Design of PID Controller for Maximum Power Point Tracking for PV Energy Systems

Saurabh Bhowmik, Raval Parth Pradip and Chitrangada Roy

Abstract Modeling of PID control system in DC–DC boost converter with variable input DC voltage at varying irradiation levels in the solar PV system has been implemented in this paper. The proposed model of PID controlled DC–DC boost converter prevents overshoot and oscillations of the output voltage obtained from it and tracks maximum power. Design and simulation of a PID control system is to soothe the output voltage of the DC–DC boost converter. The implementation results using constant irradiation and variable irradiation level with constant temperature are presented. Result and analysis supports the validity and advantages of the PID method.

Keywords DC–DC boost converter · PID controller · Irradiation · Maximum power point tracking · Solar cell

1 Introduction

Solar energy is the renewable form of energy, which can be utilized and stored in the form of voltage. However, due to its very low efficiency and unregulated characteristics makes it underrated. In the past few years, many new inventions and methods were proposed to overcome this problem. Solar Photovoltaic (PV) cell generates unregulated voltage from the solar radiations but it is very less [1]. To get the maximum power from the given system, its maximum power should be known by maximum power point tracking methods. DC–DC converters help to enhance or

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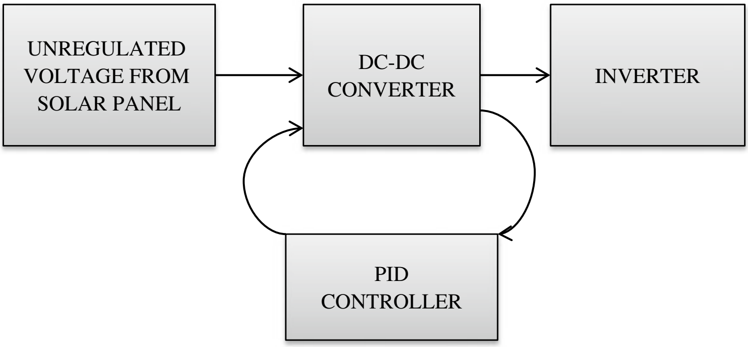

Fig. 1 General block diagram for control of DC–DC converter

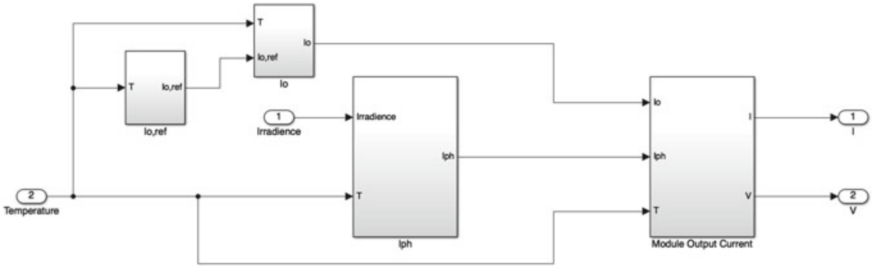

Fig. 2 Basic modeling of solar cell

reduce the voltage that is generated from the solar cell to acquire maximum power at specific voltage. To get maximum power with the help of DC–DC converters different types of controllers are used. Here, PID and normal pulse generator are used to generate the specific voltage for maximum power (Fig. 1).

2 Modeling of Solar Cell

Modeling of solar cell for different irradiation and temperature is proposed in Fig. 2 [3]. Now accordingly, the generated voltage from the solar cell is fed to the DC–DC converter. This solar cell can be tuned for a specific purpose.

3 Designing of DC–DC Boost Converter

DC–DC converter increases or decreases the unregulated voltage from the solar panel [2]. Here, the main focus is on increasing the voltage, so the boost converter modeling

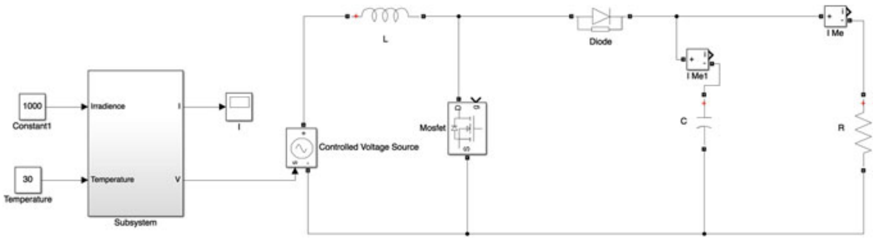

Fig. 3 Basic circuit for DC–DC boost converter

is proposed. A general model of the boost converter is shown in Fig. 3. Unregulated DC input voltage from solar cell, L is the induction, C is the capacitance, and output voltage will be taken across resistor R. The switching of MOSFET is given by the PID controller [3].

