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Design and Construction of an IMPROVED Automatic Irrigation System.

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ABSTRACT : *An improved automatic irrigation system for arid regions is presented in this work. The former was designed and constructed from analogue components like comparators in a single component module. The improved system operates on wireless technology by means of radio frequency (RF) transmission scheme between a field - soil - moisture monitoring device (transmitter) and receiver modules. The soil moisture level detector device (sensor) is placed within the field with its probes buried in the soil to a reasonable depth for optimal capillary level. The soil moisture detector communicates with the receiver device wirelessly. The receiver device consists mainly of a microcontroller, a Liquid Crystal Display (LCD) Screen, RF receiver module, mechanical switching device, a monitoring buzzer, and the associated circuitry. When both circuits are switched on, the microcontroller establishes communication with both the soil moisture detector device by searching for it. Both devices can be positioned as far as 100meters apart for effective and efficient operation. Three soil samples; top soil, Loamy soil and sandy soil were used for the experiment. The results show that as soil water increases, resistance decreases to some extent. A point is reached when further increase in soil water level does not show any decrease in resistance. At this point, it is assumed the soil moisture level is saturated. Beside it is observed, that sandy soil among the three soil samples has the least resistance, followed by loamy soil and top soil has the highest resistance, thus sandy soil has the highest conductivity than loamy soil, and top soil has the least conductivity.*

KEYWORDS: *Soil Moisture, Irrigation, Microcontrollers, Radio Frequency, Sensor.*

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I. INTRODUCTION

Irrigation is the process by which water is artificially applied to land or soil through manual or automatic means. It is used to assist the growing of agricultural crops, maintenance of landscapes (floral, gardens, lawns) and re-vegetation of disturbed soils in dry areas and during period of inadequate rainfall. Today irrigation can also be used in yielding crops production, which include protecting plants against fast suppression of weed growth in fields and help prevent soil consolidation (that is decrease in water content of soil).

As we know water plays a vital role in our everyday lives, for us humans we need water in terms of our health, domestic use, and transportation etc., the role of water for plants includes irrigation purposes and the use of water for animals in terms of their health. All of which require sufficient water. Water can be gotten through natural and artificial means in irrigation areas. The demand for water varies overtime and depends on the applied field. For instance, the water needed for an irrigation scheme is regular and must be consistent for maximum fertility of soil.

Irrigation comes in the form of manual and automatic modes of operation which both have their advantages and disadvantages. For manual irrigation it is time and labour consuming and require regular human intervention and vigilance whereas automatic irrigation system it's not labor intensive, it is easy and well configured to ON and OFF at required times. It requires less human involvement and high budget. In terms of performance the auto system of irrigation is more efficient and reliable with the latest advancement in technology. An automatic irrigation is more suitable and is widely used such device operates in soil moisture sensing to detect the field status if wet or dry.

Soil moisture sensing technique has the ability to measure the volumetric water content in soil by indirectly using some property of the soil such as electrical resistance and soil moisture, dielectric constant or interaction with neutrons or for the moisture content the relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microware radiation is affected by the soil moisture and is used for remote sensing in hydro-agriculture, it involves the use of portable probes used by farmers and gardeners that tend to indicate soil moisture soil when dry or wet.

Soil moisture sensor is important for agricultural application to help farmers manage their irrigation system more efficiently knowing the exact soil moisture conditions of their fields not only are farmers able to generally use less water to grow a crop they are also able to increase yields and the quality of the crops by improved management of soil moisture during critical plant growth stage. For urban and sub-urban areas, landscape and residential lawns use soil moisture sensors to interface with an irrigation controller connecting a soil moisture sensor to a simple irrigation clock which will convert it to a smart irrigation controller that prevent irrigation cycles when the soil is already wet and hence prevent over-irrigation and leaching of the fertilizers.

II. RELATIVE WORK

This is a literature review on automatic soil irrigation systems where adequate research was done on past works and projects as a means of improving automatic irrigating systems.

With the latest advances in technology, manual as a process is been kicked away. Today people now prefer automatic as a process of doing things. Irrigation system has evolved with developments in automation and control technology. Earlier before now manual irrigation process was done without much consideration and techniques of soil moisture content.

