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Automatic Pump Controller for Solar Photovoltaic Irrigation System

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ABSTRACT
The need of electricity for rural areas, especially for water supply systems, is crucial for farmers. Stand-alone solar systems are applicable for areas no power grid, in this system is operated when the radiation is sufficient to supply the system with can be stored water and energy. The main purpose of this journal is to develop a solar watering system capable of performing irrigation task automatically. This system uses sensor that determines soil moisture by soil moisture sensor for watering pump, water level indicator also its pumping system from well to water tank that detects ultrasonic sensor. In this system, a pump is powered by solar photovoltaic which controlled by Arduino Uno. And this journal also discusses the prototype design of microcontroller based on water irrigation which detects a soil if watering is required then the water will be maintained at the constant level. And the system is designed by applying an ultrasonic sensor, an Arduino Uno microcontroller, and a pumping machine in order to automatically switch the water filling. The prototype has shown that the system able to reduce wasteful electrical energy and human intervention at minimum cost as the entire system runs only using solar energy. The prototype can be proposed to handle the water pump problems due to the utilizations of the manual switch as well as the floating ball tap to stop the water tank filling.

KEYWORD: *Soil Moisture Sensor, Automatic Irrigation, Ultrasonic Sensor, Water Pump, Arduino Uno Microcontroller*

I. INTRODUCTION

In our day to day life, water is very essential. Plants are also essential to human life. Water is considered one of the basic needs for plant growth. But we must consider such potential situations in watering our plants such as watering too much, too little and of course, just enough for us to sustain and maintain the plant growth. Because keeping your plant properly watered is important to its health. In this research, solar photovoltaic is used as a source for water pumping. The photovoltaic modules convert sunlight direct to electricity which is used to run a dc motor pump for water pumping. It consists of solar photovoltaic modules, power conditioner to protect storage batteries from over charging during non-sunshine and a dc water pump.

Water pump is a tool used for pumping the groundwater to fill a water tank. The various water pump models have currently been used. The first model, the water pump can be operated by turning on and turning off the machine manually. On the other model, the water pump is equipped by a floating ball acted as a physically tap when the water has fulfilled a tank. However, some weaknesses can be discovered due to both models. The manually-operating water pump is not efficient because the water pump cannot turn on and turn off automatically.

Sometimes, the condition will cause the water spill when somebody forgot to turn off a pumping machine. It will affect to the wasteful electrical consumption, and it can also destruct the wall because the wall is moist, humid, and mossy. Likewise, we argue that the second model of floating ball tap-equipped water tank is more useful than manual switch, but the floater sometimes makes the tap and the pipe leakages because the ball has not firmly closed the tap frame then the water pressure cannot be retained by the pipe. To handle the problems caused by both model, we intend to propose the water pump

equipped by ultrasonic sensor with Arduino Uno microcontroller in order to make an automatic switch and control the level of the tank water filling. The sensor will automatically turn on the machine in the certain water tank level and it will be turned off automatically after the water tank is fully filled by the water

In accordance to above facts, the researchers thought of an idea of an automatic water irrigation system, conservation project which can also be useful and be able to contribute to the environment. This project design study to focus on soil condition of a certain plantation area and determine when the plants need to acquire adequate water. Soil moisture is an important parameter in monitoring of plant growth. Since soil moisture determines the amount of liquid or water content of the soil, the researchers will develop a device that will determine the moisture level of the soil that will trigger a water irrigation system to release and gives sufficient water for the plants to reach their full growth.

The technology is commonly made in order to help the people perform some activities easy. Consequently, the cultural change is usually triggered by the technological transformation. One of the present technologies is the automation technology. In some cases, the people sometimes want to carry out their work to be set automatically so that they can save the energy to perform another activity. Some sophisticated automation materials have been established in order to set some works automatically such as Arduino UNO microprocessor, which enable to control the electrical circuits logically.

Arduino is designed to control the circuit logically. Arduino possesses the main component of an integrated circuit chip that can be programmed using C^{++} language. This microcontroller is the AVR type produced by Atmel firm. The device is able to read the input, process the program, and produce many outputs based on our necessity. Therefore, microcontroller is like a human brain. At the previous works, considering to the watering purposes, it can be found that the Arduino UNO based sensors have been utilized for the plant watering system, the automated irrigation system, the soil humidity monitoring, the automated bottle filling system, the distance measurement, the temperature control. In this research, we will propose a novel utilization of Arduino Uno based sensor for the automatic water tank filling and soil moisture sensor. A prototype of automatic water tank filling and soil moisture sensor employing the Arduino Uno microcontroller is used for pump controlling.

A. Statement of the Problem

Manual irrigation system is simple and cheap but is more labor intensive and wastes water. As water is brought into the system manually, this requires high labor input, moreover it is important to check the systems regularly to improve the production and avoid water loss on the plantation and wasteful energy.

