DESIGN AND IMPLEMENTATION OF A MICROCONTROLLER BASED GSM ALERT FARM MONITORING SYSTEM

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CERTIFICATION

This project with the title

DESIGN AND IMPLEMENTATION OF A MICROCONTROLLER BASED GSM ALERT FARM MONITORING SYSTEM USING SOIL MOISTURE, TEMPERATURE, HUMIDITY, AND LIGHT

Submitted by

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Has satisfied the regulations governing the award of degree of

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DECLARATION

I Ayeni Tope Samuel hereby declare that this project work carried out is the result of my personal effort under the supervision of Dr. M.O Olaniyan of the Department of Computer Engineering, Federal university Oye-Ekiti, Ekiti State, as part of the requirement for the award of Bachelor Degree of Computer Engineering, and has not been submitted elsewhere for this purpose. All sources of information are explicitly acknowledged by means of reference.

--	29/03/2019 --------------------------------
Ayeni Tope Samuel	**Date**
CPE/13/1075	

DEDICATION

I dedicate this report to God, the Almighty; the all-knowing, the all sufficient, the giver of wisdom, knowledge and understanding.

ACKNOWLEDGEMENT

I humbly wish to appreciate the management of Federal University Oye-Ekiti, the non-academic staff of the Computer Engineering department, my supervisor Dr. (Engr) Olatayo Olaniyan and the head of department (HOD) Dr. (Engr.) Ibrahim Adeyanju, my level advisor Engineer (Mrs) Esan and all other lecturers in the department for their guidance and support throughout my stay in the university. I also acknowledge my parents for all their support emotionally, spiritually and financially.

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ABSTRACT

This project is a farm operation monitoring system using a microcontroller device that gets the status of the farm by using the following factors: soil moisture, temperature, light and humidity and send the status of the farm to the user using a SMS alert notification system all at a given time. In the field section, the Farm monitoring system was built around three sensor modules, and will be programmed using to read in data from a monitoring device that will be attached to the sensors.

The system uses hardware components, as well as software, thereby making it an embedded system. The hardware components are DHT 11 module, Moisture Sensor, Light Dependent Resistor, a Microcontroller, and a monitoring device. In addition we will use a GSM Module to send SMS alert notification to the user.

The DHT 11 module is used to measure the temperature and humidity of the soil, the moisture sensor is used to measure the soil moisture, the Light Dependent Resistor is used to measure light intensity, the Microcontroller serves as the master control for the entire system, and the monitoring device will record the properties of the soil gotten from the DHT 11 module, the moisture sensor and the Light Dependent Resistor. All the properties of the soil gotten through the monitoring device will be sent through the GSM sensor to the user's GSM device.

At the end of these research work, The microcontroller based farm monitoring system was able to get the soil moisture content, temperature, humidity and light and light of a farm at a particular time and send the status via SMS notification alert system to the farmer.

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CHAPTER ONE

INTRODUCTION

1.1 Preamble

Agriculture plays a vital role in the development of country's economy. The daily need for food shows the importance of agricultural development. Growing a particular crop in a particular region takes the privilege of monitoring the growth from cultivation till harvesting. One of the main challenges in agricultural activities is detecting soil properties. As the global climate decreases the source of water throughout the world, it is necessary to take steps for preserving it (Damas *et al,* 20017). However traditional soil moisture detection and management is done by the people itself. It requires the presence and continuous monitoring of the soil properties by the farmers in the field area. This creates a need for more labour work and maintenance, which will in turn result to more cost (Liai *et al,* 2013). In every organised system which is dependent on accurate time and data management, there is a need to have a system which can on its own serve the purpose of automatically sending alert text messages. Time and data management plays important role in the success of any organization like a farm environment where there is always variation in soil properties such as temperature, humidity, soil moisture and PH of soils; these soil properties are to be effectively managed for maximum yield.

With global mobile phone subscribers estimated to 4.5 billion by 2012 (Cellular News, 2018), the mobile phone is by far the most adopted consumer electronic in the world. As their processing power increases, the ability to leverage their mobility and computing power to solve daily problems increases. From playing games, barcode scanning, photography, to social networking, mobile phones have become integral part of our modern existence. Hence, applications that have been traditionally confined to desktop computing are steadily being adapted for mobile phones. One of these applications is that of monitoring and tracking. While desktop computing still offers more processing power, the mobile phone has the advantage of constant reachability and mobility that desktop computing lacks with comparable rich user experience (Frank *et al,* 2008).

Hence, there is the need to develop a system that will combine available resources and reach people

through short message service (SMS) using GSM module (nowsms.com, 2018) This project proposes the design of a soil moisture detector using temperature and PH sensors, and also implementing it with SMS alert notification system. The system will check and monitor five soil properties which are the soil moisture, temperature, humidity, lighting and PH.

1.2 Aim and Objectives

The aim of this project is to design and implement a microcontroller based GSM alert farm monitoring system using soil moisture, Temperature, Humidity and Light

The specific objectives of this project are:

1. To design a microcontroller based GSM alert farm monitoring system which will monitor the soil moisture, temperature, humidity, and light
2. To implement the system design with SMS alert notification system.
3. To evaluate the performance of the developed system.

1.3 Statement of Problem

Recently there is a new revolution that is picking up huge popularity in the world of modern wireless technologies and this is leading to internet of things whereby objects are able to collect and exchange data using embedded sensors and this have led to emergence of smart environment as one aspect of research. Nevertheless, there are so many problems affecting agricultural practice in Nigeria which these project have been introduced to minimize them and these includes.

Real time environmental information which in turn help the agro-based specialist achieve efficient management and utilization of agro ecological resources.

Networking without cable, through the help of GSM module embedded in the system agricultural parameters. These parameters such as soil moisture, temperature, lighting, and humidity can be received on a mobile phone based on request SMS sent to the SIM card inserted into the GSM module without human having to be present on the farm area to get the readings on a phone screen, and the user can also with the use of the GSM module send a message to open the pump. Continuous check on the environment for any change in soil moisture, temperature, humidity, and lighting. This system is to solve the problems stated above.

1.4 Scope of the Project

This project aims at designing and implementing a soil moisture detector, using temperature and Humidity sensors with SMS alert notification system. The temperature and humidity sensor will serve as the sensing device for getting soil temperature and humidity values respectively, and a GSM device attached to the soil moisture detector will send an SMS alert notification to the system whenever the values of temperature, soil moisture, humidity and lighting are requested.

This project used a soil moisture detector, temperature and humidity sensors with SMS alert notification system to monitor some selected properties of soil. Soil moisture detectors can also be adapted for use in home environments, poultry, storerooms, etc.

This project desires to focus on application inside the soil, rather than for use in homes, poultries, storerooms, etc. The goal is to utilize this technology in the ordinary farm environment. The testing will be done on readily available farms and home gardens, but with a larger vision of applying it on a larger scale.

1.5 Significance of Study

The use of SMS alert notification for the design and implementation of a soil moisture detector system using temperature sensors will be beneficial to its users in many ways, some of which are:

1. Quick Awareness of Soil Properties: The system to be designed will send a SMS alert notification the user about the status of the properties of the soil, which will be gotten by the temperature and PH sensors of the designed system, whenever the user requests for the soil properties.

2. Overall Control and Mobility: The proposed system will be fully operational from the user's cellular phone.
3. Better Monitoring and Communication: The system to be designed will have the ability of a two way communication between the user and device at any time.
4. More Applications outside Soil Environment: The system to be designed can also be partially adapted for usage in households, poultries and other suitable environments for monitoring temperature, humidity and lighting.

1.6 Research Methodology

This System was built around three sensor modules, and will be programmed to read in data from a monitoring device that will be attached to the sensors. The system used hardware components, as well as software, thereby making it an embedded system. The hardware components are DHT 11 module, Moisture Sensor, Light Dependent Resistor, a Microcontroller, and a monitoring device. In addition a GSM Module was used to send SMS alert notification to the user.

The DHT 11 module was used to measure the temperature and humidity of the soil, the moisture sensor was used to measure the soil moisture, the Light Dependent Resistor was also used to measure light intensity, the Microcontroller served as the master control for the entire system, and the monitoring device will record the properties of the soil gotten from the DHT 11 module, the moisture sensor and the Light Dependent Resistor. All the properties of the soil gotten through the monitoring device will be sent through the GSM sensor to the user's GSM device.

1.7 Bill of Materials

Design Title	
Author	**Ayeni Tope Samuel**
Document Number	
Revision	
Design Created	30 February 2018
Design Last Modified	02 June 2017
Total Parts In Design	18

Table 1.1: Bill of Materials

Category	**Quantity**	**Value**	**Unit Cost**
Capacitors	1	100u	
Capacitors	2	22n	
Resistors	2	1k	
Resistors	3	10k	
Integrated Circuits	1	ATMEGA328P	
Transistors	1	BC547	
LED	3	RYB	
Diodes	2	1N4007	
GSM MODULE	1	A6 MODULE	
Buttons	3	push button	
IC socket	28 pins	RFID MODULE	
PC Board	1	Small size	
LCD	16x2	LM016L	
POT	1	10k	
Oscillator	1	CRYSTAL	

CHAPTER TWO

LITERATURE REVIEW

2.1 Soil Moisture Measurement

Monitoring of volumetric soil moisture content in the field calls for a fast and accurate method, which allows repeated measurements through time. There are currently two approaches for measuring the spatial distribution and temporal variation of soil moisture content: point measurements and remote sensing.

This chapter reviews these techniques. The intention of this chapter is to give an overview of soil moisture measurement, temperature, humidity and light methodologies, and to highlight the essential characteristics of the point measurement and remote sensing measurement techniques, in relation to estimating the spatial and temporal variation of soil moisture profiles.

2.2 Point Measurement of Soil Moisture Profiles

It has long been recognized that reliable, robust and automated methods for the measurement of soil moisture content can be extremely useful, if not essential, in hydrologic, environmental and agricultural applications. Over the last 70 years, this recognition has fostered the investment of a considerable amount of ingenuity in developing such methods. The following sections review these methods.

2.2.1 Thermogravimetric Method

The standard method of measuring the volumetric moisture content of a soil sample is the thermo-gravimetric method (AS 1289.2.1.1-2002), which consists of oven drying at 105°C and relating the change in mass to the volume of the sample.

$$\theta = \frac{w_w \rho_b}{w_d \rho_w} \dots\dots\dots\dots\dots\dots\dots\dots. eqn\ 2.1$$

where θ is the volumetric soil moisture content fraction, W_w is the weight of water contained in the voids of the moist soil, W_d is the weight of dry soil, ρ_b is the soil bulk density (from collecting a known volume of soil), and ρ_w is the density of water.

The advantages of this method are that it is inexpensive and soil moisture is easily calculated. However, it is time consuming, difficult to obtain representative samples and destructive. Hence, this method cannot be used for repetitive measurements at exactly the same location (Roth et al., 2000).

This method is prone to large errors due to sampling, transporting, handling and repeated weighing. In addition, soils with organic matter may exhibit a mass loss during oven drying due to oxidation and decomposition of the organic matter, while some clays will retain appreciable amounts of adsorbed water. Measurement errors may be reduced by increasing the size and number of samples (Zegelin, 2006).

the volumetric fraction of each component is involved. Thus, as the soil moisture content increases, the relative dielectric constant can increase to 20 or greater (Schmugge, 2005).

2.3 Factors been Measured

2.3.1 Humidity

Humidity is the amount of water vapour present in the air. Humidity indicates the likelihood of precipitation, dew, or fog. Higher humidity reduces the effectiveness of sweating in cooling the body by reducing the rate of evaporation of moisture from the skin. This effect is calculated in a heat index table.

2.3.1.1 Humidity's effect on crop quality?

Humidity levels fluctuate with change in air temperature and plants are constantly transpiring, which adds water vapour to the air. If the humidity is too low, plant growth is often compromised as crops take much longer to obtain the saleable size.

2.3.1.2 Importance of humidity for plant growth

Humidity is important to make photosynthesis possible. In the case of Anthurium, good humidity around the plant is even more important than for most other crops, because the plant can only absorb a reduced amount of humidity and hence has less water evaporation than most plants. If the plant loses too much water, the stomata will close with the result that photosynthesis stops. If this happens, no further CO_2 can be absorbed, and CO_2 is required to keep the photosynthesis going.