Earlier irrigation systems posed many problems ranging from under-irrigation, over-irrigation which resulted in leaching, water erosion, wind erosion, etc. All these caused lower yields, lighter weight crops, slowed growth rate etc. As irrigation activities were carried out without a proper determination of the soil moisture content. This irrigation system ensured a proper and accurate measurement of the soil moisture content before Irrigation was carried out as well as monitoring systems that does not require the presence of the farmer before irrigation was effectively and efficiently carried out.[1]

With the advancement in technology, auto-irrigation can be carried out by employing a Global System for Mobile Communication, (GSM) microcontroller-based system where the user communicates with the centralized unit (microcontroller) via SMS. The centralized unit communicates with the system through short message Service (SMS) which will be received by the GSM with the help of Subscribe Identity Module (SIM) card. The GSM sends this data to A-risk microprocessor (ARM7), which also continuously receives data from the sensors in some form of code. Whenever the system receives the activation command from the subscriber, it checks all the field conditions and gives detailed feedback to the user and waits for another activation command to start the motor. The motor is controlled by a simple manipulation of the internal structure of the starter. The starter coil is indirectly activated by means of a transistorized circuit. As soon as the motor is started, a constant monitoring of soil moisture content is done and once it reaches a pre-determined threshold value, the motor is automatically turned OFF and an SMS is sent to the farmer informing him that the motor is OFF.[2].

Few research focused on reviews in the field of remote monitoring and control, the technology used had their potential advantages, which includes an innovative GSM/Bluetooth based remote controlled embedded system for irrigation. The system sets the irrigation depending on the temperature and humidity reading from sensors and the type of crop in the farm. The system is capable of automatically irrigating the field when unattended. Information is exchanged between user and the designated system via SMS on GSM network [3]. Wireless auto irrigation system had Wireless Sensor Unit (WSU), a WSU comprises of a RF transceiver, sensors, microcontroller, and power sources. Several WSUs can be deployed in-field to configure a distributed sensor network for the automated irrigation system. And Wireless Information Unit (WIU). The soil moisture and temperature data from each WSU are received, identified, recorded, and analyzed in the WIU were both systems are interfaced with common microcontrollers to give desired output.[4]

Further research on automatic irrigating systems introduced had an embedded server that use of GSM network technology. According to this research, this system, as compared to the wired link web server system, is characterized by having no wires between the web server and terminal nodes. Here, the hardware works in three modes of operation; Humidity, automatic and manual modes, in the humidity mode, the moisture content of the soil is sensed and the switching ON or OFF is done if the soil is dry. In automatic mode, the hardware automatically turns on the motor for a specified time interval and turns OFF the motor. In manual mode, the user can turn ON or OFF the motor by pressing the ON/OFF button. The settings of these features are done via an Android mobile [5].

GSM-based auto irrigation system has two major technologies behind it; primary been the "GSM" and secondary one is the microcontroller. The GSM facility serves as an important part for controlling the irrigation on field and sending the results to the farmer using coded signals to a mobile device which indirectly controls the entire farm irrigation system. The microcontroller works as a central core for functioning of the automated process after it has been initiated by the GSM-based device and finally presents the output to the device.[6].

A GSM-based auto irrigation system as shown below; A pipe is connected to from the water pump and the other end waters the field. The flow of water from the pipe is controlled by an electromechanical device called a solenoid valve. The solenoid valve used is a two-port valve for switching ON or OFF the flow of water. The solenoid converts electrical energy into mechanical energy which in turn opens (ON) or closes (OFF) the valve mechanically in accordance with the signal given by the micro controller. When the moisture sensor senses low soil moisture content, it gives a signal to the microcontroller which in turn gives a signal to the called mobile (this is kept in the auto-answering mode), the called mobile then activates the buzzer which indicates that the valve needs to be opened. Signal is given back to the microcontroller by pressing the button in the called function, the microcontroller in turn gives signal to the valve causing it to get opened, then water is applied to the field until moisture content becomes sufficient at which point, this sensor recognizes this and gives back the signal to the microcontroller and the buzzer is turned OFF, and pressing the button in the call function again, turns off the valve. This system also informs the user about many conditions like status of electricity, increased temperature, presence of smoke, water level of tank, humidity, dew point, weather conditions etc. [7]

