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A Model of Solar Powered Auto Irrigation System

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Abstract: Global economic recession has adversely affected food availability and security. To this end, an automatic micro irrigation system known as “drip” or low volume irrigation has been presented, with a view to improving food availability and security. The scheme uses a network of sensors to monitor the soil humidity and temperature. These variables are sequentially transmitted and analyzed by a microcontroller operated closed loop control system which dispenses accurate quantity of water for the crops and thus avoiding wilting of crops and waste of water. The configuration is powered by a 6 unit 200W amorphous silicon PV modules which powers a 12V submersible water pump for a small scale drip irrigation system. The simulation results of the proto- type irrigation system and practical results show good agreement.

Keywords: Irrigation system, microcontroller, soil moisture sensor, temperature sensor, water pump

1. Introduction

In the present era one of the greatest problems faced by the world is water scarcity and agriculture being a demanding occupation consumes plenty of water. Therefore a system is required that uses water appropriately. Automated irrigation systems estimate and measure the diminution of existing plant moisture in order to operate an irrigation system and also restore water as needed while minimizing excess water usage.

The soil moisture based irrigation control uses Tensiometric and Volumetric techniques, which are relatively simple but these quantities are related through a soil water characteristic curve that is specific to a soil type. Also the sensors in use require routine maintenance for proper performance. Intelligent automatic plant irrigation system concentrates on watering plants regularly without human monitoring by using moisture sensor.

The device which consists of readily available components were developed and evaluated for scheduling irrigation in maize. Proper scheduling of irrigation is critical for efficient water management in crop production, particularly under conditions of water scarcity. The effects of the applied quantity of irrigation water, irrigation frequency and water usage are particularly important.

This prototype device monitors the quantity of soil moisture and temperature. A predefined range of soil moisture and temperature is set, and can be varied with soil type or crop type. In case the moisture or temperature of the soil deviates from the specified range, the watering system is turned on/off. In case of dry soil and high soil temperature, it will activate the irrigation system, discharging water for watering the plants.

2. Proposed System

The system consist of sensors, a micro controller, an LCD display, relays, solenoid valves, a water tank/pump and solar panels. The temperature sensor is inserted in to the soil while the humidity sensor is kept above the ground level. All the sensor send their outputs to the microcontroller. The microcontroller then displays these values on an LCD screen.

A moisture sensor is inserted in the soil, this sensor records the moisture level in the soil and sends the value to the microcontroller. The microcontroller then compares value with a certain predefined ones. This predefined value can be set per the crop water requirement because different crops need different amount of water. If the moisture level in the soil drops to a particular value, the water will flow and the process of irrigation will begin.

During this time, the moisture sensor continuously sends the moisture value in the soil to the microcontroller. After some time, when moisture level in the soil reaches satisfactory level, the water automatically stops. In this way, the circuit performs the task of irrigation. The flow chart diagram of the system is shown in figure 1.

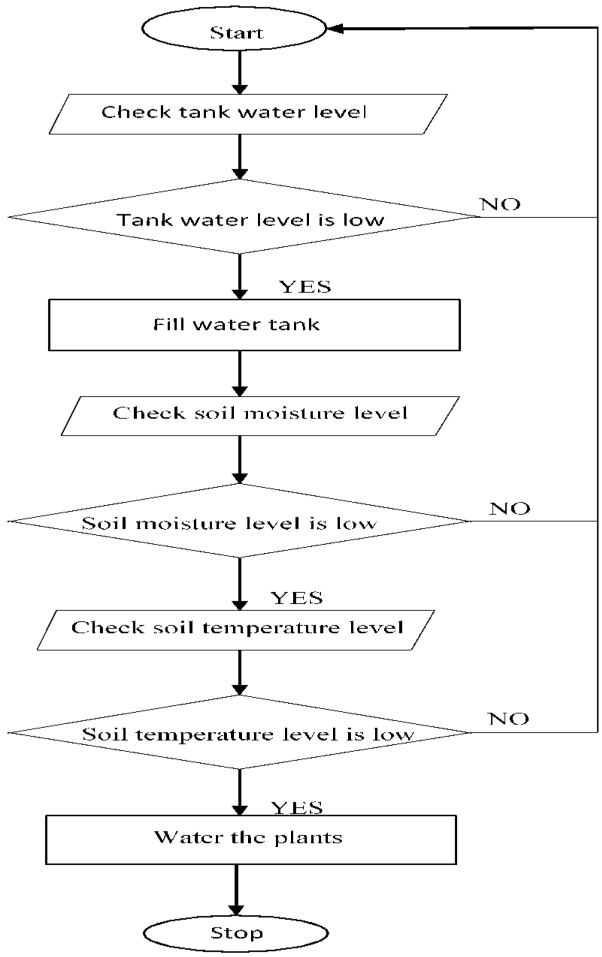

Figure 1: Simplified Flow Diagram for Automated Irrigation System

3. Methodology

The automatic irrigation system was designed to continuously sense the moisture level of the soil and apply water when necessary. The system responds appropriately by sensing and watering the soil with the exact required quantity of water and then shuts down the water supply when the required level of soil moisture is achieved.

