IRRIGATION MONITORING AND CONTROL SYSTEM USING INTERNET OF THINGS

BY
ADU OLUWATOBI SAMUEL
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APPROVAL

This project report has been approved for the acceptance by the Mechatronics Engineering department, Federal University Oye-Ekiti, Ekiti state and meets the regulations governing the award of the Bachelors of Engineering of FUOYE.

By

Supervisor

Name: ENGR. O. O. Martins

Signature: ______________

Date: 3/04/2019

Head of Department

Name: Dr Aroworefo M.O

Signature: ______________

Date: 03/04/2019

External examiner

Name: ______________

Signature: ______________

Date: ______________

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DEDICATION

This project is dedicated to God Almighty.

ABSTRACT

Agriculture is considered as the basis of life as it is the main source of food and other raw materials. This report describes an IOT Irrigation Monitoring and Control system wherein, the user can monitor and control the supply of water from a remote location.

The system makes use of a concept called IOT (Internet of Things). This enables the system to be connected to the internet using a Wi-Fi module. An Arduino Uno board was used to send the control signals and connect to the designed website. The circuit is designed to keep checking the moisture content of the soil by means of a moisture sensor and updates the "Moisture level" on the website.

The user can then check the current moisture level from a remote location and control the water supply. Consequently, the soil-moisture gets monitored and the 'water supply can be controlled just by toggling the Motor status from 'ON-OFF' or 'OFF-ON' and the "water pump" will be 'turned ON' or 'turned OFF' accordingly.

The farm model gets irrigated without the farmer necessarily reaching out to the farm land.

A future scope on this project would be to integrate an automatic control system to monitor and control the availability of water in the water tanks.

CHAPTER ONE

INTRODUCTION

Water is required for the basic growth of plant. Insufficient water in plants causes a gradual decrease in the growth and quality of the plant thereby, leading to the inability of the plant to yield much more output as expected. Irrigation has been used to assist in the growing of agricultural crops, maintenance of landscapes, and re-vegetation of disturbed soils in dry areas during periods of inadequate rainfall. Moreover, Irrigation is the application of controlled amounts of water to plants at needed intervals (Rasyid *et al.,* 2015).

Agriculture is an industry that uses a lot of water. Most of the time, this resource is not efficiently used and substantial amount of water are wasted. As a result of this, the IOT (Internet of Things) Irrigation Monitoring and Controller system provides the technology and techniques needed to automate farming activities in the agricultural industry (Martin, 2006). The system is equipped with the ability to monitor the status of the soil's humidity and then, control necessary actions pertaining to irrigating the farm land. Nowadays, farming needs sustained irrigation to give proper attention to the growth of crops on the farm land due to sporadic rainfall experienced lately. As experts always perceived, a high percentage of this irrigation water is actually wasted due to lack of supervision and real-time monitoring (Plusquellec, Burt, & Wolter, 1994). Hence, this project offers a unique feature known as the Internet of Things (IOT) which has made farm lands global and consequently promoting smart irrigation through remote sensing technologies.

The Internet of Things (IOT) is the network of physical objects devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity that enable these objects to collect and exchange data (Kumbar & Galagi, 2016). The IOT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer based systems, and resulting in improved efficiency, accuracy and economic benefit (Kanasura *et al.*, 2015). This project provides an IOT (Internet of Things) based smart irrigation concept to solve the recurring problem of drought while satisfying the plants needs using the right amount of water.

Agriculture is considered as the basis of life as it is the main source of food and other raw materials (Marie, 2005). It plays vital role in the growth of the country's economy. Growth in agricultural sector is necessary for the development of economic condition of the country. Unfortunately, many farmers still use the traditional methods of farming. In Nigeria, most of the irrigation systems are manually operated and these outdated practices needs to be replaced with automated techniques (Soleno, 2003). With agriculture being the primary economic sector of Nigeria and other developing countries, it is essential to automate it in order to increase efficiency and profitability. Hence, this can be achieved by using Internet technology and sensor network to control and monitor the irrigation of farmland online regardless of the location and to maximize the utilization of water.

1.2 PROBLEM STATEMENT

Irrigation of plants is usually a very time-consuming activity and it requires a large amount of human resources to be done within a reasonable amount of time. Nowadays, some systems use technology to reduce the number of workers or the time required to water the plants. With such systems, the control is very limited and many resources are still wasted leading to leaching of the soil. Therefore, as water supply is becoming scarce in today's world and labor cost becoming more expensive, there is an urgency of adopting smart ways of irrigation in order to meet the demand of human race.

1.3 AIMS AND OBJECTIVES

The aim of this project is to design and develop a system that monitors and controls the irrigation of a model farm using internet of things (IOT).

However specific objectives are to:

- Construct a test bed;
- Design an irrigation system that makes water available to the test bed when instructions are given;
- Design a power module that powers the converts alternating current (AC) to direct current(DC) which powers the entire system; and
- Interface the irrigation system to an internet of things (IOT) module for the purpose of performance examination.

1.4 SCOPE

The project describes how irrigation can be handled smartly using IOT (Internet of Things) technology. It aims at saving time and avoiding problems like constant vigilance. Moreover, it involves the design and calculation of the piping and fluid flow system for irrigation and circuit analysis of each components connected together. In addition to that, the internet web page was carefully interfaced and synchronized with the circuit operation. As a result of this, the whole system covers monitoring and controlling the irrigation of the farm land from data received from the moisture sensor and signals sent to the pump to irrigate the test bed.

This project focuses on using an Arduino UNO micro controller to control the irrigation process over a wireless network that is not limited by distance.

CHAPTER TWO

LITERATURE REVIEW

Throughout history, mankind has reached beyond the acceptable to pursue a challenge, achieving significant accomplishments and developing new technology. This process is both scientific and creative. Entire civilizations, organizations, and most notably, individuals have succeeded by simply doing what has never been done before. A prime example is the substantial and efficient use of water as a resource (Pavankumar, 2018). One of the most significant series of events shaping today's world is the industrial revolution that began in the late seventeenth century. Without these developments, the industrial revolution as we know it would not have taken place. It is therefore appropriate to say that few technologies developed through human ingenuity have done so much to advance mankind as the safe and dependable conservation of water.

Various researches have been carried out on how soil irrigation can be made more efficient. The researchers have used different ideas and approaches depending on the condition of the soil and quantity of water needed. Hence, different technologies used and the various designs related to this project were reviewed and discussed below.

Nandhini *et al.,* (2017) proposed an automated irrigation system for efficient water management and intruder detection system. Soil Parameters like soil moisture, pH, Humidity, pressure were measured and the sensed values were displayed to the LCD. The intruder detection system was done with the help of the PIR sensor where birds are been repelled from entering into the field. The GSM module has been used to establish a communication link between the farmer and the field. The current field status will be intimated to the farmer through SMS and also updated on the webpage. As a result of this, the farmer can access the server about the field condition anytime and anywhere thereby reducing the man power and time. SMS becomes limited in that it is generic and cannot fully tell the situation of things on the farm. Also the intruder alert system could lead to a disturbance or nuisance to the user in situations of passersby. The system architecture could be simplified and improved on.

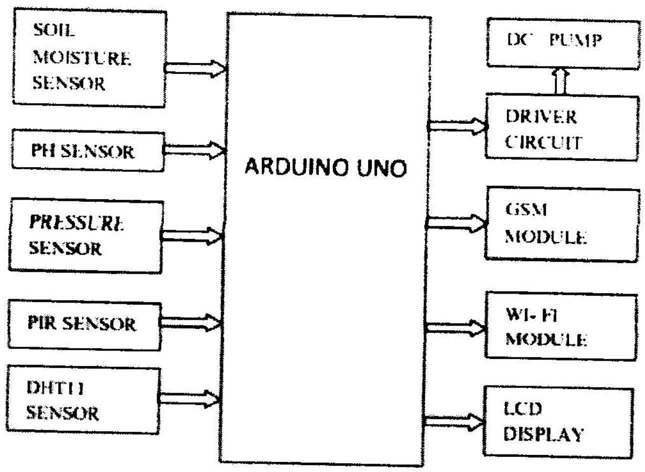

Figure 2.1- Automated irrigation system for efficient water management and intruder detection system

Source: **(Nandhini & Kumbi, 2017)**

Janani *et al.*, (2018) proposed an Automated Irrigation system to monitor soil moisture using humidity sensor. An arduino UNO was used with Bluetooth feature enabled. This method will yield 98% efficiency in terms of monitoring the soil moisture and notifying the farmers about the status of the field. Arduino used reduces the complexity of the architecture and reduces the maintenance cost of the system. It was studied that the Bluetooth used to transfer the detected values to the motor serves as a reliable transmission protocol and supports wide area coverage. The evaluation also revealed that the database maintained the supply of water to the field which helped in areas of water scarcity. Hence, the proposed system makes use of an Arduino microcontroller on which the DHT11 humidity sensor is placed. The humidity sensor used can only measure the moisture in the atmosphere and often times, the moisture in the atmosphere does not reflect the moisture in the soil or it reflects just for the top soil. A future scope will be adding a soil moisture sensor to the system and decisions and judgments can be made from the output of both sensors.