4 Designing of PID Controller

To control the switching of MOSFET in DC–DC boost converter, different types of controllers are used like P, D, PI, PD, PID, many more, and I. PID controller controls the switching of MOSFET to get the desired output voltage from DC–DC boost converter. Proportional, Derivative and Integral operations are used to reduce the error and for stability of step response in the system. These can be achieved by controlling the gains K_p, K_i, and K_d. The general equation for PID controller is given in Eq. 1 [4].

$$\mathrm{U(t)} = \mathrm{K_p\,e(t)} + \mathrm{K_i} \int_0^t e(t)dt + \mathrm{K_d} \frac{d\ e(t)}{dt} \ldots \quad (1)$$

Here, e(t) is the error in voltage output with respect to reference voltage. There are some fixed rules gain values, which is given in Table 1.

The generalized diagram for PID controller for DC–DC boost converter is shown in Fig. 4.

Here, constant 1 comes from output voltage, constant 2 comes from capacitor current, and constant 3 goes to gate of MOSFET in the boost converter.

Table 1 Rules for selecting gain in PID controller

Parameter	Response speed	Stability	Output accuracy
K_p	High	Decreases	Good
K_i	Low	Decreases	Good
K_d	High	Increases	No effect

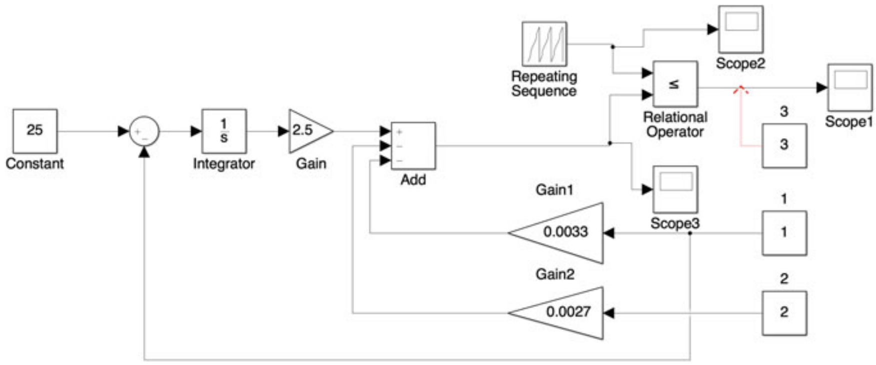

Fig. 4 Generalized diagram of PID controller for DC–DC boost converter

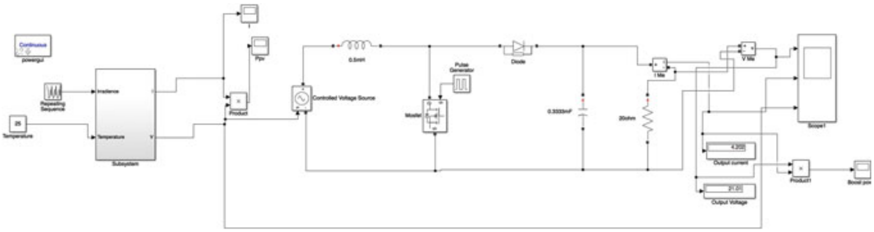

Fig. 5 DC–DC boost converter without using PID controller

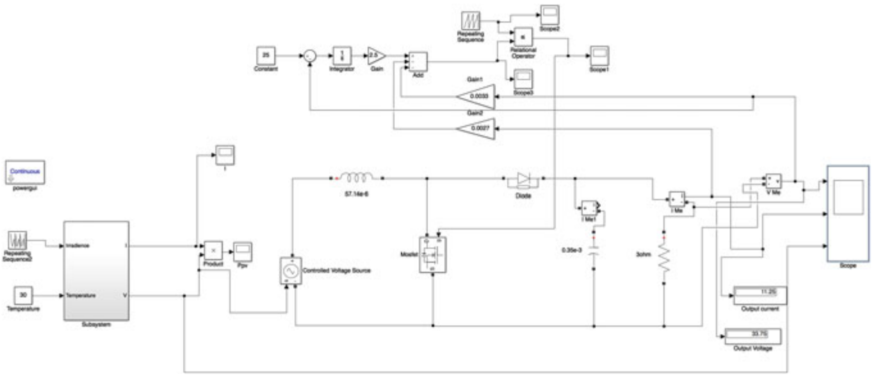

Fig. 6 DC–DC boost converter with using PID controller

5 Simulation Results

For modeling and simulation purpose, we have used MATLAB Simulink software. Figure 5 shows the diagram of system without using PID controller and Fig. 6 shows the system with PID controller.

Table 2 System parameters of variables

System parameters	Corresponding values
Irradiation	[700, 500, 450, 550, 600, 430] W/m^2
Temperature	30 °C
Inductance	57.14e–6 H
Capacitance	0.35e–3 F
Constant	25
K_p	0.0033
K_i	2.5
K_d	0.0027
Input voltage	4–8.5 V
Output voltage	25 V

5.1 Parameters Values

Following are the values useful for the system in Table 2.