The block diagram of solar powered automatic irrigation system is presented in Figure 2. It consists of a microcontroller (AT mega 328) which is the brain box of the system. Both the moisture and temperature sensors are connected to the input pins of the microcontroller. The solenoid valves and water pump are connected to the output pin of the microcontroller. If the sensors depart from the predefined range, the microcontroller activates the solenoid valves and water discharges on gravity.

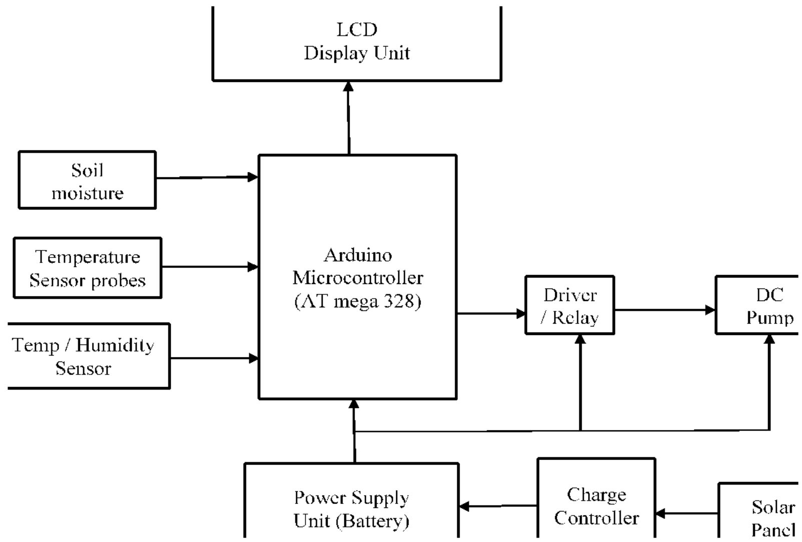

Figure 2: Solar Powered Auto Irrigation System Block Diagram

This is a simple system, using Arduino to automate the irrigation and watering of crops. The system does the control of soil moisture, temperature and humidity of the farm. In case of dry soil it will activate the irrigation system discharging water for watering plants. The system uses an LCD display to notify all actions that are taking place and a real time clock

