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Analysis of Single Axis Solar Tracking System

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Abstract: Our country's need for energy is rising in due to its expansion and development. Renewable energy sources and environmentally friendly energy generation should go hand in hand with this. Solar energy is an important primary energy source, especially in rural areas. The goal of the project is to develop and explain how to use an Arduino Uno for real-time monitoring in order to track the sun and maximize efficiency. While there are many tracking system approaches, the focus of this paper is the single-axis solar tracker due to its benefits, which include low cost, low maintenance, good efficiency, and a straightforward design. There are three subsystems in this system. 1) Mechanical system: a tracking system platform 2) Electrical system: motor drive control system, stepper motor, photovoltaic system, Arduino, and LDR. Its efficiency has been evaluated and contrasted with that of stationary solar panels. This paper describes the design of a low-cost solar tracking system.

Keywords: Photovoltaic solar cell, LDR, Arduino, DC motor, andsolar tracker

Introduction

We are all aware of the critical role that electricity plays in our daily lives. Electricity is a necessity for everyone. Electricity is necessary for all production facilities, industries, research centers, etc. in order to meet our needs and further our development. However, using electricity is one of the necessities of modern life. Although there are numerous ways to generate electricity, it is crucial that the sources we use don't pollute the environment. Thus, we have a plentiful and limitless source of energy that is best utilized for producing electricity; we call this kind of energy a "Renewable Source of Energy." Almost everywhere in the globe has access to free solar energy. A number of researchers are looking into ways to make photovoltaic systems more efficient. The electricity can be produced by employing fixed solar panels, but since the earth's position isknown to change throughout the day, these panels are unable to capture the sun's rays continuously. When sunflowers move, they follow the sun's path. As result, in order to solve this issue. In order to align the panel with the direction of the sun's rays, a solar tracking system is required. Solar panels will be rotating according to time with the rising sun and setting positions to produce their maximum output for the day.

A large number of the solar panels were fixedly placed, like on a roof. This is not the best approach because the Sun is a moving object. One way to actively track the sun is to move the solar panel in the direction of the sun using a sun tracking device. Maximizing the efficiency of the solar cells is the main objective of this project. The typical large-scale solar-tracker is not appropriate for residential use. Consequently, this project will create a low-cost solar cell sun tracking system specifically intended for residential used. There are many different kinds of solar trackers available and the majority of them make use of multiple photosensors. Solar cells, phototransistors, photodiodes, and light-dependent resistors make up the majority of these sensors. If a tracker's sensors don't all have the same characteristics, tracking could be inaccurate. The tracker is rendered inoperable if any one of the sensors is compromised.

The main objective of this project is to build a solar system model that can track the movement of the Sun without being affected by motor speed. Furthermore, a sun tracking system with a single axis will be used to increase overall electricity generation, and the design will be suitable for residential use. Since light-dependent resistors, or LDRs, are frequently found in sun tracking systems, they were selected as the sensor. This is a result of the light-sensitive LDR. As the intensity of the incident light increases, the resistance of the LDR will decrease. The motor driver L298N had been selected as the controller. Relays have been used to provide bi-directional DC motor control for the driver. The motor controller was selected due to its ease of control over both clockwise and anticlockwise rotation of the motor. The DC geared motor was also selected due to its low rpm and holding torque of up to 24 kg/cm. Finally, since the integrated circuit only requires 9 V to function, the voltage regulator LM7809 is used to change the source's input voltage to the 9 V output.

System Components

The system that is being proposed is a single-axis solar tracking device with an Arduino-based variable and compact design. The stepper motor and motor driver are used by the Arduino, which rotates the solar panel to the lighting location using information from the two LDR sensors. The voltage sensor is implemented using the voltage divider method. The battery stores the energy from the solar panel, which is then used to power the loads. A block diagram of a single-axis solar tracking system is shown in Figure 1.

