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Optimization of off-grid solar generating system with DC-DC converter

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Abstract: Electrical energy is a very complex problem for every country in the world, as well as in Indonesia in particular, with the rapid progress of the country's industry, of course, followed by an increase in the generation of electrical energy. While the current energy generation most often comes from fossil fuels, which are increasingly depleting, the energy supply will decrease and increase sales. Therefore, every country is competing to find other energy for electrical energy generation. Renewable energy is a green energy generator whose supply is abundant and inexhaustible. Solar power plants (PLTS) are one of the green energies developed by the Indonesian government to utilize energy derived from non-fossil fuels. To support this, it is necessary to study and research to be done using the DC-DC up/down converter is expected to obtain results that can be used as a reference in the development of solar power plants (PLTS). With a DC-DC up/down converter, the voltage stabilization produced by PLTS can be stabilized by a DC-DC converter from 9 volts DC to 11.5 volts for a minimum voltage. Above 12 volts to 18 volts, up to 12 volts can be stabilized.

Keywords: DC-DC converter, generation, stabilized, voltage

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Introduction

According to several previous studies, "Design of a DC to DC Converter to Stabilize the Output Voltage of Solar Cell Panels Using Boost Converter Technology," a DC-DC converter can stabilize the output voltage of solar panels +/- 10% [1]. While research entitled "Charging System Design Battery with Solar Panel Based DC-DC Converter," DC-DC converter can regulate PV voltage up to 25V [2]. Based on the study entitled "Design of a Hybrid PLT with a Two-Way Dc-Dc Converter at the Diponegoro University ICT Building Using Matlab Simulink Software", when the power generated by the solar panels is insufficient to supply the load, the program algorithm activates boost mode on the Bidirectional DC-DC Converter, causing it to discharge the battery, which transfers power from the battery to the load [3].

Because PLTS is a less continuous power plant where the energy generation is heavily influenced by sunlight, it is necessary to have research and studies conducted to obtain maximum and continuous energy, with the application of installing Dc-DC up/down converters. The purpose of installing a DC-DC converter Up/down converter in solar power plants is to optimize the energy produced. Therefore, if the energy is low, it will be increased. Likewise, if it is too high, it will be lowered by the DC-DC converter so that the resulting voltage becomes stable [3].

The grid PLTS system is an independent generating system. The system uses electrical energy from solar panels or cells that use DC or Direct Current. Then immediately converted into AC or Alternating Current using an inverter. The AC generated by this inverter then goes directly to loads requiring electrical energy, such as TVs, lamps, irons, cabinets, etc.

PLTS Centralized Solar Power Generation System (From the Grid) [4] is a power generation system that utilizes solar radiation without being connected to the PLN network. In other words, the only source of electricity generation uses radiation with the help of solar power panels to generate the system. One of the advantages of the off-grid system compared to the on-grid system is that it can still provide electricity in the event of a power outage from PLN. However, this system has a downside and may not be able to meet the total electricity demand, given the cost and volume of the battery can be very high. In addition, communal PV mini-grid requires more complex equipment and costs higher than communal PV mini-grid. The main components of an off-grid system are solar panels, charge controllers, inverters, and batteries [4],[5]. The inverter used in the off-grid system is different from the on-grid system. The off-grid inverter system used is an inverter with a two-way capability to charge the battery and drain electricity from the battery for use in the load.

On-grid solar panel system or PLTS Grid-Tie System is a system that works directly on solar panels. This technological system does not use batteries, and the electricity generated is used for various purposes. The electricity produced is AC, so this on-grid solar panel can be applied together with the PLN network. If there is excess power, the electric power will be sold to PLN. When at night, the power comes from PLN. This on-grid system of solar power plants is suitable for application in the field by utilizing the roof as a space to absorb solar energy. If installed with PLN, this system will reduce electricity costs [6].

An interconnected PLTS system (On-Grid) or a Grid-Connected PV System is a power generation system that utilizes solar radiation to generate electricity. As the name implies, this system will utilize the PLN network by optimizing solar energy through solar modules or photovoltaic modules that generate as much electricity as possible. This system is also considered environmentally friendly and emission-free. The interconnected PLTS system is also a green energy solution for the community, offices, and housing. It aims to reduce electricity bills from PLN and can provide added value for its owners [7]-[8].

