

Analysis of DC-DC Buck-Boost Converter on Solar PV Module in MATLAB/Simulink

Pavittar Singh¹ and Sunny Vig²

¹ME Student, EED,

Chandigarh University, Mohali, INDIA

pavitterbilling@gmail.com

²Assistant Professor EED,

Chandigarh University, Mohali, INDIA

sunnyleo14@gmail.com

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Abstract

There are vast applications of solar energy based modules in power now a days. It is due to the abundance of solar energy presence. For practical implementation, DC-DC converters are connected across the output of solar module. The type of converter used depends upon the application area. In this effort, DC to DC Buck-Boost Converter is employed after a solar module consisting of 36 solar cells. The output voltage readings are recorded across the load connected.

Key Words : MATLAB/Simulink, Solar Module, Solar Cell, DC-DC Buck Boost Converter.

1 Introduction

Energy crisis is a main issue in recent times and lot of research has been carried out in order to get power from renewable energy

resources. Solar energy marks its presence in this field with the largest targeted area. Solar cells are developed with best technology in order to increase the efficiency. The solar energy demand has been increased vastly with a noticeable factor i.e. approximately 5% in the past two decades [1]. Also, the environmental issues related to non renewable energy resources are the main factors which tends the researchers to look towards the application areas of renewable energy resources. Since, solar energy is the most abundant; hence it is one of the vital main energy supply resources. Main application areas of solar energy includes in commercial and industrial [7].

For practical application, a DC-DC converter is used with solar module with a load. The values of the converter elements like inductor, capacitor and switch depend on the type of application. Before DC-DC converter, Solar module consisting of 36 or 72 cells is modeled in MATLAB/Simulink. The Simulink is used to design the model by implementing the equations of a solar cell.

In this paper, a solar module is firstly designed in simulink environment and then a DC to DC Buck-Boost Converter is attached with it. Parameters of Solar Module were changed and the output graphs were plotted. The various general solar module parameters are: Short circuit current, Reverse Saturation Current, Photocurrent, Series Resistance, Shunt Resistance, Ideality Factor & Open Circuit voltage.

The I-V & P-V characteristics of a Pv cell are shown in diagram 1.1.

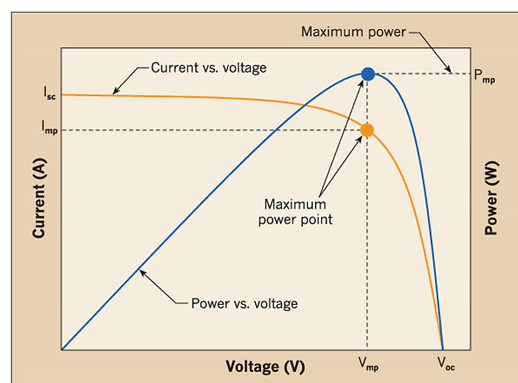


Fig.1.1 P-V & I-V Curves of a Solar Cell/Module

The basic circuit diagram of DC-DC Buck-Boost Converter is given in figure 1.2.

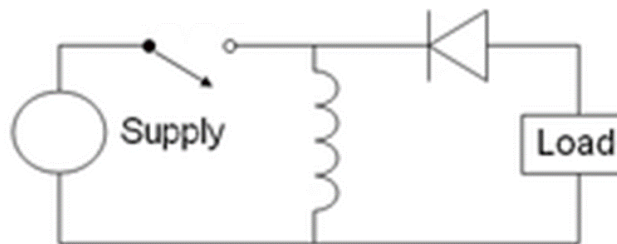


Fig.1.2 Circuit representation of DC to DC Buck-Boost Converter

As given in figure 1.2, the DC to DC Buck-Boost Converter consists of a switch, inductor, diode and a load.

2 Methodology

The first step is to design a model of solar cell in MATLAB/Simulink by implementing the circuit of a Pv cell as shown in figure 1.3. The circuit contains a diode, shunt resistor, current source and series resistor.

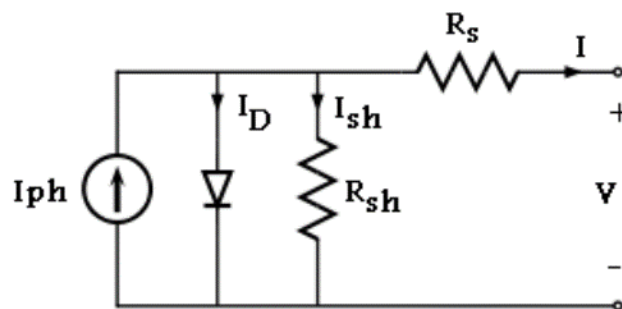


Fig.1.3. Equivalent Circuit of a Solar Cell

The second step is to implement the characteristic equation of Pv cell in MATLAB/Simulink, which can be given by

$$I = I_L - I_0 \left\{ \exp \left[\frac{q(V + IR_s)}{nkT} \right] - 1 \right\} - \frac{V + IR_s}{R_{SH}} \quad (1.1)$$

In this equation,

I = Photocurrent

I_0 = Reverse Saturation Current of the diode

q = Electron charge

V = Voltage across the diode

K = Boltzmann's constant

T = Junction temperature

N = Ideality factor of the diode

R_s = Series Resistance

R_{sh} = Shunt Resistance

The equation for photocurrent is given by

$$I_{ph} = \left[I_{SC} + K_i(T - 298) \right] \frac{\beta}{1000} \quad (1.2)$$

Where, $K_i = 0.0017 \text{ A}/^\circ\text{C}$ is the cell's short circuit current temperature coefficient and β is the solar radiation (W/m^2). Equation for reverse saturation I is given by

$$I_s(T) = I_s \left(\frac{T}{T_{nom}} \right)^3 \exp \left[\left(\frac{T}{T_{nom}} - 1 \right) \frac{E_g}{N V_t} \right] \quad (1.3)$$

Where, I_s is the diode reverse saturation current, T_{nom} is the nominal temperature, E_g is the band gap energy of the semiconductor and V_t is the thermal voltage.

