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# The Solar Panel Reliability System Is Based On Capacitor Charging Factor

**[1]Mahrizal Masri, [2]Zulfadli Pelawi, [3]Hermansyah Alam, [4]Armansyah**
[1,2,3,4]Universitas Islam Sumatera Utara Medan, North Sumatera, Indonesia

Keywords

Battery, Solar Panel, PID Controller

**Abstract.** Electrical energy is a vital sector to meet the needs of a country, especially in Indonesia. This high demand creates many problems for the country. This happens because the DC supply keypoint needs are not yet optimally reliable. This research increases the reliability of keypoints by utilizing solar panels as a source of electrical energy. Solar panels are electricity generation utilizing solar light irradiation into electrical energy using Photovoltaic (PV). Uncertain environmental conditions result in the characteristics of solar panels having an unstable voltage output. The solution to overcome this problem is to use a PID controller and an energy storage system. In this research, a DC supply voltage control system based on a PID Controller for batteries was developed to maintain maximum reliability of the distribution system. Therefore, innovative modification of a system is needed to maximize reliability.

## 1. INTRODUCTION

The utilization of renewable energy through PLTS (Solar Power Plant) systems has now become the main choice in power generation, both as a primary source and supplying energy for storage. One of the commonly used applications is Off-grid PLTS systems that operate independently, especially on a micro scale such as in lighting systems.

The electrical energy storage process in PLTS systems often uses batteries as the main source to supply load power and as an energy reserve in emergency conditions. However, the use of batteries must be well considered so that there is no imbalance between the load and the battery capacity, which can cause a decrease in the durability and service life of the battery. One of the alternatives proposed to overcome these obstacles is the use of Super Capacitors. Super Capacitors are components with high capacity and fast energy release performance, which can be used for voltage regulation on the DC bus. The use of Super Capacitors in Off-grid solar systems can help optimize the storage and use of electrical energy, and can play a role in maintaining energy.

Previous research shows that the combination of batteries and Super Capacitors can improve battery life and performance. Therefore, good energy management needs to be implemented, especially in hybrid conditions, to maintain battery stability. Without good management, battery voltage drop may occur, affecting the quality of power supplied to the load. This research uses a simulation approach with SIMULINK software to implement the placement of Super Capacitors in order to maximize the energy supply performance of the battery. The simulation involves an off-grid solar system configuration with additional PV Array components, batteries, and Super Capacitors. The parameters of the PV Array module and battery are used in the simulation to reflect realistic operational conditions.

The results of the simulation will evaluate the effect of the addition of the Super Capacitor on the battery's resistance to load, particularly under optimal sunlight receiving conditions. The simulation process is carried out by designing the system configuration, setting the simulation response through the Powergui block, and placing measurement points on each element of the component diagram. Thus, this research is expected to provide better insight into the implementation of Super Capacitors in Off-grid solar systems to improve efficiency and electrical energy resilience.

Supercapacitors supplied through the PLTS system can also be used for energy management and can maintain energy [5]. The existence of Super Capacitor components is very important in developing new opportunities for optimizing the storage and use of electrical energy which has also been explored by previous researchers to strengthen the availability of electrical energy sources.

Installation of Super Capacitors for PLTS has the possibility of replacing the battery with a similar function to operate the load. Previous researchers stated that the combination of installing a battery with a supercapacitor can increase battery life and battery performance [6], so that the Super Capacitor component must be able to work in Hybrid conditions and maintain battery stability. If the operation is not implemented, it can cause a decrease in the battery voltage in maintaining the quality of the load on the PLTS so that the load is not met, especially in conditions of increasing load. The approach of the Off-grid PLTS system in this research was designed through simulation to implement Super Capacitor placement to maximize the energy supply performance of the battery.