The application of the PLTS hybrid system or working principle can run with the PLN electricity system and is regulated in the Minister of Energy and Mineral Resources Regulation of New, Renewable Energy, and Energy Conservation (EBTKE). In this system [5] [6] [9], the PLN electricity network acts as a distributor or liaison for electric current originating from solar panels that are fed to the Therefore, during the day, electricity can utilize electrical energy from sunlight. However, at night, because there is no sunlight, so there is no electricity production from solar panels, you can still use electricity from PLN [10] [12] [13].

Methodology

The materials used in this research are PLTS off-grid specifications as follows:
Specification:
1. Solar Panel150 WP
2. DC-DC up/down Converter 10A 12volt DC 30 A
3. SCC 40A/12/24volt.
4. Inverter 300 watt /12 volt
5. Battery 65 AH VRLA

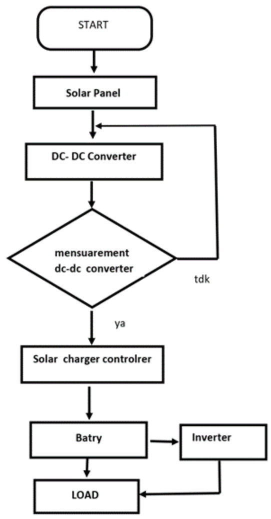

Figure 1. Flowchart on a grid modeling system

Figure 1 illustrates that the energy produced by the solar panel is directed into the up/down DC-DC converter, where the voltage will be stabilized at 12 volts DC. The voltage that results will be virtually measured. If the voltage generated by the solar panel is less than 12 volts, it will be increased to 12 volts by the DC-DC up converter. If the voltage exceeds 12 volts, then the voltage will be lowered to 12 volts DC, by energy from the battery is channeled to the DC load through the solar charger controller (SCC). If the load is AC, then the energy will flow. The voltage is 12 volts DC, and on the solar charger controller, the amount of charging current will be adjusted, as well as the voltage, so that it matches the capacity of the battery used. The amount of voltage and current is measured with a volt-ampere meter. Energy from the battery is directed to the DC load through the solar charger controller (SCC). If the load alternates current (ac), then the energy will flow to the inverter before going to the current (ac) load. If the volt meter does not match, it can be reset to SCC [13], [15], [16], as can be seen in Figure 2.

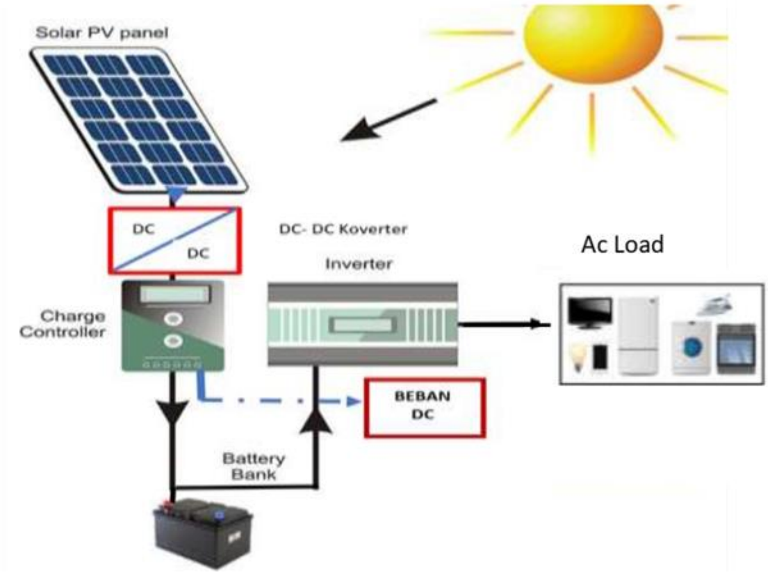

Figure 2. PLTS on grid modeling system with DC/DC converter[9]

Working diagram of the image above:

1. Sunlight falling on the solar panel will be converted into voltage and current through the control.
2. Energy from the solar panel is channeled to the DC-DC converter. The resulting voltage converter will be stabilized with a more optimal buck/boost DC-DC converter to produce a stable voltage output. The current flow is received by the solar charger controller[15],[17],[18], and [19].
3. Inside the Solar Charger Controller (SCC), the current flow will be adjusted according to the program using the voltage, current, and load. As a result, the battery charger can be programmed to last longer, as shown in Figure 2

Results and Discussions

To determine how well the DC-DC converter can stabilize the voltage generated by the solar panel, as given in Table 1, measurements are taken at the solar panel's output, and the voltage supplied to it. Table 1 shows the virtual measurement results using PV out and V out Dc-DC converter voltage magnitude.

