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Development and Implementation of an Automatic Plant Watering System

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ABSTRACT: The aim of this paper is to Automatic watering or irrigation control system has been designed and constructed. The prototype of the system worked according to specification and quite satisfactorily. The system components are readily available, relatively affordable and they operate quite reliably. The system helps to eliminate the stress of manual irrigation and irrigation control while at the same time conserving the available water supply. Improving Irrigation efficiency can contribute greatly to reducing production costs of agricultural products, thereby making the industry to be more competitive and sustainable .It can be seen from the results obtained that the system responded linearly with respect to the degree of dryness for the three soil types. There is a linear relationship between the degree of soil dryness and the time taken to irrigate the soil. At 50% dryness, irrigation duration was 2.0, 2.0 and 2.5 seconds for sandy, loamy and clayey soils respectively. While at 70% dryness, irrigation duration increased to 3.0, 7.5 and 8.0 seconds for sandy, loamy and clayey soils respectively. It is seen that irrigation in loamy soil generally took longer in loamy soil than in sandy soil, and clayey soil irrigation took longest.

KEYWORD: Moisture sensor, Relay, Water level sensor, DC motor pump, Water pump.

I. INTRODUCTION

An automatic watering system is a system which has been designed to automatically supply of adequate water from a reservoir to a farm or plants in all seasons. The major objective of this project is to see how the plant watering process or irrigation can be automated and also ensure optimal and efficient use of water in the process. In this project, the method used is to continuously monitor the soil moisture level. The system employs the use of pumping mechanism to help transfer water from the reservoir to the plant(s). This system can basically be grouped into four subsystems, which are;

- Power supply unit.
- Sensory /Control unit.
- Pumping unit.

These subsystems are what make up the complete watering system.

In tackle the problem of our society today, there is a continuous increase demand of food and this requires an improvement in food production technology. The following are problems that can be solved by this work are:

- In some countries, where the economy is mainly based on agriculture and the climatic conditions are isotropic, we are still unable to make proper use of agricultural resources. The major reason of the improper use of agricultural resources is the lack of rains and scarcity of land reservoir water.
- Another very important reason of this is due to unplanned use of water in which a significant amount of water goes to waste. In modern irrigation systems, a major advantage is that water is supplied close to the roots of the plants drip by drip due to which large quantity of water is saved.
- At the present era, the farmers make use of irrigation techniques with manual control in which farmers are able to easily water their crops at regular intervals. This process sometimes consumes more water or sometimes the water reaches which causes the crops get dried.

The solution to these problems can be found in this work which is an automatic watering system, in which the irrigation process will be carried out with the use of acute water requirements.

The main objective of this work is to design a small scale automatic watering system that would be able to use water in a more efficient way in other to prevent water loss and minimize the cost of labor. The objectives of the work are to:

- Continuously monitor the amount of soil moisture content of the plant (Usually achieved using a sensory unit in the system).
- To carry out experiment to determine the plant owners and formers to be able to properly water there crops, if the watering is required for the process of the soil water content to be used as baseline for performance assessment.
- Supply of material or crops determine the amount of water required for the plant to grow. This is dependent by how well the reading gotten from the sensor process.

- Stop the water supply when the required amount has been received by the plants. This feature is important as the amount of water available for the system is not infinite, therefore water management is paramount.

The scope of this paper is to be able to develop a system that aid plant owners and farmers to be able to properly water there crops/plants in areas of low rain fall in Nigeria (such as areas or states in the northern geopolitical zone).

II. REVIEWS ON RELATED WORK

E. Walter Coward, Jr. and Gilbert Levine review past research, emphasizing the types of studies which have so far provided information on farmer-managed irrigation systems. These include:

- Colonial compilations.
- Anthropologically, which describe irrigation systems but in which irrigation is incidental to the issues being studied.
- Irrigation ethnographic that describe how existing farmer managed systems operate.
- Development-oriented studies which either examine cases of intervention or study, farmer-managed systems in order to make policy recommendations regarding intervention.

A study of traditional irrigation systems in northern Laos is a preeminent example of irrigation ethnography (Taillard, 1972). The report gives details of the geographical zone, and the types of apparatus used to acquire in land in which farmers to be able to easily water their crops at regular interval.

Wilkinson's (1977) study of irrigation systems in Oman represents a third careful irrigation ethnography. Unlike the Grader and Taillard examples which have irrigation descriptions as their end, Wilkinson's research purpose is to understand systems and settlement forms in the context of larger historical processes of political control. However, his means to this end is a careful discussion of the local irrigation system of central Oman.

III IRRIGATION SYSTEMS HISTORY

To irrigate is to water crops by bringing in water from pipes, canals, sprinklers, or other man-made means, rather than relying on rainfall alone. Places that have sparse or seasonal rainfall could not sustain agriculture without irrigation. In areas that have irregular precipitation, irrigation improves crop growth and quality. By allowing farmers to grow crops on a consistent schedule, irrigation also creates more reliable food supplies.

