

Applications Of PV Module With Boost Converter By Using MPPT Algorithm

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Abstract – This paper presents the performance of a converter topology for PV array. Photovoltaic (PV) Modules are used to generate electricity from light. The system containing solar cell, DC-DC boost converter. When sunlight falls on the PV modules, it converts sunlight in to DC electricity. So, solar cells are interconnected in a series-parallel combination to achieve the desired power. It is a one of the renewable energy. The PV based systems are employed in stand-alone applications such as street lighting, water pumping and also accommodated in grid connected systems. The PV based systems have no wear and tear which results in less maintenance. This paper presents the simulation of a photovoltaic system using MATLAB. It is used to reduce voltage ripple.

Key words -PV cells/modules, MPPT algorithm, DC-DC boost converter modeling, Simulink model of proposed system.

I. INTRODUCTION

Now a day's solar energy is the largest renewable resource among the other renewable energy option. It is a conversion of solar energy in to electrical energy. Photovoltaic (PV) modules are used to generate electricity from light. When sunlight falls on the PV cells or modules, it converts sunlight in to DC electricity. The voltage and current generated by a single PV cell is very low. So, solar cells are interconnected in a single series-parallel combination to achieve the desired power. Desired voltage is generated by connecting the solar cells in series and the desired current is generated by connecting the cells in parallel. Apart from the advantages of renewable energy sources, the PV based power generation has added few more advantages. The PV based system has no wear and tear which results in less maintenance. The PV systems are employed in stand-alone applications such as street lighting, water pumping and also accommodated in grid connected systems. A boost converter (step-up converter) is a DC-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two combination. To reduce voltage ripples filters made of capacitors (sometimes in combination of inductors) are normally added to such a converter's output (load-side filter).

II. CIRCUIT MODEL OF PV MODULE

The PV system has non-linear I-V and P-V characters. The two main factors which affect the output of PV system are temperature and irradiation level. The change of temperature and irradiation level results in change of voltage and current generated by PV system. The nominal operating condition of the solar module is 25°C temperature, 1000W/m² (G=1) irradiation at AM of 1.5.

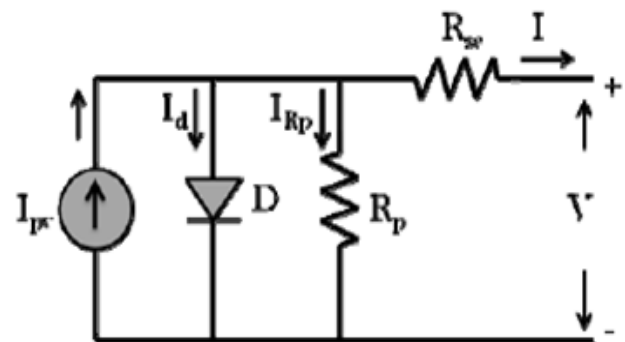


Fig1. General model of solar cell

I-V and P-V characteristics of PV cell are shown in fig.2. Open circuit voltage (V_{OC}) is the maximum voltage a cell can change under open circuit condition at I=0 and the short circuit current (I_{SC}) corresponds to short circuit at V=0 through the operation, the PV cell generates maximum power at only one point (MPP).

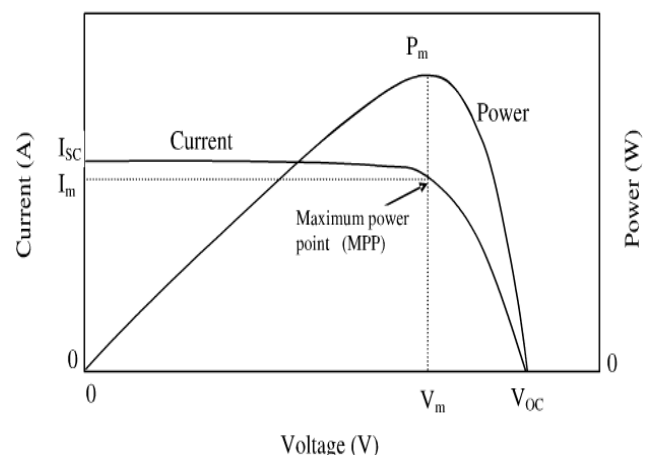


Fig2. I-V and P-V characteristics of solar cell

III. DC-DC BOOST CONVERTER MODELING

DC-DC boost converters are used in PV systems to regulate the voltage generated by the modules. DC-DC

boost converters are used in grid connected applications to step up the module voltage.

