INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS), VOL. 14, Special edition (2021); P. 70 – 78, 5 TABLE, 8 FIGS

Design of Automatic Irrigation System Usage in Banditry Prone Zones

A. A. Isah*[1], U. K. Fidelis[2], and A. E. Fredrick[3]

ABSTRACT

This paper presents a unique method of irrigation system to be used in banditry areas where farming activities are made difficult by the incessant attacks on the farm and farmers by bandits. The physical present of farmers is immaterial to check and supply adequate soil component such as soil moisture, humidity and temperature. The system components comprise of Arduino, relay mechanism, submersible water pump, moisture, and temperature and humidity sensors. For this project, non-presence of human, ensuring of proper irrigation mechanism, minimization of water loss and efficiency maximization of water utilization are all established which makes the scheme more unique.The condition of the soil in term of wetness and dryness is being sensed by the sensors and the signal is being send to Arduino system where input from the sensors is captured and interpreted base on the action to be taken on whether to supply water to the field or not through opening and closing of the valve. In the event of insufficient water, the system will continue to take the input for the supply of water or otherwise, availability of enough water to the field where the artificially supply of water is halted. This irrigation system will reduce the hardship of farmer and farm especially by the banditry attacks, saves life, enhance accuracy, save time and improve the effectiveness of the system with relatively minimal cost and ultimately enhance food production.

INTRODUCTION

Automated irrigation system provides the solution for watering the lawn and the garden automatically even in the absence of human. No individual presence is needed for watering as the system is automated considering one or more of the various parameters available for irrigation scheduling such as soil moisture measurement and temperature. This saves the greenery of the garden and provides proper amount of water needed. Soil moisture-based irrigation system, timer-based irrigation system, drip irrigation, and sprinkle irrigation are the commonly used automated irrigation system available. At this phase soil moisture-based technology has been chosen. In this project, the system is controlled by using the soil moisture measuring sensor which controls the flow of water to avoid over used or under used of it. Main components required are soil moisture sensor, control circuit, pumping unit, power supply and programming setup.

An automatic irrigation system operates as a system without manual engagement of persons which as well serve as a veritable tool to curb insecurity for farmers especially in our country Nigeria. Every irrigation system such as surface, drip and sprinkler are being automated with the help of electronic appliances and detectors such as computer, timers, sensors and other mechanical devices which serves as controller for the irrigation system.

An irrigation controller is a device to operate automatic irrigation systems such as lawn sprinklers and drip irrigation systems. The controllers have a means of setting the frequency of irrigation, the start time, and the duration of watering. The controllers have additional features such as multiple programs to allow different watering frequencies for different types of plants, rain delay settings, input terminals for sensors such as , soil moisture sensors, weather data, remote operation ,internet of things(IoT) among others.

Traditional Irrigation of plants is usually a very time-consuming activity. To be done in a reasonable amount of time, it requires a large number of human resources before now. Traditionally, all the steps were executed by humans. Nowadays, some systems use technology to reduce the number of workers and the time required to water the plants with high efficiency. The traditional irrigation method represents massive losses since the amount of water given is in excess of the plant's needs.

The contemporary perception of water is that of a free, renewable resource that can be used in abundance. However, this is not in reality; in many parts of North America, water consumption is taxed.

*Corresponding author. Email: ademoh.isah@futminna.edu.ng
[1, 3] Department of Electrical and Electronics Engineering, Federal University of Technology Minna, Niger State.
[2] Federal Institute of Industrial Research Oshodi (FIIRO) PMB 21023 Lagos.

Technology is probably a solution to reduce costs and prevent loss of resources; this involves the use of a sensors device that automatically controls the irrigation system based on the parameters.

The aim of this project is to build an automatic plant irrigation system that sense soil moisture using microcontroller.

The continuous increasing demand of food requires the rapid improvement in food production technology. In a country like Nigeria, where the economy is mainly based on agriculture, yet agricultural resources are unutilized. The main reason is the lack of rains and scarcity of land reservoir water as well as insecurity state of Nigeria which does not require the frequent presence of farmers in the field. This problem can be rectified if we use microcontroller based automated irrigation system in which the irrigation will take place only when there will be acute requirement of water.