**Literature Review**

**System of Solar Power Plants**

Solar power plants (PLTS) are power plants that convert solar energy into electrical energy. Solar power generation can be obtained in two ways, directly and indirectly. Direct solar power generation can be obtained using photovoltaics and indirect solar power generation by concentrating solar energy reflected through mirrors. In principle, solar power can be used to generate electricity in 2 ways:

1. Steam production with mirrors used to drive a turbine
2. Convert sunlight into electrical energy using photovoltaics

Solar cells or photovoltaics are devices that convert light energy into electrical energy using the photoelectric effect. First created in 1880 by Charles Fritts. The way photovoltaics work or the concept itself is by directly converting light energy into electrical energy using electric photos. Meanwhile, the concept of concentrating solar energy uses a lens or mirror system. Solar concentration by reflecting sunlight to one point is combined with a tracking system to focus the sunlight which is used to drive the heat engine. As explained, photovoltaic technology converts sunlight into electricity. The large photon energy from sunlight releases free electrons in semiconductor materials, thereby generating electrical energy, Direct Current (DC).

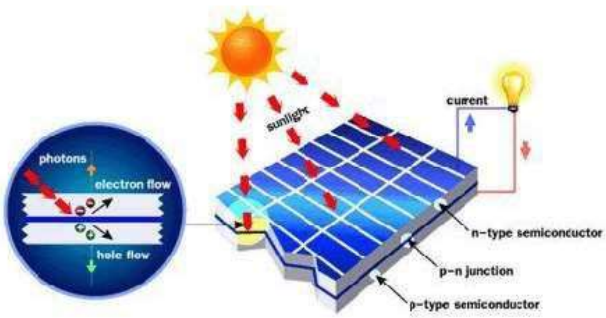



**Figure 1.** Solar Cell prosses

**Factors that influence Solar Cell measurements.**

To get maximum output from PLTS, there are several factors that really influence them, namely:

**Solar Irradiation**

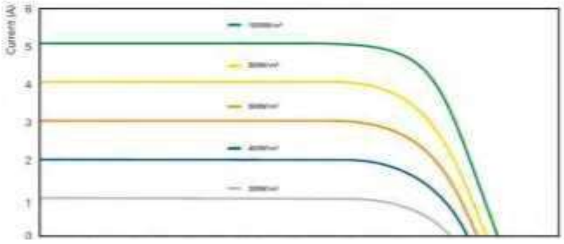
Solar irradiation received by the earth is distributed over several wavelength ranges, ranging from 3 nm to 4 microns. Some of the radiation is reflected in the atmosphere (diffuse radiation) and the rest can reach the earth's surface (direct radiation). Important quantities to measure are:

a. Special irradiance Iλ – power received by one unit area in the form of differential wavelength dλ, units: W/m2 um
b. Irradiance – integral of the irradiance spectrum for the entire wavelength, units: W/m2
c. Radiance – time integral of irradiance for a specified period of time.

Therefore, the units are the same as energy units, namely J/m2 –

Day, J/m2 – month or J/m2 – year.

Of these three quantities, the one that will be used in the analysis is W/m2 because this unit is usually used in data sheets, while the radiance quantity is usually used to calculate the estimated output power in system installations. Irradiance is an energy source for solar cells, so the output is very dependent on changes in irradiance. The image provides an example of irradiance changes to the power curve of a solar module. Judging from the picture, the power output is directly proportional to the irradiance. Isc is more affected by changes in irradiance than Voc. This is in accordance with the explanation of light as packets of photons. When the irradiance is high, that is, when the number of photons is large, the current produced is also large. Vice versa; so that the current produced is directly proportional to the number of photons. The following is a picture of the characteristics of the i-v curve regarding changes in irradiance.



**Figures 2.** Intensity of Sunlight

## 2. METHODS

The system designed in this research uses SIMULINK software using a single line diagram model of the Off-grid PLTS system. SIMULINK has a renewable energy simulation component, one of which is a PV Array. The energy storage provided in the simulation can be in the form of batteries and Super Capacitors. The PV Array component developed in the simulation uses a Polycrystalline module with a small capacity. The parameter specifications of a module used are shown in Table 1.

