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Design of a Solar Powered Battery Charger

Anis Adlina Azman[1], Zaidi Embong[1*], Afishah Alias[1]

[1]Department of Physics and Chemistry,
Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia (Pagoh Campus),
84600 Pagoh, Muar, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: Solar energy is one of several types of renewable energy on the planet. This energy may be captured by utilizing a solar cell or photovoltaic cell, which directly turns sunlight into electricity. Many tiny electrical equipment, such as battery chargers, can also benefit from solar electricity. In this project, a solar-powered battery charger for a motorized wheelchair is created to charge lead-acid batteries and to alert the user when the batteries are fully charged. The major advantage of utilizing a solar-powered battery charger is that it is one of the least expensive methods of charging batteries. Aside from that, solar-powered battery chargers are quickly gaining popularity since they have been shown to be useful in a variety of settings, particularly in the outdoors, as well as being portable and user-friendly. In this project, a constant current source is used to recharge the batteries, and the capacitance of the lead acid battery is successfully tested. When the batteries are fully charged, an LED light bulb will illuminate to indicate to the user that the batteries may now be reused.

Keywords: Solar, Photovoltaic Cell, Battery Charger, Motorised Wheelchair

1. Introduction

Renewable energy is growing increasingly popular across the world as a primary source of energy production that was previously depleted. Using renewable energy sources such as wind, sun, and water is one of the most acceptable and desired alternative highways. Solar is the most promising of these three sources since it can presently be generated at a lower cost than wind and hydro [1]. Photovoltaic systems or solar cells can be used in a variety of ways. Solar cells have been used to charge a variety of solar batteries used in the aerospace industry, electric vehicles, communication equipment, and remote motor supplies [2]. Using solar power to charge batteries is not a new idea. A simple way to accomplish this is to connect a photovoltaic (PV) panel directly to a battery.

Simple regulator architecture-based chargers do not have great efficiency. They provide a steady current to the battery throughout the first part of the charging process. They regulate steady voltage on the battery side throughout the final phase. To do this, they either reduce the voltage differential between the panel and the battery or equalize the panel and battery voltages [3]. A controller can be installed

**Corresponding author: zaidi@uthm.edu.my*

between the PV panel and the battery to increase system performance. Typically, the controller is a DC converter. It should be a buck or boost to allow for situations where the PV panel voltage is more or less than the battery voltage. An optimum control algorithm may be designed in such a system to convert the maximum available solar power into energy and charge the battery [4].

The alternate method is being devised and manufactured to provide an economical solar-powered wheelchair that is manually operated. The wheelchair runs on free solar energy. This design may be utilized in areas without power. We know that electric vehicles run entirely on electricity. Photovoltaic (PV) cells are used in solar-powered vehicles (SPVs) to convert sunlight into energy. Solar power wheelchairs are a step forward in terms of generating and utilizing energy, as well as reducing our reliance on utility supplies, which will help us reduce carbon emissions by utilizing renewable energy [5]. There are also some projects that have already successfully designed and manufactured a mobility vehicle for disabled people that is powered by free solar radiation. The design was built in the Mechanical and Industrial Engineering Department's workshop at the University of South Africa [6].

The design of a solar-powered battery charger with an optimum controller is presented in this study. The proposed system's aims are to convert as much solar power as feasible into electricity under different weather conditions and to charge the battery as quickly as possible in compliance with the battery lifespan condition. The suggested method may be used in light electrical vehicles such as motorized wheelchairs, as well as other renewable power stations that use batteries as energy storage.

2. Materials and Methods

Preliminary ideas were gathered from many sources of literature and assessed before designing the solar-powered battery charger for a motorized wheelchair. The prototype of a solar-powered battery charger for a motorized wheelchair's operating start with an 18V solar panel was used to collect solar energy. The solar charge controller regulates the 18V produced by the solar panel in order to charge the stored energy of the battery. A charge controller was used to charge the battery after the panel was connected to it. The charge controller turns the variable current flow into a steady current flow. This is also linked to a battery in order to charge it. During the charging of the battery, there is the step where capability on time dependence for battery based on capacitance, voltage, and power were examined using a multimeter. After the battery was charged, to evaluate the voltage and power of battery charging after being discharged, the battery was connected directly to an LED light bulb. Figure 1 shows a block diagram of the solar-powered battery charger for a motorized wheelchair was designed in this study.

