Design of Power Supply “Electronic Center” at Kr. Baruna Jaya 8 Using Photovoltaic-Battery Hybrid System

Soedibyo[1], Ainur Rachmad Hidayat[2], Alfin Sahrin[3], Trisna Wati[4]
Jurusan Teknik Elektro
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
dibyosoe@gmail.com[1], ainurrachmad@gmail.com[2]

***Abstract*—The utilization of solar energy as an alternative energy to generate electricity using photovoltaic (PV) connected to the grid / battery that is still working through the night has been developed in Indonesia. The use of these technologies can be done anywhere, one of which can be applied in the maritime industry. There is a electronic center room at KR. Baruna Jaya 8 that requires electric power supply continuously. Electronic Center must still be fed from the battery in the worst conditions or blackout occurs to get the delay time to turn off all the equipment and securing data. The room is supplied from the distribution panel of electronic center with a capacity of 30 kVA, 230V, 50 Hz which will redesign using PV systems - Battery. PV is connected to an inverter that can supply the power needs in the Electronic Center room. The results of simulation using PSIM software shows that the PV system can generate 25.5 kW of supply the distribution panel of Electronic Center as a substituent of fossil fuel power plants that used previously.**

Keywords*—*Photovoltaic; Battery; Inverter.

I. Introduction

Indonesia is a tropical country, therefore the utilization of solar light energy being used widely to generate an electric energy. Variety designs of Photovoltaic (PV) has been developed among the public for the benefit of industry and research. In this research, PV systems are used to supply the Electronic Distribution Panel Center KR. Baruna Jaya 8. PV installed on the ship as it sees opportunities available sunlight energy in the ocean and makes it possible to produce electrical energy.

Solar Power (PV) is a plant that uses sunlight as a source of electricity. The main tool in the form of a catcher, modifiers and generating electricity that is photovoltaic or often called modules (Panel Solar Cell). Through these tools, the sunlight is converted into electricity through a streams process of negative electrons and become into DC electricity which will immediately fill Battery / Accumulator according to the voltage and current required. Average module products that are marketed produce 12 to 18 VDC and 0.5 to 7 Ampere. The module has a capacity of diverse, ranging from 10 watts peak to 300 watts peak. The module also consists of cell mono crystal and poly crystal type. The core components of the solar power plants are the solar cell module, the regulator / controller, battery, accumulator, inverter DC to AC and loader. In use of PV as a source of electrical energy, it is necessary to plan installation process. This is done to obtain maximum results and reduce wasted energy.

II. Literature Review

Solar cells receives solar radiation in one day varies greatly. This is because sunlight has a great intensity when daylight compared to the morning. To determine the capacity of the power generated, necessary to measure the circuit current or voltage of solar with no connecting solar cells by other components. This measurement is called the open-circuit voltage or [2]. Results of the current measurement called the I-V curve as shown in Figure 2. In the I-V curves, there are things that are very important are:

A. Maximum Power Point (V_{mp} dan I_{mp})

Maximum Power Point *(V_{mp} dan I_{mp})* on I-V curve is the operating point that indicates the maximum power generated by the solar cell panel.

B. Open Circuit Voltage (V_{oc})

Open Circuit Voltage (*V_{oc}*) is the maximumvoltage capacity that can be achieved in absence of a current.

$$V_{OC} = \frac{kT}{q}\ 1n\ (\frac{I_{sc}}{I_S} + 1) \text{.......................(1)}$$

Where:

k= boltzmann constant (1,30x10^{-16} erg)

q= electron charge constant(1,602x10^{-19} C)

T= temperature in Kelvin

I_s= saturation current

C. Short Circuit Current (I_{sc})

Short Circuit Current is output of solar cell panels that can be observed under conditions with no resistance or a short circuit. To determine the short circuit current can be calculated using the following equation:

$$I_{sc} = qG(L_n + L_p) \text{.....................(2)}$$

G= generation rate

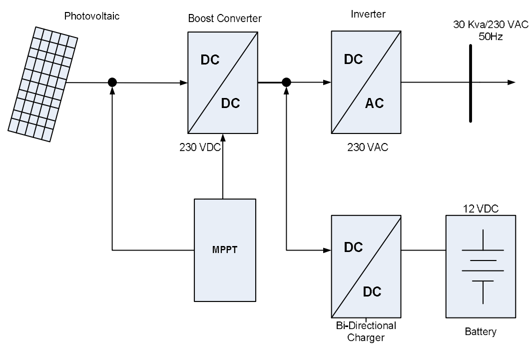
Ln= electron diffusion length

Lp= hole diffusion length

III. RESEARCH METHOD

A. Design of System

Photovoltaic systems for power requirements is designed based on the necessity of load power in Panel Electric Distribution Center. The design of solar systems can be seen in Figure 1.