Ancient civilizations in many parts of the world practiced irrigation. In fact, civilization would probably not be possible without some form of irrigation. The earliest form of irrigation probably involved people carrying buckets of water from wells or rivers to pour on their crops. As better techniques developed, societies in Egypt and China built irrigation canals, dams, dikes, and water storage facilities. Ancient Rome built structures called aqueducts to carry water from snowmelt in the Alps to cities and towns in the valleys below. This water was used for drinking, washing, and irrigation.

Modern irrigation

Modern irrigation systems use reservoirs, tanks, and wells to supply water for crops. Reservoirs include aquifers, basins that collect snowmelt, lakes, and basins created by dams. Canals or pipelines carry the water from reservoirs to fields. Canals and pipelines, just like the ancient Roman aqueducts, often rely on the force of gravity. Pumps may also move water from reservoirs to fields. Crops are irrigated by several methods: flooding an entire field, channeling water between rows of plants, spraying water through large sprinklers, or letting water drop onto plants through holes in pipes.

Letting water drop onto plants through holes in pipes, known as drip irrigation, is considered one of the most efficient methods of irrigation. Drip irrigation focuses the water onto the plant itself. Other methods can waste water by letting it absorb into the ground where there are no plants. Water can also evaporate into the air when sprayed through sprinklers.

FUTURE OF IRRIGATION

During the twentieth century, the amount of irrigated land in the world doubled. An estimated 18 percent of the world’s cropland is now irrigated. This expansion has occurred mainly in Asia, Africa, and South America.

Even desert ecosystems like those in Jordan use irrigation. Jordan uses a variety of irrigation techniques with groundwater from wells and aquifers.

To help meet the worlds demand for food, more farmland and more irrigation may be needed. Many experts fear that the expanding use of irrigation in some areas will deplete aquifers, reducing the amount of freshwater available for drinking and hygiene.

The Aral Sea, in Central Asia, has been almost completely emptied by irrigation. In 1918, the Soviet government decided that the two rivers that fed the Aral Sea, the Amu Darya and the Syr Darya, would be diverted to irrigate crops of cotton, melons, and citrus in the deserts of Kazakhstan and Uzbekistan. Canals were poorly built, and much of the water went to waste. Before large-scale agriculture was introduced in the 1940s, the Aral Sea had an area of 68,000 square kilometers (26,255 square miles). Today, the Aral Sea is three separate lakes, with a combined area of fewer than 17,000 square kilometers (3,861 square miles).

The Aral Sea ecosystem has been nearly eliminated. The areas once-thriving fishery has been destroyed. Huge fishing vessels now sit abandoned in the middle of the salty desert.

Kazakhstan and Uzbekistan are working with environmental organizations to preserve what is left of the Aral Sea while still allowing farmers to irrigate their crops. Kazakhstan, for example, built a dam to retain water in the North Aral Sea, one of three lakes now in the area. Fish are slowly returning. Improved irrigation canals from the Amu Darya and Syr Darya also reduce the amount of water lost to agriculture.

IV. LITERATURE REVIEW OF INTENDED WORK

From the reports earlier reviewed, Irrigation or plant watering has always been carried out with the help of a lot of physical labor. The intended project aims at eradicating that extra physical labor which indicates the project tends to the attributes of portability and effectiveness. It also tends to be able to function properly without the use of man power.

V. MATERIAL AND METHOD

The key focus of the work in term of methodology is the automatic irrigation or watering system is designed to continuously sense the moisture level of the soil. The system which has been developed to automatically supply of adequate water from a reservoir to a farm or plants which can be used to continuously monitor the soil moisture level. The reference level of soil moisture content was made to be adjustable for the three most common soil samples (sandy, loamy and clay soils). Also the amount of irrigation, i.e. the volume of water delivered to the soil, will be adjustable by the system operator (mild, nominal and high levels). The block diagram of the system developed is shown in figure below;

The moisture sensors were designed using probes made from corrosion-resistant material which can be stuck into soil sample. Voltage levels corresponding to the soil consistency which is measured for wets, moist and dry soil sample with which soil material are held together or the resistance of soils to deformation or rupture which may be measured more accurately in the output voltages of a comparator circuit or laboratory. Simulation studies will be carried out to evaluate the performance of the proposed soil types in the testing system. Finally, the simulation were done with the help of the proteus software

MATERIALS AND EQUIPMENT

1. **Moisture Sensor:** Soil moisture sensor measures the volumetric water content of the soil by some indirect methods which include measuring different properties of soil like electrical resistance, dielectric constant and interaction with neutrons. It has one probe like structure which will be dipped inside the soil.

Fig 1.0: moisture sensor

2. Relay: **control the operation of the pump's electrical motor**. The relay itself is remotely controlled by the water system pressure switch.