In addition, the temperature of a plant on a sunny day is mainly regulated by cooling through evaporation. Evaporating water can evacuate a lot of plant heat and is an efficient way of cooling for a plant. Open stomata ensure that a lot of heat can be evacuated. By closing the stomata, the plant temperature will often increase quickly.

2.3.2 Soil Moisture

Soil moisture (definition) a soil moisture sensor measures the quantity of water contained in a material, such as soil on a volumetric or gravimetric basis. To obtain an accurate measurement, a soil temperature sensor is also required for calibration (George, B.H. 1999).

2.3.2.1 Important of soil water

Soil water is the major component of the soil in relation to plant growth. If the moisture content of a soil is optimum for plant growth, plants can readily absorb soil water. Soil water dissolves salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants.

2.3.2.2 Why its important to measure soil moisture

If the moisture content of a soil is optimum for plant growth, plants can readily absorb soil water. Much of water remains in the soil as a thin film. Soil water dissolves salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants.

2.3.2.3 How does soil moisture affect plant growth?

If a plant's soil has too much water, the roots can rot, and the plant can't get enough oxygen from the soil. If there is not enough water for a plant, the nutrients it needs cannot travel through the plant. A plant cannot grow if it doesn't have healthy roots, so the proper balance of water is key when growing plants

2.3.3.1 Why temperature is important to plant

Temperature is a key factor in plant growth and development. Along with the levels of light, carbon dioxide, air humidity, water and nutrients, temperature influences plant growth and ultimately crop yields.

2.3.4.1 How light affects the growth of a plant

All things need energy to grow. We get energy from the food we eat. Plants get energy from light through a process called photosynthesis. This is how light affects the growth of a plant. A plant would not be able to produce the energy it needs to grow without light

2.3.4.2 Problems with too little light

Sometimes a plant will not get enough light and will have problems with too little light. Plants affected by light shortages or too little blue light will have the following signs:

i. Stems will be leggy or stretched out
ii. Leaves turn yellow
iii. Leaves are too small
iv. Leave or stems are spindly
v. Brown edges or tips on leaves
vi. Lower leaves dry up

2.4 Wireless Sensor Networks (WSN)

Wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions (i.e. temperature, sound, vibration, pressure, humidity, etc.) and to cooperatively pass their data through the network to a main location. The more modern network is bi-directional, also control of sensor activity, enabling.

The WSN is built of few to several hundreds or even thousands of sensors of nodes, where each node is connected to one (or sometimes several) sensors. Each sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source (i.e. battery or an embedded form of energy harvesting). The topology of the WSNs, from a simple star network to an advanced multi-hop wireless mesh network can vary. The propagation technique between the hops of the network can be routing or flooding. A wireless sensor network is made up of three components: Sensors Nodes, Task Manager Node (User) and Interconnect Backbone, as shown in Figure 2.1 below.

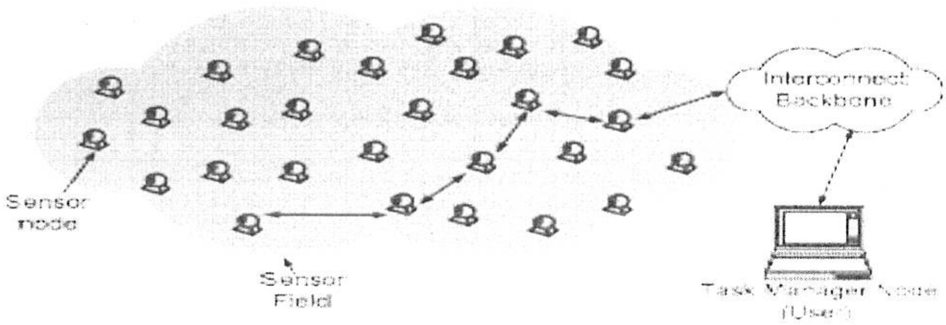

Figure 2.1: Showing a Wireless Sensor Network

Each Sensor Node can contain various sensors and actuators that are used to collect the data and control physical processes. The collected data is transferred to the User through the network that can include Internet segments. Besides collecting the data and controlling actuators, a node may need to perform some computation on the measured data. Direct communication between individual nodes can also be required. The Task Manager Node (User) performs tasks in data storage, analysis and display.

2.4.1 WSN Requirements and Challenges

It must support the following requirements in deployment: scalability, reliability, responsiveness, mobility, and power efficiency. The description of these:

i. Reliability- The ability of the network for reliable data transmission in a state of continuous change of network structure.
ii. Scalability- It is the ability of the network to grow without excessive overhead
iii. Responsiveness - The ability of the network to quickly adapt itself to changes in topology.
iv. Mobility- It is the ability of the network to handle mobile nodes and changeable data paths.

2.4.2 Characteristics of WSNs

The important characteristics of WSNs are:

i. Less power consumption
ii. Ability to cope with node failures
iii. Mobility of nodes

iv. Communication failures

v. Heterogeneity of nodes

vi. Usability in large scale

vii. Withstand in unfavorable environmental conditions

viii. Ease of use

2.4.3 Network Management:

Network management is the process of managing, monitoring, and controlling the behavior of a network. Different approaches for network management are given below:

In this section we classify existing sensor network management systems in terms of the functionality they provide. Systems for sensor networks that are based on traditional network management systems include BOSS (Song *et al.*, 2005) and MANNA (Ruiz *et al.*, 2003). BOSS serves as a mediator between Up nP networks and sensor nodes. MANNA provides a general framework for policy-based management of sensor networks. SNMP (Deb *et al.*, 2005) provides network topology extraction algorithms for retrieving network state.

Other researchers have designed novel routing Protocols for network management. For example, Top Disc (Deb *et al.*, 2001) and STREAM (Deb *et al.*, 2004) are used in SNMP for extracting network topology, RRP ` uses a zone-flooding protocol, SNMS (Tolle and Culler. 2005) introduces the Drip protocol, and Win MS (Louis *et al.*, 2006) is based on the Flexi MAC protocol. Fault detection is an important focus of the systems TP , Sympathy (Ramanathan *et al.*, 2005), MANNA (Ruiz *et al.*, 2004), and Win MS (Louis *et al.*, 2006). In these systems the central server analyses data collected from the network. The main disadvantage of such passive monitoring schemes is that they are not adaptive to current network conditions, and provides no self-configuration in the event of faults. The end user must manually manage the network and interpret the graphical representation of collected data.

2.4.4 Applications of Wireless Sensor Networks (WSNs)

1. Area monitoring

In area monitoring, the WSN is deployed over a region where some phenomenon is to be monitored. In military, it is the used 344for detects enemy intrusion; a civilian example is the geo-fencing of gas or oil pipelines.

2. **Industrial monitoring**

   a) Machine health monitoring: WSNs have been used for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionality.

   b) Industrial and control applications: The new aspects are considered as an enabler for future applications in industrial and related wireless sense and control applications, and partially replacing or enhancing conventional wire-based networks by WSN techniques.

   c) Water/Waste water monitoring: The area of water quality monitoring utilizes wireless sensor networks and many manufacturers have launched fresh and advanced applications for the purpose.

   d) Water distribution network management: Water distribution network sensors are used by manufacturers to concentrate on observing the water management structures such as valve and pipes and also making remote access to water meter readings.

2.4.5 Relationship between Existing Remote Monitoring and Control Systems

The relationships that exist between some of the existing remote monitoring and control systems are highlighted in the Table 2.1 below:

Table 2.1: Existing Remote Monitoring and Control System

Technology	Monitoring System	Module Interfaced	Processor used	Sensor Interfaced
Zigbee, internet	Laptop	-	89C52	Moisture sensor
Zigbee, GPRS	Mobile	JN5121	ARM9	Soil moisture/temperature
RF	LCD	CC1110	8051	
Zigbee, internet	Laptop, PDA	CC2420	MSP430	Temperature/humidity/illumination
GSM, RFID	-	-	-	Camera nodes, cattle sensor network, soil moisture.
RF, internet	Laptop, PDA	C43271	C43271 Psoc	Touch, temperature, moisture, light
Single sensor node	-	-	89C52	Temperature/humidity/PH
Zigbee	PC	nRF905	89C51	Temperature/humidity
Zigbee	TFT-LCD	nRF905	MCF52235	Temperature/humidity
Zigbee, internet	PC	Zigbee module 3160	SPCE061A	Temperature/humidity/soil temperature/ soil moisture/co2/ illumination

Zigbee, internet	Laptop, PDA	MSENS SoC	MSENS SoC	Air Temperature/humidity/ soil temperature/soil moisture /anemometer /radiometer /rain gauge/ CMOS image
Zigbee, internet	PDA	Zigbee transceiver	8-bit MCU	Light/ temperature / humidity
Zigbee, internet	PDA	JN5121 with on chip 32 bit core	JN5121 with on chip 32 bit core	Light/ temperature / humidity/ wind speed

2.5 Soil Moisture Sensors

This section reviews some specific soil moisture sensors based on the principles of dielectric properties and soil suction pressure.

2.5.1 Time domain reflectometers

2.5.1.1. Campbell Scientific water content reflectometer

To measure θ_g or θ_v, the water content reflectometer (WCR) employs the principles of time domain reflectometry to calculate the moisture within the soil (Campbell Scientific., 2006). One difference between TDR and WCR is that the measurement frequency of the WCR is generally between 15 and 45 MHz (Seyfried and Murdock, 2001), whereas for the TDR it can be as high as 1 GHz. Water content reflectometers (WCR) function along the principles of the TDR to calculate the soil's ε (Kelleners *et al.,* 2005). Two rods (sensor probes) attached to the WCR, along which the electrical signal is propagated, allow, based on the capacitance of the soil in which they are installed, the determination of ε and K_a. The calculations for determining the dielectric parameters are built-in to the device's circuitry, reducing the cost, and also alleviating the need for long cables between sensors and data loggers (Chandler *et al.,* 2004). The probes used in this study (WCR CS625, Campbell

Scientific Inc, Logan UT) were the latest model of this soil moisture sensor currently in widespread use. The WCR were permanently installed for the entire growing season, at a depth of 0-0.3 m. Soil temperature has a significant effect on WCR sensors, and this effect increases with the increase in the magnitude of θ_v (Seyfried and Murdock, 2001).

A scatter-plot of WCR measurements *vs.* gravimetric data showed close correspondence, even in sandy soils (< 10% clay). Studies have shown that the manufacturer's WCR sensor calibrations can be used for measurements in sandy soils and in clay soils of low electrical conductivity (Seyfried and Murdock, 2001; Kelleners *et al.*, 2005). Results from four years of studies on soils with < 10% clay, showed WCR readings to provide a precise and reliable range of soil moisture content (Chandler *et al.*, 2004); however, WCR overestimated the θ_v in soils of high clay content. In such conditions, in-situ calibrations would improve the quality of results (Chandler *et al.*, 2004). Similarly, when the EC is greater than 0.1 S m-1, field calibration of the WCR is required. The CS 625 model was used with the standard calibration provided by the manufacturer (Seyfried and Murdock, 2001), which was stated to be accurate for soils having an EC < 0.5 dS m-1, a bulk density < 1.55 Mg m-3 and a clay content < 30% (Campbell Scientific, 2006). Variations in these parameters affect the soil's electrical conductivity and at low frequencies, also affect soils' electrical properties (Chandler *et al.*, 2004).

2.5.1.2. Gro-Point

The Gro-Point (GP) moisture sensor also operates on TDR principles, but the voltage pulse is transcient in nature and not reflected by the wire guides. Placement of the sensor requires a trench at a required depth, and proper hand packing to avoid any air pockets. A data logger is attached to the sensor, and proprietary software is used to interpret the data. The sensors are usually factory calibrated for particular soil types. The GP sensor is designed and manufactured by Environmental Sensors Inc.

2.5.1.3 Portable Field Scout TDR

Time domain reflectometer based-sensors have different designs, of which the Field Scout (Spectrum Technologies Inc., 2007) is portable. The TDR 300 calculates ε based on the propagation time of electromagnetic wave, typically within ± 0.1 ns. While for water ε is 80 (udepending on temperature), for other soil constituents, such as minerals $2 < \varepsilon < 5$. Therefore the bulk permittivity of the soil is directly related to the soil moisture content.

This property makes the TDR 300 efficient for in situ determination of θ_v. The attached probes function as wave guides, with the standard TDR signals being transformed into square wave output with a frequency equivalent to θ_v .

