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The Use of Solar Power in Liquid Spraying Robots

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ABSTRACT

Solar power plants are renewable energy needed as a source of energy for electronic equipment, Robots are needed to replace human work. This study discusses robots in charge of spraying liquids and batteries charged by solar panels as a robot energy source. The analysis is carried out by measuring voltage, current, and the power generated by the solar panel, battery, and voltage regulator LM317. The results of this study used a 20 WP solar panel. 12 lithium-ion batteries are used in combination, 4 lithium-ion batteries are connected in series and 3 in parallel so that the desired capacity of 12V/8AH is obtained, and the battery is filled with a solar charge controller circuit regulated by the Arduino ATMega8. The LM317 battery voltage regulator produces direct current as the robot's main energy source. According to the test results, the robot requires 55.1 watts of power and 55.1 watt-hours of energy to function at one o'clock. The LM317 voltage regulator output voltage of 14.44 volts is sent to the battery.

KEYWORDS
Solar Panel
Battery
Solar Charge
Voltage regulator LM317
Robots

1. Introduction

Indonesia has a very large potential for solar energy and has not been utilized properly. With a potential of 207.8 GB, it is very possible to use solar energy as an energy source for various electronic equipment[1], PLTS is a power plant that utilizes sunlight through solar cells[2], which are converted into electrical energy from the sun's photons. The solar cell itself is a thin layer made of pure silicon (Si) semiconductor material and other semiconductor materials. The sunlight used by this PLTS will produce DC electricity[3]. Solar cells (photovoltaic) will produce electrical energy during the day and the battery will store the electrical energy[4]. The storage of electrical energy from photovoltaics into the battery is assisted by using a solar charge controller to prevent excess charging, which can damage the battery.

2. Literature Review

Solar cells (photovoltaic) will convert solar radiation into electrical energy during the day, and batteries will store electrical energy6. The storage of electrical energy from photovoltaic into the battery is assisted by using a solar charge controller using an Arduino ATMega 8 microcontroller and an LM317 voltage regulator5 so that there is no overcharging voltage to prevent damage to the battery7, preventing backflow to the solar panel8.

Batteries are used to provide energy for the load. Batteries occur due to electrical-chemical processes where when charging, electrical energy is converted into chemical energy9, and when used to load the battery, chemical energy is converted into electrical energy. Batteries can be connected in series or parallel. The series arrangement will increase the voltage with a constant current10. The total voltage produced is the sum of the voltages produced by the series connection of the battery. The parallel arrangement of solar cells can increase the current with a constant voltage. The total current produced is the sum of the currents produced by the parallel connection of the battery11.

This study uses DC electricity from 12 batteries to drive the liquid spraying robot. The solar panel is not the main energy source but functions to charge the battery to drive the robot. The battery used is a lithium-ion battery with a capacity of 2000 mAh per cell. with a voltage per cell of 3.8-4.2 volts.

3. Method

The PV module converts solar irradiation into electrical energy and provides a direct current voltage supply to the ATMega 8 microcontroller battery charging controller[12], which regulates the charging voltage to the battery. Once the battery is fully charged, the solar charge controller will stop charging the battery[13]. The battery is used to store electrical energy generated by the PV module. The battery provides a DC voltage source as the robot's energy supply. Fig. 1. shows the research block diagram.

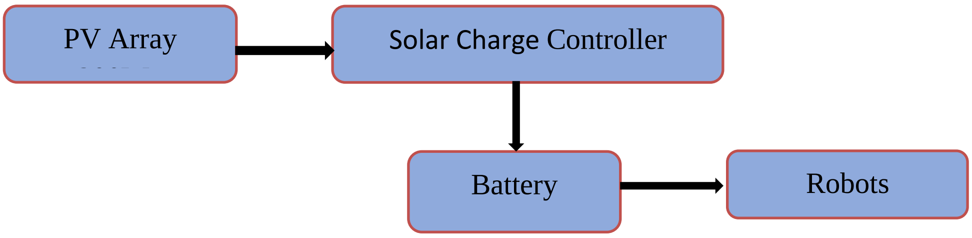

Fig. 1. The Research Blok diagram

The robot uses lithium-ion batteries that are supplied by sunlight. For that, the robot is equipped with a solar panel of 20 WP. The battery will be charged when under the hot sun and used indoors and outdoors[14]. Lithium-ion batteries are dry cells in the form of cells with a voltage per cell of 3.8-4.2 volts. To get a voltage of 12 volts, 3 batteries in series are then paralleled 4 times to get sufficient current. The robot works for 1 hour. The analysis that will be carried out includes the overall energy demand, testing the power capacity of the solar panels, and testing the capacity of the battery to be used[15].