The circuit diagram of DC-DC boost converter is

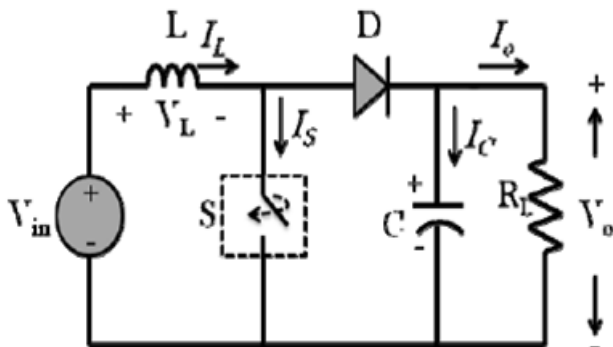


Fig3. DC-DC boost converter

The DC-DC boost converter circuit consists of Inductor (L), Diode (D), Capacitor (C), load resistor (R_L), and the control switch (S). These components are connected in such a way with the input voltage source (V_{in}) so as to step up the voltage. The output voltage of the boost converter depends on the duty cycle of the control switch. So, the output voltage can be varied by varying the ON time of the switch. Thus, for the duty cycle “D” the average output voltage can be calculated using

$$\frac{V_o}{V_{in}} = \frac{1}{(1-D)}$$

A. SECTION OF INDUCTOR

The inductor value of the boost converter calculated using

$$L = \frac{V_{in}}{(f_s \Delta I_L)} D$$

Where f_s is switching frequency and $L \Delta I$ is the input current ripple. Current ripple factor (CRF) is the ratio between input current and output current.

B. SECTION OF CAPACITOR

The capacitor value can be obtained from given equation

$$C = \frac{I_{out}}{(f_s \Delta V_o)} D$$

Where ΔV_o is the output voltage ripple

IV. SIMULATION RESULTS AND DISCUSSION

A. SIMULATION OF PV MODULE

The complete model of the PV module simulated using MATLAB/Simulink is shown in fig 4. The subsystem of the complete model, the subsystem for light generated current (I_{pv}), saturation current (I_s) and shottcky Equation (I_d) inside the main subsystem are

shown in fig 5(a). The dialogue box for main subsystem mask is shown in fig 5(b). The model is developed based on the given below equation is

$$I = I_{pv} N_p - I_s N_p \left\{ \exp \left(\frac{qV}{AkT_c N_s} + \frac{IR_{se}}{N_p} \right) - 1 \right\}$$

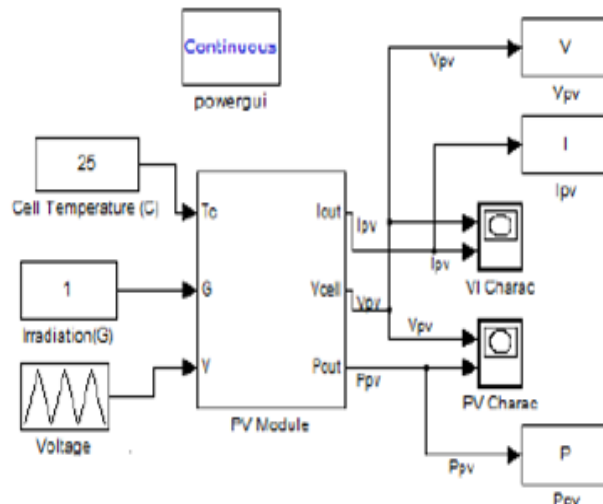
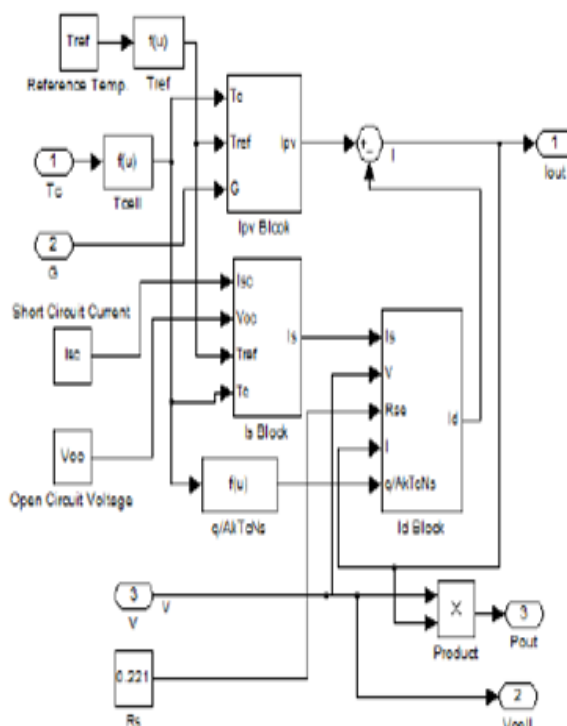


Fig4. Simulink model of proposed system

Solarex MSX60 PV module is chosen for validating the model. The maximum output power of MSX60 is 60W. The important parameters required for simulating the model are taken from the manufactured datasheet.



