

Design of Buck-Boost converter with PID controller for Solar System

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Abstract : Currently, there are numbers of technologies are available to control the output of the solar systems. In this work, to get the constant output voltage, a buck-boost converter is used. To control the converter to get constant output, a PID controller is designed. This PID controller can make the controlled system with excellent dynamic characteristics. This project considered the change in input irradiation to implement the uncertainty across the solar panel, whereas the output voltage across the load remains constant. The simulation result of the buck-boost converter with PID controller improved the output voltage with an efficiency of more than 90%

IndexTerms - Buck-Boost Converter, PID controller, Solar system.

I. INTRODUCTION

In the future, Photovoltaic (PV) systems will have a great significance of energy systems as it is a source of renewable energy that converts the light into electrical energy using semiconductor materials. The efficiency of the PV-based solar system is very-less because of the variable solar radiation. A PV cell is required to generate a constant DC voltage. To address the inconstant output voltage of the PV, a buck-boost converter has been used. It is also known as step-down and step-up, or the DC-DC converter. It is widely used as a voltage controller to control the voltage between the source and the load using PWM signals [1-3]. In this paper, the authors design a PID controller and simulate the PID to make constant output voltage of the buck-boost converter. PID is a feedback control loop system that is used in industrial control systems widely. It calculates the error value over the desired value and corrects the output based on three terms proportional, integral, and derivative. Those three controllers combined operate and give a control strategy. Moreover, PID also can be used to control the temperature, MPPT charge controller, and also used as the converter of power electronics.

II. METHODOLOGY

2.1 Matlab

In this project, we have designed the model with the help of MATLAB software. MATLAB stands for matrix laboratory. It is a high-performance language that is used for technical computing. We can solve math, design model, simulation, and engineering graphics with this software. C and Fortran Programming is also supported by MATLAB.

2.2 Buck-Boost Converter

The buck-boost is a DC-to-DC converter that is used to control the output voltage [3]. The output voltage of the converter is either less or more than the input source voltage magnitude. It is a converter which is combined a buck converter topology and a boost converter topology in cascade. The polarity of the output voltage will be the opposite of the input voltage polarity.

Here, V_i is the input voltage and V_o is the output voltage, L , C , R , D are Inductance, capacitance, resistance, and diode respectively. S is a switch, V_D and I_D are diode voltage and diode current which are 0.8 and 0, respectively. The value of resistance is 100 ohms, and inductance is 0.001 H. The input of the buck-boost converter can be a DC battery or solar panel. This circuit can operate in two ways. When the switch S is on, the diode will be reverse biased. Under the reverse biased condition current flows through the inductor. When the switch will be turned off, the second operation mode begin. In this mode, the input current flows from the inductor through the capacitor, diode and the output resistor. In this case diode operates in forward based. In the next cycle, when the switch will be on again then the energy stored in the inductor will be transmitted to the load. Then the inductor current falls down. By controlling the switch duty cycle, we can control the output voltage of the buck-boost converter. In this project, a PWM generator is used to supply the control signal to the buck-boost converter and can achieve outputs of any magnitude. The switching frequency of the PWM generator is $1e5$. If there is required some variation of the output voltage of the buck-boost converter, then the duty cycle of the PWM generator is automatically controlled with the help of the PID controller.

2.3 PID Control System

The buck-boost is a converter that convert the one level of DC voltage into the other level. It output voltage either be more or less than the input supply voltage as per the control command given by the PID controller [4-5]. This controller consists of following response.

Proportional Response: The proportional coefficient is measured by the difference between our set point and actual process variable. The value of proportional gain $K(p)$ is 100. The difference of set point and process value is referred to as Error term. The proportional gain K_p determines what is the ratio of Error signal and output response.

Integral Response: The integral coefficient K_i is measured by the Error term over time. The value of the integral coefficient is 10. Over time the integral coefficient will increase if the Error term is not zero

Derivative Response: The derivative coefficient K_d is depending on the ratio of change of the process variable. If the process variable is increase K_d causes the output to decrease. Derivative response is so sensitive to the process variable signal.

