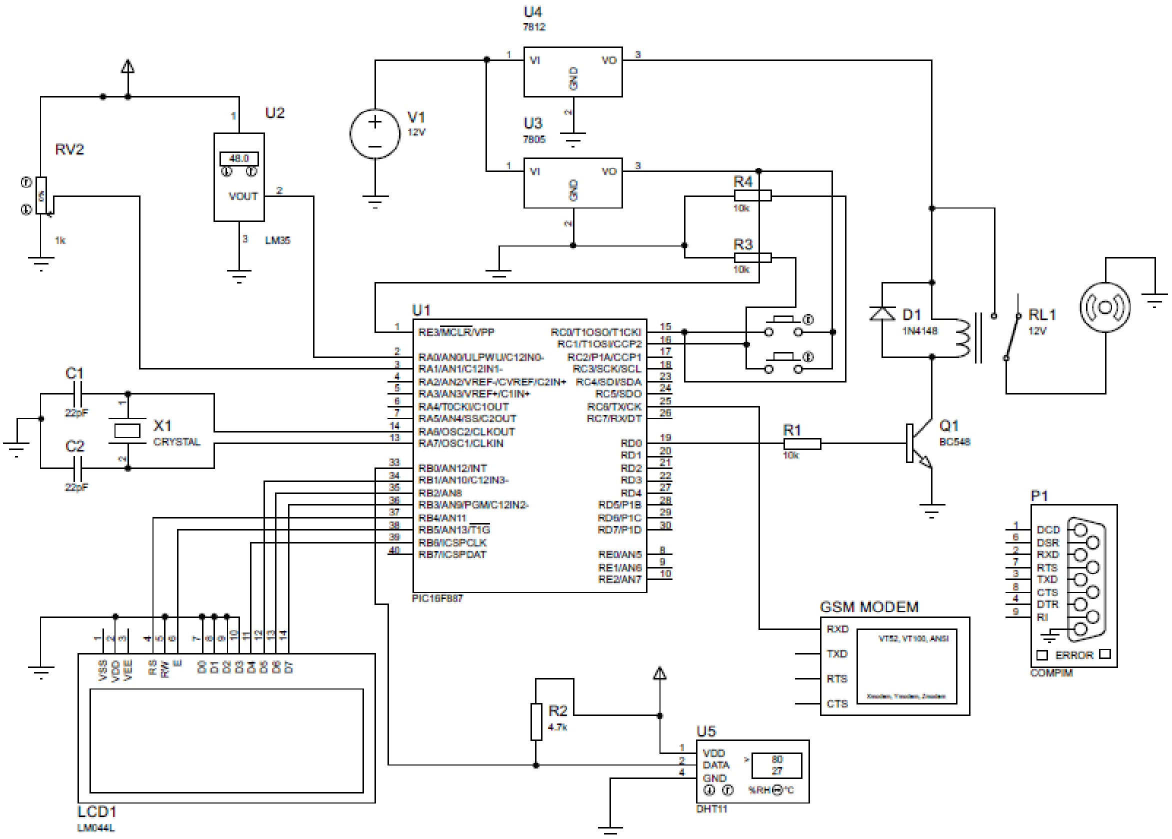

Figure 7.1 Circuit design of the system

7.3 Output from the sensing unit

Here the output from different sensors will be analyses from the simulation

7.3.1 Temperature sensor output

At the sensing unit the temperature sensor was tested if it produced the required output voltages at different range of temperature and the results are as shown in the table below:

Table 7.1 Temperature sensor output from simulation

FROM SENSOR CALCULATION		FROM SIMULATION	
TEMPERATURE (C)	OUTPUT VOLTAGE (V)	TEMPERATURE (C)	OUTPUT VOLTAGE (V)
16	0.16	16	0.1615
18	0.18	18	0.1815
22	0.22	22	0.2216
24	0.24	24	0.2416
28	0.28	28	0.2817