Table 1. Measurements May 10, 2022

Hour	Vout PV (volt)	V out DC-DC converter (Volt)
10:00	16.5	12
10:10	16.5	12
10:20	16.5	12
10:30	17	12
10:40	17	12
10:50	17	12
11:00	17	12
11:10	17.5	12
11:20	17.5	12
11:30	17.5	12
11:40	17.5	12
11:40	18	12
11:50	18	12
12:00	16.5	12

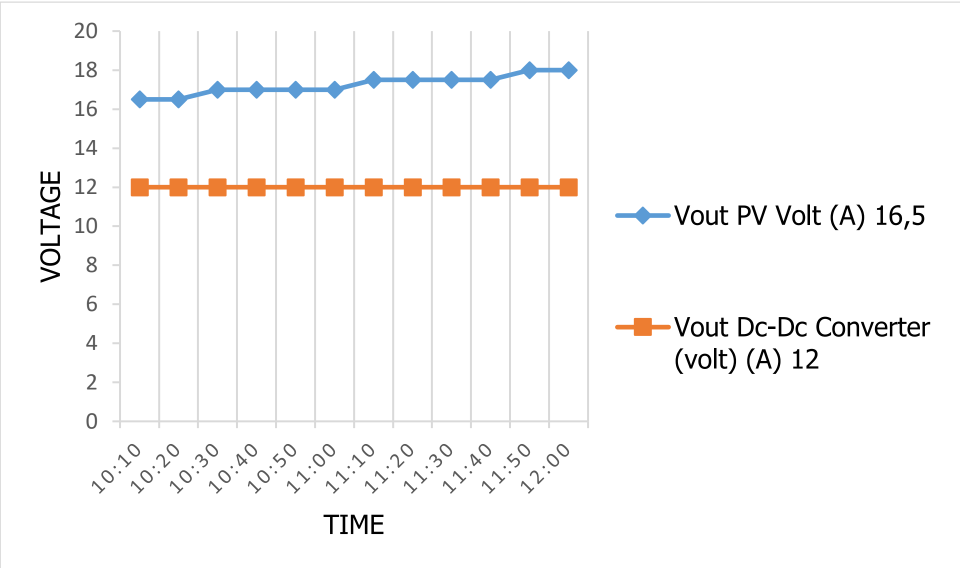

Figure 3. Characteristics of the voltage function of time

From the above characteristics, the voltage generated from the solar panel is a minimum of 16 volts DC and a maximum of 18 volts DC. After being exposed to a DC-DC voltage, the stabilized voltage becomes 12 volts DC, where the voltage will work as a voltage out of the DC-DC voltage to 12 volts DC.

Table 2. Measurements May 20, 2022

Hour	Vout PV (Volt)	V out DC-DC Converter (Volt)
13:00	17.5	12
13:10	17.5	12
13:20	17.5	12
13:30	17.5	12
13:40	17.5	12
13:50	17.5	12
14:00	17	12
14:10	17	12
14:20	16	12
14:30	12	12
14:40	9	11.5
14:50	9	11.5
15:00	10	12

