



# VOLTAGE ENHANCEMENT BY USING DC-DC BOOST CONVERTER AND SLIDING MODE CONTROLLER

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## ABSTRACT

Proportional (P), Proportional Integral (PI), Proportional Integral Derivative (PID) controller are the common control techniques which is not able to execute agreeably under variations of load for dc-dc converter. Hence nonlinear controllers are applied for controlling DC-DC converters. Due to the presence of switching action, switched mode dc-dc converters are generally variable structured systems. Hence sliding mode controller is suitable for DC-DC converters. In the present work, the boost converter is modeled and PWM based sliding mode controller is designed and simulated using MATLAB/SIMULINK. Sliding mode controller and PI controller performance is compared and the simulation results are then analyzed.

## INTRODUCTION

Nowadays, power generation using solar power had increased dramatically because it is pollution free as compare to power generation using fossil fuel. Besides, it needs low maintenance and no noise and wear due to the absence of moving parts which make solar power attractive to the people. Solar power uses solar panel to convert sun irradiation into electric energy using photovoltaic (PV) effect. The output voltage of a solar panel is varying depending on sun irradiation and temperature. As the sun irradiation and temperature changes, output voltage changing as well. Since the voltage produced is fluctuating, a lot of electronic equipment's are unable to be directly connected. Therefore, a DC-DC boost converter with constant output voltage is needed. The boost converter will step up the solar panel voltage to the suitable voltage required by electronic equipment's. By using PI controller and Sliding Mode controller boost the voltage.

## STUDY OF LOCATION

the study about microgrids has been done. “Challenges in Recent Microgrids Systems: A Review” by Ashwini Kumar and Murari Lal Azad has been much of help to understand the gap and barriers in expansion of microgrid technology. “Recent control techniques and management of AC microgrids: A critical review on issues, strategies, and future trends by Jaswant Singh and Surya Prakash Singh” has given a strong objective for this project thesis by creating an overview of methods of managing microgrids, “Design And Simulation of a PV System with DC-DC boost Converter using Mat lab Simulink” Shaha helped in the Microgrids. “Design and simulation of a PV system with DC-DC boost converter using sliding mode control”. Due to its desirable characteristics, SMC is a viable and promising approach to overcome the challenges in designing a fast and stable controller for the boost converter. Focusing on the two challenges identified in this section first reviews some of the important literatures on the conventional SMC design and points out a few drawbacks with the conventional approaches. Then, research publications focused on SM-controlled boost converter revealing some areas that warrant further research.

### Controllers used

1. PI Controller.
2. SM Controller.

### Basic circuit

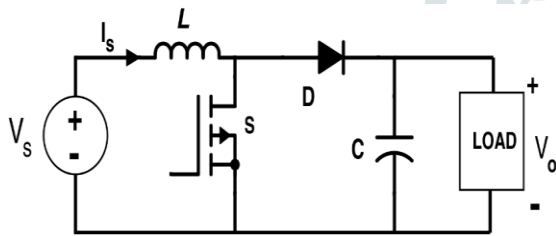


Figure.1 dc-dc boost converter.

Its operation is generally of two separate states, During the ON period, switch is made to close its

- contacts which results in increase of inductor current. During the OFF period, switch is made to open
- thus the only path for inductor current to flow through the fly-back diode ‘D’ and the parallel combination of capacitor and load. This enables capacitor to transfer energy gained by it during ON period

$$i_L = \frac{1}{L} \int V_i u dt \rightarrow (1)$$

$$\frac{dV_o}{dt} = -\frac{V_o}{RC} \rightarrow (2)$$

$$L \frac{di_L}{dt} = V_i - V_o \rightarrow (3)$$

$$i_L = \frac{1}{L} \int (V_i - V_o) u dt \rightarrow (4)$$

$$V_o = \frac{1}{C} \int (i_L - i_R) dt \rightarrow (5)$$

Combine equation (1) and (4)

$$i_L = \frac{1}{L} \int (V_i u + (V_i - V_o) \bar{u}) dt \rightarrow (6)$$

U indicate the state of a switch S and  $\bar{u}$  is inverse logic of u

State space description can developed for the control variables like voltage and current in the system. The state variables are portrayed as,

$$x = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} V_{ref} - \beta V_o \\ \frac{d}{dt}(V_{ref} - V_o) \\ \int (V_{ref} - \beta V_o) dt \end{pmatrix} \rightarrow (7)$$

Where  $x_1, x_2$  and  $x_3$  are the voltage error, voltage error dynamics, and integral of voltage error and  $V_{ref}$  is reference voltage,  $\beta$  is feedback network ratio.

