UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SOLAR WATERING SYSTEM USING MICROCONTROLLER

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Electronics Engineering (Electronics Industry) (Hons)

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ABSTRAK

Tujuan utama projek ini adalah untuk membangunkan Sistem Penyiraman Solar yang mampu melaksanakan tugas pengairan atau menyiram secara automatik dan dikuasakan oleh Photovoltaic (PV) panel. Sensor kelembapan digunakan dalam tanah untuk menyemak keperluan terhadap pengairan dan mengendalikan pam yang dikuasakan oleh sistem PV dan bateri asid. Selain input daripada sensor kelembapan, fungsi pemasa dalam PIC18F4550 juga digunakan untuk mengelakkan penyiraman banyak kali sehari. Ini memastikan tanaman atau tumbuhan di kawasan tanah lapangan tidak mempunyai masalah pertumbuhan disebabkan oleh air terlampau. Dalam usaha untuk meningkatkan penuian tenaga daripada sinaran matahari, pengikut matahari dalam bentuk paksi tunggal telah direka bentuk. “Horizontal Single Axi Tracker” (HSAT) telah dibina dan system ini berfungsi berdasarkan maklum balas daripada dua perintang LDR dan lembaran legap yang membahagikan kedua-dua perintang tersebut supaya bayang-bayang akan dibaringkan pada salah satu daripada dua apabila matahari bergerak posisi. Objektif projek adalah untuk membangunkan program dengan pengawal mikro yang menjalankan fungsi mengekalkan keseimbangan lembapan yang betul di dalam tanah dan juga membina sistem berjana daripada kuasa solar yang menguruskan pengairan secara automatik dengan mengunakan sensor kelembapan, mikropengawal dan litar-litar lain.

ABSTRACT

The main purpose of this project is to develop a Solar Watering System capable of performing irrigation or watering task automatically and is powered by Photovoltaic (PV) panels. A moisture sensor in the soil is used to check the need for irrigation in order to operate a pump powered by the PV system and lead acid battery. In addition to the input from moisture sensor, Timer function within the PIC18F4550 was also applied to prevent watering to many times per day. This ensures that the crop or plant in the field will not have growth problems due to overwatering. In order to increase energy harvesting from the sun radiation, sun tracker in the form of single axis was designed. Horizontal Single Axis Tracker (HSAT) was build based on the feedback from two Light Dependent Resistor (LDR) and an opaque sheet dividing them so that shadow will be casted on either one of them when the sun moves. The objective of project is to develop a program by using microcontroller as to carry out the function of maintaining proper balance of moisture in the soil and also to construct solar powered automatic irrigation system that runs with the use of moisture sensor, microcontroller and other required circuitry.

DEDICATION

Specially dedicate to my beloved family, supervisor, lecturer, seniors and friends who have guided and inspired me through my journey in education. Also thank you to their support, beliefs and motivation.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

PV	-	Photovoltaic
PIC	-	Programmable Interface Controller
PLC	-	Programmable Logic Controller
LDR	-	Light Dependent Resistor
LED	-	Light Emitting Diode
HSAT	-	Horizontal Single Axis Tracker
PCB	-	Printed Circuit Board
DMM	-	Digital Multimeter
IC	-	Integrated Circuit
MOSFET	-	Metal oxide semiconductor field effect transistor
PSM	-	Projek Sarjana Muda
Ah	-	Ampere-Hour
FYP	-	Final Year Project
UTeM	-	Universiti Teknikal Malaysia Melaka
FKEKK	-	Fakulti Kejuruteraan Elektronik dan Komputer

CHAPTER I

INTRODUCTION

1.1 Project Introduction

Solar energy is a free, inexhaustible resource that is environmental friendly and serves as an alternative to the increasing demand in energy usage throughout the world. According to latest figures published, the surface of the earth receives about124 exa (10^{18}) Watts or 3,850 zetta (10^{24}) Joules per year of solar power [2]. That amount of value is higher than all of energy generated in the earth. A photovoltaic (PV) module is a packaged, connected assembly of numerous solar cells. Solar Photovoltaic panels constitute the solar array of a photovoltaic system that generates and supplies direct current (DC) electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions and typical solar cell has specifications of 3.65 to 4.186 W Power maximum (Pmax) [2].

The price of solar power, together with batteries for storage, has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the power grid [2]. This has encouraged the application of solar energy in various sectors and one such important application of solar is in the industry of agriculture for the purpose of irrigation. Irrigation system is a system that supplies water to the required area of demand. It is used to assist in the growing of agricultural crops, maintenance of landscapes and in other numerous areas. Therefore, this project is to design and construct an automatic irrigation or watering system powered by Photovoltaic (PV) panels on a small level. The project constitutes of electrical part and mechanical part. The electrical part consists of Photovoltaic panel, a device to store energy such as battery, and other required electronic components to form the circuitry for the controller whereas the mechanical part would be the relay and pump or device which enables the supplying of water to the field or crop.