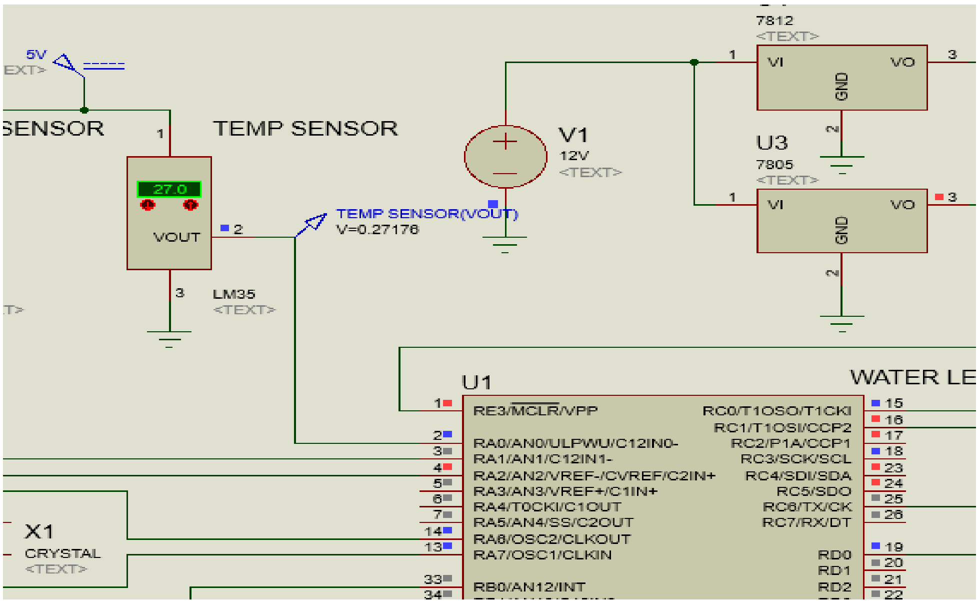

Figure 7.2 LM35 Output in simulation

From the simulation results, the output voltage of the sensors can be detected by the microprocessor without any other external circuit, as it is calculated both the output voltages of the sensors exceed the minimum analog voltage detection of microcontroller ADC which is 4.8mV.

7.3.2 Water level sensor output

Since in simulation software there is no simulation model for water level sensor, a push button is used as water level sensor and the results are as follows where by the presence of water is represented by closed switch while the absence of water is represented by opened switch:

Table 7.2 Water level sensor output

Push button condition	Output voltage (V)
Opened	0.0000
Closed	5.0053

The sensor can also be read by the microprocessor without passing any further amplification.

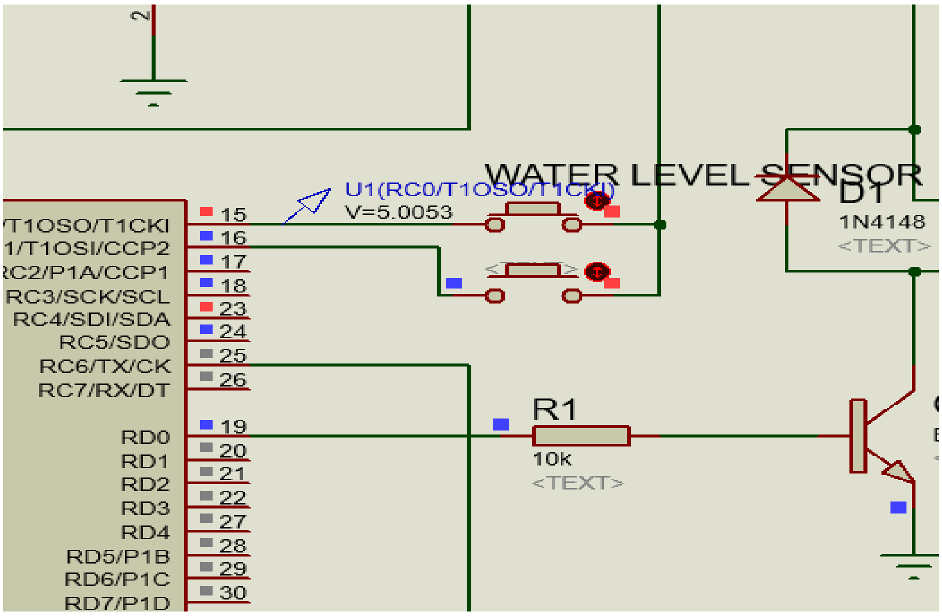

Figure 7.3 Water level sensor simulation output

7.3.3 Rain sensor output

The rain sensor is also a digital sensor with two states of ON or OFF, therefore a push button was used in the simulation and the results were as follows:

Figure7.3 Output from the rain sensor

Push button condition	Output voltage (V)
Opened	0.0000
Closed	5.0042

7.4 Output current

At the switching unit which comprises of a switching transistor and relay, the output current flowing at the base was calculated and the current that flows at the collector was also calculated using the required formula. The table below summarizes the calculated current and the measured current in the simulator.

