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Design of Single-Axis Solar Tracker based on Arduino Uno Microcontroller

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ABSTRACT

This research designed of single-axis solar tracker for the brushless DC pump in hydroponics system. The aims of this study is to make a solar tracker system as a solar cell direction controller to obtain greater solar energy efficiency and electrical power than static solar cells. To get the maximum solar energy, the position of the solar cell must be perpendicular to the direction of sunlight. This study uses the Arduino Uno microcontroller as the tracking control center and servo motor as an actuator to drive the solar cell. In this research, two LDR sensors are needed which are placed on the east and west sides of the solar cell which detects the direction of sunlight. One of the larger sensors gets sunlight so it is considered as the side that has the strongest light intensity which will be followed by the movement of the solar tracker system. The electricity produced is used to operate a brushless DC pump in hydroponic.

Key words : Design, Solar, Tracker, Single-axis, Arduino Uno

1. INTRODUCTION

Renewable energy began to get attention since the world energy crisis in the 70s and one of those energies was solar energy. Indonesia has abundant of sunlight, therefore solar power plants are very suitable to be applied in Indonesia. The use of solar energy as an alternative energy source to fulfil electricity needs in Indonesia is very appropriate considering the geographical location in the tropics with solar heat available throughout the year [1, 2]. There are two types of solar energy utilization technologies, namely thermal solar energy and photovoltaic solar energy [3, 4]. Photovoltaic solar energy technology is a technology of utilizing solar energy by converting that energy into an electric current by using a semiconductor device called a solar cell.

Solar power has several advantages, including free energy, easy maintenance and no moving components so that it does not cause noise and able to work automatically [5, 6]. Solar power also has an obstacle, namely the energy produced depends on the intensity of sunlight that is not available 24 hours a day so that it takes an energy storage medium in the form of a battery as a source when the light intensity decreases or even none at all.

In general, the solar cell is placed in a fixed position or fix, this causes the received sunlight to be less optimal because the sun is always moving, namely in the east-west and north-south directions [7, 8]. The solar cell needs to be positioned perpendicular or in the direction of sunlight coming to get optimal sunlight. Therefore we need a tracker system that functions to drive the solar cell so that it can follow the direction of sunlight. The movement of sunlight can be followed by sensing changes in the light emitted. So based on the background revealed above, in this study, the authors designed a photovoltaic (PV) or solar cell with a single axis system. So it is expected that this system can follow the movement of the sun and can produce more efficient energy values.

2. MATERIALS AND METHOD

Block Diagram System

In the block diagram (Figure 1), the system starts from the sunlight coming into the solar cell where the output of the solar cell is in the form of a voltage (V) and current (I) that comes from the intensity of sunlight. The output of the solar cell is forwarded to the solar charge controller as stabilizing the battery charging current, where the battery is the electricity storage place. In the control block consists of Arduino [9, 10], Servo Motor and LDR Sensor which are supplied from the battery. The set point in the control block is Δ Lux from both LDR sensors equal to zero. Arduino receives an error value which then gives a command to the servo motor. The error value is the setpoint minus the LDR sensor value.

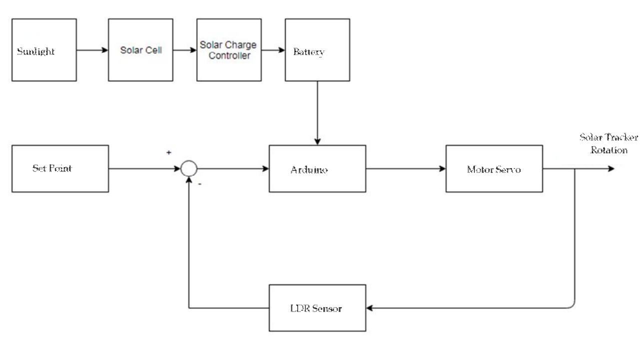

Figure 1: Block Diagram System

Solar Tracker

The Flowchart (Figure 2) starts from reading the value of the two sensors. If the value of the two sensors is smaller than the threshold, the solar tracker goes to the starting position with a angle of 20^0. Otherwise, the solar tracker will compare the values of the two sensors. If the value of the LDR-East is greater than the value of the LDR-West, the solar tracker moves towards the east. If the LDR-West sensor value is greater than the LDR--East value, the solar tracker moves west.

