



Buck-Boost Converter Using Control Proportional Integral Derivative (PID)

Rizky Aprylianto Susilo¹, Mohd. Johanuddin², Besse Ita Sari³

^{1,2,3} Department of Electrical Engineering, Samarinda State Polytechnic
Jl. Cipto Mangun Kusumo, Sungai Kledang, Samarinda, Indonesia. 75131

ABSTRACT: Solar Power Plants are systems A power plant that utilizes energy from light the sun to produce electrical energy. But often a problem was found, where the resulting output voltage not constant. For this reason, the Buck-Boost circuit is used converter, a piece of equipment that has a converting function the varying DC input voltage becomes a voltage constant DC output. In this research, a simulation was carried out to a buck-boost converter using PID control. Design simulated with Proteus 8.9. Input voltage setting is the main objective in analyzing success simulation series created. Selection of PID control constants the right one will produce a buck-boost output voltage the converter matches the setpoint and gets a response stable output voltage. By using the trial method and error obtained that with the PID constant, namely $K_p = 1.0$, $K_i = 0.01$, $K_d = 0.1$ and for an input voltage range of 12 volts up to 40 volts, the simulation results show that the voltage The output is relatively constant, namely 24 volts with a load test fixed and variable loads.

KEYWORDS: Buck-boost converter, MOSFET, PWM, PID controller

1. INTRODUCTION

Electrical energy is one of the primary needs what humans need in the era of society 5.0. along with As the demand for electrical energy increases, it becomes increasingly scarce fossil fuels so research efforts are needed to produce renewable energy. One of the renewable energies are solar panels [1], [2]. Solar Power Plants (PLTS) are systems A power plant that utilizes energy from light the sun to produce electrical energy. Lots of PLTS used as an electricity supplier because it is environmentally friendly, more effective and more efficient [3], [4]. Remembering Indonesia is a tropical area, so it would be very good if PLTS seriously developed. However, problems are often found, where the voltage is the resulting output is not constant [5], [6]. So that A system is needed that is capable of changing the voltage The output becomes constant at that voltage set [7], [8]. A buck-boost converter is an included component in PLTS which is used to regulate the output voltage from solar panels. This converter has the ability to change the output voltage to more output greater or smaller than the input voltage [7]. One control system that is widely used is PID control [9]. PID control is a combination of proportional control, integral control and derivative control. With proper determination of the PID constant, it will produce fast system response, fast settling time or approaching zero and steady state error approaching zero [8]. To get good output results then the parameters in the PID controller need to be set. These parameters are constant parameters proportional (K_p), integral (K_i) and derivative (K_d). Constant proportional (K_p) functions to reduce rise time and steady state error. The integral constant functions to eliminate steady state error. If the two controllers are combined then produces a PI controller, but the response is transient getting worse. So a derivative controller is needed (D) which functions to perfect the shortcomings of PI controller [8], [10]. The entire set of buck-boost converters and controllers Proportional Integral Derivative (PID) is realized and tested using Proteus 8.9 simulation software. Based on the background description above, the research it carries the title "Buck-Boost Converter Using Proportional Integral Derivative (PID) Control".

2. MATERIAL AND METHODS

2.1 Research Conceptual Framework

The research conceptual framework is a researcher's framework related to the scope, material limitations, and results to be achieved in the research stages, explained in the form of a flow chart.