The filter coefficient (N) of the PID system is 100000. Here, set point voltage is the reference voltage which is required voltage. Error is the difference between our set point and actual process value. Process is the system to be controlled. Output is the value of the voltage which have to be controlled. And the time (t) is the instantaneous time.

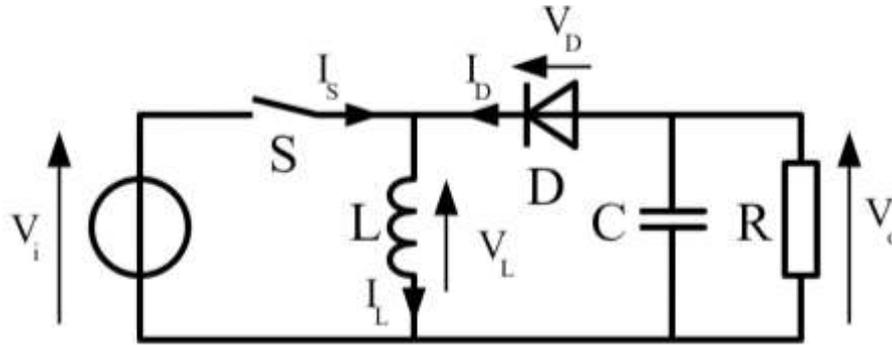


Fig.-1 : Buck-Boost converter.

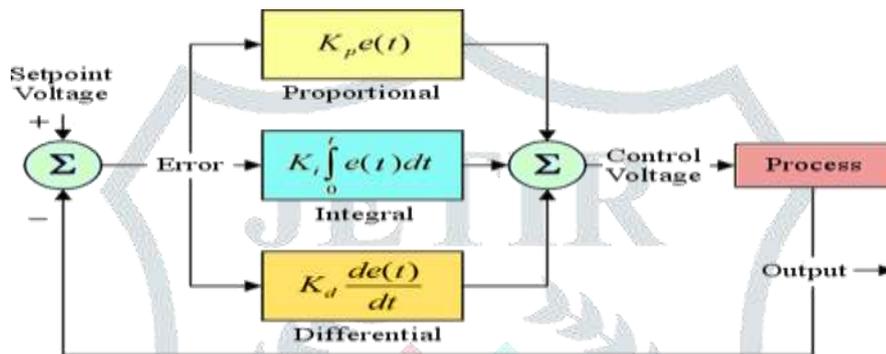


Fig.-2 : Functional Diagram of a PID Control Loop

III. PROPOSED SYSTEM

The complete circuit diagram represents in Fig. 4, It consists of a solar-powered buck-boost converter with a PID controller. Where the Fig. 3 represent the converter without PID controller, it is used to analyzed the performance of the PID module. The complete device will run with the solar input power using the Matlab module SunPower SPR-305E-WHT-D. The maximum power of this module is 305.2 watts. In this system, the buck-boost converter is used as a DC-DC converter. The output voltage of this converter can be less than or greater than the input voltage as per the requirement. Here, the PID controller is being used for controlling the buck-boost converter. So that, it can convert the required value of output voltage as per the given setpoint value of PID.

A buck-boost converter can generate both greater than or less than the input voltage. So it is helpful to get the required output voltage. If the required output is more than the buck-boost converter step-up the input. When required output is less, then the converter step-down the input. PID is most modern closed loop controlling system. It can be easily tuned. It has the stability of the system. Both the circuit response rapidly and both are easy to design. The main drawback of this converter is that its efficiency is low, so it cannot achieve high gain. It may unstable for certain application. Controlling system can also be unstable if it is not tuned perfectly. It also amplifies the noise signal. It can make a saturation effect on the system.

