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Development of Smart Solar Tracking System

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Abstract: The project is to design an active solar tracking system which able to track the sunlight with the aid of light dependent resistor (LDR) as input sensor to read the intensity of sunlight. The solar tracking system uses platform as a base and it is moved by a servo motor as the platform needs to be moved towards the sunlight to get the optimum light. The solar tracking system is programmed by using microcontroller Arduino Uno as a main controller. After the setup of the hardware and program, the tracking motion of the tracking system has been implemented to track the sun based on sunlight direction. In this work, it is designed that the motion of the tracking system is depends on the value read by LDR. As a conclusion, the solar tracking system can increase the solar panels efficiency by keeping the solar panels perpendicular with sun's position.

Keywords: Solar Energy, Solar Tracking System

1. Introduction

The solar energy or photovoltaic energy has been used widespread as an alternative energy source because the energy is free and also renewable. However, to capture solar energy, one has to place the solar panel in the direction perpendicular with respect to the incoming light from the sun. The device is used to keep the solar panel always perpendicular to the incoming sun's light and is called a Solar Tracking System. Such device has been widely employed by a number of companies such as BP Solar, Yingli Green Energy, Kyocera, Q-Cells, Sanyo, Sharp Solar, Solar World, Sun Power and SunTech company. The way that the sun energy initially in the form of light becomes useful energy is carried out through a process called a photovoltaic process. The sunlight is made of photons which are small particles of energy and absorbed by a solar cell panel. The photons 'agitate' the electrons existed in the photovoltaic cell. When the electrons move, they are 'routed' into an electric current. As it becomes an electric current, such energy can be used for various applications, such as for a water heating, home lighting etc.

Solar energy is available nearly everywhere as long as sun light is existing. The energy from the sun is free and infinite. It can be used and converted into power by a solar panel. The solar panels are able to produce power without waste or emissions. The process is natural and called as photovoltaic. For that superiority, the solar panel system was invented. Unfortunately, most of the solar panel used face only one direction or is in a static condition.

For example, if the solar panel is facing west, it will not be able to harness the (full) energy of the sun when it is rising in the east and vice versa. The amount of power that can be generated is relatively low because of the stated problem. Next, the other problem faced by domestic usage is using more power than usual. Thus, it needs to have more than one solar panel to produce enough power. This can lead to high in mass, size and cost. Therefore, this project is to design and develop an Active Solar Tracking System.

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There is only one way to enhance a solar panel performance which is to increase the intensity of light received on the panel. Unless, there is a high efficient solar panel has been developed. Therefore, solar trackers are the most suitable and proven technology to increase the solar panels efficiency. It is designed to keep the solar panels aligned with the sunlight direction. Recently, solar trackers are popular around the world to harness solar energy because it is a more efficient way. The solution is better than purchasing additional solar panels and more cost effective solution. In this project [1], the design consists of photo resistor, atmega32 microcontroller and stepper motor. The prototype uses a cadmium sulphide (CdS) photo resistor which resistance is inversely proportional to the amount of light received on it.

Solar tracker is an automated solar panel that follows the sun's position in order to increase output power. The project [2] main objective is to develop an automatic solar tracking system for low power and residential usage. Light Dependent Resistor (LDR) is used as light sensor. Microcontroller PIC16F877A controls the movement of the motor via relay for the controlling circuit. The microcontroller will receive and process data from sensors. The bi-directional DC geared motor will receive data by a relay to ensure the solar panel is always perpendicular to the sun. The direction of the motor is controlled by the relay.

A project [3] aims is to use embedded system design for designing an automatic solar tracking mechanism with minimum cost. The device for the project consists of four LDRs, solar panel, gear motor and ATMEL microcontroller. LDR gives low resistance when light falls on the sensor thus the panel is arranged so that the LDR can be compared. Gear motor are connected to the panel and the panel rotates towards LDR that have high intensity.

2. Methodology

This methodology part includes the review of research method and appropriate design that are used in this project. The objective of this project is to design an active solar tracking system based on the light intensity in directing the solar panel to the most intense to the incoming light from the sun. The method that is used to conduct this project is via hardware implementation testing.

In addition, Arduino IDE software will be involved to write and upload programming code to the physical board. Usually, an IDE contains a source code editor, a compiler or interpreter and a debugger. Interpretation and discussion will be done based on the data gathered from the hardware implementation testing. For designing process, a basic five-step process is applied in a problem-solving task. The design process may require many iterations to get a suitable design for the project. Solving a design problem is an unpredictable process and the solutions are depending on situations. The solution changes as it develops.

