INVOTEK
Jurnal Inovasi Vokasional dan Teknologi

Volume 21 Number 2, 2021
ISSN: 1411 – 3411 (p) ISSN: 2549 – 9815 (e)
DOI: 10.24036/invotek.v21i1.901

Portable power supply design with 100 Watt capacity

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Abstract

Renewable energy from solar cells is a type of alternative energy for consumers, especially those far from electricity, and saves electrical energy. This research developed an innovative tool for portable solar power generators as a source of energy, which stores electrical energy in two ways, namely solar cells and transformers. Furthermore, this research is expected to improve innovation tools for more efficient electricity supply and energy use, especially for rural communities. It also uses a variety of battery capacities to test portable power supplies. The results showed that the power supply using 100 Wp solar cells produced a capacity of 20 Ah, 60 Ah, and 100 Ah on the battery. Charging with a solar energy source on a 20 Ah battery takes a duration of 5 hours to be fully charged, while 60 Ah and 100 Ah batteries cannot be fully charged in one day. Charging a battery that has been run at a full level takes a duration of 15 hours at a temperature of 30ºC to 34ºC. Finally, this tool is expected to add variety to locally manufactured products.

Keywords: battery, charging, energy, power supply, portable.

1. Introduction

Most people use solar cells as a backup energy source and infrequently utilized remote areas as the main energy source. Electricity from solar cells can be packaged in batteries and used at night when needed instead of entirely using it in electronic equipment. Although batteries act as energy storage media, it is unable to supply power continuously. Therefore, this led to the design of photovoltaic technology to capture sunlight, thereby leading to an output voltage greater than the battery. The photovoltaic output voltage is adjusted using the Solar Charge Controller (SCC), which acts as a battery regulator. Capacity is the battery's ability to store the electrical power, which is expressed in Ampere-hours (Ah). For example, a battery has the ability to supply an average voltage of 1.75 Vdc, with each cell comprising of 2 Volts. Therefore, when the voltage drops at 1.75 Vdc it indicates that the efficient capacity has been used thoroughly utilized [1]. The design has been tested in a research with the topic "Photovoltaic modeling" based on Matlab/Simulink [2] to determine the power required for the distribution of electric power. In this research, a photovoltaic system based on Matlab/Simulink was simulated with a photovoltaic panel capacity of 100 Wp to determine the effect of solar irradiation, temperature, panel voltage, panel current, and the battery charging process [3].

Peng Yong Kong and George K Karagiannidis conducted research using Plug-in Hybrid Electric Vehicles (PHEV) and produced tools to reduce greenhouse gas emissions. The PHEV has a limited battery capacity that needs to be recharged. Efficient battery charging leads to the use of commercial value PHEV [4]. Its schemes for battery charging are classified into four categories, namely uncontrolled, indirect controlled, intelligent, and bidirectional. Furthermore, their research focused on evaluating the impact of adding charging variables to smartphones [5]. The intelligent charging scheme is carried out directly to control the parameters to achieve good performance, such as minimizing considerable power loss [6]. The photovoltaic panel setting is conducted by observing the Effect of Solar

Received date 31/01/2021, Revised date 10/07/2021, Accepted date 12/07/2021

P-ISSN: 1411-3414
E-ISSN: 2549-9815

Radiation on Module Photovoltaics of 100 Wp with Variation of Module Slope Angle. Peng Yong Kong and George K Karagiannidis research also focus on increasing solar irradiation absorption by positioning photovoltaic panels in battery charging systems. This prototype works in a state of either empty or full battery voltage. At minimum voltage, the charging process is carried out, and when the voltage is at its maximum, it stops [7]. Therefore, to protect the safety of the battery, it is necessary to pay attention to the voltage when charging. SCC worked on DC voltage and stabilized the voltage released from the photovoltaic when charging the battery.