Swapnali *et al.*, (2018) designed a smart irrigation technology based on IOT using Raspberry pi. The system can be used to control the water motor automatically and can also monitor the growth of plant by using webcam. We can watch live streaming of farm on mobile phone using suitable application by using Wi-Fi network. As the soil-moisture sensor and temperature sensor are placed in the root zone of the plants, the system can distribute this information through the wireless network. The raspberry pi is the heart of the system and the webcam is interfaced with Raspberry pi via Wi-Fi Module. Python programming language was used for automation purpose. The system is a network of wireless sensors and a wireless base station which can be used to provide the sensors data to automate the irrigation system. The system uses the sensors such as soil moisture sensor and soil temperature sensor and also ultrasonic sensor. The raspberry pi model is programmed such that if the either soil moisture or temperature parameters cross a predefined threshold level, the irrigation system is automated, i.e. the relay connected to the raspberry pi will turn ON or OFF the motor. The major limitation of this system is that it is capital intensive and the internal architecture is very complex.

Nandan & Thippeswamy, (2018) proposed a Secure intelligent Drip Irrigation System using IOT, Cloud and Mobile application using soil moisture sensor, securing crop by using camera and PIR sensor, and the system is made to operate using solar power supply as well as AC power (AC to DC adapter) supply to send data continuously even on power cut. In this system the soil moisture sensors will sends the real time values at regular intervals. The Raspberry Pi microcomputer collects the values from the sensors through serials communication. GSM GPRS module will send the data to the ThingSpeak database. Once the data is stored in the database, analysis of the data is done and the result is sent to the mobile application and web application. Along with it, data received at ThingSpeak cloud server will analyze and provides the graph to mobile and web application to take decision. Farmer will take decision of ON/OFF the water flow based on the soil moisture level; using solenoid value (electromagnetic value) for the water flow control. If the value is below the lower threshold value then drip must be ON to keep the moisture level, if the value is above the upper threshold value then drip must be OFF to save the water.

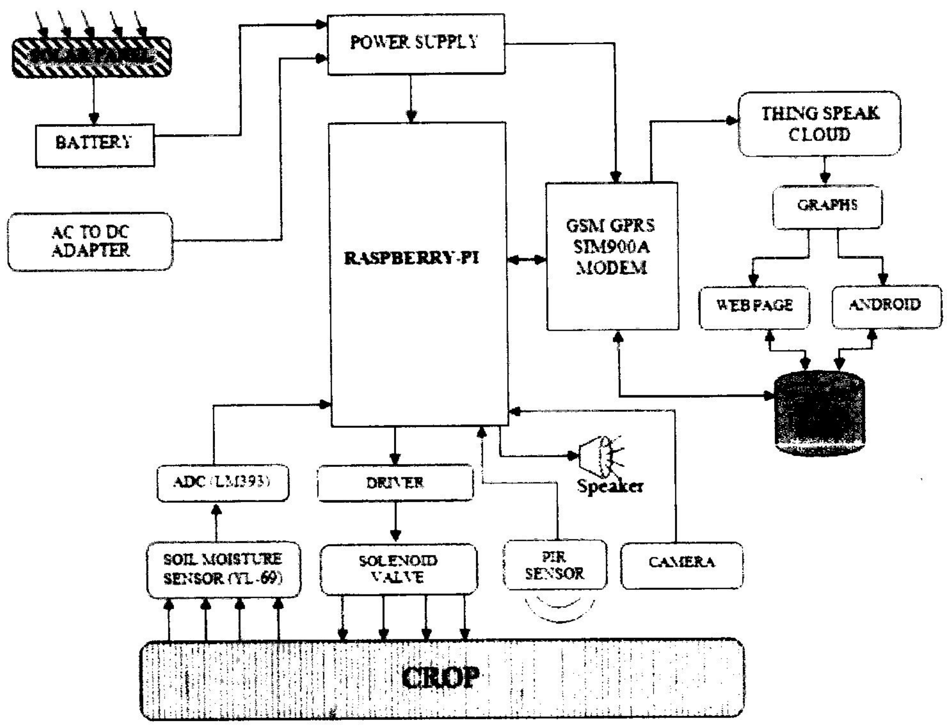

Figure 1.2- Secure intelligent Drip Irrigation System Block diagram

Source: (Nandan & Thippeswany, 2018)

Sukrit *et al.,* (2016) proposed an IOT based Smart Irrigation and Tank Monitoring System. The proposed system will allow farmers to continuously monitor the water levels inside the water tank and the moisture level in the field, controlling the supply remotely over the internet. When (Sukumar, Akshaya, Chandraleka, Chandrika, & Kumar, 2018)moisture goes below a certain level, sprinklers would be turned on automatically, thus achieving optimal irrigation using Internet of Things. Arduino which is the microcontroller of the system controls the digital connections and acts as a bridge between the sensors and the mobile phone application. The Wi-Fi module connects the Arduino board to the hotspot providing access to the Internet. The Arduino board then transmits the readings to the mobile application over the Internet.

Arif *et al.,* (2017) proposed a Smart Irrigation System using IOT. This research tries to automate the process of irrigation on the farmland by monitoring the soil water level relative to the plant being cultivated and the adaptively sprinkling of water to simulate the effect of rainfall. The hardware part consists of the moisture sensor and photocell sensor. Moreover, the software part consists of an android based application connected to the arduino board and other hardware components using Internet of Things (IOT). The android based application consists of signals and a database in which readings are displayed from sensors and are inserted using the hardware.

Sukumar *et al.,* (2018)) proposed an IOT based agriculture crop-field monitoring system and irrigation automation. In this system, low cost soil moisture sensor, temperature and humidity sensors were used. They continuously monitor the field and send it to the web server using NRF24LO1 transmitter and receiver and Ethernet connection at the receiver ends. The sensor data are stored in database. The web application is designed in such a way to analyze the data received and to check with the threshold values of moisture, humidity and temperature. The decision making is done at server to automate irrigation. With the continuous monitoring of various parameters, the grower can analyze the optimal environmental conditions to achieve maximum crop productiveness, for the better productivity and to achieve remarkable energy savings.

Vinoth *et al.,* (2017) implemented an irrigation system based on IOT. In this system, all the information were received from the sensors and the various parameters were given to the arduino uno microcontroller as an analog input. A preset value of soil moisture sensor is fixed in the microcontroller and also for fencing. When it goes beyond the particular threshold value water is automatically irrigated to the crops and once the required amount of water is fulfilled it stops. The Microcontroller transmits that information on the internet through a network of IOT in the form of Wi-Fi module ESP8266 that is attached to it. This enhances automated irrigation as the water pump can be switched on or off through information given to the controller. This proposed Irrigation system is used to get the chlorophyll content and nitrogen content of the leaf using LDR and Laser.

Agbetuyi & Orovwode (2016) designed and implemented an automatic irrigation system based on monitoring soil moisture to facilitate the automatic supply of adequate water reservoir to fields and domestic crops in all agricultural season. A pumping mechanism is used to deliver the needed amount of water to the soil. The work can be grouped into four subsystems namely; power supply, sensing unit, control unit and pumping subsystems which make up the automatic irrigation control system. A moisture sensor was constructed to model the electrical resistance of the soil; a regulated 12 volts power supply unit was constructed to power the system; the control circuit was implemented using operational amplifier and timer; and the pumping subsystem consisting of a submersible low-noise micro water pump was constructed using a small dc-operated motor. System response tests were carried out to determine the time taken for the system to irrigate potted samples of different soil types having different levels of dryness.

Akshai *et al.*, (2012) implemented an IOT based irrigation automation system. The system controls irrigation based on two inputs. One is from the moisture sensor and another is from the weather sites on the internet. Based on the input from moisture sensor, system decides to irrigate if the soil is dry. Based on the weather report, decision is made to irrigate if there is no predicted possibility of rain. In case if the weather prediction fails, irrigation is done after a preset waiting period is over. Both sensors are connected to Arduino UNO board for transmission of the measured values. The water level in the water tank is monitored by PLC using float switch in the tank. Irrigation scheduling is done based on the weather reports provided by weather stations in their websites. Hence, PLC is the heart of the irrigation control system

2.1 BASICS OF IOT

Internet of Things or IOT is an architecture that comprises of specialized hardware boards, Software systems, web APIs, protocols which together creates a seamless environment that allows smart embedded devices to be connected to the internet such that, sensory data can be accessed and control system can be triggered over internet. (Deweshvree, 2015)

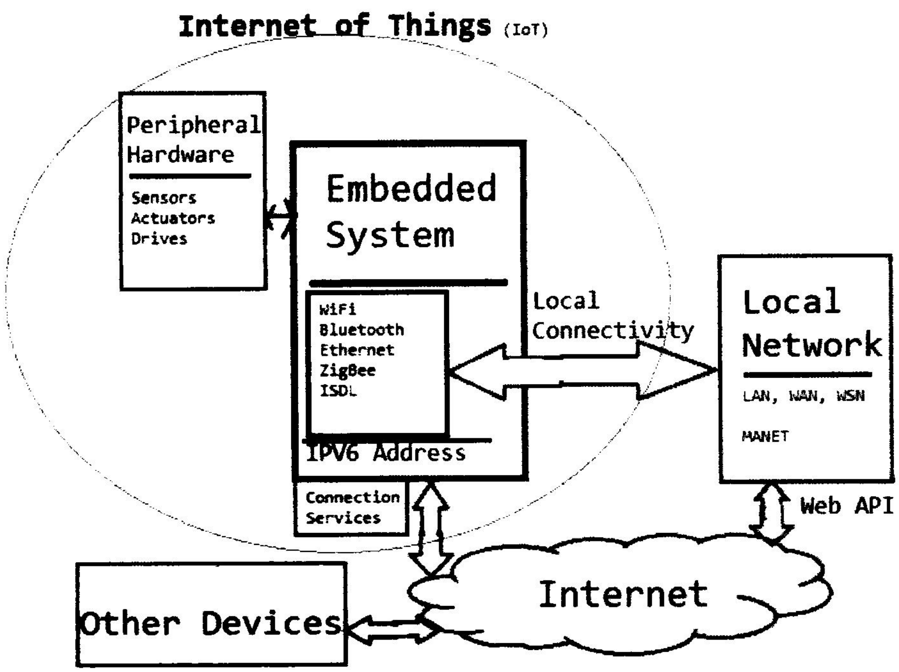

Figure 2.2- Internet of Things

Source: (Deweshvree, 2015)

2.2 IMPORTANT INTERNET OF THINGS COMPONENTS

Many people mistakenly think of IOT as an independent technology. Internet of things is being enabled by the presence of other independent technologies which make fundamental components of IOT. (Maser, 2014) The fundamental components that make internet of things a reality are:

- **Hardware**-Making physical objects responsive and giving them capability to retrieve data and respond to instructions
- **Software**-Enabling the data collection, storage, processing, manipulating and instructing

- **Communication Infrastructure**-Most important of all is the communication infrastructure which consists of protocols and technologies which enable two physical objects to exchange data.