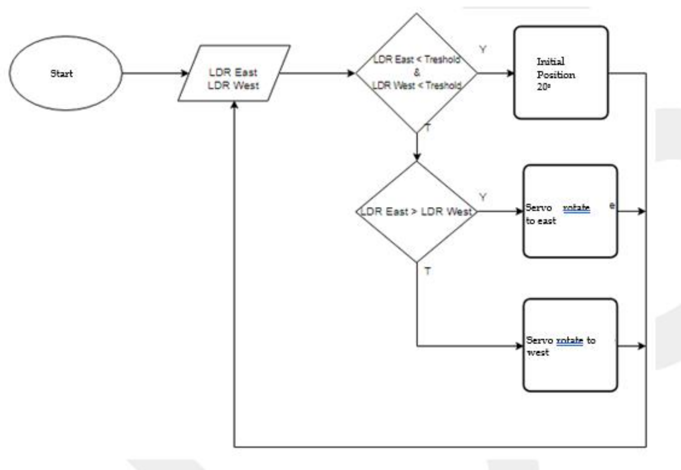

Figure 2: Flowchart of Solar Tracker

Device Design

Solar Tracker Design

The solar tracker system (Figure 3) uses hollow 4x4 lightweight steel that is designed in such a way as to support the solar tracker system. Selection of mild steel as a frame based on the nature of mild steel that is strong and light. The height of the solar cell was one meter. The components of the solar tracker system are placed in the junction box. Then the servo motor is attached to the solar cell stand. Two LDR sensors are attached to each end of the solar cell, east and west.

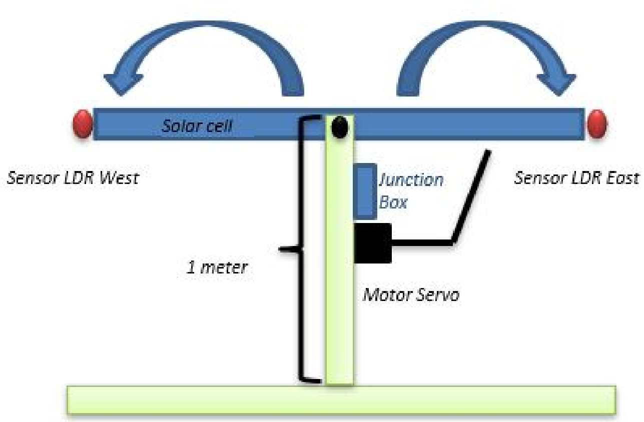

Figure 3: Solar Tracker Design

Motor Servo Design

The red cable is a power cable that serves to connect to the 5V pin on Arduino. The black cable is a ground cable that is connected to the GND pin on Arduino and the yellow cable is the servo motor signal cable connected to pin 9 on Arduino (Figure 4).

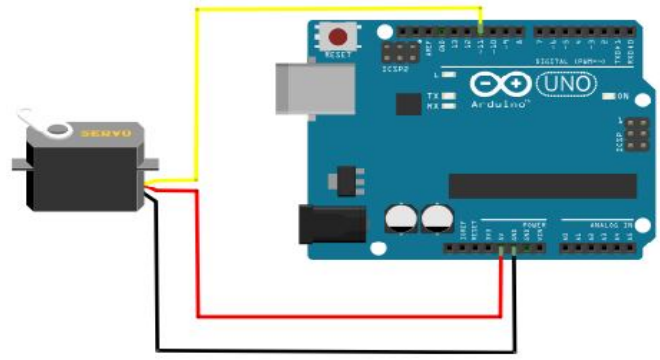

Figure 4: Motor Servo Design

LDR Sensor Circuit

This LDR sensor circuit (Figure 5) used 2 LDR sensors, one for the east part and the other for the west part. The VCC pin sensor is connected to the Arduino 5V pin, the sensor ground pin is connected to the Arduino GND pin and the sensor AO pin is connected to pin A0 and Arduino A1.

