International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 9 Issue 5 May 2025, Pages: 131-138

Sepic Converter Design for Battery Charging in Wind Power Plants

Budi Setiyono, Ravido Maedya P, Abdul Syakur

Electrical Engineering Dept. Diponegoro University
Semarang, Indonesia
budisty@elektro.undip.ac.id

Abstract—*Conventional power plants such as PLTB or other traditional power plants that use generators require a voltage regulator to regulate the fluctuating voltage on the generator. Fluctuations in power generated by PLTB or other traditional power plants are challenging to maintain system stability. Based on this, the research in this final project was conducted to improve the battery charging performance on PLTB using a sepic DC-DC converter. This circuit has a battery charging circuit breaker that can be set at a particular voltage level to maintain battery quality and extend battery life. The sepic DC-DC converter can increase or decrease the voltage to a value that can be set so that battery charging can be done optimally. Testing was carried out by measuring the voltage and current produced by the generator on the wind turbine and measuring the output results on the sepic DC-DC converter and the ability of the entire system to charge the battery. The test results show that the sepic DC-DC converter can increase and decrease the voltage to a specific value according to the set value, namely at a voltage of 14 V. This circuit will turn off when the voltage from the wind turbine generator is below 4 V and turn back on when the voltage reaches 5.5 V*

Keywords— Sepic DC-DC Converter, Wind Power Plants, Voltage, Battery

1. Introduction

The need for electrical energy in Indonesia and throughout the world continues to experience a relatively rapid increase. Some of the main factors driving this include the increasing population, the rate of economic development, and changes in energy consumption patterns that are increasingly high. Electrical energy is one of the most needed energy sources, from daily needs to industrial production processes. Electricity use covers various needs, such as lighting, industrial operations, and electronic devices. One step that can be taken is to use more environmentally friendly fuels and utilize new renewable energy (EBT) [1].

Wind energy is one of the renewable energy sources with enormous potential, although its use is still limited. In Indonesia, the average wind speed ranges from 3-5 m/s, with a total power that can be generated reaching around 9,290 MW. Although this potential is quite significant, the use of wind energy in Indonesia is still very low, only around 1% of the existing potential [2]. This potential shows an excellent opportunity to develop wind power generation (PLTB) technology and increase its capacity to provide more environmentally friendly electrical energy.

In this paper, a PLTB system is designed to focus on implementing a DC-DC converter, namely a sepic converter for a battery charging system. This DC-DC converter functions to keep the output voltage of the generator stable when the wind energy captured by the turbine cannot be predicted. This DC-DC converter is equipped with a cut-off system with a relay, a series of automatic disconnecting relays when the voltage reaches a specific voltage [6]. This relay series will protect the battery from overcharging..

2. Method

The converter created will be used as a regulator for charging the battery (accumulator), which the electricity source from the PLTB will supply. This PLTB prototype is a small-scale PLTB prototype. The switching type DC-DC converter is used because it has a relatively high efficiency for power conversion in the PLTB prototype [12]. The DC-DC converter topology also has the advantage of a simple design, so the operational costs are lower, which is sufficient for a small-scale PLTB. The PLTB prototype designed uses a Savonius-type turbine with two blades that use an off-grid system or are not connected to a power source from PLN. The Savonius turbine will convert wind energy into mechanical energy. This PLTB prototype will later be connected to an AC generator. The AC generator will convert mechanical energy from the turbine into electrical energy. The generator will output the output voltage resulting from the conversion of energy from wind energy into mechanical energy in the turbine and into electrical energy in the generator. The generator output voltage will be connected to a rectifier circuit to convert the AC from the generator to the DC current. The output of the rectifier is connected to a DC-DC converter which will regulate the voltage to remain stable even though the output voltage from the generator changes depending on wind conditions. The output voltage of the DC-DC converter is connected to an auto cut-off circuit for battery safety, after which it is connected to the battery for charging. The electrical energy stored in the battery is used to power the electrical load.