Fig1.1: relay

3. **Water level sensor:** The water level sensor is **a device that measures the liquid level in a fixed container that is too high or too low.**

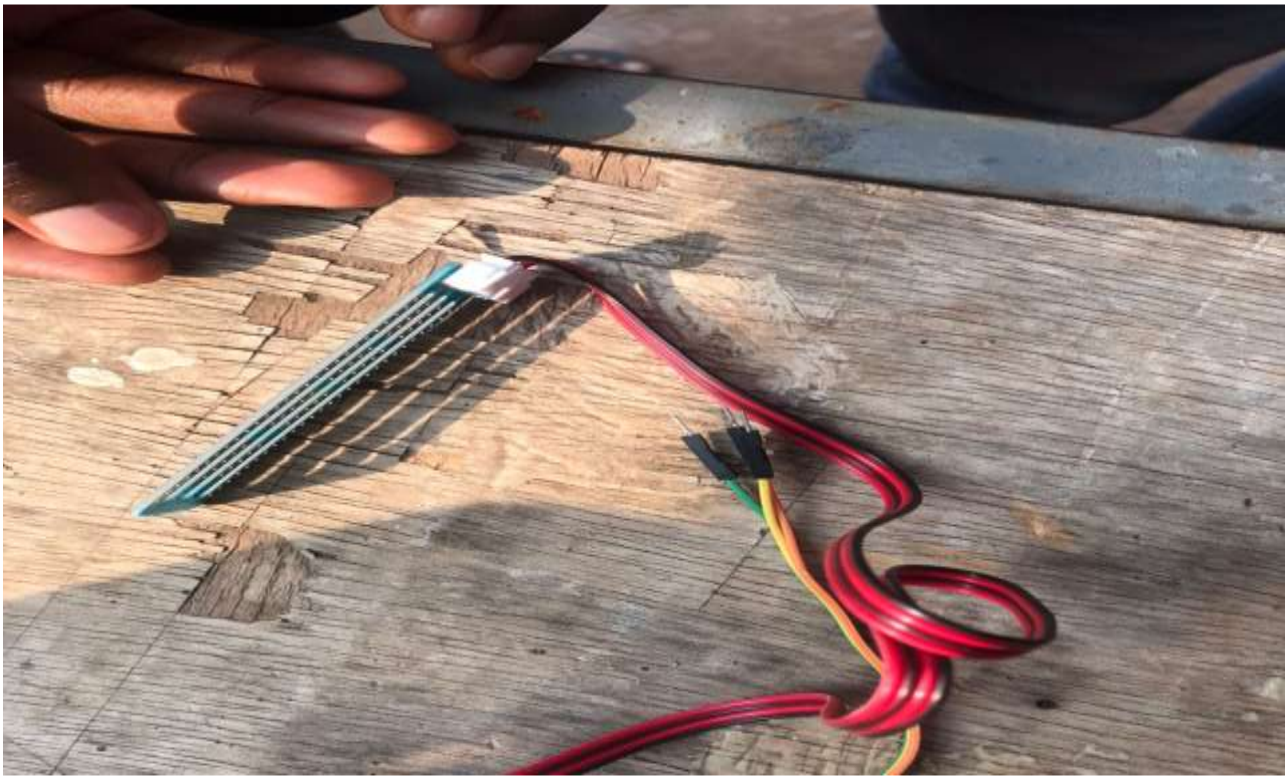

Fig 1.2: water level sensor

4. **Dc Motor Pump:** The DC motor is used **as a pump drive motor** due to its variable speed control capability, especially in the case of low speed, simple control system, high starting torque and good transient response.

5.

Fig 1.3: dc motor pump

6. **Wires:** is **a multiconductor cable that connects a submersible pump controller to the motor of the pump**, which is often located in a deep well.