Interestingly, IOT are essentially embedded systems and smart objects connected to internet with unique IP address which can be discovered and communicated over the internet. We have also seen that the IOT devices may have external peripheral like Actuators and Sensors.

2.3 EMBEDDED SYSTEM

An Embedded System is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a specific function (Weeris & Dreep, 2011). An embedded system is a microcontroller-based, software driven, reliable, real-time control system, autonomous, or human or network interactive, operating on diverse physical variables and in diverse environments and sold into a competitive and cost conscious market.

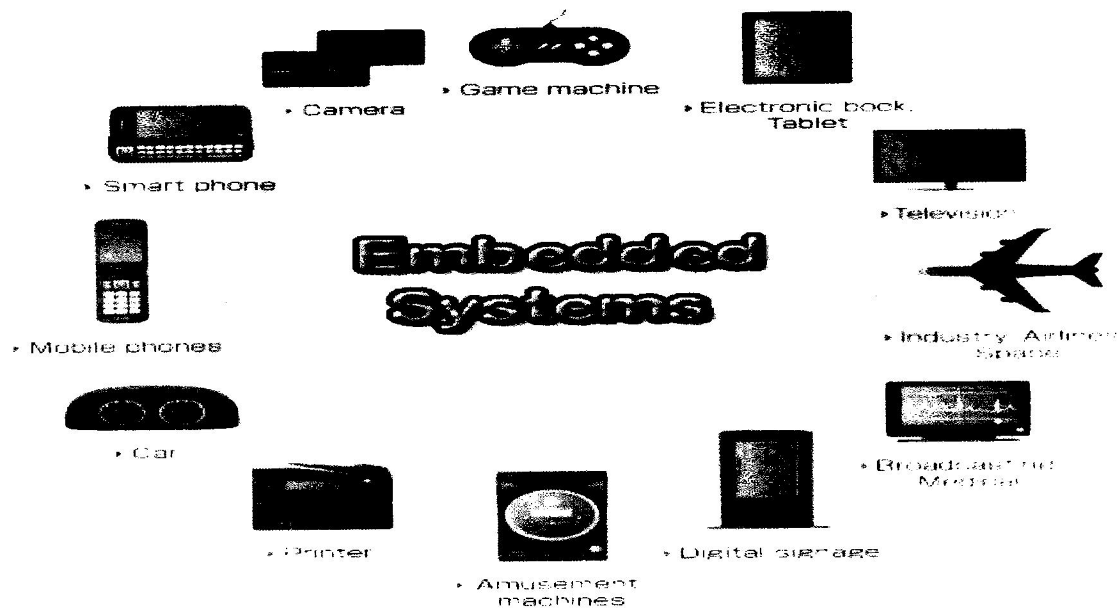

Figure 2.4-Embedded Systems

Source: (Weeris & Dreep, 2011)

Embedded systems are not always standalone devices. They consist of small computerized parts within a larger device that serves a more general purpose. Moreover, the following are some of the features of an embedded system;

- Contains a processing engine, such as a general purpose microprocessor
- Typically designed for a specific purpose or application
- Generally has application software built in, not user-selected
- Intended for applications without human intervention

CHAPTER THREE

METHODOLOGY

This section gives a comprehensive step by step procedure in achieving the IOT Irrigation Monitoring and Controller system and the concept behind the design. This system has the ability to transmit the real time data to the user through the Wi-Fi and IOT server.

3.1 IRRIGATION PLANNING

The first stage in the design analysis involves the consideration of the following;

- Crop water requirements,
- Type of soil
- The climatic condition
- Irrigation Span

Consequently, the irrigation system was designed to operate on a shallow rooted crop and continuously sense the moisture level of the soil. Three common soil samples were considered; loamy, sandy and clay soil. Hence, the system responds appropriately by watering the soil with the exact required amount of water within the confines of the irrigation span and then shuts down the water supply when the required level of soil moisture is achieved.

3.2 FABRICATION OF THE FARM MODEL

The performance of the irrigation system strictly lies on the structure of the farm and the topography. In this project, the farm model was constructed to be in a rectangular form with plywood into dimensions of 75cm X 47cm. After cutting the wood, then the structure was supported at the edges using 2X2 wood to make it more rigid and firm as shown below. Furthermore, the farm model is filled evenly with samples of loamy soil extracted from the university environment. The depth of the soil to the base of the farm model is 3cm. As a result of this, a pipe of diameter 2cm having small holes in form of pores, is positioned at the side of the farm to sprinkle water to the entire surface area of the farm.

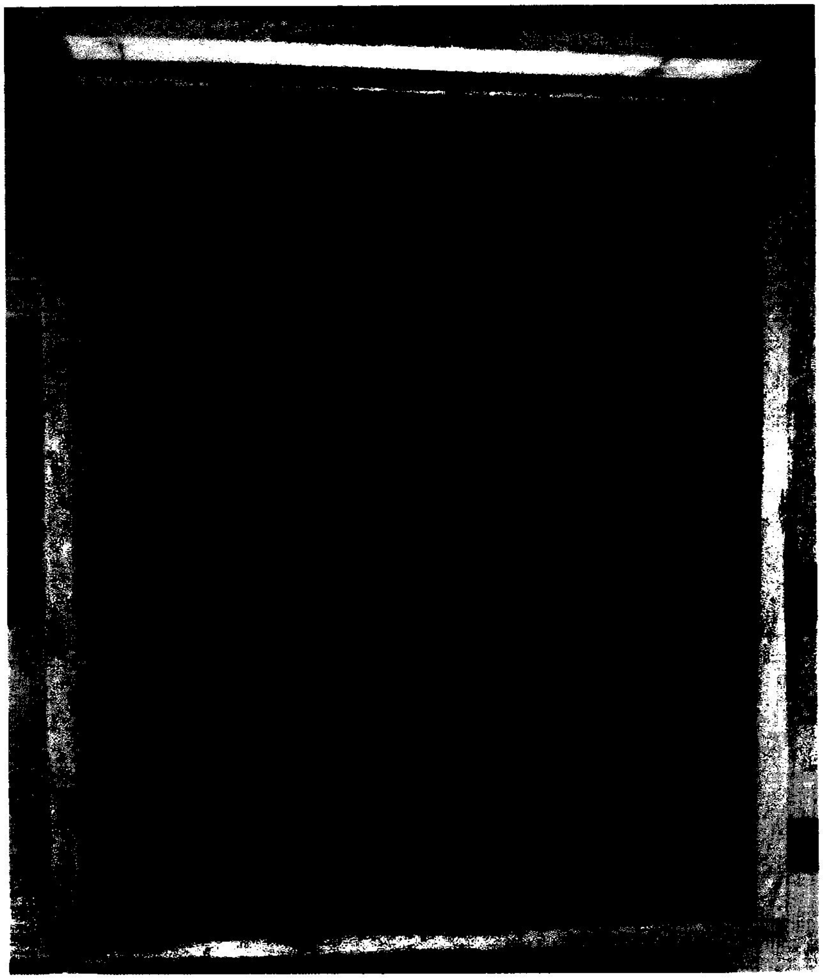

Plate 1- Picture of farm model

3.3 THE SPRINKLER SYSTEM

The type of irrigation system adopted in this project is the sprinkler system. This is due to the fact that it offers uniform water distribution as compared to the drip irrigation system. Moreover, the following were considered carefully in order to achieve the sprinkler system;

- A pump used to lift and pressurize water,
- A main line piping system to convey water from the pump to the lateral pipelines used to transport water across the irrigated field.
- Nozzles distributed along the pipe to apply the water within the field

Sprinkler system is designed to satisfy crop water requirements while applying water at a rate that minimizes runoff and excess leaching since, knowing when and how much to water is two important aspects of irrigation Therefore, the inflow rate required for the system is the required amount of water that must be supplied to avoid water stress. To accomplish this, the calculations below were performed;

The system inflow rate is given by

$$Q_s = 0.116\left(\frac{d_g A_i}{T_o}\right)$$

Source; D.L Martin (2007)

Where

Q_s = Inflow to the sprinkler irrigation system (i.e. gross system capacity), Ls^{-1}

A_i = Irrigated, m^2 ($0.4m^2$)

T_o= Time of operation per irrigation, days; (1800 seconds)

d_g = Gross depth of irrigation water applied, mm (1000mm)

$$Q_s = 0.116\left(\frac{1000 \times 0.4}{1800}\right) = 0.0257Ls^{-1}$$

Therefore, the total system capacity cannot exceed the available water supply. This implies that, if the capacity requirements are too high, the amount of area irrigated may have to be reduced, or deficit irrigation will be necessary.

