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Development of Green Energy Automatic Plant Irrigator in Debre Berhan University

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Abstract-The motivation for this project came from the countries where economy is based on agriculture and the climatic conditions lead to lack of rain & scarcity of water. Here in Ethiopia the farmers working in the farm land are solely dependent on the rain and bore wells for irrigation of the land. Even if the farm land has a water-pump, manual intervention by farmers is required to turn the pump on/off whenever needed. The aim of this project is to minimize this manual intervention by the farmers. Two main purposes of the automated irrigation are due to the high level precision of the device, there is no un-planned usage of water, a lot of water is saved from being wasted, and the irrigation is the only when there is not enough moisture in the soil and the sensors decides when the pump should be turned on/off, saves a lot time for the farmers. This also gives much needed rest to the farmers, as they don't have to go and turn the pump on/off manually. Since in Ethiopia ruler area there is no access of electricity for the farmer to use the device, the researchers use 8-cell solar panel to provide voltage for the main control circuit board which can be excited by 5-volt, and to deliver water to the plant. Solar water pump also an ideal component of this project to overcome the shortage of electricity infrastructure challenge in the area where the farmer reside.

Keywords— LM324 IC, NE555 Timer IC, Water Pump, Relay, Conductivity, Computer Simulation/PCB design layout, Solar Cell

I. INTRODUCTION

In Ethiopia, the agriculture plays the important role in the economy and development of the country. In daily agricultural field irrigation is the most important cultural practice and most labor intensive task. Knowing when and how much to water are two important aspects of irrigation. To do this automatically, sensors and methods are available to determine when plants may need water. Since irrigation system in Ethiopia has given high priority in economic development, many new technologies should have to develop to allow agriculture automation to flourish and deliver its full potential. At the present time, the farmers have been using irrigation technique in Ethiopia through the manual control in which the farmers irrigate the land at the regular intervals. This process sometimes consumes more water or sometimes the water reaches late due to which the crops will get dried. So this research project is an excellent solution for such kind of problems in the country irrigation field. Here is a simple project more useful in watering plants automatically without any human interference. We may call it as automatic plant irrigation system. The system is electronic device, It will allow irrigation to take place in zones where watering is required, while bypassing zones where adequate soil moisture is indicated. The main aim of this research project is to provide automatic irrigation to the plants which helps in saving money, laboar-power, and water. More generally this project represent designing prototype form of electronic plant irrigator device.

II. RELATED WORK

Irmak and Haman,(2001); Muoz-Carpena et al., (2002); Muoz-Carpena et al., (2005) introduces ways of knowing soil moisture status. In these articles Soil water status can be determined by direct (soil sampling) and indirect (soil moisture sensing) methods, direct methods of monitoring soil moisture are not commonly used for irrigation scheduling because they are intrusive and labor intensive and cannot provide immediate feedback. Soil moisture probes can be permanently installed at representative points in an agricultural field to provide repeated moisture readings over time that can be used for irrigation management. Special care is needed when using soil moisture devices in coarse soils since most devices require close contact with the soil matrix that is sometimes difficult to achieve in these soils. In addition, the fast soil water changes typical of these soils are sometimes not properly captured by some types of sensors.

Dr. Peter Ling, (2005) in this article, it suggested we use soil moisture detector to do irrigation. Two suggested soil moisture detector are tensiometer and dielectric sensor. Advantage of a tensiometer is that they are not affected by the temperature of the soil water solution or the osmotic potential (the amount of salts dissolved in the soil water), as the salts can move into and out of the ceramic cup freely. Therefore tensiometer readings are not affected by electro conductivity (EC) or soil temperature. But, this type of sensor will need maintenance. Water in the tensionmeter cavity needs frequent refilling when tensiometers are used in dry environments where the tensiometer becomes a source of water that seeps out due to drier surrounding soil.