In order to determine the battery performance, it is necessary to estimate the parameters with the capacity to prevent overcharging. This led to the use of sensors to detect the optimal functionality of the battery and provide information on its full capacity. State of Charge (SOC) is an important parameter and a reference used for building a control system in battery charging. In this regard, this research has designed an automatic battery charging device with a photovoltaic source. This tool has the ability to charge several batteries based on the lowest voltage level and estimate its SOC. Supposing one of the batteries is at the maximum SOC level, this tool charges it at a lower voltage. SOC as a battery cell capacity in percentage value plays a significant role in performance because it is accessible and cannot be measured directly, making it a reference for battery management systems [8].

Achmad Imam Agung et al. (2021) stated that solar power plants are portable and easily moved from one place to another. It is a technology that converts sunlight into electric current using a semiconductor device known as a solar cell. Therefore, this research aims to develop a portable solar power generation device with two battery charging sources. This is an experimental research with data collected from charging a battery of 13.4 Vdc for a capacity of 10 Ah. The battery test lasted for 6 hours using a load of four 5 watt led lights. The electrical energy storage system uses long-lasting batteries therefore it can be used off-grid. The resulting engineering is in the form of a portable power supply device consisting of a battery therefore, it is of commercial value [9].

2. Method

A battery is a device consisting of two or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell has positive (cathode) and negative (anode) poles, which indicate greater and less potential energy. The negative pole is a source of electrons when connected to a flowing circuit, and is capable of distributing power to external equipment. The electrolyte moves like the ions when the battery is connected to an external circuit, thereby leading to a chemical response at both poles. However, ion conversion in the battery drains electric current [10][11].

2.1 Battery

Lead-acid batteries have the ability to transmit high currents at a relatively cheap price compared to batteries with the latest technology, therefore they were initially widely used for motorized vehicles. Presently, the technology for this type of battery is developing with various types, one of which is Absorbed Glass Mat (AGM) and Valve Regulated Lead Acid (VRLA). The advantages of VRLA batteries are that they have a large capacity, high efficiency, relatively low prices, and are safer for the environment than the latest battery technologies such as Li-Ion. Furthermore, VRLA is widely used for battery systems in hybrid power plants because it is not made up of a valve, no access to the electrolyte, and is totally sealed, hence, it does not require maintenance. Table 1 is the specifications for deep cycle batteries suitable for solar cell systems because they have the ability to discharge several electric currents constantly for a long time. Usually, deep cycle batteries discharge up to 80% of the capacity, and with good planning and maintenance, they tend to last for approximately 10 years [5][11].

Capacity is the amount of energy stored and released by the battery. Its amount depends on the active material on the positive or negative poles, which is influenced by the number of plates in each cell, dimensions, plate thickness, electrolyte quality, and battery life. Furthermore, batteries have the ability to supply some of their contents on average when each cell is at a voltage of 1.75 Vdc. However, when the voltage continuously drops, and the efficient capacity is fully used, the cell voltage is found to be 1.75 Vdc. In this case, the battery must be charged repeatidly [13].

P-ISSN: 1411-3414
E-ISSN: 2549-9815

Table 1. Characteristics of Lead Acid [12]

Specific Energy (Wh/kg)	30-50
Internal Resistance (mΩ)	Very low
Cycle Life (80% discharge)	200-300
Fast-Charge Time	8-16 hours
Overcharge Tolerance	High
Cell Voltage (nominal)	2V
Cutoff Charge Voltage (V/cell)	2.40 Float 2.25
Cutoff Discharge Voltage (V/cell, 1C)	1.75
Peak Load Flow	5C
best results	0.2C
Charge Temperature	-20 to 50 C
Discharge Temperature	-20 to 50 C
Care	3-6 months
Security	Stable Temperature
Used Since	Around 1800s

The size of the voltage is determined by the number of battery cells contained in it, in addition to the flow of current in the conductors and the connected load. The capacity proves the battery discharges the discharging current over a certain time expressed in Ampere-hour (Ah). The battery tends to deliver a small current over a long period and vice versa. When the battery is charged, there is a buildup of electric charge. The maximum amount of electric charge is accommodated in the battery capacity expressed as Ah = I (amperes) * t (hours) and used to supply load to the customer [14] [15]. Figure 1 shows a schematic tool of the work process proposed in this research and engineered to produce AC and DC output voltages. This power supply design has a battery charging system with a solar cell source and a transformer.

