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Designing an Android-Based Solar Home System Performance Monitoring System in Pasarbatang Village, Brebes Regency

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Article Info

Keywords

Photovoltaic
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Android
Pasarbatang Brebes

Abstract

The use of renewable energy sources in the last 10 years has developed very rapidly. There are many kinds of renewable energy sources, including water, geothermal, wind, solar, biogas, biomass, and ocean waves. But what Indonesians can easily access is solar or solar power. The device used for harnessing sunlight into electrical energy is the photovoltaic (PV) solar panel. The location which is difficult to reach the electricity grid from the state electricity company (PLN) is very appropriate to be integrated with the Solar Home System (SHS) as a solution. But there are other problems that arise in the application of this SHS, namely the absence of performance monitoring on the PV used. The purpose of this research is to review the availability of solar energy sources to be used as power plants with SHS. Then with this research also known electricity generation for SHS. Remote monitoring system design for SHS can be implemented in Pasarbatang Brebes Village. The design in this study uses a sensor at the PV output to be connected to an Arduino microcontroller. The data recording from the sensor by the microcontroller is sent to the online storage media (cloud drive) via a wifi communication device. The results of the research can be accessed anywhere and anytime because the system was built using online storage media. This makes it easier to monitor the progress of the PV installed via the web or Android smartphone. Monitoring on android applications using NodeMCU ESP8266 to send and receive data. So that it can monitor the measurement results from the current and voltage sensors in real time.

Keywords: Photovoltaic, Solar home system, Cloud drive, Android, Pasarbatang Brebes

Introduction

The use of renewable energy sources in the last 10 years has developed very rapidly. Starting from the type of energy source, the amount of exploration, to the use in various fields of life in society. Based on Government Regulation number 79 of 2014 concerning National Energy Policy (ESDM, 2016), it states that the government is committed to increasing the ratio of renewable energy in the national energy mix by 23% by 2025 and the use of petroleum will be reduced to 25% in the same year (Sugiyono, 2018). There are many kinds of renewable energy sources, including water, geothermal, wind, solar, biogas, biomass, and ocean waves (Musyafiq, 2018). But what Indonesians can easily access is solar or solar power. The ease of sunshine is inseparable from the geographical aspect where Indonesia is located on the equator which gets 10 to 12 hours of sunshine on average. The tools used for the utilization of sunlight into electrical energy are solar panels or often called photovoltaic (PV) (Budi, 2018). PV panels can be applied independently (off-grid) or together with the electricity network (ongrid). Locations that are difficult to reach the electricity grid from the state electricity company (PLN) (Budiawan, 2017) are very suitable for building their own networks using solar panels as electricity generators, for a household scale it can be called the Solar Home System (SHS) (Budi, 2018). This SHS is very suitable, for example, for applications in areas far from the main electricity network, such as those implemented in the agricultural and livestock areas of Pasarbatang Village, Brebes. Another problem that arises in the application of this SHS is the process of monitoring the performance of PV (Suryawinata, 2017). The solution to this problem can be proposed by researching new and renewable energy conservation (EBT) schemes for the solar energy

source sector in terms of developing microgrid systems, management, and monitoring of renewable energy (Tricahyono, 2018).
The purpose of this research is to review the availability of solar energy sources to be used as power plants with SHS in Pasarbatang, Brebes Village; Knowing the electricity generation from solar energy sources around the SHS; Designing a remote monitoring system for SHS which is implemented in Pasarbatang Village, Brebes. The urgency for this research to be carried out is the availability of environmentally friendly power plant technology that is easy and can be used directly by the community; Limited electricity network that is difficult to reach areas far from residential areas; Remote SHS performance monitoring.

