EFFECTIVE CONTROL OF SOLAR POWER SYSTEM BY AUTOMATIC TRACKER

Wut Hmone Oo[1], Khin Mar Win[2], Hla Htay Win[3]and Thandar Aung[4]

Abstract

The research paper presents the design of automatic solar tracking control system based on microcontroller. It consists of the optimize hardware design, which is controlled by a firmware. The source code for the project is written in Mikro C Pro programming language. The main objective of this paper is to provide the maximum energy from solar panel and gives higher efficiency for the solar cells. This designed system is to control the solar panel to remain aligned with direction of the sun. The microcontroller based control circuit drives the DC motor. Microcontroller PIC16F887 is used for controlling the movement of the solar panel. DC motor is controlled by the microcontroller that receives the signals from the transistor driver of light dependent resistor (LDR). The light sensor (LDR) tracks the path of the sun by detecting the light intensity. The design of automatic solar tracker can be categorized into three sections. These are sensor unit, control unit and motor driving unit. For demonstration simplicity, the LED indicators are used to show the rotation of DC motor.

Keywords: Solar Tracking, Solar Panel, PIC16F887, DC motor, LDR Sensors

Introduction

The most abundant and convenient source of renewable energy is solar energy and widely utilized to convert the solar energy for electric power applications. Solar energy is also freely available and never run out. This system needs only maximum sunlight to generate power. Solar trackers are the most suited technology to increase the efficiency of solar panels through keeping the panels aligned with the sun's position. Solar panel directly converts solar radiation into electrical energy. A solar panel with tracking system increases the intensity of light falling on it. It can generate direct current (DC) electricity without environmental pollution. To make effective use of solar energy, its efficiency must be maximized. Efficiency of the solar energy is very high compare to any other sources of energy. The solar tracking enables more energy to be generated because the solar panels are always perpendicular to the solar energy radiated by the sun. One of the main problem is that it is not capable to produce any output power in bad weather condition.

Materials and Methods

Automatic Solar Tracking Control System

The solar tracking system consists of programmable microcontroller (PIC16F887), LDR sensors, H-Bridge DC-motor control circuit and solar panel. Solar tracking system is a power generating method from sunlight. The method of power generation is very simple and is taken from natural resources. By using automatic solar tracker, the highest power can generate from the solar panel when it is perpendicular to location of the sun. As the sun rotates from east to west, it is needed to rotate the solar panel in order to follow the sun's direction. Light sensors (LDRs) track the path of the sun by detecting the light intensity. So, the main panel rotates where the

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maximum light is absorbed. Greater the intensity of solar light falls on solar panel, the larger output observe at the output of solar panel. Motor rotates the solar panel to keep at right angle to the rays of the sun. The basic structure of the "Automatic Solar Tracking System" is as shown in Figure 1.