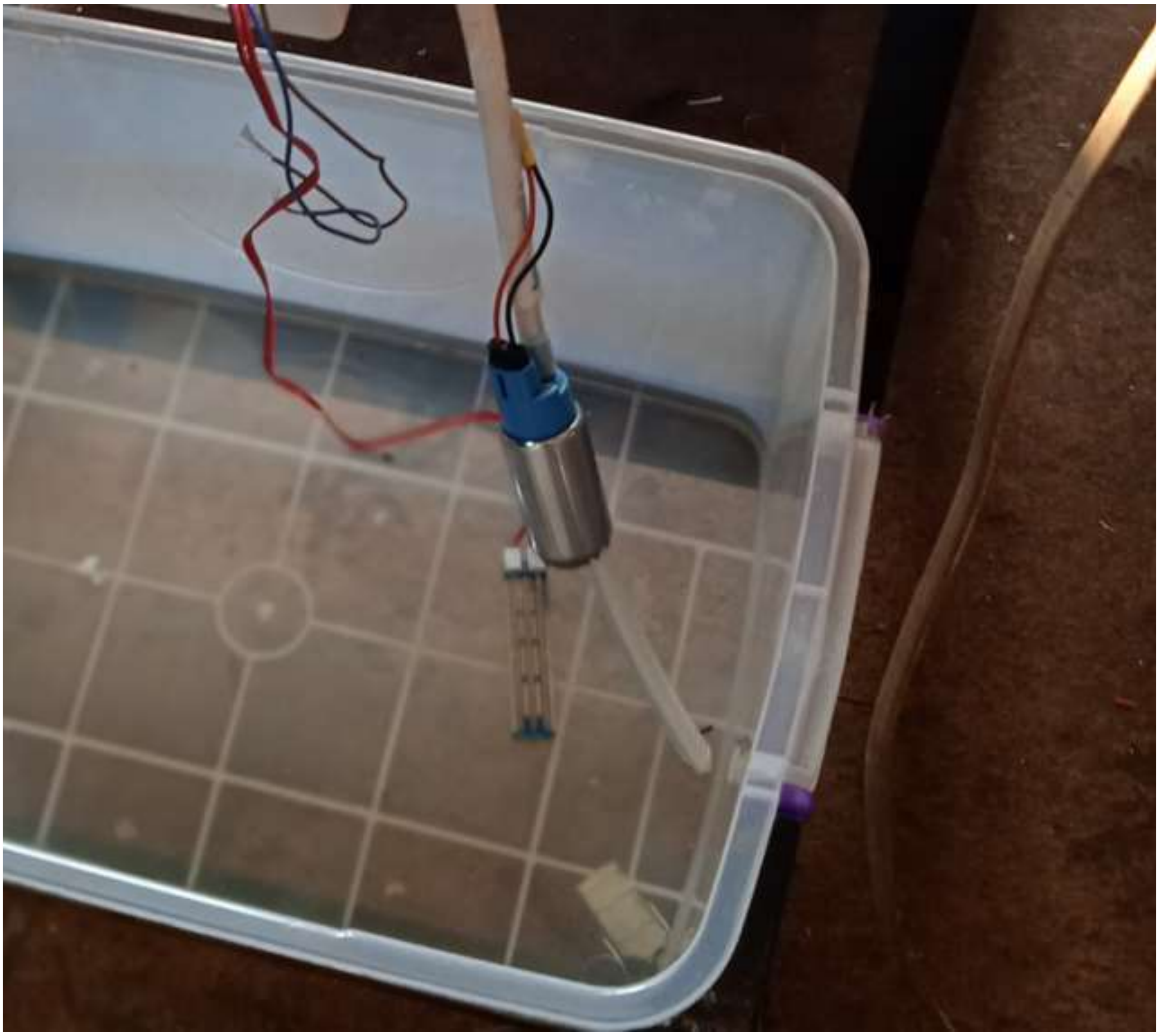

Fig 1.4: wires

7. **Vero board**: this is type of board used for making electrical circuits, where the electrical connections are formed by strips of copper on the underside of the board.

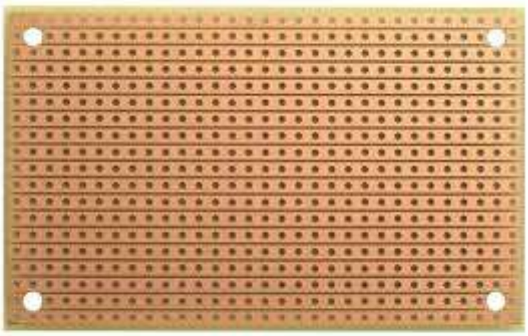

Fig 1.5: vero board

8. **Resistors**: this is passive electrical components used to provide electrical resistance in an electric circuit.

Fig 1.6: resistor

9. **Transistor**: These are very small semiconductors that regulate or control current or voltage flow in addition amplifying and generating these electrical signals and acting as a switch/gate for them.

Fig 1.7: transistor

10. **Diode**: These are electrical components that only allow electricity to flow though one end. It is mainly used in rectification.

Fig 1.8: diode

Transformer: A transformer is **an electrical device that uses the principle of electromagnetic induction to transfer energy from one electric circuit to another**.

Fig 1.9: transformer

Battery: It is a source of electric power consisting of electrochemical cells with external connections to powering electrical devices.

Fig 2.0: battery

11. **Pipes**: The piping **used to carry the fluid**. **Valves used to control the flow in the system**. **Other fittings, controls, and instrumentation**.

Fig 2.1: pipes

The power supply circuit

A step-down transformer with turn ratio of 16:1 was selected to transform the 240V mains supply voltage to 15V for the power supply. The 15 V ac was converted to dc voltage using a full wave rectifier circuit. The circuit was designed as follows:

Vdd=diode forward conduction voltage drop
Vb=base voltage
Vs= transformer secondary voltage
Vsp= peak value of transformer secondary voltage
Vm= peak output dc voltage from the diode bridge
Vac= average value of the diode bridge output voltage
Vdc= rms value of output dc voltage of the diode bridge
Y= ripple factor for a full wave rectification process using a diode bridge
Vr= ripple voltage
C = capacitance value
I = required output current from the wave rectifier circuit
F = frequency
t = time taken for filtering capacitor to discharge in compensation for the ripple in the dc output
q =charge on filtering capacitor

$V_b = 2 \times V_{dd}$……………………………………………….(1)

$V_{Sp} = 1.414 \times V_S$…………………………………………...(2)

$V_m = V_{Sp} - V_b$……………………………………………….(3)

$= \frac{V_m}{1.414}$ ………………………………………………… .(4)

$V_{ac} = \frac{2}{\pi} \times V_m$………………………………………… .(5)