Irrigation of time-based for the crops would also function well but with the disadvantage of wastage of water and causing over supply of water which can affect the productivity and growth of plants. Thus a mean to give input of when the plant requires water or in other words, the soil dryness level are to be implemented and it can be achieved with the use of soil moisture sensor. This project also carries the function of storing energy when not in use in the form of battery and thus saves energy. The control is made by means of a microcontroller which is the Programmable Interface Controller PIC18F4550. The whole system would be simulated by simulation software like Proteus or Multisim to verify the functionality of the circuit before the implementation or construction of the hardware. The hardware consist of circuits for each part such as solar charging circuit, moisture sensor circuit, pump control circuit and other necessary circuit and finally all of it is integrated together. The utilization of Automatic Solar watering system can reduce cost of agriculture, better alternative of energy source and solve many other problems in the field of agriculture.

1.2 Problem Statement

Under the field of agriculture, the demand for food crops to satisfy today's population had been increasing from day to day but since both water, electricity and fuel to drive pump are costly and scarce in supply, the production or yield of crops in many countries and rural areas has been decreasing [1]. The current watering system for both plants in the small scale and irrigation for large field of crops can be separated into manual and automated. The manual system needs labor for monitoring the productivity and health crop whereas the automated system would be systems that make use of device like timer. As the automated system works based on timing, it can cause wastage of water and over supply to plants. Hence watering system that responds based on soil moisture in the soil would provide a sustainable solution. In addition, the current watering system in agriculture consumes energy based on the size of field. A renewable energy source such as solar can be an excellent alternative and development of technology based on it can be used in areas where electrical power is difficult to obtain [1]. Thus a project that is powered by sunlight to help supply water to the desired area, only when needed through the use of microcontroller and also at the same time stores the power in the form of storage device like battery would greatly help the agriculture industry.

1.3 Objectives

The objectives for Development of Solar watering system using microcontroller are as below:

- To develop a program by using microcontroller as to carry out the function of maintaining proper balance of moisture in the soil.

- To construct solar powered automatic irrigation system that runs with the use of moisture sensor, microcontroller and other required circuitry.

1.4 Scope of Project

The scope of this project will cover the studies on the principle of automated solar watering system using microcontroller for watering and agriculture applications. It works based on the concept of efficient conversion of solar energy to electrical energy and subsequently to mechanical energy. The solar energy is harnessed through Photovoltaic which will charge storage device that runs the microcontroller and pump. Input is given to the microcontroller from sensing device that detects moisture in soil and this enables the microcontroller to trigger the load or output. The project has both hardware and software sections, with hardware consisting of required circuitry, PV panel, load pump, charge controller and storage device. The software on the other hand is Proteus for circuit designing plus simulation and also PIC C compiler to compile and build the required coding of PIC. The project is done on a small scale level, 15-20V PV panel charging battery of capacity 12V that powers the PIC microcontroller, moisture sensor circuit and 12 V DC pump. Current implementation of the project would be for gardening plant or small plant field. Enlarging the scale can be done with the project being modified in term of higher input power, larger storage device and much higher powered output load to channel the water to large areas.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is a part of scholar paper, which comprises the current knowledge in terms of research, substantive findings, facts, figures as well as theoretical and findings contributing to a particular topic or area of study. The related information and data were obtained from an acknowledged specific organization or institute or bodies. Sources and channels used to get hold of the information were from journals, articles, books, research paper and web pages.

2.2 Related Projects

At present there are multiple automated solar watering projects throughout the world and most of them are developed for the integration of agriculture field. The dissimilarity among these projects is in their attributes and method of control to achieve the same goal.

2.2.1 Automated Solar Based Agriculture Pumping

The control algorithm of the design involves a 15V PV panel charging a 12V battery that runs the 12V DC pump. It has circuit interfacing for input from analog sensor light, humidity and water sensor. The main body makes use of 8-bit ADC0808 to give digital input to Microcontroller (AT89S51) and relay board to protect microcontroller from back e.m.f of pump. The core AT89S51 enables irrigation to take place at the time of choice based on the sensor and coding embedded inside it [3].