B. Aim and Objective of the Research

The main objective is to develop an automated irrigation system by implementing a controlled technique to meet soil moisture requirement that will contribute to water conservation and minimize the labor in the field of gardening. Specifically, the aims are to:

1. Develop a program using a microcontroller that will process the data from the sensor and control the whole irrigation system;
2. Identify the suitable amount of water to be delivered that will assist in maintaining the level of soil moisture monitor the level of water tank which stores the water that will aid in the irrigation system.

II. METHOD

A. Working Principles of the System

The solar panel is kept under the sun for radiation. The photon energy from the sunlight that incident on the top metallic grid causes the electrons in the P-layer and holes in the N-layer to diffuse towards the junction. In this process the electrons collected on the N-side and holes collected on the P-side charge these two sides oppositely. This develops an open circuit voltage across the two terminals. The energy conversion process continues as long as light is incident on the active top surface of the cell.

The power developed by these cells are collected and stored in a battery. The power from the battery is sent to the DC motor. It runs the pump coupled to it. The suction head is connected to the well and discharge head is directed towards the field. The water from the well is pumped out and it is used for the domestic or agricultural purpose. In this research is used for agricultural purpose with automatic watering and water tank filling system.

B. Case Study

The emphasize area is Hngetpyittaung Village, Pyay Township, Bago Division which falls at 18˚ 47″ N-latitude, 95˚ 20″ E- longitude and altitude of 1 km above sea level. For winter crops types which cabbage, tomatoes, eggplant, onion, lettuce, etc. which the water requirement is twice a day. Once has about 50 (carrying box has 75 liters) for ¼ acre. The solar PV standalone system of case study design parameters are as shown in TABLE1. The photovoltaic (PV) water pumping system components are

1. Pump/Motor
2. Solar photovoltaic (PV) array
3. Solar array mounting structure
4. Controller (MPPT)
5. Hydraulic piping
6. Balance of system components such as cables, switches, safety equipment etc.

The main components of the system are pump, controller and solar panel.

TABLE I. SYSTEM PARAMETERS

Parameter	Value
Total head requirement, H	39.894ft
Average solar irradiation in winter	4.895kWh/ m^2
Water flow rate (gal/min), Q	27 gal/min
Volume of water requirement, V	30m^3/day
Pipe size	1.5inches
Water source	deep well
Pump size	750W
Numbers of PV module	6 modules
Charge Controller size	40A, 48V
Operating time	5 hours
Area of PV array	106.92ft^2
Proposed acres	1acre (43560ft^2)
Capacity of the tank	(3×30) = 90m^3
Number of battery	12 numbers

C. Block Diagram of Proposed System

The proposed research is solar photovoltaic water pumping with automated irrigation system is shown in

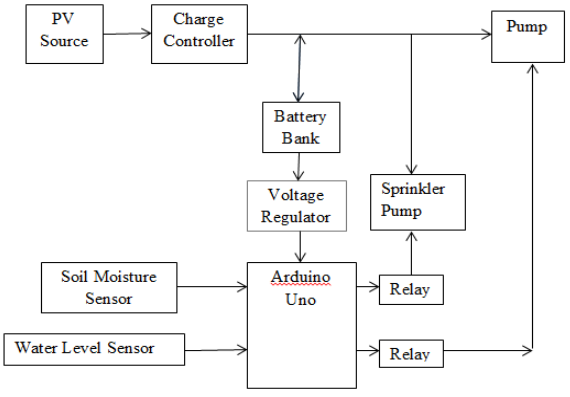


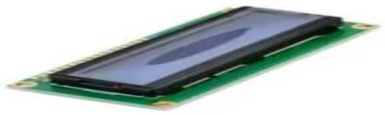
Figure1.Block diagram of automated irrigation system

III. PROJECT DESIGN

A. System Components of Prototype

To perform this research, several materials will be provided such as an Arduino Uno microcontroller, an ultrasonic sensor, HC-SR04 module, relay, an LCD 16×2 display, a 10kΩ potentiometer, two DC pump, real time clock, some connector cables including male to male cables and male to female cables, and a plastic box to cover the equipment. To control the LCD display brightness, a 10 kΩ potentiometer is equipped in the circuit.

(a) Connector cables



(b) LCD (16×2)

Figure2. The materials are (a) Connector cables and (b) LCD (16×2) display

1. Power Supply

Power supply circuit, the name itself indicates that this circuit is used to supply the power to other electrical and electronic circuits or devices. There are different types of power supply circuits based on the power and they are used to provide for devices. For example, the microcontroller based citcuits, usually the 5V DC regulated power supply circuits are used which can be designed using different techniques for converting the available 230V AC power to 5V DC power.