In this project, there is a need to develop a design of a solar tracking system that capable of rotating toward the direction of sunlight [4]. Therefore, the first step to do is to identify the problem. Since many solar systems available in the market are unable to rotate toward the direction of the light. Next, the information on how to make the solar tracking system able to rotate toward the direction of light is gathered. Moreover, the next step is to generate multiple solution based on the information. This is the process where it should define the project mechanism. However, in order to solve the solution, there is a need to define the input and output of the system. Then, project should decide the set of sequences of the system.

For specifications, the LDR will produce an analog voltage when connected to 5V power supply. The analog voltage varies in direct proportion to the input light intensity on it. The greater the intensity of light, the greater the corresponding voltage from the LDR will be. It is connected to the analog input pin on the Arduino because of the LDR produces an analog output. The Arduino will convert the analog voltage from 0-5V into a digital value in the range of 0-1023 using its built-in analog-to-digital converter, ADC. The converted digital values read from the LDR by the Arduino will be in the range of 800-1023 depends on sufficient light received on its surface.

2.1 Overview of Purpose System

First and foremost, there is need to build the voltage regulator circuit in order to supply the right voltage to the system. The overall circuit cannot operate if there is no or low power is supplied to them. The circuit consist of 1x solar panel, 4x LDR, 4x resistor, 2x servo motor and other small components. Next, Light Dependent Resistor (LDR) will be installed into the circuit. LDR is used as a sensor to detect the light intensity. Then, the LDR will send the data to the input of Arduino Uno microcontroller. The overall flowchart for Solar Tracking System is shown in Fig. 1.

Next, there is a need to install another electronic component which is the servo motor into the circuit. In this case, the servo motor is needed to control the direction of the solar panel. Last but not least, the voltage regulator circuit and all the components will be installed together with the Arduino UNO microcontroller. For power supply to the servo motor, four batteries with 1.5 voltage are used. The combination of batteries will give total power supply of 6V. The Arduino board is connected to other board and servo motor using connecting wires. Other small components used in the system are basic components such as resistors, capacitors and switches.

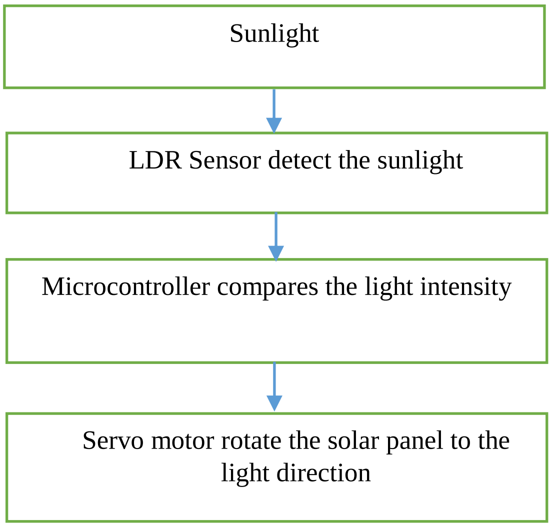

Fig. 1 - Solar Tracking System flowchart

2.2 Hardware Development

The block diagram for Solar Tracking System is shown in Fig. 2 that illustrate the overall system.

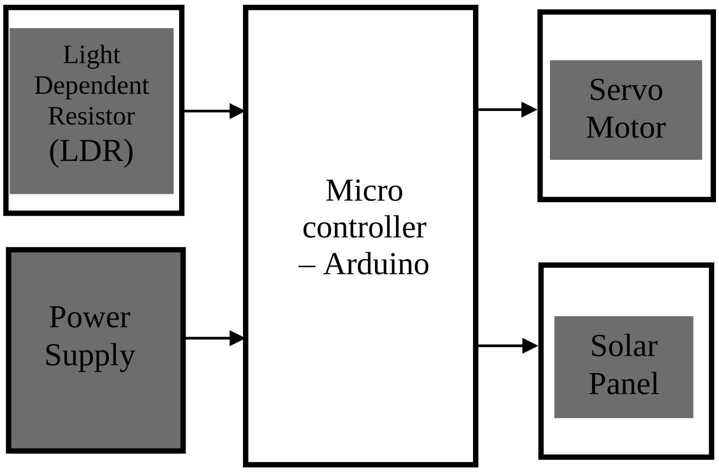

Fig. 2 - Solar Tracking System block diagram

The system consists of 3 main parts which are inputs, main controller and outputs. Inputs are for the sensor and power supply whereas outputs included with servo motor and solar panel. Microcontroller has been used as main controller to control all parts of the system.