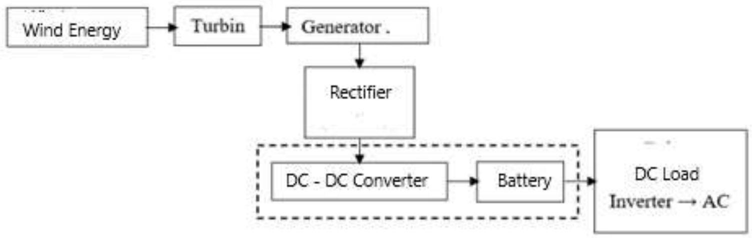

Fig.1. Design diagram of PLTB battery charging system

2.1 Design of DC-DC Sepic Converter

The parameters of the DC converter to be made are needed for the calculation and specification of appropriate component selection for the design. The DC-DC converter to be designed has the parameters shown in Table.1.

Tabel 1. Converter DC-DC parameter

Parameter	Value
Minimuminput voltage	5 V
Maximuminput voltage	20 V
Output Voltage	14 V
Maximumoutput current	1A
Switching frequency	400 kHz

The DC-DC converter used has parameters of having an input voltage between 5-20 volts. The regulated output voltage is 14 volts, close to the full voltage of the battery that will be used in this Final Project, which is 13.6-13.8 volts [6], [7]. The converter is a sepic converter type DC-DC converter that can increase and decrease the input voltage. The results of the wind speed test only got a maximum wind speed of 4.2 m/s with a voltage of 12.0-12.9 volts when no load and 7.9 volts when used to charge the battery. Wind turbines can still get higher wind potential during certain weather or seasons. As a safety measure, when the wind turbine gets higher wind energy, a septic converter is used, which can increase and decrease the voltage according to existing conditions, which are very difficult to predict.

2.2 DC-DC Converter Circuit Design

This DC-DC converter circuit consists of several components: capacitors, inductors, switching ICs, diodes, and resistors. This DC-DC converter circuit can work well from an input voltage of 5V, so it can work even though the voltage produced by the generator is low. The design of the DC-DC converter circuit is shown in Fig.2

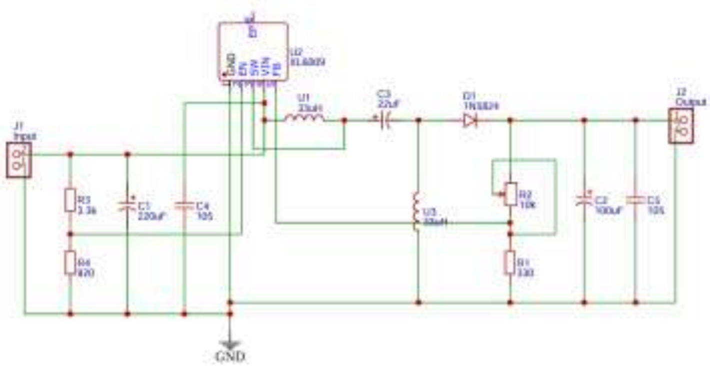

Fig.2. DC-DC converter circuit design

This DC-DC converter circuit uses the XL6009 IC, which is equipped with a 400kHz fixed-frequency oscillator and a switching device in its architecture, with a maximum current of 4A, according to the IC datasheet [14]. So, this IC can regulate the switching on the sepic DC-DC converter well.

2.3 Battery Cut Off Circuit Design

. The battery cut-off circuit protects when fully charged to prevent overcharging or overcharging the battery. Overcharging or overcharging can damage the battery or reduce the battery's lifespan. Fig.3 is a design of the battery cut-off circuit.

