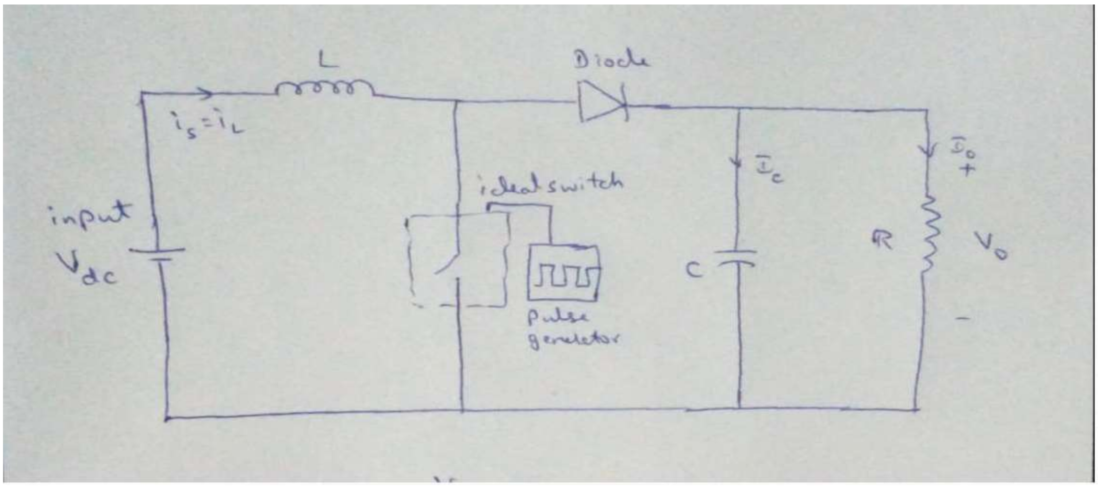
Contents :

Introduction : Step-Up Converter (Boost Converter)

- It is a DC-DC converter which produces a higher average output voltage than the dc input voltage Vdc.
- It also steps down the output current and is also called current buck circuit
- Its main application is in regulated dc power supplies and regenerative breaking of dc motors.
- It basically consists of a switch which is closed for a certain period of time ton and open for a time toff along with a high capacitor filter.
- The average output voltage value Vo depends on ton and toff.
- Pulse width modulation switching is used in which the switching duty ratio d is equal to ratio of on duration time to the time period of switch.

Below is the basic circuit of a boost converter :



- As we know the average voltage across inductor is always zero, hence based on voltage time balance equation we get ***Vo=Vin/(1-d)***
- As we know the average current through a capacitor is always zero, hence based on current time balance equation we get ***Io=Iin*(1-d)***
- The ripple in output current $\triangle$ IL = V_o*(1-d)*d*T / L
- The ripple in output voltage $\triangle$ Vo = V_o*d*T/R*C

Design Specifications:

Assumptions :

- Assuming input voltage Vdc = 20V
- Switching frequency = 5K Hz
- Load Resistance R_L=10 ohms
- Desired permissible Ripple in output current = 0.25 A
- Desired permissible Ripple in output voltage = 0.25 V
- Desired Output voltage = 50 V

Component Selection :

1. Switch : For simulation of boost converter we use ideal switch with zero internal resistance and which can operate in high switching frequency
2. Pulse Generator : We need pulse generator to produce gate pulses which can trigger the switch. The Time period of the pulse signals are assumed to be 5K Hz with 60% duty cycle calculated using

   1/(1-d) = V0(Desired)/Vdc(input)
   1-d = 20/50
   d = 0.6 = 60%
3. Inductor : Inductor is chosen based on the permissible ripple allowed in output current.

   $L = V_o*(1-d)*d*T / \triangle I_L$

Design

For inductor :- $f_s = 5\,KHz \Rightarrow T = 0.2\,msec$

$$\Delta I_L = \frac{V_0(1-d)dT}{L}$$

$$L = \frac{V_0(1-d)dT}{\Delta I_L}$$

$$L = \frac{5(1-0.6)\,0.6\times 0.2\times 10^{-3}}{0.25} = 9.6\,mH$$

$$\boxed{L = 9.6\,mH}$$

4. Capacitor : Capacitor is chosen based on the permissible ripple allowed in output voltage.

$$C = V_o * d * T / R * \Delta V_o$$

For Capacitor:-

$$\Delta V_o = \frac{V_o D T}{R C}$$

$$C = \frac{V_o d T}{R \Delta V_o} = \frac{50 \times 0.6 \times 0.2 \times 10^{-3}}{10 \times 0.25}$$

$$\boxed{C = 2.4\,mF}$$

Simulation and waveforms:

Fig 1 : Circuit diagram of a boost converter

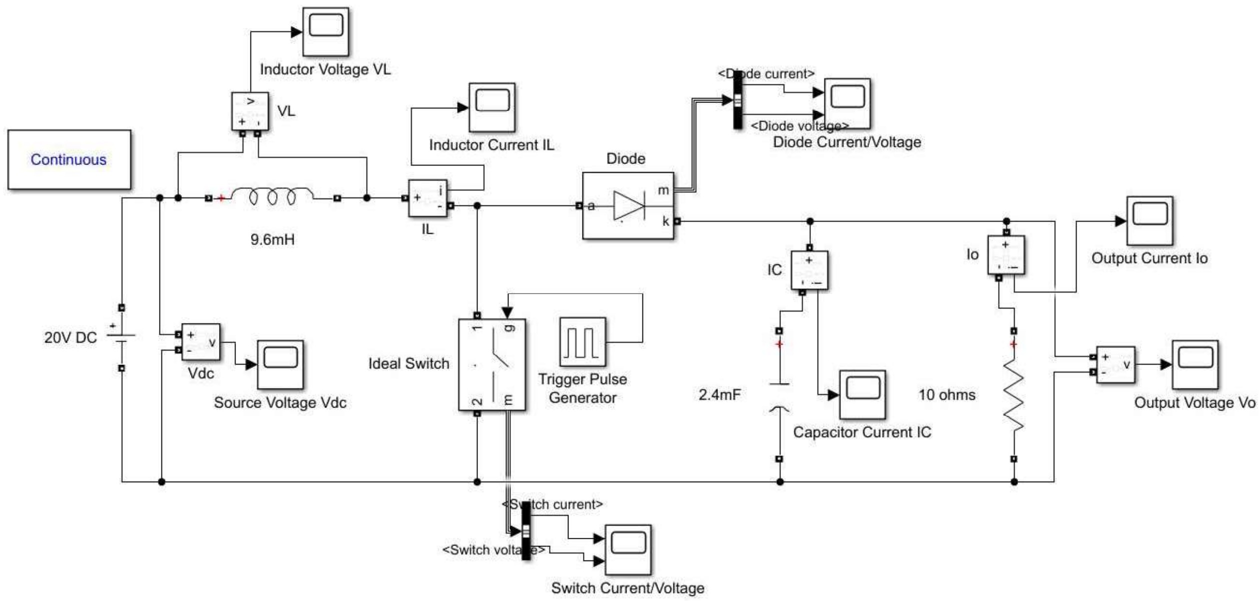


Fig 2 : Input DC Voltage source (Vdc)

