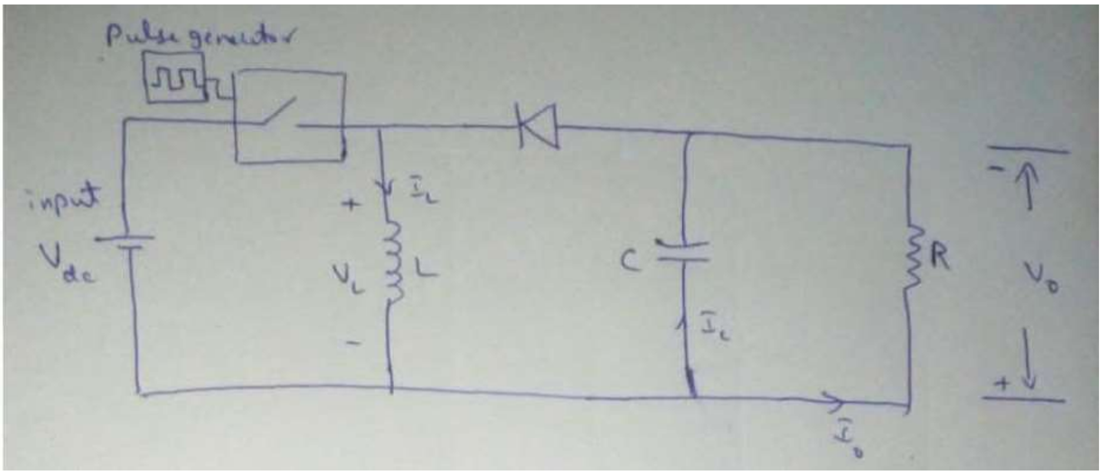
Contents :

Introduction : Buck-Boost Converter

- It is a DC-DC converter which produces either a higher output voltage or lower output voltage than the dc input voltage Vdc depending on the duty ratio of the switch.
- It is a cascade connection of two basic DC-DC converters, Buck and Boost Converters.
- It acts as buck converter for $d<0.5$ and as boost converter for $d>0.5$ and as voltage follower for $d=0.5$.

Below is the basic circuit of a Buck-Boost converter :



- As we know the average voltage across inductor is always zero, hence based on voltage time balance equation we get ***Vo=Vin*d/(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)/d***
- The ripple in output current Δ IL = V_{dc}*d*T / L
- The ripple in output voltage Δ Vo = I_o*d*T/ 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 :

  Case 1 : As Buck converter d=0.3

  $V_o=d*V_{dc}/1-d$

  $V_o=0.3*20/0.7$

  $V_o=8.57V$

  $I_o= V_o/R$

  $I_0 = 0.857A$

  Case 2 : As Boost converter d=0.7

  $V_o=d*V_{dc}/1-d$

  $V_o=0.7*20/0.3$

  $V_o=46.66V$

  $I_o= V_o/R$

  $I_0 = 4.66A$

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 30% for buck operation.

3. Inductor : Inductor is chosen based on the permissible ripple allowed in output current.

$$L = V_{dc}*d*T/\Delta I_L$$

Design

For inductor :- $\Delta I_L = \dfrac{V_{dc}\, d\, T}{L}$

For $\Delta I_L = 0.25A$ $\Rightarrow$ $L = \dfrac{V_{dc}\, d\, T}{\Delta I_L} = \dfrac{20 \times 0.3 \times 0.2 \times 10^{-3}}{0.25}$

$$\boxed{L = 4.8 mH}$$

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

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

For Capacitor :- $\Delta V_o = \dfrac{I_o\, d\, T}{C} = \dfrac{V_o\, d\, T}{RC}$

$$V_o = \frac{V_{dc}\, d}{1-d} = \frac{20 \times 0.3}{1-0.3} = 8.57$$

$$0.25 = \Delta V_o = \frac{8.57 \times 0.3 \times 0.2 \times 10^{-3}}{10\, C}$$

$$C = \frac{8.57 \times 0.3 \times 0.2 \times 10^{-3}}{10 \times 0.25}$$

$$\boxed{C = 205.7\, \mu F}$$

Simulation and waveforms for Buck operation:

Fig 1 : Circuit diagram of a Buck-Boost converter

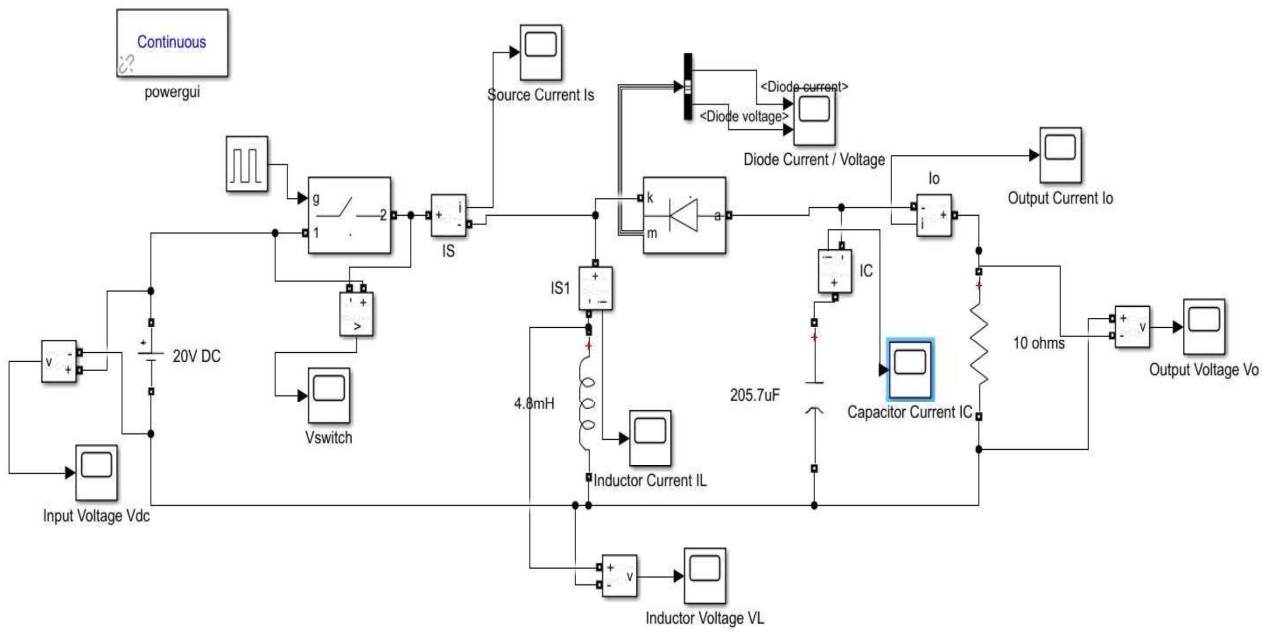


Fig 2 : Input DC Voltage source (Vdc)