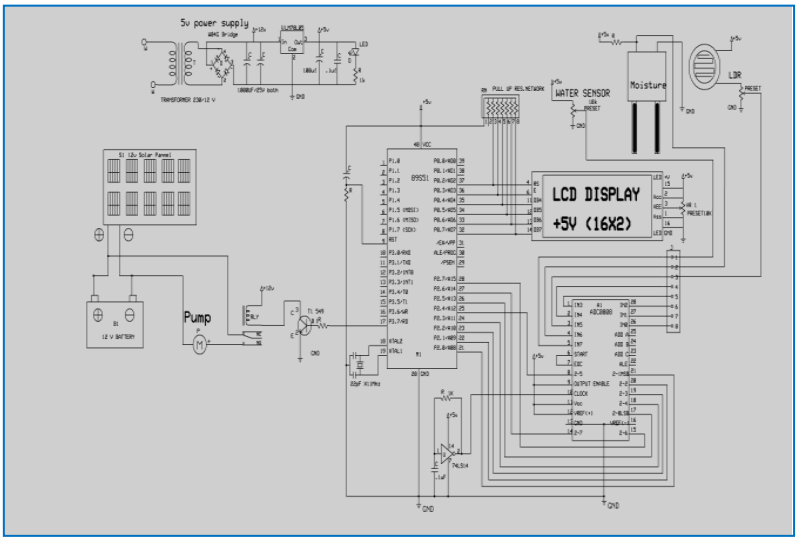

Figure 2.1: Circuit Diagram [3].

This system as a whole focuses on providing precise timing for water supply as to reduce wastage of water and over supply of water. This increases yield, reduces manpower and cost of electricity. Disadvantage of it are the variability of the solar panel energy production according to the prevailing weather conditions. Designed system specifications as mentioned above indicate a small scale field usage and bigger field would require integration of current circuit and extra buffering to complete task.

2.2.2 Development of Solar Powered Irrigation System

This project emphasizes on the development and implementation of an automated Supervisory Control Data Acquisition (SCADA) controller system that uses Programmable Logic Controller (PLC) to initiate and fulfill the task of solar fueled irrigation system. This system employs smart solar tracker system which is equipped with Light Dependent Resistor (LDR), gear box and charger to keep track of sun and increase efficiency of energy generated. PLC is used as the core of system; it receives input from the sensor and provides instruction to the output side loads to operate. Utilizing two water level sensors and two moisture sensors to grant input and as an outcome drive the water pump DC motor and two DC valves. Software SCADA computer system is for the intent of congregation and analysis of real time data. Primarily, it is meant for adding an operator on automatic irrigation system but the operator can also read and write data from the PLC plus view report of the operation [4].

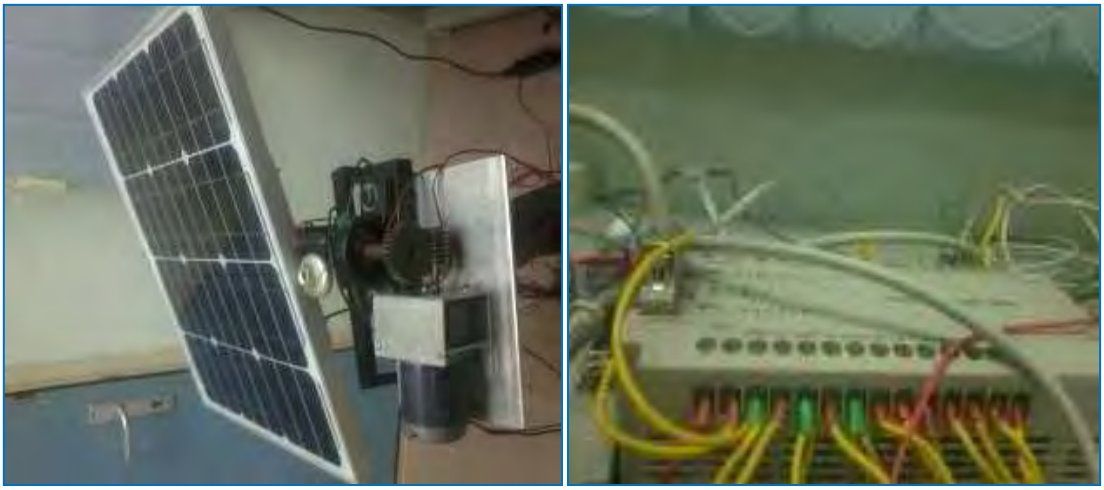

Figure 2.2: Solar Tracker and PLC [4].

Based on the analysis conducted by the paper, the system performance is quite reliable and accurate with appropriate use in controlling and monitoring of liquid vital for agriculture. Due to the diversity of build, it can be enhanced to other sectors example oil and gas monitoring system. As shown in Figure 2.2 above, the solar tracker does help increase efficiency of solar panel but provided that the own energy consumption of tracking mechanism does not deplete or exceed the extra energy generated by PV through following the sun [8]. If higher power PV is driven by the same tracking mechanism then installation of solar tracker will be worth it compared to the static panel. Another crucial attribute regarding this project is the high initial cost and complex circuitry to be developed.