V_{dc}

$y = \sqrt{\frac{{V_{dc}}^2 - {V_{ac}}^2}{1.414}}$ ……………………………………………..(6)

$V_{dd} = 0.7V$

$V_b = 2 \times 0.7 = 1.4V$

$V_s = 15V$

$V_{sp} = 1.414 \times 15 = 21.21V$

$V_m = 21.21 - 1.4 = 19.81V$

$$V_{ac} = \frac{2}{\pi} \times 19.81 = 12.611V$$

$$V_{dc} = \frac{19.81}{1.414} = 14.01V$$

$$y = \frac{\sqrt{14.01^2 - 12.611^2}}{14.01} = 0.48$$

The ripple **Ripple current peak-to-peak into the −5V output capacitor is approximately equal to twice the negative load current**.

and is related to the filtering capacitance by the following equations

$q = I \times t = C \times dV_{sp}$……………………………………..(7)

$t = 2 \times f$

$dV_{sp} = V_r$

$V_r = y \times V_{sp}$ ……………………………………………(8)

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

$C = \frac{I}{2 \times f \times V_r}$……………………………………………(9)

For the power supply to output a current of

$2.5A, I = 2.5A$

$f = 50Hz$

$$V_r = 0.48 \times 21.21 = 10.1808V$$

From eqn. (3),

$C = \frac{I}{2 \times f \times V_r} = \frac{2.5}{2 \times 50 \times 10.1808}$

$= 2{,}456uF$

The closest available capacitor value to this is the 2200uF capacitor which is still acceptable as it will further reduce the ripple in the output voltage. A 12 V regulator, uA7812 to regulate the output is due to its capability to limit the current in order to prevent excessive current and also reduce the amount of power lost as heat in the circuit. 0.1uF noise filter capacitors are used to ground the external or environmental noise voltages that the circuit may pick up. This ensures that the circuit produces an almost pure dc voltage of 12 volts.

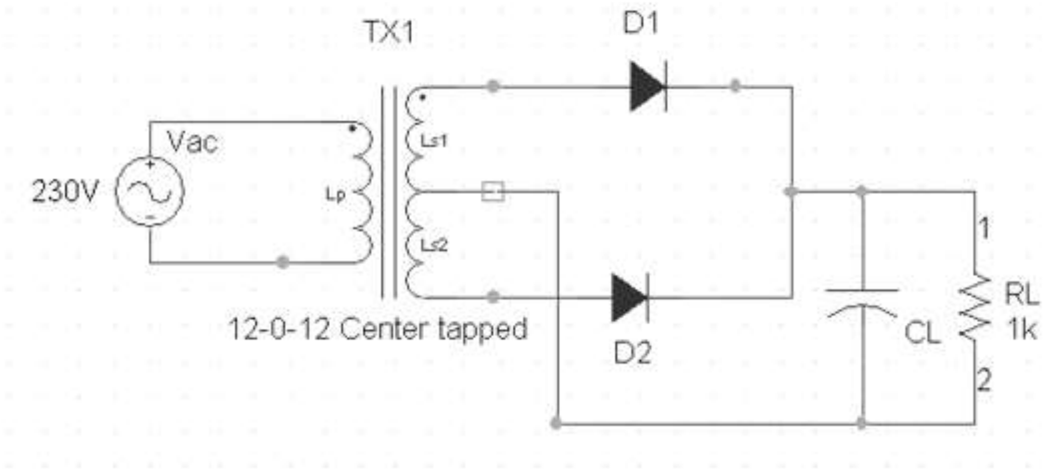

Fig 2.2 circuit diagram of power supply unit

The system also has a secondary power supply source which is a battery capable of providing the same 12 volts.

The sensor unit

The sensor unit is made up of two flat surfaced conducting metal probes. The first sensor is the water level sensor which reads the level of water in the reservoir tank and the other is the moisture sensor which reads if the soil is wet or not.

The pump

A 12 V dc-powered motor was used in designing the pump. The motor was powered from the 12V dc output from the power supply circuit. The pump was able to supply 250 cm3 of water in 10 seconds. The required irrigation time was calculated as follows:

PC = Pumping capacity of the pump/flow rate

VP = Volume of water pumped
Tv = Time taken to pump VP in seconds
Virr = Volume of water required for refilling the from dry point
Tirr = Required time for irrigation (length time for which the pump must be active)

$P_C = \frac{V_P}{T_V}$……………………………………………………. (10)

$T_{irr} = \frac{V_{irr}}{P_C}$…………………………………………………. (11)

$V_P = 250cm^3$

$V_{irr} = 200cm^3$

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

$T_{irr} = \frac{200}{25} = 8s$

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

The control circuit

One of the most important components of a poultry automatic drinking refilling system is the system controller also called a timer or clock. A 555 timer was used as the brain of the control circuit due to its operational characteristics in the mono stable mode. The timer was used to produce 11.01 V to energize the relay coil, consequently activating the pump motor circuit for about 5 seconds, which is the time needed for irrigation Tirr. Connected in the mono stable mode, the parameters of the 555 timer are as follows:

Vcc= supply voltage to the timer = Vdc
Rt= resistance tying the discharge and threshold pins to V**cc**
Ct = capacitance tying the discharge and threshold pins to ground
C**1**= decoupling capacitor for noise voltage filtering. Standard value is 0.1 **u**f
The reset pin is tied directly to V**cc**and the ground pin connected to ground. The output pin is connected to the relay. The values of R**t**and
Ct are calculated below
C**t** = 100 uf (selected for convenience)

$T_{irr} = 1.1 \times R_t \times C_t$……………………………………….(12)

$R_t = \frac{T_{irr}}{1.1 \times C_t} = \frac{8}{1.1 \times 100 \times 10^{-6}}$…………………………………(13)

= 72.8kΩ

In place of a single resistance value, a potentiometer is used for selecting values of ***Rt***.

This was done so that T_{irr} may be extended or shortened based on the water requirements in the particular water refilling container. A normally-open relay was used as the actuator to implement the triggering of the pump-motor circuit. A free-wheeling diode was connected across the relay coil to allow for current dissipation due to stored energy when the relay coil becomes de-energized. The circuit diagram for the sensing and control circuits in shown in figure 2.3

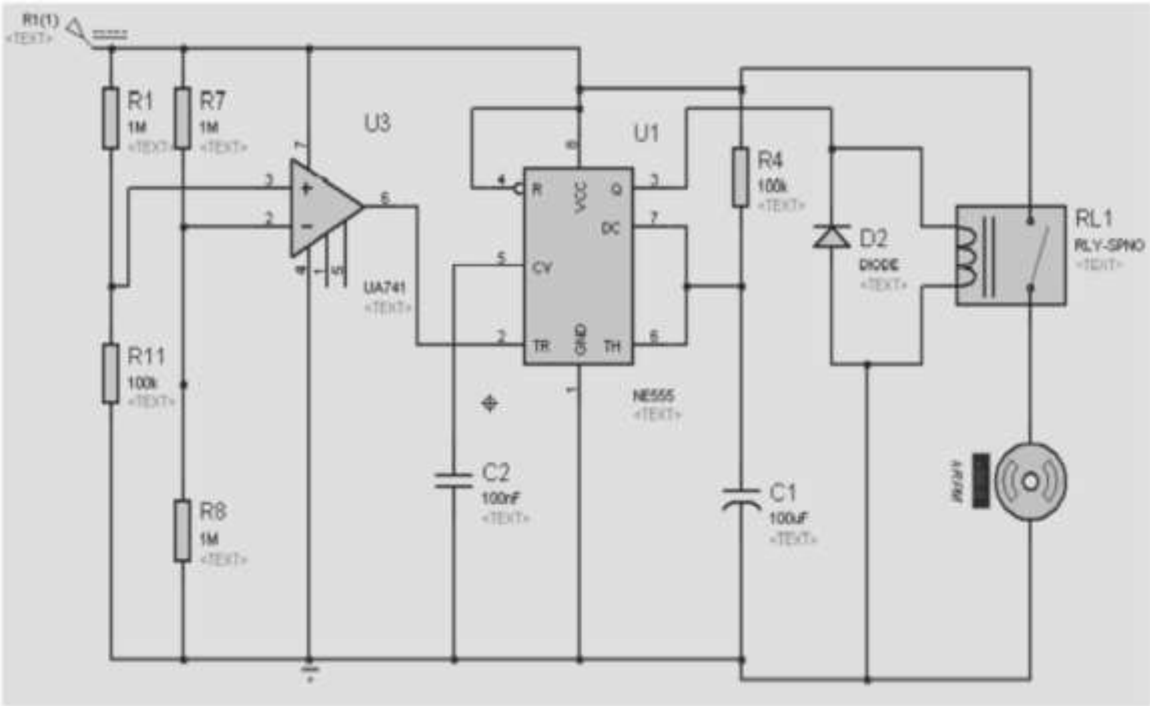

Fig. 2.3: System Circuit Diagram

As shown in fig (2.3), A moisture sensor was constructed to model the electrical resistance of the soil; a regulated 12 volts power supply unit was constructed to power the system; the control circuit was implemented using operational amplifier and timer; and the pumping subsystem consisting of a submersible low-noise micro water pump was constructed using a small dc-operated motor.

Model:

1. □The circuit is designed to sense dryness of the soil and subsequently switch on the electric pump to start the supply of water and switch off the pump whenever sufficient water is supplied.
1. □The Materials used are : Transistor 548, Resistor 1k, Variable resistor 47kΩ, Diode 1N4007, Relay 5v, LED, DC converter, Circuit board, Probes, AC water pump, Water reservoir, etc.
1. Probes of the circuit are to be inserted in the soil around plant.

Observations:

The circuit works as follow.

Soil Status	Working of Circuit
Dry	Circuit is switched on and pump starts
Wet	Circuit is switched off and pump stops

VII. DISCUSSION OF RESULT

Circuit implementation

The implementation of the electronic circuitry involved the computerized simulation of the system design, physical simulation of the circuit using a breadboard to ensure proper operation and the final implementation of the circuit on a Vero board i.e. the prototype. The simulations were done with the help of the Proteus software.