Table 7.4 Base current and collector current from simulation and calculation

FROM CALCULATION		FROM SIMULATION	
BASE CURRENT	COLLECTOR CURRENT	BASE CURRENT	COLLECTOR CURRENT
0.27mA	30mA	0.28mA	20mA

From the above results table, by comparing the simulation and calculation results, the values of collector current and base current differ by small values. The maximum current through the collector is 30mA but the simulation produces 20mA. The relay connected in the collector will work since the current does not exceed the maximum current rating.

Table 7.5 Pump current from simulation

PUMP RATING	
MAX CURRENT	FROM SIMULATION
1A	0.95A

7.5 Chapter Conclusion

From the above table of results of simulation and calculation, the value of maximum current of the pump is 1A but the value from simulation is 0.95A which means that the value has not exceeded the maximum current rating. Also the other sensors which have not appeared in the simulation results had no simulation models in the software hence only the output voltage from them have been simulated and not their specific parameters.

CHAPTER EIGHT

8.0 PROTYPE IMPLEMENTATION

8.1 Introduction

This chapter will deal with hardware testing of the components which were analysed in the data analysis chapter so as to implement the prototype for the project. Different testing parameters will be used to test if the prototype circuit can be implemented in the real time situation. The figures below show different components which were used in making the prototype of the project.

8.2 Prototype setup

The prototype implementation is done by connecting different hardware components which were selected and analysed in the data analysis chapter. The following are different components which were collected and connected to make the prototype:

i. Soil moisture sensor
ii. LM35 temperature sensor
iii. PIC16F887
iv. Transistors, Resistors and diodes for signal conditioning
v. 12V DC water pump
vi. GSM modem for sending text
vii. Mobile phone for receiving sms from the GSM modem
viii. Relay
ix. 5V Voltage regulator
x. 12V Battery
xi. Crystal oscillator
xii. Solar panel

The prototype circuit was first designed in the Proteus software as it can be seen in the figure below:

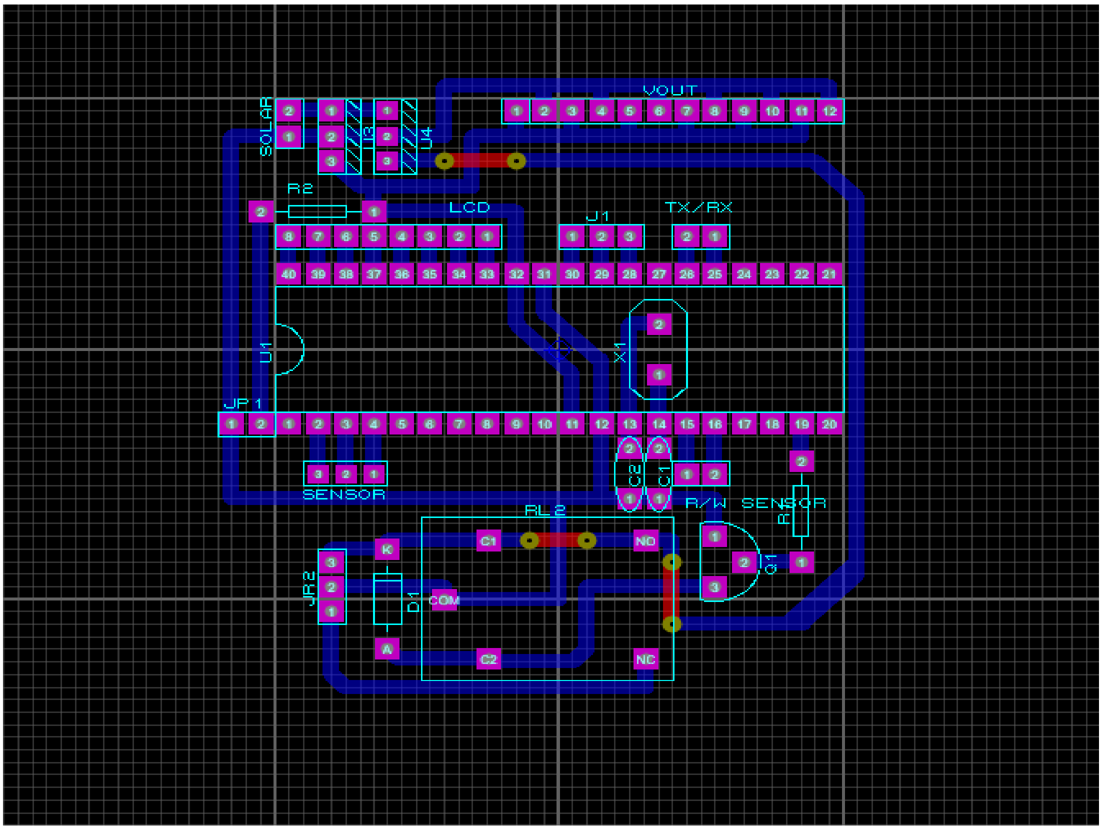

Figure 8.1 PCB layout for the design

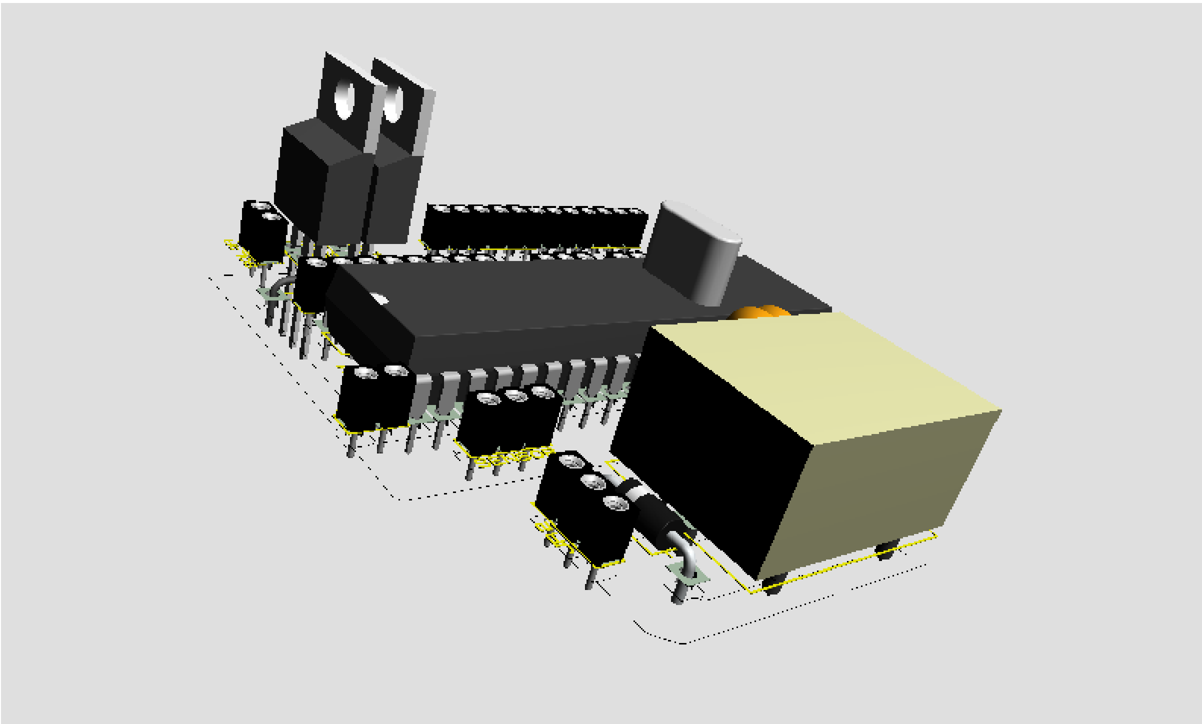

Figure 8.2 3D view of the design

After the preparations of the PCB the components are mounted to their respective places, the image in f shows the mounted components and their connections. Figure below shows component mounted on PCB.