2.2.3 Solar-Powered Automated Plant/Crop Watering System

Based on earlier reviewed journals, objective of this project is also to conserve water, effectively manage water quantity to plant, reducing human labor, and minimize electricity in addition to manipulating the renewable solar energy to power a system and store energy for later expenditure. The approach taken has major variance due to the application of Arduino Uno microcontroller embedded board. Arduino is an open-source prototyping platform based on easy-to-use hardware and software [5]. The reading from the moisture sensor is directed to the LM3914 IC (Integrated Circuit) which detects the moisture level and indicates those using 10 LEDs. Another device utilized is the Optocoupler PC817 and its output is channeled as the driving input to the Arduino. A particular threshold value triggered, initiates the Arduino to activate the pump and vice versa for value below threshold.

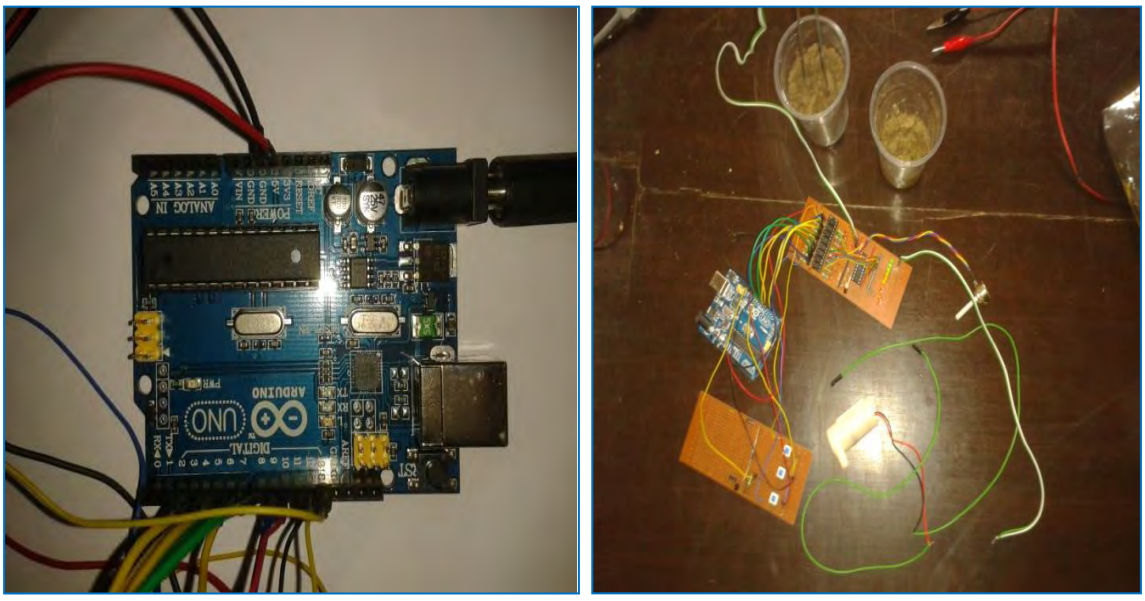

Figure 2.3: Circuit Configuration of Arduino Uno and completed circuit [5].

The versatility of Arduino board impacts very much on the scalability of this project as expanding to larger farms or field being relatively easy and requires lesser complex circuit integration. In addition, there is a switching circuit inside the model that permits selection of plant that needs to be sensed and watered, further improving the usage for variety of crops that require specific watering requirements.

2.2.4 Application of Solar Powered Automatic Water Pumping in Turkey

The architecture in this case is enormous as it accommodates 48 PV arrays of 80W, a Brushless DC motor (BLDC) motor of 96V 1.6kW, another BLDC of 48V 3kW, 8 batteries summing up to 6240W power and 3000 drippers to perform irrigation to 1000 dwarf cherry trees planted. Control mechanism splits into two utilizing the different BLDC motor of different power. The first portion of execution is direct connection of 24 PV panels with a driver that operates the 96V 1.6kW BLDC-1 motor to revolve deep well pump and transport water from the Dam Lake to water tank [6].

Figure 2.4: Dam Lake and solar panel for BLDC- 1[6].

The second portion incorporates 48V 3kW BLDC-2 motor coupled with a centrifugal pump and powered by the remaining 24 PV panels. However battery bank is also added in system to provide energy for motor in case sun irradiation is minimal. Solenoid Valve Unit (VU), Sensor Unit (SU) and Base Station Unit (BU) were designed to realize control of drip irrigation. These units comprise of RF module, Omni-directional antenna, 7V 1.8W solar panel and low power PIC18F452 micro controller. Additionally the SU has soil moisture sensor and the solenoid valve is 12V 10W rated. The soil moisture module measure water content in SU and this analog data was sensed with ADC on PIC chip and evaluated. Afterwards, the valves position either ON or OFF are defined and information is transmitted to VU for completion. Some other feature of build is DC-DC converter usage to feed and charge battery safely plus solar tracker structure for increased efficiency of PV [6].