4. Result And Discussion

The mobile robot sprays the liquid using several electronic and mechanical components[16]. The robot is equipped with an ultrasonic sensor that functions to detect the obstacle object in front of it when it moves forward[17]. The robot is driven by two permanent magnet DC motors[18], which have been equipped with a gearbox. The motor is mounted on 2 main drive wheels so that the robot's motion is determined by the rotation of the two motors to go forward or backward and turn[19]. The robot is also equipped with a high-pressure pump that functions to spray liquid. The pump type is the centrifugal type with 12 volts of working voltage. The pump will suck the liquid from the tube and spray it through the nozzle mounted on the end of the hose towards the top of Fig. 2.

Fig. 2. Liquid sprayer robot

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As Fig. 2 shows, a 20 WP solar panel was chosen to be installed as an energy source to convert the energy of sunlight into electrical energy and store it in a lithium-ion cell battery20. The battery serves to provide energy to the robot for work. The test results of solar panels can be seen in Fig. 3.

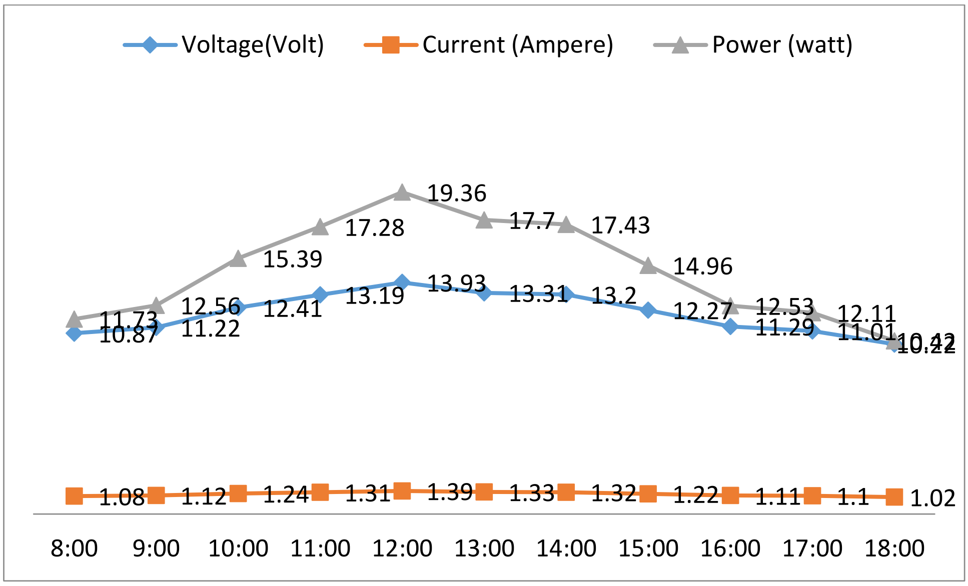

Fig. 3. Solar Panel Test Results versus Time

The results of the solar panel test versus time are shown in Fig. 3. The highest voltage is obtained at 12.00 at 13.93 volts, the lowest voltage at 18.00 is 10.22 volts, and the highest power is produced by the solar panel at 12.00 at 19.36 watts.