Gambar 1.Block diagram of the system design

B. Load Estimated

The initial step in the design of the PV system to replace the power supply on Electronic Distribution Center is the power capacity of 30 KVA distribution panel, 230V- 50 Hz which is a load divider panel and connected as a power supply of research equipment. To determine the total load consumption can be calculated from the installed capacity of power equipment and power reserve multiplied by the number of hours of usage. The determination of the total load will get the electrical load curve, the total load is the amount of energy needed on Electric Distribution Center can be known:

$$P = S.Cos\emptyset$$

$$P = 30{,}000\ X\ 0.85 = 25.5\ kW$$

$$Power\ of\ PV\ eachday = 25.,500\ X\ 7\ hours = 175000\ Wh$$

These loads are divided into two parts, namely the continuous load and intermittent load, where continuous load is the maximum load that accounted at the time of maximum operation while the intermittent load is the additional load of equipment that does not exist. The kind of load can be shown in Table 1.

Tabel 1.Load at Distribution Electronic Center

No	Beban	Daya (W)	Jml	Total Daya (W)	Lama penggunaan (Jam)(H)	Energi (WH)
I. Beban Continous						
1	Sub bottom profile	2000	1	2000	24	48000
2	Bathymetric	500	1	500	24	12000
3	Seismic	2000	1	2000	24	48000
4	Watter Mass Crculation	92	1	92	24	2208
5	Stock Assesment	150	1	150	24	3600
6	Current Profile and Pattern	350	2	700	24	16800
7	Lighting	25	10	250	24	6000
8	Gyro Compas	25	1	25	24	600
9	DGPS	5	1	5	24	120
II.Beban Intermitten						37672
Jumlah						175000

C. Calculation of Equipment Specifications

1) Load from PV

Power load will be supplied by the PV is 25,5kW. Capacity of the solar cell module can be calculated by consider several factors, namely the energy needs of the system as required, solar insulation, and adjustment factor. In this case the calculation of the solar modules capacity produced are:

$$\text{Capacity of solar module} = \frac{25{,}5KWx7\ H}{3.91\ H} = 44757{,}033W$$

Where 3.91 is average solar insulation.

2) Number of Modules

The number of modules is determined by:

$$\frac{44757.033}{250} = 179.028\ modules$$

The result is rounded off, until the number of moduls are 180 modules with each module capacity of 250 Wp.

3) Battery Capacity

The capacity of the battery is calculated based on the amount of power while PV is not working for 17 hours with a battery voltage of 24 VDC:

$$AH = \frac{100\ x\ 250\ x\ 17\ hour}{24} = 17.708\ AH$$

The capacity of the battery used is a 100 Ah with a terminal voltage of 24 volts DC, so that the necessary battery as much as 176 batteries. Charging and discharging of the battery using a bidirectional charger whereby when PV work for 7 hours during the day will make the battery fulfill and direct supply to the load, and when the PV does not work, the battery will discharge to supply the load.

4) Photovoltanic (PV)

Photovoltaic (PV) has function to capture and convert sunlight into electricity through flow of negative electrons process. The electricity generated by the photovoltaic is DC current. This study uses 180 units of PV modules with the specifications below:

Model SL ET-P660250
Maximum Power (Pm) : 250 W

Open Circuit Voltage (Voc)	: 37.58 V
Short Circuit Current (Isc)	: 8.98 A
Maximum Power Voltage (Vmp)	: 30.02 V
Maximum Power Current (Imp)	: 8.33 A
Working Temperature	: 45.3±2ºC
Tolerance	: ± 3%

5) Bidirectional Charger

Bidirectional Charger is the equipment used for system setup charging/discharging of photovoltaic to supply the load. In this study using a bidirectional circuit can be controlled by using PWM. Output voltage results is 196 VDC used during battery charging as many as 176 pieces with circuit 8 series and 22parallel. At discharging position produce output voltage 230 VDC used to supply the load.

6) Inverter

Inverter has functions to convert the DC voltage generated by the PV (stored in the battery) into AC electricity. This is done because most electrical appliances are designed with an AC voltage source. In this study inverter were able to generate a voltage of 230 V, 50 Hz using a fly back inverter. To produce the desired specifications should be noted the number on the fly back transformer turns ratio and duty cycle.

D. Model of Photovoltaic ModuleUsing PSIM

1) Equivalent Circuit

Photovoltaic consists of p-n semiconductor junction. When photovoltaic exposed to light, the current is proportional to the Photovoltaic generate radiation so as to make a diode flows current in one direction from the p-side to n- side. This area is an area electrons have diffused throughout this connection referred to as depl connection area. Electrons can move from the side of the n-type to p-type side. It is also known as the "space charge region".Model of PV circuit can be illustrated in Figure 2.