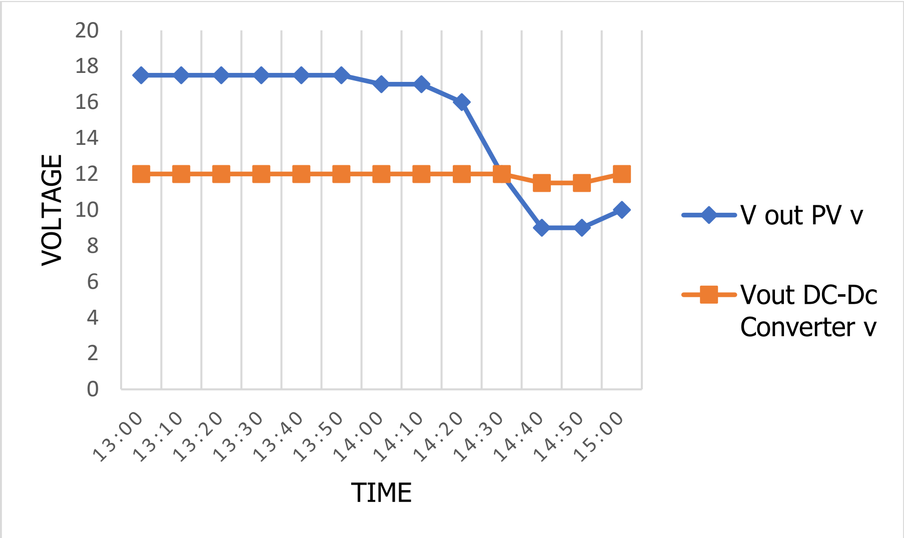

Figure 4. Characteristics of the voltage function of time

From the above characteristics, the voltage generated from the solar panel is a minimum of 9 volts DC and a maximum of 18 volts DC. Therefore, the voltage is stabilized to 12 volts DC after obtaining a DC-DC conversion. The converter work as a voltage amplifier when the voltage is 9 volts. The output voltage from the DC-DC converter to an average of 11.5 volts serves as a voltage when the solar panel voltage is 12 volts DC until the voltage reaches 18 volts DC so that the output voltage of the DC-DC converter becomes 12 volts DC.

Table 3. Measurements May 20, 2022

Hour	Vout PV (Volt)	V out DC-DC Converter (Volt)
13:00	11	12
13:10	11	12
13:20	11	12
13:30	17	12
13:40	18	12
13:50	17	12
14:00	17	12
14:10	16	12
14:20	17	12
14:30	9.5	11.5
14:40	9.5	11.5
14:50	9.5	11.5
15:00	9.2	11

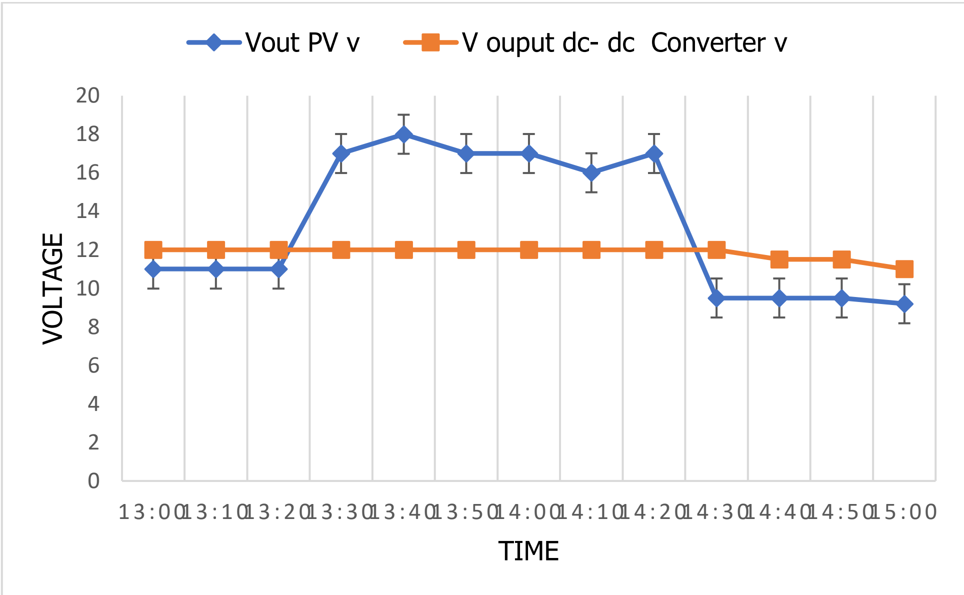

Figure 5. Characteristics of the voltage function of time

The characteristics in Figure 5 describe the magnitude of the voltage generated by the solar panel at least 9, at 2 volts DC, after switching to the DC-DC converter. First, the voltage is stabilized to 11 volts, then increased above 16 to 18 volts DC so that the output voltage of the DC-DC converter becomes 12 volts DC.

Conclusion

The solar panel voltage generation system can be optimized by following a certain procedure. The solar panel voltage can be stabilized by installing a DC-DC up/down converter. If the solar panel voltage is above the setting voltage of the DC-DC converter, then the converter will function as a down voltage so that the output is by the settings. And if the voltage (UP) of the solar panel is below the voltage setting of the DC-DC converter, the converter will function as a voltage increaser following the settings. The voltage that can be stabilized above 16 volts will be reduced to 12 volts DC. While the stabilized voltage is below the converter setting voltage from 9 volts, it is increased to 12 volts DC.

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