Tools and Materials Used

App Inventor 2 (AI2) is an open source web application originally developed by google, and currently managed by the Massachusetts Institute of Technology (MIT) (Julisman, 2017). App Inventor is a program that produces applications that can be used on the Android system. Cloud-based AI2 accessed using an internet browser. Adafruit IO is one of the MQTT (Massage Queuing Telemetry Transport) service providers for IOT (Internet Of Things), this service can be used to monitor data from sensor measurement results Maghfiroh, 2018). NodeMCU ESP8266 is a microcontroller module designed with ESP8266 in it. ESP8266 functions for Wifi network connectivity between the microcontroller itself and the Wifi network. NodeMCU is based on the Lua programming language but can also use the Arduino IDE for programming. Arduino is an open source microcontroller system minimum board. Arduino Mega ADK is a microcontroller based on the ATmega 2560. ADK itself stands for Android Development Kit. Arduino ADK is a microcontroller board that is devoted to communicating wit h Android smartphones via USB (Universal Serial Bus) communication, where the microcontroller board functions as the parent of an Android smartphone by functioning as if it were an Arduino Mega ADK computer allowing it to communicate via a smartphone (Fadhullah, 2017).
Light Dependent Resistor (LDR) or also called a photoresistor is a type of resistor where the amount of resistance is based on the intensity of the light received. The resistance value of the LDR will be large if the light intensity it receives is low. The resistance of the LDR will be small if the intensity of light received is high. This means that the resistance value of the LDR is inversely proportional to the light intensity it receives. LDR in conditions of high light intensity, the resistance value of the LDR can reach 2×10^5 Ohm, while in low light intensity conditions the resistance value decreases to 500 Ohm. The current sensor used in this final project is the ACS712 current sensor, which functions to detect the amount of current flowing through the terminal block. The device consists of a linear, low-offset, and precise array of hall-effect sensors. When current flows in the copper line at pins 1-4 the hall-effect sensor circuit will detect it and convert it into a proportional voltage. As for some of the characteristics of the ACS712 sensor, namely low noise, 5 V power supply, 66-185 mV / A output sensitivity, this current signal can be read via the Arduino analog IO port. The mean (zero amperage) sensor voltage is set at 2.5 V which is half the V_{CC} power supply voltage of 5 V (Ginting, (2018).
The voltage sensor functions as a sensor to detect the amount of voltage in the PLTS system. In designing this final project using a DC voltage sensor module that can be directly connected to the Arduino board. In principle, this module uses a resistive voltage divider, to run it using an input voltage of 5 V or 3.3 V. In 4 its use is for a maximum voltage reading of 25 V where 5 times the VCC, so if the VCC voltage used is 3, 3 V, the maximum detected voltage is 16.5 V. Solar Charger Controller is an electronic device used to regulate direct current which is charged to the battery and taken from the battery to the load. Solar charge controller regulates overcharging (excess charging), because the battery is full and excess voltage from the solar cell. The solar charge controller applies Pulse width modulation (PWM) technology to regulate the function of charging the battery and releasing current from the battery to the load. solar cell 12 V generally has an output voltage of 16 - 21 V. Servo motor is a DC motor with a closed feedback system where the rotor position will be informed back to the control circuit in the servo motor. This motor consists of a DC motor, a series of gears, a potentiometer, and a control circuit. Potentiometer serves to determine the angular limit of the servo rotation. While the angle of the servo motor axis is adjusted based on the pulse width sent through the signal leg of the servo motor cable. The DC-DC Step Down Voltage Regulator Module is a module used to reduce the voltage from 5 - 32 V_{DC} to 0.8 - 30 V, the microcontroller used is IC XL4005. According to the datasheet, the capabilities of this module can reduce the voltage to the desired value by adjusting the Rmultiturn (variable resistor) by turning it (Junaidi, 2018).

Method

The steps taken in the research are preceded by making several designs for supporting devices in the process of making an Android-based SHS performance monitoring tool. The first device design to do is design a solar cell system that is used as an energy source by converting solar energy into electrical energy. The process of the stages of the solar cell system begins with the light energy that comes from sunlight falling on the earth which is absorbed by the solar cell. Light energy is then converted into chemical energy by solar cells which is then converted again into electrical energy (Risma, 2019). The electrical energy generated is flowed through the cable and into the solar charge controller which functions as a control for the output voltage generated and distributed into the power storage. Power storage in the form of a battery is used to store the electrical energy generated. A lamp is used as a load for indicators and takes current and voltage measurements (Muhamad, 2019). The next step is to make a device that controls the solar cell transmitter system to Arduino. The way this system works is to carry out the process of sending current and voltage to the solar cell which is then detected by the measured current and voltage sensor in the form of data into the Arduino Mega ADK microcontroller to process the data and display it on the LCD (Pangestu, 2019). The flow diagram of how the solar cell transmitter system to Arduino works can be seen in Figure 1 (a).