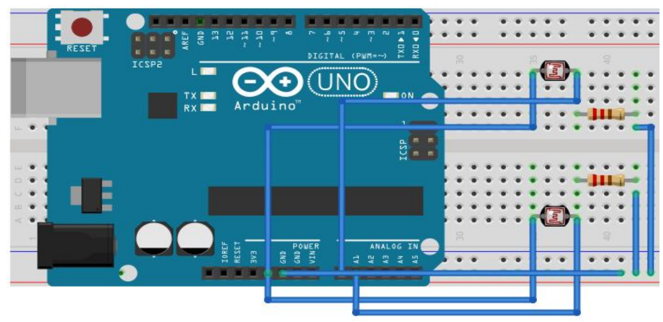

Figure 5: LDR Sensor Circuit

Solar Tracker Circuit

The following is the installation of a solar tracker component circuit (Figure 6). Consisting of one Arduino, one servo motor, two LDR sensors. The servo motor circuit and the LDR sensor circuit are combined into Arduino. Where all three servo motor cables are connected to 5V pins, pin 11 and GND pins on Arduino Uno. Then the LDR sensor circuit is connected to the 5V pin, GND pin and pin A0 and A1 on Arduino.

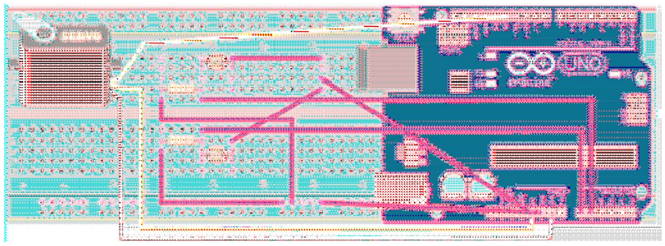

Figure 6: Solar Tracker Circuit

Static Solar Cell Testing

The test uses solar cell 50 Wp, battery 20 AH and loads the LED light then the circuit is made in such a way as to retrieve data. This test starts at 06.00 a.m. until 06:00 p.m. Solar cells are faced perpendicular to the top with data retrieval taken every hour for three days. The parameters measured are the voltage (V) and current (I) of the solar cell.

Testing the LDR Sensor

This test aims to determine whether the LDR sensor can read input correctly. This test uses 2 LDR sensors that have been arranged in such a way that the sensors are placed on both ends (east and west) of the solar cell to capture sunlight.

Testing the Solar Tracker System

If the system has been completed, then a test is carried out to observe whether the system has been running according to the order. The solar tracker system testing is carried out from 6:00 to 18:00. If the system has an error, it will immediately assemble and restart the system until the system complies with the command.

3. RESULTS AND DISCUSSION

Static Solar Cell Testing

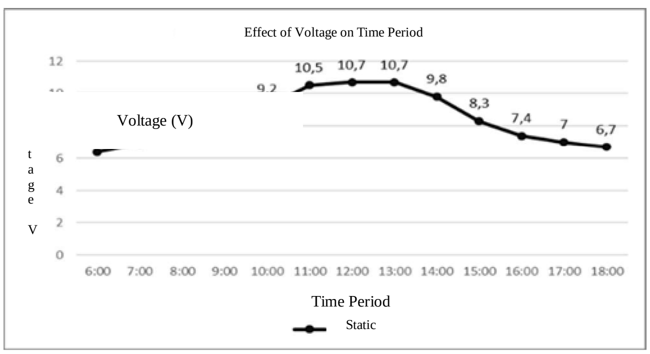

Figure 7: Effect of Voltage on Time Period

On the solar cell graph (Figure 7) about effect of voltage on time period, it can be seen that at 12.00 p.m. the highest voltage output value was obtained with a value of 10.7 V. This is due to the direction that sunlight comes perpendicular to the solar cell.

