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SOLAR PANEL TRACKER BIDIRECTIONAL MICROCONTROLLER BASED ON ARDUINO UNO

Prawiro Harjono, Syamsu Marlin, Abel Setiawan
Faculty of Engineering, Universitas Bung Karno
Emails: prawiro.harjono@gmail.com,syamsu.marlin45@gmail.com, abelsetiawan0@gmail.com

ABSTRACT:
Problems always occur in solar panel users, namely the efficiency of solar panels in solar panel generation systems. This causes the need for a solar tracker system. The tracker system serves to increase the productivity of solar panels. This research designed a tracker system consisting of Arduino Uno, LDR sensor, ADXL335 sensor, GY271 sensor and servo motor. The LDR sensor can detect the level of sunlight and send a signal to the Arduino Mega which will then be processed and send commands to the servo motor to move following the Arduino Mega command, which is towards the direction of the light source. The ADXL335 sensor and GY217 sensor function to determine the slope and cardinal direction of the solar panel that will be displayed on the 20x4 LCD.

Keywords: Panel surya, Solar Panel, Solar panel Tracker.

INTRODUCTION

The world's energy needs continue to increase. According to projections by the International Energy Agency (IEA), until 2030 world energy demand will increase by 45% or an average increase of 1.6% per year (Aleklett et al., 2010).

The energy crisis has become one of the issues that is often heard lately, especially in various countries, including in Indonesia. Current energy needs reach 3 x 1020 joules per year (Aleklett et al., 2010). One of the world's energy sources that has not been maximally utilized is solar energy. Solar energy that reaches the earth is 2.6 x 1020 joules per year (Aleklett et al., 2010). So that solar energy is very potential to be used as an alternative energy source (Shaaban & Petinrin, 2014). One of the uses of solar energy is to convert it into electrical energy with the use of solar panels (Moheimani & Parlevliet, 2013).

Solar panels are devices that are able to convert solar energy into electrical energy (Moheimani & Parlevliet, 2013). Therefore it is needed A system that can work automatically to control and move solar panels to stay perpendicular to the direction of sunlight to obtain maximum output power (Sumathi et al., 2017).

RESEARCH METHODS

The method used to complete this research is to create a basic framework for solving the problems raised in this research (Frankenberger et al., 2013). This methodology contains the steps that will be taken to complete the research (Fidel, 1984). In this study, the method used was to design a prototype solar tracker with an Arduino UNO microcontroller (Motahhir et al., 2019).

Tool Creation

In making a Two-Way Solar Panel Tracker Based on Arduino Microcontroller, there are three main stages that must be done, namely mechanical system design including servo components, electrical system design, and programming design on software. The electrical system design includes a series of LDR sensors with wheatstone bridges, ADXL335 sensors as solar panel tilt detectors, GY271 sensors as cardinal directions, 20x4 LCD as displays, DC motor drivers, Tp4065 Battery Lithium Charger, and Li-Ion Battery 18650 which is the Arduino power source. And in the software programming part lies in the Arduino IDE programming which will be inputted on the Arduino Uno microcontroller (Kadir et al., 2012).

2.2.1. Electrical System Manufacturing

This stage compiles an electrical system that supports the performance of the solar tracker so that it can work perfectly (Visconti et al., 2015). Includes LDR sensor as servo motor motion trigger, HMC5883L sensor to determine cardinal direction, and ADXL335 Sensor as tilt degree gauge.

From the diagram above, it can be concluded that the main source of electricity comes from the conversion of sunlight into electricity in the following performance sequence:

Sunlight is absorbed by solar panels into Peak Wattage (Wp). The results of the conference are used to charge the battery through BMS (Battery Management System).

From BMS will be distributed DC power to other hardware such as Arduino, ADXL 335 Sensor, GY-271 / HMC5883L Sensor, and Servo Motor.

At this stage in designing a prototype must make an illustrative image in order to predict what items and components are needed in designing a two-way Solar Panel Tracker. In simplifying the process, a tool flowchart is needed. Here are the stages in assembling an electrical system:

Creating a DC Power Source Circuit

In working on this prototype, applying an Off-Grid or Stand Alone system without help from PLN so that the source of electricity is generated by solar panels to charge the battery in order to turn on the Arduino Uno component.