A hybrid irrigating system which had wireless sensors and GSM was proposed. The authors in their research used wireless sensor networks for the field conditions while the mobile phone was used to control the watering operation of the field. To implement the control of watering, the microcontroller computed the number of missed calls from the user's mobile to determine the type of operations to execute. In doing this, the microcontroller was coded to compute a number of missed calls to correspond to a particular instruction to be performed. This system however, had a challenge in the limited number of instructions that could be executed. There is also the additional problem for users to remember the number of missed phone calls that corresponds to each instruction to be executed.[8]. A distributed irrigation system was discussed where a single board computer was used to control the solenoids of a group of nozzles in the network using a wireless network and GPS (Global Positioning System). The conditions of the field were transmitted remotely to a central server using Ethernet Radio.[9]

A GSM-based irrigation controller system which consists of three main systems; integrated hardware system, communication system and control strategy. The integrated hardware system consists of power supply system, microprocessor system, sensing system, pump switching system, intrusion detection system, GSM communication module and LCD display system. The communication system implements the communication protocol to facilitate data communication among the devices of the integrated hardware and also between the user and the controller system while the control strategy is responsible for operating the irrigation system.[10]

A proposed GSM-based auto irrigation system with voice commands and remote monitoring of farms. His work focused on the illiterate farmer who is incapable of reading and writing, hence sending of texts was a problem. He designed a system where the farmer just speaks a command into his mobile and a speech to text converter converts the commands into text. His model uses the Hidden Markov Module for speech recognition and a Field Programmable Gate Array (FPGA) or processor-based system to store text. His system also includes a wireless network based remote monitoring of the field's temperature and moisture. His model is basically the same as the other GSM controlled modules safe for the incorporation of a speech to text converter to eliminate the sending of texts by the farmer. The proposed model however had the limitation of remembering the command words corresponding to each instruction to be executed. GSM based auto irrigation system generally is advantageous in the aspect of it being monitored/controlled from anywhere in the world. GSM based auto irrigation system has its limitations; the problem of power supply is a major challenge especially in rural arid regions where electrification is often absent and the intensity of sunlight is high. To solve this, a solar panel can be introduced to convert solar energy to electrical energy to serve as a source of power for the system. This saves the cost of using generators as source of power, it also reduces pollution in the form of noise and smoke.[1]

Some Authors gave feasible solution to the problem of power supply posed by other irrigation systems. In their work, rather than depending on epileptic power supply which is often the case in remote parts of Nigeria, or on the use of fossil fuels which are short term energy sources for power generation and could possibly cause noise and air pollution, renewable solar energy was used as the power source. The authors employed the use of solar modules which cleanly converts sunlight into electricity as well as maximize the energy from the sun by including sun tracking technology so that the modules are constantly aligned towards the direction of the sun. Furthermore, they stated that the electricity can be stored in DC batteries for later usage when sunlight is not readily available. The system proposed by these authors also makes use GSM remote monitoring and control technology to monitor activities in the field as well as dispense water when the soil moisture content falls below a predetermined threshold value and turns OFF the motor when the soil moisture content is sufficient. [11,12 &13]

A microcontroller based low-cost soil temperature and moisture monitoring system that can track the soil temperature and moisture at different locations of the field in real time and thereby allows water to be sprinkled onto the field if the soil temperature goes above and/or the soil moisture falls below a prescribed limit depending on the nature of the crop grown on the soil. Though the moisture sensor suffers temperature drift and non-linearity effects, the non-idealities are minimized with the aid of ANN (Artificial Neural Network) based temperature compensation.[14].

III. METHODOLOGY

The methodology employed in this research study is an improved means of irrigating a field when the soil moisture is sensed dry and not to pump water when soil is wet through developed technique. For improvements RF modules and LCD screen were added.

3.1 FEATURE OF THE PROPOSED IMPROVED AUTO-IRRIGATION SYSTEM.

RF Modules (Wireless-based) were added into the proposed auto-irrigation system, which has the ability to receive and transmit soil moisture status from soil sensors (probes) with the aid of a microcontroller to drive necessary actuators to pump ON and OFF on detection of soil moisture level. And in addition to the improved system a user interface screen was added to show the status of the soil, status of pump (ON or OFF) which were displayed on the LCD screen with adequate fast feedback information.

Fig.3.1 Proposed Block Diagram of Improved Automatic Irrigation System with features.