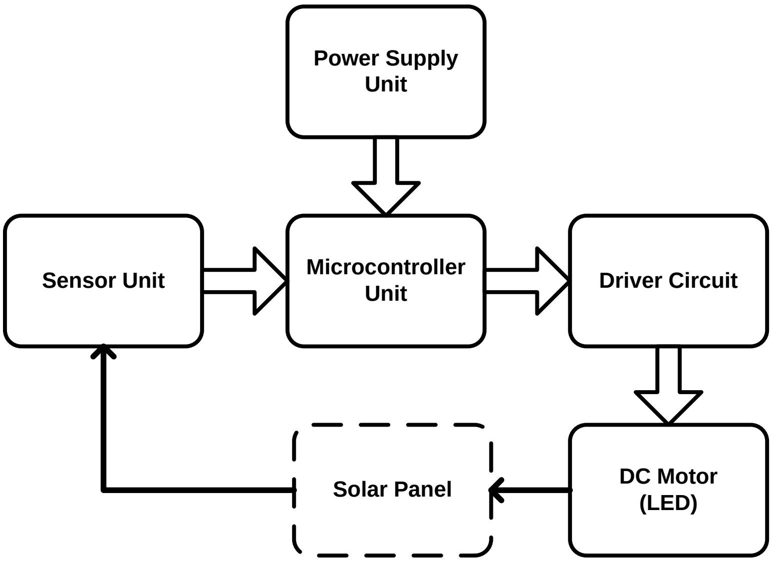


Figure 1 The block diagram of the automatic solar tracking control system

Design and Construction of Solar Tracker

The automatic solar tracking control system is composed of three main units such as sensor unit, control unit and motor driving unit. The major part of the whole system is microcontroller. In sensor unit, LDR senses the intensity of sunlight and the microcontroller receives the digital output through the driver transistor. The control unit decides in which direction the panel rotates to get the maximum intensity of the sunlight on the solar panel. With the sun always facing perpendicularly to the panel, the maximum energy can be absorbed and the panel operates at its highest efficiency in motor driving unit.

Sensor Circuit

The sensor unit consists of two light dependent resistors (LDRs). Light dependent resistors are used to detect change in light intensity or as a light sensor. The resistance of LDR varies in proportional to the intensity of light falling on its surface. In complete darkness, LDR produces its greatest resistance. The characteristic of the LDRs are chosen as 100kΩ in complete darkness and 500Ω when totally saturated with light. Under ambient light, resistance varies between 2.5kΩ and 10kΩ. The LDR can be applied on light-sensitive detector circuits and light and dark activated switching circuits. In this research, the LDR sensor circuit is connected as a dark activated switching circuit as shown in Figure 2.

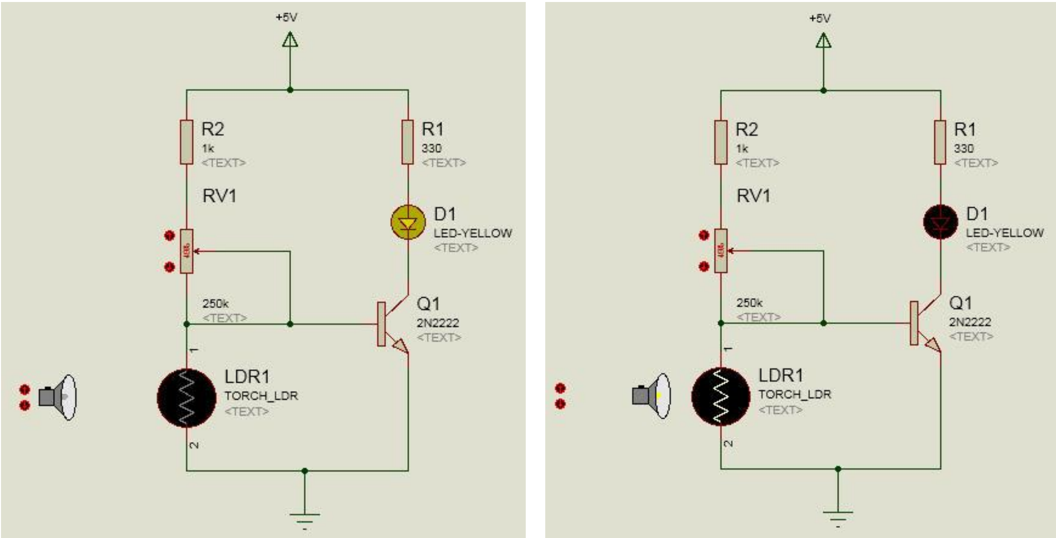


Figure 2 LDR sensor circuit connecting as a dark activated switch

Application of Microcontroller

Microcontroller PIC16F887 is the main control unit of the whole system. It consists of 40-pin dual in line package. In this research work, only 8-pin are used to operate the automatic solar tracking control system. The Master Clear Pin (pin number 1) is not used in this circuit so it is connected to power supply via 10 kΩ resistor to disable this pin. The 8 MHz crystal oscillator is connected to RA6 (pin number 13) and RA7 (pin number 14) which have the alternate functions of external clock input and clock output. The two sensors are connected to RA2 (pin number 2) and RA3 (pin number 3) to give the analog signal to microcontroller. DC motor circuits are connected to RB0 (pin number 33) and RB1 (pin number 34) conjunction with the Darlington pair transistor. The power supply in V_{DD} (pin number 32) and the ground pin V_{SS} (pin number 12) are connected to +5V regulated power supply unit to power up the system.

