Optimization Circuit Based Buck-Boost Converter for Charging the Solar Power Plant

Rohana*[1], Suwarno[2]
[1]Electric Power Systems and Power Electronics, Universitas Muhammadiyah Sumatera Utara (UMSU),
JL. Kapten Mukhtar Basri, 3, Telp (061) 6622400, Medan (20248), North Sumatra, Indonesia
[2]Electrical Engineering, Faculty of Industrial Technology, Institute of Technology Medan, JL. Gedung Arca,
52, Telp. (061) 7363771, Medan (20217), North Sumatra, Indonesia
*Corresponding author, e-mail: arnomed@yahoo.com

Abstract

This paper discusses the optimization circuit based buck-boost converter for charging a battery from solar panel modules. The combination of the circuit buck-bust converter and a step-up current can increase the percentage of battery chargers. The method used in the optimization of solar power plants by increasing the output current from the solar panel to be optimized for battery charging, so it does not requires time and the batteries are safe. This is because sunlight can be used when bright about 4-5 hours per day. By increasing the output current of the current produced solar modules can accelerate the battery charging time. The combination of using the voltage stabilizer can produce a steady output voltage and current riser, although the voltage to an output of the solar panels is quite small (± 6 volts), can optimize the charger works well. By combining between the voltage stabilizer and a step-up current is obtained that the incoming voltage to the battery at 12,4V the current rise of 21.5% for a 12V battery, 7Ah, whereas the incoming voltage to the battery at 12,1V the current rise 10.99% for battery 12V, 120Ah. This study shows that the current rise is already above 10%.

Keywords: optimization of the circuit, buck-boost converters, battery chargers, panel modules

1. Introduction

Indonesia is located on the equator, so that Indonesia has abundant solar energy resources with the intensity of solar radiation on average about 4.8 kWh/m^2/day in the entire territory of Indonesia. With the abundance of solar energy sources that have not been used optimally, while on the other hand there are some areas of Indonesia that has not been electrified because it is not covered by the grid, so the Solar Power Plant (SPP) with the system is modular and easy to move is one solution which can be considered as one of the alternative power generation. Unfortunately, the cost of generating solar power is still more expensive when compared with the cost of generating conventional power plant, because until now the main tool for converting solar energy into electrical energy (photovoltaic modules) is still a tool that is imported from abroad.

Solar Power is a plant that uses sunlight as a source of electricity. The main tool to capture, change and generating electricity is called photovoltaic or generally Panel Solar Cell. With such a device sunlight converted into electricity through a process streams of negative electrons and positive in the cell module due to the difference electron. Results from the flow of electrons will be the DC power that can be directly used to charge the battery according to the voltage and amperage required. The average solar cell module products in the market produces a voltage of 12-18 VDC and between 0.5-7 amperes. The module also has the capacity vary from 10 to 200 Watt Peak also has a cell type monocrystal and polycrystal.

The positioning modules solar panels on the most optimally capacity of 100 Wp solar panel module with 8 watt LED lamp load and 20 watts are in a position of 0 degrees on the horizontal axis [1].

Buck-boost converter design results to work in accordance with its function is applied to the WP and PV. In WP, buck-boost converter can stabilize the output voltage of 14.35V with a minimum input voltage of 2.98V, while the buck-boost converter in PV can stabilize the output voltage of 14.67V with a minimum input voltage of 5.38V [2].

Solar Power Generation in Indonesia, the most popularly used for rural electrification (isolated), the system as it is popularly known as SHS (Solar Home System). SHS is generally in the form of small-scale system, using solar modules 50-100 Wp (Watt Peak) and generate electricity at 150-300 Wh. As the scale is small, the system DC (direct current) is preferred, to avoid losses and self consumption due to the use of the inverter. Because the systems in which small and mounted in a decentralized manner (one home of the plant, so it does not require the distribution network) SHS ideal for rural electrification where the distance from the house of one another apart, and its electricity requirements are relatively small, namely only to meet the basic needs (lights).

