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AUTOMATIC SOLAR TRACKING SYSTEM USING PILOT PANEL

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Abstract

Solar tracker is an automated solar panel that can effectively improve energy efficiency of a solar photovoltaic (PV) panel. The solar panel are intended to follow and track the direction of the highest light intensity from the sun. Development of dual axis solar tracker involves design implementation and software description for the control program. Arduino UNO, DC gear motors and light dependent resistors (LDRs) have been mainly used in the system. The L298N driver has been used to drive DC motors for making the direction and speed decisions of motors. The tracker's control algorithm has been implemented via A Tmega 328p microcontroller on a simple and cheap mechanical structure. The hardware design has been implemented in order to provide high efficiency from the solar PV panel in this work. The movement of dual axis solar panel has been controlled by using the difference of light intensity values from four sensors. The test result has confirmed that the solar panel is controlled by the program to be normal to the sun all the day time in order to provide the maximum energy efficiency. The system can be applicable to receive the maximum energy efficiency from the solar panel all the year around.

Keywords: Arduino, LDR, photovoltaic, solar tracker, microcontroller

Introduction

Global energy consumption is dramatically increasing due to higher standard of living and the increasing world population. The world has limited fossil and oil resources. Solar tracking system is the most immediate and technologically attractive use of solar energy. Solar energy is one of the primary sources of clean, abundant and inexhaustible energy that not only provides alternative energy resources, but also improves environmental pollution. Solar energy is the potential source to be the major energy supply for the future. The sun's position in the sky varies with equipment over any fixed position. If PV systems are built at fixed position, they cannot track the sun. Solar tracker is an automated solar panel that follows the Sun to increase the generated maximum power.

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Different mechanisms are applied to increase the efficiency of the solar cell to reduce the cost. Solar tracking is the most appropriate technology to enhance the electricity production of a PV system. The orientation of the solar panels may increase the efficiency of the conversion system from 20% up to 50%.

Mechanism of Solar Tracking System

The sun tracking solar power system is a mechatronic system that integrates electrical and mechanical systems, and computer hardware and software. Generally, solar tracking system can be classified as either open-loop tracking types based on solar movement mathematical models or closed-loop tracking types using sensor-based feedback controllers. In the open-loop tracking approach, a tracking formula or control algorithm is used. The control algorithms are executed in a microprocessor controller. This system always involves complex tracking strategies using microprocessor chips as a control platform. In the closed-loop tracking approach, various active sensor devices, such as charge-coupled devices (CCDs) or light dependent resistors (LDRs) have been utilized to sense the Sun’s position and a feedback error signal can be generated to the control system to continuously receive the maximum solar radiation on the PV panel.

Design implementation is essential in dual-axis solar tracker. It needs more complex technology and necessary moving parts than single axis solar tracker and fixed panel. By utilizing dual-axis solar tracker, the energy manufacturing is at an optimum and energy output is enhanced year round as the sun’s position in the sky will alter gradually during a day and over the seasons throughout the year. Based on this background, solar tracking system has been implemented with the major components of Arduino Uno, DC motors and light dependent resistors (LDRs) in this research.

Development of Automatic Dual Axis Solar Tracker

The developed dual-axis solar tracker consists of 20W solar panel, two DC gear motors, Arduino UNO board as the main components. Arduino UNO microcontroller board and Arduino programming language are mainly used to control the whole circuit. Each of four sensors is connected to the input pins of Arduino UNO board; A0, A1, A2 and A3 respectively. The different values of input data from the sensor are read and calculated by Arduino microcontroller. By comparing these results, the microcontroller determines the highest intensity value and then controls the direction, position and speed of two DC gear motors for altitude and azimuth angles by using a L298N motor driver. A 12 V battery is used to charge the whole circuit (microcontroller and motors). But Arduino UNO can work with 5 V that is output power of L298N motor driver. Liquid crystal display (LCD) displays the direction of solar PV panel by the program. Block diagram of automatic solar tracking system is shown in Figure 1.