SYSTEM TESTING AND RESULT

The system was tested using different soil samples. Below is a table of the results obtained. Table 1.0 shows the amount of time the system took to irrigate different soil samples in different initial states. Figure 2.4 is a graphical representation of the result.

Table 1.0: The results obtained from operational test of the system

Soil sample	**Soil type**	**Initial soil state**	**Irrigation time**
A	**Sandy**	**100**	**5.0**

B	**Sandy**	**70**	**3.0**
C	**Sandy**	**50**	**1.5**
D	**Loamy**	**100**	**12.0**
E	**Loamy**	**70**	**7.5**
F	**Loamy**	**50**	**2.0**
G	**Clay**	**100**	**15.0**
H	**Clay**	**70**	**8.0**
I	**Clay**	**100**	**2.5**

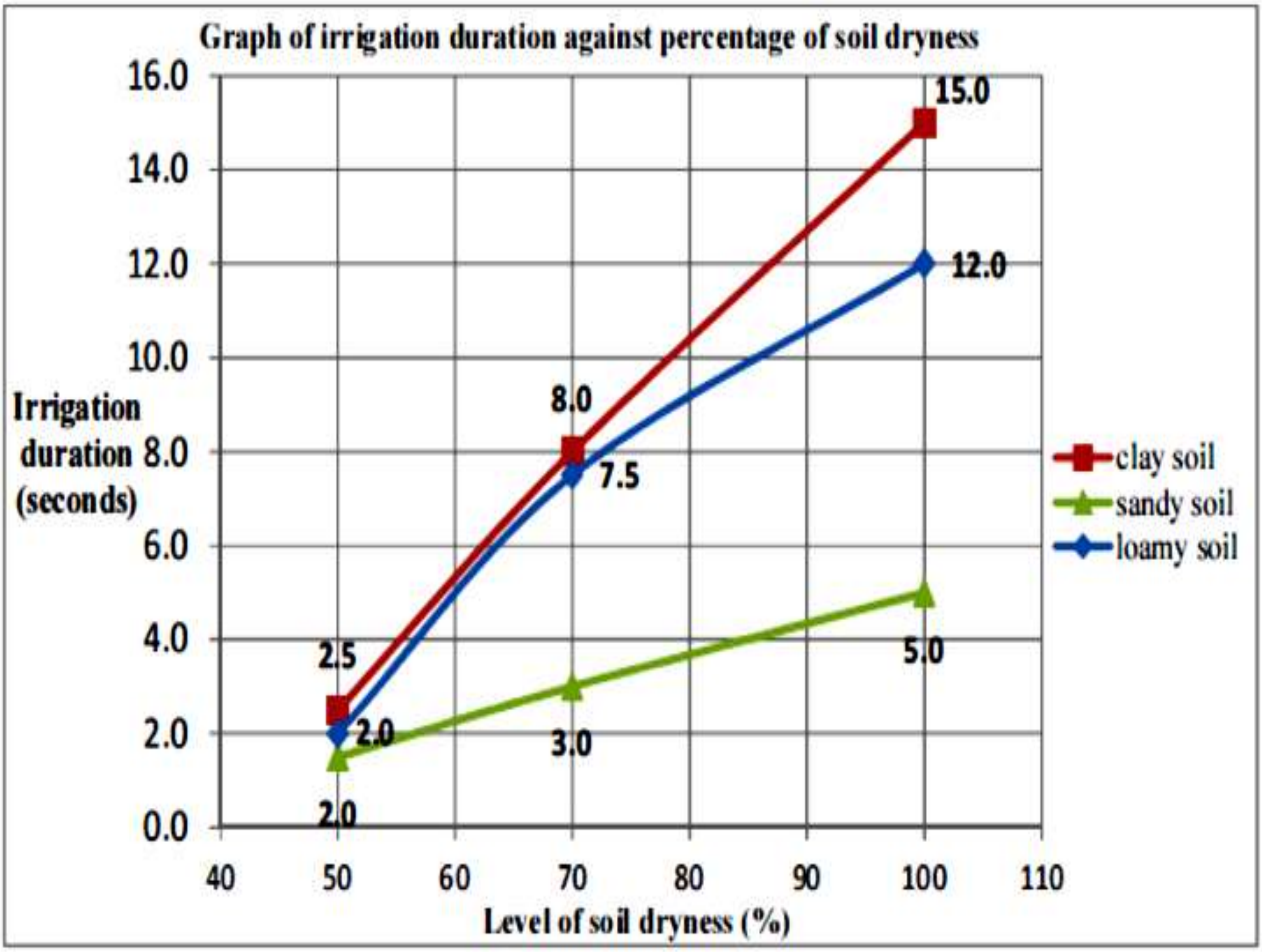

Figure 2.4: Graph of the system's response to soil samples of different conditions

RESULT ANALYSIS

It can be seen from the results obtained that the system responded linearly with respect to the degree of dryness for the three soil types. There is a linear relationship between the degree of soil dryness and the time taken to irrigate the soil. At 50% dryness, irrigation duration were 2.0, 2.0 and 2.5 seconds for sandy, loamy and clayey soils respectively. While at 70% dryness, irrigation duration increased to 3.0, 7.5 and 8.0 seconds for sandy, loamy and clayey soils respectively. It is seen that irrigation in loamy soil generally took longer in loamy soil than in sandy soil, and clayey soil irrigation took longest.