Fedro S. Zazueta et al., (1993) defined sensor as a device placed in the system that produces an electrical signal directly related to the parameter that is to be measured. In general, there are two types of sensors, continuous and discrete. Continuous sensors produce a continuous electrical signal, such as a voltage, current, conductivity, capacitance, or any other measurable electrical property. For example, sensors of different kinds can be used to measure temperature, such as thermistors and thermocouples. A thermocouple will produce a voltage difference that increases as the temperature increases. Continuous sensors are used where values taken by a state variable are required and an on/off state is not sufficient, for example, to measure pressure drop across a sand filter. Discrete sensors are basically switches, mechanical or electronic, that indicate whether an on or off condition exists. Discrete sensors are useful for indicating thresholds, such as the opening and closure of devices (vents, doors, alarms, valves,etc.). They can also be used to determine if a threshold of an important state variable has been reached. Some examples of discrete sensors are a float switch to detect if the level in a storage tank is below a minimum desirable level, a switching tensiometer to detect if soil moisture is above a desired threshold, and a thermostat to indicate if a certain temperature has been reached.

Sensors are an extremely important component of the control loop because they provide the basic data that drive an automatic control system. Understanding the operating principle of a sensor is very important. Sensors many times do not react directly to the variable being measured. For example, when a mercury thermometer is used to measure temperature, temperature is not being measured; rather, a change in volume due to a change in temperature is measured. Because there is a unique relationship between the volume and the temperature the instrument can be directly calibrated to provide temperature readings. The ideal sensor responds only to the "sensed" variable, without responding to any other change in the environment.

Fedro S. Zazueta et al., (1993) this study also shows that the existence of a few factors that need to be consider when we are choosing our sensors. Factors that need to be considered are such as sensors accuracy and time response. In certain project, if we will need a system that has high accuracy and fast response sensor with high accuracy and fast response are needed. In certain cases, the factors are not essential.

Dukes, Michael D. et al., (2005) in this patent, it stated that a controlled irrigation system can include a control device for determining whether to irrigate soil and at least one irrigation structure having an actuator for controlling water flow. The actuator can be communicably coupled to the control device for delivering water to irrigate a region. The controlled irrigation system further can include at least one time domain reflectometry sensor ("TDRS") located in the soil and communicably coupled to the control device for measuring soil moisture where the control device determines whether to irrigate the soil based on data from the at least one TDRS. Additionally, a method for controlling an irrigation system can include providing multiple TDRS's having probes, distributing each TDRS at a different soil depth, measuring soil moisture content, and irrigating soil based on the measuring step.

Jimmy Sturo, (2006) In this article, it stated that there are three types of solenoid valve which are general-purpose type, low pressure steam type and the high pressure steam type. Valve is one the components that will need maintenance. The solenoid valve can get damaged after a period of time. Thus, a replacement solenoid will be needed.

III. DESIGN AND IMPLEMENTATION

In this work, the automatic plant irrigator device here presented consists of the following major units: sensors, comparator circuit, timer circuit , indicator unit, solar cell and the pump and the core work of detecting soil moisture is done by the comparator circuit. The diagram below describes the flow of operations in the system as well as their inter-operability (Fig.1).