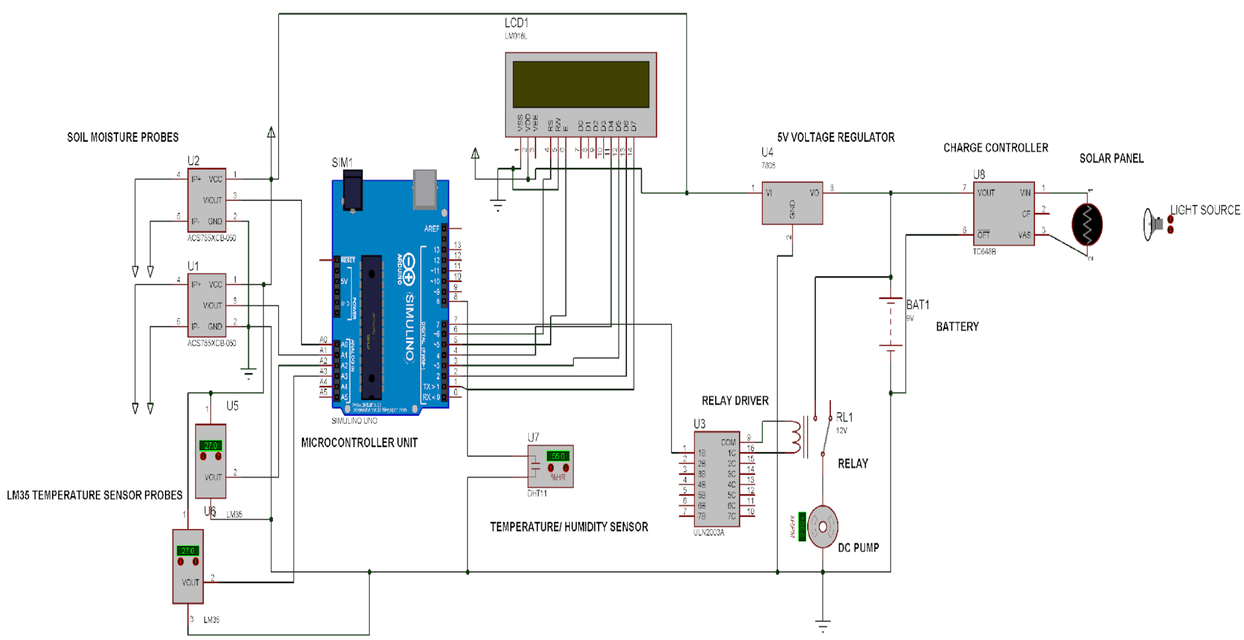

Figure 3: Solar Powered Auto Irrigation System Circuit Diagram

This system is implementable on a large scale for large farm. It can further prove to be more advantageous owing to the prevailing conditions and water shortages. The optimum irrigation schedules can be determined especially in farms to conserve water.

3.1 Fuzzy Logic Irrigation Control System

This involves a prediction of a crop water demands with a precision of the proper quantity of water needed according to weather and soil moisture conditions. These conditions are collected in form of data from sensors located in the specified farm.

Figure 4 represents the water-tank model proposed for the irrigation system. The tank is usually filled by water pump when empty and the outlet is controlled by solenoid valve.

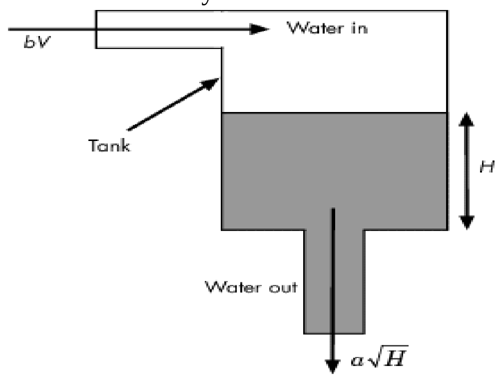

Figure4: Water Tank Model

The model shown in figure5 contains the water tank system plant and a simple proportional-integral-derivative (PID), called Controller, in a single-loop feedback system.

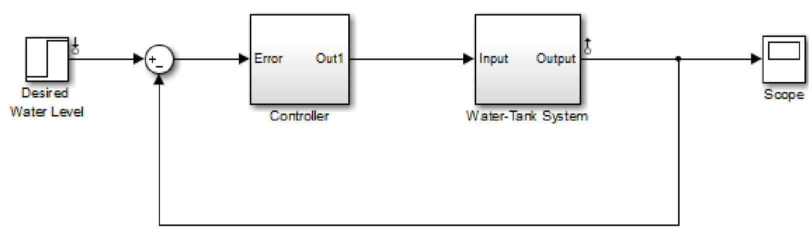

Figure5: Water Tank System Model

The Water-Tank subsystem of the model appears in figure 6 below.

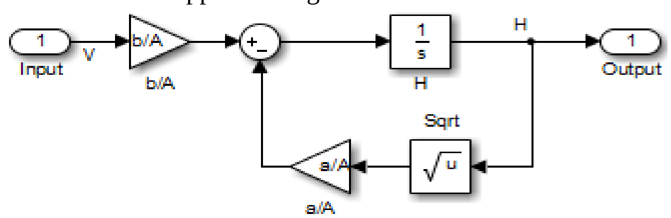

Figure6: Water Tank Subsystem Model

From the above model water enters the tank from the top at a rate proportional to the voltage, V, applied to the water pump. The water leaves through an outlet in the tank base at a rate that is proportional to the square root of the water height, H, in the tank. The presence of the square root in the water flow rate results in a nonlinear plant.

Table 1 describes the variables, parameters, differential equations, states, inputs, and outputs of the water-tank system as being carried out.

Table 1.Water Tank System Variables and Parameters

Variables	***H*** is the height of water in the tank. ***Vol*** is the volume of water in the tank. ***V*** is the voltage applied to the water pump.
Parameters	***A*** is the cross-sectional area of the tank. ***b*** is a constant related to the flow rate into the tank. ***a*** is a constant related to the flow rate out of the tank.
Differential equation	$\frac{dVol}{dt} = A\frac{dH}{dt} bV - a\sqrt{H}$
States	H
Inputs	V
Outputs	H

The model contains a PID Controller block that controls the height of the water in the water tank system.
The PID Controller modelled in this work must control the water tank system response time such that:

- Overshoot is less than 5%.
- Rise time is less than 5 seconds.

3.2 Soil Bed Model

The soil is modelled water holder or reservoir having an input pipe from the sprayer and an output pipe. The input flow rate is variable by a control valve from the sprayer. The output flow rate is dependent on the amount of water in the soil bed, more water in the soil bed results in a faster output flow rate.