Although there is no clear limit, solar power plants that use solar modules more than 100Wp (energy output> 400Wh), and therefore more likely to use the system AC (alternating current), because electricity can be used after deducting losses and self consumption inverter still quite adequate.

As a result of increasing energy prices, many people turn to energy more economical and environmentally friendly alternative energy. The use of alternative energy is growing, it is due to the supply of electric energy sources, mostly located away from remote areas so that the use of alternative energy into electrical energy is expected by the public in the future. Preliminary studies conducted by the researchers on the energy of the sun (solar cells) in Indonesia has a very large potential for solar energy with an average daily insolation 4.5 to 4.8 kWh/m²/day.

Research on Solar Power Plant, there have been several previous researchers, whose results can already be demonstrate that the potential for development of Solar Power Generation in Indonesia is very possible and has favorable prospects both in terms of saving energy as well as from the economical in the long term. The intensity of solar radiation on average in all regions in Indonesia around 4.8 kWh/m^2 with the potential to generate electricity and can be used as an alternative energy source.

Obstacles encountered in the application of solar power in Indonesia is the high cost of investment, the main device that Solar Power photovoltaic modules are imported from other countries and the efficiency of the photovoltaic modules is only 16% which caused the price of solar power per kW is still very high. Therefore, to increase the installed capacity of solar power, the Government needs to issue regulations or to add local content to the manufacture of devices supporting solar.

In his research, that the control method proved by using multilevel buck and boost converters in the pickup, which is explained by the small signal model. The experimental results are provided to verify the design with a power output of 2 kW. light load conditions and fully examined by modeling the battery as a variable load for multilevel buck and boost converter. Converter models tested were behavioral control circuits and the transfer function of the converter is extracted to approach a constant resistance [3].

Analyze, design and realization of the DC/DC buck-boost converter operates in the PV system using a buck or boost converter by selecting different combinations of switches .the system has been designed and implemented in the laboratory. The experimental results of prototype circuit conducted to confirm the integrity of the proposed circuit, and can be used in various applications such as solar battery charger, mobile charger and for DC power supplies [4].

Due to the popularization of portable electronic products and electric bikes, a low voltage charger is necessary. Therefore, a buck-boost type charger is proposed in this paper. The proposed buck-boost type charger is composed of an integrated boost/buck power converter and a switched capacitor circuit. A boost converter and a buck converter sharing a power electronic switch are integrated to be a boost/buck power converter to simplify the power circuit. The salient feature is that the switched capacitors circuit can control the DC link voltage with two DC voltage levels. The switched capacitor circuit can change the output voltage of the boost converter according to the utility voltage to advance the power efficiency and reduce the input voltage of the buck converter to increase the step-down voltage ratio. From the experimental results, it can be seen that the proposed buck-boost type charger can achieve a unity power factor, output a regular DC voltage, and charge the battery set [5].

The proposed system of controller based Buck Boost converter is found to be more compact, user friendly and more efficient. The inbuilt ADC and PWM channels in the ATmega8L Microcontroller make the control module of the converter very compact. The Buck Boost

controller with ATmega8L as its integral part senses the output voltage and varies the PWM duty ratio so that the output voltage at lower wind speeds is also maintained above the battery charging voltage (54 V). Hence the voltage produced at lower wind speeds is also effectively utilized and the efficiency of the proposed system is 15% higher than the existing system [6].

The PV system in solar cell does not produce pollution, have no moving parts, and consume no fossil fuel during power generation. The present research paper describes the programming of the PV system and Matlab/Simulation of the Perturb and Observe technique of MPPT and DC-DC buck converter for charging the battery. This charged battery can be used at night, during rainy days and in winters. Therefore, it is our wish to make the PV system more efficient so that it can help for betterment of life [7].

Non-inverting Buck-Boost type Battery charger has been proposed for charging Batteries using solar array. The circuit structure is simpler and much cheaper compared to other control mechanisms where much hard ware is required. It operates in constant current and constant voltage (taper charge) mode to efficiently and fully charge Batteries, with protection features in built. The main advantage is it reduces the hardware the disadvantage is that losses will be more in the Buck-Boost operation Efficiency needs to be improved to make it more optimal [8].