The next step is to design a monitoring system with a monitoring system working process using two light sensors and Arduino ADK 2560 as a microcontroller to control the servo motor as an actuator (Angelia, 2018). This system uses two light sensors in the form of an LDR (Light Dipendent Resisitor). Light sensor 1 is a sensor used to detect sunlight from the east, while light sensor 2 is a sensor used to detect sunlight from the west. If the sun's position is right above the sensor, sensors 1 and 2 will get the same level of light intensity and change the direction of the solar panels according to the direction of the sun's light. The way the monitoring system works is starting from the input in the form of an LDR sensor facing the east and west directions. Both LDR sensors are on and catch the sunlight coming from a certain direction (Pramana, 2017). The two sensors identify the difference in error in the ADC values captured based on the value of sunlight intensity. Determination of the ADC value is determined by getting the error value> = 61.5 then the servo motor moves east, if the ADC error value <= 61.5 then the servo motor moves west, then if the eastern ADC value LDR <100.50 & west LDR <100.50 then the servo motor moves in the upright position. The flow chart of how the monitoring system works can be seen in Figure 1 (b).

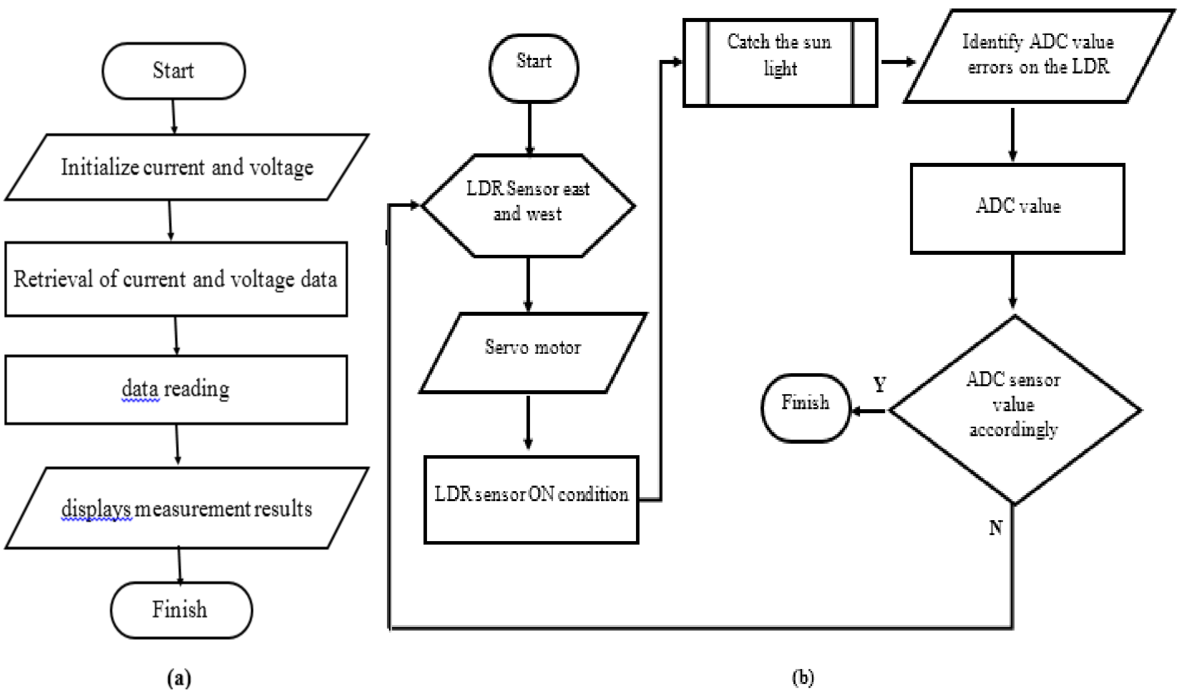

Figure 1. The Flowchart of How the Solar Cell Transmitter System to Arduino (a) and Monitoring System (b)