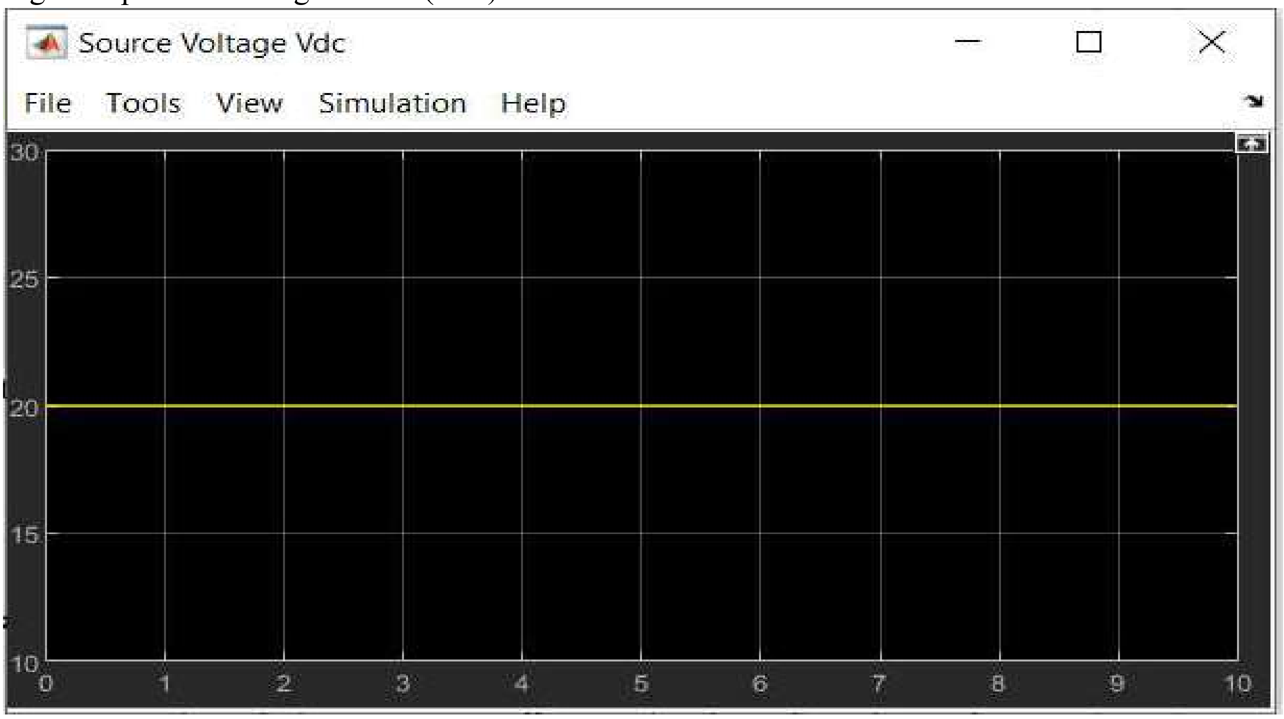


Fig 3 : Source Current waveform / Switch Current Is

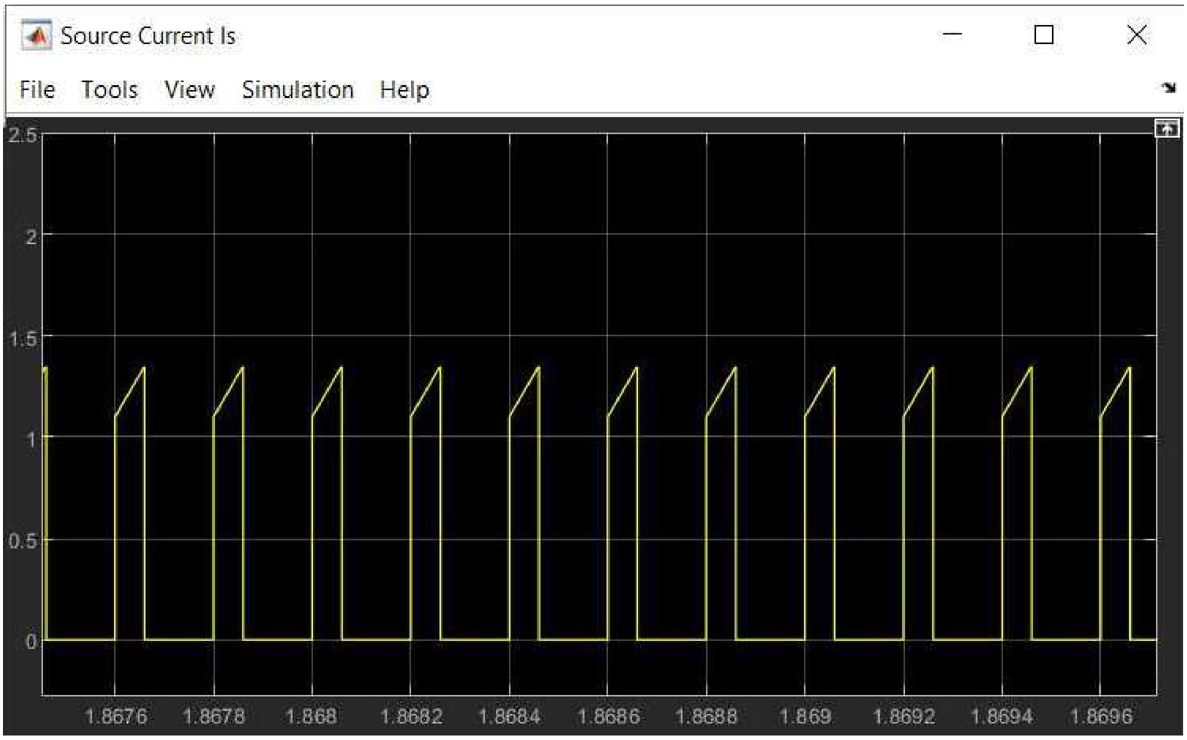


Fig 4 : Output Voltage waveform (V_o)