The scheme of this research method is the work process of the tool engineered to produce AC and DC output voltages. Therefore, it can be used for difficult areas from electricity such as plantation or agricultural areas. The design of this solar generator is portable, hence it can be painstakingly moved from one place to another. solar cells are designed separately from the product to be developed, making it easy for users to move them to places where electricity is most needed. The portable designed tool consists of Solar Charge Control (SCC), battery, inverter, and transformer. The innovation of this tool is to charge the battery using solar energy sources absorbed by solar cells, with a transformer used as a charger. This power supply device acts as a backup for electricity supply in terms of power failure. Electronic equipment under 100 Watts, such as lamps, laptops, projectors/infocus, LED televisions, fans, and HP chargers, can be used on this tool for a maximum of 12 hours. Meanwhile, the advantages of this tool include a more practical design, a portable, easy to operate and maintain, and the ability also to charge the battery using an electricity source.

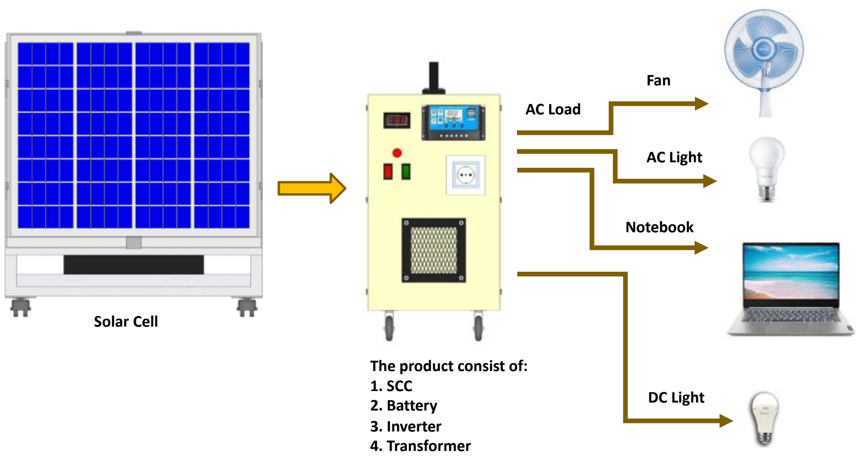

Figure 1. Schematic of the battery charging device

P-ISSN: 1411-3414
E-ISSN: 2549-9815

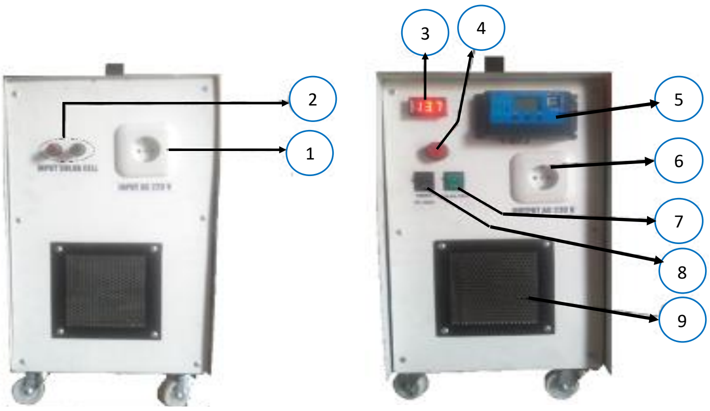

Figure 2. Parts of a portable power supply [16]

Figure 2 consists of the following.

1). The input voltage of 220 Vac uses electrical energy from the transformer to charge the battery.

2). The solar cell input uses energy from the solar panel module to charge the battery.

3). The LCD displays the voltage value when the battery is charged using input from electricity.

4). Indicator light as a marker when 220 Vac output is activated.

5). Solar Charger Controller (SCC) is a controller between the solar panel, and the battery which prevents it from overcharging

6). 220 Vac output voltage is used for 220 Vac electrical load.