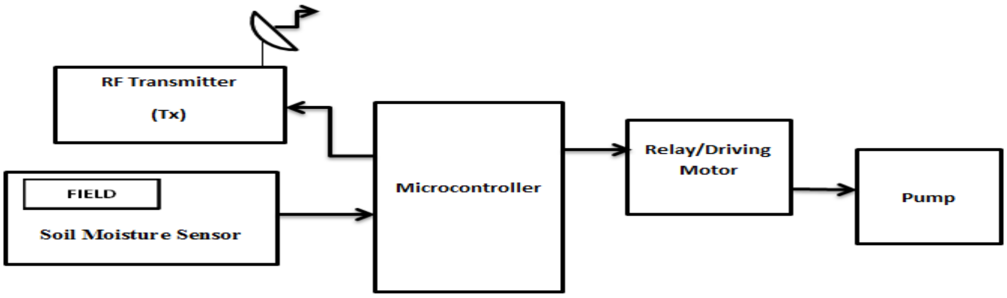

Fig **3.2 Sectional Block Diagram of RF Module Showing Transmitting Part.**

RF transmitter is used for the purpose of transmitting the moisture sensor output and the motor status in the form of packets to the receiver via radio waves after a field communication has been established. Here the term packets refer to the array of data including soil moisture and status of motor. Prior to the data transmission, microcontroller formats the data in a particular format that is to be transmitted by the RF Module through the microcontroller. RF Module here is programmed to transmit the data at 443Mhz.We have used simple wire antenna of length around 5cm in the Transmitter and receiver module. This module uses the Frequency-shift keying (FSK) modulation that means the digital data from microcontroller are modulated with carrier waves before being transmitted

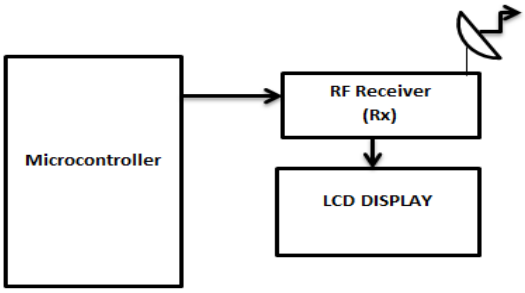

Fig 3.3 Sectional Block Diagram of RF Module Showing Receiving Part.

RF Receiver

The RF Module of the receiving part is configured here as the receiver that receives the data bytes transmitted by the transmitter and stores them in the microcontroller. Stored data are been processed by microcontrollers and then sends a signal for it to be displayed on LCD. RF receiver is programmed to detect the transmitted signal by unique phase locked loop (PLL) with frequency of 443Mhzas carrier frequency. Similar antenna type as in transmitter is used to tune the particular carrier wave.
Our RF receivers consist mostly of Buzzer and LCD display and a micron roller, mechanical switch device and other associated circuitry.

3.2. Principle of Operation of improved Auto Irrigation System.

The improved automated irrigation system consists of moisture sensor, analog to digital converter, microcontroller, Relay driver, buzzer,

A field connection must be established between the RF module of the transmitter circuit and receiver circuit which can be positioned as far as 60-100 meters apart for efficient and effective operation. When both circuits are switched ON the desired field connection is established. That is the transmitter circuit scans and searches for the receiver circuit and synchronizes. The Microcontroller communicates with soil moistures probes which are buried in the given field. The moisture sensor is buried in the field at a required depth. If the moisture content in the field gets reduced to lower threshold limit, the signal is produced from the microcontroller of the receiving circuit to turn ON relay. The relay in turn triggers the buzzer and at the same time sends a signal to switch on pump. Moisture level sensed from the sensor will be displayed in the LCD display at the receiving unit of RF module.

The image below shows the soil moisture sensors probes buried in the given field connected to the receiving circuit which sends a signal to the transmitting circuit of soil moisture content for necessary actions to be carried out

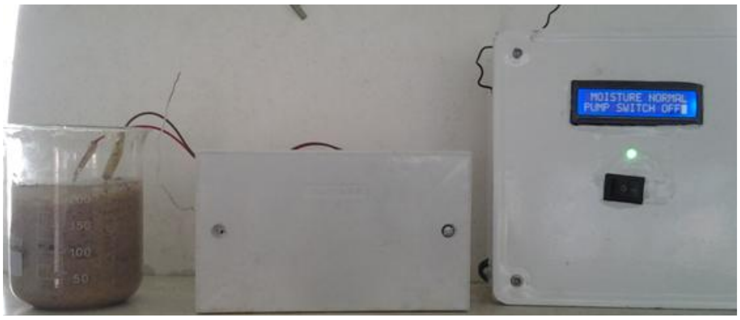

Fig.3.6 **showing soil moisture status and pump status displayed on a LCD screen.**

The Microcontroller will be used to control the whole system. It is used read the sensors regularly and when the sensors sense the dry condition, the microcontroller will switch on the water pump and switch off when all the sensors are sensed wet. The microcontroller does the above job by receiving the data from the sensors, and these data are processed via RF modules which receive and transmit data of soil status on LCD screen.