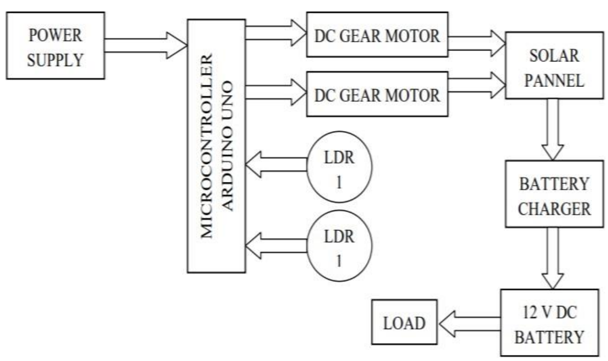

Fig. 1. Block Diagram of the System

The paper compares two signals from different sensors using a balanced concept. A light sensor has been used is the Light Dependent Resistor (LDR). The divider between the two light sensors will cast a shadow on one side of the sensor if the solar panel is not perpendicular to the sun. The Arduino Uno microcontroller serves as the brain of the controlling circuit, directing the motor's movement. The Arduino Uno microcontroller receives data from the sensors and processes it. The microcontroller will transmit data to make sure the solar panel is oriented perpendicularly to the sun with the Bi-directional DC gear motor. The motor's attached solar panel will respond in accordance with the motor's direction

Circuit Diagram

A. Power Supply Circuit Diagram

In this project power supplies through the transformer, For successful this operation we are using 9V DC supply which is given by power supply circuit. For the output of the 9 V DC supply, we are stepping down the AC supply by the transformer. The transformer primary side has a 230V AC supply whereas at the secondary winding the voltage is stepped down to a 12V AC supply and this voltage is rectified using bridge rectifiers.

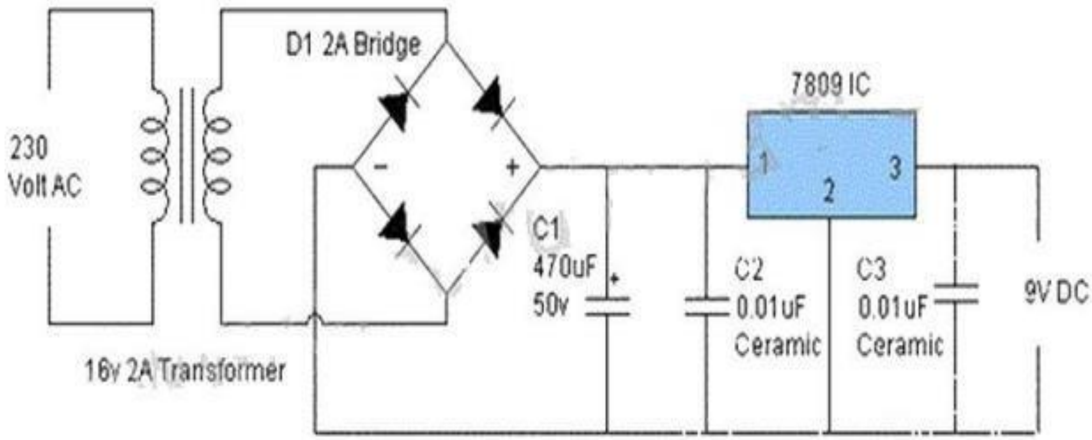

Fig.2. -Power-Supply-Circuit-Diagram

The rectified output is 12V DC which is again applied to a voltage regulator LM7809 (to provide +9v). After that, we are using capacitors in parallel for the filter this voltage and at least we get a 9V DC power supply which is required for operating microcontroller as well as to give supply to the DC gear motor to operate. Figure 2 below shows the main inpur power-supply-circuit diagram.

B. Battery Charger Circuit Diagram

In order to use the energy that the solar panel's output stores in batteries, we need to design a battery charger circuit. Lead acid or nickel-cadmium batteries can be charged with solar energy using this circuit for a solar charger. Rechargeable batteries with a voltage of 9 to 12 volts are charged by the circuit using solar energy harvesting for various applications. In addition to regulating voltage and current, the charger has the ability to cut off power above a certain voltage. This circuit makes use of an IC LM317 variable voltage regulator and a 12-volt solar panel. The solar panel contains 1.2 volt solar cells in each. The battery can be charged using the 12 volts DC that the panel provides. D1 permits the voltage regulator IC LM317 to receive the charging current. You can control the output voltage and current by using its adjust pin. The battery charger's circuit diagram is shown in Figure 3.