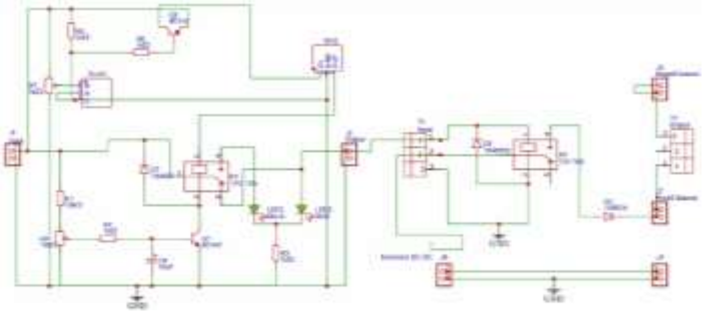

Fig.3. Battery cut off circuit design

This circuit uses a relay as a battery charging current breaker. It works by turning the relay on and off. Relay K2 is a relay for the load, while relay K1 functions as a control relay (controller) or driver for relay K2 (load relay).

The load relay driver circuit uses a circuit as in Fig.4. This circuit functions as a battery voltage detector. The circuit's input is connected to the battery, while the output is connected to the load relay. This circuit will regulate the load relay when it is off or does not flow current to the battery and when it is on or flows current to the battery.

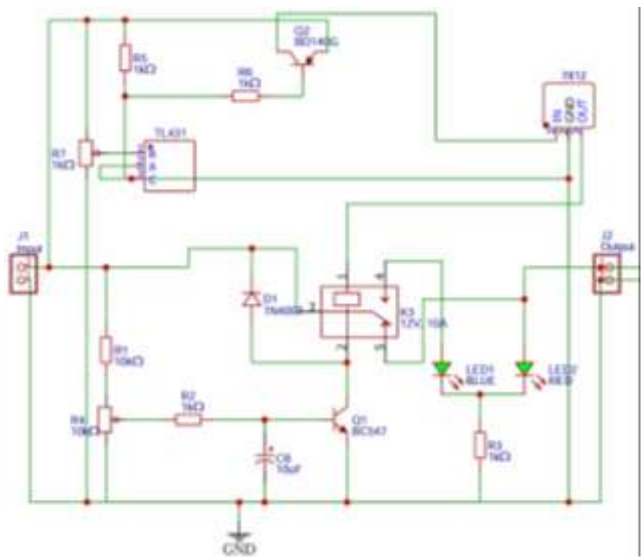

Fig.4. Load relay driver circuit

The battery applied in this Final Project is a VRLA (Valve Regulated Lead Acid) type, which is maintenance-free. Based on the results of the relatively low wind turbine power with the highest output power during the experiment with a wind speed of 4.2 m/s, namely 3.56 Watts, and the average power during the experiment with a wind speed of 2.2 m/s to 4.2 m/s, namely 1.7275 Watts, it can be calculated for the battery capacity requirements used to store the energy produced by the wind turbine.

3. **Test Result**

3.1 Sepic DC-DC Converter Test Results with Power Supply

This sepic DC-DC converter is tested using a power supply and a multimeter. This test is done by giving input voltage to the DC-DC converter with a power supply, and then the output voltage of this converter will be measured using a multimeter. This test uses a power supply as an input voltage source so that the input voltage can vary with a specific voltage range according to the specifications of the DC-DC converter. This test diagram can be seen in Fig.5.

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 9 Issue 5 May 2025, Pages: 131-138