The next step is designing an android application system using the NodeMCU ESP8266 receiver to android. This android application system design receives data from the monitoring results of the current and voltage sensors displayed on the application. The work process of the NodeMCU ESP8266 receiver system to android begins with the initialization of the NodeMCU ESP8266 in the form of providing input values of measurement results by current and voltage sensors sent via an intermediary wifi network (Rochmanda, 2016). The process is continued by identifying the wifi network that is already connected to NodeMCU ESP8266. Enter the decision command to ensure that the wifi network is connected. Continue with data collection by NodeMCU ESP8266 on the IO Adafruit website (Tian, 2017). The final stage in this process is to display the results of sensor data in the form of graphs in real time on the android application. The flow chart of how the NodeMCU ESP8266 receiver system works to android can be seen in Figure 2 (a).

The next step is making a receiver and transmitter relay control system on Android which is used to cut off the flow of excess voltage and current. The working process of this relay control system is by looking at the indication on the Andorid display which shows the presence of excess current or voltage. Input the decision command to provide the value of the measurement results displayed on the android application, consisting of a solar cell relay output; charge controller relay output; and output relay power storage (accumulator). The results of the decision can be in the form of graphs of real time measurement of currents and voltages. If there is an excess value of current or voltage, then the android system relay can be controlled off. The system then detects a wifi network connection on the NodeMCU which is made from a decision command to ensure that the wifi network is connected. After the system is connected to the Android application, then the system displays data in the form of a graph of sensor measurement results on the Android application. The system displays publication data by installing this monitoring application on a mobile, then the device will connect and display the measurement data. The flow chart of how the receiver and transmitter relay control system works on Android can be seen in Figure 2 (b).