3.4 SYSTEM COMPONENTS AND DESCRIPTION

Table 1- materials used and why they were used

S/N	System Components	Qty	Model or Version	Description	Why Used
1.	WIFI Module	1	ESP8266 WiFi	The module contains an inbuilt firmware which supports serial interface and can be controlled using AT commands	It provides networking functions from another application processor to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime.
2.	Arduino	1	UNO R3	Arduino is an open-source prototyping platform based on	It was used as the major

				easy-to-use hardware and software	**microcontroller** to the whole system
3.	Bridge Rectifier	1		A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC	The bridge rectifier is used because of its merits like good stability and full wave rectification
4.	Voltage regulator	1	7805	Is an integrated circuit that maintains the voltage of a power source within acceptable limits	To keep the voltage in a circuit relatively close to a desired value.
5.	Diodes	**4**	IN4007	It is a two terminal electronic component that conducts electricity in one direction and only when a certain minimum potential difference or voltage is applied to its two terminals.	It was used because of its unidirectional behavior to current.
6.	Capacitor			A capacitor or condenser is a passive electronic component consisting of a pair of conductors separated by a dielectric.	To store electric charge.

7.	**Soil moisture sensor**	1	SEN-13637	This is a three pin screw pin terminal pre-soldered to the board for easy wiring with two large extended pads functioning as the probes for the sensor.	To detect the moisture content in the soil.
8.	Resistor	5		Is a passive two-terminal electrical components that implements electrical resistance as a circuit element	To control the flow of current
9.	Water Pump			This is an mechanical devce that uses rotation to impart velocity to a liquid	The pump was used to deliver the water from the tank to the farm land
10.	Liquid Crystal Display	1	LCD 16X2	This is an electronic display module which uses liquid crystal to produce a visible image	To display the data received from the sensors in real time.

3.5 COMPONENT OVERVIEW

3.5.1WIFI MODULE

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to the Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware. The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community

Features:

- 802.11 b/g/n
- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack
- Integrated TR switch, balun, LNA, power amplifier and matching network
- Integrated PLLs, regulators, DCXO and power management units
- +19.5dBm output power in 802.11b mode
- Power down leakage current of <10uA
- 1MB Flash Memory
- Integrated low power 32-bit CPU could be used as application processor

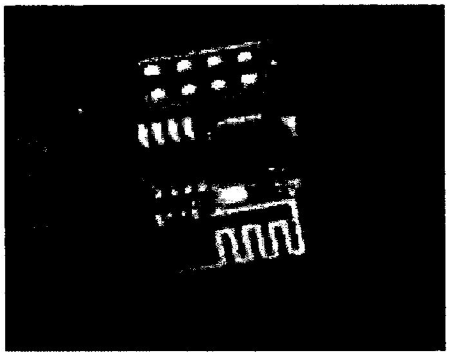

Figure 3.1- Picture of a Wi-Fi module

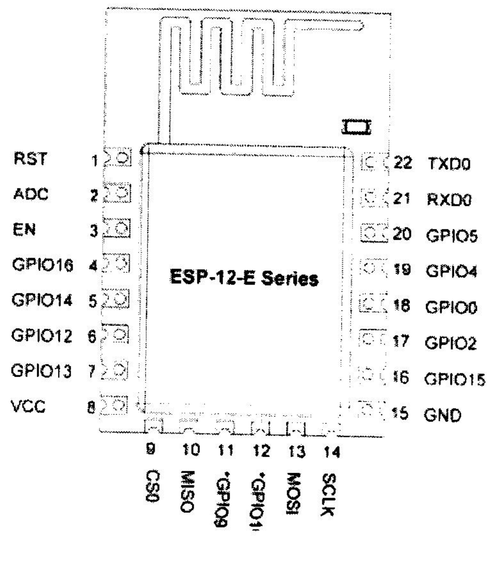

Figure 3.2- Internal circuity of the ESP-12-E series

3.5.2BRIDGE RECTIFIER

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), current that flows in only one direction, a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid state diodes, vacuum tube diodes, mercury arc valves, and other components. The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification. In positive half cycle only two diodes (1 set of parallel diodes) will conduct, in negative half cycle remaining two diodes will conduct and they will conduct only in forward bias only.

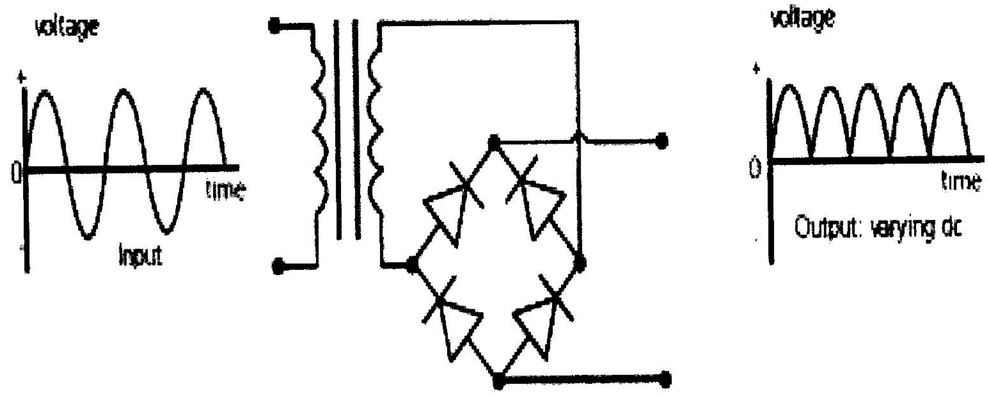

Figure 3.3- Schematic diagram of a bridge rectifier showing its input and output graph representation

3.5.3TRANSFORMER

A step-down transformer with turns ratio of 16:1 was selected to transform the 240V mains supply voltage to 12V for the power supply. The 240V AC was converted to dc voltage using a full wave rectifier circuit.

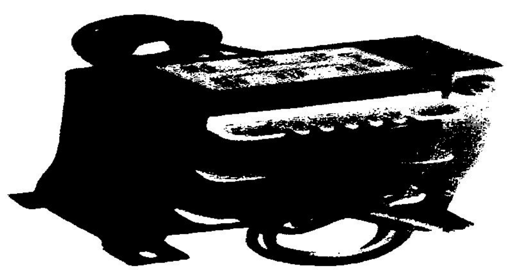

Figure 3.4- Picture of 12v step-down transformer

The circuit was designed as follows:

V_{dd} = diode forward conduction voltage gap

V_b = voltage drop across the diode bridge at any instant

V_s = transformer secondary voltage

V_{sp} = peak value of transformer secondary voltage

V_m = peak output dc voltage from the diode bridge

V_{ac} = average value of the diode bridge ouput voltage

V_{dc} = rms value of output dc voltage of the diode bridge

γ = ripple factor for a full wave rectification process using a diode bridge

V_r = ripple factor

C = capacitance value

I = required output current from power supply circuit

f = frequency of the ac mains supply voltage

t = time taken for filtering capacitor to discharge in compensation for the ripple in the dc output

q = charge on filtering capacitor

$$V_b = 2 \times V_{dd}$$

$$V_{sp} = 1.414 \times V_s$$

$$V_m = V_{sp} - V_b$$

$$V_{ac} = \frac{2}{\pi} \times V_m$$

$$V_{dc} = \frac{V_m}{1.414}$$

$$\gamma = \frac{\sqrt{V_{dc}^2 - V_{ac}^2}}{V_{dc}}$$

$$V_{dd} = 0.7V$$

$$V_b = 2 \times 0.7 = 1.4V$$

$$V_s = 12V$$

$$V_{sp} = 1.414 \times 12 = 16.97$$

$$V_m = 16.97 - 1.4 = 15.57V$$

$$V_{ac} = \frac{2}{\pi} \times 15.57 = 9.9V$$

$$V_{dc} = \frac{9.9}{1.414} = 7.011V$$

$$\gamma = \frac{\sqrt{9.9^2 - 7.011^2}}{17.011} = 0.41$$

The ripple in the output voltage is directly proportional to the output current and is related to the filtering capacitance by the following equations

$$q = I \times t = C \times dV_{sp}$$

$$t = 2 \times f$$

$$dV_{sp} = V_r$$

$$V_r = \gamma \times V_{sp}$$

$$2 \times I \times f = C \times V_r$$

$$C = \frac{I}{2 \times f \times V_r}$$

For the power supply to output a current of 2.5A, $I = 2.5A$

$$f = 50Hz$$

$$V_r = 0.48 \times 16.97 = 8.1456V$$

$$C = \frac{I}{2 \times f \times V_r} = \frac{2.5}{2 \times 50 \times 8.1456} = 3069\mu F$$

Therefore, the closest available capacitor value to this is the 2500μF capacitor which is still acceptable as it will further reduce the ripple in the output voltage.

3.5.4THE SOIL MOISTURE SENSOR

The sensor was constructed using two cylindrical galvanized metal probes. The probes were slotted firmly into a block of varnished wood with a spacing of four centimeters between them in the wood block. An insulated conducting wire was attached to each probe. The wires were held firmly, beneath the probe heads, to the wood block. A second wood block was then attached using metal studs to the wood block holding the probes in order to ensure absolute firmness of the assembly (i.e. to prevent the probes from popping out of the holding block). The opposite sides of the holding block were also secured together with studs. Cylindrical rubber bungs were attached to the base of the holding block for elevation above the soil surface and also to prevent excessive contact of the wood block with soil moisture. The rubber bungs were also secured to the holding block using metal studs. The whole assembly was seven centimeters long, two and half centimeters wide and eight centimeters in height.

