Design and analysis of multiple charge controller systems in hybrid power generation

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Abstract. Currently, the demand for electricity is increasing from time to time. While the existence of fossil fuels to generate electricity is depleted. This condition resulted in the use of renewable energy source in electrical power generation. Since the electricity generated from renewable energy sources is not constant because it is depending on the climatic conditions, a controller of the charging and discharging mechanism on a battery is necessary for it to work optimally for storing electricity. To overcome this problem, one of the solutions is by applying hybrid power generation technology. One the important equipment related to this technology is the application of a charge controller. The charge controller here is used to control the charging and discharging mechanism to store electricity in a battery. The charge controller is found mainly in a standalone mechanism where the controller only has one input from one renewable energy source. If we have more than one renewable sources, therefore we need a charge controller with multiple input terminals. This study examines and compares the design of a standalone charge controller and a multiple input charge controller. The result shows that it is more efficient to use a multiple input charge controller rather than to use two single input charge controller.

1. Introduction

Demand for electricity continues to grow not only in Indonesia but also worldwide. So far, costs and investments used by non-renewable energy plants are considered as important issues in the generation of electricity [1]. Therefore, we need a way to overcome the existing problems, one of which is using renewable energy around us, such as wind, sunlight, water, etc. [2].

In the current period, solar energy and wind energy are considered to be the most effective resources which attract a lot of attention due to their processing to become energy sources that can provide energy for relatively easy loads [3]. But one of the problems with the use of solar and wind energy in its processing to supply energy that can subsequently meet the needs of the load is that the available energy is not constant and changes depending on climatic conditions, solar radiation, wind circulation, temperature, etc. that occur later [4]. Therefore, a battery is required to be installed and connected between the load, the solar panels and the wind turbine used as a secondary source [5]. With very bright sunlight / very strong wind, which will result in excess voltage (overvoltage) generated can damage the battery because the charge generated becomes constant (changing) [6]. Therefore, we need a system to overcome the above problems, that is, a charge controller that will be used to control the battery, so that later the problem of damage to the battery due to existing problems can be overcome and the resulting charge can be constant.
2. Methodology

2.1. Solar panels
Solar panels are panels made of solar cells to absorb sunlight as an energy source to generate electricity and heat. The process of converting light to electricity is called the photovoltaic effect. Photovoltaic solar cells use a thin layer of semiconductor material charged differently between the top and bottom layers. The semiconductor material can be covered by a veil between a sheet of glass and/or polymer resin.

The panels are connected in series to provide increased voltage while the panels are connected in parallel to produce higher currents. Solar panels typically have a glass layer through which the light must pass before entering the cell. MPPT (Maximum Power Point Tracking) keeps the panel at its ideal voltage while producing the voltage required by the battery.

MPPT is a DC-DC electronic converter that optimizes compatibility between solar arrays and batteries. Usually, this takes care of the panel output and compares the battery voltage. Finally, we can find the right energy that can be removed by the panel to charge the battery [7].

2.2. Wind turbine
Wind energy is part of a renewable energy system. Wind turbines are used to convert wind kinetic energy into mechanical energy for generators, which convert mechanical energy into electricity. The wind turbine of the wind power system is connected to the gearbox. The gearbox has an electromechanical interface. The gearbox output is supplied to the permanent magnet synchronous generator (PMSG), which produces the AC output [8].

2.3. Solar panel-wind turbine system
The hybrid energy system combines solar and wind energy. The hybrid system is a combination of photovoltaic (PV) arrays, wind turbines. Hybrid power systems have several advantages over a single system. In hybrid energy systems, the outputs of the solar and wind energy systems are added in parallel to compensate for the absence of a power system. solar and wind energy systems can operate individually or together [9].

2.4. Battery
A battery is a device that contains an electrical cell that can store energy that can be converted to energy. Batteries produce electricity through chemical processes. A battery or accumulator is an electric cell in which a reversible electrochemical process occurs with high efficiency. What is meant by reversible electrochemical reaction is that, in a battery, the process of converting chemicals into electricity (emptying process) and vice versa from electrical energy to chemical energy (charging process) through the regeneration process of the electrodes used is to pass an electric current in the opposite polarity direction in the cell [10].

2.5. Charge controller
Charge controller is an electronic circuit that regulates the charging process of a battery or battery (battery bank). The voltage generated by PLTB and PLTS generally ranges from 12 volts to the top. This controller acts as a battery voltage regulator, so it does not exceed its energy tolerance limit. In addition, this controller also prevents the current flow from the battery to return to the generator when the charging process is not in progress (for example, at night), so that the battery that was charged does not use energy. If the battery or the battery is full, the flow of the generator will be disconnected, so that the battery is no longer charged, to prevent damage to the battery and prolong the life of the battery. Controlling the battery charging process by opening and closing the current flow from the generator to the battery is the most basic function of a charger controller [11].
2.6. MPPT

An example of a charge controller that can be used to overcome problems caused by battery damage is MPPT (Maximum Power Point Tracking). MPPT is used as a device mounted on a solar cell or a wind turbine that connects a photovoltaic (PV) panel or a wind turbine and a battery. There are several MPPT algorithms that vary in complexity, switching speed, hardware design, etc. This algorithm is used to control the buck-boost converter cycle on the MPPT controller. The panel voltage and current depend on the type of MPPT algorithm used to identify the panel's peak force [12].