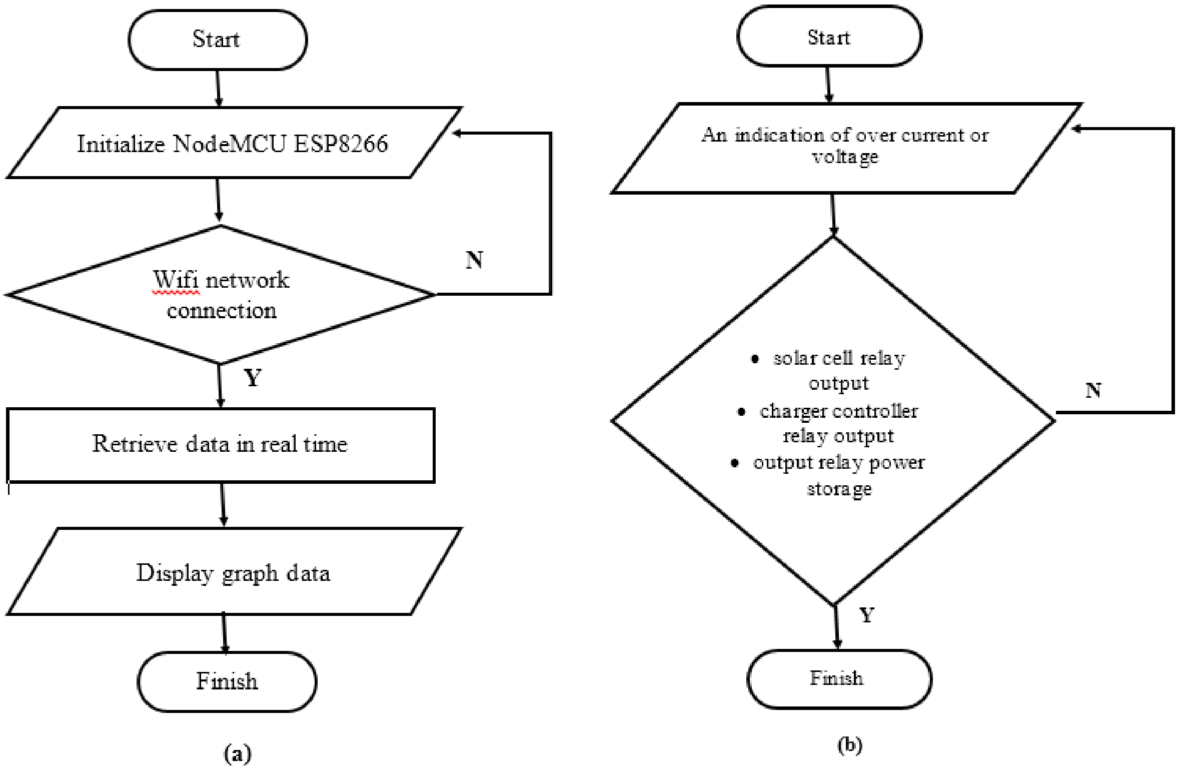

Figure 2. The Flowchart of How the NodeMCU ESP8266 Receiver System (a) and Receiver Transmitter Relay Control System (b)

Results and Discussion

This chapter discusses the testing system that has been designed, namely a remote solar cell tracking system monitoring tool. Furthermore, the process of testing the tool can work normally in accordance with the system being made. Discussion of each system test will be discussed in the explanation below. Sensor testing is done to ensure that the sensor can work and can respond to changes in voltage and current. Light sensor testing or LDR (Light Dependent Resistor) aims to find out how the type light sensor works to follow the movement of sunlight from east to west. In this test, there are two sensors, namely the light sensor 1 as the eastern sensor and the light sensor 2 as the western sensor. The testing process is carried out by displaying the results of the eastern and western ACD LDR sensor values on the Arduino application monitor serial screen. Based on the test results, the value of each light sensor displayed on the Arduino application monitor series is obtained. The monitor series displays the values of both sensors when getting the intensity of sunlight. based on the results of these values, the comparison of the conditions when the solar panel moves to the position and direction of the sun's rays falling on the solar panel. the second test of LDR sensors against sunlight is carried out when the position of the solar panels moves eastward at 08.00-11.55 WIB; The position of the solar panels when they are perpendicular to the sun occurs at 11.55-12.15 WIB; and the position of the solar panels when they move to the west facing the sun, the sun occurs at 12.16-16.00 WIB. Based on the results of the light sensor test in table 1, the eastern light sensor receives more sunlight, the ADC value will be low compared to the western light sensor ADC value, with the average difference in the ADC sensor value of 60.35. So that it will give orders to actuators or servo motors to move the solar panels towards the east. when the light sensor on the solar panel is in a position perpendicular to the sun, the resulting light sensor ADC value is the same or has an average difference value of 0.3. So that it gives commands to the servo motor to move the solar panels perpendicular to the sun. when the light sensor on the solar panel is in a position facing west towards the sun, the resulting light sensor value is different, namely the ADC value generated by the western light sensor is less than the eastern light sensor. The average difference in ADC values generated based on the data was 85.35. So that it will give orders to the servo motor to move the solar panels to the west. Table 1 below is the results and data analysis of the light sensor test at the position of the solar panel moving eastward; perpendicular ; and west to the direction of sunlight.