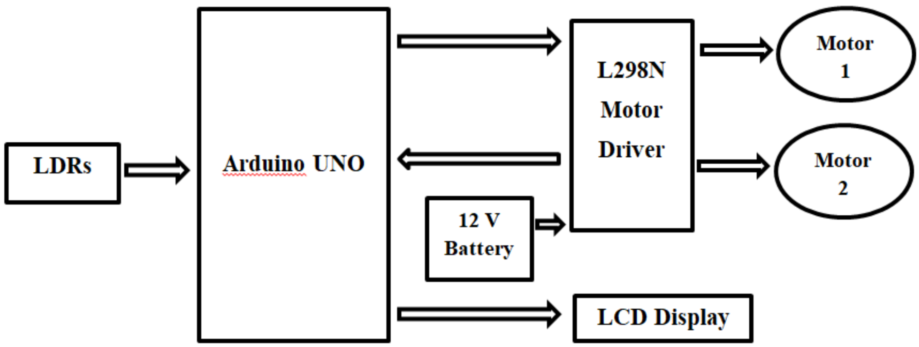

Figure 1: Block diagram of automatic solar tracking system

Function of Light Sensing Circuit

The light sensing circuit uses four LDRs for measuring the light intensity from the sun. Light intensity values from light sensing circuit have been read by the microcontroller and The LDR gives out an analog signal, which is directly proportional to the input light intensity on it. That is, the greater the intensity of light from the LDR, the greater the corresponding voltage will be. Since the LDR gives out an analog voltage, it is connected to the analog input pin of the Arduino. The Arduino, with its built-in ADC (Analog to Digital Converter), then converts the analog voltage (from 0-5 V) into a digital value in the range of (0-1023). Light sensing circuit is assembled as shown in Figure 2.

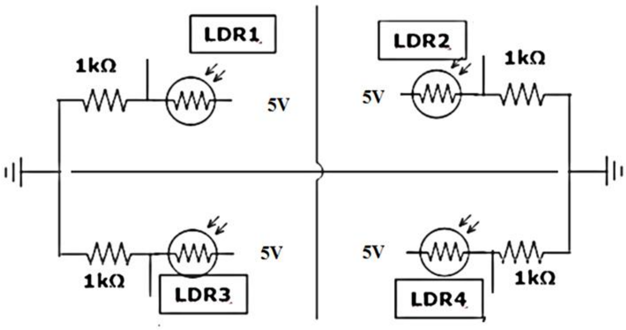

Figure 2: Light sensing circuit diagram

Reading Light Intensities from Light Dependent Resistors

It is investigated that the light intensity values are slightly different under the same light condition although almost the same size LDRs and same resistance valued resistor are used in the light sensing circuit. The different values of light intensity from each LDR in the circuit are read by the Arduino Microcontroller and these data are displayed on the "Serial monitor" of Arduino IDE as seen in Figure 3 by the following program.

```
void setup( ) {    Serial.begin(9600);   }
Void loop ( ){
int Val = analogRead(LDR1); // reading inputs
int Val = analogRead(LDR2);
int Val = analogRead(LDR3);
int Val = analogRead(LDR4);
Serial.print(Val1); //print the light intensities on serial monitor of Arduino
Serial.print(Val2);
Serial.print(Val3 );
Serial.print(Val4);
Delay(100);
 }
```