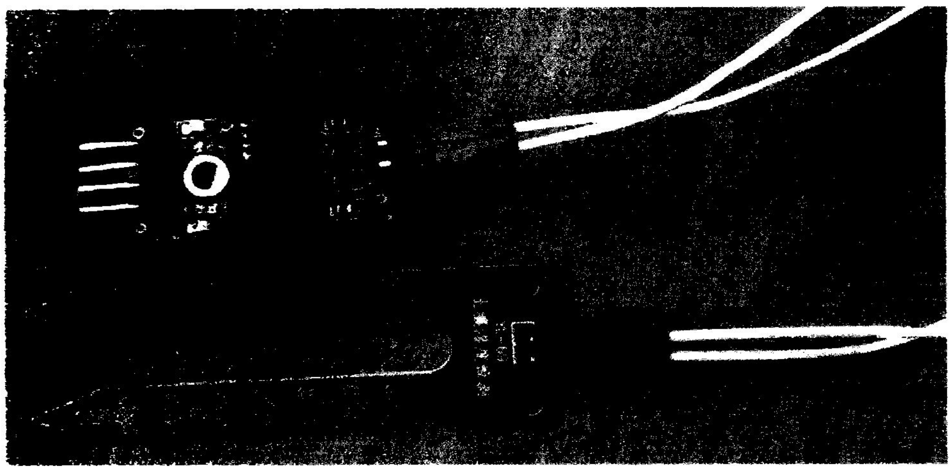

Figure 3.5- Picture of the moisture sensor used

3.5.5 SUBMERSIBLE WATER PUMP

A submersible pump (or sub pump, electric submersible pump) is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitation; a problem associated with a high elevation difference between pump and the fluid surface.

Specifications:

Voltage: 5-12V

Maximum lift: 150cm

Flow rate: 900L/h

Diameter: 2cm

Length: 5cm

Height: 10cm

Material: Plastic

Driving mode: DC design, magnetic driving

The motor was powered from the 7.001V output dc voltage of the diode bridge. The pump was able to supply 250 cm^3 of water in 10 seconds. The required irrigation time was calculated as follows:

P_c = pumping capacity of the pump

V_p = Volume of water pumped

T_p = Time taken to pump V_p in seconds

V_{irr} = Volume of water required for irrigating the soil from dry point

T_{irr} = required time for irrigation(length time for which the pump must be active)

$$P_c = \frac{V_p}{T_p}$$

$$T_{irr} = \frac{V_{irr}}{P_c}$$

$$V_p = 250cm^3$$

$$V_{irr} = 200cm^3$$

$$P_c = \frac{250}{10} = 25cm^3/s$$

$$T_{irr} = \frac{250}{10} = 8s$$

It is with this time T_{irr} in mind that the control subsystem was designed.

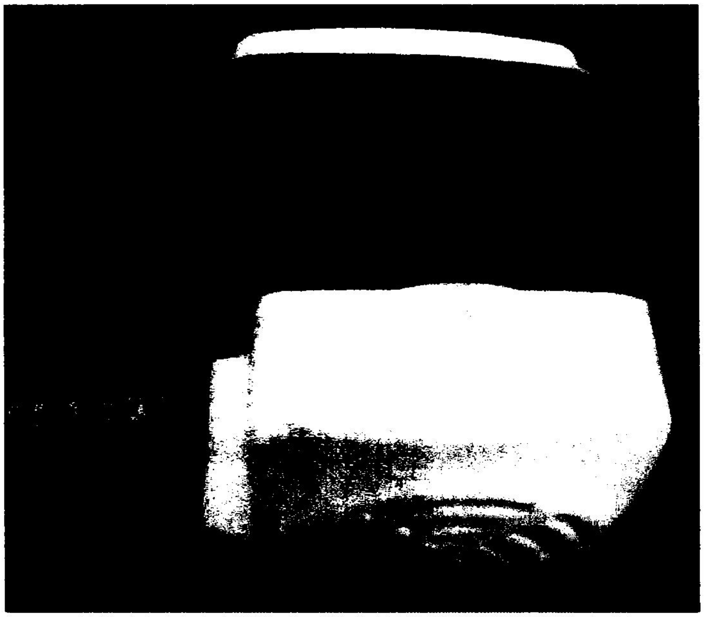

Figure 3.6-Submersible Pump

Source: Banggood

3.5.6 RELAY SWITCH

Relay is an electromagnetic device which is used to isolate two circuits electrically and connect them magnetically. They are very useful devices and allow one circuit to switch another one while they are completely separate. They are often used to interface an electronic circuit (working at a low voltage) to an electrical circuit which works at very high voltage. For example, a relay can make a 5V DC battery circuit to switch a 230V AC mains circuit. Thus a small sensor circuit can drive, say, a fan or an electric bulb.