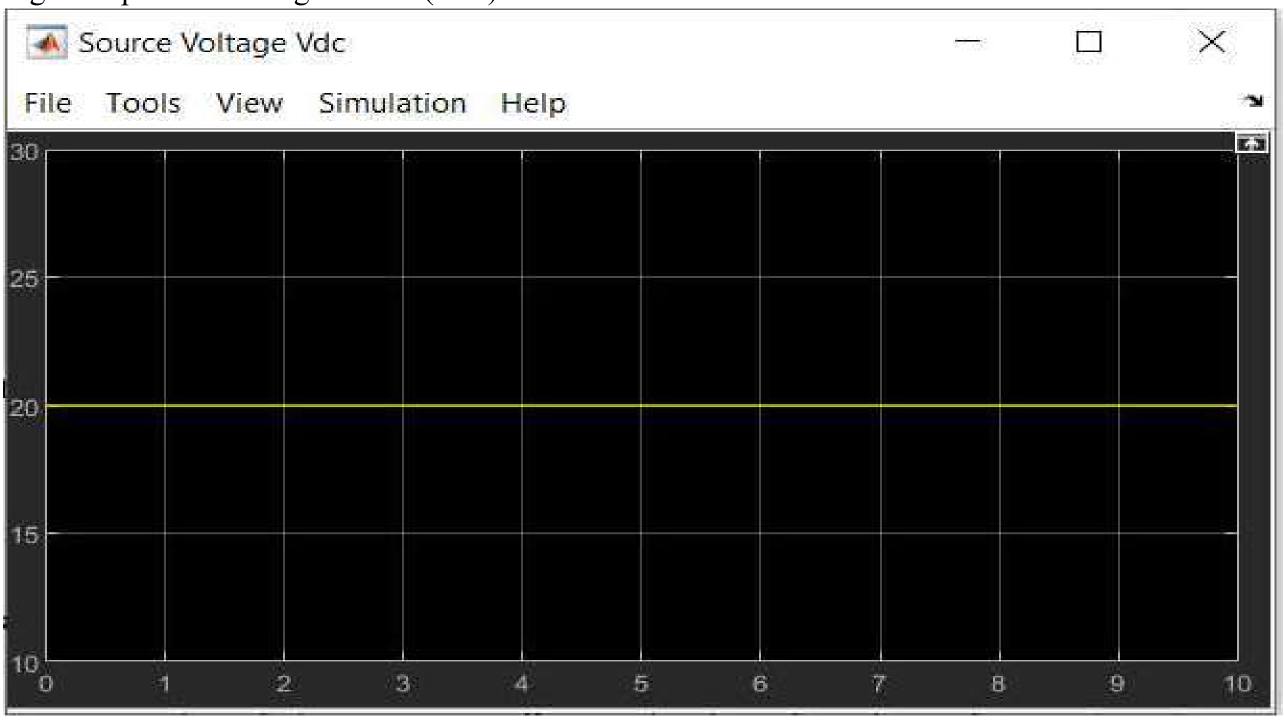


Fig 3 : Source Current waveform / Inductor Current IL

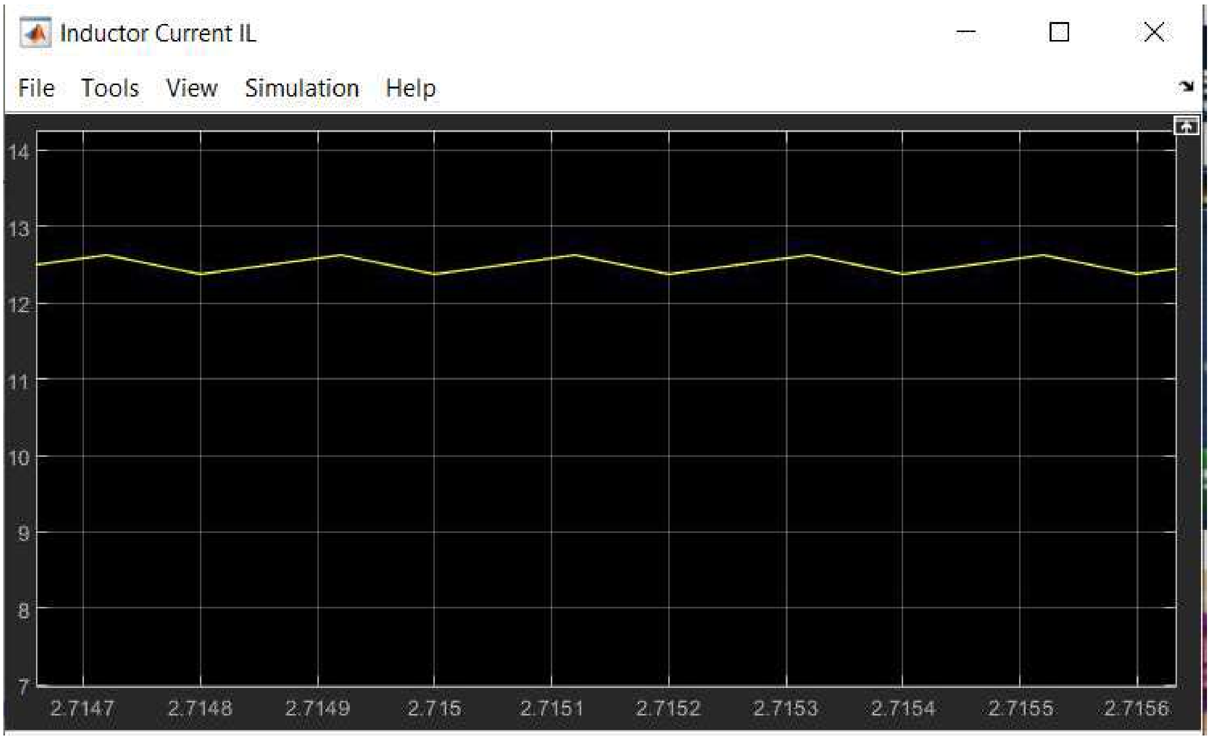


Fig 4 : Output Voltage waveform (V_o)