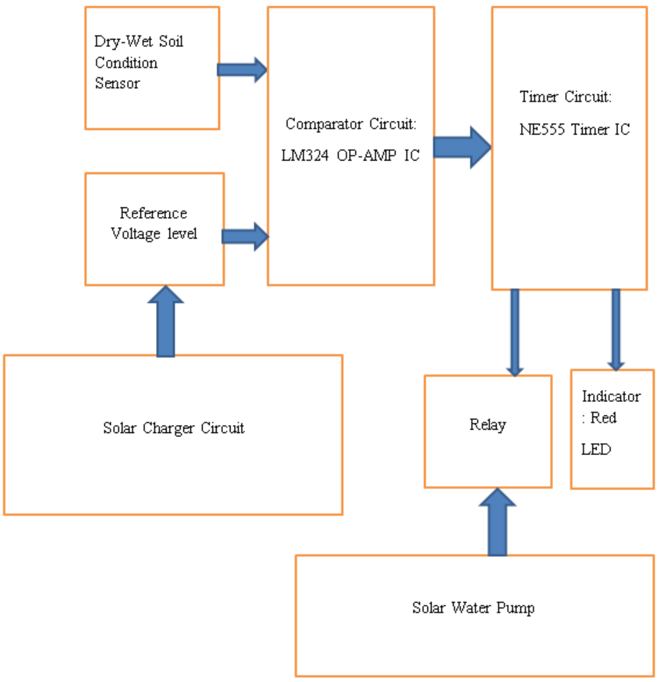

Figure 1.Block Diagram of the operations of the system

Taking advantage of the electrical conductivity property of wet soil, we used the copper conductors as the soil moisture sensor. When the soil wet the two copper wires installed becomes short, voltage is transferred to the copper which in turn is transferred to the comparator circuit for further processing. The LM324 IC comparator was used to compare the inputs from the electrodes in the soil and with a pre-set resistance/reference voltage and output a HIGH or a LOW with respect to the result from the comparison. This HIGH or LOW was fed into the timer circuit/NE555 IC which in turn uses this to control the water pump by energizing or de-energizing the relay and the circuit operation states is displayed by blinking the LED.

The specific software tools deployed for the virtual design and the implementation of the device are Multisim-Ultiboard 13.0 and Circuit Wizard.

MultiSim is an interactive circuit simulation package that allows us to view the circuit in schematic form while measuring the different parameters of the circuit. The ability to create a schematic quickly and then analyze the circuit through simulation makes MultiSim a wonderful tool to help us to understand the concepts covered in this project. There are two kinds of component models used in MultiSim: those modeled after actual components and those modeled after "ideal" components. Those modeled after ideal components are referred to as *virtual* components. The difference between the two types of components resides in their rated values. The virtual components can have any of their parameters varied, whereas those modeled after actual components are limited to real-world values.

Circuit Wizard is revolutionary new system that combines circuit design, PCB design, and simulation and CAD/CAM manufacturer in one complete package. By integrating the entire design process, this tool provides us with the entire tool necessary to produce an electronics project like presented in this paper from start to finish.

IV. RESULT AND DISCUSSION

When the soil is dry, the sensor output voltage is about 0.01uV which is the input to comparator op-amp(LM 324 IC) at inverting terminal and the reference voltage is about 4.5V which is a voltage applied to the non-inverting terminal of comparator op-amp (LM 324 IC) . The voltage is amplified in the op-amp and the output of it is given to NE 555-timer IC. This voltage is enough to energize and turn on the relay and hence the water pump starts watering the plant. Similarly when the soil is wet, the sensor output voltage is about 4.89 V which is the input to comparator op-amp(LM 324 IC) at inverting terminal and the reference voltage is about 4.5V which is a voltage applied to the non-inverting terminal of comparator op-amp (LM 324 IC) , now the input voltage is greater than that of reference . The voltage is amplified in the op-amp and the output of it is given to NE 555-timer. This voltage is not enough to energize the relay therefore the relay is turned off and hence the water pump stop watering the plant.