**Table 1.** PLTS Module Specifications

| Polycrystalline Solar Panels | |
|---|---|
| Maximum Power | 20 W |
| Maximum Power Voltage | 17.2 V |
| Maximum Power Current | 1.16 A |
| Open Circuit Voltage | 20.64 |
| Short Circuit Current | 1.3 A |
| Nominal Operating Cell Temp | 45 ± 2Co |

Simulation of the placement of Super Capacitors is implemented with a load connected to a battery. Specifications for the battery are shown in Table 2.

**Table 2.** Battery Specifications

| Lead Acid Batteries | |
|---|---|
| Batteries | 12 V |
| **Constant Voltage Charge** | **7.2A** |
| **Stand by use** | **13.6 V – 13.8 V** |
| **Initial current** | **Less than 2.88 A** |

The results that will be studied in this research simulation are the effect of adding a Super Capacitor on the level of battery resistance to load with maximum sunlight conditioning. The stages of designing simulation research are carried out using the following procedures: The results that will be studied in this research simulation are the effect of adding a Super Capacitor on the level of battery resistance to load with maximum sunlight conditioning. The stages of designing simulation research are carried out using the following procedures:

1. Create a system configuration by adding PV Array, battery and Super Capacitor components in the simulation layout.
2. Insert Powergui block for simulation response settings.
3. Place measurement points on each component element of the diagram.
4. Enter the PV Array and battery parameter values according to the available data specifications.
5. Add load components assuming constant electrical power with a nominal limit of 12 V, 10 Watts.
6. Add a Super Capacitor component which will then be used when implementing loading on the battery.

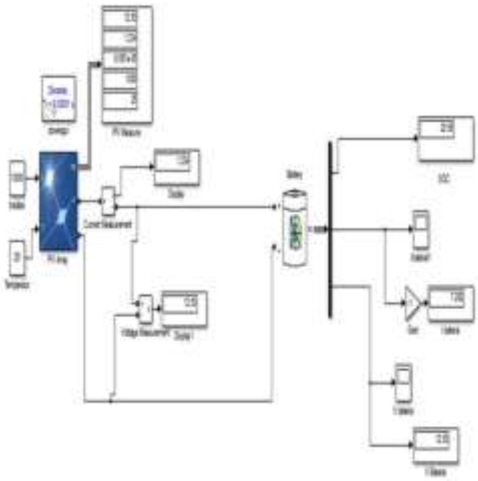
After determining the stages of creating a simulation, the system is operated through testing under conditions of solar radiation and maximum temperature. The steps for simulation testing for data retrieval from the PLTS system are explained in the following steps:

1. The system is set to a response time of 10e-5, namely for 0.0001 seconds of simulation operation.
2. The illumination and temperature in the simulation are conditioned to a maximum with values of 1000/m and 25oC.
3. The first condition is treated in a PLTS system connected to a battery without load to determine the output voltage and current from the PLTS to the battery.
4. The next condition is added to a constant load which is assumed to be a lighting load with a specified amount of electrical power.
5. After operating these two conditions, the addition of a Supercapacitor is given to the system by referring to the reference voltage on the battery of 12 V.
6. Specifications for the size and number of capacitors are given, namely 13 V/60F and 2.7 V / 3000 F
7. The results of all operating conditions are analyzed according to the characteristics of each treatment in the simulation.

The system operated in the simulation is a DC load. The power produced is in the form of a direct current system. From each component generated on the generator side to the load usage, an approach can be made using electrical power calculations. Then, with capacitance and voltage, a capacitor can store energy. The Super Capacitor component designed in the simulation is used to help the system maintain the supply of electrical energy from the battery.

## 3. RESULT AND DISCUSSION

Based on the design of the system model developed at the design stage and data collection techniques for simulation, this research is a type of conventional system without a controlling component. The circuit model has been studied by previous researchers using a super capacitor connected directly to the battery, classified as a Passive Hybrid system. The initial conditions of the designed system are shown in Fig 3.