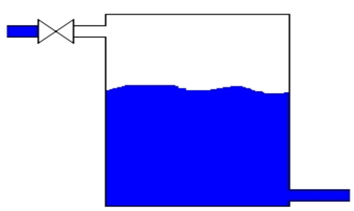

Figure 7: Soil Bed Model

The water will drain out of the soil faster when there is more water in the soil bed and slower when there is less water in the soil bed. The goal of the control system is to take a set value and change the input valve so that the inflow rate will compensate for the outflow. The soil bed can be represented in Simulink using the following block.

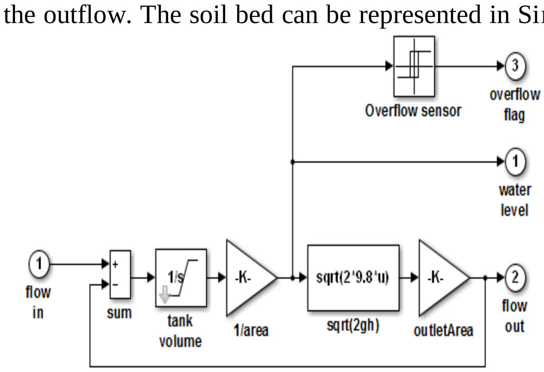

Figure 8: Simulink Subsystem showing the Soil as a Water Holder

This block diagram can then be used in developing a control system for the soil bed using fuzzy logic. The fuzzy controller inputs are the amount of error in the soil bed water level and the rate of change for the soil bed water level.

4. Results

The simulation results proved that soil moisture depletion never reaches 100% due to the use of FIS. This means that our model prohibits the soil water content from reaching the permanent wilting point, thus no water stress occur. Besides, when soil moisture depletion ratio reaches the maximum allowable depletion value, the irrigation system equipment is powered ON and valves are opened for a determined time period. Thus it reduces controlling of power switching, hence it is thrifty in terms of power and water consumption. Moreover, the model is adaptive and adjusts its behaviour according to changes in parameters.

The simulation results show that fuzzy model is a quick efficient tool for predicting evapotranspiration and the needed amount of water. Thus, indicating its suitability for water conservation and irrigation management.

In agriculture, the superior water system requires real estimation of crop water needed by plants depending on different factors, such as evapotranspiration. Evapotranspiration (ET) means the losing of water from both: the soil surface (evaporation) and plants (transpiration).

When the soil moisture is dry below the pre-set value the moisture sensor sends message to the microcontroller and after receiving message from micro controller solenoid valve will switch on automatically.

In the same way when the pre-set value of temperature goes high then the temperature sensor sends message to the microcontroller and after receiving message from microcontroller solenoid valve will switch on automatically.

If all the sensors go high at the same time, sensor from particular function will send message to microcontroller and after receiving message from microcontroller respective action will be carried out.

5. Conclusion

Automatic irrigation control system was modelled, constructed and operated. The prototype of the system worked according to specification satisfactorily. The system components are readily available, relatively affordable and they operate quite reliably. The system helps to eliminate the stress of manual irrigation (watering can), convectional irrigation (fadama) and irrigation control while at the same time conserving the available water supply. Improving irrigation efficiency can contribute greatly to bumper harvest and reduce production costs of agricultural products, thereby making the industry to be more competitive and sustainable.

References

[1]. Abubakar S. S. Energy Commission of Nigeria (1998).

[2]. Allen R. G., PereiraL. S., Raes D., and Smith M. Crop evapotranspiration: guidelines for computing crop water requirements. *FAO irrigation and drainage paper 56*.FAO, Rome, Italy1998.

[3]. Ball R. A., Purcel l L.C., and Carey S. K. Evaluation of solar radiation prediction models in North America. *Agronomy Journal* 2004. 96(2):391-397.

[4]. Braun J.E., and Mitchel l J.C. Solar geometry for fixed and tracking surfaces. *Solar Energy* 1983.31(5): 439-444.

[5]. Bristow, K. L. and Campbell. G. S. On the relationship between incoming solar radiation and daily maximum and minimum temperature. *Agricultural and ForestMeteorology*1984.31:159-166.

[6]. Burt, C. M., Clemmens A.J., Bliesner R., Merriam J. L. and Hardy L. *Selection of irrigation methods for agriculture*. On-farm irrigation committee of the environment and water resources institute. ASCE2000.

[7]. Muñoz-Carpena, R. *Field Devices for Monitoring Soil Water Content*. *EDIS*. Retrieved July 7, 2008, from Institute of Food and Agricultural Sciences, University of Florida.

[8]. Peatman, J., Design with microcontrollers, McGraw-Hill, New York (1988).

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