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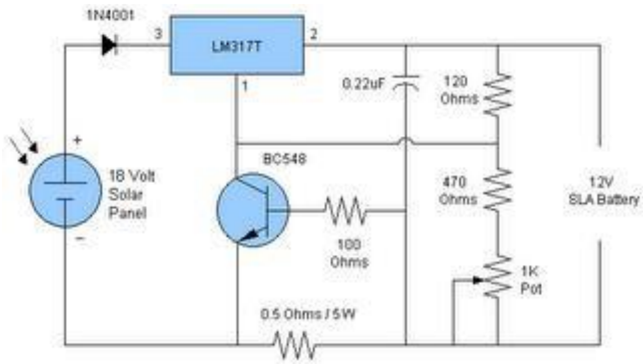

Fig.3. Battery-Charger-Circuit-Diagram

C. Overall Circuit Diagram

In this project power supplies through the transformer, for successful this operation we are using 9V DC supply which is given by power supply circuit. For the output of the 9 V DC supply, we are stepping down the AC supply by the transformer. The transformer primary side has a 230V AC supply whereas at the secondary winding the voltage is stepped down to a 12V AC supply and this voltage is rectified using bridge rectifiers.

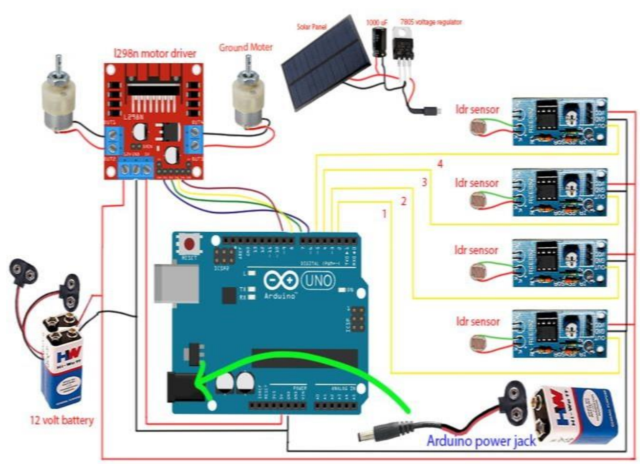

Fig.4. Overall Circuit Diagram of the System

The rectified output is 12V DC which is again applied to a voltage regulator LM7809 (to provide +9v). After that, we are using capacitors in parallel for the filter this voltage and at least we get a 9V DC power supply which is required for operating microcontroller as well as to provide power for the DC gear motor to run. Figure4 shows the overall circuit diagram.

Proposed System

Initially, the microcontroller reads the voltage from the panel's output. When input data exceeds a predefined threshold, tracking is activated. From its starting position, the panel is rotated clockwise and then anticlockwise. The location where the voltage is found to be higher indicates thedirection of the sun's path. This is the default direction for the next search operation. The panel is then gradually rotatedin that direction. At each step, the voltage is measured. At each step, this data is compared to previously stored data in memory. The process will continue as long as the voltage rises. When the voltage is found to be lower than the previous one, the panel returns to the previous position. Thisis the best position for maximum power at any given time. When an optimal position is found, the microcontroller resets the timer and awaits the next operation. The next operation is determined by the delay time. Figure 5 shows the tracking operation in the form of a flow chart.

Software Implementation

A. Program-Flowchart-of-the-System

The variable, input, output pins, header files, and start are all regarded as initialized. After that, the dada from LDRsis read. The variable, input, output pins, header files, and start are all regarded as initialized. After that, the dada from LDRs is read. The motor turns in a clockwise (CW) direction. Alternatively, the motor will rotate in either CCW(Counter-Clockwise) or ACW (Anti-Clockwise) mode if the Arduino's direction pin is set to LOW.