H-Bridge DC-Motor Control Circuit

To control the rotation of the DC motor, H-Bridge Circuit is constructed by using the bipolar power transistors as shown in Figure 3. When the clockwise signal coming from the microcontroller, the motor rotates in clockwise direction. When the counter clockwise signal coming from the microcontroller, the motor rotates in counter clockwise direction.

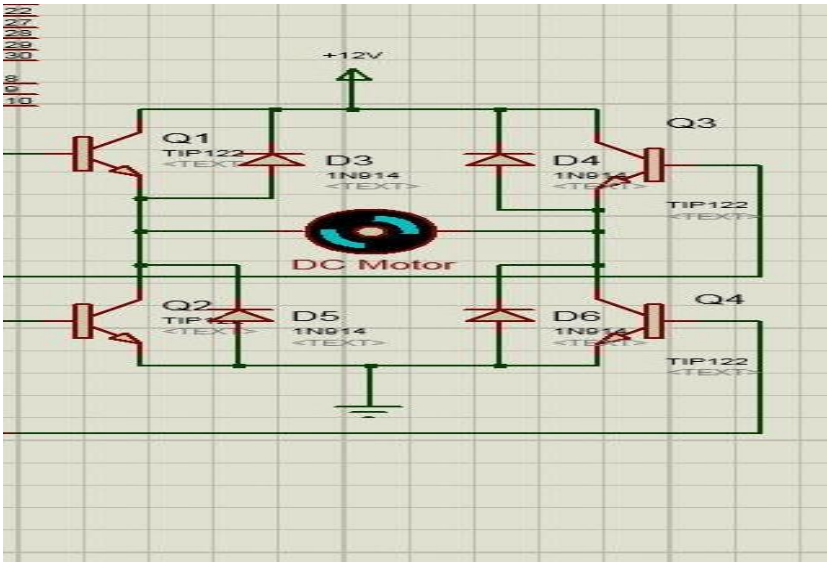


Figure 3 The H-Bridge DC motor control circuit

Circuit Design and Circuit Simulation

Firstly, the circuit design is created by using Proteus 8.1 software and circuit simulation is made on it. The Proteus 8.1 software is a Printed Circuit Board (PCB) design software integrated with the simulation of the circuit design. It is integrated with real time simulation of the electronic circuit and test whether the circuits design is working properly or not. The main purpose to design with Proteus software is to get the optimum circuit diagram without spending any actual circuit components by damaging due to circuit fault. After doing several circuit simulations again and again on the Proteus software, the optimum circuit design is obtained. The circuit simulation by Proteus 8.1 is as shown in Figure 4.