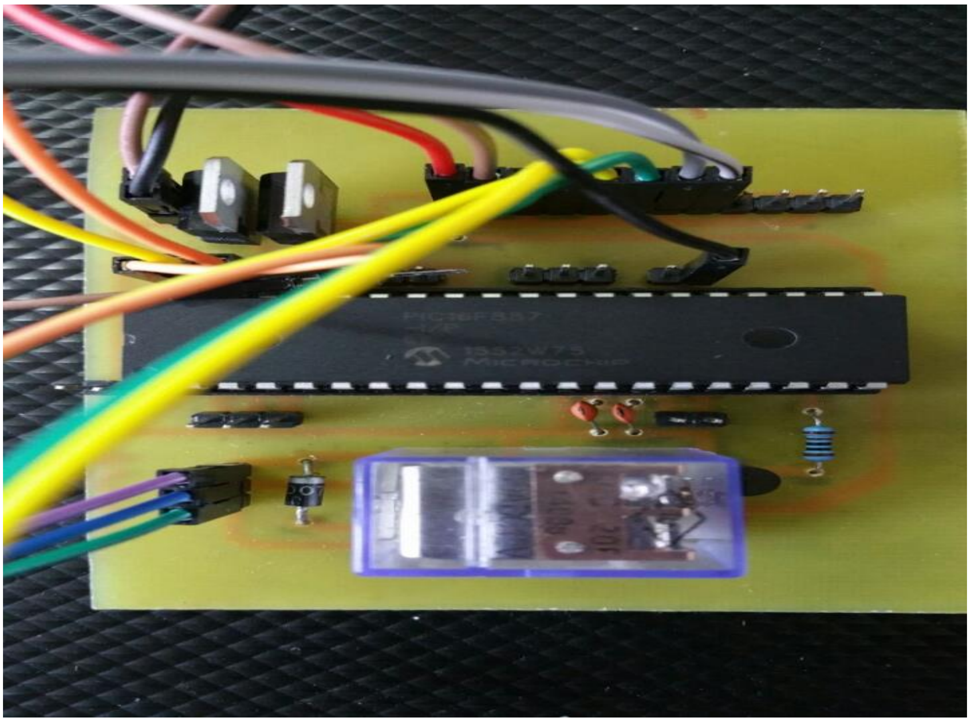

Figure 8.3 Connection of different components which makes a prototype

Figure 8.4 Irrigation system mechanical model

The results are recorded and compared to the expected values to show if the circuit operates as required and if it can be fully developed to a functional prototype. The image below shows different components which are used to make the prototype implementation for the project.

8.3 Voltage supply through the circuit

The circuit designed uses a 12v from a battery charged by a solar panel. The circuit consists of components which uses 12V DC and 5V DC. The relay and a pump uses 12V DC while other components use 5V DC. The 5V is obtained using the voltage regulator which inputs 12V and output 5V.

The following table shows the expected values of the input voltage to the circuit and the output voltage from the voltage regulator.

Table 8.1 Output voltage from the voltage regulators of the circuit

Expected Voltage values		Values from the prototype circuit	
Input value from the battery	Output voltage from the Voltage regulator	Measured input voltage	Measured output voltage from regulator
12V	5V	11.89V	4.96V

8.4 Output from the sensors

8.4.1 Temperature sensor output

The temperature sensor (LM35) was tested if it produced the required output voltages and compared with the simulation results at different range of temperatures and the results are shown in the table below:

Table 8.2 LM35 output from the prototype

FROM SIMULATION		SENSOR OUTPUT	
TEMPERATURE	OUTPUT VOLTAGE (V)	TEMPERATURE	OUTPUT VOLTAGE (V)
28C	0.28	28	0.279
29C	0.29	29	0.287

8.4.2 Soil Moisture Sensor output

The soil moisture sensor was tested if produced the required output voltages at dry soil conditions and wet soil condition s and the results are shown in the table below:

Table 8.3 Output from the soil moisture sensor

SENSOR OUTPUT	
CONDITION	OUTPUT VOLTAGE (V)
DRY	0.279
WET	4.65

8.4.3 Water level sensor output

The water sensor gave two outputs for two different conditions as follows:

Table 8.4 Water level sensor output

CONDITION	OUTPUT (V)
When water is above the minimum level	2.53
When water is below the minimum level	0.01

The results from the above table show that the water level sensing circuit performed as required.