Nowadays, in the age of advanced electronics and technology, the life of human being should be simpler and more convenient, there is a need for many automated systems that are capable of replacing or reducing human effort in their daily activities and jobs. Here the introduction of one such system, named as automatic irrigation system, which is actually a model of controlling irrigation facilities is mechanism that use sensor technology to sense soil moisture with a microcontroller in order to make a smart switching device to help in making work easy to millions of people by reducing human intervention on the system and also improving efficiency as compared to traditional method of irrigation. Can we automatically water our home and garden plants without bothering our neighbors when we decide to go on vacation or somewhere else for a long period? Since irregular watering leads to the mineral loss in the soil and may end up with rotting the plants, can we then somehow know if the soil really needs to be watered and if so, when exactly do we have to water the plants? Is it possible in any way from remote location to water our plants? These are some questions that can be heard quite often and answer on all of them is encouraging and affirmative, because advanced technology provides us with alternative to the local cum traditional method with a very wide range of possibilities nowadays.

With growing development in the technology in the technology cloud storage and the internet of things, smart system has become the latest trends in major agricultural region of the world. Austin

Reliable drought monitoring is a critical for evaluating drought risk and reducing potential agriculture losses. Liu X., Pan Y., Sun P., Yang T., Zhang Q. and Zhu. X (2020).

Kodili H. (2020) presented a paper reference ecological factor as responsible for the uncontrolled North-South migration of herd's men which encourages the struggle for- and access to- land and its resource between herds and farmers.

Water is a resource that all living species need. It is therefore very precious and has to be conserved and preserved for the generations to come. Water saving is an essential part of sprinkler irrigation owing to the impact of climate change and rising energy cost.

Agriculture as an industry uses a lot of water. Most of the time, this resource is not efficiently managed and used as such, substantial amounts of water are wasted. In the near future, these wastes will represent in an economic sense a large sum of money. Managing this resource efficiently will be a dual win in terms of time and money. This system does not depend on electricity. With the exponential growth of the human race that means the growth of population, the conventional or ancient farming method are becoming unable to cope with the growth satisfaction.

The soil moisture sensor has been used and based on the sensed values PIC microcontroller is used to ON/OFF the motor pump. Weather forecasting is not included in this system. Khriji *et al* (2014) presented a complete irrigation solution for the farmers based on WSN. The automated irrigation system using low-cost sensor node shaving reduced power consumption can reduce the water waste and is cost effective Joaquin Gutierrez (2013) proposed a gateway unit which handles sensor information, triggers actuators, and transmits data to web application. It is powered by photovoltaic panels and has duplex communication link based on cellular internet interface that allows for data inspection and irrigation scheduling to be programmed through web page.

Supporting farmers with decision tools and automation technology is a purpose of application in agriculture. Integrate products, knowledge, and services for better quality, productivity, and profit expected to increase from 30 million in 2015 to 75 million in 2020.

The quality and safety of farm products are related to public health and can also affect social stability, economic development, and national security, which are global problems

Besides, different plant species require different amounts of water, intelligent systems necessary for efficient water utilization and dynamic plant growth. Munir M. S.,Bajwa I. S, and Cheema S. M. (2019). Irrigation systems can also be adapted to various specific crop needs and only require minimum maintenance Nageswara R., Rao and Sridhar B. (2018). This system focuses on humidity variations that connect with temperature change data by sensors and can control the watering system. To provide cloud-based computing to the system, the level of precision has increased according to farmers' use of the system. Real-time environmental parameters such as ambient temperature, soil moisture level, and tank water level significantly affect the continuation of the plant life cycle. Saraf S. B. and Gawali D. H. (2018). Supporting farmers with decision tools and automation technology is a purpose of application in agriculture. However, daily activities leave many people without enough time to water their plants. Plants that are not treated will wither and do not provide benefits. Smart solutions are needed for better crop maintenance for more efficient water resources, even in adverse weather conditions.

MATERIALS AND METHODS

The system has three major parts; Moisture sensing part, control section and the output section shown in figure1The soil humidity was detected usingYL-69 soil sensor (a resistance type sensor). The control unit was achieved using ATMega328 microcontroller based on Arduino platform. The output was the unit used to control the irrigation system by switching it on and off depending on the soil moisture contents. Two stages of design were undertaken; hardware and software. From the figure 1, there are three functional components in this project. These are the moisture sensors, gravity tank and reservoir sensor, and the motor/water pump.

Thus, the Arduino Board is programmed using the Arduino IDE software. The function of the moisture sensor is to sense the level of moisture in the soil. The motor/water pump supplies water to the plants.