Table 1. Light Sensor ADC Value on Sensor Testing

Sun in the East			Sun when Upright			Sun in the West		
LDR 1	LDR 2	Time	LDR 1	LDR 2	Time	LDR 1	LDR 2	Time
9	69	08.00	78	78	11.55	88	3	12.16
9	69	08.15	78	78	11.55	88	3	12.16
9	69	08.30	78	78	11.56	88	3	12.30
8	69	08.45	78	78	11.56	88	3	12.30
8	69	09.00	78	78	11.56	89	3	12.55
8	69	09.15	78	78	11.57	89	4	13.00
9	69	09.30	79	78	11.57	89	4	13.00
9	70	09.45	79	79	11.57	89	4	13.20
9	70	09.50	79	79	11.58	88	4	13.45
9	69	09.55	79	79	11.58	88	3	13.45
8	69	10.15	79	80	11.59	88	3	14.00
8	69	10.20	79	80	11.59	89	3	14.20
9	70	10.30	80	80	12.00	89	3	14.30
9	70	10.40	80	80	12.00	89	4	14.45
10	70	10.45	79	80	12.05	90	4	15.00
10	70	11.15	79	80	12.05	90	4	15.00
11	71	11.20	79	80	12.10	90	5	15.20
11	71	11.35	80	80	12.10	91	5	15.30
12	71	11.45	80	81	12.15	91	5	15.45
12	71	11.55	80	81	12.15	91	5	16.00

The next step is to conduct a voltage test, this test aims to determine the performance of the voltage sensor in detecting voltage in a closed and open circuit and to compare the measurement results on the system with a multimeter measuring instrument. Based on the results of these comparisons, the difference in voltage values read by a multimeter with a voltage sensor is analyzed. The test is carried out using open and closed circuits or with no load. The voltage sensor being tested is a sensor located on the battery. The battery used has a capacity of 9 Ah and has a normal voltage of about 12 V. This test V_0 is a voltage condition in an open circuit or there is no load, and V_1 is the voltage in a closed circuit or with a load. Load using a DC lamp 10 W. ΔV_0 and ΔV_1 is the difference from the voltage reading using the voltage sensor displayed on the LCD screen and a multimeter measuring instrument. The overall test results carried out for 10 hours, from 0700-16.00 WIB in sunny weather can be seen in Table 2. which is the result of testing the voltage sensor on the battery.

Table 2. Light Sensor ADC Value on Sensor Testing

V_0 Multimeter (V)	V_1 Multimeter (V)	V_0 Sensor (V)	V_1 Sensor (V)	ΔV_0 (V)	ΔV_1 (V)
12,39	12,15	13,20	13,08	0,81	0,93
12,42	12,19	13,18	13,15	0,76	0,96
12,46	12,18	13,23	13,11	0,65	0,93
12,47	12,21	13,53	13,43	1,06	1,22
12,94	12,73	13,77	13,52	0,83	0,79
12,55	12,34	13,30	13,13	0,75	0,79
12,53	12,27	13,24	13,15	0,71	0,88
12,37	12,17	13,26	13,15	0,89	0,98
12,43	12.20	13,29	13,19	0,86	0,99
12,41	12,18	13,37	13,24	0,96	1,06

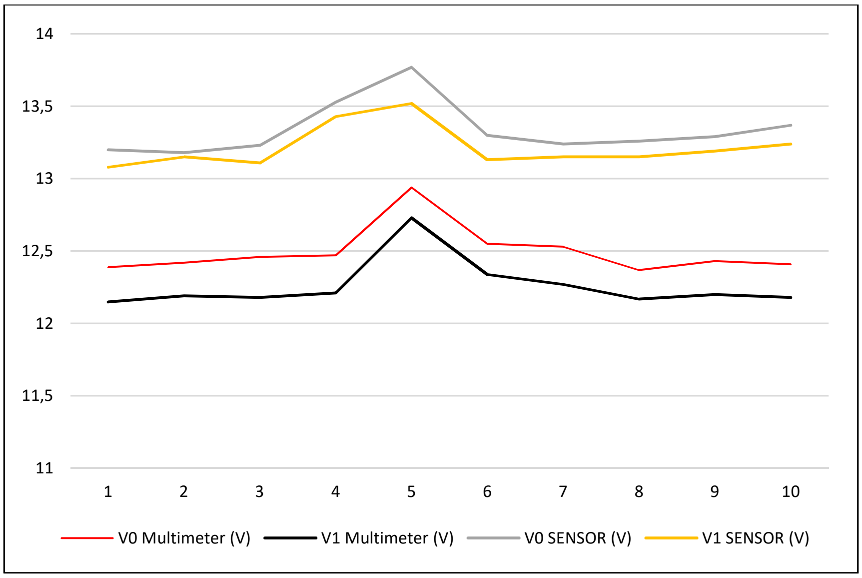

Figure 1. Graph of Measurement Results for Voltage Value on Multimeters and Sensors