8.4.4 Rain sensor output

Table 8.5 Rain sensor output

CONDITION	OUTPUT VOLTAGE (V)
When it is raining	4.75
When it is not raining	0.00

8.4.5 Humidity sensor

When humidity in the atmosphere was is too high, the system sends message to the farmer as it says “TOO HIGH HUMIDITY” so as the farmer can take actions as to avoid fungal diseases caused by the high humidity in the air.

8.5 Voltage across the pump

When all the conditions required for irrigation by the designed system were met, the voltage across the water pump was about 11.06V and when one or more conditions were not met the voltage across the pump was about 0V.

8.6 GSM Module Output

When water level in the tank is below the minimum value, the water level sensor detects and sends signal to the PIC so as to enable the GSM module to send the message to the framer showing “LOW WATER LEVEL”

8.7 Chapter Conclusion

This chapter has described about the prototype implementation and its performance testing. the results obtained after testing the prototype shows that most of the specific objectives were met, this implies that the designed system is expected to solve the stated problem. The next chapter concludes the project, it gives out the conclusion and recommendation about this project.

CHAPTER NINE

9.0 CONCLUSION AND RECOMMENDATION

9.1 Introduction

This chapter consists of the conclusion and recommendation for the implementation of the project. The conclusion will provide the general information about how the project was done to reach the project objectives as intended.

9.2 Conclusion

This report has provided all basic information concerning the existence of the problem and the procedures towards solving it. The implemented system is expected to automate irrigation process. The automation will be performed by system by measuring the required parameters of different condition required for irrigation such as soil moisture, Temperature, water level and Rainfall. When the parameter values required for irrigation are met, the system commands water pump to start irrigation until soil moisture returns to the standard level.

The collection of data has played a major role in obtaining the design requirements for the system. These design requirements are analysed in the data analysis where by different calculations and design procedures are done to obtain the components values and specifications. These values are used in the system design, simulation and later in the implemented prototype. In simulation, the simulation software was used to simulate the circuit. The implemented prototype has been tested and appeared to give many expected results. However, there is a slight difference in the calculated or expected values and the prototype testing parameter values which is caused by the mathematical approximations in the calculation of the component values in the system and design analysis. The system can still perform well to solve the stated problem but with reduced intelligence.

Considering these results obtained after prototype testing, the overall performance of the designed system is as required and have met the designing objectives. As manual irrigation systems waste a lot of water and time for farmers, this system will help them to save their time also to save water and cost as it irrigates only when water is needed in the soil and it does all that process automatically.

9.3 Recommendation

The project has undergone all methodologies to its completion, but there are different ideas and additions which can be added to reach the objectives or improve the project objectives to another level.

Appendix A

Cost Estimation

DESCRIPTION	AMOUNT
Transportation Fee	**10,000**
Printing & Binding	**80,000**
Internet usage	**20,000**
Electronic components	**90,000**
PCB Board	**7,000**
PIC Microcontroller	**25,000**
Total	**232,000**

Appendix B

SCHEDULE OF PROJECT ACTIVITIES SEMESTER I

ACTIVITIES															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16
A	■	■													
B	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
C			■	■											
D					■	■									
E						■	■								
F								■	■	■	■				
G												■	■	■	
	PROJECT DURATION IN WEEKS														

KEY:

- A. Selection of project title
- B. Literature review
- C. Writing project proposal
- D. Project defending
- E. Data collection
- F. Report writing
- G. Report assessment and submission

Appendix C

SCHEDULE OF PROJECT ACTIVITIES SEMESTER II

ACTIVITIES															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**16**
A															
B															
C															
D															
E															
F															
	DURATION OF PROJECT IN WEEKS														

KEY:

A. Data analysis

B. Design the circuit and simulation of the design circuit

C. Data analysis

D. Building of circuit and testing of prototype

E. Project report writing

F. Literature review

Appendix D

Simulation code

```
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D4 at RB6_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D7 at RB3_bit;

sbit LCD_RS_Direction at TRISB4_bit;
sbit LCD_EN_Direction at TRISB5_bit;
sbit LCD_D4_Direction at TRISB6_bit;
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D7_Direction at TRISB3_bit;

//DHT11 DEFINITONS
//sbit DHT11_Pin at PORTB.B0;
//sbit DHT11_DIR at TRISB.B0;
//extern unsigned int DHT11_TMP;
//extern unsigned int DHT11_HUM;
//extern char DHT11_CHKSM;
//END OF DHT11 DEFINITONS

long veri;
int isi,nem;
char bekleme=0;
```

```
char txt[7];
int x;
   char* message;
   float temp;
   float sumtemp;
////////////////////////////////////////////////////
void send_to_modem1(char* s)
{
//while(*s)
//UART1_WRITE(*s++);
UART1_Write_Text(s);
}

void send_sms()
{
send_to_modem1(message);
delay_ms(100);
//uart1_write(terminator);
delay_ms(1000);
}
void sendsms(){



                      UART1_Write('A');  UART1_Write('T');UART1_Write('E');
UART1_Write('0');
                      UART1_write(0X0D);
                        delay_ms(1000);
```

```
UART1_Write('A'); UART1_Write('T');
UART1_write(0X0D);
 Delay_ms(1000);

UART1_Write('A'); UART1_Write('T'); UART1_Write('+');
UART1_Write('C');

UART1_Write('M'); UART1_Write('G'); UART1_Write('F');
UART1_Write('=');
UART1_Write('1');

UART1_write(0X0D);
      delay_ms(1000);

UART1_Write('A');   UART1_Write('T');  UART1_Write('+');
UART1_Write('C');
 UART1_Write('M'); UART1_Write('G'); UART1_Write('S');
UART1_Write('=');
  UART1_Write('"');
           //delay_ms(1000);

/* here TODO loop through the mobile number
i = 0;
do{
   // UART1_Write(modem_number[i]);
    i++;
} while(i<10);
*/
```

```
UART1_Write('0');UART1_Write('7');UART1_Write('1');UART1_Write('8');UART1_Write(
'9');


UART1_Write('0');UART1_Write('8');UART1_Write('7');UART1_Write('4');UART1_Write(
'0');

  UART1_Write("");

                UART1_write(0X0D);

                delay_ms(500);



                //Message: TODO send a format

                //UART1_Write('L');
UART1_Write('O');UART1_Write('W');UART1_Write('_');UART1_Write('W');UART1_Wri
te('A');

              // UART1_Write('T');UART1_Write('E');
UART1_Write('R');UART1_Write('_'); UART1_Write('L');UART1_Write('V');
UART1_Write('L');

                 send_sms();

               //UART1_Write_text(message);

                  UART1_write(0X0D);

                UART1_write(26);

                UART1_write(0X0D);

                }
////////////////////////////////////////////////

const char character[] = {28,21,30,4,15,21,7,0};


void CustomChar(char pos_row, char pos_char) {

  char i;

    Lcd_Cmd(64);

    for (i = 0; i<=7; i++) Lcd_Chr_CP(character[i]);
```

```
   Lcd_Cmd(_LCD_RETURN_HOME);
   Lcd_Chr(pos_row, pos_char, 0);
}
const char character2[] = {28,20,28,0,0,0,0,0};

void CustomChar2(char pos_row, char pos_char) {
  char j;
   Lcd_Cmd(64);
   for (j = 0; j<=7; j++) Lcd_Chr_CP(character2[j]);
