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Analysis of High Frequency and Low Frequency Charging Systems on 12VDC Solar Power System Batteries

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Abstract. *Batteries are an essential product for alternative energy, required for various electronic devices and everyday human needs. Rechargeable batteries must be carefully managed to avoid quick damage due to improper charging systems or poor-quality chargers. Charging a 12V battery is done by continuously flowing current until the battery voltage reaches its specified value. As technology advances, many battery chargers are available on the market, using either high or low frequencies. By comparing the measurement results of high-frequency charging systems (using MOSFET and switching) and low-frequency systems (using transformers), we can draw conclusions that demonstrate the performance and quality of charging in these different systems.*

Keywords: *Renewable energy, high-frequency charger, low-frequency charger*

1. Introduction

Batteries are an important component in human life and the rapid development of technology (Hamdani et al., 2018). Various electronic devices and power plants use 12VDC batteries as a power source (Dharmawan et al., 2021). An example is the Solar Power Plant (PLTS) system which utilizes battery energy as a power supply for the plant (Tharo et al., 2022).

A battery is a device that functions to store electrical energy resulting from the charging process (Tharo et al., 2024). The working principle of a battery in producing electrical energy is to change the chemical energy contained in the active materials that make up the battery through an electrochemical reaction between reduction and oxidation (Palumbo et al., 2003).

The use of battery power in an electronic device causes a decrease in the electrical energy stored in the battery (Dhakal et al., 2021). Therefore, it is necessary to recharge the battery through a charging system. The battery charger functions to recharge the power by utilizing the PLN 220V AC electric current,(Jatoi et al., 2021) which is then converted into DC voltage according to the required battery specifications (Attia et al., 2025).

In various types of chargers, some systems use MOSFETs and switching (high frequency), as well as those that use transformers (low frequency) (Rahman et al., 2021). With the increasing variety of charger products, this analysis will compare the charging system on chargers that rely on MOSFETs and switching with chargers that utilize transformers (Zulkarnaen et al., 2024). Through this analysis, we will be able to find out which charger is more efficient and faster in recharging the battery.

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2. Theoretical Basis

2.1. Battery

A battery is a source of direct current that can convert chemical energy into electrical energy through a reversible electrochemical process (can occur again) (Tharo, Arnita, et al., 2024). This reversible electrochemical process converts chemical substances into electrical energy (Koutroulis & Kalaitzakis, 2004). When the battery is used, a chemical reaction occurs, producing deposits on the anode and cathode so that there is no potential difference left—in other words, the battery becomes empty (Anisah et al., 2022). When the battery runs out of power, it requires recharging from electrical power to chemical power through a charging system (Iskandar et al., 2021). Because batteries are classified as secondary elements, they can be recharged when empty (Dharmawan et al., 2021).

2.1.1 How Batteries Work

The way a battery works has 2 systems, namely battery charging (charge battery) and battery discharging (discharge battery) (Davis et al., 2018).

2.1.1.1. Battery Discharge

Battery discharge is the process by which the power in the battery is consumed so that it decreases or runs out (Zulkarnaen et al., 2024). When the cell is connected to the load, electrons in the battery will flow from the anode to the cathode through the load.(Kako et al., 2024) Meanwhile, negative ions move towards the anode, and positive ions flow to the cathode (Prayogo, 2019).