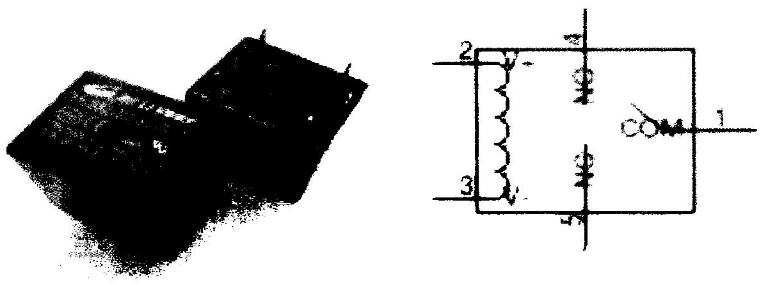

Figure 3.7- A relay and its schematic representation

Source: Goodsky

3.6 BLOCK DIAGRAM AND CIRCUIT ANALYSIS

3.6.1BLOCK DIAGRAM

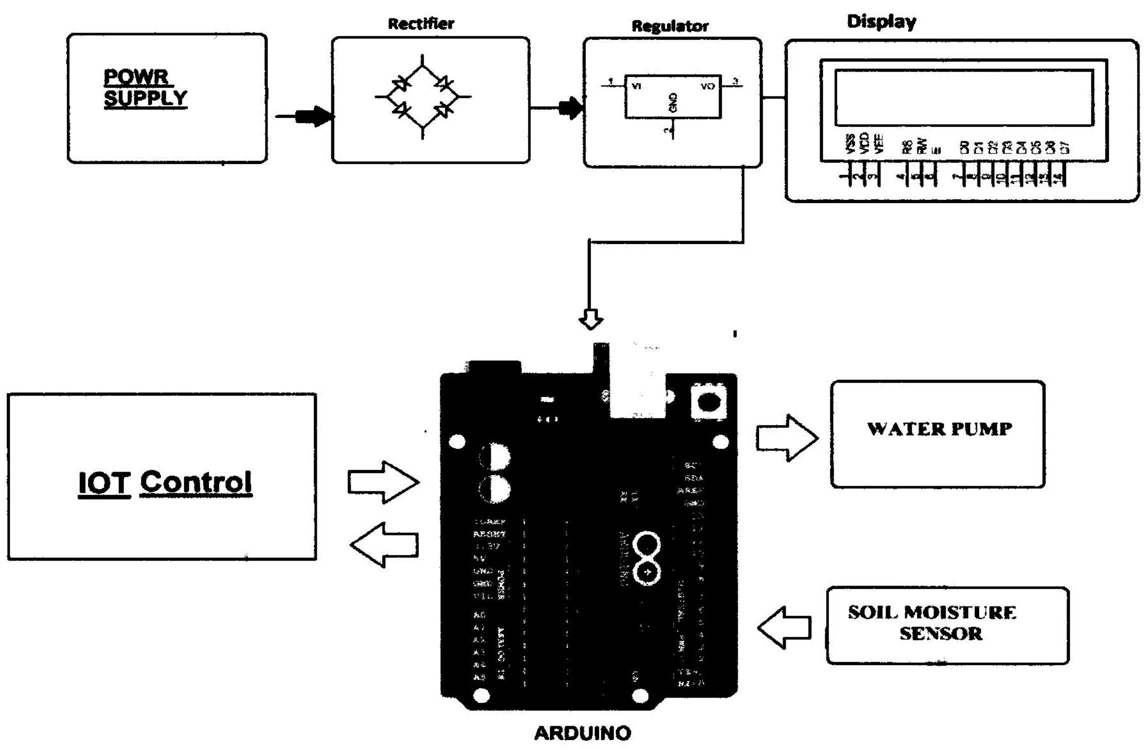

Figure 3.8- Block diagram of the IOT Irrigation Monitoring and Controller System

3.6.2 CIRCUIT DIAGRAM

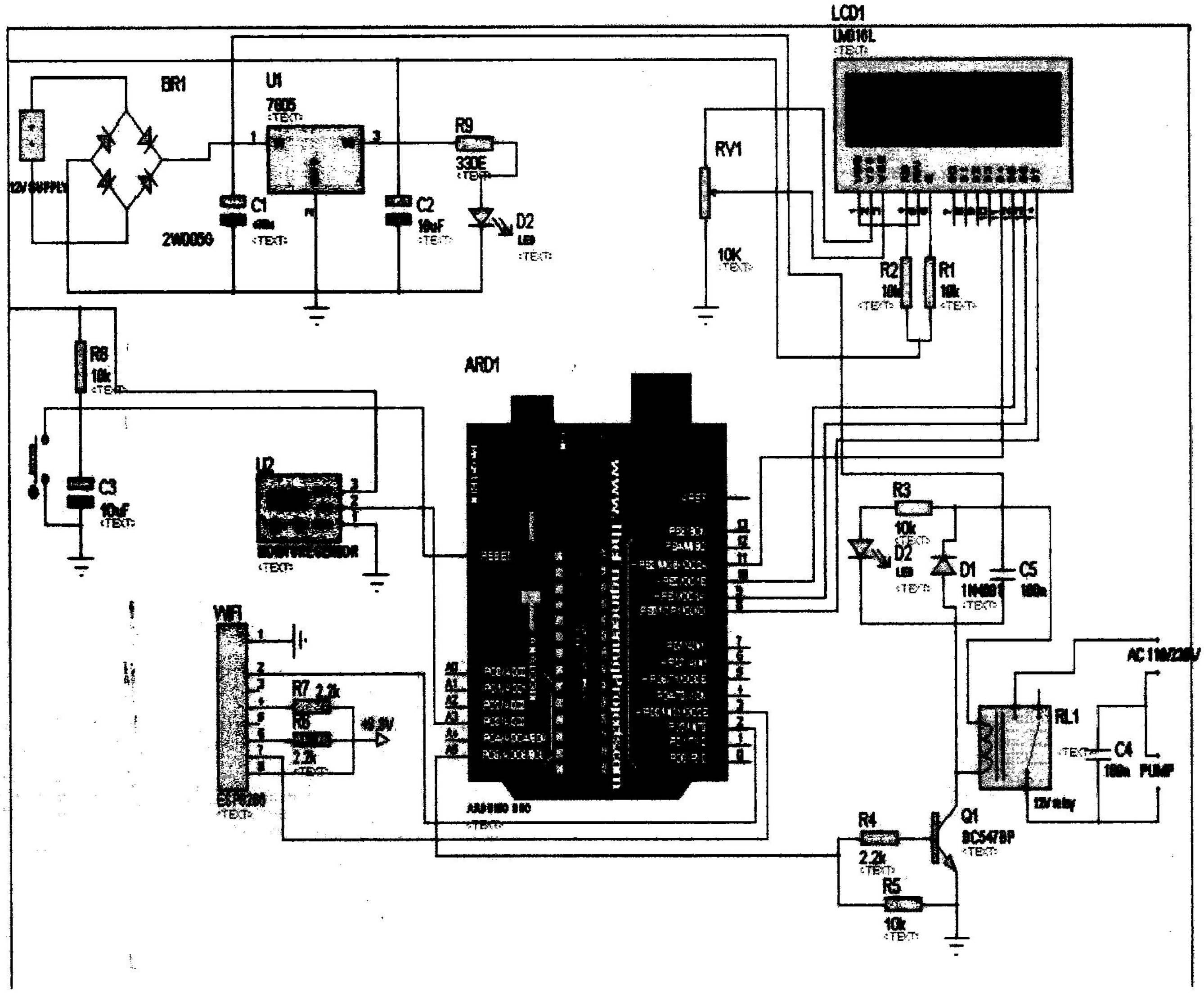

Figure 3.9- Circuit Diagram of the IOT Irrigation Monitoring and Controller System

3.6.3 CIRCUIT EXPLANATION

The implementation of the electronic circuitry involved the computerized simulation of the system design, physical simulation of the circuit using a breadboard to ensure proper operation

and the final implementation of the circuit on a Printed circuit board(PCB). The entire circuit comprises of the power supply section, sensing section and control section. Moreover, the power supply components involve the bridge rectifier which consists of four diodes connected together and a step down transformer. The filtered DC is taken care of by a voltage regulator connected in parallel to the rectifier which then delivers a constant 5V DC to other components of the circuit. The sensing circuit involves the moisture sensor which is connected to Analog pin 3 of the Arduino and the other pins of the sensor to the LCD and GND respectively. Resistors are connected in parallel to the LCD display as shown above to limit the current.

Consequently, the control circuit comprises of the wifi module and the Pump. The wifi module is connected to digital pin 3 and 2 of the arduino UNO and the other pins are connected to a 2.2k ohms resistor respectively with a ground. From the above circuit, the pump is connected to the high voltage side of the power circuit to enable optimum performance.

3.7 CODING

The coding of the Arduino UNO R3 was written with the help of the Arduino IDE software, using the high level programming language 'C'. The code defines the username and password at login to the online web server. Furthermore, the LCD (Liquid Crystal Display) has been configured to display the current status of the PUMP and moisture sensor using the program code. Hence, the code was debugged thoroughly to avoid errors and synchronized to the online server using the appropriate libraries. Details of the code can be found in the appendices.

3.8 DESIGN CALCULATIONS & APPLICATIONS

In this project, three parameters were considered in the design of the piping and flow system. They are;

- ✓ The distance of the pipe from the source to the sprinkler
- ✓ The diameter of the pipe (this may influence the pressure)
- ✓ The Elevation of the tank containing water

As a result of this, the following parameters were obtained;

Taking density of water to be $\rho = 1000kg/m^3$ and $g = 9.81m/s^2$ and, h when measured was 0.25m

Static pressure in the tank: $P = \rho \times g \times h$

$$P = 1000 \times 9.81 \times 0.25$$

$$P = 2.45kN/m^2$$

Moreover, the velocity of water flowing through the pipe can also be obtained since the pipe diameter and flow rate is known

$Diameter\ of\ the\ pipe = 0.025m$

Flow rate delivered by the pump neglecting losses

$$Q = \frac{900\text{L}}{\text{h}} = 0.9m^3/h$$

$$= \frac{0.9}{3600} = 2.5 \times 10^{-4}\ m^3/s$$

$$Q = AV$$

$$\text{Area of the pipe is given by} = \frac{\pi d^2}{4}$$

$$A = \frac{\pi \times 0.025^2}{4}$$

$$A = 4.9 \times 10^{-4}\ \ m^2$$

So that,

$$Velocity\ of\ flow\ \ V = \frac{Q}{A} = \frac{2.5 \times 10^{-4}}{4.9 \times 10^{-4}} = 0.51\ m/s$$

Furthermore;

Area of farm model is

$$A = 0.75m \times 0.47m$$

$$A = 0.3525\ m^2$$

We also need to know the total head loss of the system which is given by

$$h_l = h_{lminor} + h_{lmajor}$$

Where $h_l = total\ head\ loss$

h_{lminor} *is the minor head losses due to entries and exits along the channel, fittings and valves*

h_{lmajor} = *is the major head loss caused due to friction and viscous effects.*

So from Bernoulli equation;

$$\frac{P}{\rho g} + \frac{v^2}{2g} + z = constant$$

And

$$h_l = \frac{P}{\rho g} + \frac{v^2}{2g} + z$$

Substituting values obtained above;

$$h_l = \frac{2.45 \times 10^3}{1000 \times 9.81} + \frac{0.51^2}{2 \times 9.81} + 0.50$$

$$h_l = 0.249 + 0.013 + 0.50$$

$$h_l = 0.762m$$

Thus; h_{lminor} can be gotten since for a straight pipe k(head loss coefficient) is 0.8 then;

$$h_{lminor} = K\frac{V^2}{2g}$$

$$h_{lminor} = 0.8 \times \left(\frac{0.51^2}{2 \times 9.81}\right)$$

$$h_{lminor} = 0.01\text{m}$$

$$h_{lmajor} = H - h_{lminor}$$

$$h_{lmajor} = 0.762 - 0.01 = 0.752m$$

Hence, the head loss due to friction and viscous effect is minimal and within design requirements.

Therefore, the velocity of discharge can be calculated since $V = \sqrt{2gH}$

$$V = \sqrt{2 \times 9.81 \times 0.762}$$

$$V = \sqrt{14.9504} = 3.86m/s$$

This implies that, the resulting reduction in flow area at the discharge increases the velocity and increases the head loss due to friction. Hence, the value gotten was suitable for the design.

Power consumption of the system; The circuit uses standard power supply comprising of a step-down transformer from 230Vto 12V and 4 diodes forming a Bridge Rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470μF to 1000μF. The filtered dc being unregulated, IC LM7805 was used to get 5V DC constant at its pin number 3 irrespective of input DC varying from 9V to 14V.

The regulated 5V DC is further filtered by a small electrolytic capacitor of 10μF for any noise so generated by the circuit. One LED is connected of this 5V point in series with a resistor of 330Ω to the ground i.e., negative voltage to indicate 5V power supply availability. The 12V point is used for other applications as and when required.

CHAPTER FOUR

RESULTS AND DISCUSSION

The IOT Irrigation Monitoring and Controller System use a Wi-Fi module (ESP8266-12) which connects the system to the internet. This module controls a pump for supplying water to the field on the information obtained from the moisture sensor and then updates in real-time to the online server and it is also been displayed to the LCD. As a result of this, the whole system is monitored and controlled through the internet. The project depicts the concept of Internet of Things (IOT) and the results obtained are discussed as follows;

4.1 MODE OF OPERATION

The IOT Irrigation system was designed to continuously sense the moisture level of the soil. The system responds appropriately by watering the soil with the exact required amount of water and then shuts down the water supply when the required level of soil moisture is achieved. The system has a plug which needs to be connected to an AC power supply. Furthermore, once the power button is switched ON, the whole circuitry comes ON and every component becomes active down to the soil moisture sensor. Hence, the condition of the soil at that moment can be obtained from the sensor as displayed in real-time both online and to the LCD screen. This enables the user to make intelligent decision concerning the information gotten from the system on whether to switch the pump ON or not.

The online server is implemented on the IOT gecko platform which supports IOT development. It can be accessed anytime and anywhere using any network provider. Interestingly, once the system is ON, the user can also monitor and control the farm land directly from the internet without necessarily going to the farm. The interface of the online platform is shown below and consists of basically, the status of the pump (ON or OFF) with a control icon and the continuous update of the moisture content.