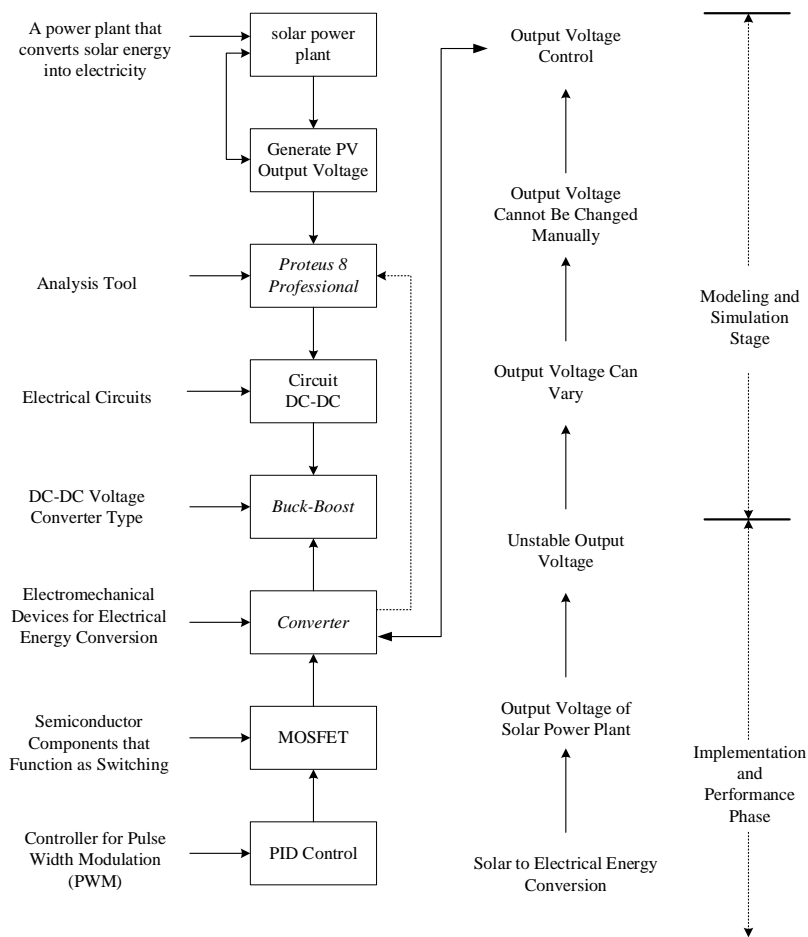


Figure I. Research Conceptual Framework

In Figure I. above shows the photovoltaic output voltage converter using Proportional Integral Derivative (PID) control and simulated in Proteus 8 professional software with a buck-boost converter circuit model. In addition, there is also an element of interference such as unstable photovoltaic output voltage. So that this voltage converter is expected to be able to maintain the voltage in normal operating conditions after the disturbance so that the distribution of electrical energy is not interrupted and does not cause losses to its users. The conceptual framework above shows that when there is instability in the output voltage, the system performance will be disrupted which results in the output voltage cannot be varied or changed manually, therefore one way to reduce the impact of these disturbances is to use Proportional Integral Derivative (PID) control with a buck-boost converter circuit. This buck-boost converter contains semiconductor components that function as switching called MOSFETs. Where the switch will be controlled by Proportional Integral Derivative (PID) to produce Pulse Width Modulation (PWM) on a DC voltage source that is kept constant. Based on the description above, the conceptual framework in this research consists of two stages, namely as follows:

1. Modeling and simulation stage to model the buck-boost converter circuit in simulation form using Proteus 8 professional software, then tested to see that the design is ready for analysis for voltage converters using Proportional Integral Derivative (PID) control.
2. The application and performance stage is an analysis of the design that has been made with conditions when only using Proportional (P), Proportional Integral (PI), Proportional Derivative (PD) controls and when using Proportional Integral Derivative (PID) controls.

2.2 Research Operational Framework

In Figure II shows the flow chart of the research operational framework, that the research process starts from a literature review consisting of a literature review and a case review, until the results of the literature review are obtained in the form of varying output voltages and Proportional Integral Derivative (PID) control specifications. Then the acquisition of data from reference data and data sheets will be processed. The program (software) to design the buck-boost converter circuit and design the Proportional Integral Derivative (PID) control system and analyze it is using Proteus 8 professional software, Arduino IDE software and Microsoft Office 2019 (Microsoft Word 2019). The research continues with the process of designing a buck-boost converter circuit and Proportional Integral Derivative (PID) control system design. After that, testing of the circuit that has been designed will be carried out, then the data obtained from the simulation test results of the circuit design will be implemented whether it is appropriate or not, for comparison the data will be adjusted to the limits used. Furthermore, the final stage is the results and discussion obtained in the form of circuit design and simulation of the buck-boost converter when using Proportional Integral Derivative (PID) control.

