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Design And Simulation Of Electric Center Distribution Panel Based On Photovoltaic System

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Abstract. The solar energy as an alternative energy to generate electrical energy using photovoltaic (PV) connected to the grid of batteries that work all night widely developed in Indonesia. The ability to use PV for power conditioning and power factor compensation has been proven by researchers. However, most of the applications described in the engineering literature are used on a three phase system using techniques developed for active filters. Inverter can supply requirements in the vessel control room Baruna Jaya 8. PV systems are designed to generate 250 kW. From the simulation and test results using PSIM software it is found that the PV system can generate 250 kW power to supply the distribution panel as alternate of fuel on the ship Baruna Jaya 8.

1. Introduction

Indonesia is one of tropical country that solar energy is widely used to generate electricity. Many photovoltaic (PV) that have been developed among the community both for industrial and research purposes. In this paper, the PV system is used to supply electrical energy at the Distribution Panel Control of the Baruna Jaya vessel. PV is installed on the ship due to solar energy opportunities in the sea to produce large amounts of electrical energy. Solar Power (PLTS) are electricity generator that use solar energy as a source. The main tool is a catcher, modifier and producer of electricity called photovoltaic or Solar Cell Panel (module) [1]. Solar energy is converted into electricity through the process of negative electron flows, then becomes a DC electric current that will directly charge the Battery / Accumulator based on the required voltage and current. The average of marketed module product produces 12 to 18 VDC and 0.5 to 7 Ampere. The module has a variety of capacities, ranging from 10 watt peaks to 200 watt peaks. The module consists of monocrystal and polycrystal cell types [2]. The core components of this solar power are solar cell modules, regulators/controllers, battery, accumulators, DC to AC inverters and loaders. In utilizing PV as an electrical energy source, planning for the installation process is needed to obtain maximum results and reduce wasted energy [3][4].

2. Literature Review

In the recent research solar energy using Arduino UNO controller, its compare with static parabolic reflector and without parabolic reflector. Solar energy using Arduino UNO with parabolic reflector has a best performance with average output voltage 7.8 volts and 6,14 mA. The system can be efficient of energy for many application especially it use to operate motor DC [5]. Numerical method is present to validate optimization solar panels position for Beirut [6]. Where the method is for determine of solar irradiance for Beirut, Lebanon. The method can applied to any region and the result has a



constant tilt angle, a monthly adjustable tilt angle, and solar tracking system. However this method is applied for the normal direct radiation. Mirror reflected solar panel (MRSP) was advance from parabolic reflector with automatic cooling and tracking [7]. Tracking system target is sun light approximately in perpendicular direction. The tracking with cooling reflection was higher power than tracking without reflection cooling. But the reflection cooling has appetite because the output power downward during noon to afternoon. In this paper the solar energy system for the needs of electricity power is designed based on the load power requirements of the Distribution Control Panel. The solar power system design can be seen in Figure 1. The initial step in designing a PLTS system for the Control Panel Distribution is the power capacity of the distribution panel of 30 KVA, 230V-50 Hz where the panel supplies and is connected as a controller of research equipment.

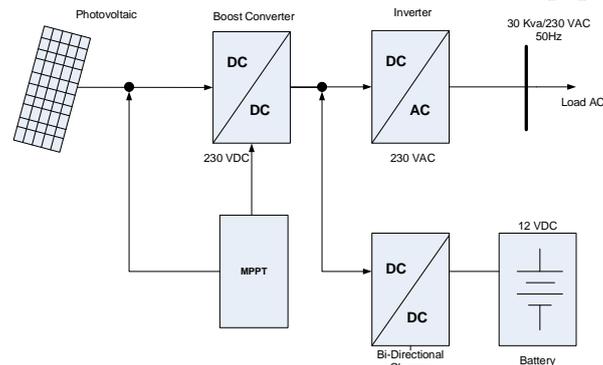


Figure 1. Block of planning system diagram

2.1 Load Estimation

In the design of the PLTS system for the distribution panel of the Baruna Jaya vessel, determines the total daily load, from the determination of that total daily load, we will obtain an electric load curve [2]. The total daily load is the amount of energy needed by the electricity load every day, and can be shown in Table 1.