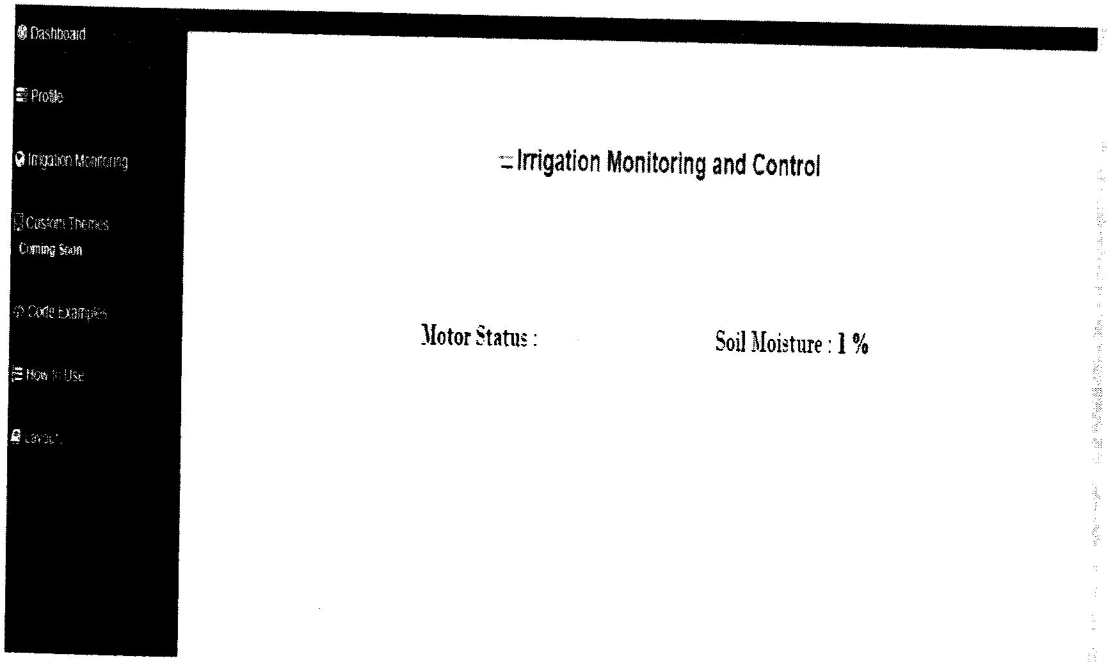

Figure 3.1- Screenshot of the Sensed Values Displayed On User Device

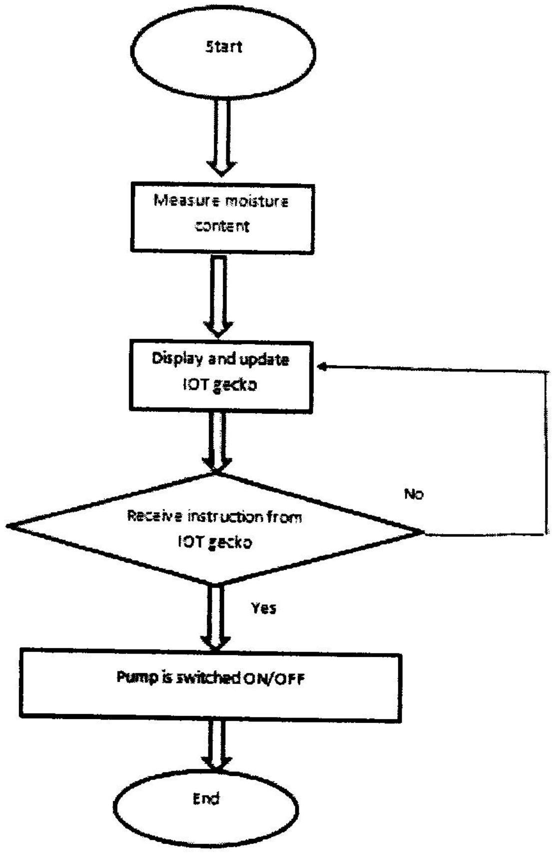

Figure 4.2- Flow Chart of the IOT Irrigation Based system

4.2 TESTING AND ANALYSIS

The system was tested using different soil samples. The table shows how long it took different soil samples at different moisture levels to get to the 100% reading on the moisture sensor. Below is a table of the results obtained;

Table 1- Results obtained from tests using the system on different soil samples.

Soil Sample	Soil Type	Initial soil state (% gotten from the moisture sensor)	Irrigation time (seconds)
A	Sandy	0	6.0
B	Sandy	50	3.5
C	Loamy	0	8.0
D	Loamy	50	4.0
E	Clay	0	10.0
F	Clay	50	5.5

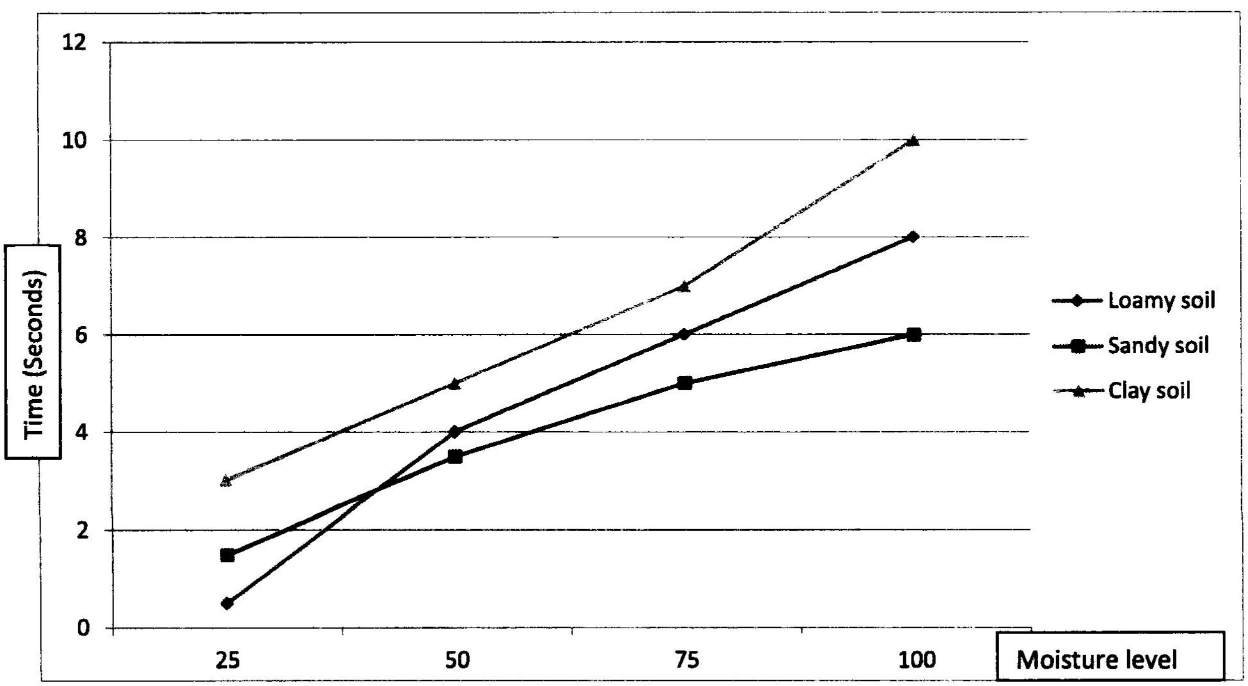

Figure 4.3- Graph of the system's response to soil samples of different conditions

It can be seen from the results obtained that the system responded linearly with respect to the degree of dryness for the three soil types. There is a linear relationship between the degree of soil dryness and the time taken to irrigate the soil. At 50% dryness, irrigation durations were 2.5, 4.5 and 8.2 seconds for sandy, loamy and clayey soils respectively. While at 100% dryness, it is seen that irrigation in loamy soil generally took longer in loamy soil than in sandy soil, and clayey soil irrigation took longest.

Moreover, in the process of testing we were able to deduce the efficiency of the pump used in terms of the power transmitted to the fluid

From pump specification;

Power absorbed by the pump $= 12W\backslash$

Torque $= 1.35Nm$

Angular speed $= 60rpm$

Then,

$$\omega = speed \times \frac{2\pi}{60}$$

$$\omega = 60rpm \times \frac{2\pi}{60}$$

$$\omega = 6.284\, rad/sec$$

So that, Power transmitted to the fluid by the pump can be calculated as

$$P_{out} = T \times \omega$$

$$P_{out} = 1.35Nm \times 6.284$$

$$P_{out} = 8.48W$$

Power output

$$Pumping\ efficiency = \frac{Power\ Output}{Power\ input} = \frac{8.48}{12} \times 100 = 70.6\%$$

Efficiency in terms of pressure head was calculated as shown below;

Since $H\ from\ the\ design\ is\ 0.762m$

Then,

$$Power\ input = IV$$

$Power\ input =$ 1 × output dc voltage of the diode bridge = 1 × $7.011V$= 7.011V

$$Power\ output = \rho gQH = 1000 \times 9.81 \times 2.5 \times 10^{-4} \times 0.762 = 1.868W$$

$$efficiency = \frac{Power\ Output}{Power\ input} = \frac{1.8688}{7.011} \times 100 = 27\%$$

From the above value, we were able to realize that the efficiency obtained was as a result of the presence of losses caused by fittings, curves and viscous effects.