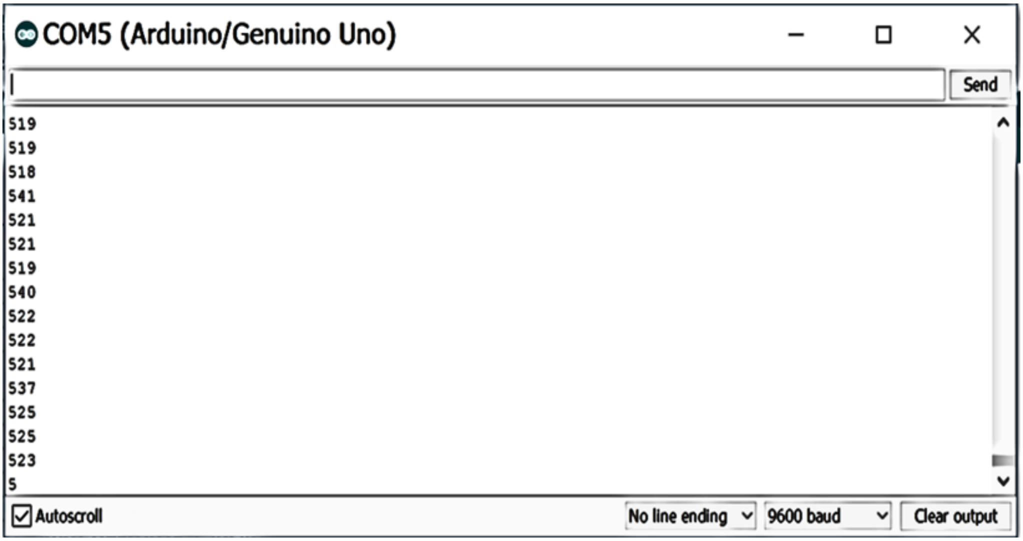

Figure 3: Different values of light intensity on the serial monitor

Building the Control Circuit

Arduino UNO microcontroller board and programming language based on Arduino platform are mainly used to control the operation of the whole circuit. Light dependent resistors are connected to the analog pins of Arduino UNO; A0, A1, A2 and A3, as the input data. The digital pins of Arduino UNO; D4, D5, D6 and D7 are connected to In1, In2, In3 and In4 pins of L298N dual H-bridge motor driver respectively and EnA and EnB pins of the motor driver are connected to D9 and D10 of Arduino respectively. EnA and EnB pins of the driver are attached to the Pulse Width Modulation (PWM) pins of Arduino; D9 and D10 respectively. The output pins of the motor driver are connected with two DC motors for the pitch and azimuth angle of solar panel respectively. The pins of liquid crystal display are connected to the digital pins, power supply and ground. The whole circuit diagram is shown in Figure 4 and connection in control circuit of the automatic dual axis solar tracker in Figure 5.