Table 1. Load Estimation of the Baruna Jaya Ship Distribution Panel

No	Load	Power (W)	Jml	Total power (W)	Length of Use (Jam)(H)	Energy (WH)
1	Fan	100	4	400	10	4000
2	Computer	700	8	5600	10	56000
3	LCD Proyector	255	2	510	3	1530
4	Printer	30	4	120	3	360
5	TL Lamp	25	10	250	10	2500
6	DC power supply	160	8	1280	10	1280
7	Gyro Compas	25	1	25	10	250
8	DGPS	5	1	5	10	50
9	Others	200	1	200	8	160
Total						66130

Note: Data refers to Oceanography of LIPI RV Baruna Jaya 8

2.2 Calculation Of Plts Load Energy Equipment Specifications

The amount of load energy that will be supplied by the PLTS on the Baruna Jaya vessel is 8390 W. The power capacity of solar cell modules can be calculated by several factors, those are the required

system energy, solar insulation, and adjustment factor. The power capacity of the solar modules produced is:

$$\text{Module Power Capacity} = \frac{66130 \text{ wH}}{3,91}$$

$$= 16913,04 \text{ W}$$

Where 3,91 is average sun isolations.

2.3 Number of Modules

The number of modules are determined by:

$$\frac{16913,04}{7 \times 250} = 9,66 \text{ modul}$$

Rounded up, so the number of modules are 10 units with the capacity of each module is 250 Wp.

2.4 Battery Capacity

Battery capacity is calculated based on the amount of power produced by 10 solar modules for 10 hours with a 12VDC battery voltage, namely:

$$AH = \frac{10 \times 250 \text{ w} \times 10 \text{ jam}}{12} = 2083,33 \text{ AH}$$

The battery capacity used is 100 Ah with a terminal voltage of 12 Volt DC, so the battery needed is 20 batteries. The load on the solar cell system takes energy from the Battery Charger Regulator (BCR). The current capacity that flows in BCR can be determined by knowing the maximum load installed. The maximum load occurs is approximately 1500 Watts with the maximum load of the system voltage is 12 volts, so the current capacity that flows in BCR is:

$$Imaks = \frac{1500}{12} = 125 \text{ A}$$

So the BCR capacity used must be greater than 125 A.

2.5 Equipment Specifications

2.5.1 Solar cell or photovoltaic (PV). Solar cells or more often called photovoltaic (PV) function to capture and convert solar energy into electricity through a negative electron flow process. Electricity generated is DC electricity. This study uses 100 units of PV modules with specifications:

Model SL ET-P660250

Maximum Power (Pm)	: 250 W
Open Circuit Voltage (Voc)	: 37,58 V
Short Circuit Current (Ioc)	: 8,98 A
Maximum Power Voltage (Vmp)	: 30,02 V
Maximum Power Current (Imp)	: 8,33 A
Working Temperature	: 45,3±2°C
Tolerance	: ± 3%

2.5.2 Battery Control Regulator (BCR). Battery Control Regulator (BCR) is an equipment used for setting the charging system from the Solar Panel. This study uses BCR that can be enabled under Normal or Auto Load position conditions. This study uses 3 units of BCR with specifications:

Output Voltage	: 12 VDC
Power Consumption	: 10 mA (standby)
Turn of Charge Battery	: 14.50 +/- 0.01 V
Recharge Battery position	: 13.50 +/- 0.10 V
load shutdown	: 11.20 +/- 0.01 V
Reset the load voltage	: 12.60 +/- 0.01V

Low battery warning sound :11.60 +/- 0.10 V

2.5.3 *Inverter*. The inverter function is to change the DC voltage produced by PV (stored in a battery) into the AC phase. This is done because most electrical equipment is designed with an AC voltage source. The inverter in this study was able to produce voltage from the original condition that is 12 VDC to 220 VAC. This study uses 1 inverter unit with specifications:

Model	: SDA-1000
Type	: Modified Wave
Input Voltage	:12 VDC
Output Voltage	: 220 VAC-240 VAC
Rated power	: 1000 W
Peak power	: 2000 W
Efficiency	: > 70%

3. Metode

3.1 Simple Equivalent Series

Solar cell consists of p-n semiconductor junction where when it exposed to light, the proportional currents in the solar will generate radiation. The PV circuit model can be illustrated in Figure 2.