## System Modeling

State space description can developed for the control variables like voltage and current in the system. The state variables are portrayed as, from previous chapter DC-DC boost converter Where  $x_1, x_2$  and  $x_3$  are the voltage error, voltage error dynamics, and integral of voltage error and  $V_{ref}$  is reference voltage,  $\beta$  is feedback network ratio.

By substituting the (5),(6) equations for control variable  $x_2$  in (7)

$$x_{boost} = \begin{pmatrix} x_1 = V_{ref} - \beta V_o \\ x_2 = \frac{\beta}{R_L C} \frac{dV_o}{dt} + \frac{\beta}{LC} (V_o - V_i) \bar{u} dt \\ x_3 = \int (V_{ref} - \beta V_o) dt \end{pmatrix} \rightarrow (8)$$

State space description can obtain from equation (8) by differentiating with respect to time which is essential for control design of boost converter. Where  $x_1, x_2$  and  $x_3$  are the voltage error, voltage error dynamics, and integral of voltage error and  $V_{ref}$  is reference voltage,  $\beta$  is feedback network ratio.

$$\dot{x}_1 = \frac{d}{dt} (V_{ref} - \beta V_o) = x_2 \rightarrow (9)$$

$$\dot{x}_1 = -\beta \frac{dV_o}{dt} = x_2 \rightarrow (10)$$

$$\dot{x}_2 = \frac{\beta}{R_L C} \frac{dV_o}{dt} + \frac{\beta}{LC} (V_o - V_i) \bar{u} \rightarrow (11)$$

$$\dot{x}_2 = \frac{-x_2}{R_L C} + \left( \frac{\beta V_o}{LC} - \frac{\beta V_i}{LC} \right) \bar{u} \rightarrow (12)$$

$$\dot{x}_3 = V_{ref} - \beta V_o = x_1 \rightarrow (13)$$

Obtaining equation (10),(12),(13) in matrix form,

$$\dot{x}_{boost} = Ax_{boost} + Bu$$

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 \\ 0 & \frac{-1}{R_L C} & 0 \\ 1 & 0 & 0 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} 0 \\ \left(\frac{\beta V_o}{LC} - \frac{\beta V_i}{LC}\right) \\ 0 \end{pmatrix} u \rightarrow (14)$$

Where,

$$A = \begin{pmatrix} 0 & 1 & 0 \\ 0 & \frac{-1}{R_L C} & 0 \\ 1 & 0 & 0 \end{pmatrix}, B = \begin{pmatrix} 0 \\ \left(\frac{\beta V_o}{LC} - \frac{\beta V_i}{LC}\right) \\ 0 \end{pmatrix}$$

### SIMULATION RESULTS

To implement the main idea that was described all along, and to observe the results of the system, we have chosen the simulation environment as MATLAB SIMULINK. In this, all the components and controllers existing in the formerly expressed system are modelled and designed the main circuit and sub circuits.

### SUBSYSTEM OF SMC CONTROLLER

This block diagram indicates the subsystem of sliding mode controller. In this we use three gains for generate gate signal .i.e., gate current

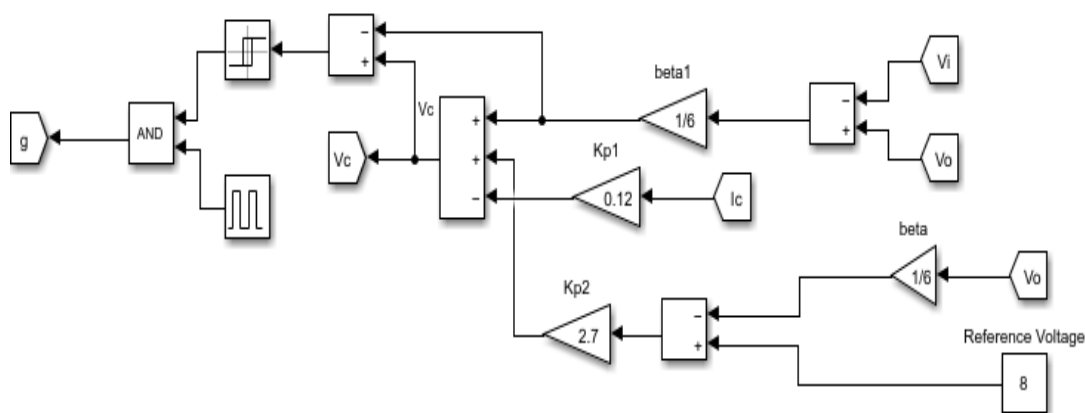


Figure.3 Simulation model for the subsystem of Sliding mode controller.