To find the number of panels needed:

Σp=(Total Energi)/(Peak Sun Hours)=Watt Peak

Σp=(Watt Peak)/(Panel Capacity consumed)=Watt Peak

To find the number of batteries needed:

Σb=((Total Energy)/(DOD x Battery Capacity))x Operating Time=Number of Batteries

So if you want to run Arduino Uno components with an Off-Grid system with the following calculations.

Table 2.1 Energy requirements per component.

Nama Komponen	V	A	Watt	Operasi (Jam/h)
Arduino Uno 1	5	0.5	2.5	1
Arduino Uno 2	5	0.5	2.5	1
Sensor ADXL335	3	0.35	0.9	1
Sensor GY271	5	0.35	1.75	1
Servo 1	4.8	0.125	0.6	1
Servo 2	4.8	0.125	0.6	1
Total Energi				

Source : Doc. Personal

Looking for solar panel needs:

Σp=9Wh/(3.6 PSH)=2.5Wp

Σp=2.5Wp/(2.4 Wp)=1 piece 2.4Wp solar panel

Looking for battery needs:

Σb=((9 Wh)/(6% x (11.1 V x 3A)))x 1.hour

σb=0.4 /1 set

(3.7V 1.5Ah Battery

in series 3 series 2 Parallel)

It can be concluded that the Li-ION 18650 3.7V 1500mAh battery assembled into a series of 11.1V 1500mAh is enough to turn on 2 main components, namely Arduino Uno and BMS 3S as the Charger. And also with a solar panel capacity of 1 unit of 2.4 Wp 12V 200mA enough to charge Li-ION 18650 batteries.

Creating an LDR Sensor Family

LDR is assembled with a wheatstone bridge with R1=R2=R3 having the same R, while R4 is Rldr. Wheatstone bridge is an arrangement of electrical circuits to measure an unknown resistance. This series It works by balancing twice of the bridge circuit, one leg which includes components known to work similarly to potentiometers. For the 1-line diagram used in this solar panel tracker system as follows:

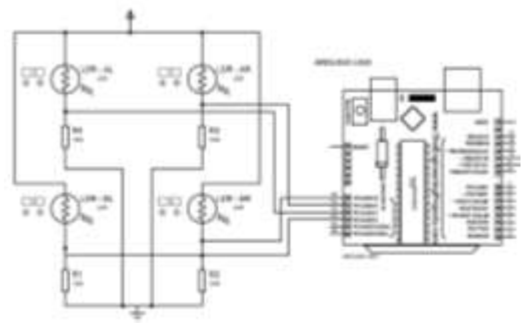

Figure 2.2 LDR to Arduino sensor circuit diagram

The 4 LDR sensors will be placed at the top of the solar panel and parallel to the solar panel which aims to direct the solar panel to the light source as shown below:

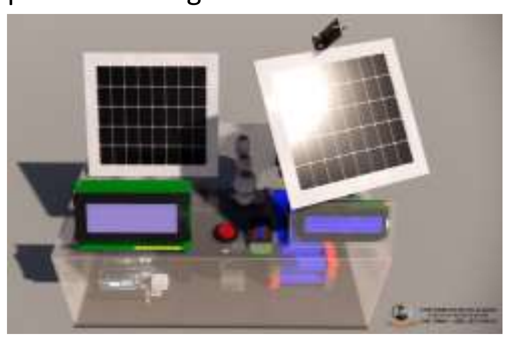

Figure 2.3 Prototype Solar Panel Tracker

- **BMS**

This component functions as a lithium battery charger and also as a link from the battery to the load, namely Arduino Uno.

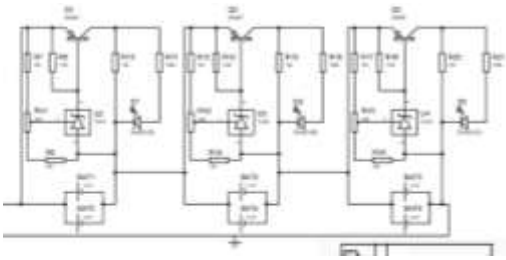

Figure 2.4 Schematic diagram of BMS 3S module

● **Installing DC Servo Motor**

The Servo motor used in the assembly of Solar Panel Tracker, namely Tower Servo Pro 9G.