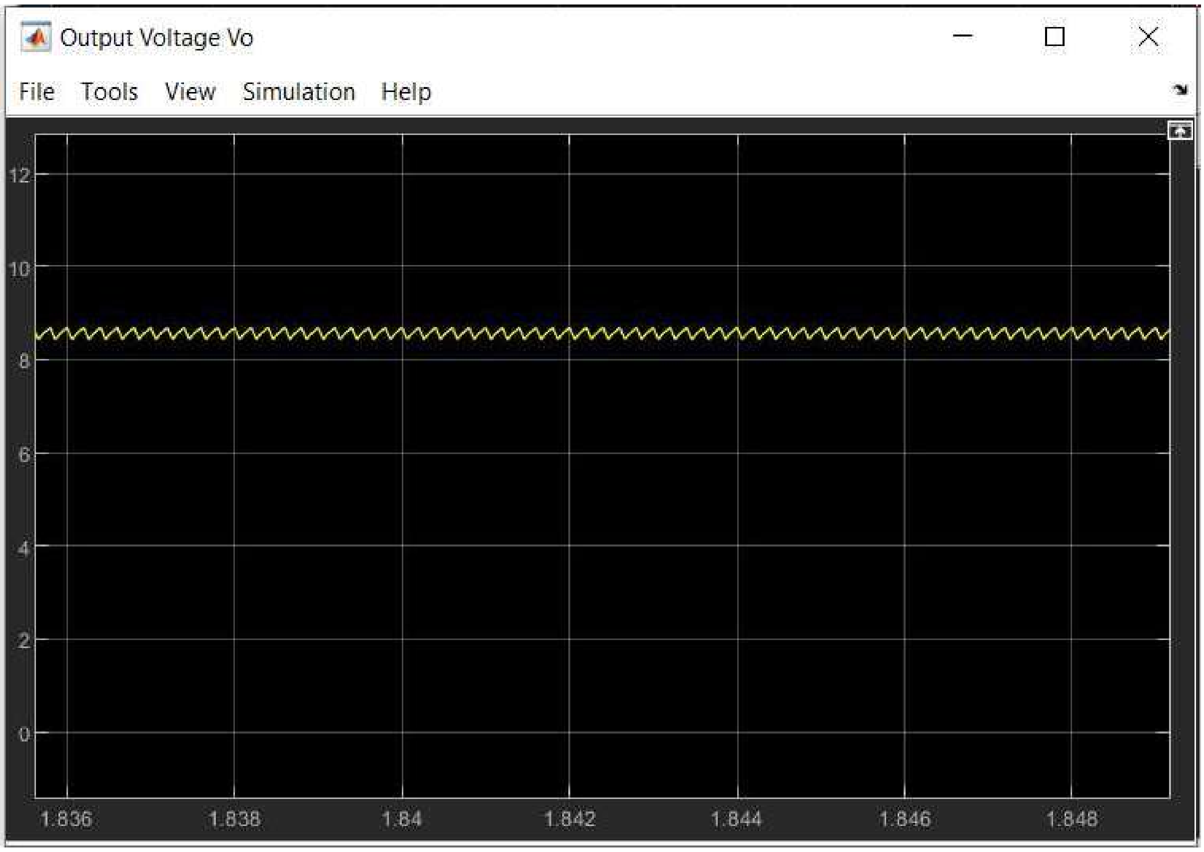


Fig 5 : Output Current waveform (I_o)