7). Switch 1 for on/off charging via a solar cell.

8). Switch 2 for on/off output 220 Vac.

9). Air circulation.

3. Results and Discussion

The filling test section uses two methods, namely solar cells (sunlight) and a transformer with batteries consisting of 20Ah, 60Ah, and 100Ah. Field testing was carried out by observing the measured initial and final battery voltages for approximately 15-30 minutes. The real value of the battery voltage is observed immediately after the battery is charged because it stabilizes slowly untill it reaches a constant value. In testing the power supply charging with a solar cell source, the battery charging process is carried out using a 100 Wp solar panel as an energy source. Table 1 shows the length of time taken to charge the battery fully. For instance, when the weather is unfavorable, the battery that is not full on the first day of testing continues to charge the next day. Figure 3(a) shows the process of testing battery charging using solar energy sources, such as solar cells with a capacity of 100 Wp. Figure 3(b) shows the observation of the battery voltage measurement results displayed from the SCC of 12.8 Vdc.

Table 2 results from testing and observing the power supply using a solar cell with a capacity of 100 Wp and using batteries with capacities of 20 Ah, 60 Ah, and 100 Ah. On a 20 Ah battery, the process of charging the battery is full in one day with a charging time of 5 hours, while on the 60 Ah and 100 Ah, it continues to the next day. A 60 Ah battery requires a duration of 14 hours to be fully charged, while a 100 Ah battery takes 17 hours with an average weather temperature of 29°C. Battery charging time is affected by its capacity and weather conditions. For instance, the process is faster when the weather is sunny and not cloudy. Several tests have been carried out at a temperature of 30°C to 34°C making the solar panel charging process more leverage.

P-ISSN: 1411-3414
E-ISSN: 2549-9815

(a) (b)

Figure 3. (a) Direct output voltage absorbed from sunlight, (b) Current while charging the battery.

Table 2. Charging the battery using solar cell

Capacity Battery (Ah)	Test			
	Initial Voltage (Vdc)	Final Voltage (Vdc)	Temperature (ºC)	Charging Duration (Hour)
20	11.9	12.8	29.3	5
60	12	12.6	29	16
100	12	12.6	29	20

The results of direct observations and measurements of the solar cells' absorption are displayed on the SCC screen with the voltage value dependent on the weather conditions. In the testing process for charging a 100 Ah battery using a 100 Wp solar panel, the level of radiation depends on the amount of light intensity and weather temperature. For instance, when the intensity of sunlight is high, the value of the voltage increases, and vice versa.

3.1 Charging the power supply using a transformer

The battery charging test process uses an electricity source through a 10 Ampere transformer with a duration of 4 to 17 hours for a 100 Ah battery capacity. Current flows from the electronic circuit that has been designed for the transformer to ensure the electronics module runs properly. Table 3 shows the test of charging the feeder using a 220 Vac power source with a duration of 17 hours needed for a full charge. In this test, the required transformer is 10 Ampere with an average charging current of 3 Ampere. Testing power supply devices with this method are carried out to overcome unfavorable weather conditions, thereby hampering the power charging process. Therefore, this power supply device has two functions, namely, work when charging the battery with a solar cell source and also with an electricity source using a transformer.

Table 3. Tests on charging the power supply using a transformer

Battery Capacity (Ah)	Initial Voltage (Vdc)	Final Voltage (Vdc)	Charging Duration (Hour)
20	11.8	12.8	4
60	11.9	12.8	14
100	12	12.8	17

P-ISSN: 1411-3414
E-ISSN: 2549-9815

The battery charging test process uses a 220 Vac electricity power source, with a capacity of 100 Ah used to indicate the duration needed to obtain full charge condition. The battery charging test uses PLN electricity with a current capacity of 20 Ah, 60 Ah, and 100 Ah. Furthermore, the initial and final battery voltages are measured before and after charging it from 15-30 minutes.