Description of Major blocks of our proposed Improved Auto-Irrigation system.

Sensing Unit: This unit Consist of sensors that measure soil moisture content by measuring the conductivity of the soil. Metallic probes are the conducting materials used to sense the moisture of the soil. They work on the principle of change in resistance. Basically, moisture sensor is a metallic strip. Resistance of metallic strip changes according to moisture level in soil. If moisture is high, resistance will be low and if moisture in soil is low, resistance will be high. Because moisture increases the conductivity of metallic strip. PIC microcontroller is used to measure the change in resistance of moisture sensor. This change in resistance is used to turn on or turn off dc water pump with the help relay interfacing with the microcontroller.

Microcontroller Unit: This unit consists of a microcontroller that is made up of several component for decision making and gives instruction to determine when irrigation is to be done. The Microcontroller sends and receives soil information (data bytes) from the sensing unit to the RF Module. These received data are stored in the memory. The received data is in the form of packet constituting soil moisture, and water pump status in the exact format transmitted through the transmitter. Microcontroller then separates each individual information i.e., soil moisture, and water pump status. And then processes them to be displayed in the LCD at the receiving section where Data's that has already been encrypted from transmission are received. In this project the microcontroller is responsible for reading the sensors data, store, and process the same data to control the irrigation system. At the same time the soil condition obtained from sensors is transmitted through the RF module. There by making the microcontroller arrange the data into the particular format before transmitting it through the transmitter. The transmitted data is then sent to the receiver unit with the aid of a microcontroller it displays encrypted data on LCD. To ensure the security of the transmission system we can use certain code for certain data for example, we can use alphabet A for "moisture low" and receiver section should be programmed to decode that particular alphabet A to obtain the predefined "moisture low" else this alphabet has no meaning.

The process can be regarded as a data encryption process. A microcontroller is an entire computer manufactured on a single chip. Microcontrollers are usually dedicated devices embedded within an application.

The program that runs in the microcontroller;

1. Checks and compares the converted analog signal from the sensor with predefined threshold values. (This is the main program).

2. Subroutines that are executed to either energize or de-energize the relay,
   The microcontroller is interfaced with the sensor to receive inputs which determine the energizing or de-energizing of the relay.

The microcontroller employed for use is the AT89S52 IC. It is a typical 8051 microcontroller manufactured by ATMEL. It is a low-power, high performance CMOS, 8-bit microcontroller with 8K bytes of in-system programmable flash memory technology and is compatible with the industry standard 8051 instruction set and pin-out. The on-chip flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer

The microcontroller contains an event driven program which is executed to either energize or de-energize the relay so as to switch on the pump in accordance with the detected soil moisture level output from the Operational Amplifier (LM324) functioning as the soil moisture sensor. It sends a signal to the micro-controller by using a comparator. Here comparator acts as an interface between the sensing arrangement and the microcontroller. The programmed microcontroller chip always checks port p3.2 which is pin 12 of the microcontroller chips. Whenever the microcontroller sees a low (0 to 1.875V DC) level, it confirms the absence of soil moisture and processes the signal to control the outputs. Therefore, if pin 12 of the microcontroller chip is low i.e., the output from the Operational Amplifier is low indicating a low soil moisture level, the program is executed such that the microcontroller signals the buzzer to set ON, and the relay is energized, the relay in turn, switches ON the pump to supply water to the soil irrigation begins. Irrigation continues until pin 12 of the microcontroller is high (5V) i.e., the output of the Operational Amplifier is high indicating a high soil moisture content at which point, the microcontroller signals the relay and de-energizes it and the pump is turned OFF and the buzzer is out OFF and irrigation is complete all of which is displayed on the LCD screen. The micro-code burnt into the microcontroller remains dormant until the chip is placed in a properly designed circuit and powered. The essence of the buzzer alarm and LCD Display is to alert the user that water level is low so as to check if the pump is operating well and also to ensure there is sufficient water in the given field.
Also, some basic circuit is required for proper operation of the microcontroller in the main circuit; one of such basic circuit is a reset circuit that ensures the microcontroller is properly initialized on power ON by starting from the beginning of the micro code inside. R10 (10KΩ) and C3 (10µF) are used to form the reset circuit as prescribed by the manufacturer of AT89S52. For these projects a RF module was introduced to transmit and receive soil moisture content.