Figure 1. Flow chart to finish paper.

Figure 1 above is an image of the completion of the work we did. The writer first collects the literature, then makes a conceptual design of the existing system and begins to design the necessary charge controller (here the author uses photovoltaic and wind turbines as a source). After designing the charge controller, the recorder performs a simulation of the charge controller system in hybrid power generation and collects data generated from the simulation. Here the type of charge controller used by the author is MPPT.

In this study, the sequence of the matlab simulation block diagram I used is shown in Figure 2 and Figure 3.

Figure 2. Block diagram of the matlab simulation using two charge controller.

Figure 2 above is a block diagram of a simulation job using the matlab on which the author is working. It can be seen that the order of the first process is for the author to initially determine the design of the PV and wind turbine that are used first. Then, the authors determine the converter used in both (in PV and wind turbine). Then design the MPPT used and finally determine the battery and charge used.
In Figure 3 above, a block diagram of the Matlab simulation job using the multiple input charge controller is shown. The work order of the Matlab simulation is the same as in Figure 1, but the difference is that, in this figure, MPPT is used only 1. Therefore, the output converter in both systems (PV and wind turbine) goes directly to 1 to the charge controller (MPPT) and then the output of the charge controller goes directly to the battery and finally is distributed to the charge.

3. Results and analysis

The simulation in Figure 4 uses one MPPT, where one MPPT is connected to the Photovoltaic Panel (PV) while the other is connected to the Wind Turbine. Then, the output of the two MPPT is connected to the battery. The battery output is connected to the inverter and then the inverter output is connected to the load.
Figure 5. Multiple input charge controller design.

The simulation in Figure 5 above uses two MPPT, where the MPPT is connected to the photovoltaic (PV) panel and the wind turbine. As in the previous figure 4, the output of the two MPPT is connected to the battery and the battery output is connected to the inverter, and the inverter output is connected to the load.

The results of the simulation with project figure 4 and 5 are shown below.

Figure 6. Photovoltaic output current and output voltage with single input charge controller.

Figure 7. Single input MPPT wind turbine output current and output voltage charge controllers.
In Figure 6 above, it can be seen that the output and the PV output wave are constant. In the design using a single input charge controller, it can be seen that the waveform at the constant photovoltaic output voltage is the same as the waveform of the photovoltaic output current.

In Figure 7 above, it can be seen that the result of the wind turbine output current wave appears constant the same as the PV current output wave in Figure 6 before. The simulation results show that the output waveforms of the PV and wind turbine output voltage are almost the same and constant.

In Figure 8 above, it can be seen that the waveform of the battery's output current in the multi-input charge controller appears constant. In the results of the simulation with a single input charge controller, the results are shown in Figure 8 and Figure 9 above. The resulting wave is constant, although there is an increase in voltage at any given time. It can be concluded that, using an MPPT mounted in each hybrid generation of energy, the value of the current and voltage is constant and an increase occurs only at a certain moment.

Whereas, using a multiple input charge controller, the output results are as follows.

In Figure 10 above, it can be seen that the waveform of the PV output current appears constant. In the design using a multiple input charge controller, it can be seen that the waveform at the constant photovoltaic output voltage is the same as the waveform of the photovoltaic output current.
In Figure 11 above, it can be seen that the result of the wind turbine output current wave appears constant the same as the PV current output wave in Figure 7 before. Just like using an MPPT, waveforms using two MPPT in PV and wind turbine are constant.

In Figure 12 above, it can be seen that the waveform of the battery's output current in the multi-input charge controller appears constant. In the simulation results with the multiple input charge controller, the results are shown in Figure 12 and Figure 13 above. The resulting wave is constant, although an increase in voltage at any given time is the same as using one for MPPT. It can be concluded that, using two MPPTs installed in each hybrid power generation, the current and voltage values are constant and only increase at a certain moment.

The advantage if using a charge controller with many inputs is if one of the used hybrid plants has a problem and cannot supply batteries, then another hybrid plant can work to supply batteries. And if you use multiple input charge controllers, this can make the costs incurred in controlling the battery more efficient, as it requires only one MPPT.

**4. Conclusion**

In the results obtained, we can know that the results of the tracking on a single input and on a multi-input load controller are constant. This may be due to the irradiance in the PV and the speed of the wind turbine used is the same and is not changed. So it needs to be done to radiate and the speed of wind turbines has changed its value.

**5. Future work**

The potential for using a charge controller in this hybrid power generation is still great. Therefore, the act of comparing the system in this hybrid power generation if MPPT is not used and using MPPT before being stored in the battery. And also comparing how the MPPT charge controller system works in a state of irradiance and changes in wind speed.

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