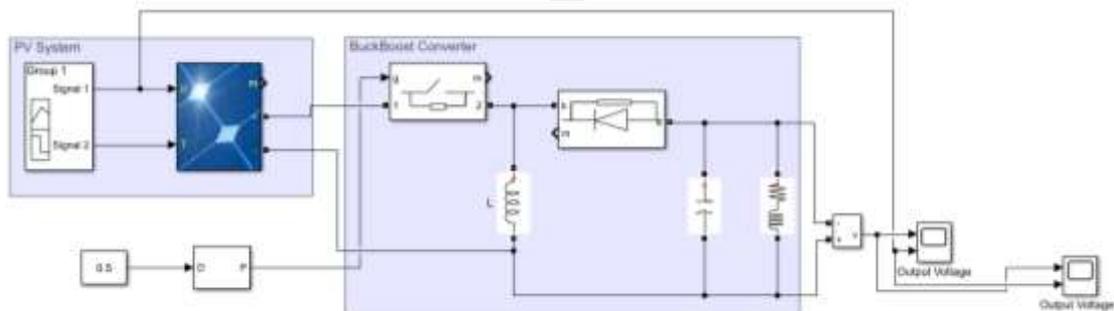


Fig. 3 Module without PID controller.

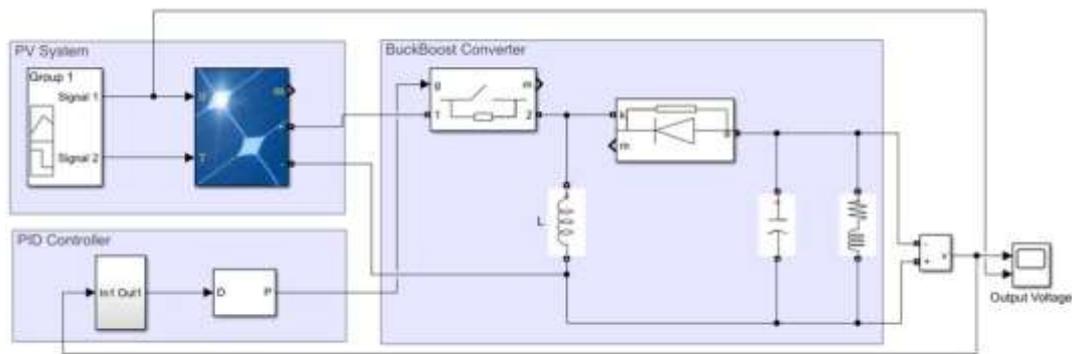


Fig. 4 Complete module with PID controller.

IV. RESULTS AND DISCUSSIONS

In order to check the accuracy of proposed model, simulation analysis was conducted on the two different solar modules provided with and without the PID controller as given in Fig. 3 and Fig. 4 respectively.

Simulation results without the PID controller shown in Fig. 5, the input irradiance is varying between 400 w/m² to 500 w/m² across the given solar panel. The irradiance decreases 500 to 400 at 0 sec to 0.5 sec and again increases 400 to 500 at 1.5 sec. As per the given irradiance, the output voltage across the DC/DC converter is not constant. The output voltage is continuously varying. The maximum and minimum overshoot voltage will be 900 V to 1000 V.

This is the simulation results for the PID based module shown in Fig. 6, the input irradiance is varying between 400 w/m² to 500 w/m² for the solar panel as given for the Fig. 5. Here the input irradiance is varying but the output voltage is constant after settling time.

In PID controlled model shown in Fig. 4., the set point voltage is 300 volts. The Fig. has a rise time of 0.008 sec, it is without voltage oscillation. the settling time is about 0.015 sec and the maximum overshoot voltage will be 1000 V. After the settling time the output voltage is settle down to 300 V, which is the required output voltage. The system has very excellent characteristics because we can see it has a very short rise time, there is no oscillation, and can achieve the required output voltage. So, the circuit of this control system can make satisfactory results.