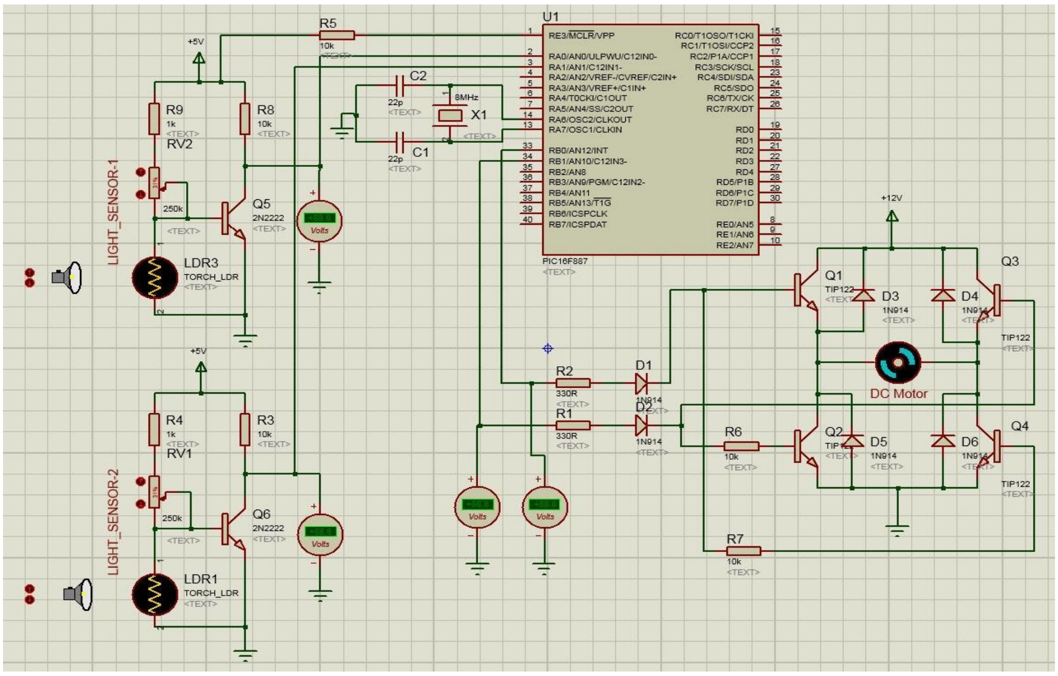


Figure 4 The simulation circuit by Proteus 8.1 software

Creating Circuit Track Lines for PCB Design

The "TraxMaker" is electronic design automation software for printed circuit board design. It is also PCB layout program associated with CircuitMaker2000. The printed circuit layout diagram for the "Automatic solar Tracking Controlled Circuit" was designed with "TraxMaker"- PCB Software including Top Layer (copper surface side for circuit track lines also called solder side) and Bottom Layer (components mounting side). The Top Layer and Bottom Layer are printed out and then copied on the surface of the printed circuit board (PCB). The photograph of the printed circuit track lines is as shown in Figure 5.

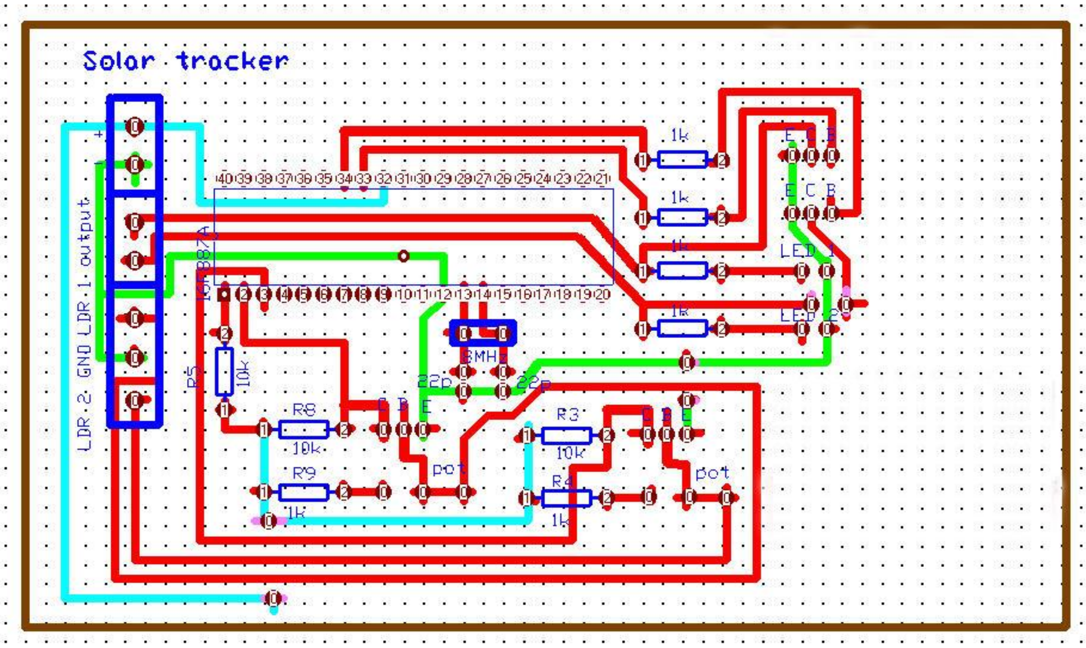
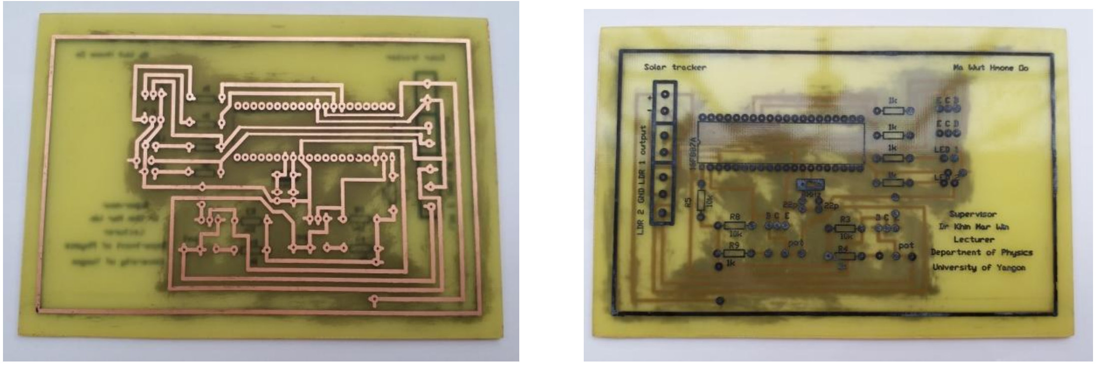