### RESULTS

The results in this paper are obtained for three aspects and the analysis and observations are done based on the waveforms obtained

1.Input irradiance current waveforms of PV array.

2. Input temperature voltage waveforms of PV array.
3. Output voltage of PV array.
4. Output voltage of boost converter SM Controller .
5. Output voltage of boost converter with PI Controller.
6. Output current of DC-DC boost converter with SMC.

### 1. Input irradiance vs current and power waveform.

The relation between irradiance and current given in below, if the irradiance of PV cell increases then current and power also increases.

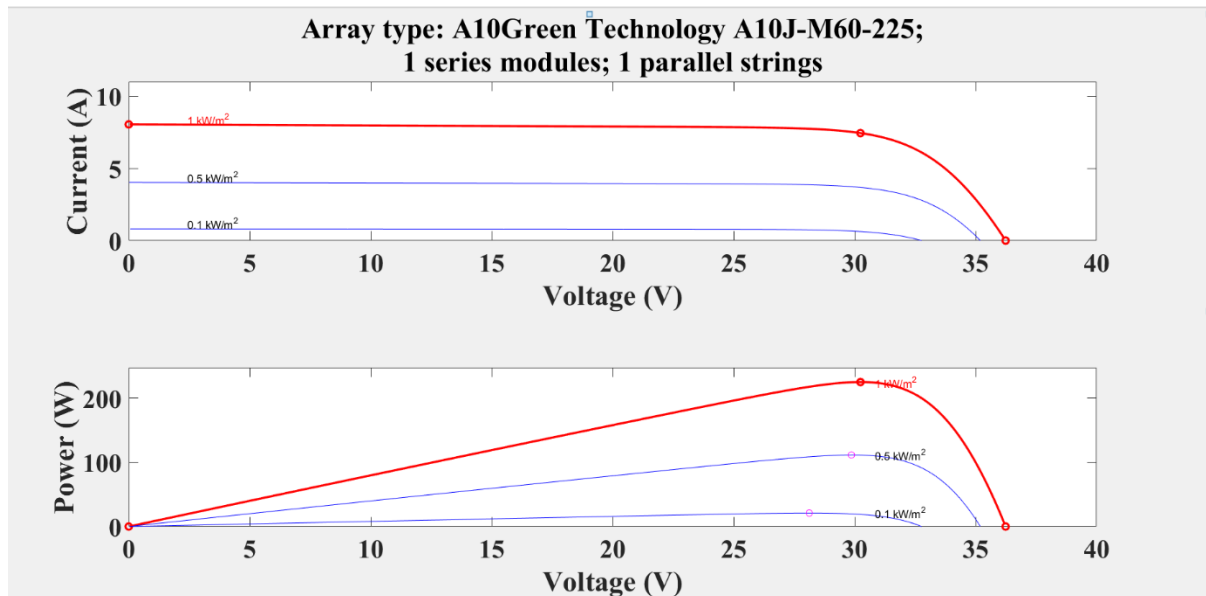


Figure.5.3 V-I characteristics with respect to irradiance

### 2. Input Temperature vs current and voltage waveform.

Temperature and voltage are inversely proportional if temperature decreases then voltage of the PV array increases, the relation given in the below waveform.