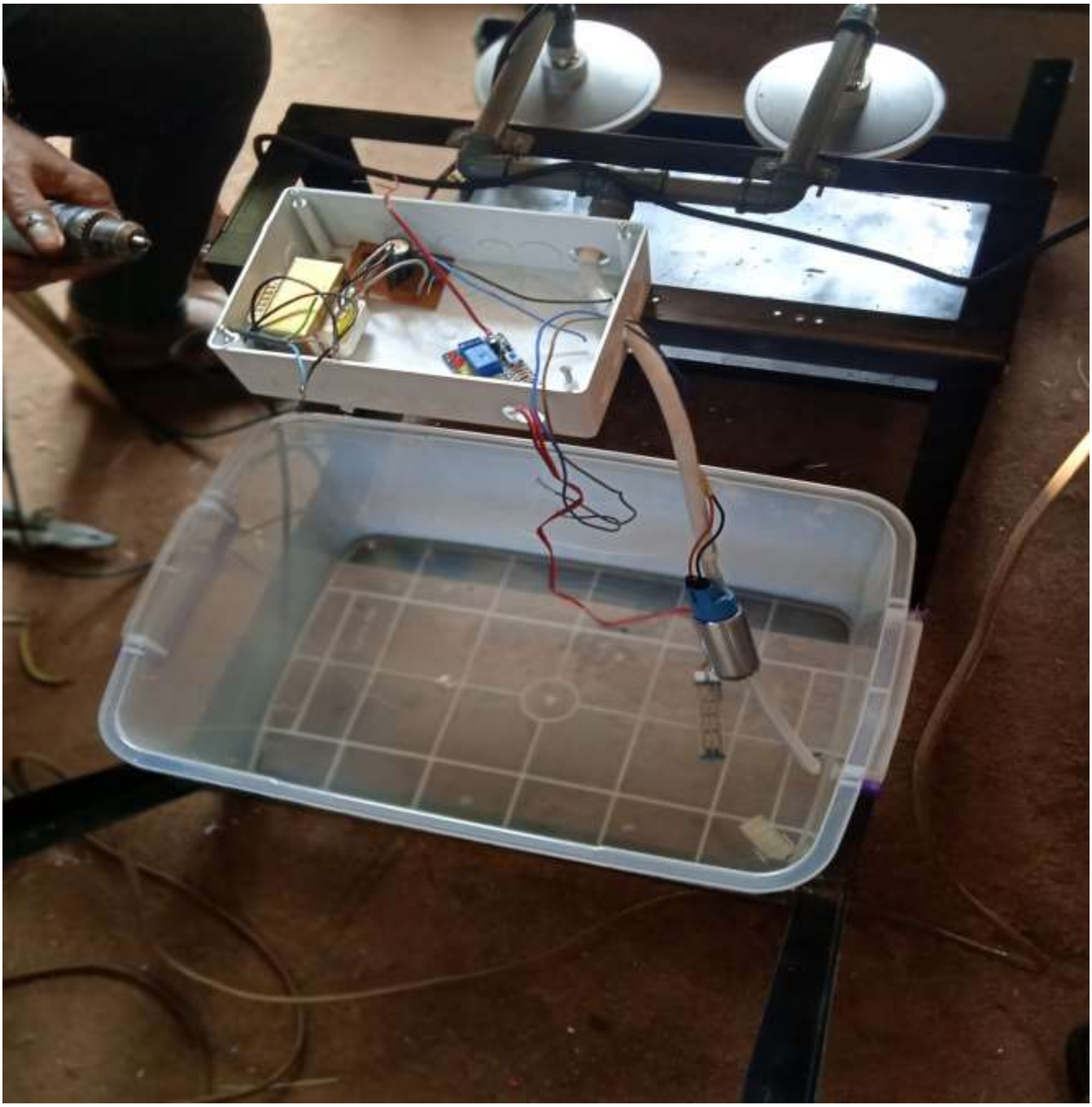

Fig 2.5: Picture of the complete project assembly.

CONCLUSION

An Automatic watering or irrigation control system has been designed and constructed. The prototype of the system worked according to specification and quite satisfactorily. The system components are readily available, relatively affordable and they operate quite reliably. The system helps to eliminate the stress of manual irrigation and irrigation control while at the same time conserving the available water supply. Improving Irrigation efficiency can contribute greatly to reducing production costs of agricultural products, thereby making the industry to be more competitive and sustainable.

The system was tested on three types of soil and from the result analysis sandy soils require less water than loamy soils and clay soils require the most water for irrigate.

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