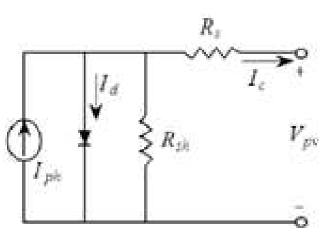


Figure 2. Model of photovoltaic using single battery

E. Theory of Mathematics Model

From figure 1 characteristics of photovoltaic at equivalent circuit can be formed below:

$$I = I_{ph} - I_d(e^{\frac{qV_{PV}}{kT}} - 1) \text{ ....(3)}$$

F. Practical Model of PV Circuit

Photovolaic array can be connected serial or parallelwith battery. Ouput of photovoltaic array can be showed by this equation below:

$$Vtot = N_s U_{cell}$$

$$Itot = N_p I_{cell}$$

$$Ptot = N_s N_p I_{cell} \text{ ....(4)}$$

We assume using two serial photovoltaic, model of photovoltaic array showed in figure 3 below.

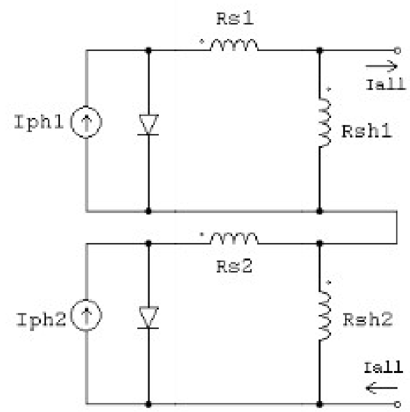


Figure 3.Model of PV circuit array

IV. SIMULATION RESULTS

Refer to parameters of PV SLET-P660250 that one modul has maximum power is 250 watt. At Integration Modeling of PV on figure 3 have number five moduls, because we simulate with the capacity

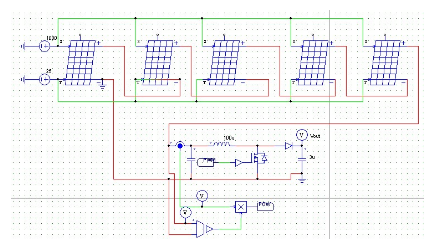
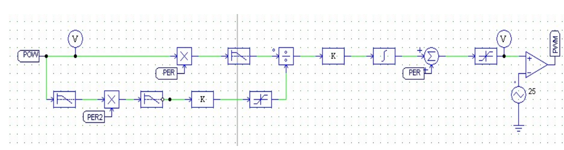


Figure 4. Modelof PV on PSIM

9% of real pv consist of 6 serial and 3 parallels. Therefore, total power of PV generated by PV integration is 44757.033 Watt. The power will supply to panel distributionelectronic center.

A. MPPT Design with Buck-Boost Converter Modification

Buck-Boost converter used to increase voltage output of PV. Figure 5isBuck-Boostconverter modification circuit.



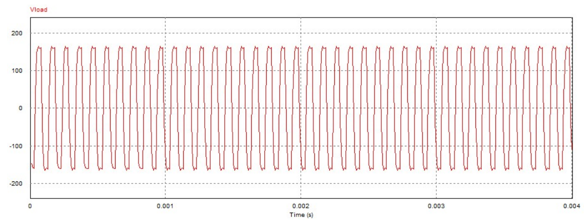


Figure 5. Model of MPPT Modification Circuit

B. Battery Modeling

Battery modeling in figure 6 base on this equation below:

$$E = E_0 - K \frac{Q}{Q - \int i_b dt} + A \exp(-B. \int i_b dt) \text{ .... (5)}$$

In battery modeling consists of a controlled voltage connected in series with a resistance R, while equation is implemented with blocks of control can adjust the voltage output from voltage input.

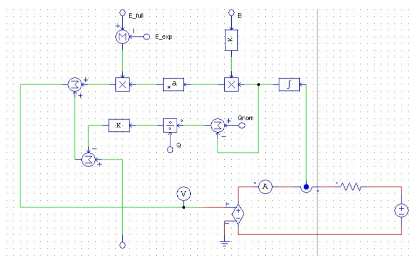


Figure 6.Equivalent circuit of battery circuit modeling

C. Design of Single Phase Inverter

The type of used Inverter is full-bridge inverter. Modeling of inverter circuit consists of DC voltage, S1, S2, S3, S4, and the load R. The L is the inverter output filter shown in Figure 7.