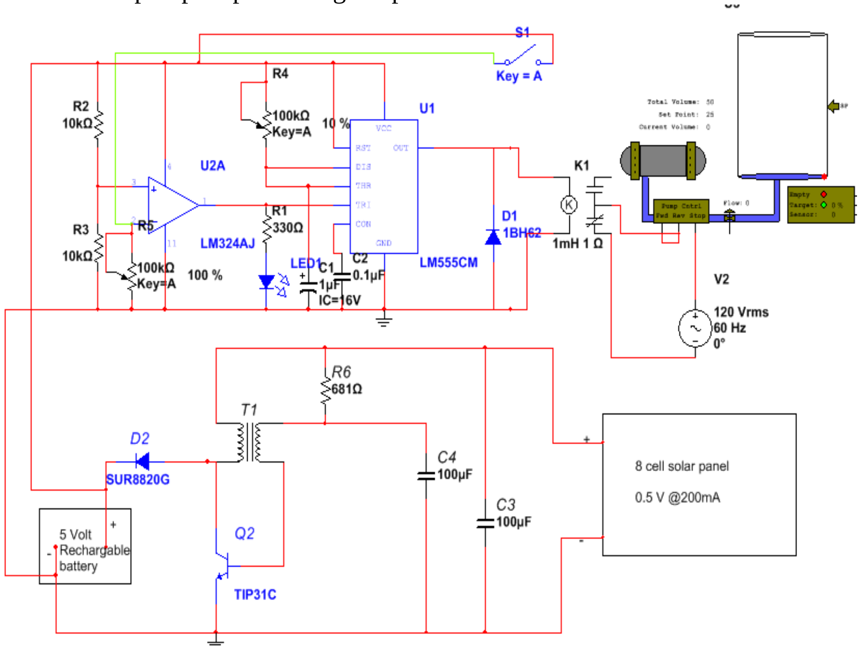

Figure 2. Automatic Plant Irrigator Circuit diagram

Figure 2 is the circuit that can irrigate the plants regularly. The circuit comprises a sensor part built using only one op-amp (U2A) of quad op-amp IC LM324. Op-amp U2A is configured here as a comparator.

Two stiff copper wires are inserted in the soil containing plants. As long as the soil is wet, conductivity is maintained and the circuit remains off. When the soil dries out, the resistance between the copper wires (Switch S1) increases. If the resistance increases beyond a preset limit, output pin 1 of op-amp U2A goes 'low'. This triggers timer IC2 (NE 555) configured as a monostable Mmultivibrator. As a result, relay K1 is activated for a preset time. The water pump starts immediately to supply water to the plants. As soon as the soil becomes sufficiently wet, the resistance between sensor probes decreases rapidly. This causes pin 1 of op-amp U2A to go 'high'. LED1 glows to indicate the presence of adequate water in the soil. The threshold point at which the output of op-amp U2A goes 'low' can be changed with the help of preset potentiometer R5.

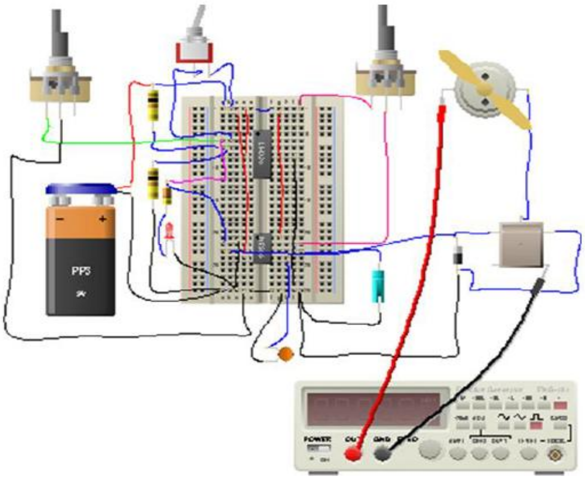

Figure 3. Modelling Automatic Plant Irrigator Circuit Design on Breadboard

To arrange this circuit, copper wires are inserted in the soil to a depth of about 2 cm, keeping them 3 cm apart. When the soil gets dried, potentiometer R5 adjusted towards ground rail until LED1 turns off and relay K1 is energized. The motor starts pumping the water. LED1 glows up as the water reaches the probes. The timing components for U1 are selected accordingly. The timing can be varied with the help of preset potentiometer R4. To model the soil moisture states on computer simulation the switch S1 has been used.

Since solar panel battery chargers are wonderful devices that use green energy and save money by using the sun to power devices. Based on this fact in this project we have been introduced it to recharge the battery that supply power to the main control circuit .This 8-cell solar panel can able to recharge batteries that have capacity to store from 5-12V.