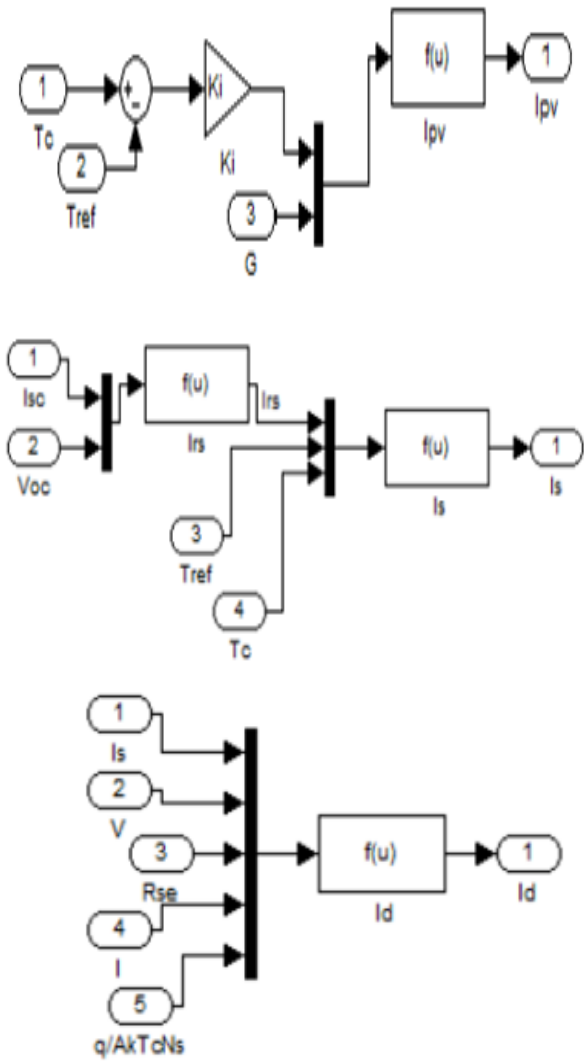


Fig. 5(a) Subsystems of the proposed system

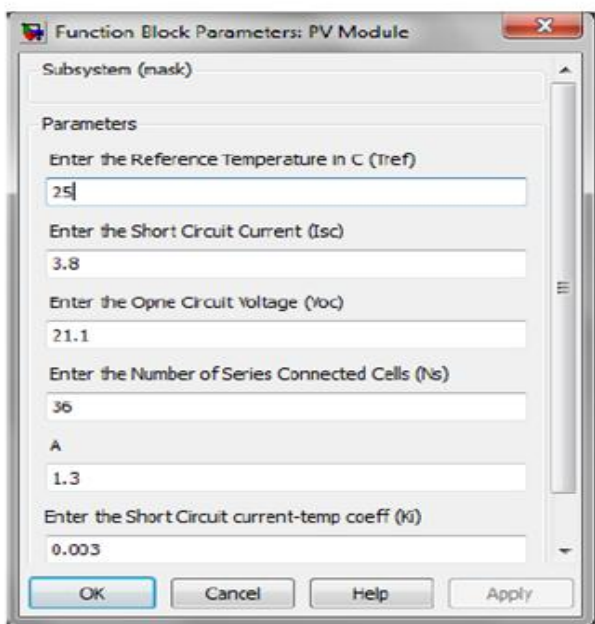


Fig. 5(b) subsystem mask dialog box

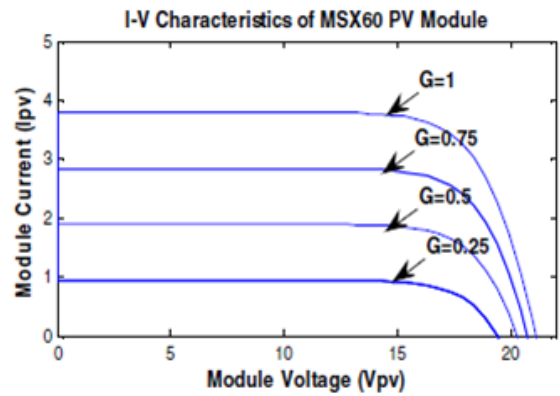


Fig. 6(a) I-V characteristics of MSX 60 at different irradiation level and constant temperature (25°C)