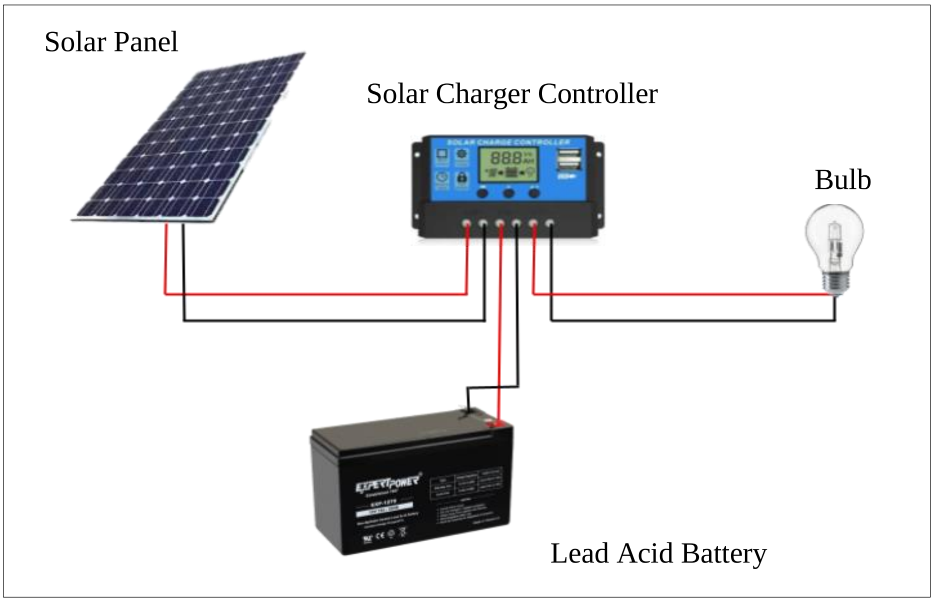

Figure 1: Block diagram of solar-powered battery charger

2.1 Battery

This project used lead acid batteries of 12V with 7.2Ah because it is the only viable battery technology for electric vehicles. The maximum charging current of this battery is 2.16A. Electricity produced by the solar panel is stored in a battery [7]. The use of lead-acid batteries can prevent battery life from being shortened owing to overcharging. The solar power supply system, which includes a polycrystalline silicon solar panel and a solar charge controller, charges this battery.

2.2 LED light bulbs

The LED bulbs serve as the load in this system. An LED driver circuit, which includes a full wave bridge rectifier, PT4115, the buck converter circuit, and LEDs, is the internal circuit of an LED bulb. The PT4115 is a buck converter circuit with a continuous conduction mode. The power switch and high-side output current sensing circuit are part of the PT4115's internal structure. The buck converter circuit will assist in lowering the voltage applied to LEDs.

2.3 Solar panel

Solar panels generate electricity, which may then be utilized to charge the batteries. The photovoltaic effect converts the light energy of the sun's beams directly into electricity in solar cells. This project's power supply system was powered by a 10-watt polycrystalline silicon solar panel. Polycrystalline silicon gets its name from the existence of numerous crystals in a single cell. This type of solar panel converts solar energy into electricity with excellent efficiency [8].

2.4 Battery charging controller

In this project, a solar charge controller is employed to ensure the battery's safety. The charge controller maintains the charge level on a 12V lead acid battery indefinitely. In addition, the charge controller permits the maximum solar panel current to charge into the battery, and the on-board temperature sensor regulates the charging rate depending on environmental conditions. Because the sun's rays are not constant on the solar panel, the voltage generated fluctuates. This shifting voltage might influence the performance of the battery. Hence, this project wants a device that can deliver a steady DC output. As a result, a charge controller is employed.