2.5.2. Frequency domain reflectometers

2.5.2.1. C-Probe (EnviroScan)

EnviroScan systems may have several FDR sensors mounted on a probe, which is then inserted into a PVC access tube. Before installation all the sensors are normalized by taking readings in air and submerged in water. The installation requires a certified person to ensure good probe-soil contact and operation of all the mounted FDR sensors. A separate data logger is attached to download and store the data. Data transfer to a computer for interpretation requires proprietary software developed by EnviroScan. The device was designed and is produced in Australia by Sentek Environmental Technologies.

2.5.2.2. Echo probe

An Echo probe operates on the principle of capacitance, and it measures the dielectric constant of soil. It is made up of copper electrodes further sealed in epoxy-impregnated fiberglass (Fares and Polyakov, 2006). Manufactured by Decagon Devices, Inc., (Pullman, WA, USA), there are several lengths available. Typically echo probes are permanently installed throughout the growing season, and connected to either a data logger or telemetry system through which soil moisture content readings may be transmitted. The Echo probe measures soil ε in volts, by measuring the charge time of a capacitor placed in the soil. Although the Echo probe displays readings in volts, it is easiest to interpret these readings as a trend line for the purposes of scheduling irrigation.

2.5.2.3. Theta probe

The Theta probe is another capacitance-based instrument, but does not require an access tube for installation. It consists of steel pins that act as a transmission line; these pins work by monitoring soil moisture changes, using the properties of radio frequency energy when transmitted into and reflected by the soil. The probe head houses an internal circuitry and a sensor which can be used for point measurements or continuous monitoring. The output is in volts and can be converted to soil moisture based on a linear calibration equation (Charlesworth, 2005).

2.5.3. Tensiometers

This device used for measuring soil φ_m is comprised of a tube filled with water, attached to ceramic cup on one end and a vacuum gauge on the other. During installation, the ceramic tip or cup must make firm contact with the soil at the desired depth. To ensure good contact between the tensiometer and soil, water or soil slurry can be used during insertion into the soil. This includes pushing the device right to the bottom of the hole prepared for it. The maximum pressure range is from 0-75 kPa, and pressure readings are then converted to θ_v through the soil characteristic curve (http://www.irrometer.com). The same principle is used with Water Mark equipment data readings, expressed in centibars (McCann *et al.*, 1992).

2.5.4. Electrical resistance sensors

An electrical resistance device is housed in a gypsum block or other granular matrix material. Usually an auger is used to place these sensors at multiple depths throughout the soil profile, and slurry or water is used to ensure firm contact with surrounding soil. The moisture data is transmitted to and stored in a data logger. These sensors read in centibars of soil tension, ranging from 0-200 kPa, and then converted to θ_v (McCann *et al.*, 1992; Spaans and Baker, 1992).

2.5.5. Neutron probe

Neutron probes or neutron moisture meters (NMM) are another way of measuring θ_v. They are considered to be among the most robust and accurate methods of soil water content measurement (Charlesworth, 2005). The principle is that fast moving neutrons arising from a small radioactive source collide with hydrogen ions in the soil and are slowed down; the higher the water content, the higher the extent of collisions. (George, 1999) However, due to perceptions of radiation safety threat, its use has declined.

2.6 GSM Technology

GSM (Global System for Mobile communications) is a digital cellular technology used for transmitting mobile voice and data services which is developed by Group special mobile (founded 1982) which was an initiative of CEPT (conference of European post and telecommunication). GSM provide data transfer speeds around 9.6 Kbit/s, allowing the transmission of basic data services such as SMS (Short Message Service). Another major advantage is its international roaming capability, allowing the users to access the same services even when travelling abroad.

This gives consumers to have the same number connectivity in more than 210 countries. GSM satellite roaming has also widened its service access to areas where terrestrial coverage is not available. GSM-1800 is used to send information from the Mobile Station to the Base Transceiver Station (uplink) and 1805 - 1880 MHz for the other direction (downlink), providing 374 channels (channel numbers 512 to 885) and duplex spacing is 95 MHz . GSM gives worldwide connectivity, transmission quality, high reliability, uninterrupted phone call. It uses encryption and TMSI instead of IMSI. SIM is provided with 4-8 digits PIN to validate the ownership of SIM.

2.6.1 GSM Applications in Various Fields

1. City Area Monitoring System

The city area monitoring system allows a home owner or the particular area monitor to tenuously monitor the various significant home sensor conditions as well as those are tied to flooding, fire, and gas leaks to detecting burglars in their starting stages and alert the people about the sudden events.

Home owners or the particular area monitors can monitor their homes or the particular location via their mobile phone or by using the Internet. This system can also be used in alerting the people about the security firms, defense organizations and municipalities to constantly monitoring and locating the little spots in suburban neighborhoods and compounds using web based free GIS Maps application. This system can play a vital role in monitoring the house through detectors, detecting any abnormal event, alerting home owner through SMS when the event occurs, notifying security service providers or the Civil Defense Department/Security firm with the emergency and its type so they can take immediate action.

2. GSM Based Health Monitoring System

The movement of physically handicapped or aged people and the people suffering from some severe diseases are usually restricted to their homes, because of their health conditions.

They are kept into helpless situation when they need to go out even for small work (Lai et al., 2009). Here there is another example for monitoring patients remotely using GSM network & Very large Scale integration (VLSI) technique. The System continuously monitor the health conditions and send the information regularly to the hospital as shown in Figure 2.2 below (Lai *et al.,* 2009). The abnormal deviation in the set values of any of these parameters will be immediately sensed and local help is sought from the nearby people. It is a bi directional communication system in which the Doctor/care taker, at any time, can send SMS to know the present parameter status of the person or patient. It enables the doctors to monitor patient's parameters (heartbeat, ECG, body temperature) in real time through an SMS.

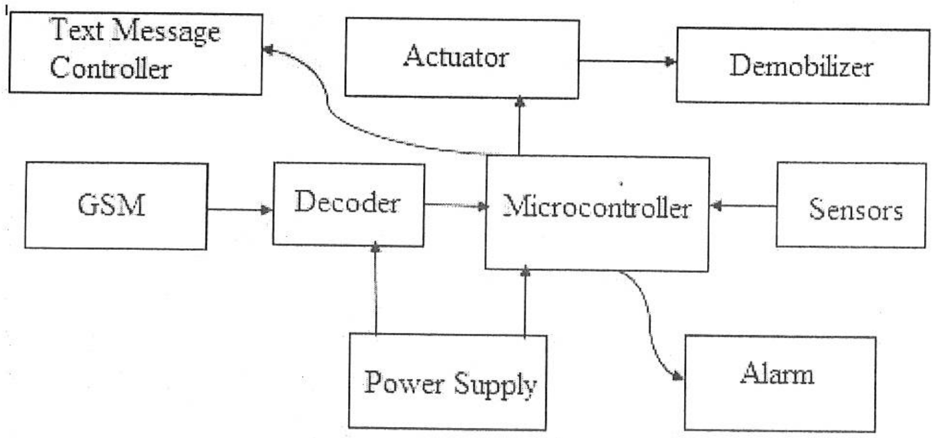

Figure2.2: Block Diagram of a GSM Based Health Monitoring system

3. Antitheft Security System Using GSM

This system utilizes an embedded system design with Dual Tone Multi Frequency (DTMF) and a GSM to monitor and safeguard a car. In a situation where there is high level of theft, there is serious requirement of better security system which does not put human life to risk (Manjula *et al.,* 2009). This tends to utilize the availability of GSM technology to accomplish this purpose. By simply dialing the number of the mobile phone attached to the circuit and sending a code after the phone has automatically been answered, puts the system to either "active or " state. In case of any theft attempt, the system is automatically switched off and an alert message is send to the owner. Hence the car will always remain protected.

The absence of security personnel in a packed car is a great discomfort to car owners. Thus in order to enhance an improved and life risk free security system we use this technology , here the purpose is to aid a better security system of cars with the use of GSM. Hence this system monitors one's car against theft, and sends the text message to the car owner, indicating him that his car is being tampered. The system will also stop the car (that is stopping the car from moving) and set up an alarm for the people around to notice what is happening.

2.7 RELATED WORKS

In the process of developing an automated wirelessly monitored irrigation system, several methods were followed.

2.7.1 Remote Monitoring using GSM

The subscriber or user sends activation command to the system via SMS. The system (Deepak *et al.,* 2015) will check the moisture level and if it is less than the prescribed level, the system will start the motor. While the motor is running, the system will monitor the soil moisture and water level constantly.

If the moisture level reaches the sufficient level, the motor will be turned off. The corresponding event of the operation of motor is notified to the user using SMS. This motor is controlled by a starter which is indirectly activated by a relay circuit. Using GSM technique, an automated remote monitored irrigation system is provided. The system sets the time period depending on the temperature and humidity of the soil for irrigating the land. The humidity and temperature level of the soil and the crop varies for various types of crops.

2.7.2 Monitoring using fuzzy controller

The system (Liai *et al.,* 2013) consists of two units, WSN and a monitoring center. Nodes in the monitoring area collect information of the soil moisture and growth information of different crops in different periods using solar power. Wireless Sensor Network (WSN) contains many sensor nodes and controller nodes. The data sensed from the WSN is given as inputs to the monitoring center which in turn gives the information about the irrigation, demand of the water level and control over the opening or closing of the valves. Zigbee network in a mesh network topology is used to meet the network coverage and reduce the energy consumption and the cost. Some of the nodes are assigned as routers and coordinators. Sensor nodes sense the temperature and humidity whereas the routing nodes route the communication information and forwarding the data to the relevant nodes and the coordinator node receives data from the routing nodes and sent it to host computer monitoring center through RS232 serial bus. The monitoring center record the real time moisture value form all the nodes and calculate crop irrigation water requirement and output the result to WSN and control to the valves. The soil moisture sensor TDR-3A is used for measuring the moisture value.

2.7.3 Monitoring using humidity sensors

For measuring the humidity value of a region, SY-HS-220 humidity sensor (Nilesh *et al.*, 2013) is used. It works on the operating temperature range of 0 – 60°C. Temperature value is sensed by the sensor LM35IC in which the output voltage is linearly proportional to the Celsius temperature. TinyOS (Alagupandi *et al.*, 2014) is an open source component based low power operating system which is designed only for embedded system application. TinyOS based IRIS motes is used to measure the moisture level of paddy field and MD100CB sensor motes are used to reduce the number of motes used. A low cost soil moisture sensor is used to control water supply in water deficient areas. The sensor communicates the information via XBEE wireless communication module to a centralized server.

The server provides the control to the water supply and displays the moisture data in a more user friendly interface. Two galvanized metallic electrodes are kept at a distance of 30mm inside the soil area in an acrylic sheet. The change of impedance between two galvanized metallic electrodes due to the varying moisture content in the surrounding medium is measured. Based on all these measurement, the data is transferred to the server for processing.

2.7.4 Monitoring in drip irrigation

In order to achieve the effective usage of water in drip irrigation (Mahir and Semih, 2011; Ahmed *et al,* 2014), sensors are scattered throughout the field region. Sensors are used to sense the water level in the well as well as in the water tank. If the measured value is less than the prescribed value, then alert is given to the user. If the level of the water in the tank is low, then it directs the command to the nearby well. The pump is activated thereby the valve is opened and the water is pumped out to the well. Sensors in the field sensed the value of temperature and moisture in the field and based on the input value, the system decides either to open the valve or not.

2.7.5 Remote Monitoring using sensors

In the irrigation monitoring system (Lutful *et al.,* 2013), the information regarding soil moisture, temperature etc. are sensed by the Bluetooth wireless transmitters and the time specific decision for irrigation is made according to the information sensed. The irrigation control unit gets the decision and sends the position of the irrigation system using GPS receiver to the base station through real time monitoring. Base station in turn sends control signals to the irrigation control station to operate the device for water usage. Also distributed irrigation system (Shock *et al.,* 1999), sensor based irrigation system and automated field-specific irrigation system are also provided good irrigation control. Yet, all these do not consider the pollution of water.