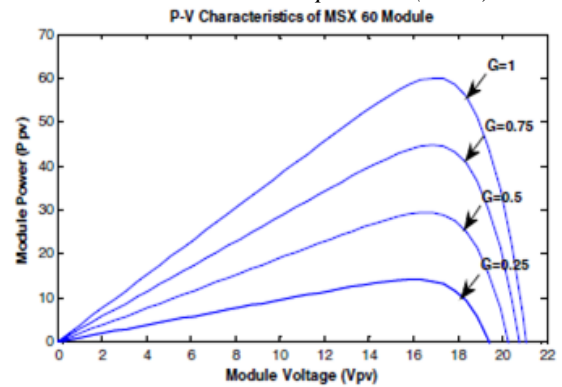


Fig.6(b) P-V characteristics of MSX 60 at different irradiation level and constant temperature (25°C)

Fig 6(a), and 6(b) shows the I-V and P-V characteristics curves of MSX 60 module obtained from the simulation under various irradiation levels.

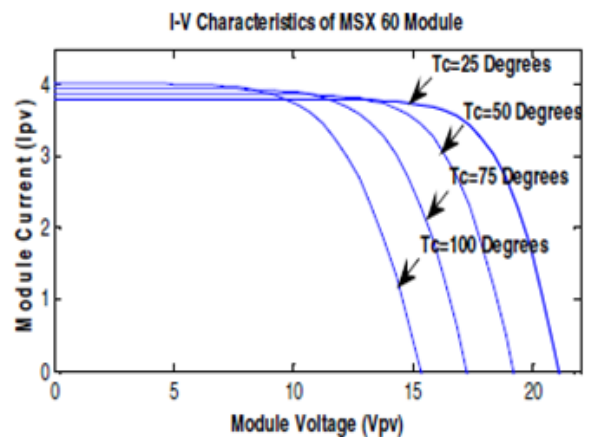


Fig. 7(a) I-V characteristics of the MSX 60 at different temperature and constant irradiation level ($G=1$)

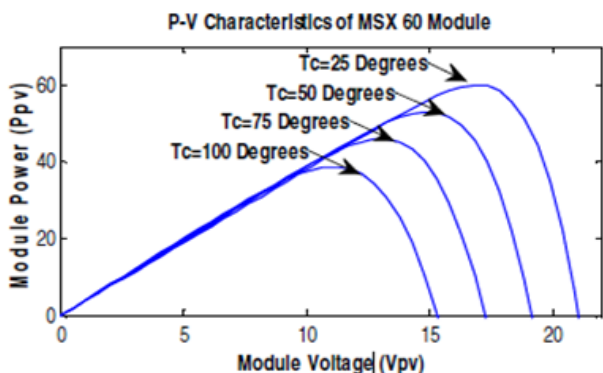


Fig. 7(b) P-V characteristics of the MSX 60 at different temperature and constant irradiation level ($G=1$)

Fig 7(a) and 7(b) shows the I-V and P-V curves under different level of temperature.

B. SIMULATION OF DC BOOST CONVERTER

The boost converter is simulated by using MATLAB/Simulink. The result obtained from the boost converter was presented. The open loop simulation performed with the input voltage of 16v for the duty cycle $D=0.33$. Fig 8 shows the simulation circuit of designed boost converter. The PWM pulse generation and the control pulse for the switch are shown in fig 9.