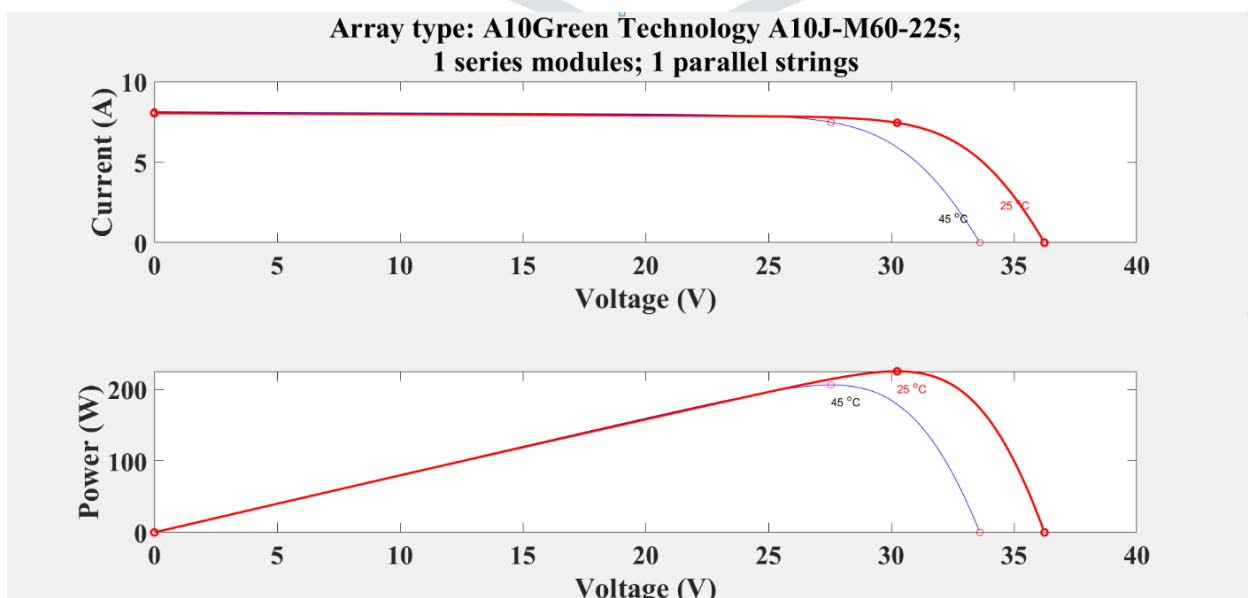
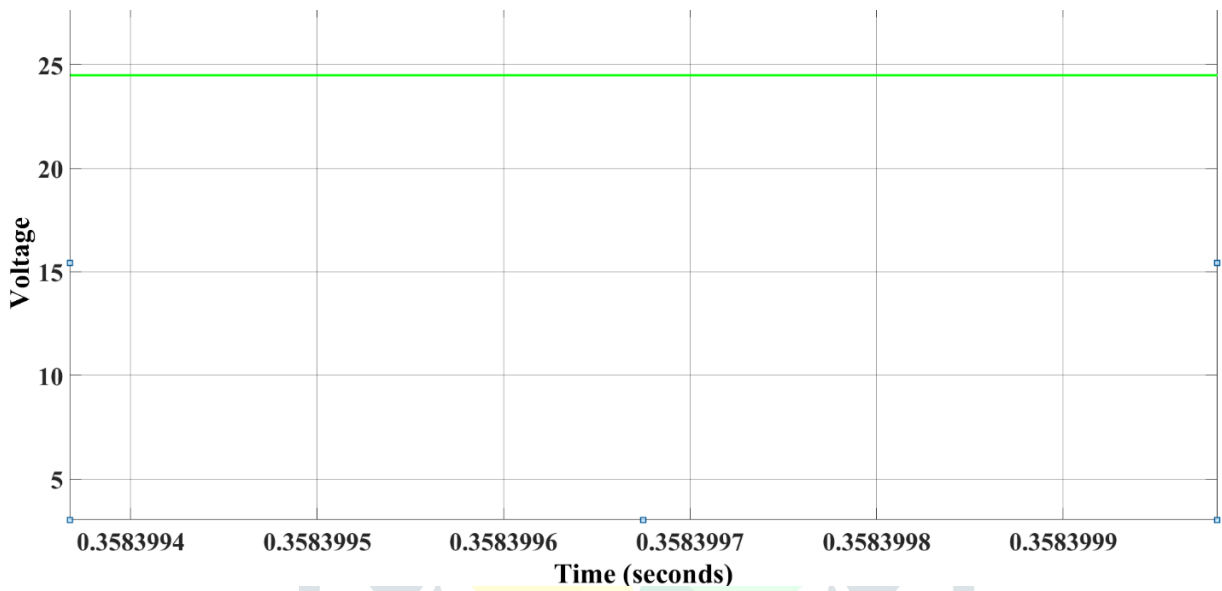


Figure.5.4 V-I characteristics with Temperature.

### 3. Output voltage waveform of PV array.

Output voltage of PV array of input boost converter. Which is 24v, this is input of DC-DC Boost converter.