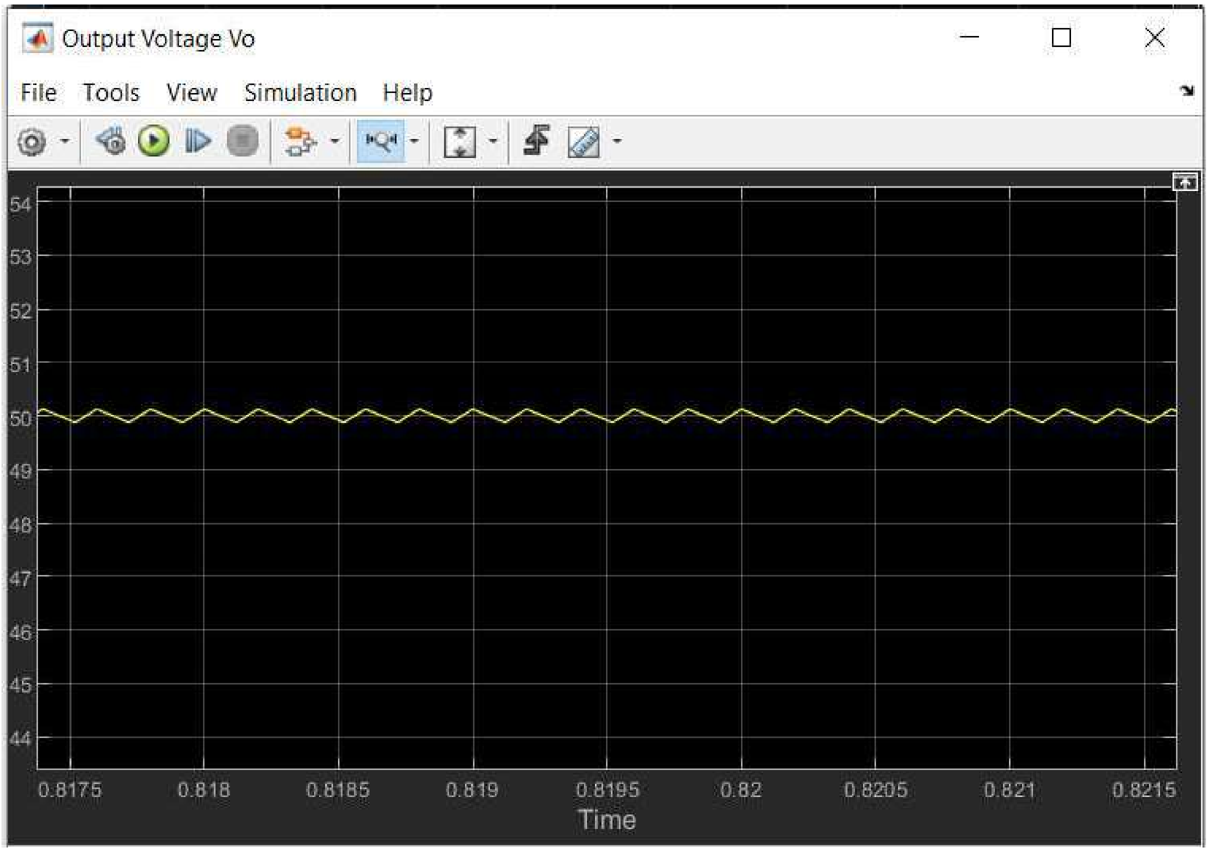


Fig 5 : Output current waveform (I_o)