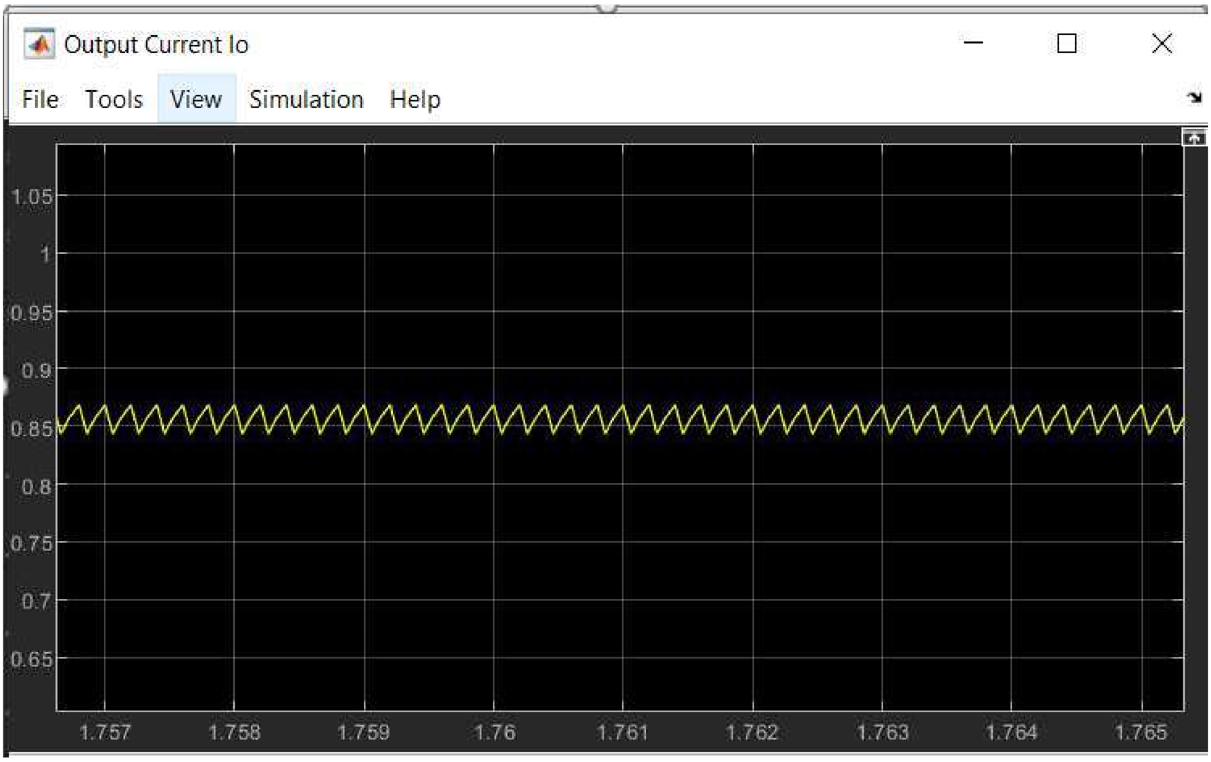


Fig 6 : Voltage across Switch

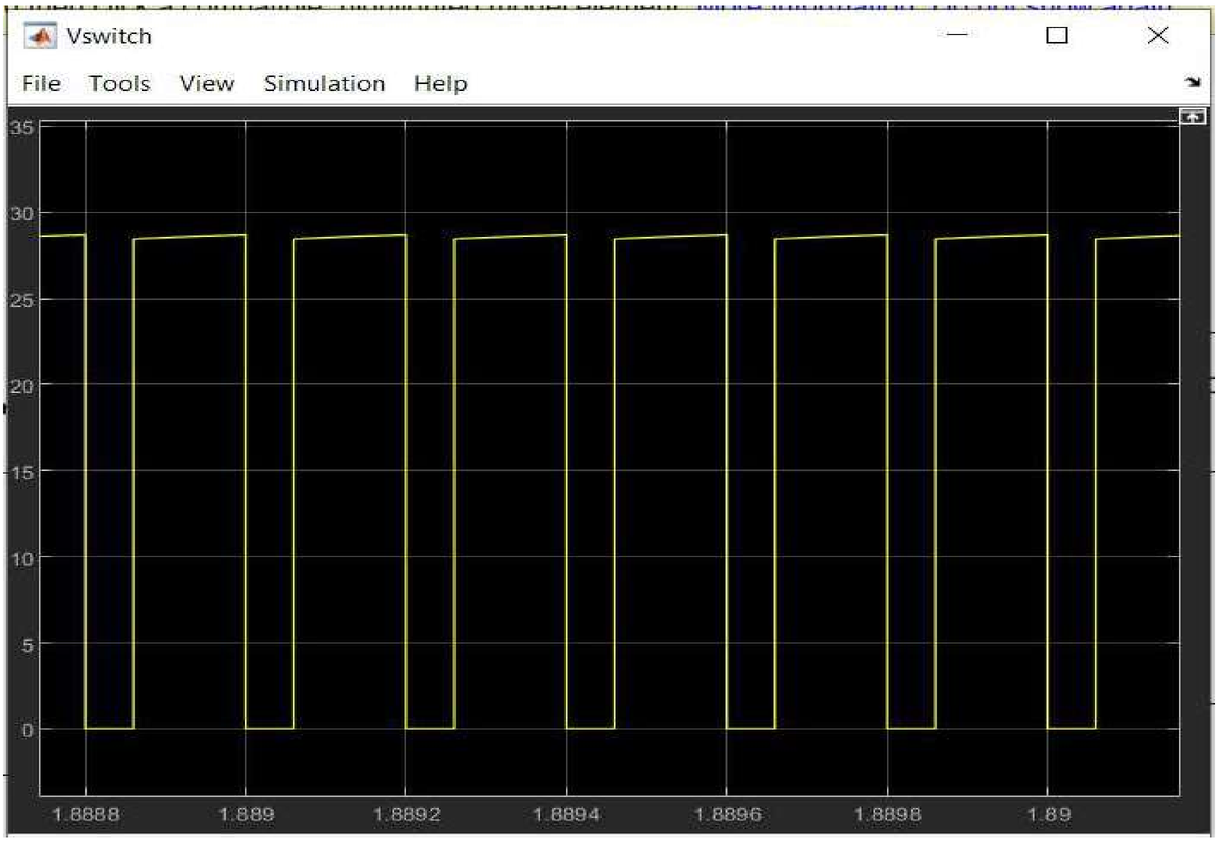


Fig 7 : Voltage across inductor (VL)