### 4. Output voltage of boost converter SMC

Output voltage of DC-DC boost converter in the scope is given in bellow that is 48volts.

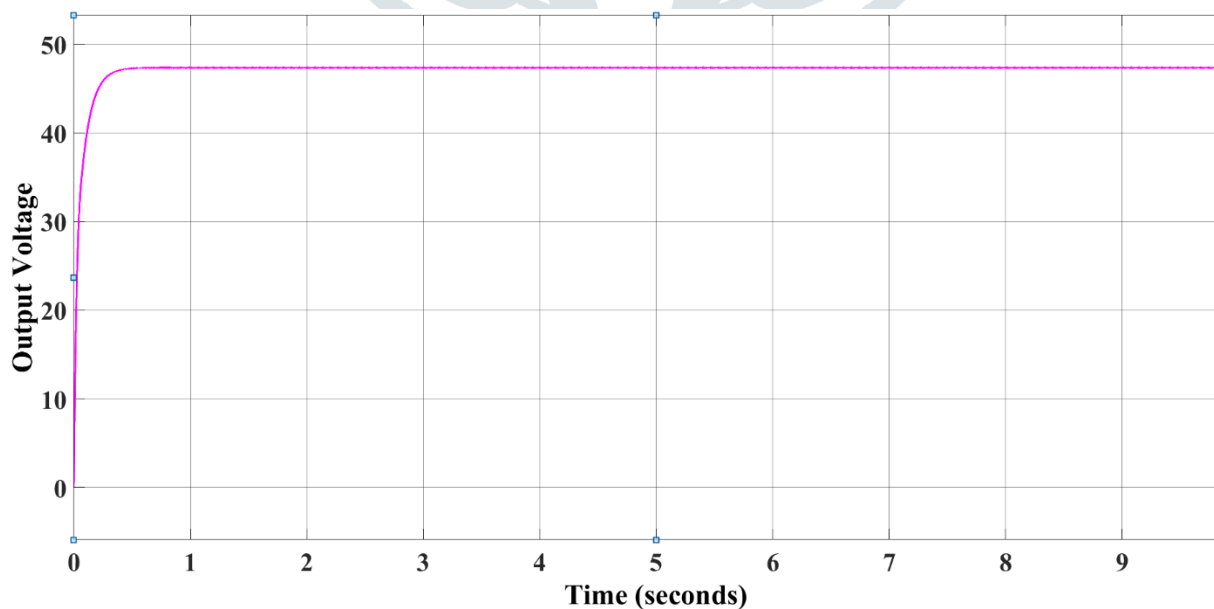


Figure.5.5 output voltage of DC-DC boost converter SMC.

#### 4 .Output voltage wave with PI controller.

This is the output voltage waveform of PI controller, when compared to sliding mode controller output voltage with this PI controller output voltage is less that is nearly 35volts.