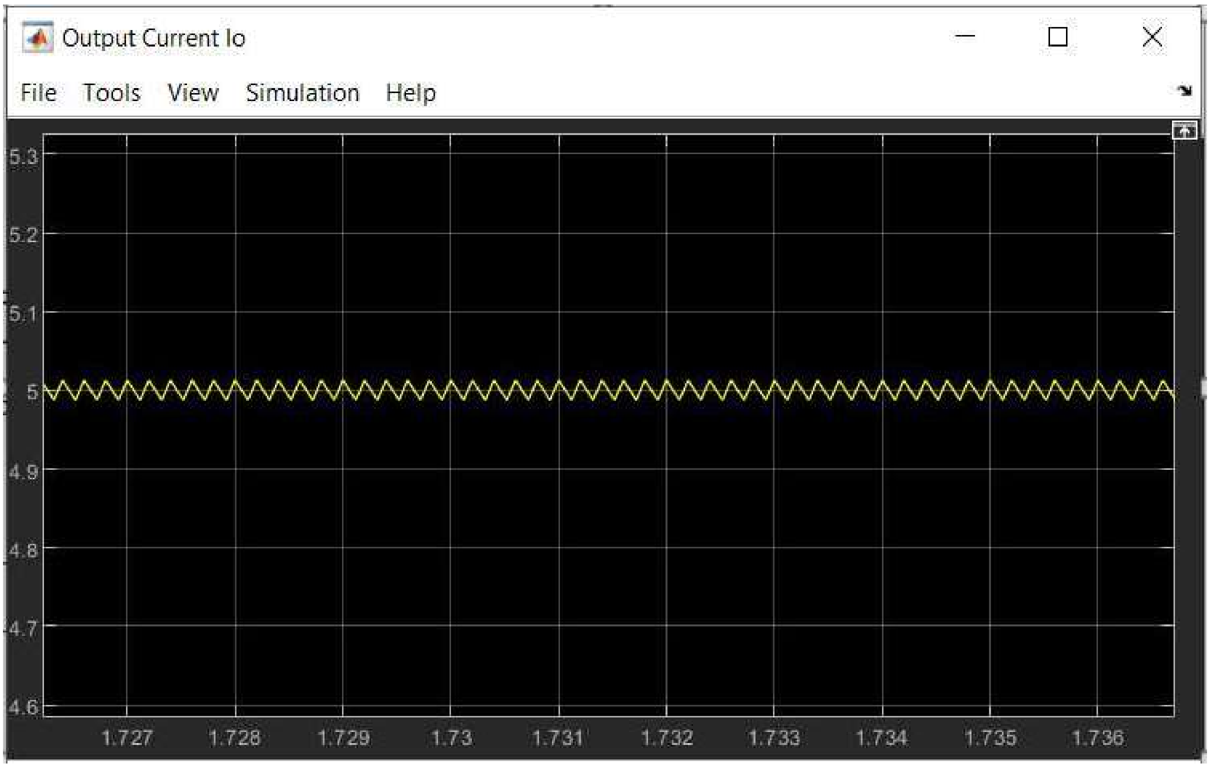


Fig 6 : Voltage across Inductor (V_L)