2.5 Calculations

The lead acid battery that is used is 12V and 7.2Ah. So, the power of the battery will be using this formula:

$$P = VI \qquad Eq.\ 1$$

This equation is used to estimate the capacitance of the battery charging. The formula of battery capacitance is:

$$Q = CV \qquad Eq.\ 2$$

$$Q = I \times t \qquad Eq.\ 3$$

$$C = \frac{Q}{V} \qquad Eq.\ 4$$

Where:
P = power in watts (W)
Q = Charge in coulombs (C)
C = Capacitace in farads (F)
V = voltage in volts (V)
I = Current in amperes (A)
T = time in seconds (s)

2.6 Duration of battery charging full

It is important to evaluate the time required to charge the 12V, 7.2 Ah lead acid battery. Thus, the duration taken to fully charge the lead acid battery based on the highest current from the solar PV panel is given:

$$\text{Battery capacity} = \text{Solar value} \times \text{Time} \qquad \textit{Eq. } 5$$

$$\text{Time} = \frac{Battery\ Capacity}{Solar\ Value}$$

$$\text{Time} = \frac{86.4\ Wh}{8.5\ W}$$

$$\text{Time charging} = 10.16\ \text{Hours}$$

3. Results and Discussion

3.1 Solar power supply system design

The solar power supply system is intended to be the primary power source for the motorized wheelchair. Polycrystalline silicon solar PV panel, solar charging controller, 12V with 7.2Ah lead acid battery, and DC load comprise the solar power supply system. Figure 2 depicts an overview of the solar power supply system architecture. Through the solar charger circuit, the solar panel is linked to the solar charger controller to charge the battery. The solar charger circuit's output is linked to the DC load, which is a bulb. A multimeter is used to measure the charging and discharging capability on time dependence for the battery based on its voltage and current.

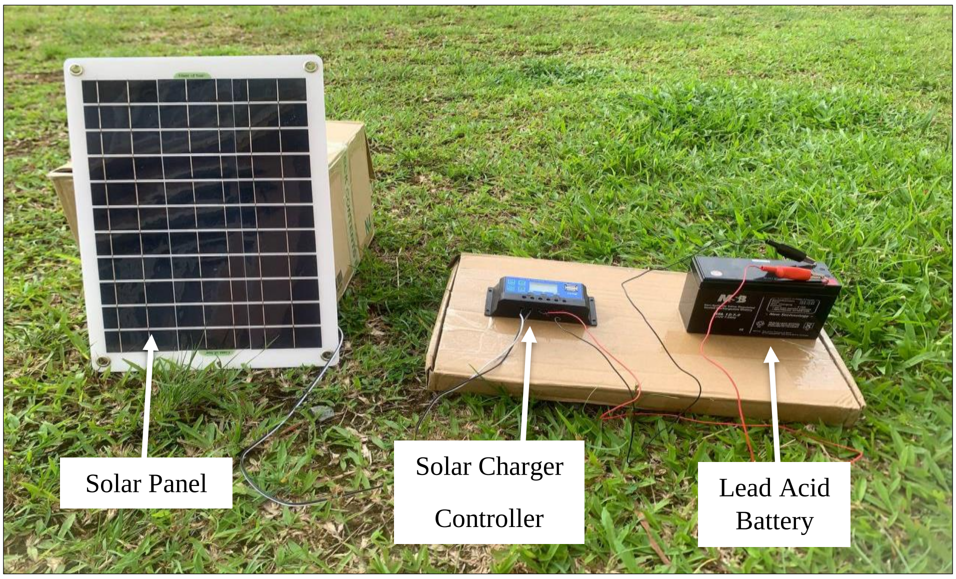

Figure 2: Solar power supply system

3.2 Battery charging measurement by solar panel

Experiments have been conducted on the prototype. Figure 3 shows a measure of voltage versus time of battery charging, and Figure 4 shows the battery charging current. As the controller steadily increases the input current, the input voltage from the PV panel drops in accordance with its I-V curve. The charging current of the battery grows proportionally until the maximum power is reached. As a result of the decreased power, the battery charging current will drop. When the PV voltage falls below the under-voltage protection limit (14V), the controller will turn off the PWM signal and restart it when the PV voltage rises. Because the battery voltage does not vary rapidly, the maximum power is obtained when the battery current reaches its maximum value, as seen in Figure 5.