2.7.6. Weather Monitoring System using Microcontroller

The measurement of temperature and humidity remotely by using the sensor is not only important in weather monitoring but also crucial for many other applications such as agriculture and industrial processes. A device for real time weather monitoring is presented in this paper to monitor the temperature and relative humidity of the atmosphere via GSM network, using analog and digital component. The sensor output will be given to the ADC. The microcontroller will read the ADC output and display the parameter value on the LCD. An LCD display is also connected to the microcontroller to display the measurement. For analysis and achieving purposes,.(Karishma Patil1 *et al.,* 2016)

2.7.7. Design and Implementation of Automated irrigation system using ZIGBEE and GSM

Automated irrigation system using ZIGBEE and GSM for agricultural crop. In these system use the Wireless Technology. The system has represented the wireless sensor network of soil-moisture, temperature and humidity sensor and water level sensor placed into root zone of the plant. In traditional approach to measure these factors in an agricultural environment meant individuals manually taking measurements and checking them at various times. This paper includes the monitoring of the system using zigbee and GSM (Mamta patidar *et al.*, 2015)

2.7.8. Wireless Monitoring of Soil Moisture, Temperature & Humidity Using Zigbee in Agriculture

Monitoring agricultural environment for various factors such as soil moisture, temperature and humidity along with other factors can be of significance. A traditional approach to measure these factors in an agricultural environment meant individuals manually taking measurements and checking them at various times. This paper investigates a remote monitoring system using Zigbee. These nodes send data wirelessly to a central server, which collects the data, stores it and will allow it to be analyzed then displayed as needed and can also be sent to the client mobile

(Prof C. H. Chavan *et al.*, 2014).

2.7.9 Design of Remote Monitoring and Control System with Automatic Irrigation System using GSM-Bluetooth

Design of an economical and generic automatic irrigation system based on wireless sensors with GSM-Bluetooth for irrigation system controller and remote monitoring system. This system has simpler features designed with the objective of low cost and effective with less power consumption using sensors for remote monitoring and controlling devices which are controlled via SMS using a GSM module. A Bluetooth module is also interfaced with the main microcontroller chip. This Bluetooth module eliminates the usage charges by communicating with the appliances via Bluetooth when the application is in a limited range of few meters. The system informs user about any abnormal conditions like less moisture content and temperature rise, even concentration of CO2 via SMS from the GSM module or by Bluetooth module to the farmer's mobile and actions are taken accordingly by the farmer. In future, the farmer will be able to monitor and control the parameter by GSM and Bluetooth technologies. (S.R.N. Redd 2012)

Table 2.2: Summary of Related Work and Limitations

Name &Year	Topic	Limitation
Mamta patidar and Prof S.Belsare (2015)	Design and Implementation of Automated irrigation system using ZIGBEE and GSM	1. Reduces the creation of employment. 2. Can only be monitored using wireless technology
Prof C. H. Chavan, Mr.P. V.Karande (2014)	Wireless Monitoring of Soil Moisture, Temperature & Humidity Using Zigbee in Agriculture	Ones these factors reaches its critical level, the device alerts the user but the pump can be on only manually
Karishma Patil, Mansi Mhatre, Rashmi Govilkar,Shraddha Rokade, Prof.Gaurav Gawas (2016)	Weather Monitoring System using Microcontroller	1. If we want continuous monitoring of required parameter then we have to keep pc on at receiver that will increase the power consumption. 2. Less Secured. 3. Limited Communication range 4. Low data rate.
S.R.N. Redd 2012	Design of Remote Monitoring and Control System with Automatic Irrigation System using GSM-Bluetooth	The farmer cant request for the status of the farmer, Only gets info via SMS or Bluetooth when an abnormal situations like low moisture is discovered.
Lutful et al., 2013	Remote Monitoring Using Sensors	Does not include the use of GSM module, and might lead to water pollution
Nilesh R. Patel, Rahul B. Lanjewar, Swarup S. Mathrukar, Ashwin A. Bhandekar (2013).	Monitoring using humidity sensors	
Nilesh R. Patel, Rahul B. Lanjewar, Swarup S.	Monitoring using humidity sensors	

Mathrukar, Ashwin A. Bhandekar (2013).		
Deepak Dharrao, Laxman Kolape, Sanjeet Pawar and Aniket Patange (2015)	Remote Monitoring using GSM	1. The status of the farm or factors can only been known when the user requests for it. 2. The critical level can only been know when a request for the status is made
Liai Gao, Meng Zhang, Geng Chen (2013)	Monitoring using fuzzy controller	
Mahir Dursun and Semih Ozden (2011).	Monitoring in drip irrigation	Several sensors has to be scattered throughout the field region to get a accurate result this leads to high cost .
Ayeni Tope. S (2018)	Design and Implementation of microcontroller Based GSM Alert Farm Monitoring System Using Soil Moisture, Temperature, Humidity, and Light.	No much limitations for now, except from the fact that there is no pump machine included due to its cost 3. It only functions when plugged into alternating current (AC) source

CHAPTER THREE

DESIGN METHODOLOGY

3.1 An overview of the System

This System was built around three sensor modules, and was programmed to read in data from a monitoring device that will be attached to the sensors. The figure 3.1 shows the block diagram of the system. The system makes use of hardware components, as well as software, thereby making it an embedded system. The hardware components are DHT 11 module, Moisture Sensor, Light Dependent Resistor (LDR), a Microcontroller, and a monitoring device. In addition a GSM Module was used to send SMS alert notification to the user.

The DHT 11 module was used to measure the temperature and humidity of the soil, the moisture sensor was used to measure the soil moisture, the Light Dependent Resistor was used to measure light intensity, the Microcontroller served as the master control for the entire system, while the monitoring device will record the properties of the soil gotten from the DHT 11 module, the moisture sensor and the Light Dependent Resistor. All the properties of the soil gotten through the monitoring device will be sent through the GSM sensor to the user's GSM device.

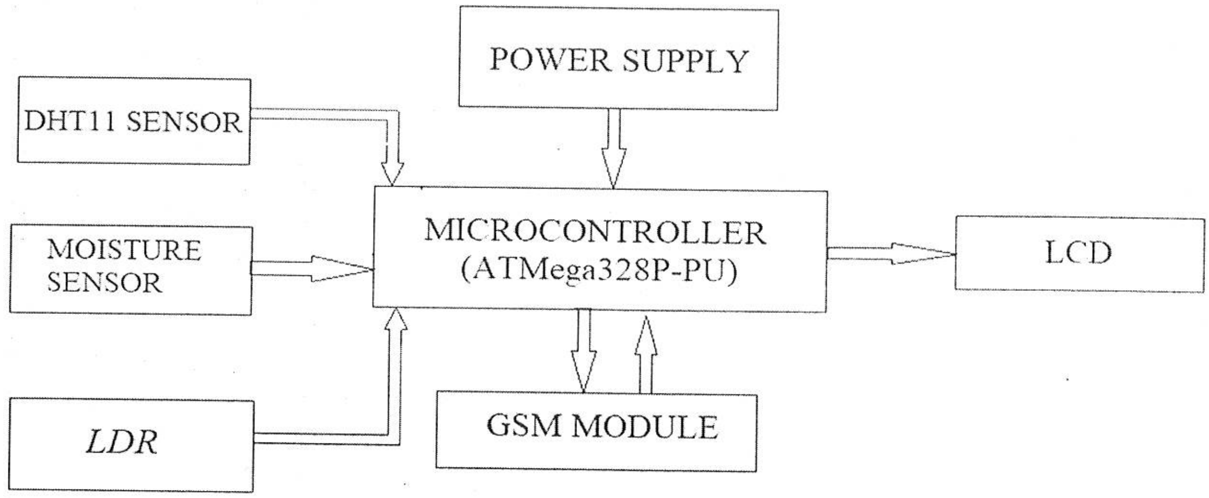

Figure 3.1: Block diagram of the farm monitoring alert system

3.2 Complete system design

Proteus simulation application was used for the circuit design (see Figure 3.2 below). As seen in Figure 3.2, the success or failure of the SMS to the mobile phone will be indicated by the DC motor; The GSM module have two of its pins connected to the pin 2 and 3, and the other two pins to the moisture sensor. The moisture sensor which has three pins will have two of its pins connected to the GSM module, and the third pin connected to pin 15 of the ATmega 328 microcontroller; the function of the LCD is to display the status of the notification system. In addition to the major components of the notification system, other tools such as resistors, capacitors, LED, oscillator, transistor, etc. have been added to the circuit diagram to make the system function effectively.

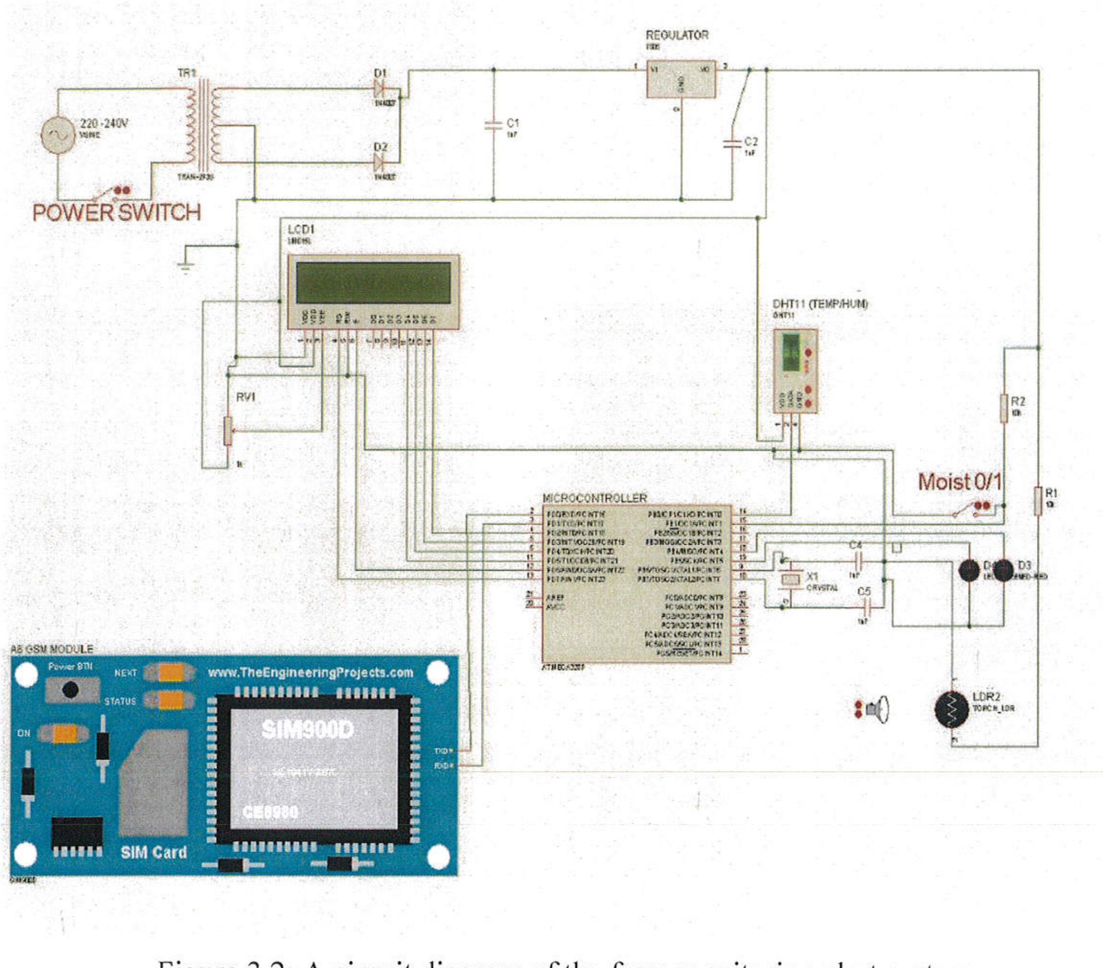

Figure 3.2: A circuit diagram of the farm monitoring alert system

3.3 Sensors

Sensors was used to obtain the required soil properties which are moisture, temperature, and humidity. For these project, the sensors discussed below will be used.

3.3.1 DHT11 Sensor Module

The DHT11 sensor module is a humidity and temperature sensor module. This module integrates DHT11 sensor and other required components on a small PCB. The DHT11 sensor includes a resistive-type humidity measurement component, an NTC temperature measurement component and a high-performance 8-bit microcontroller inside, and provides calibrated digital signal output. It has high reliability and excellent long-term stability, thanks to the exclusive digital signal acquisition and temperature and humidity sensing technology. This sensor uses a 3.3V - 5.5V DC supply, measures humidity between the range 20% – 90% humidity, and measures temperature between 0 – 50°C .