2. Method research

Redesigned optimization tool charger: The design is intended to improve the initial optimization tools that have a laboratory test, but still need improvement in order to produce better optimization tool.

Testing the new design tool: The design tool that has been done is modified by adding a voltage stabilizer (buck-boost converter), will be tested in laboratory before it is implemented/disseminated on solar power generation.

Trial prototype: Trial prototype optimization tool charger on solar cell panel was conducted to determine the capacity of the power in solar power plants (Figure 1).

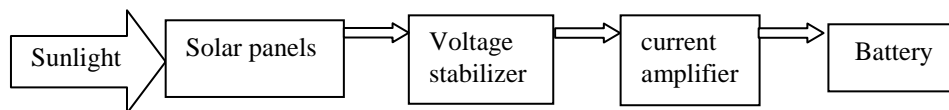Sunlight → Solar panels → Voltage stabilizer → current amplifier → Battery

Figure 1. Method research

3. Results and Discussion

Test results on the battery charging 7Ah, 12V, DC is obtained as shown in Table 1 and Figure 2.

Table 1. Data measurements of voltage and current at the input and output

| No.	V_{in} (volt)	V_o (volt)	I_{in} (A)	I_o (A)	% Increase in current	Information
1.	14,4	12,4	0,07	0,08	12,5	When the initial charging
2.	14,4	12,5	0,06	0,07	14,3	Process charger
3.	14,4	12,4	0,05	0,06	16,7	Process charger
4.	14,4	12,4	0,04	0,05	20,0	Process charger
5.	14,4	12,4	0,03	0,04	25,0	Process charger
6.	14,4	12,5	0,02	0,03	33,3	Process charger
7.	14,4	12,4	0,01	0,02	50,0	Process charger
8.	14,4	12,4	0,01	0,01	0,0	When the end of charging (battery is full)

The average increase (%)=   21,5
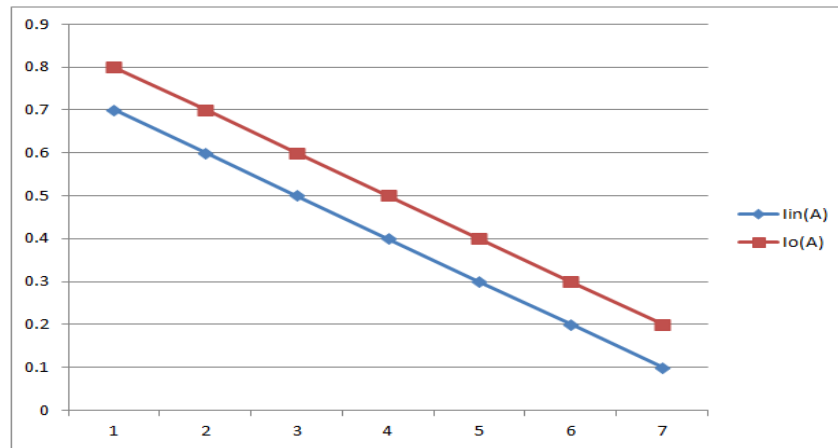
Figure 2. Graph current rise in battery charging 12V, 7Ah

Test results on the battery charging 120Ah, 12V, DC is obtained as shown in Table 2 and Figure 3.