Solar water pump gives additional future for this project, since the pumps are specially designed to utilize DC electric power from photovoltaic panels. The pump can able to operate during low light conditions at reduced power. Solar water pumps have one significant advantage over other types of pumps; they do not require the presence of an electric line in order to operate. This make them extremely useful in ruler locations such as farm in Ethiopia, since there is no access of electricity in a place the where farmers are reside.

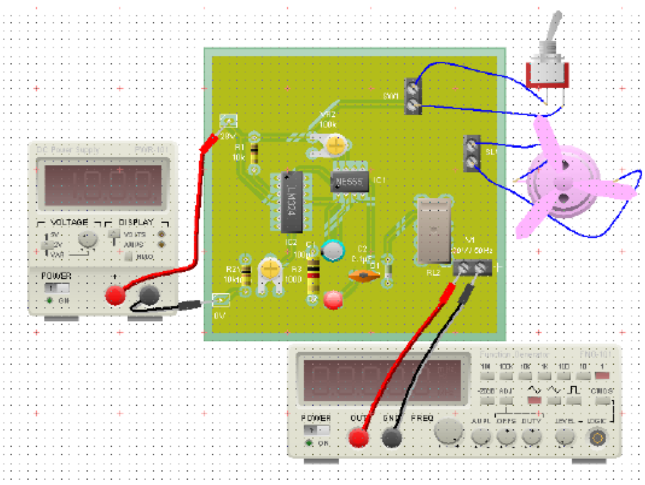

Figure 4. PCB layout of automatic plant irrigator

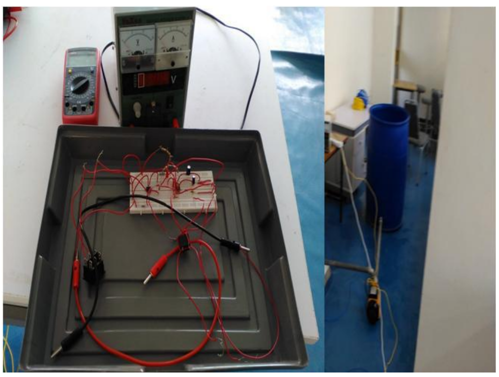

Figure 5.Electronic plant irrigator devise Prototype, designed in Debre Berhan University Applied Physics, Electronics LAB.

Table 1 shows the reading obtained from sensor, OP-AMP output and relay condition.

Soil Condition	Input at Inverting Terminal of LM 324	Reference Voltage at Non-Inverting Terminal of LM 324	LED-Status	Relay-Status	Water Pump-Status
Dray	0.01uV	4.5 V	ON	ON	Start Watering The plant
Wet	4.89 V	4.5 V	OFF	OFF	Stop Watering Plant

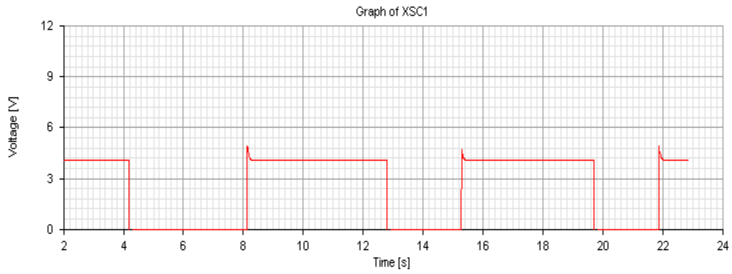

Figure 6. The output taken from the timer IC output pin (pin 3), the voltage vary with time on the output pin based on the soil condition to energized and de-energized the normally closed relay.

V. CONCLUSIONS

Efficient irrigation management is a major concern in many planting systems. In this project, presented technology which allowed farmers to maximize their productivity while saving labor. This report shows in detail, the design of the hardware architecture. The performance of the whole system proved its high reliability.

Potential applications of this system can be extended by integrating automatic embedded system water-level controller with it to protect the water pump from dry run.

The circuit is more effective indoors if one intends to use it for long periods. For regulating the flow of water, either a tap can be used or one end of a rubber pipe can be blocked using M-seal compound, with holes punctured along its length to water several plants.

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AUTHOUR DETAILS

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