This project uses Arduino Uno to controls the motor. Follow the schematic to connect the Arduino to the motor driver, and the driver to the water pump. The motor can be driven by 230V. The moisture sensor measures the level of moisture in the soil and sends

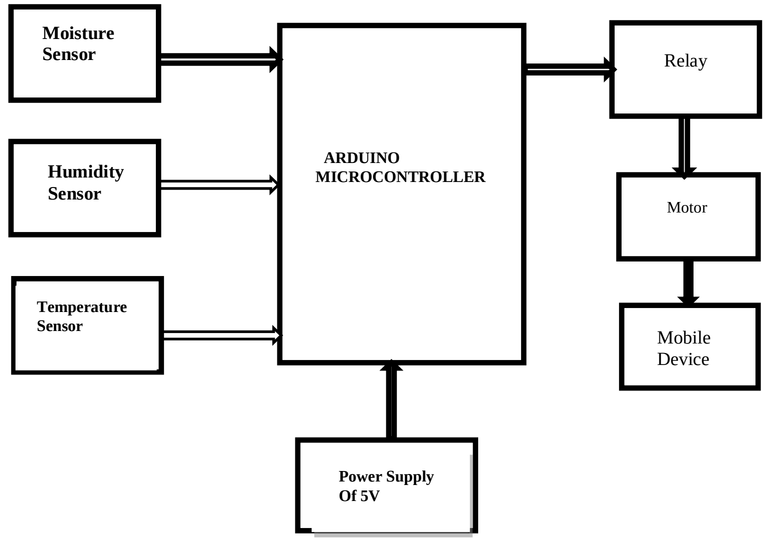

Fig. 1. Schematic system block diagram of irrigation

the signal to the Arduino if watering is required. The motor/water pump supplies water to the plants until the desired moisture level is reached.

Design of Power Supply 12V and 5V combo power supply

Electrical power is the rate of movement of electrons that produce energy. As a result of the electronic age many products need electrical power to perform certain activities. Being able to manipulate electrical power comes at a cost. In today's world there is always the bottom line, cost. Power supplies are the devices that can manipulate electrical power to be used in various applications. Power supplies can be expensive but there are cheaper alternative solutions that can produce the same output. A power supply includes conversion steps and has to be reliable enough not to damage what it is hooked up to. Both aspects need specific parts in a certain orientation to create those specific outputs Every circuit runs on a different voltage, some circuits' runs on 5V, 9V and soon. But in this project, we used 5V and 12V were used. An ATMEGA 16bit microcontrol which requires 5V power supply is used because the operating voltage for ATMEGA16microcontrol is 5V. If voltage is greater than 5V then the microcontroller may get damaged. To avoid this, it is always advisable to use a5Vpower supply for micro controller circuits.

Below is a block diagram of dc power supply in which four steps are given named as:

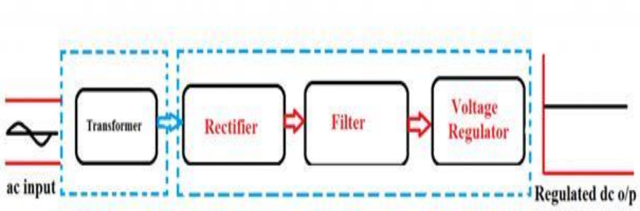

Fig. 2. System power supply block diagram

This power supply consists of transformer (Step down), rectifier (ac to dc conversion), filter (removing ripples from dc current) and voltage regulator (regulating dc supply).

This is a simple approach to obtain a 12V and 5V DC power supply using a single circuit. The circuit uses two ICs 7812(IC1) and 7805 (IC2) for obtaining the required voltages. The AC mains voltage will be stepped down by the transformer T1, rectified by bridge B1 and filtered by capacitor C1 to obtain a steady DC level. The IC1 regulates this voltage to obtain a steady 12V DC. The output of the IC1 will be regulated by the IC2 to obtain a steady 5V DC at its output. In this way both 12V and 5V DC are obtained. Such a circuit is very useful in cases when we need two DC voltages for the operation of a circuit. By varying the type number of the IC1 and IC2, various combinations of output voltages can be obtained. If 7806 is used for IC2, we will get 6V instead of 5V. Same way if 7809 is used for IC1 we get 9V instead of 12V.

Working principle of the overall system

The system consists of Soil Moisture Sensor, a PIC Microcontroller and a Relay interface board. The irrigation system consists of lanes through which each segment of the land is flooded and the flooding is controlled using valves as shown in the Figure 5. There is also a motor pump that is used to fill the water, Tanker.

The power supply unit of +5V and +12V were tested for the output voltage under no-load and full-load conditions.

Under no-load, the voltage of the +5V supply section was measured to be 4.92V while that of the +12V supply was measured to be 11.93V. At full- load, the respective voltages were measured as 4.82V and 11.81V.