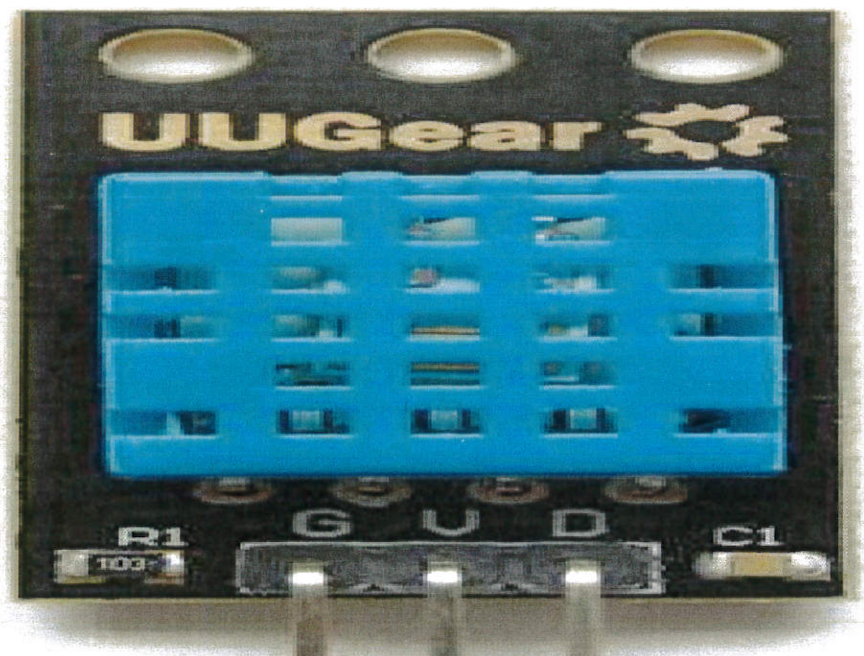

Figure 3.3: Showing a DHT 11 sensor module

3.3.2 Moisture Sensor

The Soil Moisture Sensor uses capacitance to measure the water content of soil (by measuring the dielectric permittivity of the soil, which is a function of the water content). Simply insert this rugged sensor into the soil to be tested, and the volumetric water content of the soil is reported in percent.

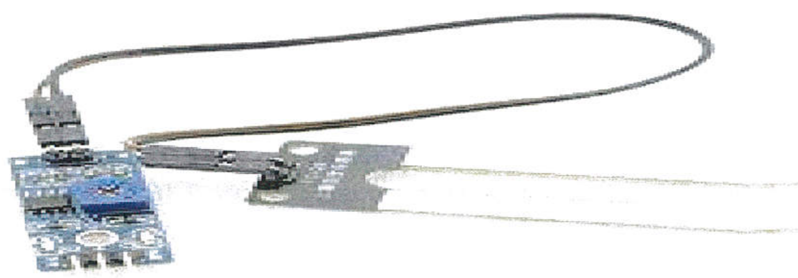

Figure 3.4: Showing a Moisture sensor module

3.4 Power Supply

A power source is a device which delivers an exact voltage to another device as per its needs. Power sources, which are sometimes called power adapters, are available in various voltages, and they have varying current capacities, which is the maximum capacity of a power supply to deliver current to a load. For this project, a 5V power source will be required, as the sensors require a 5V DC to work *(Instructables, 2018).* This power source will convert a 110/240V AC into 5V DC. The power unit is developed following this stages;

3.4.1 Step down stage

Alternate Current Input Coming from the wall, the AC alternates from a minimum to a maximum voltage at a frequency of 50Hz between the range of 220 – 240 volts (in Nigeria and other 60Hz countries) is step down through the use of step down transformer to about 22 -24 volts.

Figure 3.5 Showing Step down transformer

3.4.2 Rectification

Rectification is the conversion of alternating current (AC) to direct current (DC). This involves a device that only allows one-way flow of electrons. As we have seen, this is exactly what a semiconductor diode does. The simplest kind of rectifier circuit is the half wave rectifier. It only allows one half of an AC waveform to pass through to the load. For most power applications, half-wave rectification is insufficient for the task. The harmonic content of the rectifier's output waveform is very large and consequently difficult to filter. Furthermore, the AC power source only supplies power to the load one half every full cycle, meaning that half of its capacity is unused. There is a need to rectify AC power to obtain the full use of both half-cycles of the sine wave, a different rectifier circuit configuration is used which is a circuit is called a full-wave rectifier this is shown in figure

3.4.3 Smoothing

Now we have at least consistently positive voltage levels, but they still dip down to zero 120 times per second. A large capacitor, which can be thought of like a battery over very short time periods, is installed across the circuit to even out these rapid fluctuations in power. The capacitor charges when the voltage is high and discharges as the voltage is low.

3.4.4 Regulation

In this stage the smoothed voltage is then controlled to maintain a constant range. For this project I utilize two voltage regulator LM7805 and LM7812 which are to regulate the voltage to 5V and 12V respectively.

- 5V to power the micro controller, light emitting diodes (LED), Liquid crystal display (LCD).
- 12V to power the relay

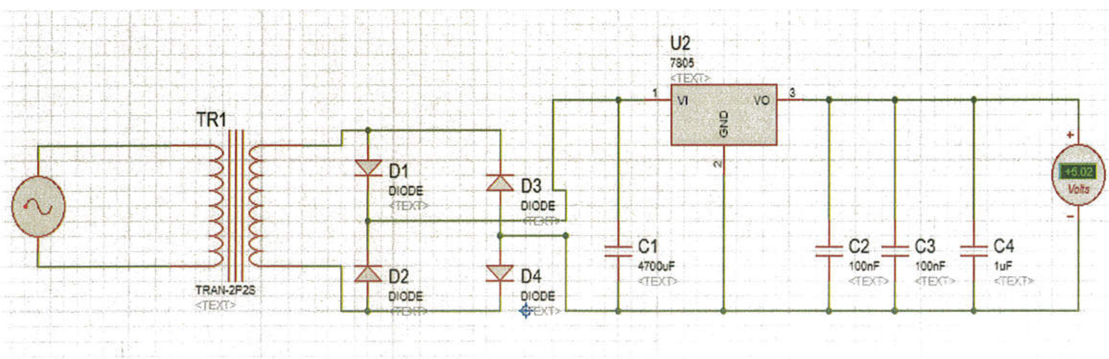

Figure 3.6: Showing The schematic diagram of a 5V power source

3.5 Microcontroller

For this project, the ATmega 328 microprocessor chip was used. ATmega 328 microprocessor is a high-performance single-chip microchip created by the Atmel in the mega AVR family. The Atmel 8-bit AVR RISC-based microcontroller combines 32kB ISP flash memory with read-while-write capabilities, 1kB EEPROM, 2kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter, programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5V. The device achieves throughout approaching 1 MIPS per MHz. The ATmega 328 is commonly used in many projects and autonomous systems where a simple low-powered, low-cost microcontroller is needed (Microchip, 2018).

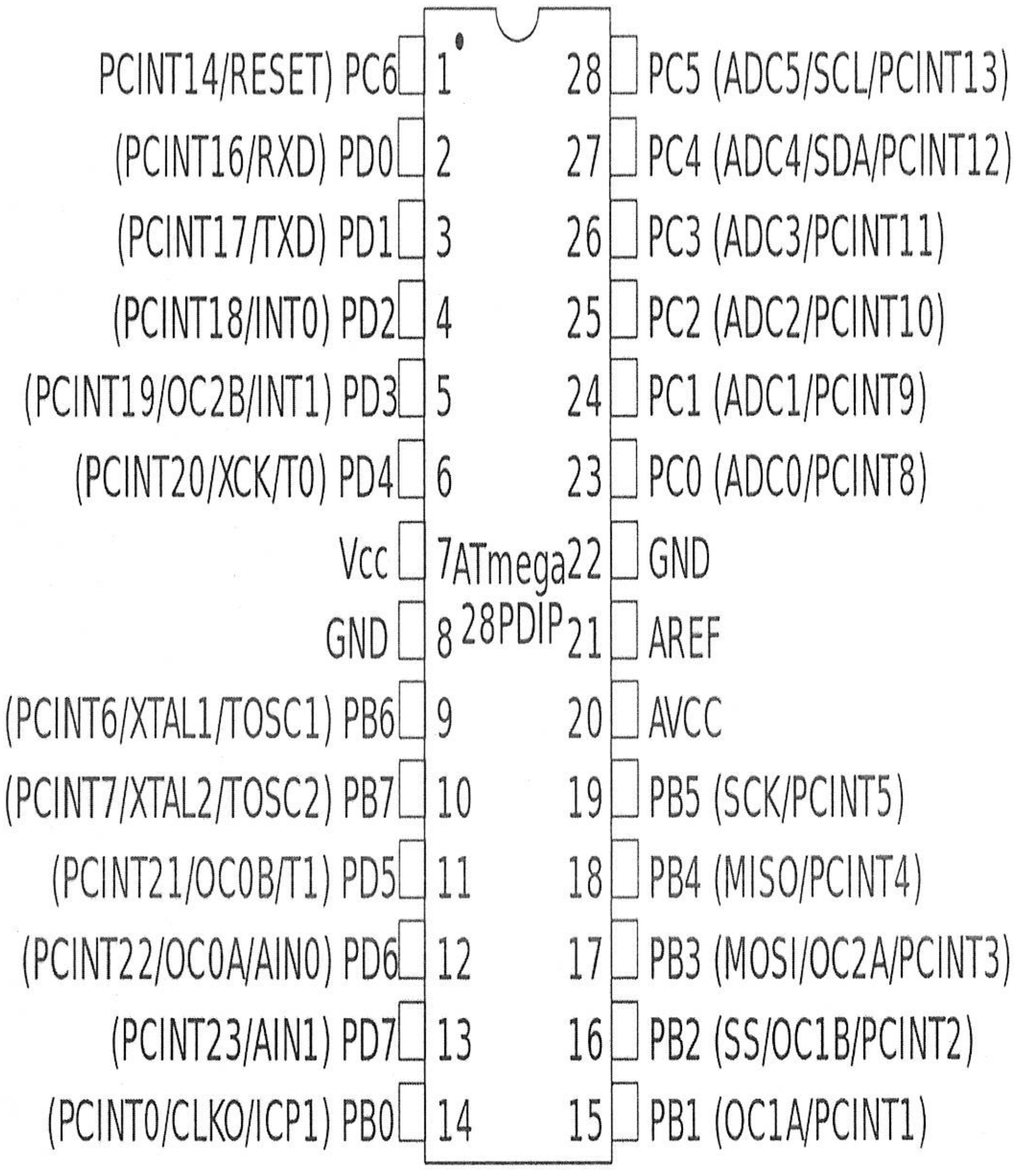

Figure 3.7: ATmega 328 Microprocessor Schematic Diagram.

3.6 GSM A6 MODULE

The GSM module was connected to the microcontroller to read and output the data obtained and to wirelessly transmit this data via the GSM to the display paired with it.

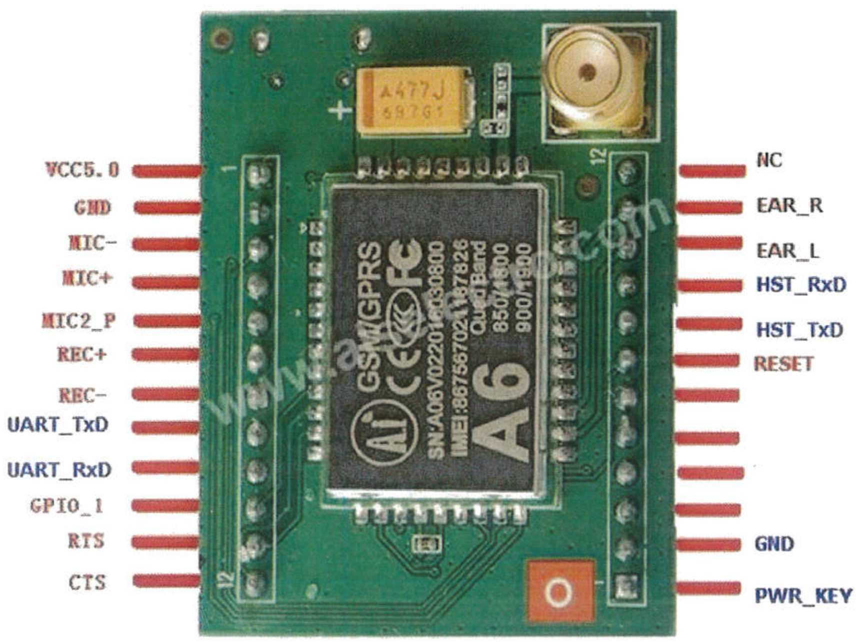

Figure 3.8: Showing a GSM A6 Module (Alselectro, 2018).