**Figures 3.** PLTS Desing Schemes.

The 20 WP PV Array module is given input parameters using data in accordance with the Irradiance and Temperature specifications which are fully implemented in order to simulate the generation of electrical energy in maximum generation conditions. The maximum performance characteristics of the Polycrystalline module are shown in Figure 3. For the constant load connection position used in the simulation it is adjusted to the limits nominal voltage in addition to the electric power and balanced by the placement of the Super Capacitor which can be seen in figure 4.

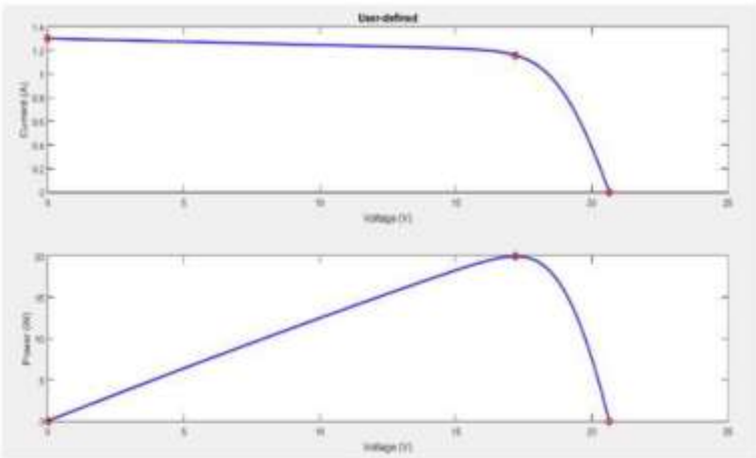


**Figure 4.** Characteristics of Solar Cell Modules

The system condition without load in the simulation has a battery power of 15.29 W. The stage after being given a Super Capacitor of 13V/60 F shows the condition of changes in voltage and current during load conditions. The battery tends to experience a slight decrease in power of 0.57% compared to the initial condition. This is because this capacity with a stored energy of 5070 J only uses 1 component from a fixed Super Capacitor. The voltage limit applied to the system by the Super Capacitor previously developed by researchers is 11.5 V, so the voltage value has not yet adjusted to the nominal battery voltage standard. Then at the stage of adding the Super Capacitor by changing the value to 2.7 V / 3000 F, the same simulation start conditions were treated for the installation of the load.

The addition of a Super Capacitor at this stage provides quite significant results with the specified nominal value. The amount of electrical power received by the battery is 91.36 W with the energy in one Supercapacitor unit being 11760 J. In this condition the capacity The battery can increase due to the increase in the capacitance of the Super Capacitor. The simulation system treatment approximates the capacity of the battery operation to the permitted value. This stage shows an increase in battery voltage and current of 18.47% compared to initial conditions. The capacitor simulation is determined by increasing the number of units made in series in 5 units, then connected in parallel so that the total voltage becomes 13.5 V. The current charging system in the battery can reach its operating value to maintain the supply of electrical energy to the load.

## 4. CONCLUSION

Based on the results of research on the control system at the Sterilization Gate, it is concluded: The control system can work manually and automatically. Manual operation by pressing the ON/OFF button and the direction of the selector switch towards the Manual position. An Arduino type microcontroller can be applied to this tool well, and is able to receive sensor input and regulate the pump operating time. Using 2 batteries without charging the solar panel can last for ± 6.96 hours. The use of simulation in research for the placement of Super Capacitors in Off-grid PLTS systems produces results in batteries that are able to be balanced by maintaining the voltage condition of the battery connected to the load and providing charging current to the battery. The use of a load can affect the performance of the battery as energy storage. The use of Super Capacitors proposed in the research can be further developed for the use of micro-scale Off-grid PLTS that require battery life with fairly simple cost estimates for a Passive Hybrid system.

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