2.5 Voltage Regulation (V.R)

$$V_R = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100 \qquad (1)$$

Where,

V_{NL}= No-load Voltage

V_{FL}= Full-load Voltage

Table 1. For the unit's operating on+5V and +12V

For the unit's operating on+5V		
VR (%)	V_{NL}(V)	V_{FL}(V)
2.03	4.92	4.82
For the unit's operating on+12V		
VR (%)	V_{NL}(V)	V_{FL}(V)
1.00	11.93	11.81

From the results obtained above, the performance of the power supply is satisfactory.

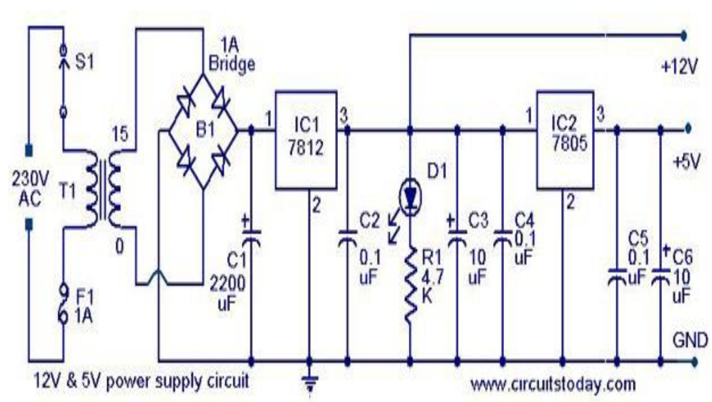

Fig. 3. Power Supply Circuit Diagram

Switching/Sensing Unit

This unit consists of a transistor (BC109) operating as a switch, relays and a DC motor. That is a vital component in the operating mechanism of the design.

Transistor

This is a three terminal, three-layer device formed by adding a second p or n region to a p-n junction diode. With two n-regions and one p-region, two junctions are formed and it is known as an NPN transistor. The common emitter configuration for an NPN transistor is generally used in switching applications.

Relay Switching Circuit/Connection

This is an electromagnetic switch which is activated when a current is applied to it. A relay uses small currents to switch huge currents. Most relays use principle of electromagnetism to operate but still other operating principles like solid state are also used. A contact or is a type of relay which can handle a high power required to control an electric motor or other loads directly. Solid state relays have no moving parts and they use semiconductor devices to perform switching.

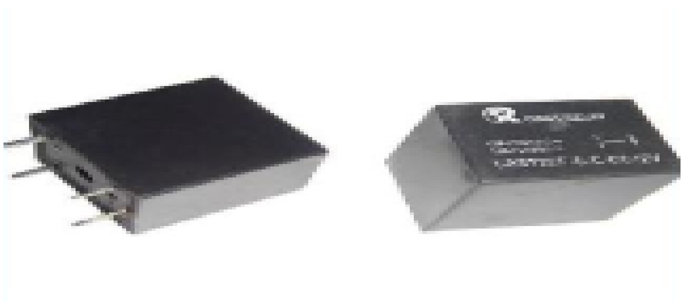

Fig. 4. 5VDC Coil Relay

Sensing Unit

Theanalogueconfigurationwasselectedasitsmorestablecomparedtothedigitalconfiguration.The PCB drive pin A0 was connected to the Arduino analog pin A0.

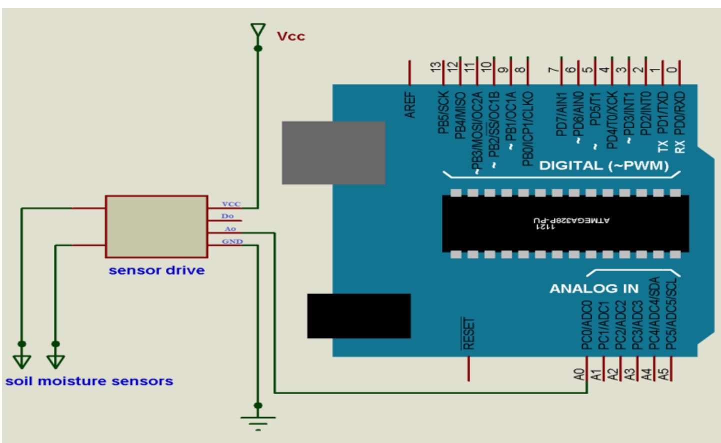

Fig. 5. Connection to Arduino board

The output of the sensor to the Arduino analog pin A0 was resistance. The resistance to flow of current between the sensor probes changes with soil moisture level and soil type. The current passing through the sensor probes (Iout) for different soils and different soil moisture levels was calculated as shown below:

To protect the microcontroller from back e.m.f during switching a diode was connected across the relay. The connection was shown in tables 2,3,4 and 5. To protect the microcontroller from back e.m.f during switching a diode was connected across the relay.