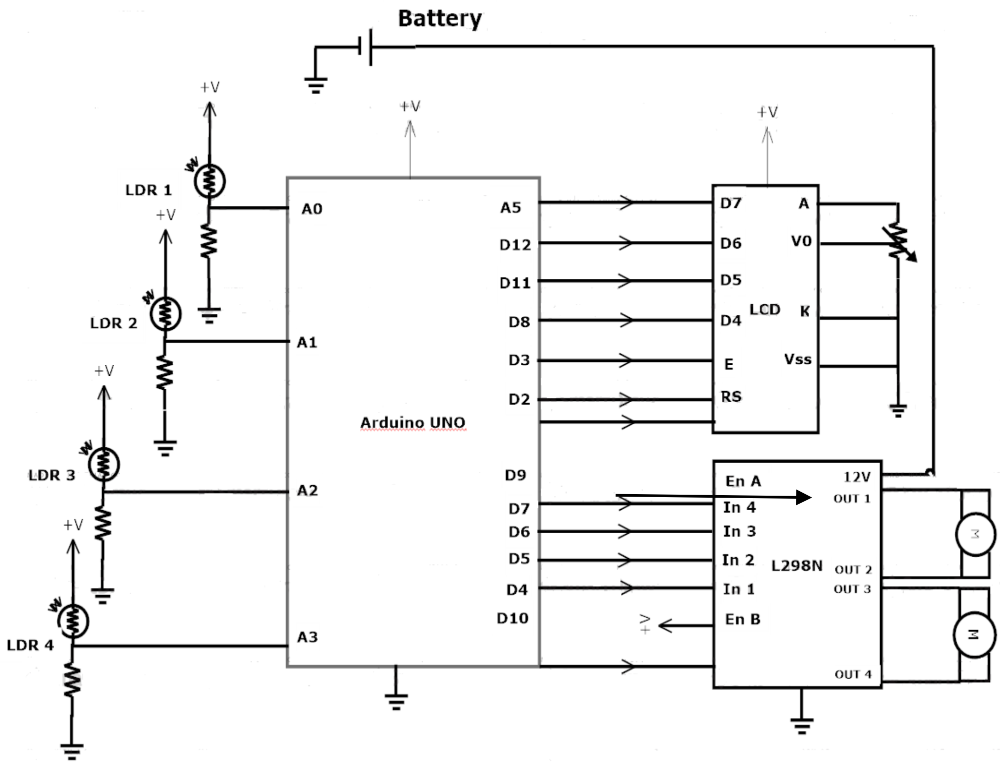

Figure 4: The whole circuit diagram of the dual axis solar tracking system

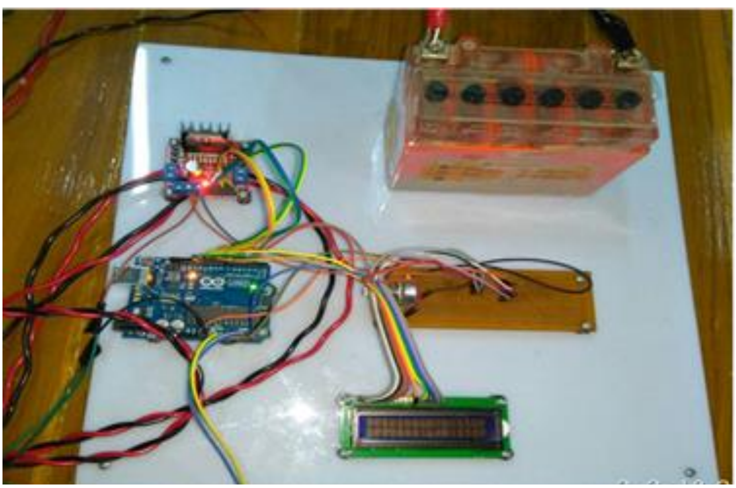

Figure 5: Connection in control circuit of automatic dual axis solar tracker

Operation of the control circuit

The calibration of four sensors under the same light source is very important to get nearly equal resistances. The difference light intensities from four sensor inputs are used to control the direction, position and speed of two DC motors for pitch and azimuth angle tracking of solar panel. According to the control program, Motor1 has been used for the pitch angle tracking and Motor2 has been used for the azimuth angle tracking of solar panel. The difference values of light intensities from LDR1 and LDR2 have been used to determine the direction and speed of Motor 1. The difference value of light intensity (I) from LDR3 and LDR4 have been used to determine the direction and speed of Motor 2. How the tracking system operates after receiving the input signals in order to be normal the solar panel toward the sun is depicted in Table 1.

The speed of Motor 1 and Motor 2 also vary with the difference light intensity values from LDRs by the control program. Therefore, the solar panel follows and tracks the direction of the highest light intensity of the sun to be normal to the sun all the day time because it is attached to pitch and azimuth angle tracking of motors. Liquid crystal display (LCD) displays the directions of solar PV panel as output on the display screen. The flow chart of operation of the control circuit for automatic dual axis solar tracker is shown in Figure 6.

Table 1: Operation of the control circuit with the difference value of light intensity (I) from LDRs

Condition	Responsible motor	Type of movement	Rotated direction
$I_{LDR1} > I_{LDR2}$	Motor 1	pitch angle	counter clockwise
$I_{LDR2} > I_{LDR1}$	Motor 1	pitch angle	clockwise
$I_{LDR3} > I_{LDR4}$	Motor 2	azimuth angle	counter clockwise
$I_{LDR4} > I_{LDR3}$	Motor 2	azimuth angle	clockwise