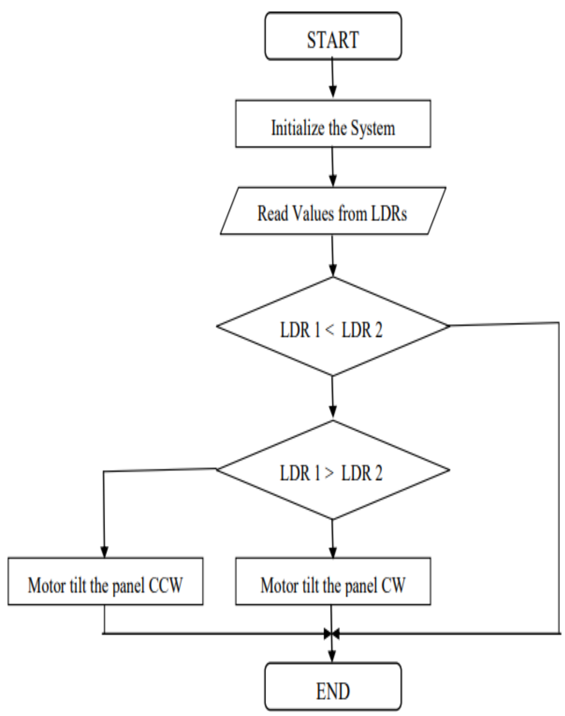

Figure 5: Program Flowchart of the System

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B. Simulation-and-Compiling

The entire system is simulated and compiled using the Arduino IDE software. The compiled code test was successfully completed as shown in Figure 6.

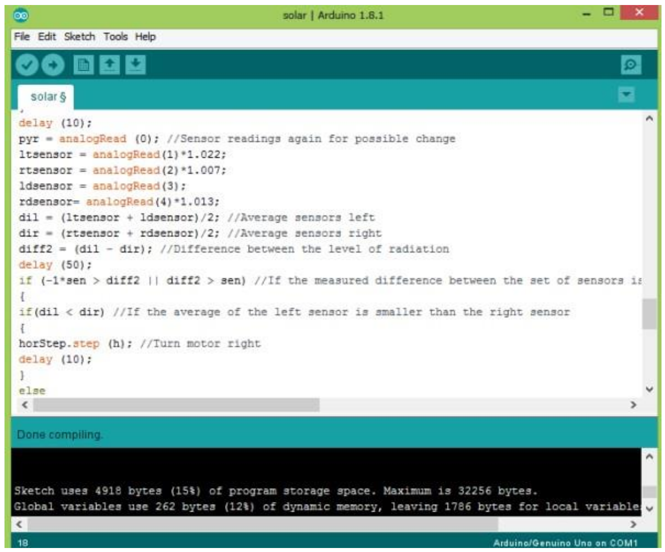

Figure 6: Compilation Result of the Program

Hardware Implementation

This section will focus on the hardware approach in designing and implementing the Single Axis Solar Tracker

A. Hardware Components Used

The following elements were necessary for the Single Axis Solar Tracker System to operate:

- Arduino Uno R3 (Microcontroller)
- DC Gear Motor
- 2 Pair of LDR Sensor's
- 6 V Solar Panel
- Motor Driver L298N
- Transformer 230/12 V AC
- PCB
- Diode IN4007
- Resistors

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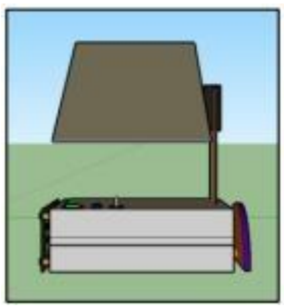
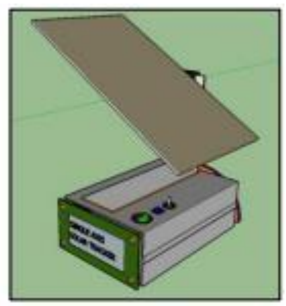
- Connecting Wires
- LED

B. *Hardware Design for the System*

This section goes over the hardware design concept for a single-axis solar tracker. The Sketch Up 3D software was used to create the drawing for this prototype hardware. In the below Figure 7 shows simulated model of the mechanical structure designed in Blender is created in order for the structure to support a Solar Panel.

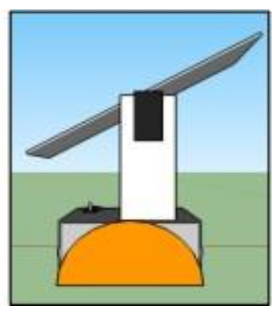


(A) Front View



(B) Isometric View

(C) Side-I View



(D) Side-II View

Figure 7: Different Views of Hardware Design

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C. Testing-of-the Proposed-System