Sensing Unit

Proteus allows engineers to run interactive simulations of real designs for circuit simulation. It has a range of simulator models for popular micro-controllers and a set of animated models for related peripheral devices such as LED and LCD displays, keypads and more. It is possible to simulate complete micro-controller systems and thus to develop the software for them without access to a physical prototype.

It has simulated our hardware model using the software Proteus ISIS. The simulator models such as Atmega328, LED, LCD display, Switches, pot, Relay, Resistors, Transistor and sources were used and results were verified with hardware results.

Sensing Unit

The Arduino Uno is programmed with the Arduino IDE software. The Arduino microcontroller is an easy to use yet powerful single board computer that is of significance in the professional market. The Arduino is open-source, which means hardware is reasonably priced and development software is free. The Arduino Uno board features an Atmel ATmega328 microcontroller operating at 5 V with 2 Kb of RAM, 32Kb of flash memory for storing programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, which translates to about executing about 300,000 lines of C source code per second. The board has 14 digital I/O pins and 6 analog input pins. There is a USB connector for talking to the host computer and a DC power jack for connecting an external 6-20 V power source, for example a 9 V battery, when running a program while not connected to the host computer. Headers are provided for interfacing to the I/O pins using 22 g solid wire or header connectors.

The Arduino programming language is a simplified version of C/C++. Having the knowledge of C makes the Arduino programming the familiar. An important feature of the Arduino is that you can create a control program on the host PC, download it to the Arduino and it will run automatically. Remove the USB cable connection to the PC, and the program will still run from the top each time you push the reset button.