5.2 Simulation Results

Figure 7 shows the output waveform of system without using PID controller and Fig. 8 shows the output waveform system with PID controller.

The Fig. 7 gives three-output waveform at different irradiation levels. The third graph gives the output voltage of the solar cell which is varying in the range of

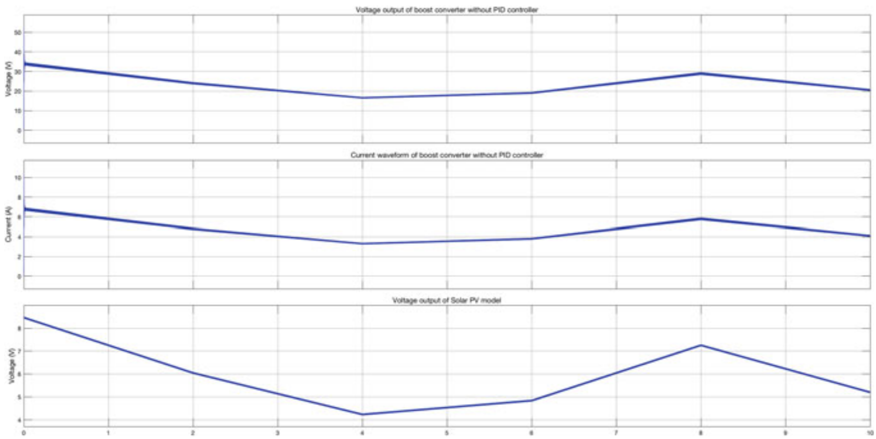

Fig. 7 Output waveform of the system without using PID controller

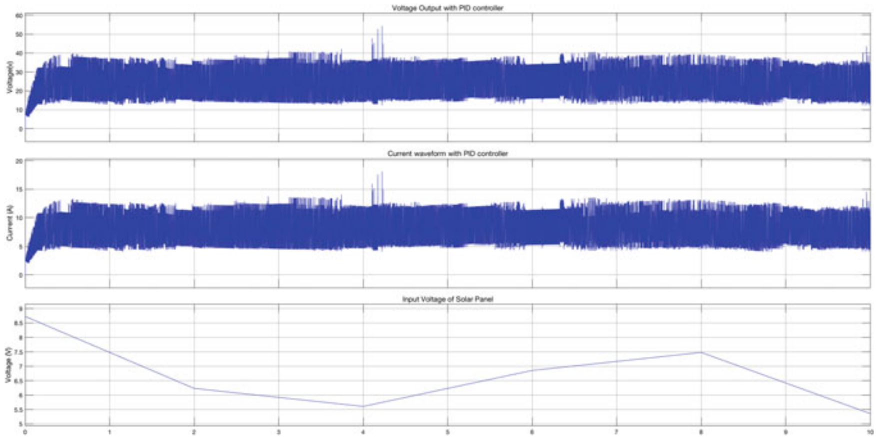

Fig. 8 Output waveform of the system with using PID controller

4.2–8.5 V at different irradiation levels and further, it is fed as the input of the boost converter. The unregulated variable voltage is because of the frequent changes in irradiation levels. The second graph gives output current of DC–DC converter with respect to time at different irradiation levels. The first graph gives the output of DC–DC boost converter with respect to time without using PID controller in the boost converter. Where it is observed that output voltage of the boost converter has increased and is varying in the range of 25–40 V at five different irradiation levels. In order to obtain maximum power irrespective to any available voltage from the solar cell, it is required to track the voltage to 25 V (as per calculation). Thus, the PID controller has been introduced to provide gate pulse and to drive the MOSFET of the boost converter, so to obtain maximum power.

The Fig. 8 gives three-output waveform at different irradiation levels using PID controller. The third graph gives the output voltage of the solar cell which is varying at different irradiation levels. The second graph gives output current of DC–DC converter which is almost linear with respect to time at different irradiation levels. The first graph gives the output of DC–DC boost converter with respect to time using PID controller in boost converter. Where it is observed that output voltage of the boost converter has increased and is almost linear (average of 25 V) at five different irradiation levels which is required to obtain maximum power from the system.

6 Discussion and Conclusion

As we can see that because of the variable irradiation levels that have been given at different instant of time, the voltage level changes with that. Now with normal pulse generator, the output voltage changes with great difference in voltages. Now with the help of PID controller, we are able to achieve less overshoot and more constant voltage. The output waveform was magnified for better results and can be observed that it has less difference in output voltage.

Now with the help of comparing the results, it can be concluded that PID controller is more suitable for the linear system. It has overshoots and zero state errors but in minimal. We can achieve good results with less error with the help of PID controller for solar cell.

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