3.7 Light Dependent Resistor (LDR)

An LDR is a component that has a variable resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits. There are several applications of the LDR, and the most common application is in the lighting switch, to turn on a light at a certain level. LDRs can also be used to control the shutter speed on a camera; the LDR would measure the light intensity which then adjusts the camera shutter speed to the appropriate level (Kitronik, 2018).

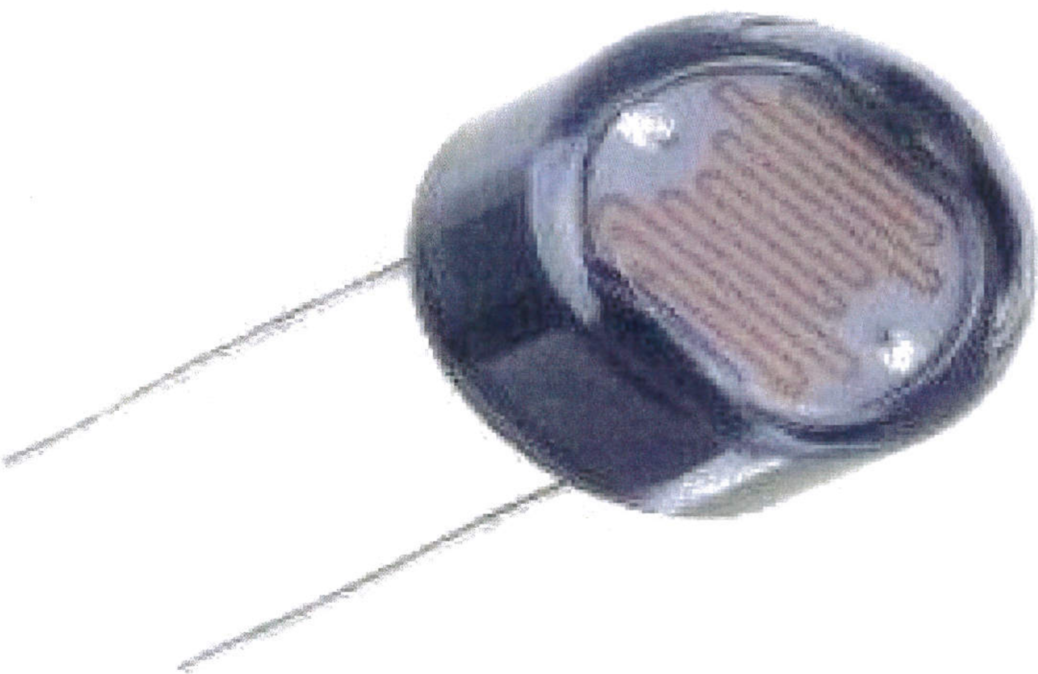

Figure 3.9: Showing a Light Dependent Resistor

3.8 Design Algorithm

Step 1: Start.

Step2: Initialise the system

Step3: Select the critical temperature of plant

Step4: Display the present state of the farm

Step5: Check if temperature is equal to critical temperature

Step5.1: Else go to step4

Step6: Check if there is a request for farm status

Step6.1: Else go back to step4.

Step7: Stop

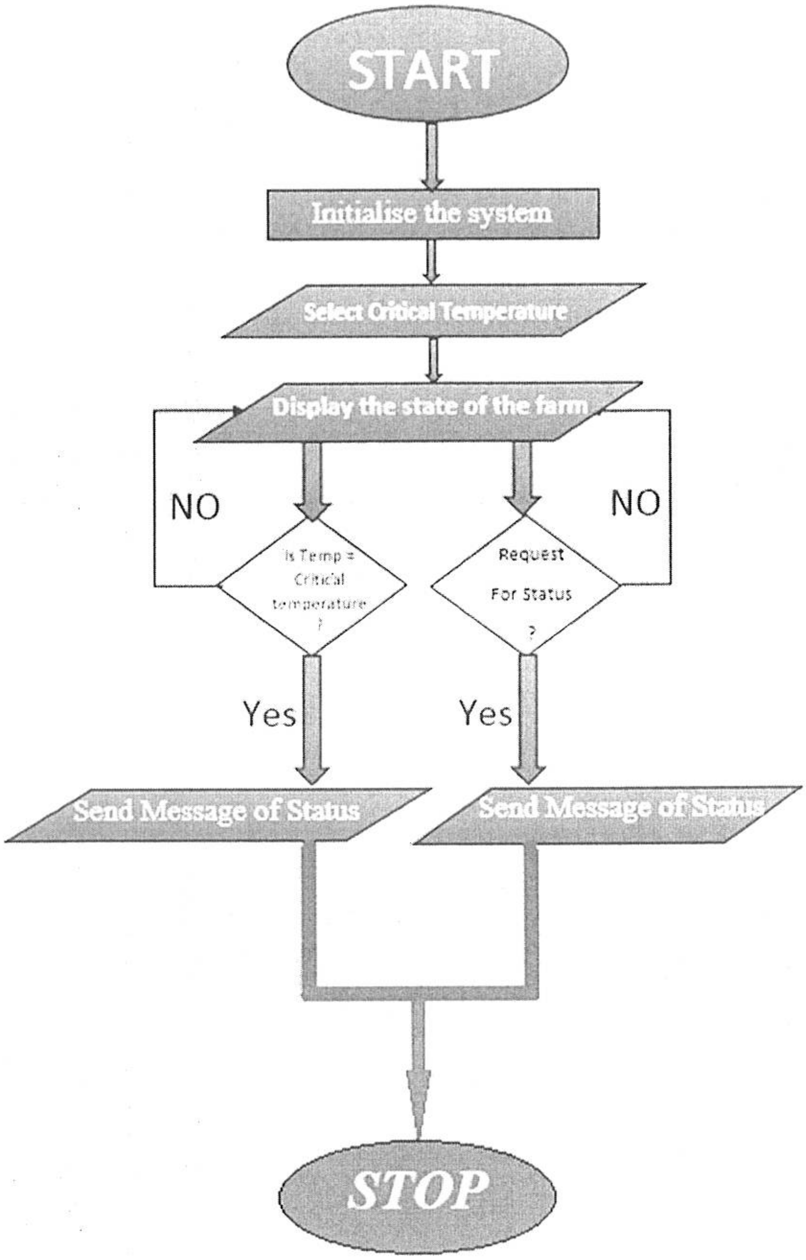

Fig3.10: Showing the flow chart for the farm monitoring alert system

3.9 Software Implementation

Proteus 8 was used, it is one of the best simulation software for various circuit designs of microcontroller. It has almost all microcontrollers and electronic components readily available in it and hence it is widely used simulator. It can be used to test programs and embedded designs for electronics before actual hardware testing. The simulation of programming of microcontroller can also be done in Proteus. Simulation avoids the risk of damaging hardware due to wrong design.

3.9.1 Evaluation

In order to ensure that all the necessary specifications and requirements are met, the performance of the system was evaluated in real life situations. The three major metrics to be used are Hardware testing, functional requirements and user evaluation.

3.9.2 Hardware Testing

Under this section, system hardware was tested independently to ensure that every component is in good working condition. For example, the voltage of the power source must be 5V, as any voltage that is less than or greater than 5V will have an effect on the system. Also, the AC current to be used to power the power source must be within the range of 110-230V; any voltage greater than 230V will damage the power source.

3.9.3 Functional Requirements

It was evaluated based on the effectiveness of the power unit, display unit, processing unit and sensor and actuators. It was also evaluated based on its response to requests, user-friendliness, safety, security, management, and tolerance.

3.9.4 User Evaluation

Generally, the notification system performance must be excellent; it must have zero tolerance to theft and it must not be easily manipulated. The software interface must be user friendly such that, it can be easily accessed by those who have little knowledge about the use of mobile phones.

However, it should be noted that some environmental factors such as temperature would affect the accuracy of the system. The system will perform better in the soil than when the temperature is higher. Also there will be a delay of about few seconds before the administrator will get the SMS notification. The system will be a good notification system for detecting soil properties and it can be adopted for usage outside soil environment.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Simulation Results

When the simulation of the design of the Soil Moisture Detector system was carried out using Proteus simulation tool, the LCD display of the system design showed a result 'Farm update: CRITICAL ALERT!' (see Figure 4.1 below), indicating that the program is compatible with the system design and that the GSM module will send an update to the mobile device that has been programmed to work with it.

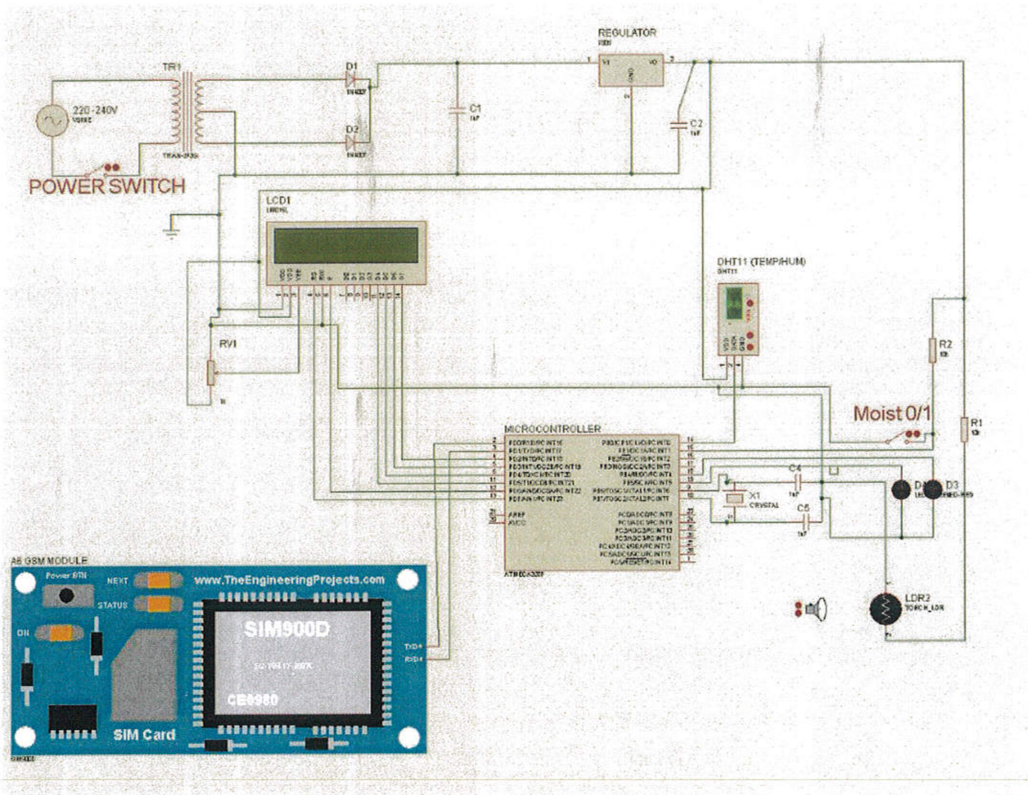

Figure 4.1: Simulation Setup on Proteus Application

4.2 System Implementation

The construction of this project was done in four different stages: Firstly, the implementation of the components in the system design onto a solderless experiment board (breadboard). Next is the transfer of components from the solderless experiment board to the development board, and then soldering the components permanently on the development board. Thirdly, the development board was connected to the power source and the system was tested to ensure it was connecting and sending notifications correctly to the connected GSM mobile device. Finally, the entire project was coupled together into a casing. The Bill of Engineering Measurement and Evaluation (BEME) which highlights all the components used for the system implementation are listed in the Appendix section of this report.

4.3 Components implementation on solderless experiment board (Breadboard)

Firstly, the microcontroller (after it has been programmed using the universal programmer), the GSM A6 module, the LDR, glass probe sensor, DHT11 sensor module and the 5V DC power source were all setup on a breadboard and interconnected to each other. Interconnections were done using jumper wires and a Multimeter was used to test every component to verify whether or not they are in good conditions. The Multimeter was also used to measure the voltage and current that gets to every component present in the connection.

4.4 Components implementation on development board

After a successful components layout and testing on the breadboard, the components were then transferred to the development board and were permanently soldered to the development board as seen in Figure 4.2 below. The microcontroller was placed on an IC holder before soldering it to the development board. Connection ports (12V and GND) were used to connect the development board to the power source.