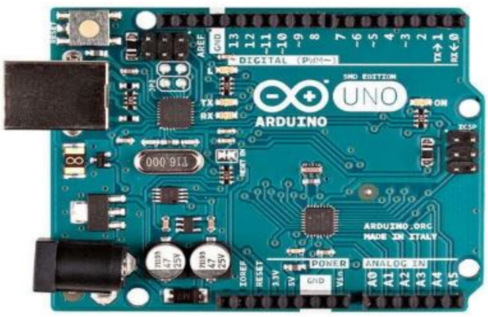

Fig. 3 - Arduino Uno microcontroller

Arduino Uno is a main controller for the system. It is used for processing the input and output of the data and controlling the solar tracking system. Fig. 3 shows the Arduino Uno that has been used in the system. Arduino is used because of its suitability for small systems and is easily programmable [7]. It also can control many types of sensors especially servo motor.

Fig. 4 - Light Dependent Resistor (LDR)

For the input part, Light Dependent Resistor (LDR) is connected to the main controller, Arduino Uno. LDR is used for detecting the sunlight and gives out data to the microcontroller to be processed [5]. LDR functions as sun light detector and it indicates the direction of the sun light by comparing the intensity of the received sun light. Fig. 4 shows the Light Dependent Resistor (LDR).

For the system output, servo motor has been used to move the solar platform. It will receive processed data from the microcontroller and moves as programmed. The movement is according to direction of the sunlight received at Light Dependent Resistor. Fig. 5 shows the servo motor that has been used for the tracking system.

Fig. 5 - Servo motor

3. Result and Discussion

Fig. 6 shows the complete and final circuit of the solar tracking system. For this part, result and analysis are parted into segment which are outcome and analysis for LDR sensor and servo motor. LDR sends data to microcontroller and microcontroller controls the servo motor to move the platform of the solar tracking system.

The LDR is used to detect the light intensity. The 4 LDRs will give out data to the Arduino based on the intensity of light detected. The data received from the LDR then will be processed through the calculation programmed in order for the platform to get the optimum sunlight.

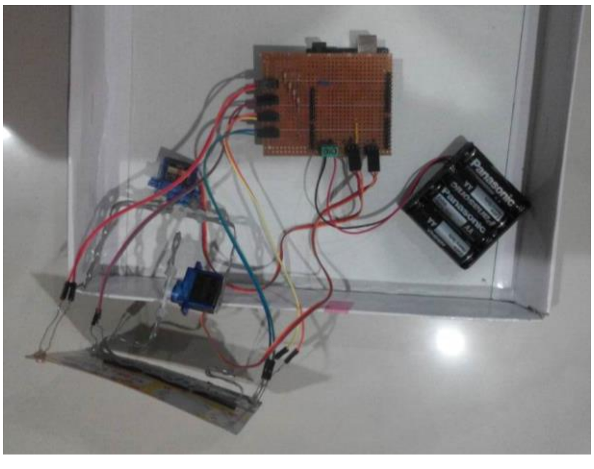

Fig. 6 - Complete circuit of Solar Tracking System

The servo motor is used to move the platform in which the 4 LDRs are placed so that the platform can gain max intensity of light. Both servo motor used is 180^0 . This is to avoid the motor to keep turning and caused the wire to be tangled. Based on the coded build, the servo motor will move either $+1^0$ or -1^0 based on the calculation coded to the Arduino. The servo has a limit coded and will move from 20^0 to 160^0 .

The analysis will be based on the design of this solar tracking system. The mechanical part is focused on the movement of the platform towards the light. The platform is connected to perforated metal and moved by servo motor which also connected to perforated metal that is also moved by servo motor. Fig. 7 shows the servo motor location in the platform.