Table 2. Data measurements of voltage and current at the input and output

| No.	V_{in} (volt)	V_o (volt)	I_{in} (A)	I_o (A)	% Increase in current	Information
1	14,5	21,1	0,75	0,79	5,1	When the initial charging
2	14,5	21,1	0,67	0,68	1,5	Process charger
3	14,5	21,1	0,65	0,71	8,5	Process charger
4	14,5	21,1	0,55	0,63	12,7	Process charger
5	14,5	21,1	0,51	0,52	1,9	Process charger
6	14,5	21,1	0,50	0,51	2,0	Process charger
7	14,5	21,1	0,35	0,42	16,7	Process charger
8	14,5	21,1	0,25	0,32	21,9	Process charger
9	14,5	21,1	0,15	0,21	28,6	Process charger
10	14,5	21,1	0,1	0,1	0	When the end of charging (battery is full)

The average increase (%)=   10,99
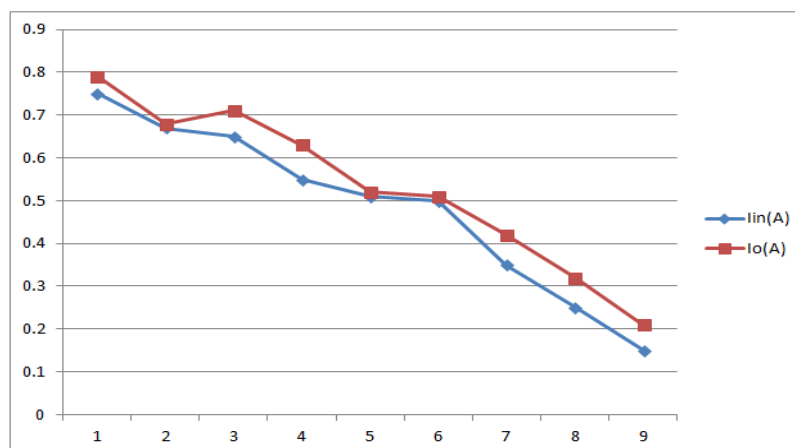
Figure 3. Graph current rise in battery charging 12V, 120Ah

3. Conclusion

Charging the battery 12V, 7Ah obtained that, the charging voltage of 12.4 volts with an average rise of 21.5% charging current and charging the battery 12V, 120 Ah obtained that, the charging voltage of 12.1 volts with an average increase in the charging current of 10.99%.

Acknowledgment

References

[1]   Suwarno. *Optimization of Solar Panel Module Positions.* International Journal of Engineering Research (IJER). ISSN: 2319-6890 (online), 2347-5013 (print). 2017; 6(3).

[2]   Suratno Armayasari, M Razali, Suwarno. Application of Buck Boost Converter on Wind Power and Photovoltaic. *International Journal of Engineering Science and Computing (IJESC).* 2016; 6(8).

[3]   Karim Colak, Mariusz Bojarski, Erdem Asa, Dariusz Czarkowski. *A Constant Resistance Analysis and Control of Cascaded Buck and Boost Converter for Wireless EV Chargers*. Department of Electrical & Computer Engineering. New York University, Polytechnic School of Engineering, New York, USA. 2015.

[4]   Tareq ALNEJAILI, Said DRID. *Design and Implemetation of a Modified DC-DC Converter Suitable for Renewable Energy Application*. The 3nd International Seminar on New and Renewable Energies, Unité de Recherche Appliquée en Energies Renouvelables, Ghardaïa – Algérie. 2014

[5]   Jinn-Chang Wu, Hurng-Liahng Jou, Jie-Hao Tsai. A Buck-Boost Type Charger with a Switched Capacitor Circuit. *Journal of Power Electronics.* 2015; 15(1): 31-38.

[6]   N Prakash, D Ranithottungal, M Sundaram. *An Effective Wind Energy System based on Buck-boost Controller*. Research Journal of Applied Sciences, Engineering and Technology. 2013. 6(5): 825-834.

[7]   Priety, Vijay Kumar Garg. To Perform Matlab Simulation of Battery Charging Using Solar Power With Maximum Power Point Tracking(MPPT). *International Journal of Electronic and Electrical Engineering.* 2014; 7(5): 511-516.

[8]   A Srilatha, M Kondalu, S Ananthasai. Non-Inverting Buck–Boost Converter for Charging Lithium-Ion Battery using Solar Array. *International Journal of Sience Engineering and Technology Research.* 2014; 03(11): 2364-2369.