2. Arduino Uno

"Uno" means one in Italian. Arduino Uno is a microcontroller board based on the ATmega 328P. It has 14 digital input/output pins (of which 6 can be used as PWM output), 6 analog inputs, a USB connection, a power jack, a rest button and more. It contains everything needed to support the microcontroller, simply connect it to a computer with a USB cable or power it with a AC to DC adapter or battery to get started. In this project, it is used for pump controller.

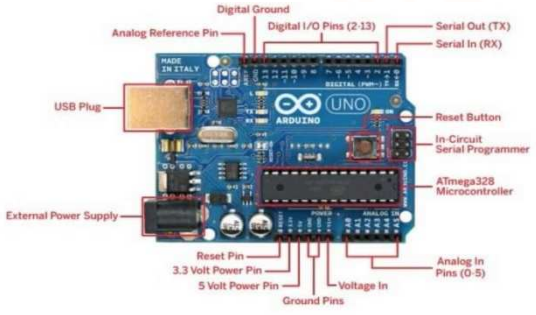
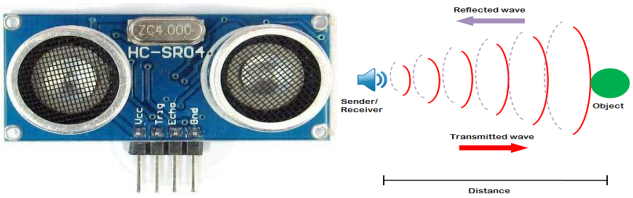


Figure3. Arduino Uno

3. Ultrasonic Sensor Module



(a)Sensor (b) Sensor's working

Figure4. Ultrasonic Sensor Module

Ultrasonic sensor HC-SRO4 is used to measure distance in range of 2cm-400cm with accuracy of 3mm. The sensor module consists of ultrasonic transmitter, receiver and the control circuit.

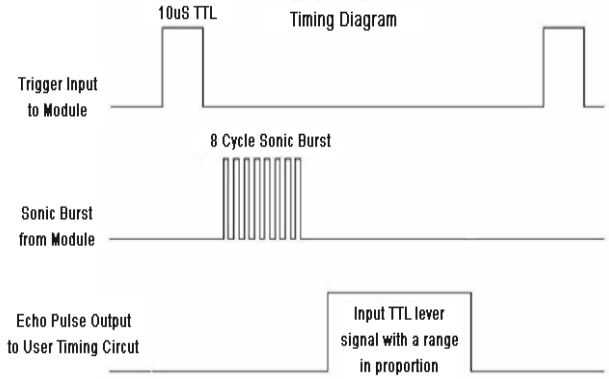


Figure5. Ultrasonic Timing Diagram

The ultrasonic sensor module works on the natural phenomenon of ECHO of sound. A pulse is sent for about 10us to trigger the module. After which the module automatically sends 8 cycles of 40 kHz ultrasound signal and checks its echo. The signal after striking with an obstacle returns back and is captured by the receiver. Thus the distance of the obstacle from the sensor is simply calculated by the formula given as

Distance = (time x speed)/2

Here we have divided the product of speed and time by 2 because the time is the total time it took to reach the obstacle and return back. Thus the time to reach obstacle is just half the total time taken.

4. Hygrometer

Various types of sensors can be used for the measurement of soil humidity. In that project, the sensor is used for soil moisture. Soil moisture sensors measure the water content in soil. The sensor has two probes which are together acting as a variable resistor. The soil is wetted; the probes will be the better conductivity and will result in a lower resistance. It is used for both digital and analog. Output of the sensor gives as a input of a Arduino Uno. In this prototype, sensor is connected to the Arduino Uno pin (A1). Hygrometer is one type of humidity sensor which has ability of measuring the water vapour in the atmosphere. It used for both digital and analog. Output of the sensor gives as a input of a Arduino Uno.

Figure6. Soil moisture sensor

5. Relay Circuit

The water pump is connected to the circuit through a 12V relay. One relay is connected to the Arduino Uno pin (6) for pumping pump and has a BC547 transistor circuit of a common emitter configuration for interfacing with the board. And Arduino Uno pin (8) is used for watering pump.

Figure7. Relay

IV. RESULT AND DISCUSSION

A. Circuit Board

The prototype circuit is shown in Figure(8).