This servo will be installed in a vertical position that serves to move the Solar Panel up and down to change the degree of inclination of the solar panel.

After the two servos are ready, install them in the prepared box as shown below:

2.2.2. Manufacture of Mechanical Systems

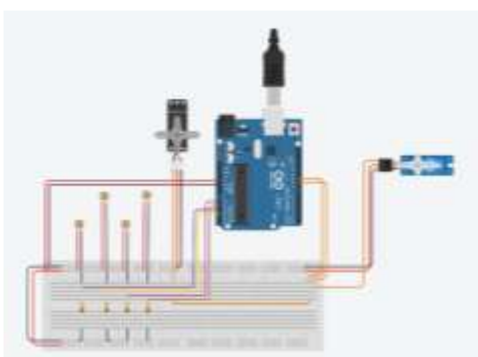

Figure 2.5 Solar panel tracker circuit on breadboard

Where in the solar panel tracker system uses 2 servo motors. Servo 1 serves to move the panel vertically connected to the input pin 9 on the Arduino device that can move from an angle of 20 ° - 60 °.

As for servo 2, it functions to move the panel horizontally connected to the input pin 10 on the Arduino device which can move from an angle of 0 ° - 180 °.

RESULTS AND DISCUSSION

In making a prototype, testing and data analysis are needed to find out the performance of the tools that have been made whether they are in accordance with what was planned or not (Bottari et al., 2010). By testing, it can be known the suitability of the tool with what is planned and the weaknesses that occur in the tool so that ways can be found to improve or develop in a better direction (Kelley et al., 2003). This solar tracker prototype generally consists of two systems, namely an electronic system and a mechanical system (Kelley et al., 2003). The electronic system itself has a supporting system, namely power supply, DC motor driver, ADXL335 sensor, GY 271 sensor, LDR sensor with wheatstone bridge, and signal conditioning. Before connecting the entire electronic system support system, each of these support systems is tested (Salkin et al., 2018). In addition to these four supporting systems, static solar panels and solar panels were also tested with tracking systems (Liu et al., 2013).

3.1. Calculation of the total capacity of the Solar Panel Cell circuit

Solar panels are designed based on the calculation of battery capacity ranging from 12V, 24V, 36V, 48V.

Calculating the Voltage on solar panels

Figure 3.1 Solar Panel

Source : Doc. personal

How to find out the capacity of solar panels by counting the number of cells assembled on a panel (Kavlak et al., 2018). An example as shown above is a solar panel with a voltage of 12V, a current of 200mA, and produces 2.4Wp.

To find out how much voltage each cell has, the calculation is carried out as follows:

Σv=(Voltage)/(number of cells in series)=(12V)/(25Cells in series)=0.5V per piece

So from each piece of cells assembled in series produces a voltage of 12 Volts. Calculation of cross-sectional area of solar cells:

Length = 135mm

Width = 110mm

A = PxL

A = 135mm x 110mm

A = 148.5cm2

In each solar panel assembly, you must also pay attention to the distance between solar cells, which is ± 1.4mm so that each series of cells does not occur short circuit.

3.2. Software Program Preparation & Testing

After making a program in the Arduino IDE or called sketch, testing is carried out to check whether there are errors in sketch making. Checking can be done with the compile menu available in the Arduino IDE software. If this test is successful, it can be continued with the steps of making an electrical system. But if it fails, it must repeat the previous step.

3.2.1. Arduino Uno Microcontroller Testing

Testing the Arduino Uno system is to ensure that the system used in this practice is not damaged. So that the program implanted in the microcontroller is able to control the speed of rotation of the servo as expected. Here's the arduino uno testing:

Prepare several components, namely:

- Arduino Uno.
- LED.
- PC / Laptop.
- Arduino IDE software.
- Arduino Uno USB Board cable.

Test stages

Connect Arduino UNO with PC/Laptop using USB Board cable.

1. Open the Arduino IDE.
2. Create a sketch on the Arduino IDE.
3. Upload the program turns on the LED.

From the test results show that PWM on Arduino can work well.