RF module Unit: This unit consists of the receiver and transmitter sections which must be connected together wirelessly before field communication takes place. Where data of soil moisture content is gotten and processed onto the display screen. The wireless communication technology is used to interact between user and system. That is to send and receive soil moisture information, status of pump. All sensors are interfaced with microcontrollers. RF modules are electronic devices that receive and demodulate radio frequency (RF) signals, and then modulate and transmit new signals. They are used in many different video, voice and data applications. RF modules consist of an antenna to receive transmitted signals and a tuner to separate a specific signal from all of the other signals that the antenna receives. Detectors or demodulators extract information that was encoded before transmission. Radio techniques are used to limit localized interference and noise. To transmit a new signal, oscillators create sine waves which are encoded and broadcast as radio signals.
Radio frequency module are based on operations over a certain distance and transfer information within a data rate. The RF modules are very small in dimensions and have a wide operating voltage range i.e., 3v to 12v.
Basically, the RF module used is 433Mhz frequency band. The transmitter draws no power. When transmitting logic zero while fully suppressing the carrier frequently that consumes significantly low power in battery operation. When logic one is sent carrier is fully on to about 45mA, with a 3 volts power supply.

Wavelength; using the equation below

$$F = C / \lambda \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where C = Speed of light = 3×10^8

F = Frequency = 433 MHz
ƛ = Wavelength = C/F ………………… (2)

Using equation (2) $= \frac{3x10^{8}}{433 \times 10^{6}} =$ 6.9 $x10^{11}$m

Frequency range, Distance between receiver and transmitter units when connection is established;

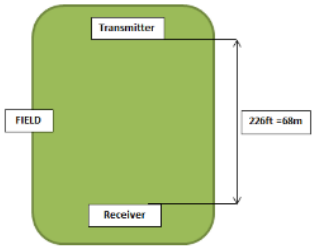

Fig. 3.7: Measured field distance between Transmitter and Receiver.

The data is sent serially from the transmitter which is then received by the tuned receiver. The transmitter and receiver are interfaced to the microcontrollers for data transfer. All required RF functions are integrated, only an external crystal and bypass filtering are needed for operation. The RF Module features a completely integrated PLL (Phase Locked Loop) for easy RF design, and its rapid settling time allows for fast frequency-hopping, bypassing multi-path fading and interference to achieve robust wireless links.

Features of RF Module.

i. **LCD Display unit (LCD):** This unit displays soil moisture information gotten from the receiving unit of the RF module. LCD is used here to display Soil moisture status Obtained from receiver unit of RF Module. LCD is an integrated module capable of showing alphanumeric symbols. These are basically used as a feedback element, showing the states of the system or other information. LCD can add a lot to application in terms of providing useful interface for the user.

ii. **The Driver Unit:** This unit consists of an electromechanical relay and sprinkler system attached to a pump. It works in accordance with the control signal from microcontroller. Here the relay and its associated driving circuit are implemented here to operate the water pump for irrigation purpose. The suitable logic on the output pin of microcontroller biases the transistor to trigger the relay so as to operate the water pump.

iii. **The power supply unit:** This unit powers the whole system based on a 240v mains. AC supply which is regulated to 12v to power the relay and Buzzer, led/output and 5v to power the microcontroller. From block diagram, the proposed system consists of power supply unit, here power supply is a step-down transformer, which steps down the voltage to 12VAC by using a bridge rectifier. This A.C is converted to D.C then it is regulated to 12v and 5v, using a voltage regulator to supply the buzzer (output indicators), and also used to power the microcontroller

SOIL MOISTURE MEASUREMENT

The following equations helped to determine when to carry out irrigation i.e. what to consider when calibrating the soil moisture sensor for the threshold value

AD = (FC – PWP) x MAD……………………… (3)
AWC = FC – PWP………………………………. (4)
FC – AD = LL……………………………...... (5)