3.2 Power supply load test

Figure 5 (a) shows the measurement results using a fan load, with an observed alternating voltage of 221 Vac. Figure 5(b) shows the alternating current measured using a fan load, which was carried out with any electrical load under 100 Watts. Table 4 shows the loading test results on the power supply using a battery variation of 20Ah, 60Ah, and 100Ah, respectively. The electrical equipment is load variation with different battery capacities used to determine the supply resistance. The parameters measured in this test are the battery voltage before and after being given a load and calculating the duration of the load user. The initial and final voltages of the battery are measured before being given a load and after it has been removed. The duration of use is calculated from when the load starts until it is turned off, as indicated by the inverter alarm sound. Therefore, it is necessary to charge the battery for continuous durability. Figure 6 compares loading using different electrical equipment, namely fan, laptop, and television with powers of 46 Watt, 45 Watt, and 85 Watt. The chart diagram shows that the difference between the measurement and nominal voltages is very small compared to the percent error.

(a) (b)

Figure 5: Fan loading (a) Measurement of alternating output voltage (b) Measurement of alternating current when loading fan

Table 4: Electric load usage when the battery is full

Load	Power	Battery voltage	Output voltage	Battery 20 Ah	Battery 60 Ah	Battery 100 Ah
	(Watt)	**(Vdc)**	**(Vac)**	**Duration of Electric Power Usage (Hour)**		
Fan	46	12.8	221	2.5	6.5	13
Lamp	30	12.8	221	4	11	20
TV	85	12.9	223	1.3	3.5	7

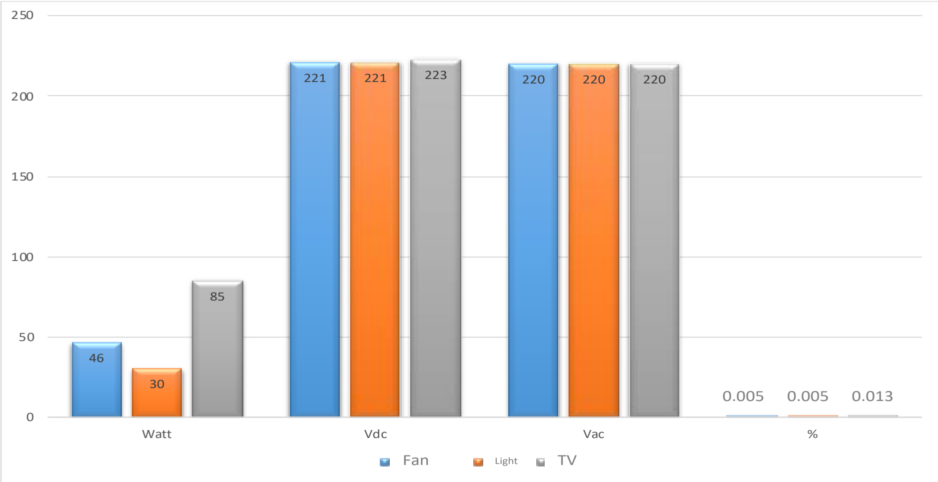

Figure 6: Comparison of voltage values for each electrical load

4. Conclusion

Based on the design, testing, and observation of the tool, it can be concluded that the battery's capacity significantly determines the consumption of the stored power. For instance, suppose the amount of electrical load used to test the electrical loads comprises varying capacities, the duration of use also becomes different. Furthermore, charging batteries using solar energy sources through solar cells with battery capacities of 20 Ah, 60 Ah, and 100 Ah requires different durations depending on weather conditions and the solar cells' capacity. The results of weather observations from charging the battery are at an average temperature of 29^{o}C. Therefore, it is imperative to charge the battery with a transformer source in case the weather is not favorable. This electrical loading test is used with three batteries, namely 20Ah, 60Ah, and 100Ah capacities. On average, a battery is stated to be fully charged when its voltage reaches 12.8 Vdc. Functionally, this innovation tool adds to a variety of products used for alternating and direct voltages as well as for electrical loads below 100 Watts.

5. Acknowledgment

The authors are grateful to the Asian Development Bank (ADB) Project, Universitas Riau, for funding this research.

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