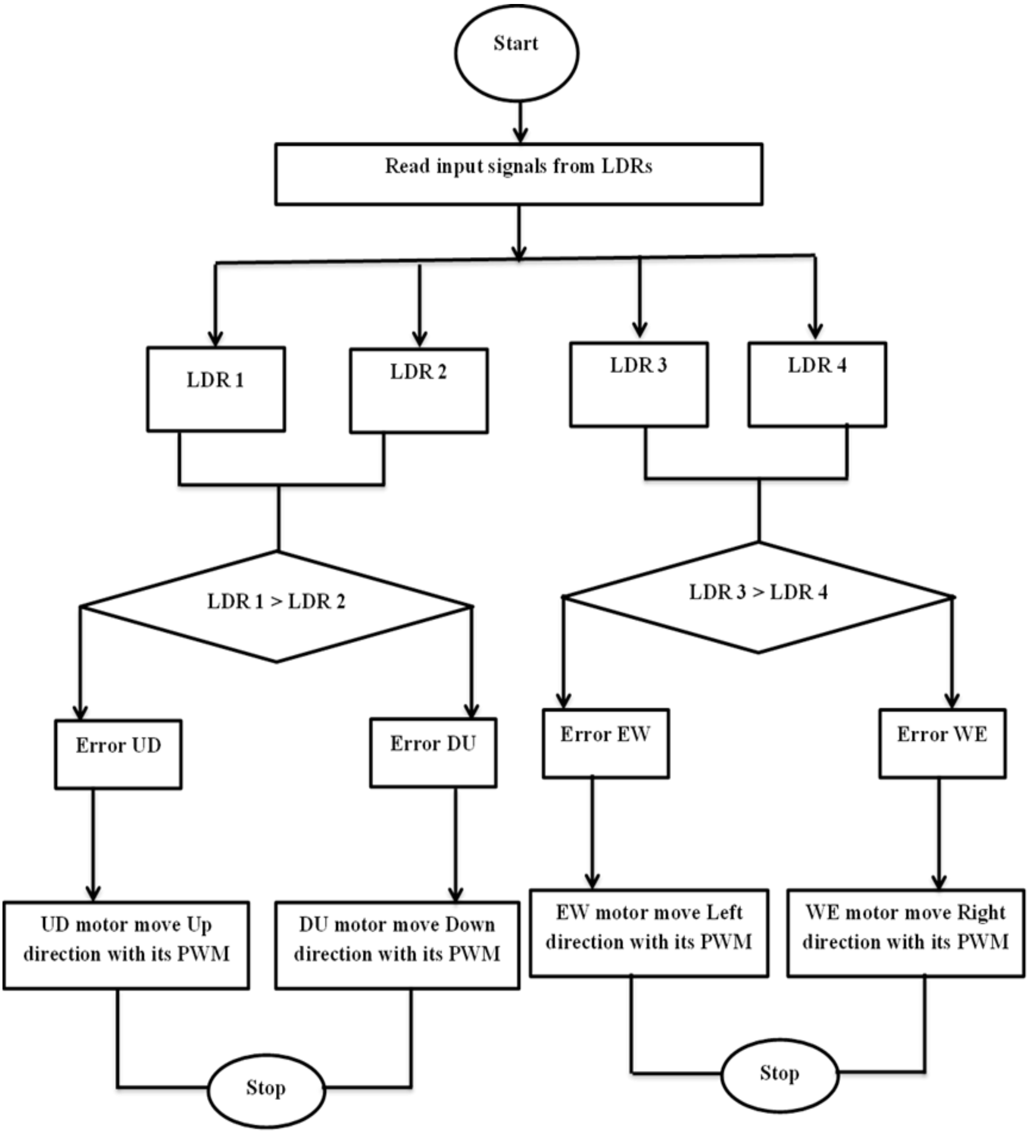

Figure 8: Flow chart of operation of the control circuit for automatic dual axis solar tracker

Designing the Mechanical Structure

The mechanical structure of the automatic dual axis solar tracker has been designed and implemented to hold up the weight of PV panel. In the mechanical structure, two similar DC gear motors are used to obtain the required torque to move the PV panel in pitch and azimuth angle tracking. Light sensing circuits are placed on one side of the PV panel.