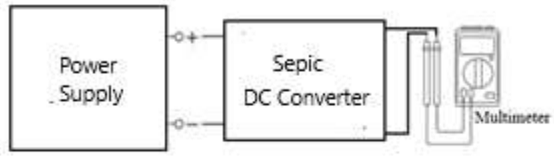

Fig.5. Test diagram of DC-DC converter SEPIC with power supply

The test results of the DC-DC converter sepic with power supply are shown in Table 2. Based on Table 3.1, the DC-DC converter test without load can produce a constant voltage from the changes in the input voltage given. When the input voltage is 5 V to 20 V, the output voltage shows a fairly steady voltage, namely at a voltage of 14.0 V. When the input voltage is below 4 V, there is a voltage drop whose value approaches 0. Voltage drops are caused by the EN pin setting on the XL6009 IC working well, putting the circuit in an off condition. After all, the input voltage is below the minimum specification of the DC-DC converter circuit. After being off, the circuit will return to on at a voltage of 5.5 V. Based on the results in Table 2, this DC-DC converter has worked well. Constant voltage is needed for battery charging in the PLTB system used in this Final Project. The changing output voltage from the generator can be stabilized using a DC-DC converter so that battery charging can work well.

Table 2 DC-DC converter SEPIC test results

Input Voltage (V)	*Output Voltage* (V)
4	0
5	14,0
6	14,0
7	14,0
8	14,0
9	14,0
10	14,0
11	14,0
12	14,0
13	14,0
14	14,0
15	14,0
16	14,0
17	14,0
18	14,0
19	14,0
20	14,0

3.2 Battery Cut Off Circuit Test Results

This test uses a power supply to set the voltage when the cut-off and when the recharge starts. The cut-off voltage is set at 13.8 V according to the full voltage of the 12 V battery. The voltage when the recharge start condition is set at 12.5 V, so the battery voltage is not too low—the cut-off voltage setting and when the recharge start condition can be adjusted by turning the potentiometer. When the battery is charging, the LED indicator that lights up is red, while after the cut-off, the LED indicator that lights up is blue. This test diagram can be seen in Fig. 6.

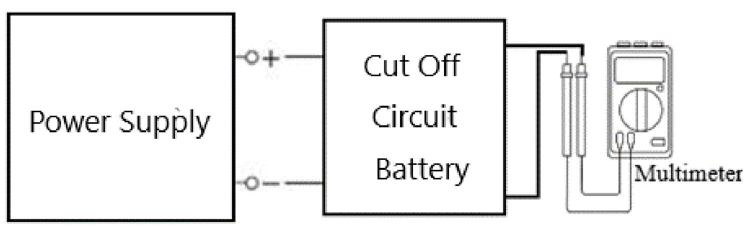

Fig.6. Battery cut off circuit test diagram with power supply

The test results of the battery cut-off circuit with a power supply are shown in Table 3.. Based on Table 3.2, the cut-off circuit has worked well. When the condition starts charging the battery from a low battery voltage, the cut-off circuit can cut off the charging voltage for the battery when the voltage is 13.8 V as set. When the condition is cut off, or after the battery charging is interrupted, this circuit can work according to the voltage setting of the condition to start recharging the battery that has been set, namely at a voltage of 12.5 V.

Table 3. Battery cut off circuit test results

Voltage (V)	LED Indicator	
	Condition Starts charging	Condition after *Cut Off*
12,4	Red	Merah
12,5	Red	Merah
12,6	Red	Blue
12,7	Red	Blue
12,8	Red	Blue
12,9	Red	Blue
13,0	Red	Blue
13,1	Red	Blue
13,2	Red	Blue
13,3	Red	Blue
13,4	Red	Blue
13,5	Red	Blue
13,6	Red	Blue
13,7	Red	Blue
13,8	Blue	Blue
13,9	Blue	Blue

3.3 Battery Charging Circuit Test Results

This test is done by using a power supply to supply this circuit. This circuit is connected to a 12V 5Ah battery load to charge the battery. This circuit is also connected to a 12V LED load with a power of 1.5 Watts. This LED is used to load the battery so that in the cut-off condition when the battery is full, its capacity can be reduced because there is a load. This aims to test the circuit to see when it can be reconnected with the input voltage to the battery to be recharged. This test diagram can be seen in Fig.7.