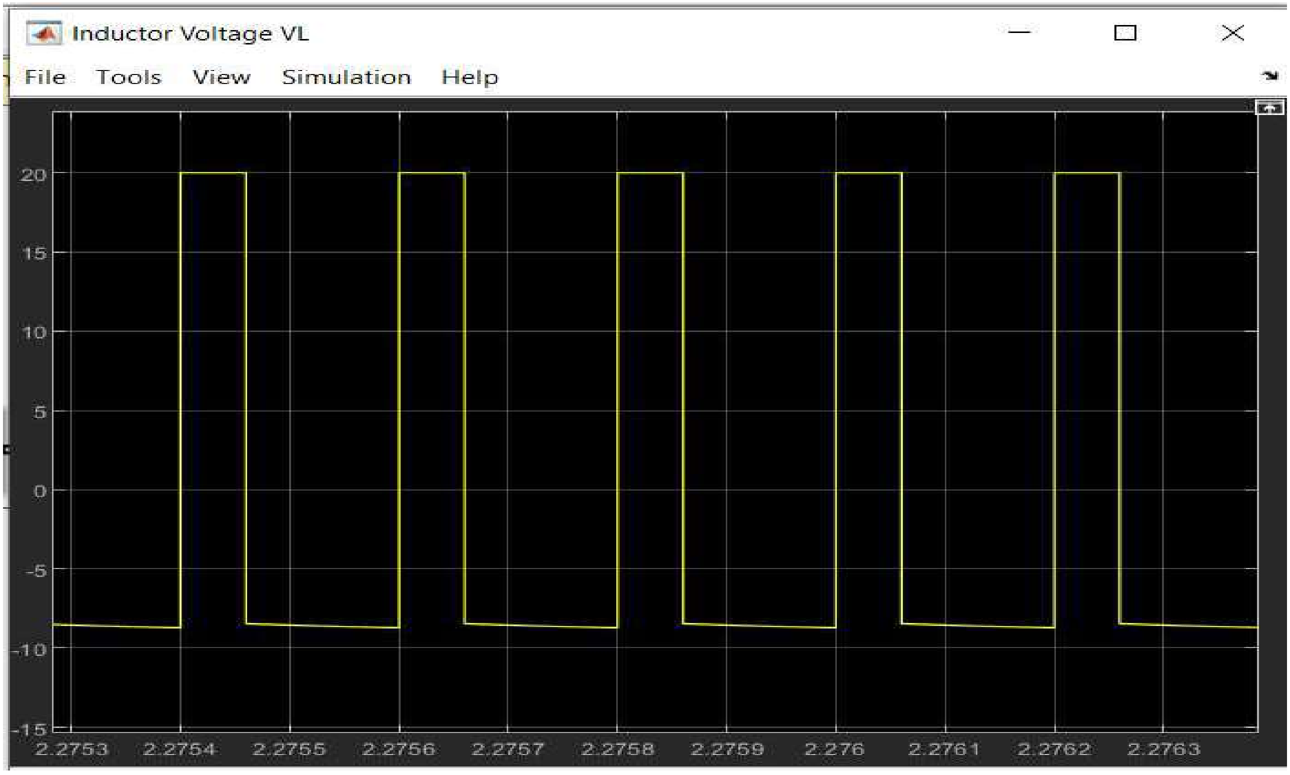


Fig 8 : Current through inductor (IL)