Where,

i. Allowable Depletion (AD) represents the amount of soil moisture that can be removed by the crop from the soil before it starts to stress to get water.
ii. Field Capacity (FC) refers to the amount of water left behind in the soil after gravity drains saturated soil.
iii. Permanent Wilting Point (PWP) refers to the amount of water in soil that is unavailable to plants.
iv. Lower Soil Moisture Limit (LL) is the soil moisture value below which the crop will become stressed because it will have insufficient water. Water LL is reached, it is time to irrigate.
v. Maximum Allowable Depletion (MAD) is the fraction of the available water that is 100% available to the crop.

vi. Soil saturation refers to the situation where all the soil process are filled with water. This occurs below the water table and in the unsaturated zone above the water table after a rain or irrigation event. After the rain/irrigation event, the soil moisture (above the water table) will decrease from saturation to field capacity.

IV. EXPERIMENTAL TEST

Experimental tests were performed on varies soil samples to know the capillary in the various soils used.
Equipment used: Analog Millimeter, Calibrated Beakers, Container filled with water, Meter rule. Proposed built device. Soil samples.
Soils used: Loamy, Top and sandy soils.
Aim: To know water capillary among selected soil samples.
Procedures taken:

Setting up the laboratory for experiment refer to fig. 3.6, some samples of dry loamy soil were collected and put in a container then probes from transmitter unit of device were placed at a measured distance of 4.5cm between probes then device sensed and sent a signal indicating that soil was low on water which was displayed on receiver part of the proposed device. Terminals of multimeter were put at the same spot on each probe, then water was gradually poured at measured quantity in milliliters we got to see the resistance level was decreasing and varying on screen of multimeter, then as water level increased, we got to observe a saturation point.

4.1 TEST RESULTS

The following values were obtained for the 3 soil types.

Table 4.1 Soil type: loamy, showing water level (ml) / resistance (Ω)

S/N	Water level (ml)	Resistance (Ω)	STATE
1.	50	170	VARYING
2.	65	160	VARYING
3.	80	150	VARYING
4.	95	140	VARYING
5.	110	130	VARYING
6.	125	120	SATURATION
7.	140	110	SATURATION
8.	180	110	SATURATION
9.	200	110	SATURATION
10.	300	110	SATURATION

TABLE 4.2 Soil type: top soil showing water level (ml) / resistance (Ω)

S/N	Water level (ml)	Resistance (Ω)	STATE
1.	75	50	VARYING
2.	100	45	VARYING
3.	125	40	VARYING
4.	150	35	VARYING
5.	200	30	VARYING
6.	225	20	SATURATION
7.	250	15	SATURATION
8.	225	10	SATURATION
9.	275	5	SATURATION
10.	300	0	SATURATION

Table 4.3 Soil type: sandy soil, showing water level (ml) / resistance (Ω)

S/N	Water level (ml)	Resistance (Ω)	STATE
1.	80	200	VARYING
2.	105	180	VARYING
3.	130	160	VARYING
4.	155	140	VARYING
5.	168	130	VARYING
6.	180	120	SATURATION
7.	180	120	SATURATION
8.	180	120	SATURATION
9.	385	120	SATURATION
10.	350	0	SATURATION

Experimental Calculations:
From the tables above the following calculations were be made;

i. Gradient of conductivity (m), = $\frac{\text{Higher water level (ml) - Lower water level (ml)}}{\text{Higher Resistivity }(\Omega)\text{ - Lower Resistivity }(\Omega)}$.

Using the linear graph equation, y = mx + c (to get graphical results)
Where y = Water Level (m)
m = gradient of conductivity
x = resistance in (ohms)
c = intercept

For **loamy soil**, using the above formulars we have,

Gradient of conductivity (m) $= \frac{110 - 50}{110 - 150} = \frac{60}{-40} = -1.5$

For intercept using y = mx + c
50 = (-1.5)170 + c
50 = -255 + c
c = 50 + 255 = 305