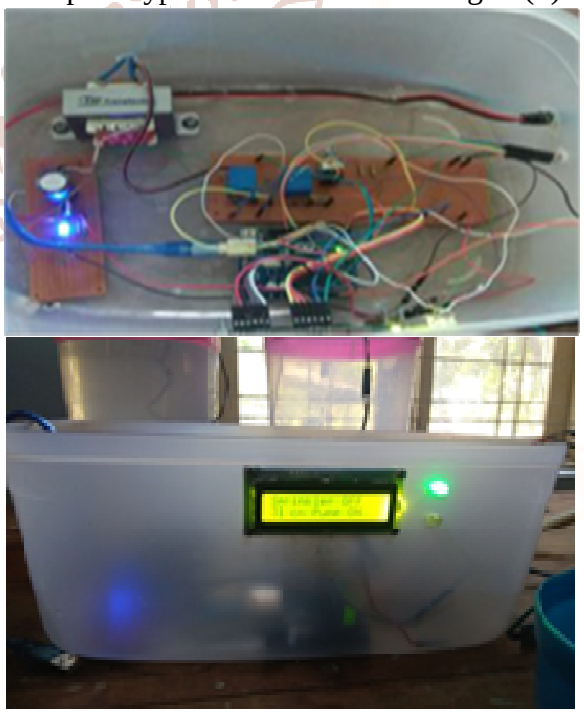


Figure8. Circuit board

B. System Flow Chart

The system flow chart is shown in Figure (9).

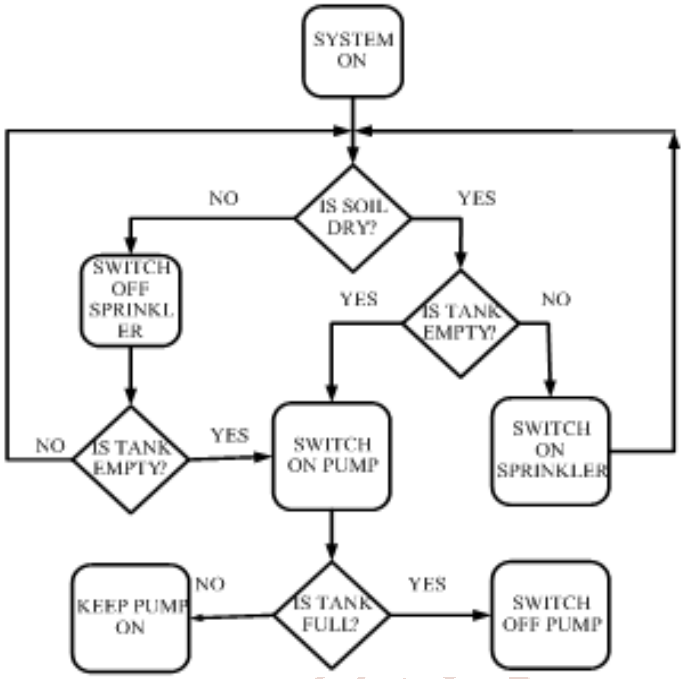


Figure9. Flow chart of the system

(a) Sprinkler OFF and Pump ON

(b) Sprinkler ON and Pump OFF

(c) Sprinkler ON and Pump OFF

(d) Sprinkler OFF and Pump OFF

Figure10. LCD display of Automatic water tank filling and watering pump control system

C. Operation of the Pump Controller

The system is used two 12V DC submersible pump which is supplied by one source. It includes watering and water tank filling pump. For watering pump, when the soil moisture sensor is injected into the ground, the control system has to be initiated so as to act on the sprinkler irrigation system. The moisture sensor works by measuring resistance between its probes. Values were taken and recorded using a multi-meter. These values were when the soil is dry and when the soil is saturated. This gave us a threshold on which to code our program to determine when the soil is dry and when it is wet. When the soil is dry, the system turns ON for watering. When the soil is wet enough, the pump turns OFF. This irrigation system is only turned on the pump when the tank is not empty. For pumping pump, when the tank is empty, the system turns on the pump. Once the tank is filled up, the pump is turned OFF. Once a circuit is completed, respective information is recorded and displayed onto the LCD. When the watering pump in the tank is turned on, the water pumping pump from the well is turned off.

D. LCD Display of Automatic Water Tank Filling and Watering Pump Control System

The system managed to start up, giving displaying status of all components on the LCD is shown in Figure 10.

V. CONCLUSION

The development of our project is the automatic soil moisture sensing water irrigation system with water level indicator. This is the device that will provide the needed water when the soil moisture sensor detects if the soil is dry. The prototype can be proposed to handle the water pump problems due to the utilizations of the manual switch as well as the floating ball tap to stop the water tank filling.

The cost effective sensor and module would be useful in small and medium scale farms and homes where it is economical to save electric power, labor, time and water stored in tanks and watering system. I hope to this system, people will enjoy supplying water spills and a wasteful electrical consumption.

RECOMMENDATION

The researchers recommend that this research may be used as reference for further development of new methods and devices for watering and protection system of the plantation, such as : adding a CCTV camera to monitor the daily watering of plants and animal disturbances, adding a light post within the vicinity or corners of the plantation area, adding and mixing of fertilizer to water which may flow in every plot that can help the plants grow faster and lastly ,it can expanding the system and study the implementation of the system in a large scale plantation.

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