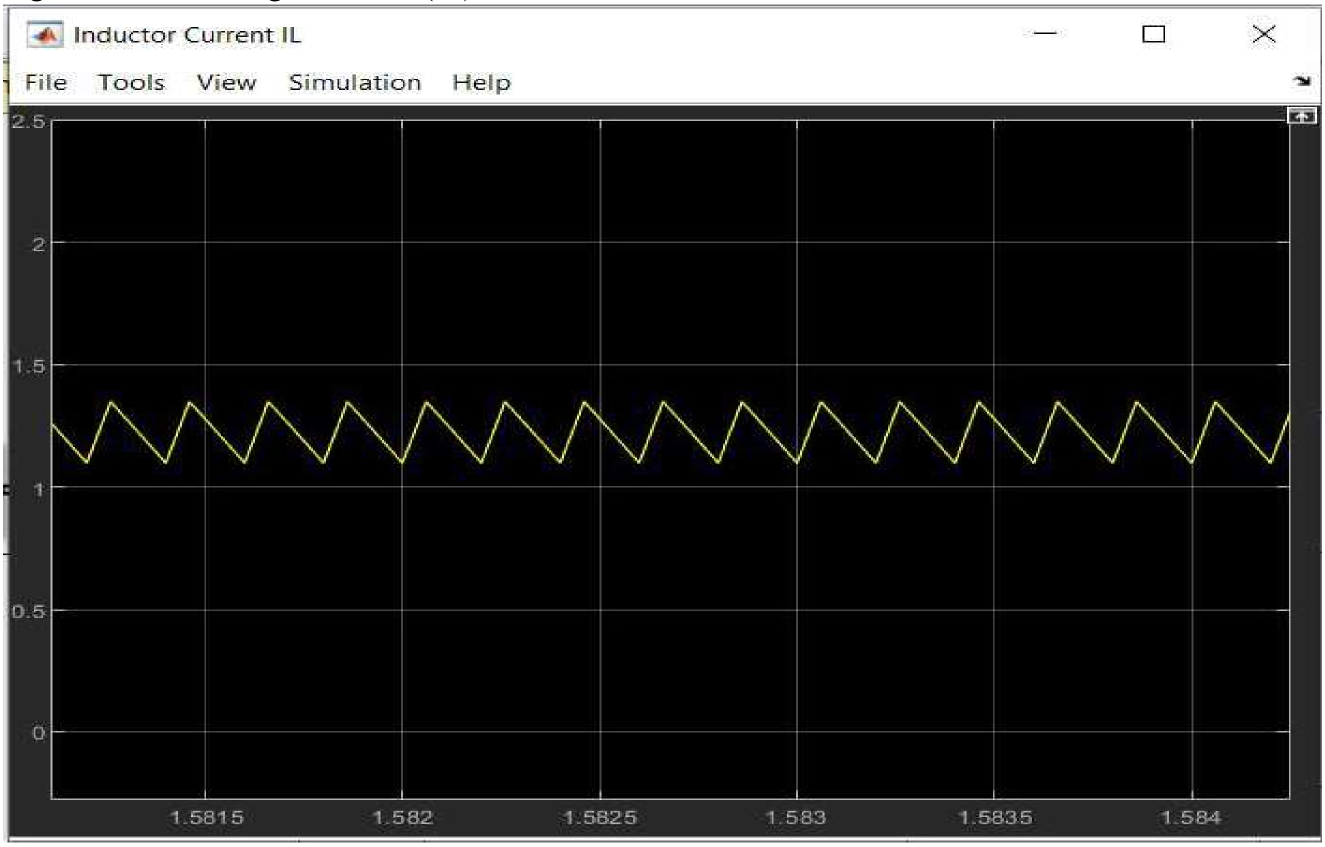
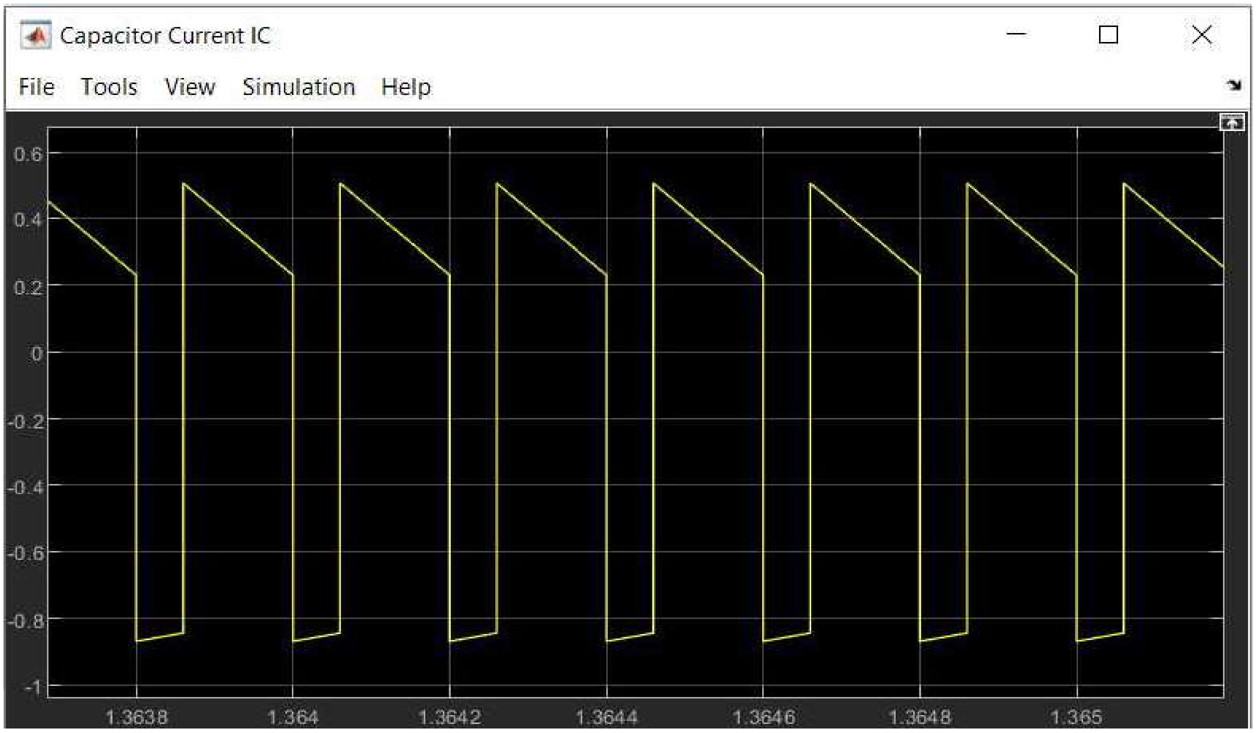