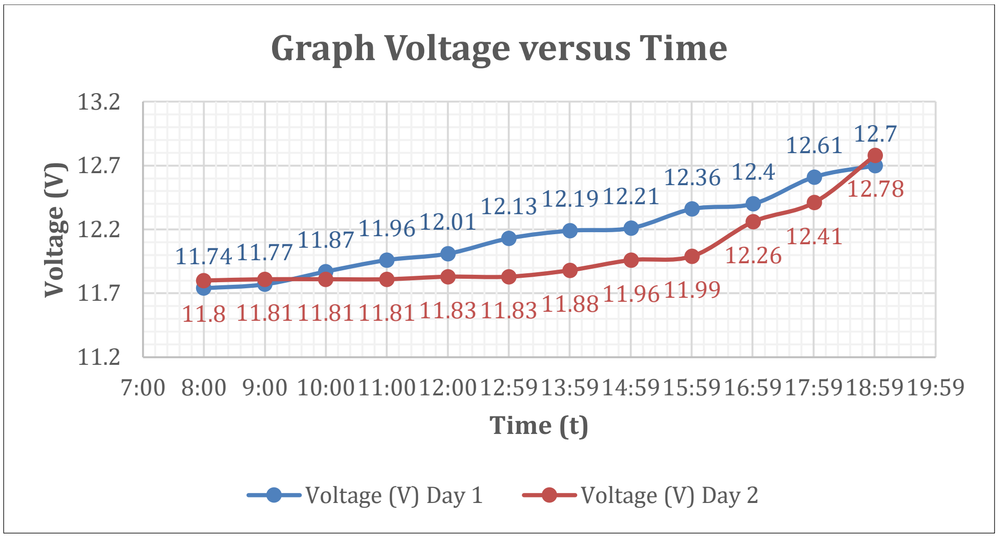

Figure 3: Measured voltage of battery charging through solar PV

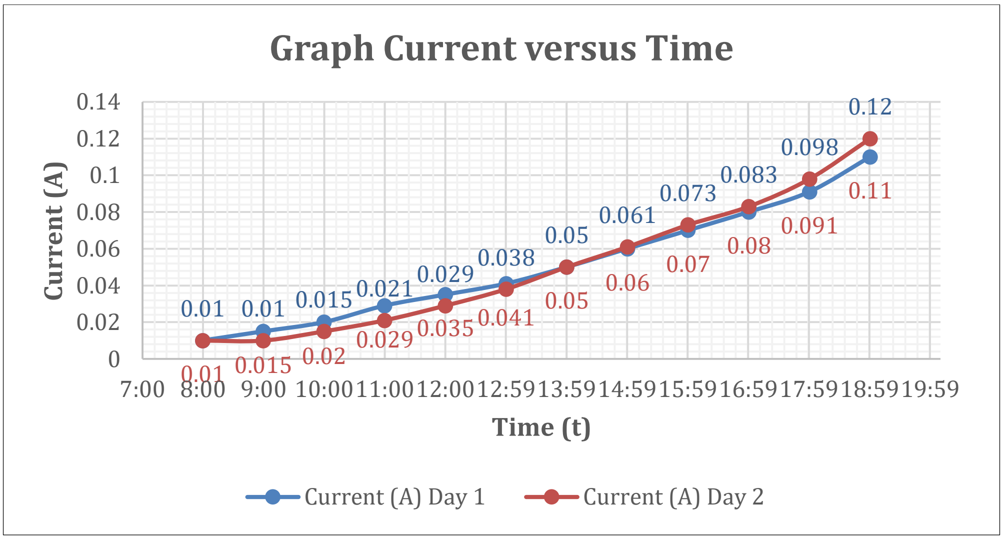

Figure 4: Measured current of battery charging through solar PV

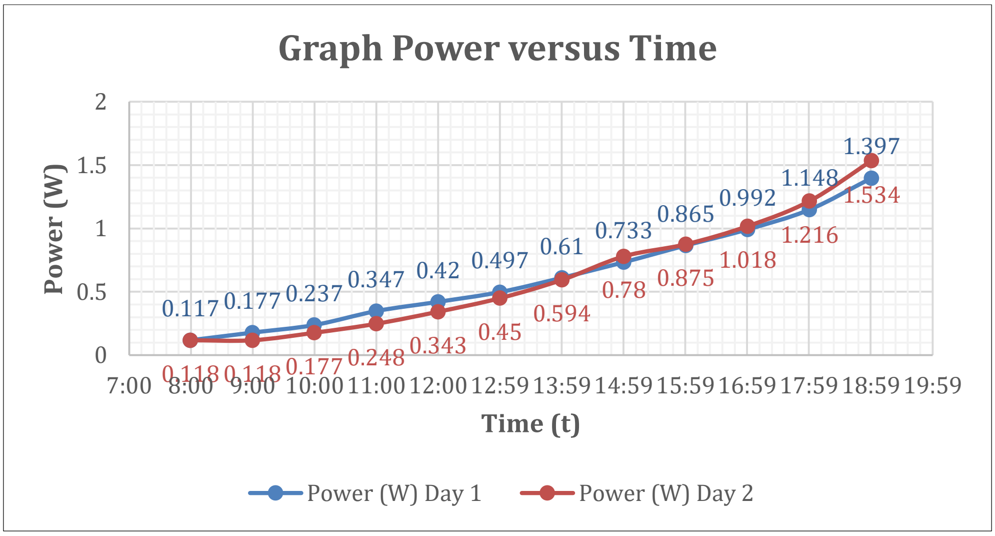

Figure 5: Measured power of battery charging through solar PV

3.3 Battery charging being discharged

The lead-acid battery is a type of battery that is widely used in the application and development of renewable energy systems. Furthermore, methods for designing efficient solar chargers to control the charge and discharge of a battery are being developed. It improves efficiency and increases battery life. LED bulbs are an interesting light source in a lighting system because they have many advantages such as energy efficiency, environmentally friendly, low voltage power supply, and design flexibility. For the reasons stated above, we investigate the use of LED light bulbs in this work. The power flowing through the battery and the light bulb are both evaluated.

Figure 6 depicts the design of the investigated system. The system consists of a 12V with 7.2 Ah lead acid battery and a light bulb as the load. For this study, two LED light bulbs of 5W and 10W are used. The battery is discharged by connecting the lead acid battery and the light bulb directly. The electrical properties of the system are extracted using a Fluke Model 115 multimeter.

(a) (b)

Figure 6: Discharging battery using load; a) 5W LED light bulb, b) 10W LED light bulb

The initial voltage, discharge current, and discharged voltage values are all affected by the size of the load. The initial discharged voltage will have a lower value if the load is large. More current is consumed during discharging. As a result, the battery runs out faster. In addition, Figures 7 and 8 show the current-voltage characteristics for each load type.