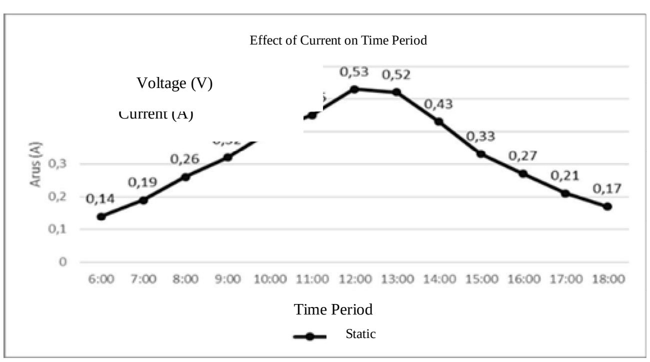

Figure 8: Effect of Current on Time Period

On the solar cell graph about effect of current on time period (Figure 8), it can be seen that at 12.00 p.m. the highest current output value was obtained with a value of 0.53 A. This is due to the direction that the sunlight comes perpendicular to the solar cell.

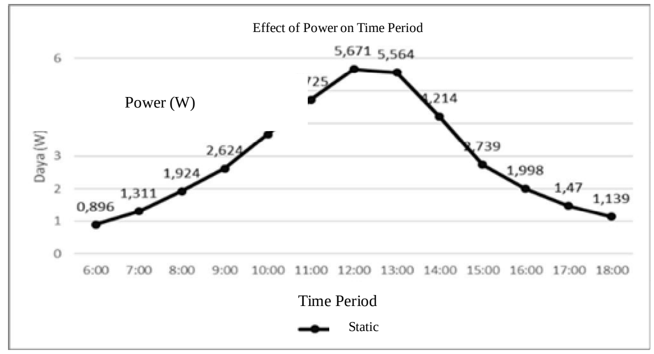

Figure 9: Effect of Power on Time Period

Based on the calculation, the power value is obtained as shown by the solar cell graph (Figure 9) about effect power on time period, the highest power value is obtained at 12.00 p.m. with a power value of 5.671 W.

LDR Sensor Testing

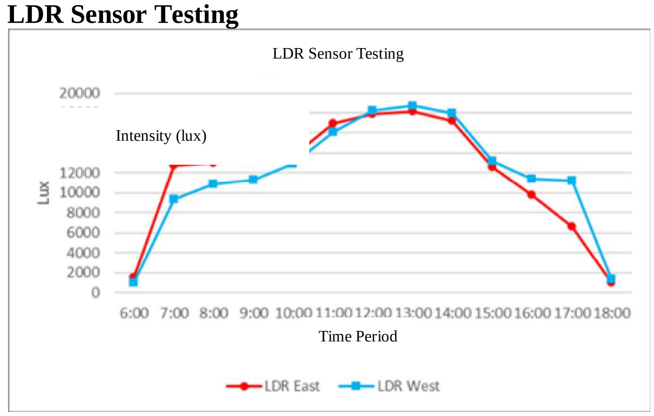

Figure 10: LDR Sensor Testing

From 06.00 a.m. to 11.00 a.m., the LDR-East sensor gets more sunlight than the LDR-West sensor, then from 1.00 p.m. to 6.00 p.m. (Figure 10), the LDR-West sensor gets more sun than the LDR-East sensor. This was caused by the movement of the sun from the east to the west.