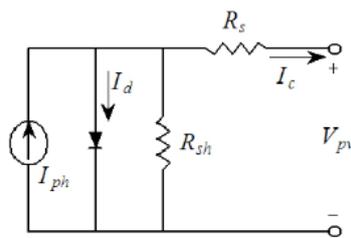


Figure 2. Potovoltaic model with single Battery

3.2 Mathematical Model Theory

From Figure 1, the characteristics of solar cells in the equivalent circuit can be formulated into:

$$I = I_{ph} - I_d \left(e^{\frac{qV_{PV}}{kT}} - 1 \right) \tag{1}$$

3.3 Practical Model Of PV Series

Photovoltaic arrays can be connected in series-parallel batteries. The photovoltaic array output will be shown in the following equation:

$$\begin{aligned} V_{tot} &= N_s U_{cell} \\ I_{tot} &= N_p I_{cell} \\ P_{tot} &= N_s N_p I_{cell} \end{aligned} \tag{2}$$

We assume using two series of circuits, the photovoltaic array circuit model is shown in Figure 3.

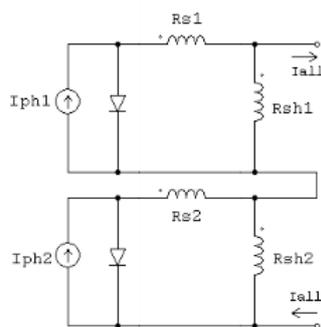


Figure 3. Model series of PV array

3.4 PV Simulation Model on PSIM

Referring to the PV SL ET-P660250 parameter that one module has a maximum power of 250 watts. In PV integration modeling, Figure 4 is 10.

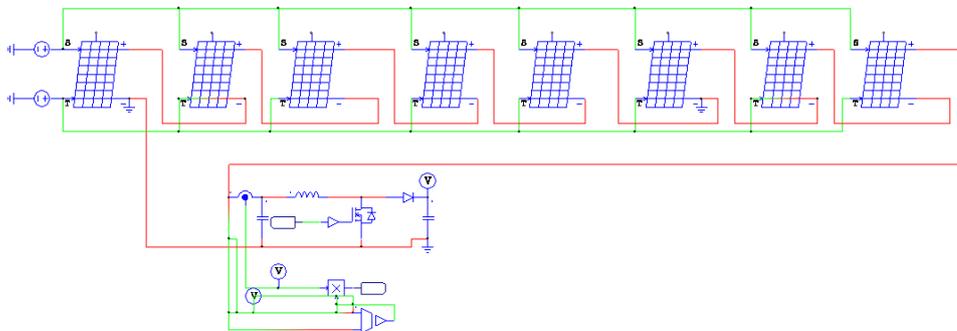


Figure 4. PV simulation on PSIM

3.5 MPPT Design with Modified Buck-Boost Converter

Buck-Boost is used to increase the voltage level of the PV output. Figure 5 is a modification of the Buck-Boost converter circuit.

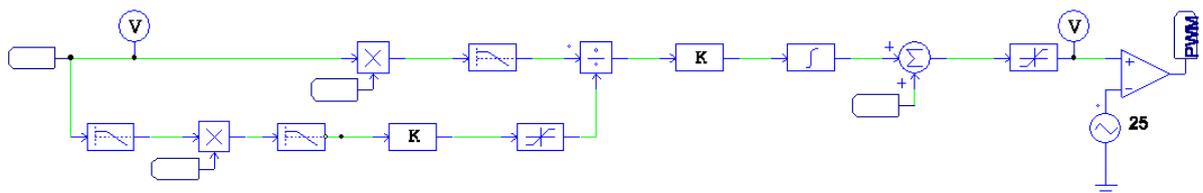


Figure 5. Modification series of Buck-Boost converter

3.6 Battery Modeling

Battery modeling in Figure 6 is based on the equation:

$$E = E_0 - K \frac{Q}{Q - \int i_b dt} + A \exp(-B \cdot \int i_b dt) \tag{3}$$

Battery modeling consists of voltages that can be controlled by V_{in} which is connected in series with the resistance R , while the equation is implemented with control blocks whose output values can regulate V_{in} voltage.

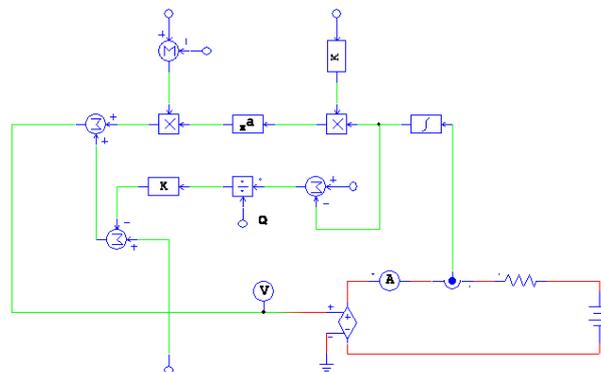


Figure 6. Equivalent series of battery

3.7 One Phase Inverter Design

This inverter used is the full-bridge inverter type. The inverter modeling circuit consists of Vdc, S1, S2, S3, S4, and R loads. While L is the output filter of the inverter circuit that is shown in Figure 7.