The robot under study can move and perform liquid spraying work controlled by the ATMega 8 microcontroller21. The amount of energy required to supply the robot as a whole can be determined by knowing that the total current of the load used is 4,517 A. It takes 4,517 AH of energy to work for 1 hour, and the battery voltage is 12.2 volts.

$$P = v.i$$
$$P = 12{,}2.4{,}517 \tag{1}$$
$$P = 55{,}1\ watts$$

the energy required to supply the robot for 1 hour is

$$E = P.t$$
$$E = 55{,}1.1 \tag{2}$$
$$E = 55{,}1\ wh$$

The overall power of the robot while working is 55.1 watts. The energy used by the robot to work for 1 hour is 55,1 watt-hour. Solar panels are used only to charge the battery, not as a main power supply source[22]. The main power supply of the robot is a battery. The battery used is a lithium-ion battery with a capacity of 2000 mAh per cell, and there are 4 cells in parallel, so the total battery capacity is 8000 mAh or 8Ah. The current required to charge the battery is a maximum of 20% of the battery capacity. Thus, the batteries used are:

$$I_{charge} = 20\%.8$$
$$I_{charge} = 1{,}6\ Ampere \tag{3}$$

The power capacity of the panel can be calculated if the current flowing is 1.6 amps with a working voltage of 12 volts. This can be done using the following formula:

$$P = v.i$$
$$P = 12.1,6 \quad (4)$$
$$P = 19,2\ watts$$

Regulators are used to limit the output voltage of solar panels. Without a voltage regulator, the panel will go up and down according to the light conditions. This voltage will make the battery charging process unstable. The regulator works to limit the voltage at a certain voltage value. In this design, the regulator is set to operate at 14.4 volts, which is the battery voltage when fully charged. Test the regulator. It is done by using a solar panel that is dried directly under the hot sun and measuring the input-output of the regulator. Fig. 2: Results of measurements made when testing the LM317 voltage regulator.

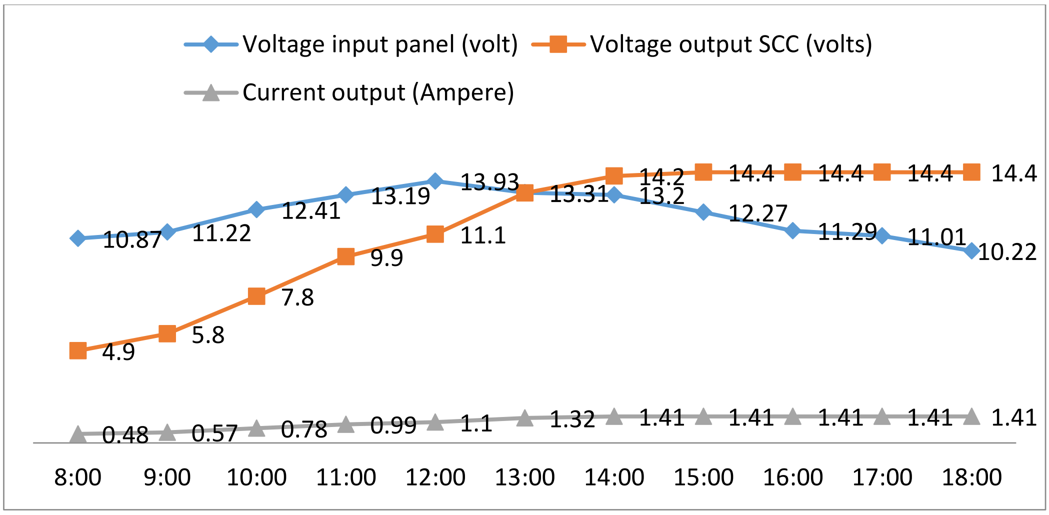

Fig. 4. battery charging test process agains time

Fig. 4 shows the battery charging test. The time it takes is 3.5 hours with a large charging voltage reaching 13.6 volts, which is 20% above the normal battery voltage. The series battery voltage is 11.4 volts if you add 20% to 13.68 volts. After 3.5 hours, the battery is declared full.

5. Conclusion

The solar panel test of 20 WP can charge 12 full batteries connected in series and parallel. The DC voltage charging from the solar panel to the battery is regulated by the LM317 voltage regulator controlled by the ATMega 8 microcontroller so that there is no overload in the charging voltage. The battery can drive the liquid spraying robot. The total current size of the robot when working is 4,517A, which is with a battery voltage of 12 volts.

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