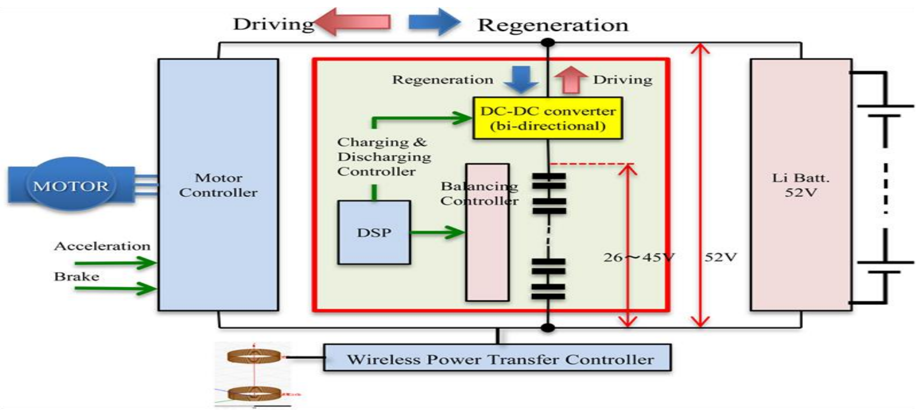

Figure 2. Battery discharging system

2.1.1.2. Battery Charging

Battery charging is a process carried out to recharge the electrical power in a battery that has been depleted due to power consumption.(Iskandar et al., 2021) The charging process must be carried out appropriately, connecting the cathode and anode of the charger correctly so that there is no short circuit that can damage the charger or the battery itself.(Tharo, Sutejo, et al., 2024) During the charging process, there are chemical reactions that occur, namely:

- The flow of electrons occurs in reverse, flowing from the anode through the power supply to the cathode.
- Negative ions move from the cathode to the anode.
- Positive ions flow from the anode to the cathode. Thus, the chemical reaction during charging is the opposite of the reaction during discharging (Prayogo, 2019).

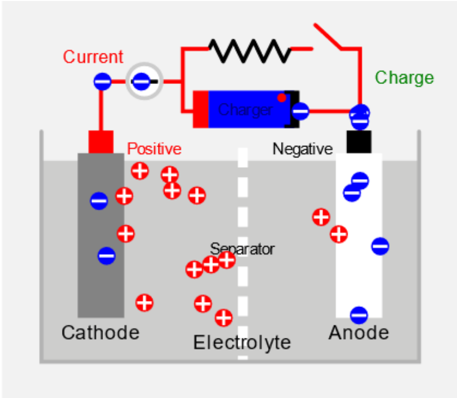

Figure 2. Battery charging system

2.2. Charger

A charger is an electronic circuit that functions to convert AC voltage to DC, where one of the main components is a rectifier diode (Koutroulis & Kalaitzakis, 2004). In this analysis, two charger models are used, namely low-frequency and high-frequency chargers (Dharmawan et al., 2021).

2.2.1. Low-Frequency Charger

Low-frequency charger is a charger circuit that uses a manual induction system without feedback.(Davis et al., 2018) In this circuit, the 220V AC voltage is directly fed to the step-down transformer. The output of the transformer then flows to the rectifier diode, which is then stabilized with a capacitor and MOSFET (Rahman et al., 2021).

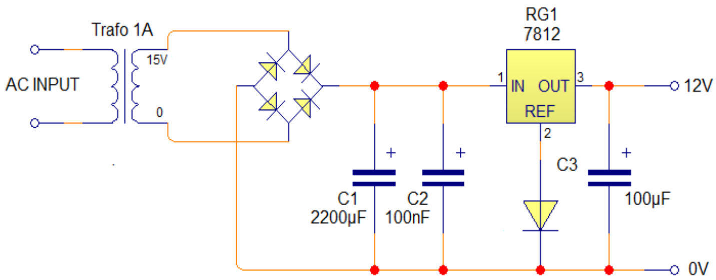

Figure 3. Low-frequency charger circuit schematic

2.2.2. High Frequency Charger

A high-frequency charger is a charging circuit that uses the SMPS (switching mode power supply) system (Koutroulis & Kalaitzakis, 2004). In this charger circuit, the 220V AC voltage is not directly supplied to the transformer, but through a rectifier diode that functions to control the MOSFET switch (Davis et al., 2018). This charger uses a MOSFET that will operate when it receives DC voltage on its gate.