Figure 5 The circuit track line diagram of "Automatic Solar Tracking Control System" in both solder side and components side

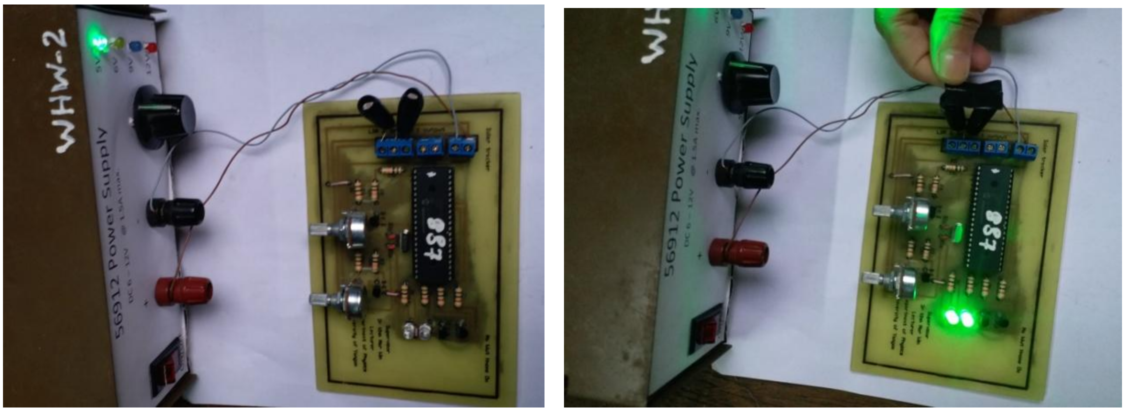
Etching Procedure

The printed carbon powders on solder side were placed on the copper side of the printed circuit board (PCB). The PCB was pressed and heated at the back side for ten minutes to cover the copper surface with carbon print lines. After pressing and heating process, the PCB was cooled down and the paper on the PCB was removed by soaking it in the water. To remove the unwanted copper surface area on the circuit, the PCB was slowly shaken in the ferrous chloride solution until copper dissolved into ferrous chloride and this process is called etching. After removing unnecessary parts of the copper surface, just only circuit diagram remained on the PCB. Finally the circuit components are mounted and soldered on the PCB in their positions on it. The circuit track line diagram of "Automatic Solar Tracking Control System" in solder side and component side are shown in Figure (6).