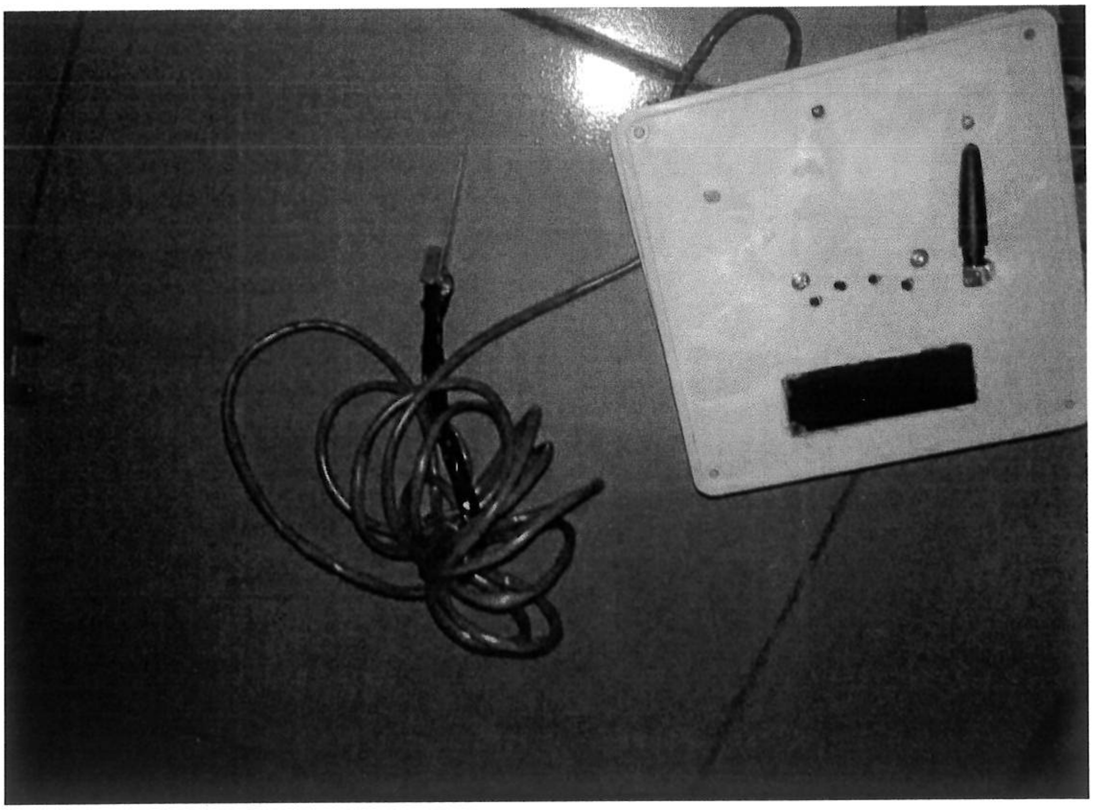

Figure 4.2: Development Board after Component Implementation

4.5 Device Testing

After a successful layout of components on the development board, there is need to interconnect the development board with the electromagnetic door lock and the power source using connecting cables. The working process of the system is shown in the Figures 4.3 and 4.4 below. The GSM A6 module requires a 5V power supply, and this power is supplied by the power source. The development board is also connected to the power source through its ports 5V/12V and GND. There are two situations upon which the system sends notifications to the mobile device: firstly, when the system reaches its critical points, and secondly, when the user request for the status of his farm (see Figure 4.3 below). When the device started working, it sent an SMS notification to the mobile device as seen in Figure

4.4 below. The working principle of the system is such that a user can at any time request for the status of the farm by sending a request status message to the system, and the designed system will respond with an update through a SMS notification. Also, the system will alert the user automatically whenever the soil properties reach critical point. If the status of the soil properties is requested by the user, the system alerts the microcontroller does not only respond by sending a SMS notification to the mobile device, it also shows the result of the soil properties on the LCD screen in front of the system. Whenever soil properties reach critical point, the system keeps alerting the user after every ten minutes delay.

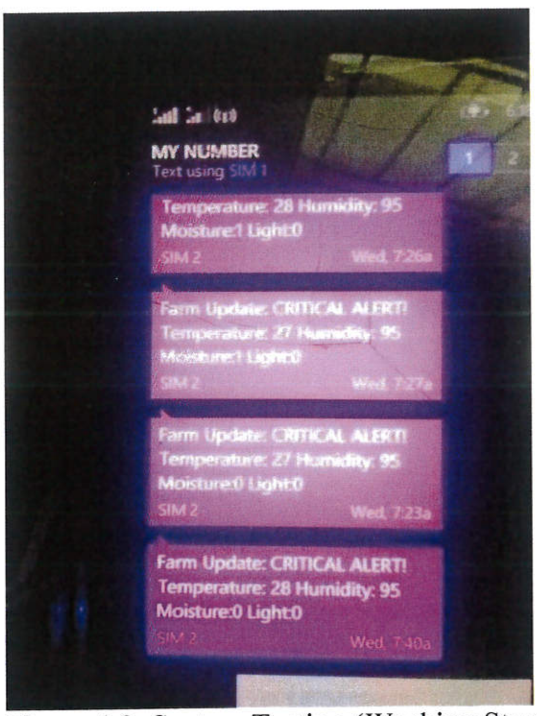

Figure 4.3: System Testing (Working Stage)

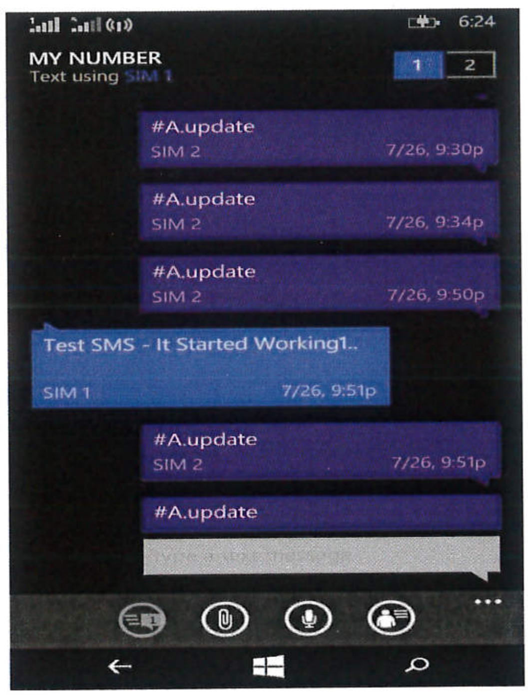

Figure 4.4: System Testing (Initial Stag 2)

4.6 Testing Of Prototype of Designed System

After a successful components interconnection, the whole connection is tested to check whether or not it is in good working condition. If the connections perform the desired operation, then there is need to couple the components together into a casing. For this project, the casing used is made up of plastic which has been formed into the shape of a box, and the components are well laid and screwed to the box. The LCD is placed in front of the designed system so as to be the first point of contact whenever a user wants to access the system. The power source is as well housed inside the box. The Figure 4.5 below shows the developed prototype of the soil moisture detector system.

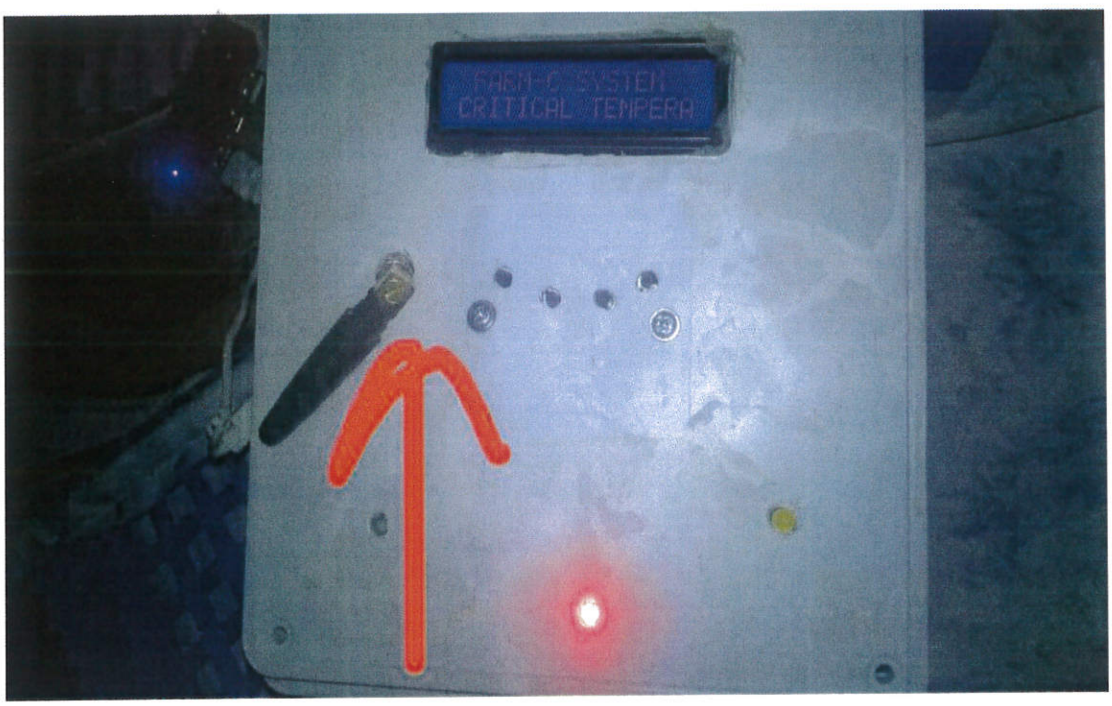

Figure 4.5: The prototype of the Soil Moisture Detector System using Temperature and PH sensors, with SMS alert Notification System.

The four black buttons labelled from 1 – 4 in Figure 4.6 below have their respective functions: button 1 is used to clear/cancel the displayed soil properties, button 2 is used to decrease the value of temperature (i.e. for minimum temperature settings), button 3 is used to increase the value of temperature (i.e. for maximum temperature settings) and, button 4 is used to set maximum temperature settings as well as to select maximum temperature. The button indicated with an arrow in figure 4.5 above is used to carry out some hidden functions which are: whenever the network is bad and message sent to the system is delaying, tap this button for five seconds so as to reset the GSM network.

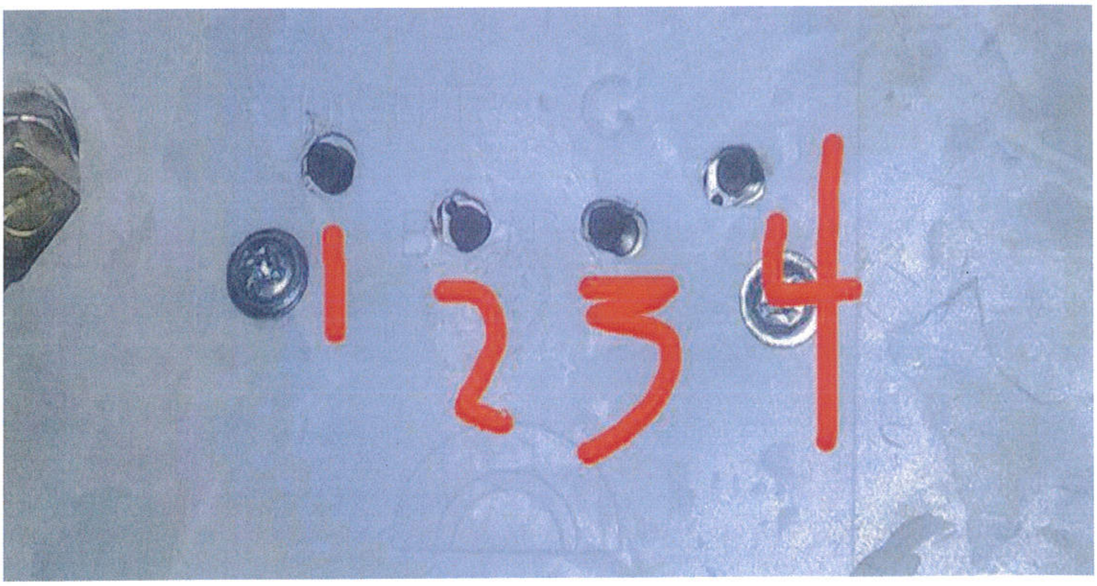

Figure 4.6: The prototype of the Soil Moisture Detector System (a closer view).