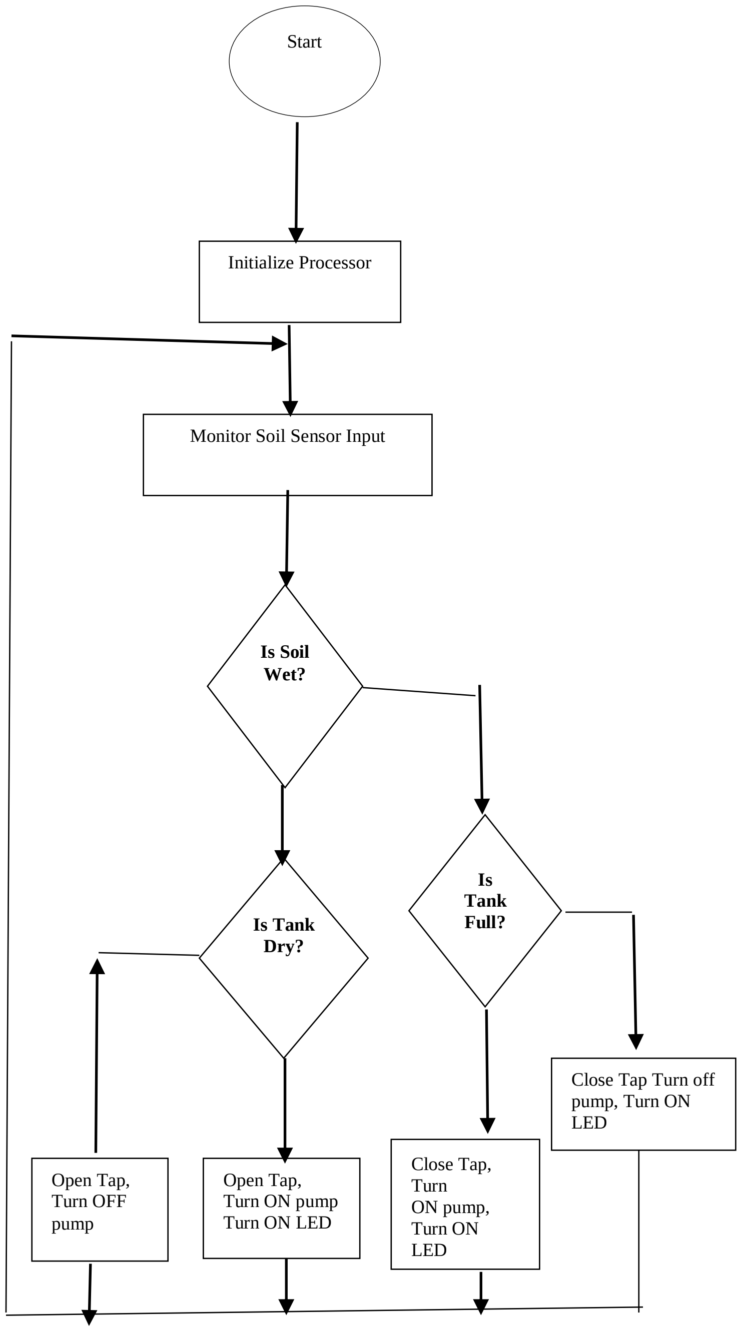

Fig. 6. Flow chart of the system programming

The Prototype of the Automatic Irrigation System

The diagram show below is the prototype of automatic irrigation system comprises of the soil moisture, temperature and humidity sensor, Arduino microcontroller tested and working in good condition for proper accessibility of the research work

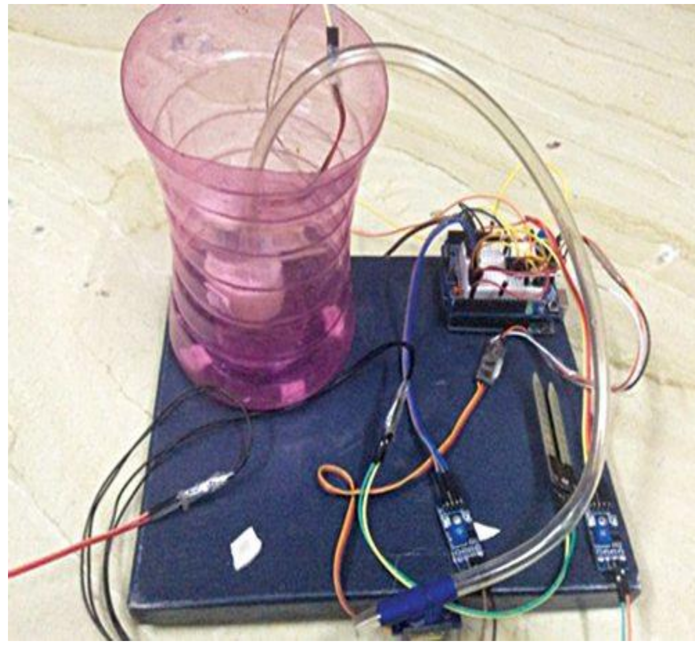

Fig. 7.Design prototype of irrigation system

RESULT AND DISCUSSIONS

This chapter deals with the description of tests performed on the various sections of the overall system and their corresponding results as well as the result of the overall system. In order to verify the correct functionality of the system, each component had to be tested individually. To achieve the effective testing of these various components, the following tools were used:

Digital Multimeter: A digital multimeter is used to measure two or more electrical values principally voltage, current and resistance in the system of the design.

Vero board/Bread board: I t is used in constructing electronic circuit of the board.

Sensor Probes: Sensor probe are molecules that report the presence of specific ions, molecules event in vitro or in cells by communicating a measurable signal often of light base readout.

Soldering Iron & Lead Cable: A soldering iron is used to heat solder usually from electrical supply at high temperature above melting point of metal alloy.

Light emitting diodes: This are used for night lighting and outdoor lighting of the system for indication of some functional part.

Proteus and Multisim LAB simulation software: This software perform intuitive analog and digital circuit, single-chips simulation.

Designing the PBC board: It is used to mechanically support and electrically connect component using conductive tracks, pads.
Arduino Uno board: This an open-source electronic platform based on easy-to-use hardware and software for actuation control and operation.
USB programming cable (A to B): It is used to connect the system to some part of the board for effective system data communication.
Solid wire for connections: This is useful for wiring a breadboard during the design processes.

The testing was done on each and every components/sections that make up the circuit to ensure proper and satisfactory operation. The debugging was done using the Arduino Uno and Proteus LAB simulation software; Each and every section of the code was debugged properly to ensure proper functionality thus a step debugging was done. This is a facility in the Arduino Uno and Proteus LAB simulation software that makes it easy to step into program and at the same Time views the registers and flag settings.

Simulation results using MultiSim

By varying the resistance (700 kΩ) in the potential divider circuit as a representation for the dry/wet condition of the sample soil, the circuit was tested and the results are tabulated below:

Table 2. simulation results.