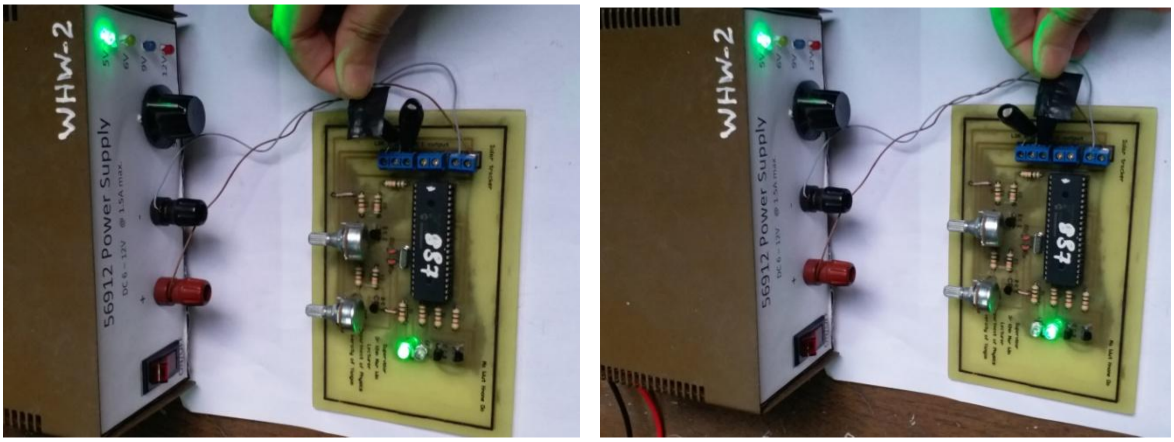
(a) In solder side (b) In component side

Figure 6 The circuit track line diagram of in solder side and component side



(a) Testing in both light conditions (b) Testing in both dark conditions

Figure 7 Testing the photograph of the "Automatic Solar Tracking Control System"



(a) LDR1 (b) LDR2

Figure 8 The photograph of the method of testing of each sensors in dark condition