3.2.2. LDR Sensor Testing

LDR sensors in electronic systems function as inputs in the form of resistance. This resistance value will later be processed in the program to determine the movement on the motor. LDR sensor testing is carried out with Arduino Uno with the following calculations:

Calculating the LDR Voltage read:

Vb=(Bit b (Readable bit))/(Total bit (10 Bit arduino input)) x 5V

Example:

Vb=(Bit b)/(Bit tot) x 5V

Vb=100/1023 x 5V

Vb=0.489V

After obtaining the formula, the input in the Arduino sketch includes the Vb float variable; and in the Void loop Vb=(ldr/1023)*5;

Determine the amount of Lux produced:

In determining the nominal resistance produced by LDR, it can be calculated by the formula:

$I=I_1=I_2$

V/Rtot =VR/10=Vb/Rldr

Rtot = 10 + RLDR

5V/(10+Vldr) =Vb/Rldr

5 RLDR = Vb (10) + Vb RLDR

(5-VB) RLDR = 10Vb

RLDR = (10 vb)/(5 vb)

After obtaining the formula, it is inserted into the sketch on the Arduino by adding the Rldr float variable; and in the Void loop section plus Rldr = (10*Vb)/(5-Vb);

Determine the amount of Lux produced:

Tabel 3.1 Electrical Characteristic LDR

Electrical characteristics

Parameter	Conditions	Min.	Typ.	Max.	Units
Cell resistance	10 lux 100 lux	20 -	- 5	100 -	kΩ kΩ
Dark resistance	10 lux after 10 sec	20	-	-	MΩ
Spectral response	-	-	550	-	nm
Rise time	10ftc	-	45	-	ms
Fall time	10ftc	-	55	-	ms

Sumber:https://components101.com/resistors/ldr-datasheet

Based on the table above Cell resistance 10 lux = 20 to 100 kΩ if 100 = 5 kΩ then:

Lux=(Y - Y_1)/(Y_2-Y_1) =(X - X_1)/(X_2-X_1)

Y_1 = 100 X_1 = 5

Y_2 = 10 X_2 = 20

Lux=(Y -100)/(10-100) =(X - 5)/(20-5)=(Y - 100)/90 =(X - 5)/15

Lux=-100 = -90((X-5)/15)

Lux=-90 ((X - 5)/15)+100

After obtaining the formula that will be used input into the Arduino IDE by adding the Lux float variable; and in the Void loop plus section

Lux = -90x((RLDR-5)/15)+100;. Because the nominal produced when dark is minus the value then add the formula if (Lux<0) Lux=0; So when the nominal resistance is less than 0 it will produce 0.

If everything has been sketched on the Arduino IDE, then immediately test the 4 LDR sensors used as follows:

Figure 3.3 LDR testing with HP flashlight light

LDR Sensor 1

Table 3.2 LDR sensor test results 1

No.	Jarak (cm)	Intensitas (Lux)	Tegangan (Volt)	Hambatan (Ohm)
1	5	68.93	2.52	10
2	10	91.63	1.95	6.39
3	15	98.8	51.71	5.2
4	20	109.76	1.26	3.37
5	25	111.41	1.18	3.1
6	30	115.69	0.96	2.3

Sensor LDR 2

Table 3.3 LDR 2 sensor test results

No.	Jarak (cm)	Intensitas (Lux)	Tegangan (Volt)	Hambatan (Ohm)
1	5	67.13	2.43	9.2
2	10	89.83	2.13	5.74
3	15	97	1.83	4.69
4	20	107.96	1.53	3.64
5	25	109.61	1.23	2.59
6	30	113.89	0.93	1.54

Sensor LDR 3

Table 3.4 LDR 3 sensor test results

No.	Jarak (cm)	Intensitas (Lux)	Tegangan (Volt)	Hambatan (Ohm)
1	5	65.93	2.39	8.9
2	10	88.03	1.99	5.44
3	15	95.2	1.69	4.39
4	20	106.16	1.39	3.34
5	25	107.81	1.09	2.29
6	30	112.09	0.79	1.24

From the test results, it can be seen that the longer the distance between the LDR sensor and the light source, the smaller the measured resistance. And the closer the LDR sensor is to the light source, the greater the voltage generated.