   Lcd_Cmd(_LCD_RETURN_HOME);
   Lcd_Chr(pos_row, pos_char, 0);
}
    /////////////////////
    unsigned char error;
unsigned char i;
unsigned int adc_value,adc_value1,adc_value2;
char moisture;//humidity;
char* moisturestate;
char* waterlevel;
char* rainstate;
 unsigned char ones,tens,hundreds,fractional;
// unsigned int temp;
 //int sumtemp;

 int flags=0;
 ///////////////////////
```

```
void main() {


 long count;
count=0;
   ADCON1=0x0f;
ANSEL  = 0b00000111;              // Configure AN2 pin as analog
  //ANSEL  = 0x01;              // Configure AN1 pin as analog
 // ANSEL  = 0x00;              // Configure AN1 pin as analog
  ANSELH = 0;                  // Configure other AN pins as digital I/O
  C1ON_bit = 0;               // Disable comparators
  //ADCON1=0;
  C2ON_bit = 0;
  TRISA=0XFF;
  TRISC=0b00000011;
  PORTC=0;
  TRISD=0;
  PORTD=0;
  Lcd_Init();
 Lcd_Cmd(_LCD_CURSOR_OFF);
 Lcd_Cmd(_LCD_CLEAR);
 Delay_ms(100);
 Lcd_Out(1,1,"AUTO IRIGATION SYS");
 Lcd_Out(2,1,"INITIALIZING");
 Delay_ms(1000);
  ADC_Init();
  //DHT11_init();
  Lcd_Cmd(_LCD_CLEAR);
```

```
  uart1_init(9600);

 while(1)
 {

 adc_value1 = ADC_Read(1);     //Read Moisture from ADC
 adc_value2 = ADC_Read(2);     //Read Humidity from ADC

 adc_value1 = adc_value1 *5;
 adc_value1 = (double) adc_value1 /1024;

 adc_value = adc_value*488;
 adc_value = adc_value/10;
  //DHT11_Start();
  //DHT11_Read();


/*if(DHT11_CHKSM==((DHT11_TMP>>8)+(DHT11_HUM>>8)+(DHT11_TMP&0xff)+(
DHT11_HUM&0xff)))
  {
    Lcd_Out(2,1,"HUMIDITY:");
    CustomChar(2, 16);
   // Delay_ms(100);
   // CustomChar2(1, 18);
   //inttostr(DHT11_TMP>>8,txt);
  // lcd_out(1,8,txt);
   inttostr(DHT11_HUM>>8,txt);
```

```
 lcd_out(2,10,txt);
 Delay_ms(100);
  //CustomCharZ(4, 16);

}*/
 // Lcd_Cmd(_LCD_CLEAR);
 /////cheking moisture state
 if( adc_value1<2){moisturestate="LOW";}
if( adc_value1<4&&adc_value1>2){moisturestate="NORMAL";}
if( adc_value1>3){moisturestate="HIGH";}

//////////////////////////////

///////////////////water lelvel
  if(portc.B0==1){waterlevel="NORMAL";}
  if(portc.B0==0){waterlevel="LOW";}

//////////////////
////// rain stste




////////////////////
Delay_ms(10);
Lcd_Out(3,1,"MOISTURE:");
Lcd_Out(3,10,moisturestate);
Lcd_Out(4,1,"WATER LEVEL:");
```

```
 Lcd_Out(4,13,waterlevel);


 temp = (adc_Read(0)*(1.5*306.9));
    sumtemp=temp*100;
/*ones = temp%10;
temp = temp/10;
tens = temp%10;
temp = temp/10;
hundreds = temp%10;


ones = ones|0x30;
tens = tens|0x30;
hundreds = hundreds|0x30;
Delay_ms(100);*/


Lcd_Out(1,1,"TEMPERATURE:");
Lcd_Chr(1,13,hundreds);
Lcd_Chr(1,14,tens);
Lcd_Chr(1,15,ones);
adc_value = adc_value/10;
fractional = adc_value%10;
fractional |= 0x30;
Lcd_Chr(1,16,'.');
Lcd_Chr(1,17,fractional);
// Lcd_Chr(1,18,'C');


Lcd_Chr(1,19,'C');
```

```
        //sumtemp=tens;
 //////  Washa pump


 if(adc_value1<3&& PORTC.B0==1&&sumtemp<40&&PORTC.B1==0){


    PORTD.B0=1;


 }
 else{portd.B0=0;}


   if(PORTC.B0==1&&flags==1){
  flags=0;
  }
   if(PORTC.B0==0&&flags==0){
   message="LOW WATER LEVEL";
     sendsms();
  flags=1;
  }
  Lcd_Cmd(_LCD_CURSOR_OFF);
Lcd_Cmd(_LCD_CLEAR);
Delay_ms(100);
}


}
```

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