S/N	Soil Moisture level	Output of the sensor circuit (Volts)	Output of the main pump controlling circuit (Volts)
1	Below lower level	2.372	0
2	Increasing to the standard level	4.50	10
3	More than higher level	5.262	10
4	Decreasing but higher than lower level	4.37	10

The working of the relay for various test conditions is tabulated in table 3

Table 3: operation of relay for various soil moisture contents

S/N	Voltage range	Soil condition	Q	Amplifier output (digital)	Relay reference pin voltage	Relay-NO contact	Water pump operation
1	>5V	Excess wet	0	1	1	Open	OFF
2	<5V& >3V	Optimally wet	0	1	1	Open	OFF
		Optimally dry	1	0	0	Closed	ON
3	<3V	Dry	1	0	0	closed	ON

Soil condition analysis

The Volume weight content (VWC) Of sand soil, clay soil and loamy soils were calculated. The raw data collected from the soil moisture sensor was recorded as shown in table 4. The soil was measured in equal amount of 250gramms. Water was added in the soils in steps and the sensor values recorded.
The data obtained from the sensor reading and recorded in table 4 was used to plot a graph of Soil water content against sensor reading.

Table 4. Weighted volume content of soil types

Soil water content (cm_3)	Sensor Readings (cm^3)		
	Loamy soil	Sandy soil	Clay soil
0	1020	1021	1021
50	581	545	780
75	361	233	567
100	236	233	294
125	202	183	273
150	190	181	234
175	181	171	221

.
The raw data collected from the temperature and humidity sensor was recorded as shown in table 5. The soil temperature and humidity were measured within an interval of an hour and the data were collected.

Table 5. Temperature and humidity measurements

Time	Temperature (T^0)	Humidity (HR)
1.00	10.91	59
2.00	10.81	59
3.00	10.81	57
4.00	10.71	6 1
5.00	9.91	63
6.00	9.51	58
7.00	9.61	55
8.00	10.71	54
9.00	12.81	46
10.00	12.51	49
11.00	12.61	51
12.00	11.71	54
13.00	12.21	54
14.00	11.91	56
15.00	12.01	57
16.00	13.21	54
17.00	12.91	59
18.00	12.31	61
19.00	11.91	62
20.00	11.11	66
21.00	10.81	69
22.00	10.81	70
23.00	10.11	73
0.00	9.31	80

The data obtained from the soil moisture and water content reading and recorded in table 3 was used to plot the graph of figure 7.
The Graph was plotted using the scale of 2cm to represent 200 unit on soil moisture sensor (Y) axis and the scale of 2cm to represent 25 unit on water contents (X) axis.

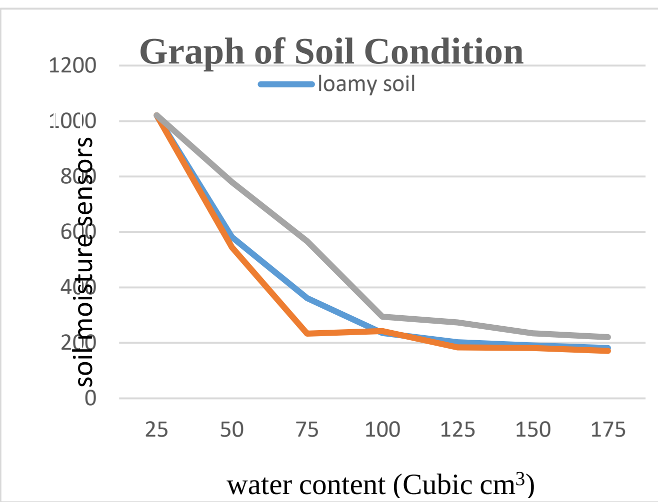

Fig. 7. Graph of Soil Condition

The system measuring sensor (YL-69) used is a resistance sensor type. Its output is the resistance in the soil between the two SMS probes. The obtained graph is an exponential one. The value of the soil resistance decreases with increase in water content to a certain point.

To come up with the results the three soils were dried using a frying pan until all the moisture content was lost. 250 grams was measured for the red soil, black soil and the sand soil. Water was added in steps of 25cm3 and sensor value recorded. The value of soil sensor at dry soil was almost equal for the three soils at 1020, 1021, 1021 for black soil, sand soil and red soil respectively. On adding 50cm3 the resistance value reduced drastically to the range of 500. On adding more water, the resistance value kept reducing. At around 100cm3 of water, the reduction on the soil resistance started reducing at a much lower rate. This is because at this point the soil is now becoming saturated with water and thus adding more water has a small effect on the soil resistance. The sensor was calibrated and three states defined. The states are soggy, moist and dry. When the dry state was achieved the control unit (micro controller) switched the water pump ON via a relay circuit. The three states were indicated using three different LEDs and an LCD. The LCD also indicated when the pump was running. The control circuit and the sensor circuit were powered using a 9V alkaline battery which was connected via a voltage regulator with an output of 5V.