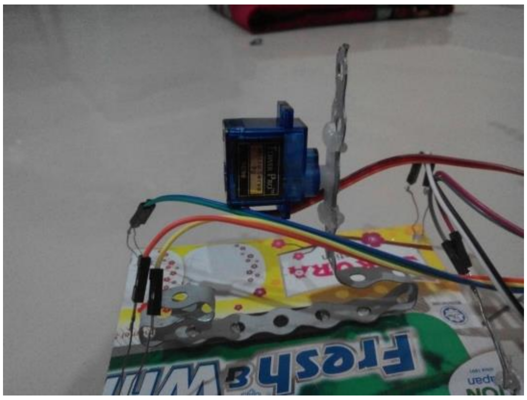

Fig. 7 - Complete circuit of Solar Tracking System

The method of analyzing the solar tracking system is by determining the efficiency of the solar tracking system tracking the sun against the fixed solar [6]. Results were recorded on the same day for 3 different hours to monitor the differences between fixed panel and tracked panel. Table 1 shows the result for fixed panel and Table 2 shows the result for tracking panel. The data are based on time taken between 1030 until 1630.

Table 1 - Fixed panel and tracking panel results

Time	Fixed panel				Tracking panel			
	Top	Bot	Left	Right	Top	Bot	Left	Right
1030	986	1012	984	1013	1016	1015	1016	1015
1330	1019	1018	1019	1018	1019	1019	1019	1018
1630	1010	981	1011	982	1010	1008	1009	1008

Based on the results, graph for fixed panel and tracks are created as shown in Fig. 8 and Fig. 9. Graphs show LDR reading based on time taken between hours 1030 until 1630 for fixed panel and tracking panel. LDR data is based on Arduino input. The LDR produces an analog voltage when connected to 5V power supply, which varies in direct proportion to the received sunlight. It is connected to the analog input pin on the Arduino. Then, the Arduino will convert the analog voltage value into a digital value which is in the range of 0-1023 using the built-in analog-to-digital converter, ADC. The digital values read by the Arduino will be in the range of 800-1023.

Therefore, based on result taken LDR reading data are varying from lowest data, 984 to highest data which is 1019. The data are in digital value and the higher value means higher light intensity received by the solar panel. 4 LDRs are placed at different locations on each type of panels. The LDR locations are on top, bottom, left and right of the platform. From the table and graph, it shows that for solar tracking panel has higher average for all the reading data from all locations than for fixed panel reading data. Other than that, data range for fixed panel also has higher range than data range for tracking panel. The range for fixed panel is from 984 to 1019 whereas for tracking panel the range is from 1008 to 1019.