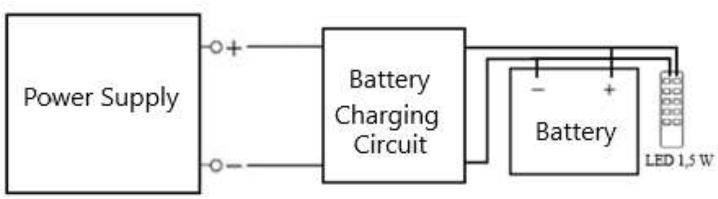

Fig.7. Test diagram of battery charging circuit with power supply

The results of the battery charging circuit test with a power supply are shown in Table 4.. The table shows that the circuit can break the circuit at a voltage of 13.8 V and can start recharging the battery at a voltage of 12.5 V. The data in the table shows that the circuit has worked well, as demonstrated by previous tests. The current value drops when the battery voltage starts to rise. When the battery voltage shows 12.8 V, the current flowing is 0.33 A, while when the largest battery voltage is 13.7 V, the current flowing is 0.29 A.

Table 4. Results of battery charging tests

	LED Indicator	Current(A)

Charging Voltage (V)	Battery Voltage (V)	Condition Starts charging	Condition after *Cut Off*	
14	12,4	Red	Red	0,33
14	12,5	Red	Red	0,33
14	12,5	Red	Red	0,33
14	12,6	Red	Blue	0,33
14	12,7	Red	Blue	0,33
14	12,8	Red	Blue	0,33
14	12,9	Red	Blue	0,33
14	13,0	Red	Blue	0,32
14	13,1	Red	Blue	0,32
14	13,2	Red	Blue	0,32
14	13,3	Red	Blue	0,32
14	13,4	Red	Blue	0,32
14	13,5	Red	Blue	0,30
14	13,6	Red	Blue	0,30
14	13,7	Red	Blue	0,29
14	13,8	Blue	Blue	0,29
14	13,9	Blue	Blue	0

4. **Conclusion**

Based on the results of testing and discussion that have been carried out in this paper, the following conclusions can be obtained:

1. The SEPIC DC-DC converter circuit can work well by maintaining output stability for battery charging in the voltage range of 5 V-20 V. At voltages below 4 V, the circuit will turn off the output voltage of the SEPIC DC-DC converter is almost close to 0 V. When after turning off the circuit will return to on at a voltage of 5.5 V.

2. The battery charging cut-off circuit can cut off the charging current when it reaches a battery voltage of 13.8 V and can reconnect the battery charging current when the battery voltage is 12.5 V.

5. **References**

[1] PPPPTK dan BMTI, “Modul Pengembangan Keprofesian Berkelanjutan Teknologi PLTB,” Jakarta, Indonesia: Kementerian Pendidikan Dan Kebudayaan Direktorat Jenderal Guru dan Tenaga Kependidikan, 2015.

[2] R. F. Muhammad, dan Hendrayana, “Analisa Potensi Energi Angin Dengan Distribusi Weibull Untuk Pembangkit Listrik Tenaga Bayu (PLTB) Banda Aceh,” Jurnal Ilmiah Pendidikan Teknik Elektro ISSN: 2549-3698, Vol. 1, No. 1, hal. 1-8, 2017.

[3] N. Yuniati, dan I. W. Aji, “Modul Pembelajaran Pembangkit Tenaga Listrik,” Yogyakarta, Indonesia: Universitas Negeri Yogyakarta, 2019.

[4] Prihananto, M. Facta, dan Sudjadi,” Perancangan Cut Off Sebagai Pemutus Tegangan Dan Arus Sistem Charging Baterai,” Jurnal Transient ISSN: 2302-9927, Vol. 7, No. 4, hal 911-917, 2018.

[5] R. Fibrianti, "Rancang Bangun SEPIC (Single-Ended Primary Inductance Converter) untuk Aplikasi MPPT (Maximum Power Point Tracker) Jenis ConstantVoltage (CV)," Jurnal Teknologi Elekterika ISSN: 1412-8764, Vol. 17, No. 2, hal. 46-53, 2020.