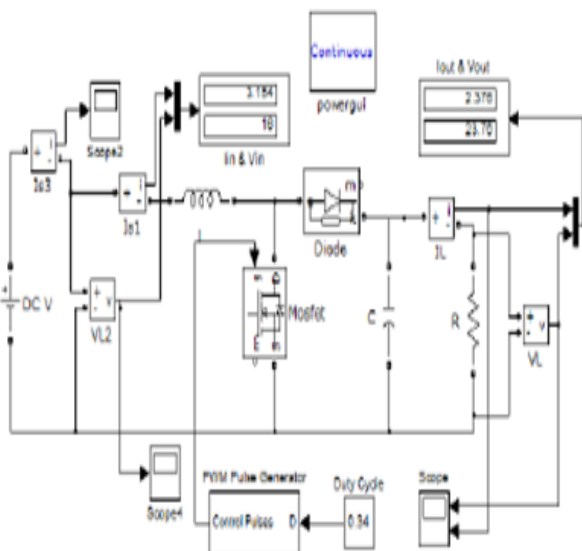


Fig.8 DC-DC boost converter simulation circuit

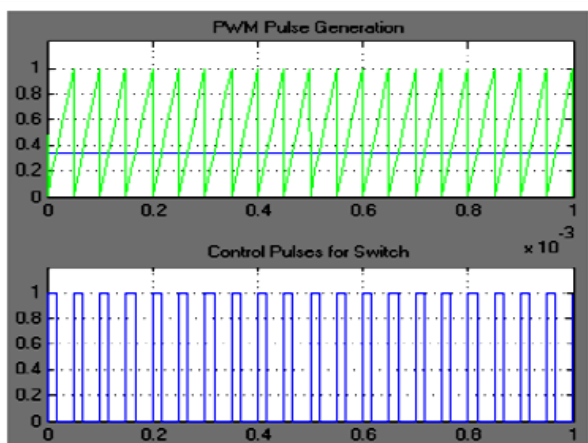


Fig.9 PWM pulse generation

Fig.10 (a) shows the waveform of input voltage of boost converter. The output voltage and output current of the boost converter at constant input voltage is presented in the fig 10(b) and fig 10(c) respectively. The output voltage and the current approach the desired values. The boost converter and the PV module are integrated for analysis as shown in fig.11. The DC-DC boost converter fed in to the PV module. The input voltage of boost converter shown in fig.12 is the output of PV module. The output voltage and current waveforms obtained from the PV feds boost converter are depicted in fig 12.