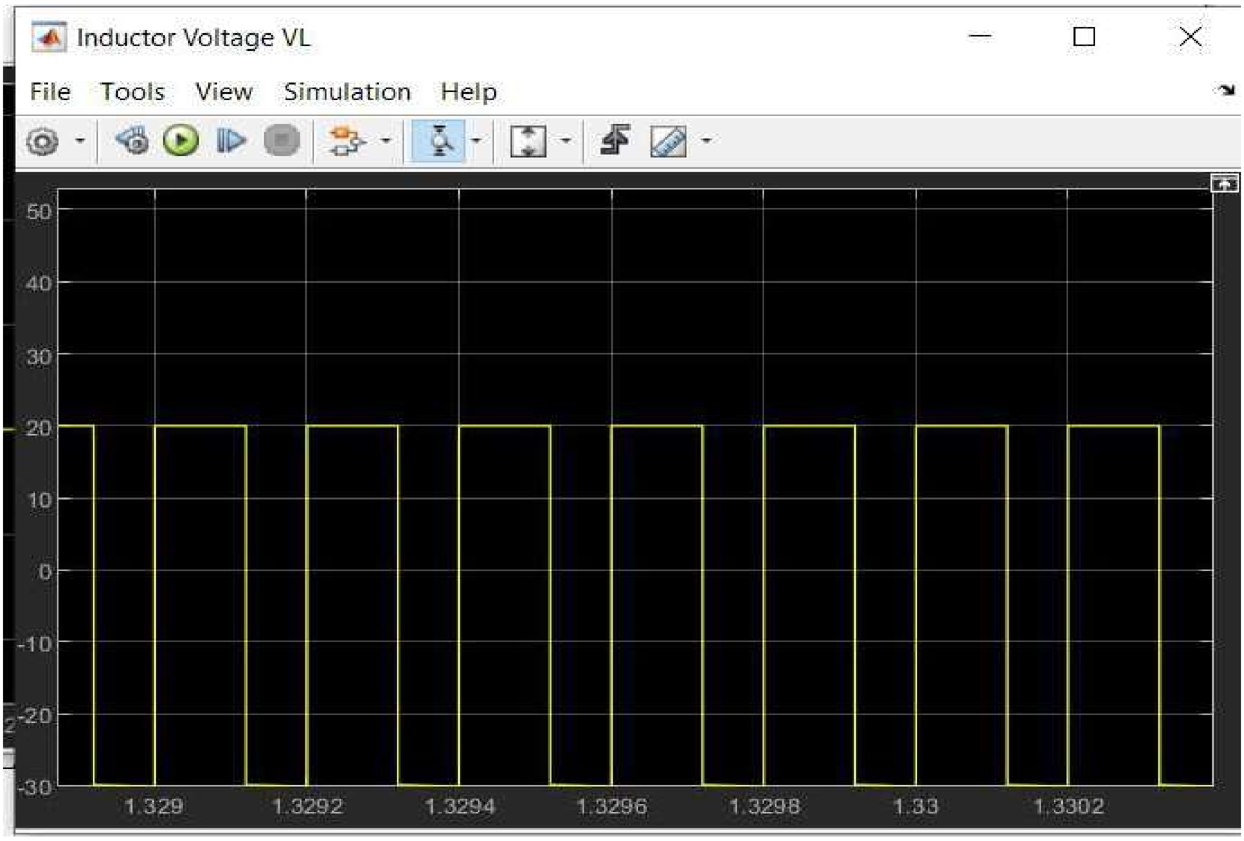


Fig 7 : Current through diode (I_{diode}) and Voltage across diode (V_{diode})