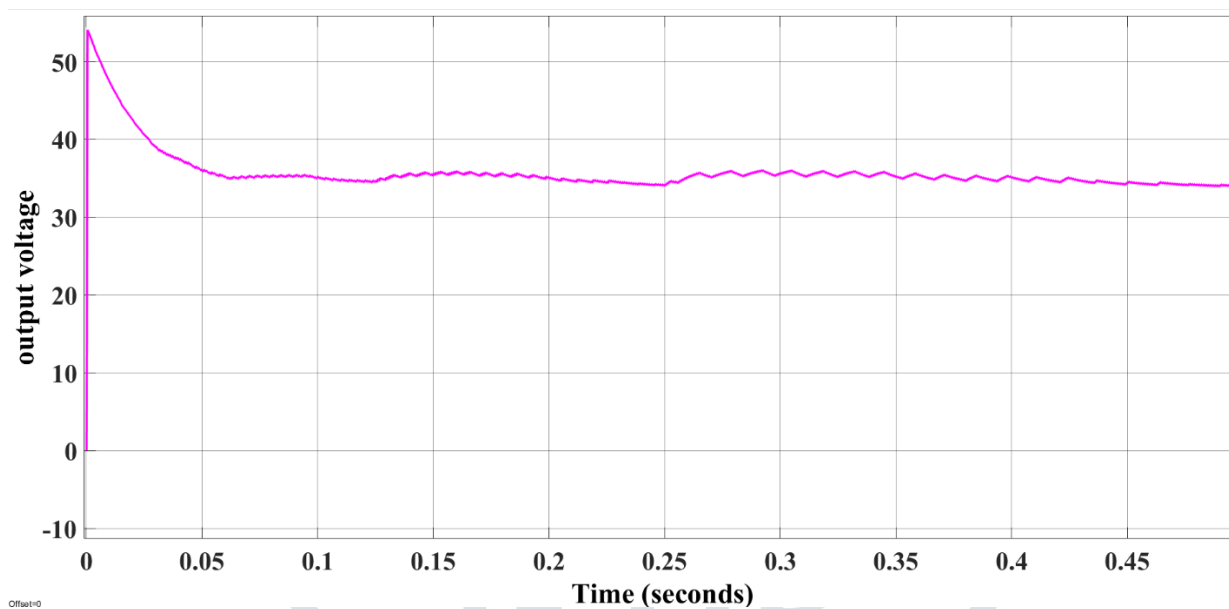


Figure.5.6 output voltage of DC-DC boost converter PI controller.

#### 6 .Output current of boost converter with SMC:

This graph indicates the current vs time curve of DC-DC boost converter with SMC. The output current of SMC is 0.2amperes.

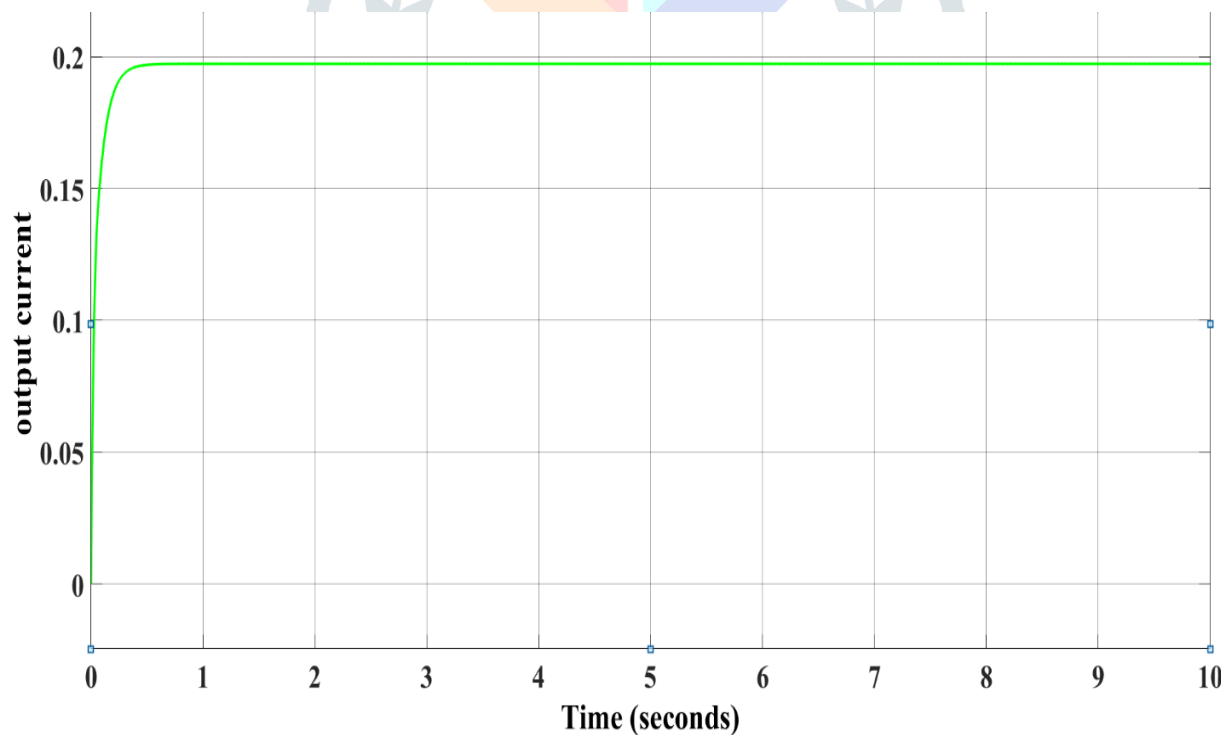


Figure 5.7 Output voltage DC-DC boost converter with SMC.

The analysis has been carried out to verify the operation of boost converter with the parameters calculated .

## Observations

The SM controller has been the conventional controller for many applications since centuries for its excellent tuning properties and ability to improve the performance of the system by a great margin, when compared to PI controller. However, there is an exponential growth in the increment of usage of non-linear loads in the world.

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