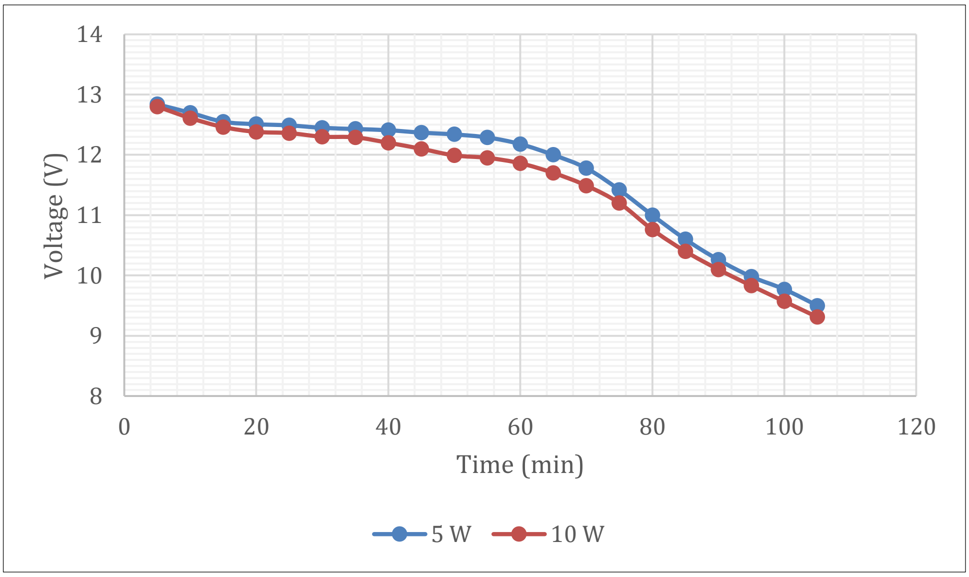

Figure 7: Voltage of discharging lead acid battery using LED light bulb as load

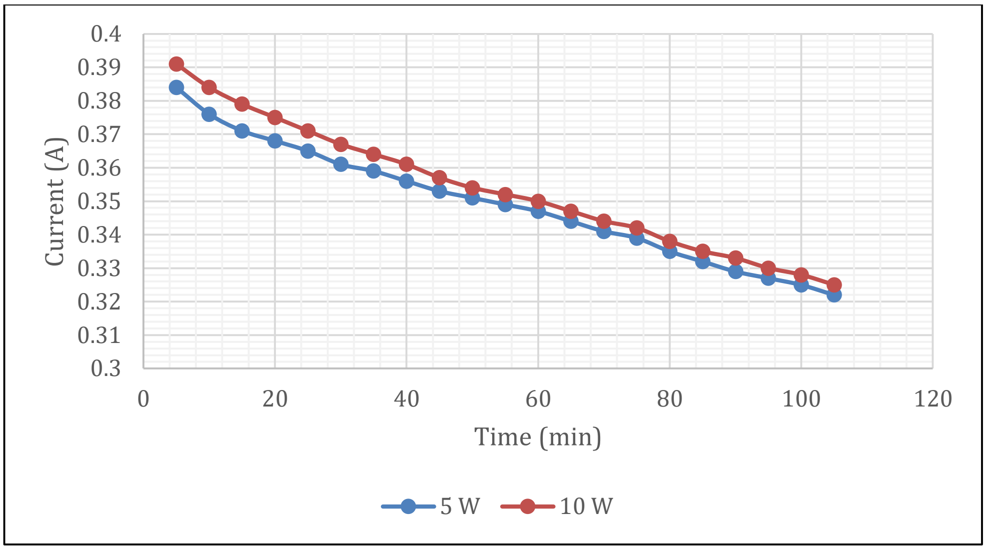

Figure 8: Current of discharging lead acid battery using LED light bulb as load

The battery voltage drops faster, and the battery discharges faster than in the case of LED bulbs. Both the current and voltage of a 10W and 5W LED light bulb decrease as the voltage decreases. At higher voltage levels, the 10W LED light bulb consumes more power. A non-linear discharge behavior occurs in the final phase. The battery is no longer able to power the load. As seen, the battery voltage of a 10W LED bulb and a 5W LED bulb drops rapidly to 9.31 V and 9.50V, respectively. Based on Figure 9, this study discovered that both the 10W and 5W LED bulbs can draw power from the battery for an extended period of time while emitting the same amount of heat. As a result, both LEDs are more efficient and save energy costs.