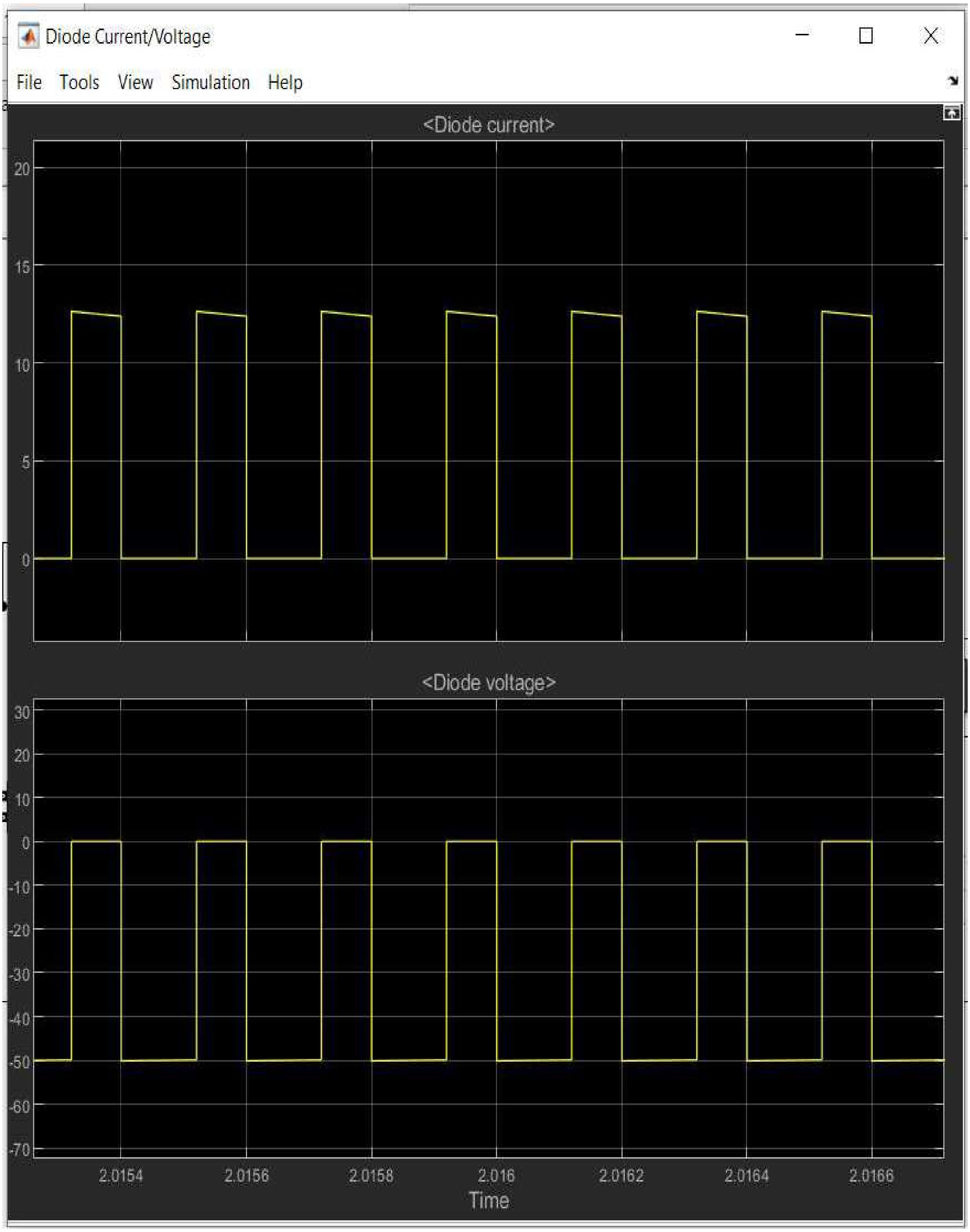


Fig 8 : Current through Switch and Voltage across switch

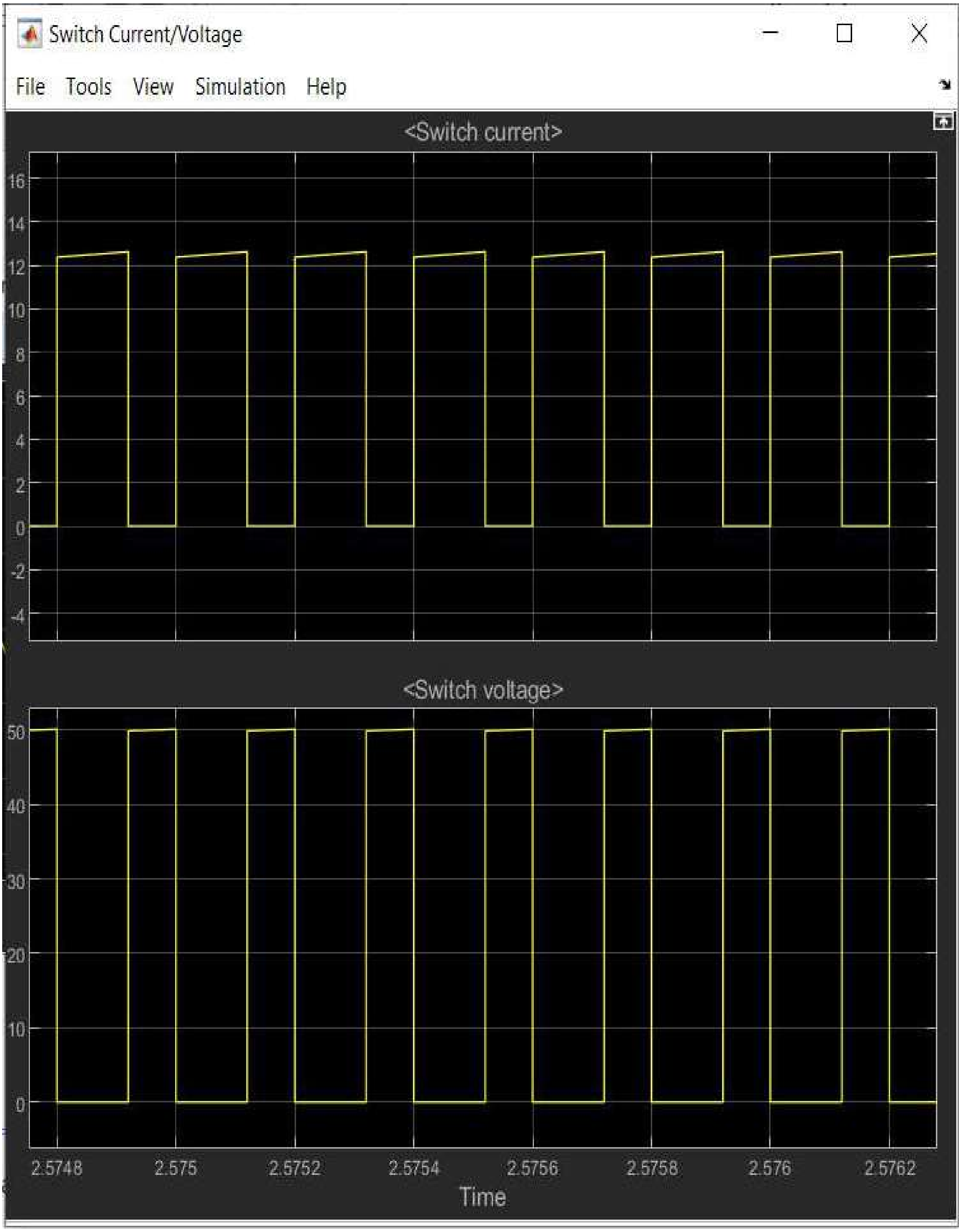