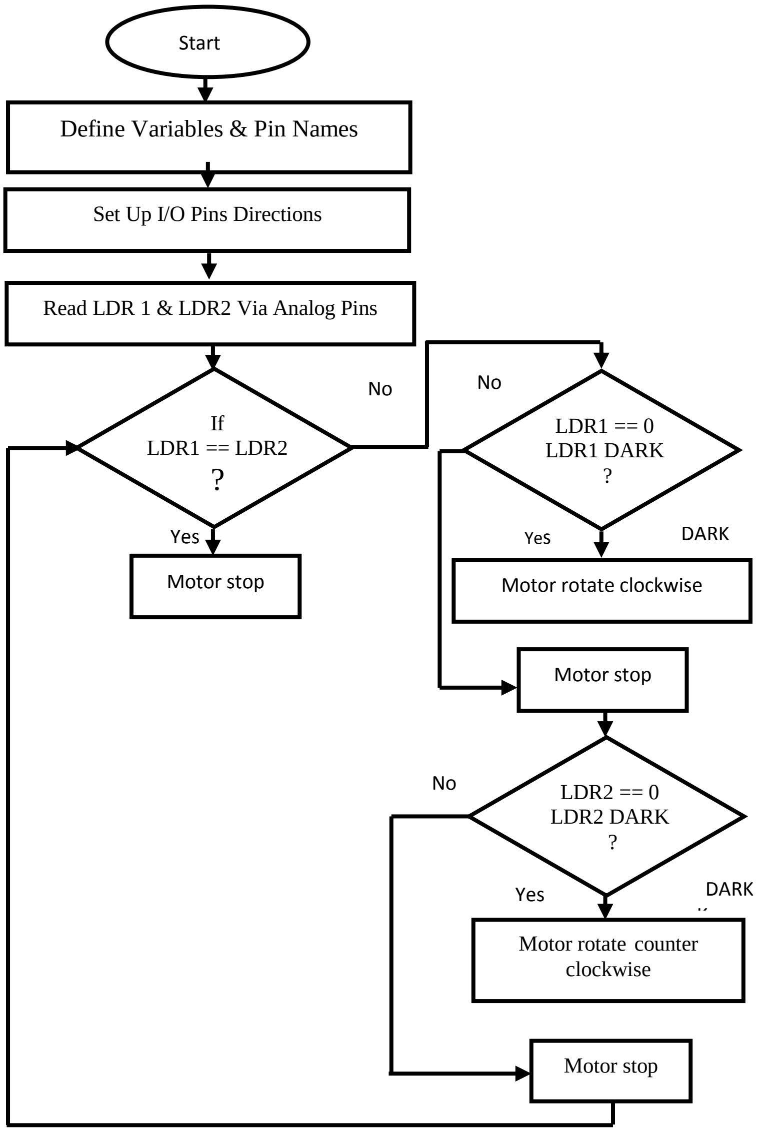


Figure 9 Flow chart of the Solar Tracker

Operation of the System

The two LDR sensors are mounted on the printed circuit board (PCB) instead of the two sides of solar panel. When the intensity of light falling on the LDR, the operation will be started. Rotation of the motor depends on the intensity of light. In this circuit, the LED indicators stand for operating of the DC motor which rotates the solar panel. The DC motor will not rotate when the same amount of light falling on both LDR1 and LDR2. If LDR1 and LDR2 are not the same condition, the motor will rotate toward the direction of sun by facing up right direction. In the noon, sun is ahead and both sensors have same intensity of light, in such cases the DC motor stops, and there is no rotation. Moreover, solar panel also remains stable in night when there will be no light.

Result and Discussion

The “Automatic Solar Tracking Control System” is constructed and tested several times. The tracking system relies mainly on PIC16F887 microcontroller. The output of the controller is used LED indicator instead of the DC motor. The automatic solar tracking control system is one part of the solar power system. This control system operates together with the other units of the solar power system such as solar panel, linear actuator or DC motor, solar charge controller, battery, and inverter. The basic design of the control system provides the solar panels to gain the efficient energy from the sun. The linear actuator or DC motor is used to move the solar panel so that sun’s beam is able to remain aligned with the solar panel. In this research, the detail designs and explanations of LDR sensor with dark detector circuit are included. In a dark, a photo resistor can have a resistance as high as several mega ohms (MΩ) and as low as a few hundred ohms in the light. Thus, 250 kΩ variable resistor is connected in series with the LDR for the purpose, adjusting the critical resistance value of the LDR sensor according to the intensity of light falling upon it.

Conclusion

The use of solar tracking system is the most effective and efficient ways of generating maximum photovoltaic power. All the components in solar power system can be changed according to the energy requirement and the load of the solar panel. If more solar panels are used for more energy, the load of the solar panel must be determined and suitable motor must be used to rotate the solar panel. However, there can be the surrounding effects, such as weather condition especially heavily overcast conditions, in rainy season, and the shade of trees near the solar panel. So, Power produced from the solar energy depends very much on the weather condition. All power generating systems have strengthens and weakness. One of the main advantages of using solar tracker is to solve the power requirement without electricity for rural areas. The result shows that higher generating power efficiency is indeed achieved using the solar tracking system. The proposed method is verified to be highly beneficial for the solar power generation system.

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Appendix

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/*****************************************************************
* File Name: Solar_Tracker_Dark_.c
* Author:    Wut Hmone Oo
* Date:      14 November 2018
* Notes:- Device: PIC16F887
*         Oscillator: 8 MHz Crystal
*         A DC Motor is connected at PortB RB0 & RB1 via H-Bridge Transistors
*         Q1-Q4.
*         Two LDRs are connected at portA RA0 & RA1 via transistor Q1 & Q2.
*         If one LDR is dark, motor rotates one direction. And if other LDR
*         is dark motor rotates opposite direction.
*****************************************************************/
void main(){
  ANSEL = 0;              // All I/O are configured as digital
  ANSELH = 0;
  PORTB = 0;              // Clear PORTB
  TRISB = 0;              // PORTB as output
  PORTA = 0;              // Clear PORTA
  TRISA = 0x03;           // Set PORTA pins RA0 & RA1 as inputs
for(;;){
      if(porta.F0 == 0) {     // If LDR1 is dark, then
       portb.F0 = 1;       // Motor rotates Clockwise
     }else{
      portb.F0 = 0;       // Otherwise motor stop
     }
     if(porta.F1 == 0) {     // If LDR2 is dark, then
       portb.F1 = 1;       // Motor rotates Counter Clockwise
     }else{
       portb.F1 = 0;       // Otherwise motor stop
     }
    }                     // Endless loop
}
```