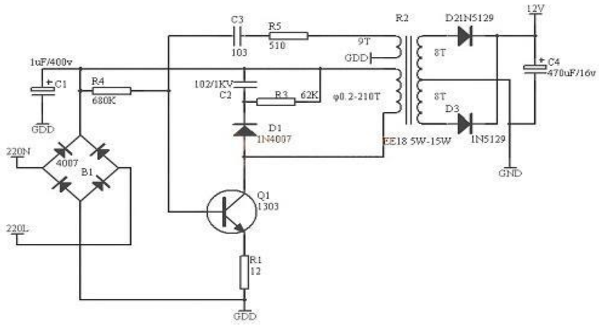

Figure 4. High frequency charger circuit schematic

3. Method

The research method used is a comparative method of charger types, some things that will be indicated are the increase in power and electric current in the 12VDC PLTS system battery type KJ JM12-55 with the time method, To find out the increase in power from the research, it can be done using a multimeter or voltage meter. With the data obtained from the research results, we can determine which charger quality is better and faster in charging the 12VDC PLTS system battery.

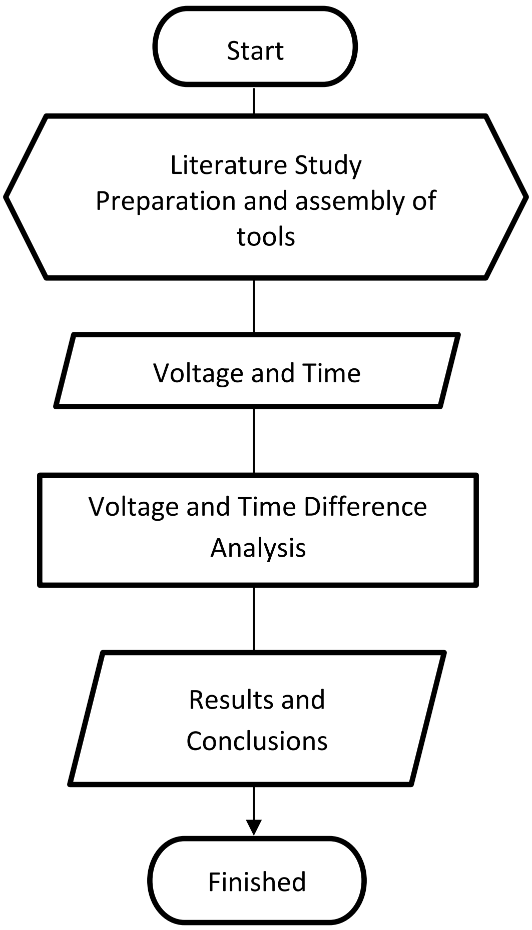

Figure 5. Flowchart of charging research system

4. Results and Discussion

4.1 High-Frequency Charger Testing on 12VDC Solar Power Plant Batteries

All figures Testing on this high-frequency charger was carried out using a 12 VDC volt 55Ah PLTS battery under normal conditions, aiming to determine the duration of time required to fully charge the battery. Based on the test results, the following data can be obtained:

Table 1. High-frequency charger research results

No.	Time (Minutes)	Voltage
1.	0	11,8
2.	15	12
3.	30	12,2
4.	45	12,4
5.	60	12,6
6.	75	12,8
7.	90	13
8.	105	13,2
9.	120	13,4

The results of the load test show that the test is carried out every 15 minutes. Before charging, the battery voltage was recorded at 11.8 volts. After 15 minutes of charging, the battery voltage increased to 12 volts and the battery charge level reached 10%. At the 60th minute, the battery voltage became 12.6 volts and the charge level reached 50%. After 120 minutes, the voltage reached 13.4 volts and the battery was fully charged to 100%. From this test, it can be concluded that the increase in voltage every 15 minutes is 0.2 volts.