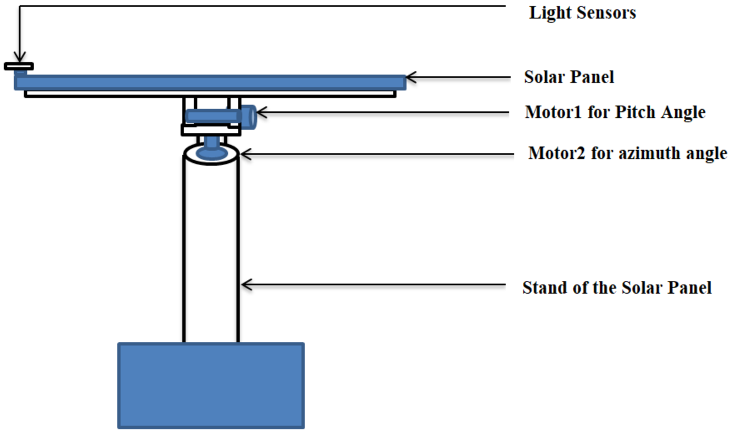

Figure 6: Designed mechanical structure of automatic dual axis solar tracker

Testing Automatic Solar Tracking System

The complete dual-axis automatic solar tracker is illustrated in Figure 7. The maximum solar tracking has been experimentally tested and the data obtained for the orientation of the panel with maximum intensity tracking are presented in Table 2. It has been found that the solar panel follows and tracks the direction of the highest intensity of the sun to be normal to the panel at each interval during testing. It is worth to note that although there is slight variation in intensity, the orientation of the solar panel has changed distinctly.

Figure 7: Complete dual-axis automatic solar tracker

Table 2: The data of the orientation of the dual-axis automatic solar tracker with maximum intensity

Time	Volt (V)	South-West	North-West
12:00 NOON	19.89	207°	313°
12:30 PM	19.64	207°	313°
1:00 PM	19.53	212°	320°
1:30 PM	19.73	213°	320°
2:00 PM	19.81	217°	323°
2:30 PM	19.75	218°	323°
3:00 PM	19.86	218°	326°
3:30 PM	19.87	218°	326°
4:00 PM	19.73	223°	326°

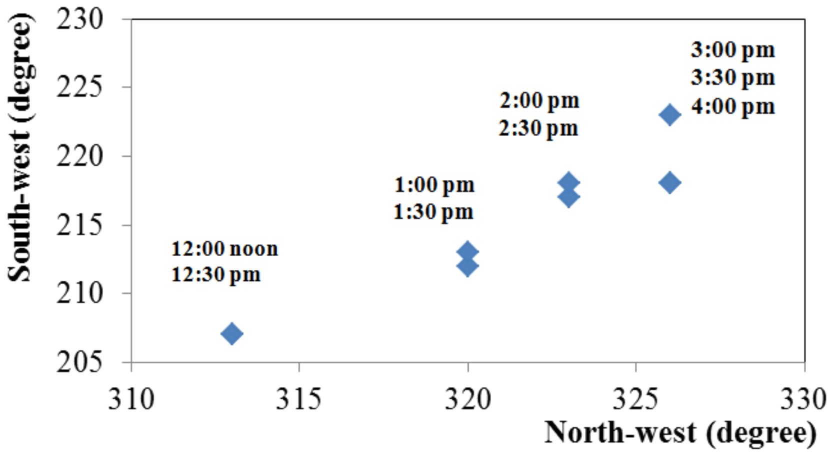

Figure 8: The variation of orientation of the dual-axis automatic solar tracker with maximum intensity

Conclusion

This dual-axis automatic solar tracker has been developed by design implementation and software description for controlling the tracker. The improvement in the hardware design of this solar tracker has also been implemented in order to provide high efficiency from a solar PV panel. The data obtained from the test has confirmed that the dual-axis automatic solar tracker could follow and track the direction of the highest light intensity from the sun. Based on the data obtained, it is concluded that the response of orientation of the solar panel to the light intensity is plausible to be applicable for the solar tracking in the year round.

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