3.2.3 ADXL 335 Sensor Testing

The following is a test conducted on the ADXL335 accelerometer sensor to find out how the sensor responds to the given tilt. By using this sketch IDE, you can find out the measurement results of the ADXL335 sensor module.

3.2.4 GY-271 Sensor Testing (HMC5883L)

In testing the GY-271 sensor we need a sketch of an Arduino as follows:

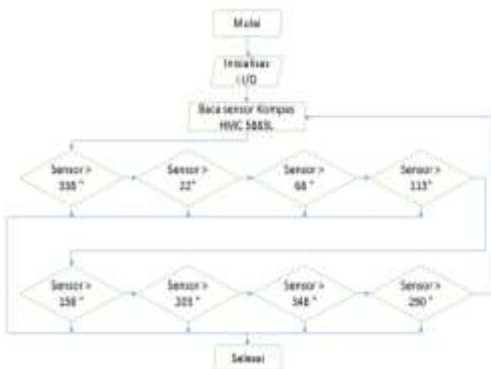

Diagram 3.1 GY271 compass sensor flowchart

After everything goes well, the program is declared complete.

3.3. Comparison of Static Solar Panel and Tracker System.

The results of testing between solar panels with static positions and solar panels with tracker systems are intended to find out how much efficiency level is produced by the two solar panels. Here are the results of measurements of two solar panel systems:

A. Static solar panel measurement results and tracker:

No	Waktu	Solar PV module Fix					Solar PV module Tracker				
		Volt	Ampere	Watt Peak	Efisiensi		Volt	Ampere	Watt Peak	Efisiensi	
1	8.02	11.2	0.11	1.23	51.33	%	13.30	0.17	2.23	93.10	%
2	9.05	11.4	0.12	1.37	57.00	%	11.98	0.16	1.92	79.87	%
3	10.00	10.5	0.13	1.37	56.88	%	11.90	0.17	2.07	86.28	%
4	11.04	12.8	0.14	1.79	74.67	%	13.60	0.16	2.18	90.67	%
5	12.04	12.9	0.18	2.32	96.75	%	13.00	0.18	2.34	97.50	%
6	13.18	8.05	0.16	1.32	55.01	%	11.88	0.19	2.22	92.57	%
7	13.56	10.5	0.15	1.58	65.63	%	11.50	0.17	1.96	81.46	%
8	15.08	5	0.12	0.6	25.00	%	9.60	0.18	1.71	71.20	%
9	15.56	4.3	0.13	0.56	23.29	%	10.92	0.17	1.82	75.99	%
Total		82.15	1.244	11.59	53.67	%	107.68	1.544	18.45	85.40	%

From the results of experiments conducted for 1 day with different weather, and both solar panels facing North, it can be concluded that solar panels with a tracker system can produce higher power than solar panels installed with a direction and slope remain unchanged with average Peak Wattage results from trackers of 2.05Wp and 1.29Wp from static solar panels. And from the calculation of the average efficiency within 9 hours, solar panels with a tracker system have a greater value of 77.16% with efficiency obtained from static solar panels of 62.88%. with the following calculation:

Peak Watt=Volt x Ampere

Efficiency=(Watt Peak)/(Max Power PV) x 1/100

Example:

Peak Watt=11.24V x 0.17A

=1.89Wp

Efficiency=(1.89Wp)/2.4Wp x 1/100 =78.68%

At the time of measurement, the ratio between static solar panels and trackers was only 3 minutes per hour because it avoided overheating of the components in the prototype box.

CONCLUSION

Based on the results of prototype trials that have been carried out, the conclusions of this study are as follows:

1.From the measurement results of solar panels with trackers have an average peak wattage of 2.05Wp while static solar panels have an average of 1.29Wp.

2.Solar panels with trackers have higher efficiency when compared to statically installed solar panels. Where at the time of the comparison trial can be seen at 10.00 a.m. the measurement results of static solar panels 10.05V and Tracker 11.9V.

3. Because the solar panel used has a small capacity that makes it difficult in the measurement process, especially during cloudy weather.

4.After the Senor trial, ADXL335 has a deficiency in vibration that causes errors in the solar panel tilt reading.
5. In assembling solar cell circuits, the distance between cells has a standard ± 1.4mm so that each cell circuit does not occur short circuit.

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