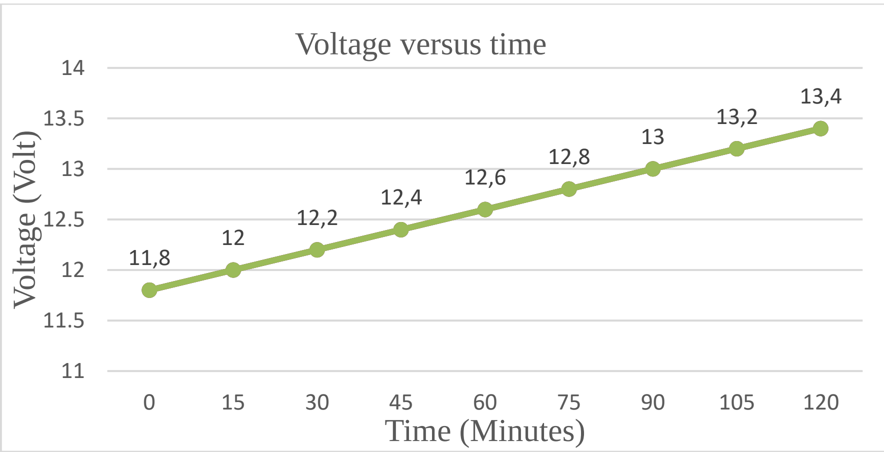

Figure 6. Graph between time and battery voltage for high-frequency charger

In the results above, it can be seen that battery charging increases consistently with a time interval of every 15 minutes. The lowest voltage recorded during 15 minutes of charging is 11.8 volts, while the highest voltage achieved during 120 minutes of charging is 13.4 volts.

4.2. Testing Low-Frequency Charger Output on 12VDC Solar Power Plant Battery

Testing on this low-frequency charger was carried out using a 12 VDC volt 55Ah PLTS battery under normal conditions, aiming to determine the duration of time required to fully charge the battery. Based on the test results, the following data can be obtained:

Table 2. Low-frequency charger research results

No.	Time (Minutes)	Voltage
1.	0	11,5
2.	15	11,8
3.	30	12,1
4.	45	12,4
5.	60	12,7
6.	75	13
7.	90	13,3
8.	105	13,6
9.	120	13,9

The load test results show that the test is carried out every 15 minutes. Before the charging process, the battery voltage was recorded at 11.5 volts. After 15 minutes of charging, the battery voltage increased to 11.8 volts, with a charging rate of 10%. At the 60th minute, the battery voltage became 12.7 volts and the charging rate reached 50%. After 120 minutes, the battery voltage reached 13.9 volts, and the battery was fully charged to 100%. From this test, it can be concluded that the increase in voltage every 15 minutes is 0.3 volts.

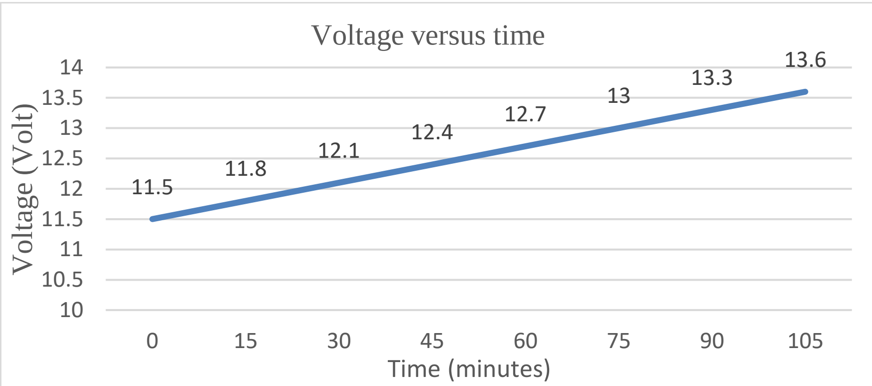

Figure 7. Graph between time and battery voltage for low-frequency charger

In the results above, it can be seen that battery charging increases consistently with a time interval of every 15 minutes. The lowest voltage recorded during 15 minutes of charging is 11.5 volts, while the highest voltage achieved during 120 minutes of charging is 13.6 volts.

Conclusions

Based on the test results, both through measurements and calculations from the analysis of low and high-frequency chargers, the following conclusions can be drawn: In a study of low and high-frequency chargers with battery loads in a solar power system, it was revealed that a low-frequency charger in strong conditions can charge the battery faster than a high-frequency charger. Under normal conditions, the charging of the solar power battery reaches 100%. From the data obtained, the high-frequency charger showed an increase of 0.2 volts every 15 minutes, while the low-frequency charger showed an increase of 0.3 volts in the same period. This shows a difference of 0.1 volts between the two types of chargers. Thus, it can be concluded that the low-frequency charger is more effective in the battery charging process under normal conditions.

Conflicts of Interest

The authors declare no conflict of interest.

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