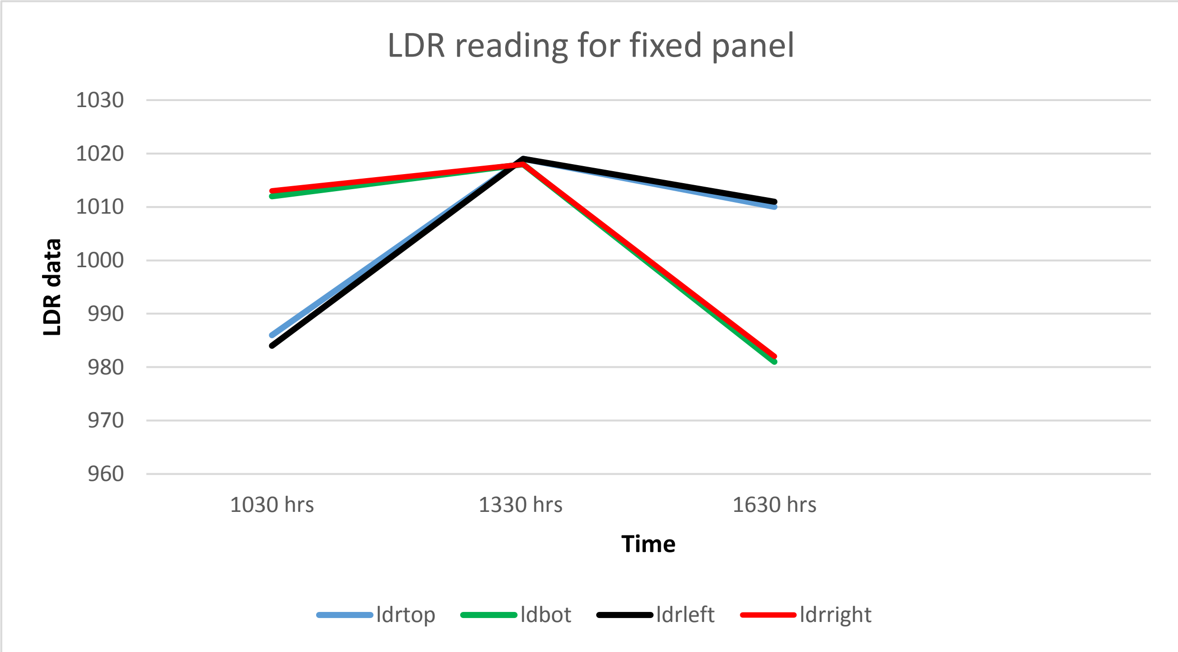

Fig. 8 - Result for Fixed Solar Panel

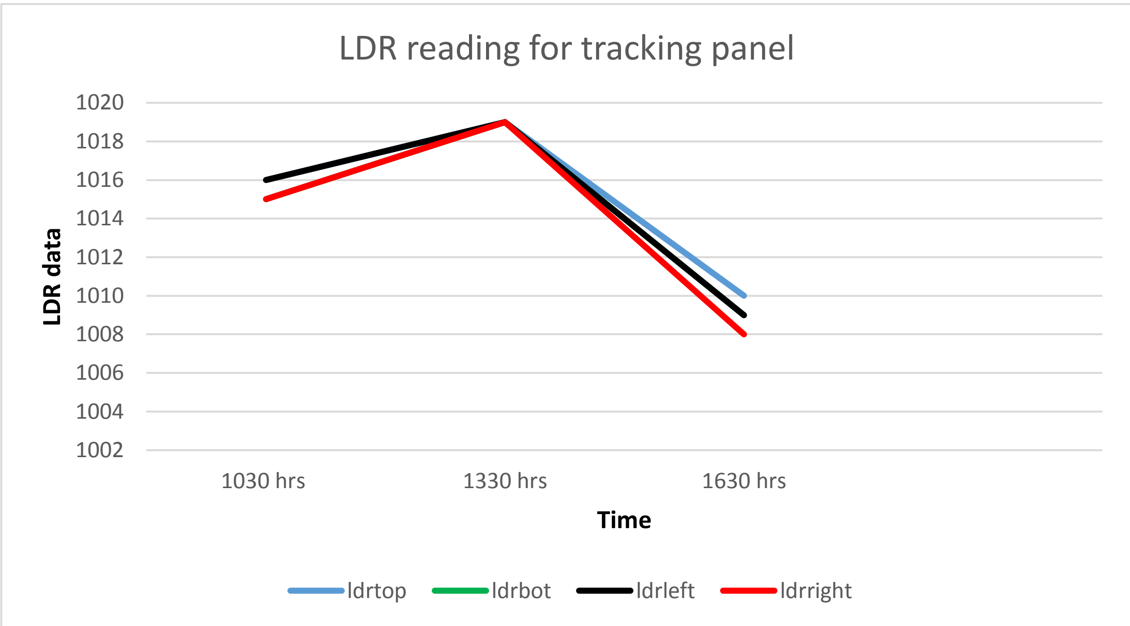

Fig. 9 - Result for Tracking Solar Panel

The values can be used to illustrate the difference between the tracking panel and fixed panel in term of efficiency. By taking the average values of LDRbot for both fixed and tracked panel. Then 1023 is used as the based because of the maximum value. It is calculated as a percentage and will be compared. The value may not give a clear indication of the increase in efficiency, but it shows that the tracking panel has better efficiency.

$$\text{Average value of LDRbot(tracked) or LDRbot(fixed)}/1023 * 100 \tag{1}$$

$$\text{LDRbot(tracked) } 1014/1023 * 100 = 99.12 \tag{2}$$

$$\text{LDRbot(fixed) } 1003/1023 * 100 = 98.04 \tag{3}$$

The difference between the values from tracked panel and fixed panel is 1.08%. This means there is an efficiency increment of 1.08%. From the analysis, it shows that the solar tracking panel has higher efficiency and received higher light intensity than the fixed panel. This is because solar tracking panel can detect sunlight and change panel direction based on light intensity. As a result, light intensity reading average is higher than fixed panel data. Therefore, a solar tracking panel is better than existing fixed solar panel in terms of received sun light used for creating power and energy.

4. Conclusion

After the completion of the project, the project objectives are met. As a conclusion, a solar panel that can detect and track the sun was designed successfully. The program was built for the project to work and as a result, a solar tracking system was developed.

For future project, a more efficient sensor seriously need to be taken into account as to improve the sensitivity of the sensor which would lead to increase in efficiency. A power supply that is rechargeable is also recommended for it that could save on costing if it used frequently.

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