4.3 PROJECT ASSEMBLY PICTURES

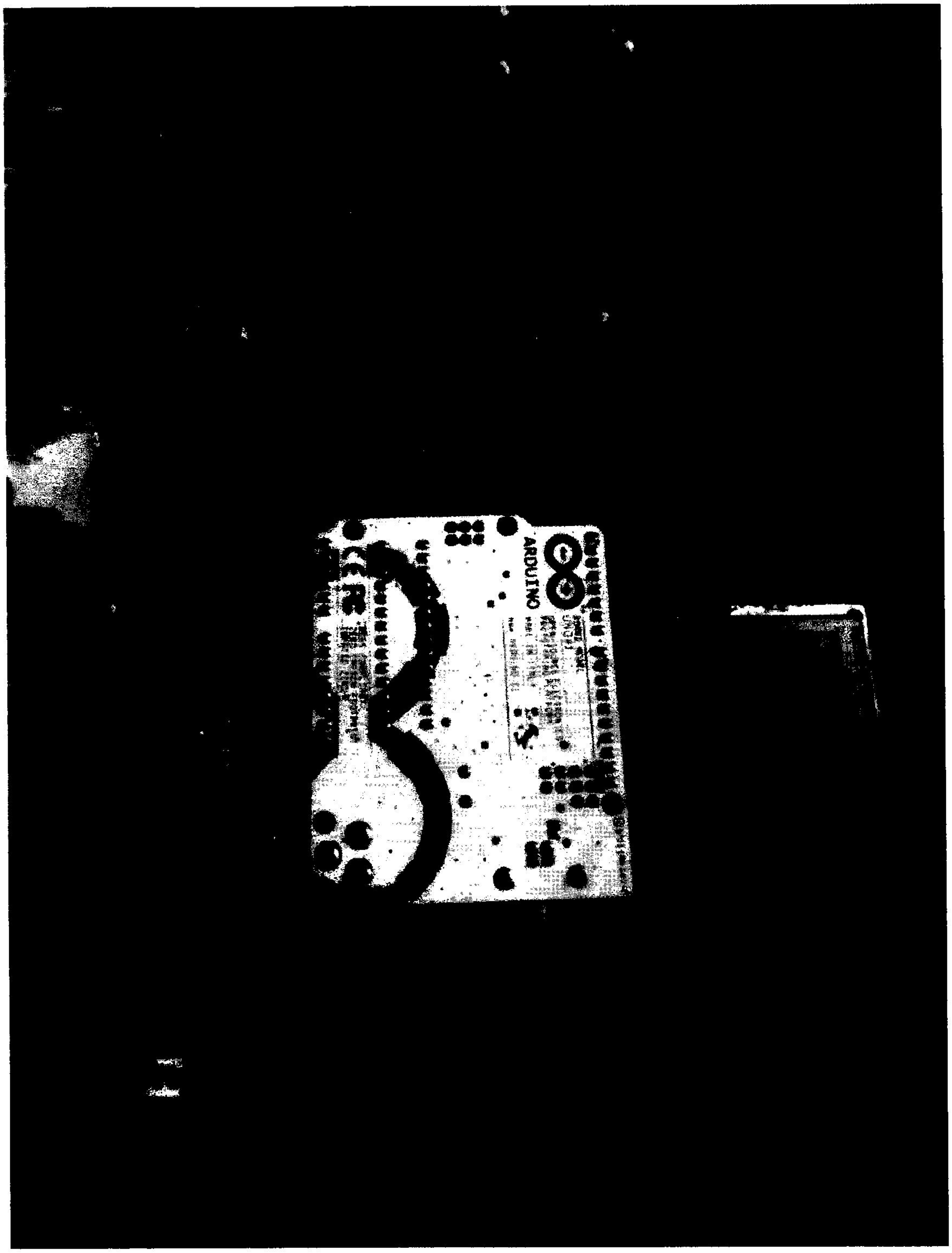

Plate 2- Picture showing the assembled system components on a PCB

Plate 3- system assembly

CHAPTER FIVE

SUMMARY AND CONCLUSION

The IOT Irrigation Monitoring & Controller System has been designed and constructed. The prototype of the system worked according to specification and quite satisfactory. The system helps to eliminate the stress of manual irrigation and at the same time, conserving the available water supply. Therefore, applying the internet of things to the highly effective monitoring and control of irrigation has been confirmed to have a significant impact on ensuring the efficient use of water resources as well as ensuring the efficiency and stability of the crops. The system was tested on three types of soil and from the result analysis sandy soils require less water than loamy soils and clay soils require the most water for irrigation.

5.1 APPLICATIONs

1. It is a valuable tool for accurate soil moisture control in highly specialized greenhouse vegetable production.
2. Vegetation of disturbed soil
3. Monitoring the health of plants on the farm lands.

5.2 FUTURE IMPLEMENTATION

A wireless sensor and GPRS (General Packet Radio Service) based automated irrigation system can also be employed. The system can be further improved by making it powered by a solar system; that way, power outage will not be an issue. For a large scale implementation a more powerful water pump can be used. An automatic control system can also be integrated to monitor and control the availability of water in the water tanks and the supply of it to the farm land.

For large scale implementation, several moisture sensors would be planted in the ground over specific radiuses to cover the entire farm land to avoid making judgments over little samples.

BILL OF ENGINEERING MATERIALS USED

Table 3- Bill of engineering materials used.

Category	Quantity	References	Value	Prices(#)
Capacitors	1	C1	470uF	200
	2	C2,C5	10uF	500
	1	C3	104J/400V	200
	1	C10	104	250
Resistors	1	R1	330E	100
	4	R2-R4,R9	10k	1000
	3	R5-R6,R8	2.2k	300
	1	R7	1k	100
Integrated Circuits	1	U2	7805	5500
Transistors	1	Q1	BC547BP	500
Diodes	2	D1-D2	RED LED	200
	1	D3	1N4007	400
Others	2	AC 110/230V,PUMP	pbt	15000
	1	BR1	2W005G	2000
	1	J6	12V SUPPLY	4500
	1	LCD1	16X2	1000
	1	MOISTURE SENSOR	female strip	1500
	1	RL1	12v relay	2500
	1	RV1	10K	500
	2	SW1	reset	400
	1	UNO1	ARDUINO	4500
	1	WIFI1	ESP 01	4000
Miscellaneous				10000
Total				60,150

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APPENDICES

Irrigation Monitoring and Control Program Code

```
// include the library code:

#include <LiquidCrystal.h>

#include <IOTgecko.h>

#define esp_baudrate 115200

///////variables///////////////

String id = "oluwatobi.adu.1143@fuoye.edu.ng"; // IOTgecko login id

String pass = "1907"; // IOTgecko login password

String ssid = "IOT"; // SSID/name of your wifi router or wifi hotspot

String pass_key = "project1234"; // Wifi password

bool notConected = true;

bool login = false;

const int no_of_senddata = 2;

const int no_of_getdata = 1;

String IOT_data[no_of_senddata];

int motor_status[no_of_getdata];

int pump_status = 0;

unsigned long current_time ;
```

```
////////////pins//////////////
const int pump = A5;
const int sensor_pin = A4;
// initialize the library with the esp8266(wifi module) current baudrate
IOTgecko gecko = IOTgecko(esp_baudrate);
LiquidCrystal lcd(13,12,11,10,9,8);
void setup()
{
 lcd.begin(16, 2);
 Serial.begin(115200);
 pinMode(pump,OUTPUT);
 digitalWrite(pump,LOW);
 lcd.clear();
 lcd.setCursor(1, 0);
 lcd.print(F("IOT Irrigation"));
 lcd.setCursor(3, 1);
 lcd.print(F("Monitoring"));
 //Serial.println(F("IOT Irrigation"));
 delay(2000);
```

```
lcd.clear();

lcd.print(F("Connecting Wifi"));

gecko.listen();

while(notConected)

{

 if(gecko.GeckoConnect(ssid,pass_key))//connect to wifi with given SSID and password

 {

  while(!login)

  {

   if(gecko.GeckoVerify(id,pass))//login to IOTgecko.com with given ID and password

   {

    lcd.clear();

    lcd.print(F("Connected"));

    login = true;

    notConected = false;

   }

  }

 }

 delay(1000);
```

```
 }
}
void loop()
{
 IOT_data[0] = "2";//(String)pump_status;
 IOT_data[1] = (String)get_humidity();
 lcd.clear();
 lcd.print(F("Moisture is "));
 lcd.print(IOT_data[1]);
 lcd.print(F("% "));
 lcd.setCursor(0, 1);
 lcd.print(F("Pump is "));
 if(pump_status==1)
 {
  digitalWrite(pump,HIGH);
  lcd.print(F("ON"));
 }
 else if(pump_status==0)
 {
```

```
  digitalWrite(pump,LOW);

  lcd.print(F("OFF"));

 }

 int IOT_status = gecko.SendandGetGParams(IOT_data,no_of_senddata, motor_status ,
no_of_getdata);//send and get data on IOTgecko.com

 if(IOT_status == VALID)

 {

  if(motor_status[0]>=0)

  {

   if(motor_status[0]==1)

   {

    digitalWrite(pump,HIGH);

    pump_status = 1;

   }

   else if(motor_status[0]==0)

   {

    digitalWrite(pump,LOW);

    pump_status = 0;

   }
```

```
    }
  }
  else
  {
   lcd.clear();
   lcd.print(F("reconnecting"));
   while(!gecko.GeckoReconnect())//reconnect to the IOTgecko.com
   {
    //Serial.println(F("conncetion failed.....reconnecting"));
    delay(2000);
   }
   lcd.clear();
   lcd.print("Connected");
   //Serial.println(F("connected succesfully"));
  }
  delay(3000);
}
int get_humidity()
{
```

```
int analog = analogRead(sensor_pin);

analog = map(analog , 0 , 1023 , 100 , 0);

return analog;

}
```