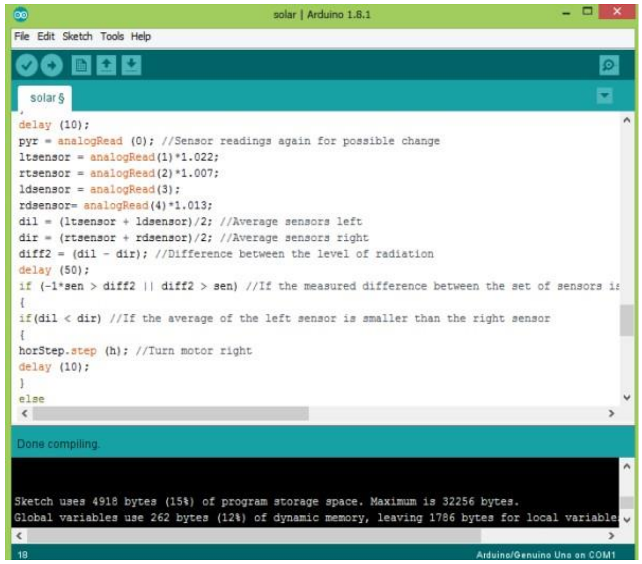

Figure 8 shows the Single Axis Solar Tracker System'soverall testing results.

Result and Discussion

This section described the outcomes of outdoor testing.On February 9, 2022, the outdoor testing will take place at SVKM's Institute of Technology. The testing is only carried out if the weather is favourable. The power, voltage, current, and efficiency of a variable-angle solar tracker and a fixed- angle static solar panel were compared. We exposed stimulation model to sunlight for 7 hours, and data and analysis were collected from 10 a.m. to 4 p.m. We chose this time because the intensity of sunlight was high, and the results are tabulated below, based on recent literature. The voltage is measured every hour. Simultaneously, another solar panel of the same specification is fixed in place, and voltage is recorded throughout the day. Short circuit currents are also measured every hour for both solar panels. We use two 3 Volt LED circuits as a load and measure voltage and current. Table 1 compares the output values of solar panels with fixed and variable angles.

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Table 1: Comparison-of-Solar-Panel-Output-Values-Between-Fixed-and-Variable-Angles

Time (Hours)	Solar Panel Output Values With Fixed Angle (90°)				Solar Tracker Panel Output Values With Variable Angles			
	Angle (°)	Voltage (V)	Current (I)	Power (W)	Angle (°)	Voltage (V)	Current (I)	Power (W)
10. 00 AM	90	3.5	0.03	0.105	135	4.3	0.05	0.215
11. 00 AM	90	4.3	0.05	0.215	115	5.1	0.10	0.51
12. 00 PM	90	5.0	0.07	0.350	90	5.5	0.13	0.715
01. 00 PM	90	5.7	0.18	1.026	90	5.9	0.21	1.239
02. 00 PM	90	5.1	0.11	0.450	90	5.5	0.16	0.88
03. 00 PM	90	4.5	0.06	0.561	65	5.1	0.11	0.561
04. 00 PM	90	3.2	0.02	0.064	45	4.8	0.07	0.336
	Total Power			2.771 W	Total Power			4.456 W
	Average Power			0.395 W	Average Power			0.636 W

Figure 9 depicts the power vs. time characteristics of the 1 Watt solar panel both with and without a photocell using data from Table 1.

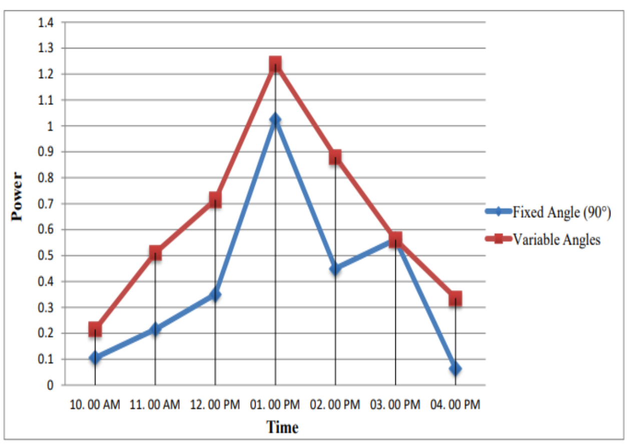

Figure 9: Power Vs Time Graph

Conclusion

Initially, the microcontroller reads the voltage from the panel's output. When input data exceeds a predefined threshold, tracking is activated. From its starting position, the panel is rotated clockwise and then anticlockwise. The location where the voltage is found to be higher indicates the direction of the sun's path. This is the default direction for the next search operation. The panel is then gradually rotated in that direction. At each step, the voltage is measured. At each step, this data is compared to previously stored data in memory. The process will continue as long as the voltage rises. When the voltage is found to be lower than the previous one, the panel returns to the previous position.

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