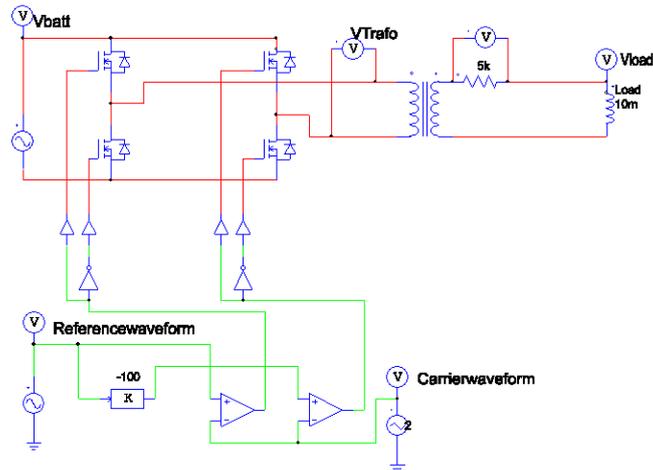


Figure 7. One Phase Inverter circuit

4. Simulation Result

PV output can be seen in Figure 8. We can see that the output is a 230 volt DC signal

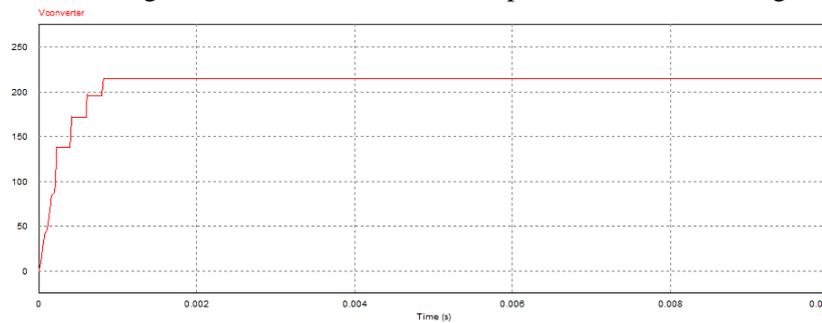


Figure 8. Output of PV Voltage

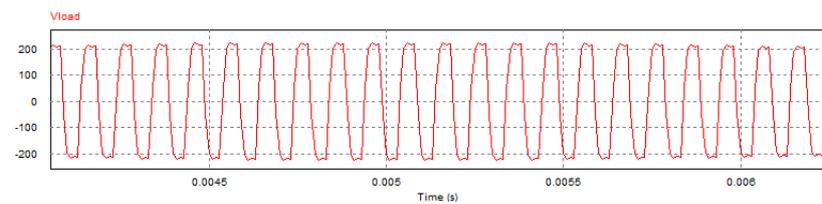
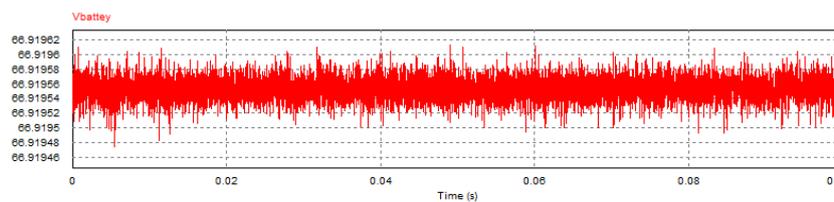


Figure 9. Output of Inverter Voltage



Figurer 10. Charging and Discharging Battery

5. Conclusion

From the simulation results it can be concluded that the PV output voltage of 230 Volts DC with an output of 230 volts is expected to supply distribution panels on the Baruna Jaya 8 vessel with a capacity of 25000 watts. The modules needed to meet a power of 25,000 watts require 100 units modules with a capacity of module is 250 watts per unit. From the simulation results, it is expected to be implemented in real-time to supply the Baruna Jaya 8 Vessel panel as a substitute for fossil energy.

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