[6] N. Najib, A. Syakur, dan Y. Alvin, “Perancangan Sistem Charging Baterai pada Prototipe Alat Ukur Tegangan Ujung Feeder Berbasis IOT,” Laporan Tugas Akhir, Program Studi Teknik Elektro, Universitas Diponegoro, Semarang, 2020.

[7] H. Lesmana, “Rancang Bangun Pembangkit Listrik Tenaga Angin Untuk Kebutuhan Listrik Skala Kecil,” Laporan Tugas Akhir, Jurusan Teknik Elektro, Universitas Islam Indonesia, Yogyakarta, 2011.

[8] On Semi, “SEPIC Converter Analysis and Design”, AND90136/D, United States, 2021.

[9] H. Asyari, “Pengisian Baterai Menggunakan Buck-Boost Converter pada Sistem Energi Surya,” Laporan Tugas Akhir, Jurusan Teknik Eletro, Universitas Negeri Semarang, Semarang, 2019.

[10] F. F. Muhammad, “Desain Sistem Pengendali Pengisian Baterai pada Mobil Listrik,” Laporan Tugas Akhir, Jurusan Teknik Elektro, Universitas Semarang, Semarang, 2023.

[11] S. Meliala, M.Rijal, dan Taufiq, “Studi Kapasitas Baterai 110 Volt DC Unit I pada Gardu Induk 150 KV Bireuen,” Jurnal Energi Elektrik, Vol. 10, No. 02, 2021

[12] P. Horowitz, dan W. Hill, "The Art of Electronics Third Edition," New York, United States: Cambridge University, 2015.

[13] Irkham, I. Setiawan, and A. Nugroho, "Perancangan Boost Converter sebagai Suplai Inverter menggunakan DSPIC30f4011 dengan Metode Kontrol Proportional Integral," Jurnal Transient ISSN: 2302-9927, Vol. 7, No. 3, hal 737-744, 201

[14] XL Semi, “XL 6009 Datasheet,” Rev. 1.1, XL Semi, [Online]. Tersedia: https://www.xlsemi.com.

[15] D. S. Yanaratri dkk., "Estimasi SOC Saat Discharging pada Baterai VRLA berbasis Elman Backpropagation," Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika, Vol. 12, No. 4, Hal. 862 - 876, Oktober, 2024.

[16] Irawan, “Pengaruh Variasi Depth of Discharge terhadap Kerusakan Baterai VRLA,” Laporan Tugas Akhir, Jurusan Teknik Mesin, Institut Teknologi Sepuluh November, Surabaya, 2016.

[17] [17] A. F. Farizy, D. A. Asfani, dan Soedibjo, "Desain Sistem Monitoring State of Charge Baterai pada Charging Station Mobil Listrik Berbasis Fuzzy Logic Dengan Mempertimbangkan Tempera1ture," Jurnal Teknik ITS ISSN: 2337-3539, Vol. 5, No. 2, hal. B278-B282 ,2016.

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 9 Issue 5 May 2025, Pages: 131-138

Authors

Budi Setiyono, born in Purbalingga on May 21, 1970, completing his undergraduate and master's degrees in the Electrical Engineering Department of Gadjah Mada University in the field of Electronic Signal Processing. Become a lecturer in Electrical Engineering Department Diponegoro University since 2000. The field of science is a technique of automatic control with specialization in modeling and intelligent Control.

Ravido Maedya Putrawerdana, born in Temanggung, May 13, 2000. He was educated from Pancasila Kindergarten in 2004 - 2006, Jampiroso 2 Elementary School in 2006 - 2012, Temanggung 2 Junior High School in 2012 - 2015, and Temanggung 1 Senior High School in 2015-2018. Currently, the author is studying for a Bachelor's degree in Electrical Engineering at the Faculty of Engineering, Diponegoro University, concentrating in Electrical Power Engineering, class of 2018.