The data obtained from table 4 from temperature and humidity sensors and Time of the day was used to plot the graph.
The graph was plotted using the scale of 2cm to represent 10 unit on temperature and humidity sensors (Y) axis and the scale of 2cm to represent 1unit on Time of the day (X) axis.

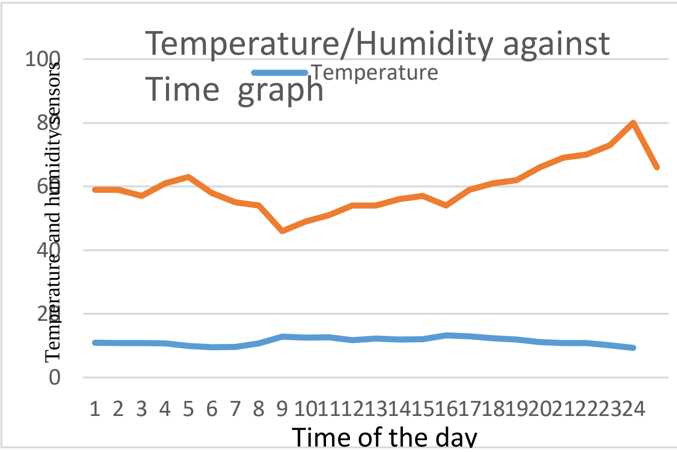

Fig. 8:.Graph of temperature/humidity against time.

From the graph above the temperature and humidity sensor were used as the dependent variable while the time was the independent variable. The trend shows that there is an inverse relationship between temperature and humidity. During the day, there is rise in temperature and decrease in humidity and vice versa during the night time as depicted in the table.

CONCLUSION

Thus, the "automatic soil moisture sensor irrigation system using microcontroller" has been designed and tested successfully. It has been developed by integrated features of all the hardware components used. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. The system has been tested to function automatically. The moisture sensors measure the moisture level (water content) of the different plants. If the moisture level is found to be below the desired level, the moisture sensor sends the signal to the IC (Microcontroller) which triggers the Water Pump to turn ON and supply the water to respective plant using the Rotating Platform/Sprinkler. When the desired moisture level is reached, the system halts on its own and the Water Pump is turned OFF. Thus, the functionality of the entire system has been tested thoroughly and it is said to function optimally

REFERENCES

Austin M.,Brittany S., Jose N., Juan P.,Mauricio G., Santiago G., and Yogang, S. (2021). The journal of contemporary water research and education. (171)1: 49-62.

Chen C., Jiang Y., Jiang P., Issaka Z., and Li H. (, 2019). Overview of emerging technologies in sprinkler irrigation to optimize crop production. *International Journal of Agricultural and Biological Engineering*. (12) 3:1–9.

Elijah O., Rahman T. A., Orikumhi I, Leow C. Y and. Hindia, M. N. (2018). An Overview of Internet of Things (IoT) and Data Analytics in Agriculture. *Benefits and Challenges. IEEE Internet Things J*. (5)5: 3758–3773.

Kodili Henry C. (2020). Constructing the herder- farmer conflict as (in)security in Nigeria. *African security volume 13.*

Liu X., Pan Y., Sun P., Yang T., Zhang Q. and Zhu. X (2020). A remote sensing and artificial neural network-based integrated agricultural drought index. *Index development and applications. Catena*, vol. 186, Article ID 104394.

Mahbub M. (2020). "A smart farming concept based on smart embedded electronics, internet of things and wireless sensor network. *Internet of Things*, vol. 9, Article ID 100161.

Munir M. S., Bajwa I. S, and Cheema S. M. (2019). An intelligent and secure smart watering system using fuzzy logic and blockchain. *Comput. Electr. Eng*, vol. 77:109–119, https://doi.org/10.1016/j.compeleceng.2019.05.006.

Nageswara R., Rao and. Sridhar B. IoT based smart crop-field monitoring and automation irrigation system. *Proc. 2nd Int. Conf. Inven. Syst. Control. ICISC 2018*, no. Icisc, pp. 478–483, 2018. https://doi.org/10.1109/icisc.2018.8399118

Saraf S. B. and. Gawali D. H. (2018). IoT based smart irrigation monitoring and controlling system. *Rteict 2017 - 2nd Ieee Int. Conf. Recent Trends Electron. Inf. Commun. Technol. Proc*., vol. 2018:815–819, 2018. https://doi.org/10.1109/rteict.2017.82567.