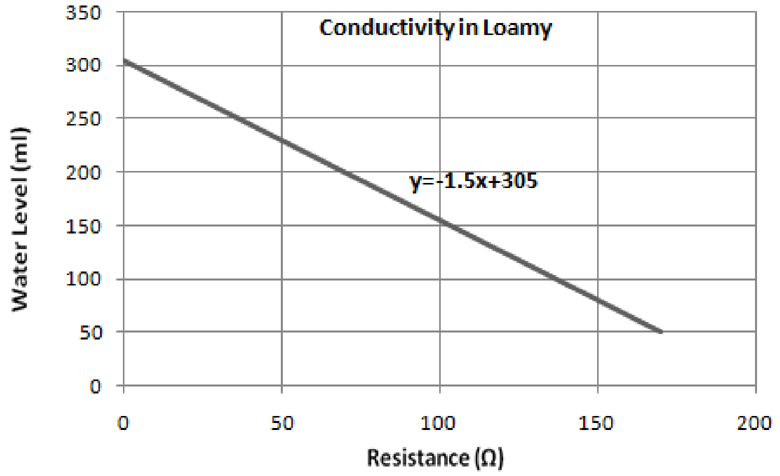

Fig.4.1 Graph of Water level (ml) / Resistance(Ω) for loamy soil.

For **Top Soil**,
Gradient (m) = - 5
Intercept = 300

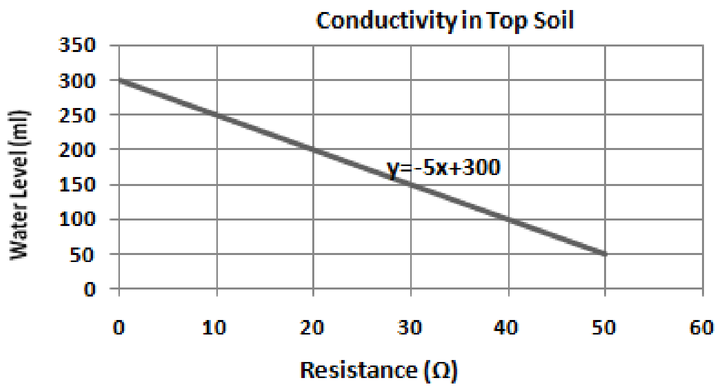

Fig.4.2 Graph of Water level (ml) / Resistance(Ω) for Top Soil

For **Sandy Soil**,
Gradient (m) = - 1.25
Intercept = 350

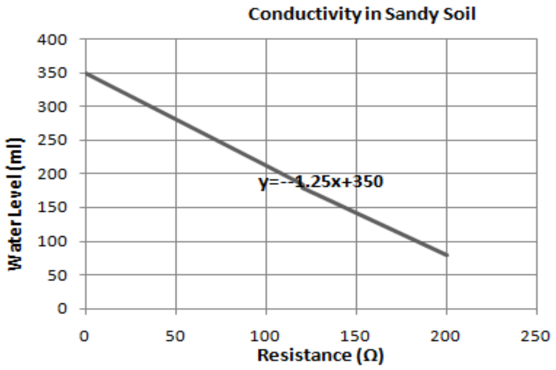

Fig.4.3 Graph of Water level(ml) / Resistance(Ω) for sandy soil.

*The same formulars were used to derive the gradient and intercept for other soil samples.

4.2 RESULT ANALYSIS

Results were obtained on three (3) different soil samples, graphs were plotted to show that increase in water level (*ml*) in soil decreases the resistance (Ω). And further addition of water doesn't show any decrease in resistance and at such point it is assumed that water level of soil is saturated. The result also shows the soils porosity. The greater the soil porosity the more it easily conducts electricity. From the performance test, Sandy soil has the least resistance, followed by loamy and top soil. Hence sandy soil has the highest conductivity than loamy and top soil. The high conductivity rate of sandy soil clearly defines its porosity. Clearly it shows that,
The resistance (Ω) varies with water level (*ml*).
Resistance (Ω) varies with conductance.
Conductance varies directly with water level (ml) of soil. That is if the soil moisture is high the soil conducts more because of movement of ions in the electrolytes in the soil which is a measure of the soil conductivity that tends to increase but if soil moisture is low the conductivity of soil decreases.

V. CONCLUSION

The Improved Automatic Irrigation System has the ability to monitor and control the activities on the applied field by sensing the soil moisture and sends signals of moisture content of the soil through automatic wireless means of RF Modules, were an improved device with accurate soil moisture measurement and control in fields based on RF Modules and a display LCD Screen. This can also be useful for increasing the economy and demand of food necessity. Microcontrollers were well programmed to carry out the desired irrigation task with the of sensors, resistors, capacitors, operational amplifiers and many more. An experimental test was carried out were results were analysed on three different soil types to check the operational performance of the proposed device.

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