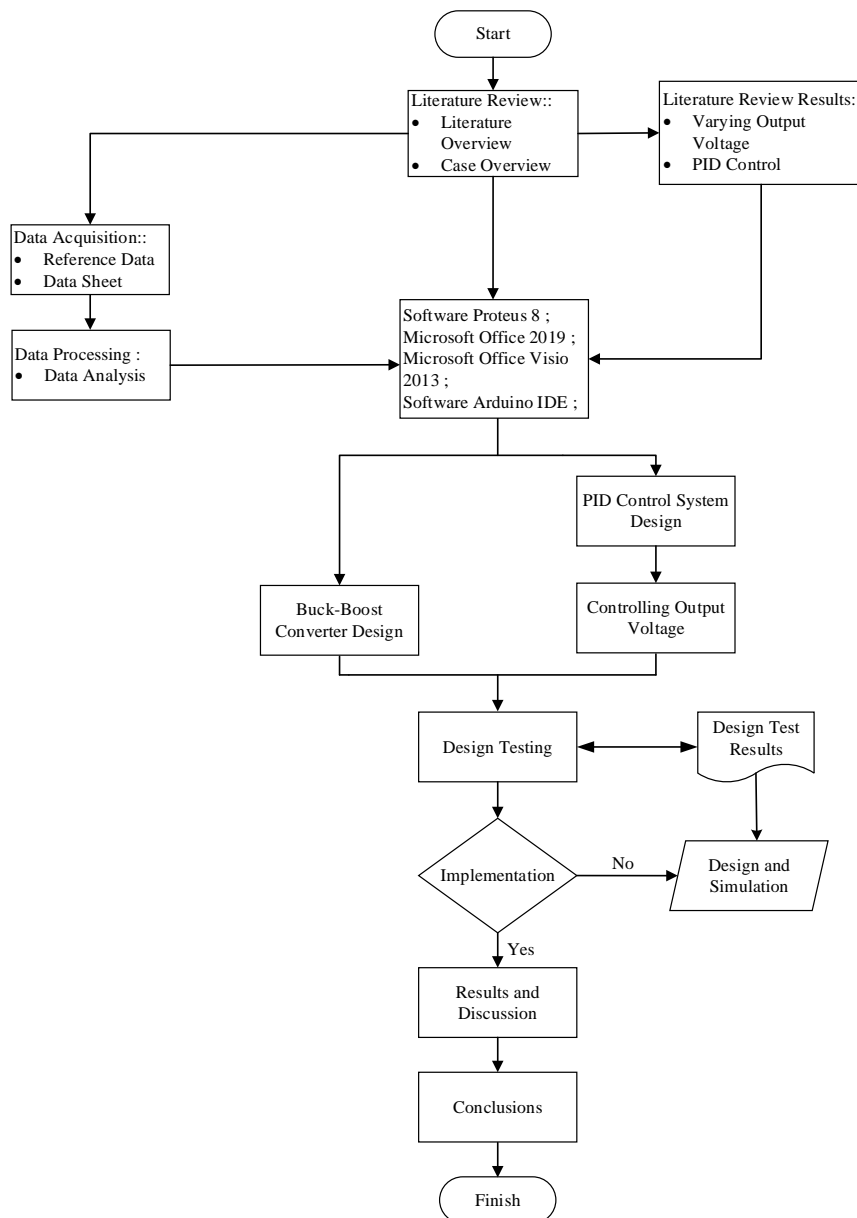


Figure II. Research Operational Framework

2.3 Proportional Integral Derivative (PID) Control Block Diagram

A block diagram is a concise explanation of the cause and effect between input and output in a system in the form of an arrangement of blocks. The block diagram for Proportional Integral Derivative (PID) control can be seen in Figure III.

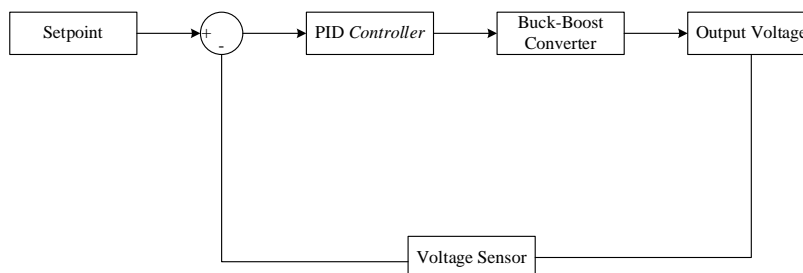


Figure III. Proportional Integral Derivative (PID) Control Block Diagram

3. RESULTS AND DISCUSSION

3.1 PID and PWM Control Design

The controller is used to control the output voltage from the buck-boost converter so that the output voltage is stable. The controller used is the Arduino Uno microcontroller by using the PID controller algorithm. In making this controller that is considered is about the setpoint of the buck-boost output that must be maintained which is seen from the ADC data. seen from ADC data. For frequency settings displayed on the program,

```
setPwm Frequency (9, 8);
```

Then the sensor will read the voltage from pin A0,

```
sensor = analog Read(A0);
```

To convert the analog reading value to digital, the number read will be multiplied by 5 and then divided by 1024.

```
compare = (sensor * 5) / 1024
```