Solar Tracker Testing

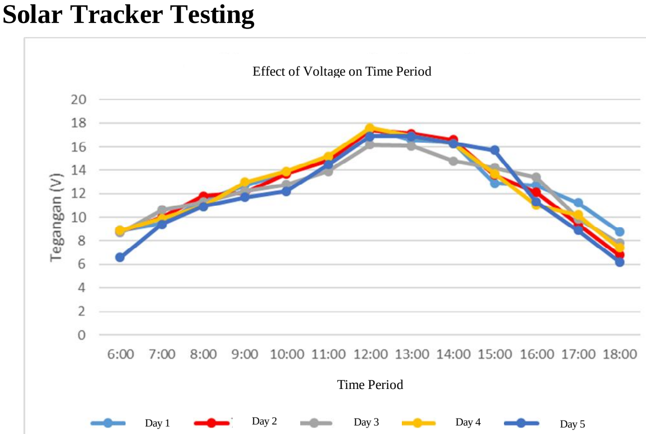

Figure 11: Effect of Voltage on Time Period of Solar Tracker Testing

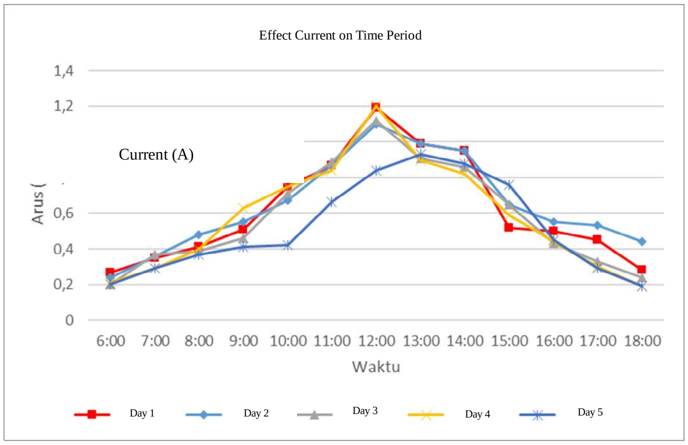

Figure 12: Effect of Current on Time Period of Solar Tracker Testing

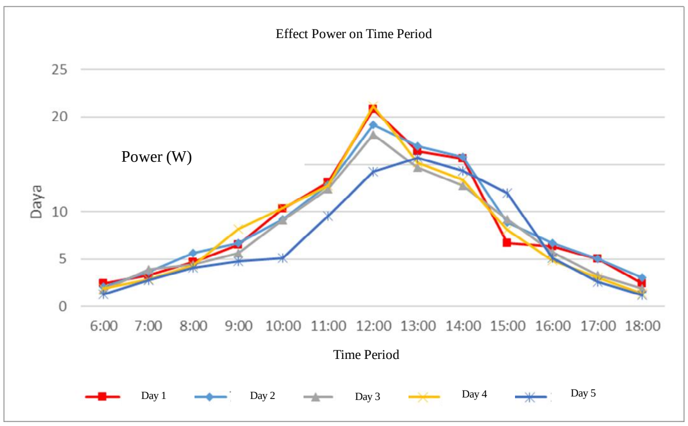

Figure 13: Effect of Power on Time Period of Solar Tracker Testing

The solar tracker system (Figure 11, Figure 12 and Figure 13) only operates for 12 hours starting from 06.00 to 18:00. The electricity produced is used to operate DC brushless pumps on hydroponics 24 hours a day. The efficiency of solar tracker during five days were 3.53%, 3.51%, 3.27%, 3.55%, 3.41%.

4. CONCLUSSION

The design of single-axis solar tracker in the use of brushless DC pumps in hydroponic has been successful, so that by using the solar energy tracking system absorbed by solar cells it is better than static solar cell 45°. The solar tracker system only operates for 12 hours starting from 06:00 to 18:00. The electricity produced is used to operate brushless DC pumps in hydroponics 24 hours a day. The efficiency of solar tracker for five days was 3.53%, 3.51%, 3.27%, 3.55%, 3.41%. There is a relationship that is directly proportional between the intensity of sunlight entering the solar cell and the power output of the solar cell. If the intensity of sunlight received by the solar cell is getting bigger, the greater the output of the solar cell produced.

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