4.7 System Evaluation

In order to ensure that all the necessary specifications and requirements are met, the performance of the system has been evaluated according to real life situations. Both the simulation program and the hardware have been tested in real scenarios by many users. The two major metrics that have been used are hardware testing and functional requirements.

4.7.1 Hardware Testing

Under this section, all system hardware were tested independently using a Multimeter to ensure that every component is in good working condition. The system hardware components that were tested are the power source, the GSM A6 module, the microcontroller, the LDR, and the DHT 11 sensor module.

1. Testing the Power Source

It is important that the power source must be tested since it provides power to the entire system. Any damage that results from the power source may damage the entire system. The result of testing the power source shows us that, the voltage of the power source must be 5V, as any voltage that is less than or greater than 5V will not make the system work or will damage the system respectively. Also, the AC current to be used to power the power source must be within the range of 110-240V; any voltage greater than 240V will damage the power source itself.

2. Testing the GSM Module

The GSM A6 module requires a power supply within the range of 4.5V-5.5V and a minimum current of 2A. It works best within the temperature range of 10°C to 55°C and within a humidity range of 0 to 95%. The GSM module supports dual-band GSM/GPRS network for SMS message data remote transmission.

4.7.2 Functional Evaluation

The system has been evaluated by different users using different GSM devices, and based on its response to different mobile devices, whether or not it sends correct information after reading soil properties, whether or not it sends notification in time, data management, and theft tolerance. See Table 4.1 below

Table 4.1: Performance evaluation of the soil moisture detector system

Functional Evaluation	**Yes**	**No**
Response to diverse mobile phones	Yes	
Send correct information	Yes	
Read correct soil properties	Yes	
Send notification within normal time range		
Data management		No
Theft tolerance		No

According to the diverse users who tested the system, the system performance is excellent; the system has no tolerance for theft and its data cannot be altered. The system is user friendly and it can easily be used by everyone. The scope of its application also extends beyond farm environment only.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The system that has been designed and implemented is a Soil Moisture Detector System which used Temperature and Humidity sensors, with alert notification system to notify the user of the soil properties. The user can manually request for the soil properties by sending a SMS to the GSM module of the soil moisture detector system, and the system will respond be sending a SMS notification back to the user who requested for the soil properties. Also, whenever the soil properties reach critical points, the system automatically sends a SMS to the user notifying him about the status of the soil. This notification repeats every ten minutes till the user takes action. The system sends notifications of four soil properties which are: temperature, humidity, pressure and light intensity.

The system is so user friendly that, it can be deployed even by those who do not have good knowledge of electronics. It can not only be implemented in farm environments, it can be adapted for usage in poultries, homes, etc. Improvements definitely can be made in order to make soil moisture detector system safer, more reliable and better.

5.2 RECOMMENDATIONS

Several improvements can be made on the system to make it a more efficient detector system. M Some of the improvements are highlighted below:

1. A PH sensor could be added so as to obtain the PH value of the soil as part of the soil properties that will be gotten.
2. A space for water pump could also be added. This is because there may be need to pump water to the soil for the purpose of irrigation, especially when the temperature of the soil goes above critical point, thereby making life easier for the user.
3. Improvement can be made to the system to ensure it can be powered without (ac) source by using a battery.

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APPENDIX

```
#include <LiquidCrystal.h>
#include <SoftwareSerial.h>
#include <Adafruit_Sensor.h>
#include "DHT.h"
int incomingByte = 0;
SoftwareSerial cell(10, 11);
char phone_no[]="+2348137469500";
String incomingString="";

// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(3, 4, 5, 6, 7, 8);
//TEMPERATURE/HUMIDITY SENSOR DECLARATION

#define DHTPIN A2
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

//PIN DECLARATION
int ldr     = 9;
int moist   = 12;
int set     = A0;
int clr     = A1;
int inc     = A4;
int dec     = A3;
int test    = A1;
```

```
//INDICATORS
int red    = 13;
int green  = 13;

//ACTUATOR PIN
int valve = A5;
int moists =0;
int tempmin = 20;
int tempmax = 27;
boolean state;
void setup(){
 cell.begin(19200);
Serial.begin(19200);
//PIN MODE DECLARATION
pinMode(ldr, INPUT);
pinMode(test, INPUT);
pinMode(moist, INPUT);
pinMode(set, INPUT);
pinMode(clr, INPUT);
pinMode(inc, INPUT);
pinMode(dec, INPUT);
   pinMode(red, OUTPUT);
   pinMode(green, OUTPUT);
   pinMode(valve, OUTPUT);

//INITIALISING ALL INDICATORS/ACTUATORS
digitalWrite(red, LOW);
digitalWrite(green, LOW);
```

```
digitalWrite(valve, LOW);

// INTIALISING SYSTEM LCD DISPLAY
lcd.begin(16,2);
lcd.print("    Hi!          ");
lcd.setCursor(0, 1);
lcd.print("====>              ");
 delay(1000);
lcd.setCursor(0, 1);
lcd.print("=======>             ");
 delay(1000);
lcd.setCursor(0, 1);
lcd.print("=========>            ");
 delay(1000);
lcd.setCursor(0, 1);
lcd.print("==============>              ");
 delay(1000);
 lcd.begin(16,2);
lcd.print(" FARM-C SYSTEM        ");
lcd.setCursor(0, 1);
lcd.print("    BY            ");
 delay(2000);
 lcd.begin(16,2);
lcd.print(" AYENI TOPE S.        ");
lcd.setCursor(0, 1);
lcd.print("CPE/13/1075            ");
 delay(3000);
lcd.begin(16,2);
```

```
lcd.print(" FARM-C SYSTEM              ");

//NETWORK CHECKING
 lcd.setCursor(0, 1);
 lcd.print("Checking.                  ");
 delay(1000);
 lcd.setCursor(0, 1);
 lcd.print("Checking....               ");
 delay(1000);
 cell.println("AT");
 delay(100);
 cell.print("ATD");
 cell.println(phone_no);
 delay(30000);
 cell.println("ATH");
    delay(100);

//DELETE GSM MESSAGES
 cell.println("AT+CMGD=1,4\r");
 delay(100);
 cell.println("AT+CMGF=1\r");
 delay(100);
 cell.println("AT+CNMI=2,2,0,0,0\r");
 delay(100);

}
```

```
void loop(){
 cell.listen();
//FETCHING TEMPERATURE AND HUMIDITY
 int hum = dht.readHumidity();
 int temp = dht.readTemperature();

// FETCHING STATES OF INPUTS
 int ldrstate    = digitalRead(ldr);
 int moiststate  = digitalRead(moist);
 int setstate    = digitalRead(set);
 int clrstate    = digitalRead(clr);
 int incstate    = digitalRead(inc);
 int decstate    = digitalRead(dec);
 int teststate   = digitalRead(test);

//TEST NETWORK
 if(digitalRead(clr)==HIGH){
if(digitalRead(moist)==HIGH){
 moists=0;
}else{moists=1;}

//--Start: Send SMS --
    cell.println("AT+CMGF=1");
    delay(1000);
    cell.print("AT+CMGS=\"");
    cell.print(phone_no);
    cell.write(0x22);
    cell.write(0x0D);  // hex equivalent of Carraige return
```

```
    cell.write(0x0A);  // hex equivalent of newline
    delay(1000);
    cell.print(String("Farm Update Temperature: ") +temp + String(" Humidity: ") +hum+
String(" Moisture:") +moists+ String(" Light:")+digitalRead(ldr));  //The text of the
message to be sent
    delay(500);
    cell.println (char(26));//the ASCII code of the ctrl+z is 26
    delay(500);
    lcd.setCursor(0,1);
    lcd.print("                ");
    cell.print("AT+CNMI=2,2,0,0,0\r");
    delay(1000);
 //--End: SMS--
 }
// END TEST NETWORK


//TEST NETWORK
 if(temp>=tempmax){
  if(digitalRead(moist)==HIGH){
 moists=0;
}else{moists=1;}
//--Start: Send SMS --
    cell.println("AT+CMGF=1");
    delay(1000);
    cell.print("AT+CMGS=\"");
    cell.print(phone_no);
    cell.write(0x22);
    cell.write(0x0D);  // hex equivalent of Carraige return
    cell.write(0x0A);  // hex equivalent of newline
```

```
    delay(1000);

    cell.print(String("Farm Update: CRITICAL ALERT! Temperature: ") +temp + String(" Humidity: ") +hum+ String(" Moisture:") +moists+ String(" Light:")+digitalRead(ldr)); //The text of the message to be sent

    delay(500);

    cell.println (char(26));//the ASCII code of the ctrl+z is 26

    delay(500);

    lcd.setCursor(0,1);

    lcd.print("CRITICAL TEMPERATURE                ");

    cell.print("AT+CNMI=2,2,0,0,0\r");

    delay (600000);

 //--End: SMS--

 }

// END TEST NETWORK


//TEMPERATURE MODIFICATION

  if(setstate==HIGH){

  state=false;

  while (state==false){

  lcd.begin(16,2);

  lcd.print(" SET TEMP MAX      ");

  lcd.setCursor(0,1);

  lcd.print("TEMPMAX:");

  lcd.setCursor(9,1);

  lcd.print(tempmax);


setstate = digitalRead(set);

incstate = digitalRead(inc);

   delay(500);
```

```
 if (incstate == HIGH)  {
  tempmax++;
  delay(10);
  lcd.setCursor(11,1);
  lcd.print(tempmax);
 }

decstate = digitalRead(dec);
 if (decstate == HIGH){
 tempmax-=1;
 delay(10);
 lcd.setCursor(11,1);
 lcd.print(tempmax);
 }

 if (tempmax < 10)
 {
 lcd.setCursor(12,1);
  lcd.print("  ");
   }
    if (tempmax <= 20)
          {
     tempmax=20;
     lcd.setCursor(11,1);
     lcd.print(tempmax);
        }

   if (tempmax >= 70)
```

```
        {
    tempmax=70;
     lcd.setCursor(11,1);
     lcd.print(tempmax);
        }
if(digitalRead(set)==HIGH){
state=true;
lcd.begin(16,2);
lcd.print("TEMP MAX SETTED      ");
lcd.setCursor(0,1);
lcd.print("TEMPMAX:");
lcd.setCursor(10,1);
lcd.print(tempmax);
delay(200);
lcd.begin(16,2);
lcd.print(" FARM-C SYSTEM            ");

}
if(digitalRead(clr) == HIGH){
tempmax=27;
state=true;
lcd.begin(16,2);
lcd.print("TEMP MAX SETTED      ");
lcd.setCursor(0,1);
lcd.print("TEMPMAX:");
lcd.setCursor(10,1);
lcd.print(tempmax);
delay(200);
```

```
 }}}
// END OF TEMPERATURE MODIFICATION


//GSM UPDATE MODE
  while (cell.available() > 0) {


    char inByte = cell.read();
    Serial.write(inByte);
     if(cell.find("#A.update"))
    {
if(digitalRead(moist)==HIGH){
  moists=0;
}else{moists=1;}
     //--Start: Send SMS --


     cell.print("AT+CMGF=1\r");


     delay(1000);


     delay(1000);


     cell.println("AT+CMGS=\"+2348137469500\"\r");     //Number to which you want to
send the sms
     delay(1000);
```

```
    cell.println(String("Farm Update Temperature: ") +temp + String(" Humidity: ") +hum+
String(" Moisture:") +moists+ String(" Light:")+digitalRead(ldr)); //The text of the
message to be sent


    delay(1000);

    cell.write(0x1A);


    delay(1000);

    cell.print("AT+CNMI=2,2,0,0,0\r");

    delay(1000);

    //--End: SMS--

    cell.println("AT+CMGD=1,4\r");

    delay(1000);

  }

 // END GSM UPDATE MODE

    if(cell.find("#A.pump")){

    lcd.setCursor(0,1);

    lcd.print("PUMP ACTIVATED      ");

    delay(100);

    digitalWrite(valve, HIGH);

  }}


//FARM STATE UPDATE

if(digitalRead(moist)==HIGH){

  moists=0;

}else{moists=1;}

  lcd.begin(16,2);

  lcd.print("  FARM-C SYSTEM              ");

  lcd.setCursor(0,1);
```

```
lcd.print("T=  H=   M=  L=          ");
lcd.setCursor(2,1);
lcd.print(temp);
lcd.setCursor(6,1);
lcd.print(hum);
lcd.setCursor(11,1);
lcd.print(moists);
lcd.setCursor(15,1);
lcd.print(ldrstate);
delay(3000);
 }
```