Based on Figure 1.Test results, it can be seen that the voltage value at the beginning of data collection, namely at 10:00 - 12:00 using a multimeter, is 12.39 V to 12.47 V when no load, 12.15 V to 12.21 V with load. while the measurement with sensors is worth 13.20 V to 13.53 V without load, 13.08 V to 13.43 without load. data collection of voltage values at 13.00-14.00 WIB using a multimeter is worth 12.55 V to 12.41 V when without load, 12.34 V to 12.18 V with load. while the measurement with sensors worth 13.30 V to 13.37 V without load, 13.13 V to 13.24 without load. Maximum stress occurs when data collection is 12.00-13.00 WIB, namely 12.94 V without load and 12.73 V with load for measurements on a multimeter. While the sensor is 13.77 V without load and 13.52 with load. When the open circuit or no-load condition results in a difference in the average voltage value of 0.82 V, while in a closed circuit or using a load, the difference in the average voltage value is 0.95 V. The voltage value on the battery is generated from measurements with a multimeter and The sensor has a trend that the voltage value always increases by 0.24% to 0.35% according to time, meaning that the greater the value of the sunlight intensity received. the voltage value in the data collection process after the peak value, the trend of the battery voltage value tends to decrease by 0.11% to 0.15% by measuring using a multimeter, but measurements using the sensor value actually experience an increase in the voltage value of 0.15% to by 0.20%. this happens because of the intensity of sunlight that enters the two LDR sensors and is still read simultaneously by the system.
This next test aims to determine the performance of the ACS712 current sensor in reading DC currents. Current testing is carried out on the battery (power storage) and solar panels simultaneously with a multimeter and sensor. The sensor used is located on the load or battery. The test is carried out by comparing the current reading on the ACS712 current sensor with a multimeter measuring battery with a capacity of 9Ah and a voltage of 12V. In Table 3. ΔA is the difference from the current reading using a multimeter measuring instrument with the ACS712 sensor located on the battery battery. Based on Table 3. in testing the value of the current flowing in the power storage and solar cell shows the average difference in current of 0.33 A and 0.14 A. multimeter, the magnitude of the current value is directly proportional to the voltage value obtained at any given time and vice versa. this is in accordance with the existing theoretical basis that the current value is directly proportional to the voltage value and vice versa.

Table 3. Measurement of the Current Value

Power Storage			Solar Cell		
Multimeter (A)	ACS712 (A)	Δ A (A)	Multimeter (A)	ACS712 (A)	Δ A (A)
1,28	1,02	0,26	0,64	0,68	0,04
1,27	0,87	0,4	0,65	0,67	0,02
1,19	0,74	0,45	1,00	0,75	0,25
1,17	0,87	0,3	1,03	0,87	0,16
1,19	0,94	0,25	1,03	0,88	0,15
1,23	0,92	0,31	0,98	0,82	0,16
1,28	0,90	0,38	0,97	0,81	0,16
1,27	0,89	0,38	0,97	0,81	0,16
1,20	0,88	0,32	0,94	0,76	0,18
1,18	0,88	0,3	0,94	0,76	0,18

Conclusion

Solar cell moves to follow sunlight automatically based on 3 conditions, namely the solar cell facing east, perpendicular and west. When facing east, the average difference in ADC sensor values is 60.35, perpendicular to the average difference between ADC sensors is 0.3 and facing west, the average difference in ADC sensors is 85.35. Monitoring can be done through an android application that displays the results of the current and voltage values in 3 parts, namely the solar panel, battery and load in real time. the current value obtained is directly proportional to the voltage value on the measurement with a multimeter or sensor and vice versa. The relay control system in the application has an average delay time of 5.91 seconds.

Recommendations

The solar cell tracking system can be developed using a dual axis so that it will move more freely. The light sensor can be combined with a device or angle sensor so that it will be more accurate and precise in receiving sunlight and the solar cell will move precisely according to the movement of the sun.

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