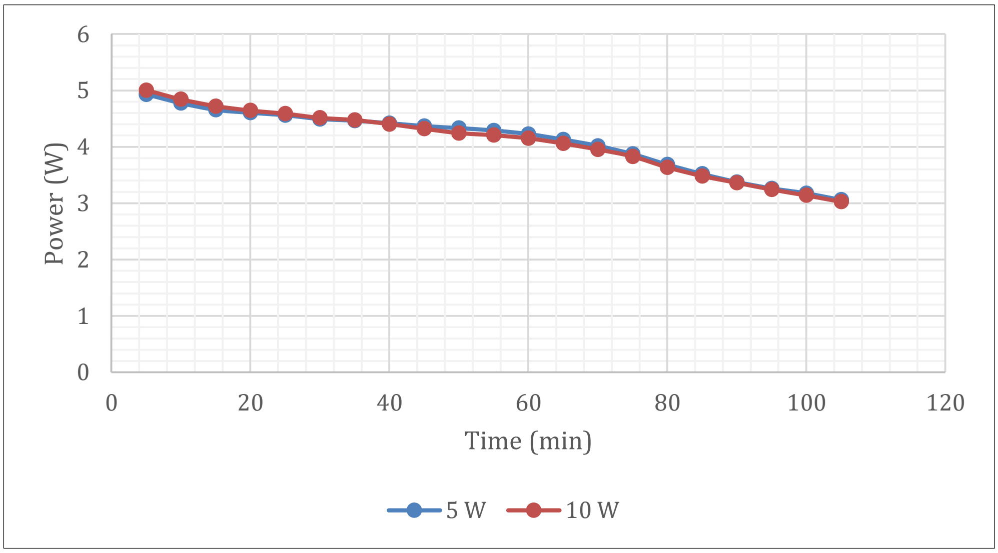

Figure 9: Current of discharging lead acid battery using LED light bulb as load

4. Conclusion

This paper presents the design of a solar-powered battery charger for a motorized wheelchair. In general, this system has been created effectively in accordance with the project's objectives. PV solar generation has been properly sized in order to supply companionable output power to the operational load. With the aid of a solar power supply system, the battery supply may last around 24 hours. The PV solar generation system's difficulty is that the solar panel is unable to get the maximum solar energy owing to the sun's shift toward the fixed position of the solar panel. Further experiments are planned to use a higher-wattage solar panel to shorten the time it takes to charge the battery.

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