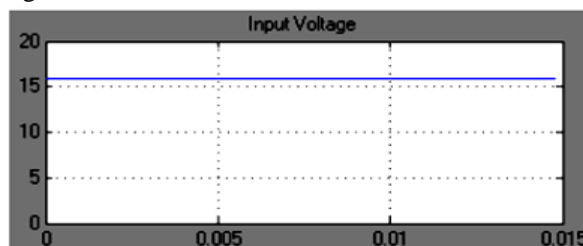


Fig.10 (a) Input voltage of DC-DC boost converter

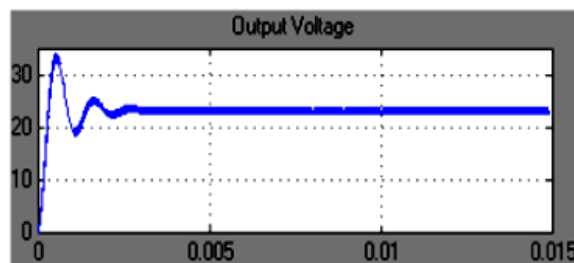


Fig.10 (b) output voltage of boost converter constant DC input supply

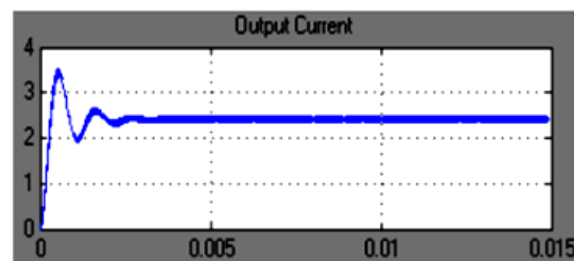


Fig.10 (c) output current of boost converter constant DC input supply

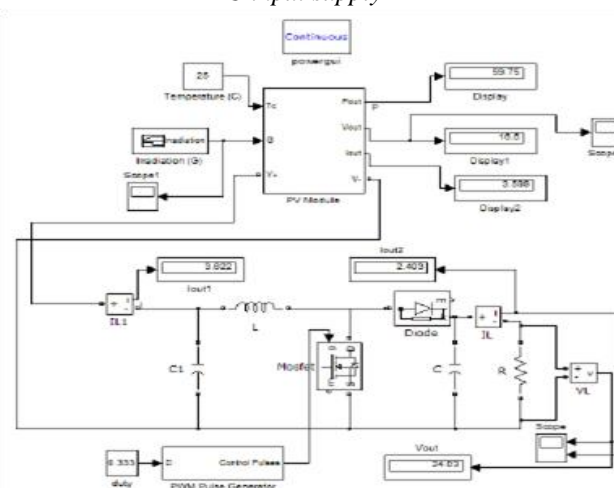


Fig.11 PV fed DC-DC boost converter

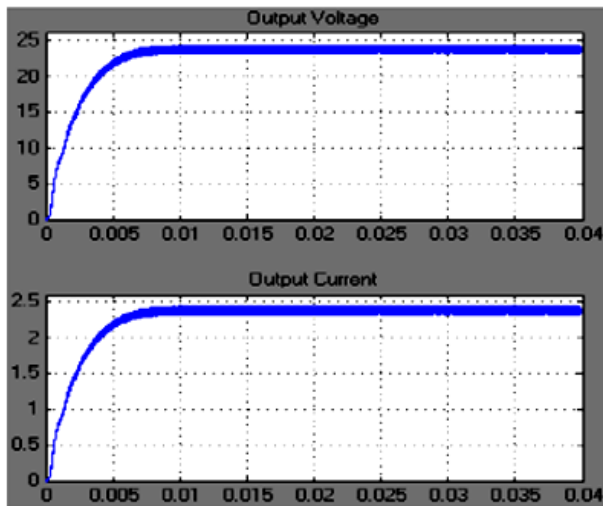


Fig. 12 output voltage and current waveform of PV fed converter

The model is simulated under constant cell temperature of $T_c=250^\circ\text{C}$ and different irradiation level and the output of the PV module model is fed into the converter. The irradiation level has changes from 1 to 0.75 at $t=0.015$ and $t=0.030$ the irradiation decreased from 0.75 to 0.5 as shown in the fig.13. The voltage and current of the boost converter under these conditions is presented in fig. 14. the boost converter is simulated for the fixed duty cycle of 0.3.

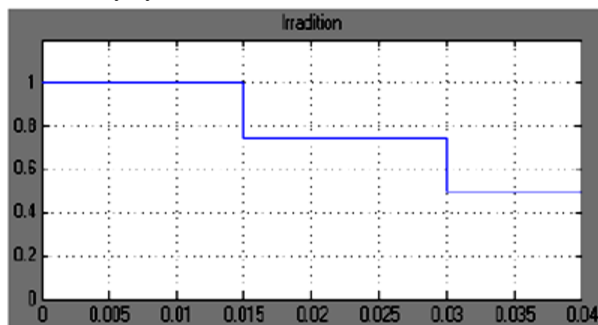


Fig.13 change in irradiation level of PV module

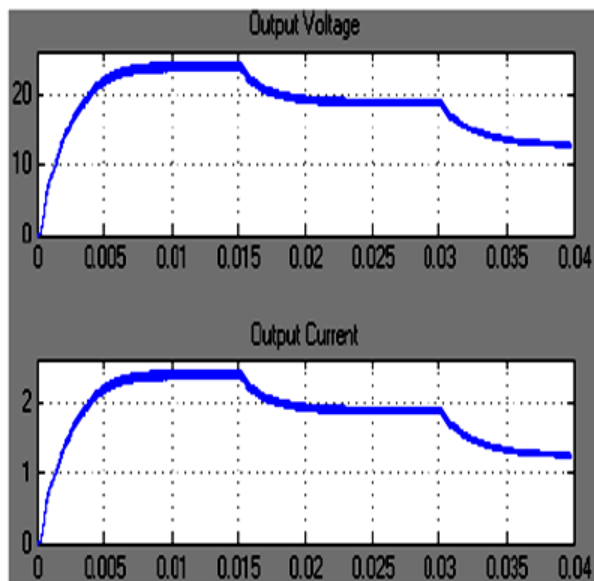


Fig.14 output voltage and current waveforms of boost converter at differential irradiation level.

V. CONCLUSION

A circuit based system model of PV modules helps the performance of commercial PV modules. A general model of PV module is developed commonly used blocks in the form of masked subsystem block. I-V and P-V characteristics outputs are generated for MSX 60 PV module under different irradiation and different temperature levels. The DC-DC boost converter is also simulated and the results are obtained from the converter with constant DC input supply and by interconnecting the PV modules with it. The results show the close match between the output of converter with constant DC input and the PV fed converter. The output voltage and the current of the PV fed DC-DC boost converter obtained for change of irradiation levels at constant temperature is also presented.

We realize that the basic function of DC-Dc converter in PV system is like intermediate power processor which changes the current and voltage levels such that maximum power can be extracted from the PV array. Changing voltage and current level is nothing but converting a given fixed load to a variable load.

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