In the two command lines below, calculations are performed when the voltage passes through the voltage divider,

```
current = compare / 2; double teg_out = current * 12;
```

Then the time calculation is carried out, to find out the resulting voltage difference, as well as calculating the various error parameters required to adjust the output voltage,

```
unsigned long now = millis();
double timeChange = (double)(now - lastTime);
double dErr = (error - lastErr) / timeChange;
error = sp_teg - teg_out;
lastErr = error;
lastTime = now;
errSum += (error * timeChange);
Output = kp * error + ki * errSum + kd * dErr;
```

3.2 Testing Phase

At this stage is the data collection stage collected based on tests carried out on simulation of the circuit created. Specifications for simulation on buck-boost converter circuit, namely with a load R of 12 ohms, an inductor of 100 uH and a capacitor of 8600 uF.

Table I. Testing Data Minimum Input Voltage Value (12 V) To Maximum (40 V)

V input (V)	Setpoint (V)	- V output (-V)	Error (%)
12	24	24.3	1.25
15	24	24.6	2.5
18	24	24.4	1.67



20	24	24.3	1.25
22	24	25	4.16
25	24	24.3	1.25
28	24	24.4	1.67
32	24	24.6	2.5
37	24	23.9	0.41
40	24	25	4.16

From the test results above, it can be seen from the testing data and waveform graphs buck-boost converter works and works well at minimum to maximum voltage although the voltage on the input side changes, the voltage on the output side is relatively constant, which is close to the desired output voltage (24 volts) with an error of under 5% with PID parameters namely $K_p = 1,0$, $K_i = 0,01$ and $K_d = 0,1$. Also tested with different PID parameter values but the resulting output voltage parameter values but the resulting output voltage value has not meet the desired setpoint.

Table II. Testing Data Maximum Input Voltage Value (40 V) To Minimum (12 V)

V input (V)	Setpoint (V)	- V output (-V)	Error (%)
40	24	25	4.16
38	24	24.6	2.5
35	24	23.1	3.75
30	24	24.5	2.08
26	24	23.9	0.41
23	24	24.9	3.75
21	24	24.3	1.25
17	24	24.5	2.08
14	24	24.5	2.08
12	24	24.3	1.25

From the test results above, it can be seen from the testing data and waveform graphs buck-boost converter works and works well at maximum to minimum voltage although the voltage on the input side changes, the voltage on the output side is relatively constant, which is close to the desired output voltage (24 volts) with an error of under 5% with PID parameters namely $K_p = 1,0$, $K_i = 0,01$ and $K_d = 0,1$. Also tested with different PID parameter values but the resulting output voltage parameter values but the resulting output voltage value has not meet the desired setpoint.

Table III. Test Data Of Fixed Input Voltage Value (40 V) With Varying Loads R Load Varies

V input (V)	R beban (Ω)	Setpoint (V)	-V output (-V)	Error (%)
40	5	24	24.2	0.83
40	7	24	24.3	1.25
40	8.5	24	24.4	1.67
40	10	24	24.7	2.91
40	12	24	25	4.16
40	13.5	24	23.7	1.25
40	16	24	22.7	5.41



40	17	24	23.2	3.33
40	19	24	24.5	2.08
40	20	24	25.1	4.58

Testing buck-boost converter using PID control PID control is carried out with a variable load of 20 ohms at the maximum voltage of 40 V. This test aims to determine whether the system can maintain stability in accordance with the desired setpoint with a change in load. load changes. In this test, an input voltage of 40 V with the desired buck-boost output voltage of 24 V with PID parameters K_p , K_i , and K_d . (setpoint) is 24 V with PID parameters namely $K_p = 1.0$, $K_i = 0.01$ and $K_d = 0.1$.

From each test result that has been done, the buckboost converter can work according to its purpose with good results. good results.

4. CONCLUSION

Based on the simulation results and discussion of the analysis analysis of the buck-boost converter circuit using PID control it can be concluded that:

1. The output voltage on the output side of the buck-boost converter can be maintained relatively constant by using PID control system even though the voltage on the input side DC source and R load changes.
2. In this study, the PID parameter setting value using the trial and error method with the values $k_p = 1.0$, $k_i = 0.01$, and $k_d = 0.1$.
3. Buck-boost converter testing is influenced by parameters such as duty cycle and the value of components to be used. components to be used.
4. The test results obtained a minimum voltage of 12 V when duty cycle 37.5% while the maximum voltage is 40 V when the duty cycle is 67%.

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