3 Simulation Models

The Equation 1.1 is modeled in Simulink to plot the I-V and P-V curves. Then, 36 cells are combined in series to get curves for Solar Module. The Simulink model is given in figure 1.3.

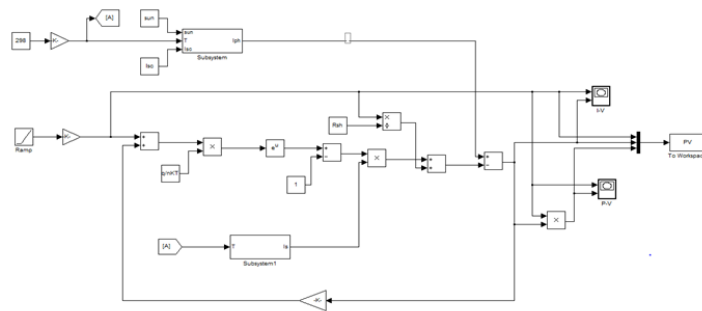


Fig.1.4. Simulink Model of Solar Pv module

The model of photocurrent is shown in figure 1.5 and it is modeled from equation 1.2

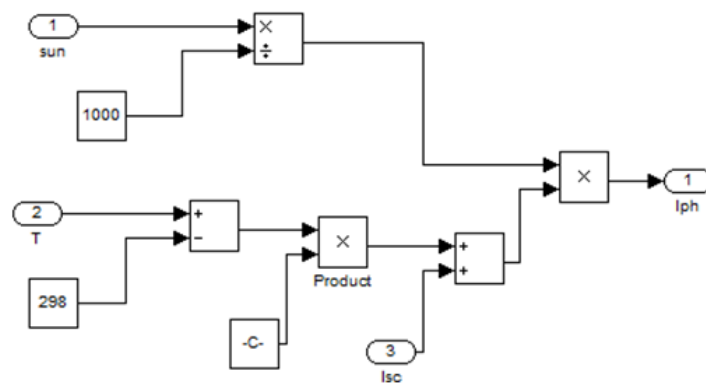


Fig.1.5. Simulink Model of Photocurrent Subsystem

The model of reverse saturation current is shown in figure 1.6 and it is modeled from equation 1.3

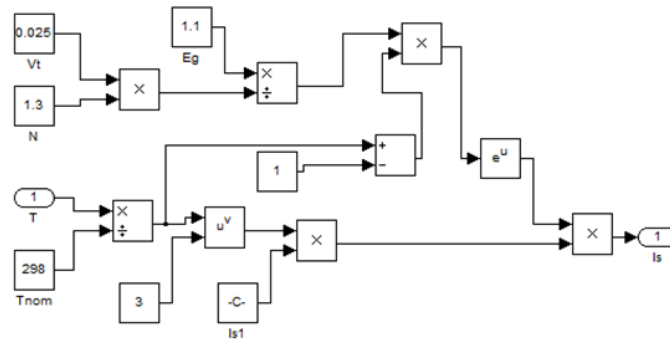


Fig.1.6. Simulink Model of Reverse Saturation Current Subsystem

The PV Module model is obtained by adding 36 solar photo-voltaic cells in series and the model is given in diagram 1.7.

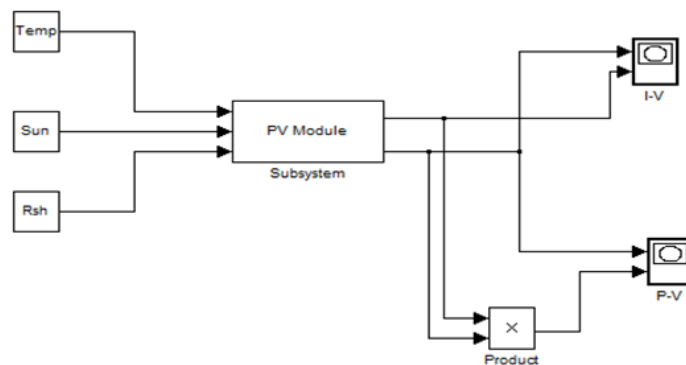


Fig.1.7. Simulink Model of Solar Module

4 Results

The model of the designed PV Module is simulated in MATLAB/Simulink and a output voltage of 19.50V is obtained across PV Module. The solar radiation is varied from 600W/m² to 1400W/m². Then, the DC to DC Buck-Boost Converter is attached with module. Following table shows the output of the system designed:

S. No.	Solar Insolation (W/m ²)	O/p Voltage of Module (V)	O/p Voltage of Converter (V)
1	600	17.2	27
2	800	18.6	29.2
3	1000	19.5	30.9
4	1200	21	32.3
5	1400	22.2	33.6

Table 1.1. Output Voltage of Module

5 Conclusion

There is a significant increase in the output voltage of solar module after attaching the DC-DC Buck Boost Converter. This model can be further extended to MPPT algorithms like P&O, Fuzzy Logic and ANN based. The converters can also be changed to study the effects on the output voltage.

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