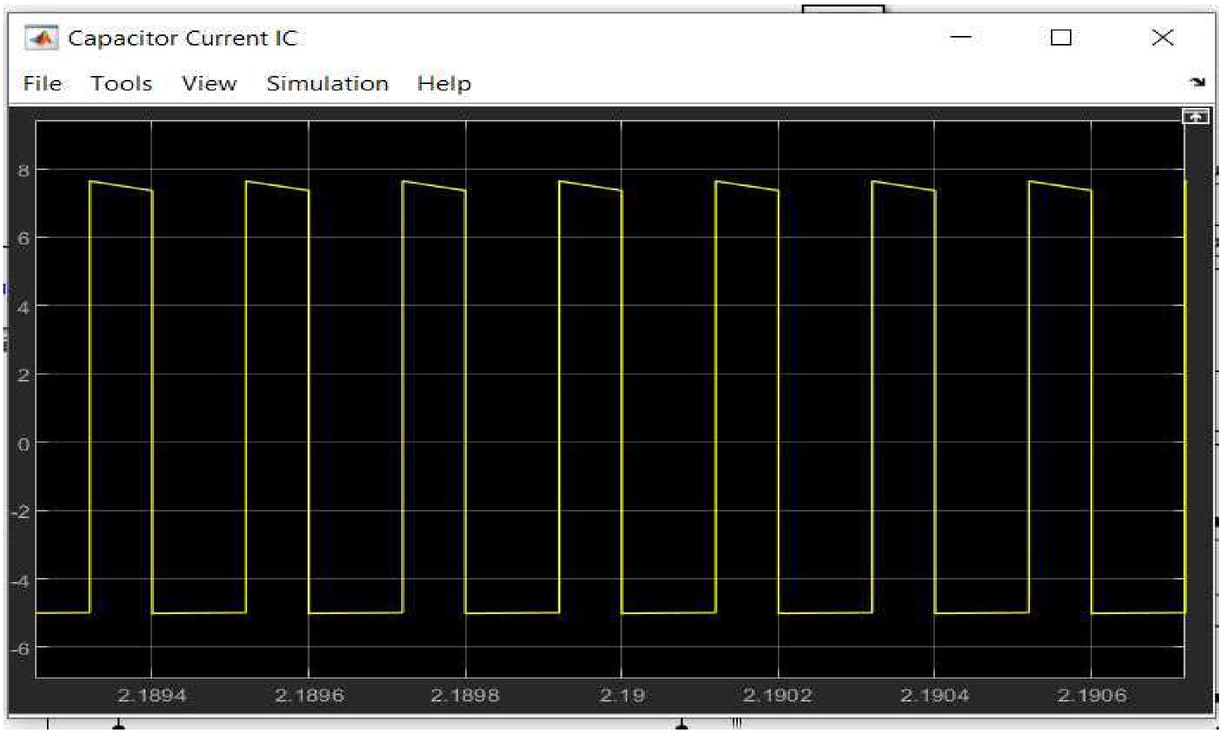


Fig 9 : Current through capacitor (I_C)



Conclusion :

Boost converter is simulated in Matlab and desired output is obtained.