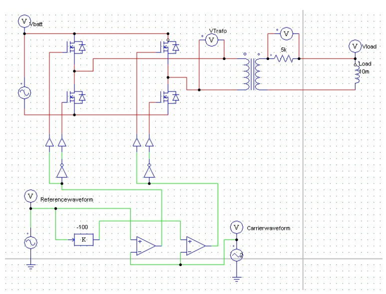


Figure 7. Single Phase Inverter Circuit

D. Simulation Results

The voltage output of PV can be seen in Gambar 8. The voltage output is DC signal 230 volt.

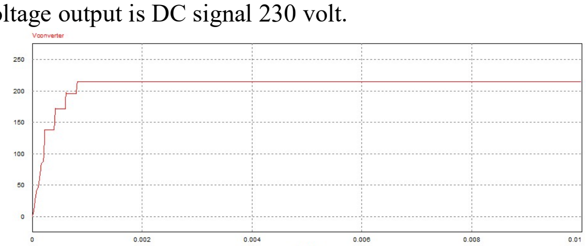


Figure 8.Voltage Output of PV

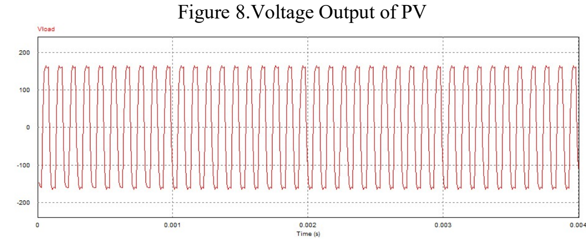
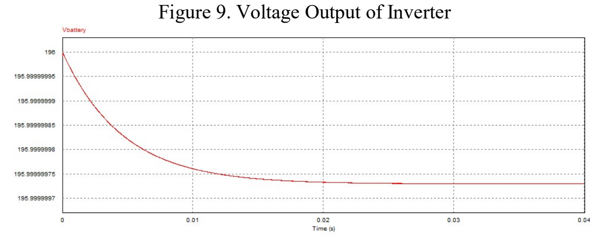


Figure 9. Voltage Output of Inverter



Gambar 10. Voltage Discharge of Battery (17 H)

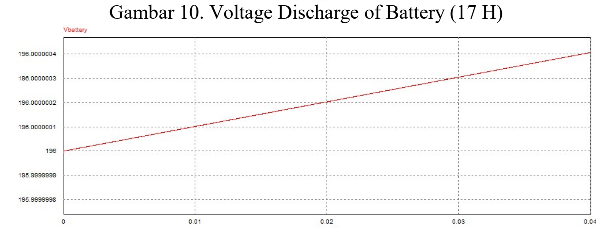


Figure 11. Voltage Chargeof Battery (7 H)

V. CONCLUSION

From simulation results can be concluded that voltage output of PV is 230 volt DC hoped can supply panel distribution electronic centerwith power capacity 44757 Wattusing PV. Modul needed to fulfill the needs is 180 moduls with 250 Watt per unit modul.On the condition of PV is off or blackout, the panel can be supplied from the battery to data security. From the simulation results obtained output voltage of inverter is 230 Volt AC at electronic distribution center panel, as a substitute for fuel oil (BBM) and fuel generators.

DAFTAR PUSTAKA

[1] G.Y. Choe J. S Kim, H. S. Kang.B K. Lee " A optimal design methodology of an interleaved boost converter for fuel cell application", Journal of Elect Eng. Tech. Vol. 5, no. 2.pp. 319-328, 2010

[2] Imawan, Pramudya Santoso, Aria I ketutPria Utama."Study of Ship developmentusing hybrid source".Institut Teknologi Sepuluh Nopember. 2012, National Seminar of Food and Energy Sovereignty

[3] Li, Ji.;Chen, Yu.;Liu, Yunda."Research on a Stand-alone Photovoltaic System with a Supercapasitor as the Energy Storage Device".School of Information Engineeering, Inner Mongolia University of Science and Technology Baontu.2012 Science Direct, Energy Procedia.

[4] Mahmoud, Marwan.;Jallad, Ja'far Saif.''Design and Simulation of a Phovoltaic System With Maximum Power Control to Supply a Load With Alternating Current". An-Najah National University 2012

[5] Abidin, Zainal, Custer, Johny;"Design of Alternative energy system as electricity source of Electric Laboratory". State Polytechnic of Bengkalis. 2013 Inovtek, Vol 3, No 2, Page 98-102

[6] Salman, Adi.; Williams, Arthur.; Amjad, Hanya.; Kamran,M.; Saad, M.''Simplied Modeling of PV Panel by Using PSIM and its Comparison with Laboratory Test Results". Dublin Institut of Technology (DIT). 2015 IEEE, Global Humanitarian Technology Conference