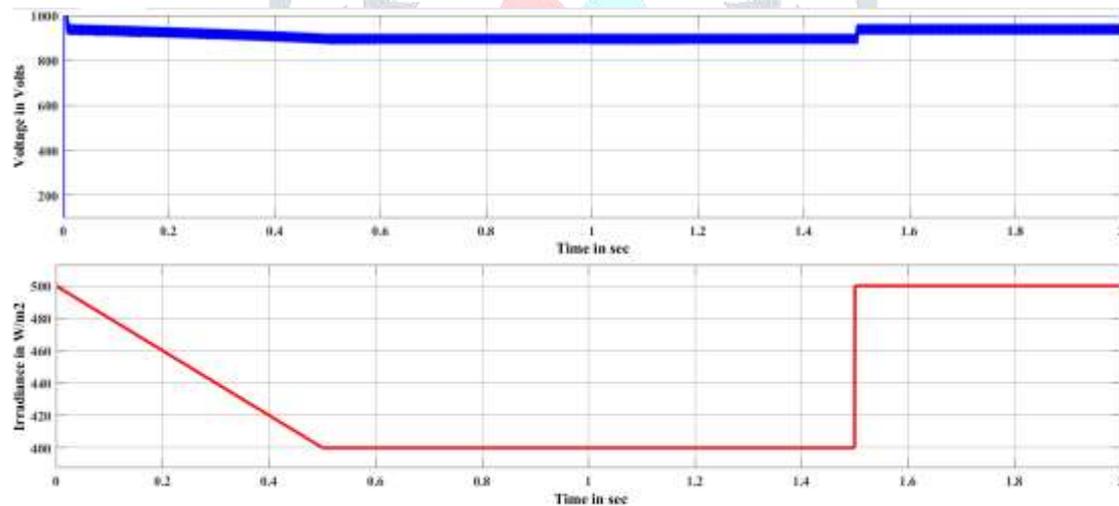


Fig. 5: Output result without PID.

V. CONCLUSION

In this paper, our main goal is to get constant output voltage from any renewable energy source like a solar panel. As the solar output is not constant and it is varying with time with change in input irradiance, and other factors like temperature. But the load required constant output for better operation. Therefore, in the proposed work, the Buck-Boost converter with PID controller is presented. The simulation results indicate that the proposed model has excellent dynamic and steady-state performance. So, by using this model output solar system can be improved for the small or microgrid system, where the constant voltage generation having the more importance.

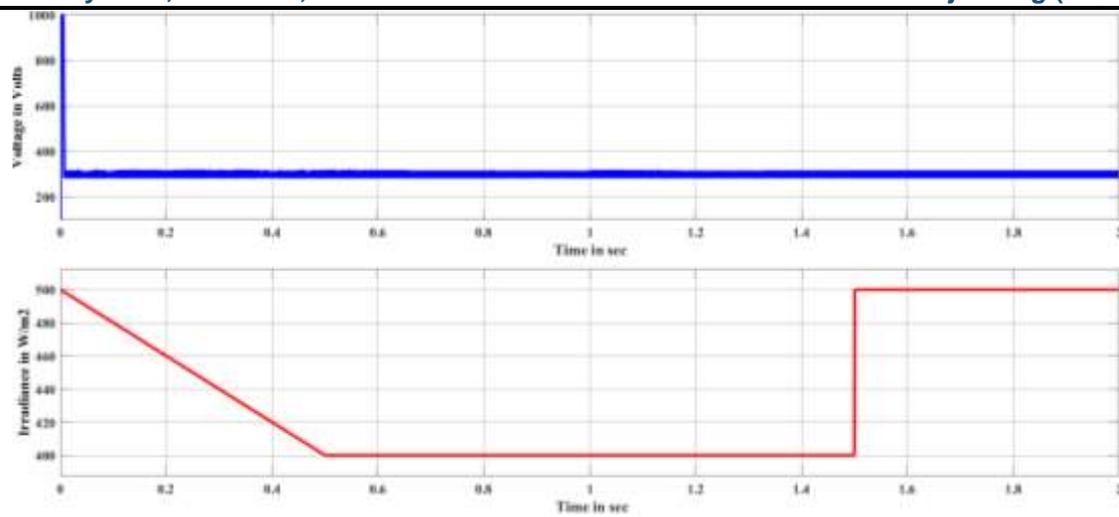


Fig. 6: Output Results with PID

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