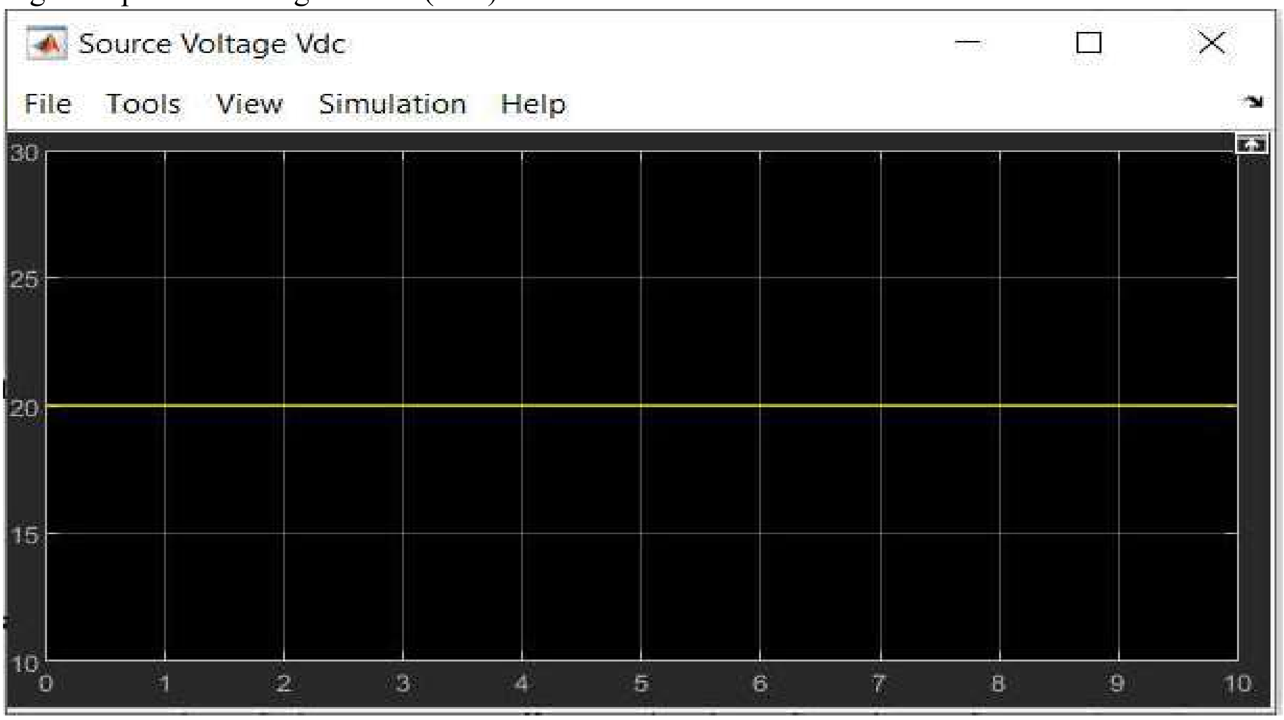
Fig 9 : Current through diode(I_{diode}) and Voltage across diode (V_{diode})

Fig 10 : Current through capacitor (I_C)



Simulation and waveforms for Boost operation:

Fig 2 : Input DC Voltage source (Vdc)



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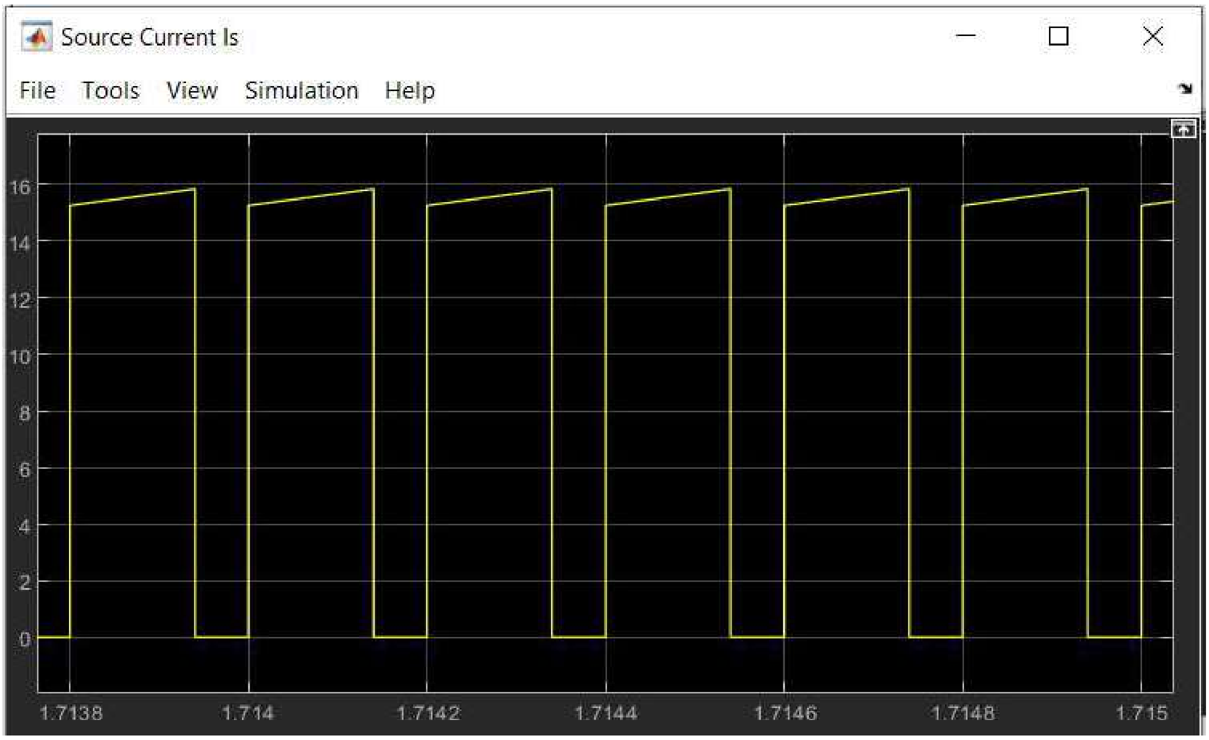

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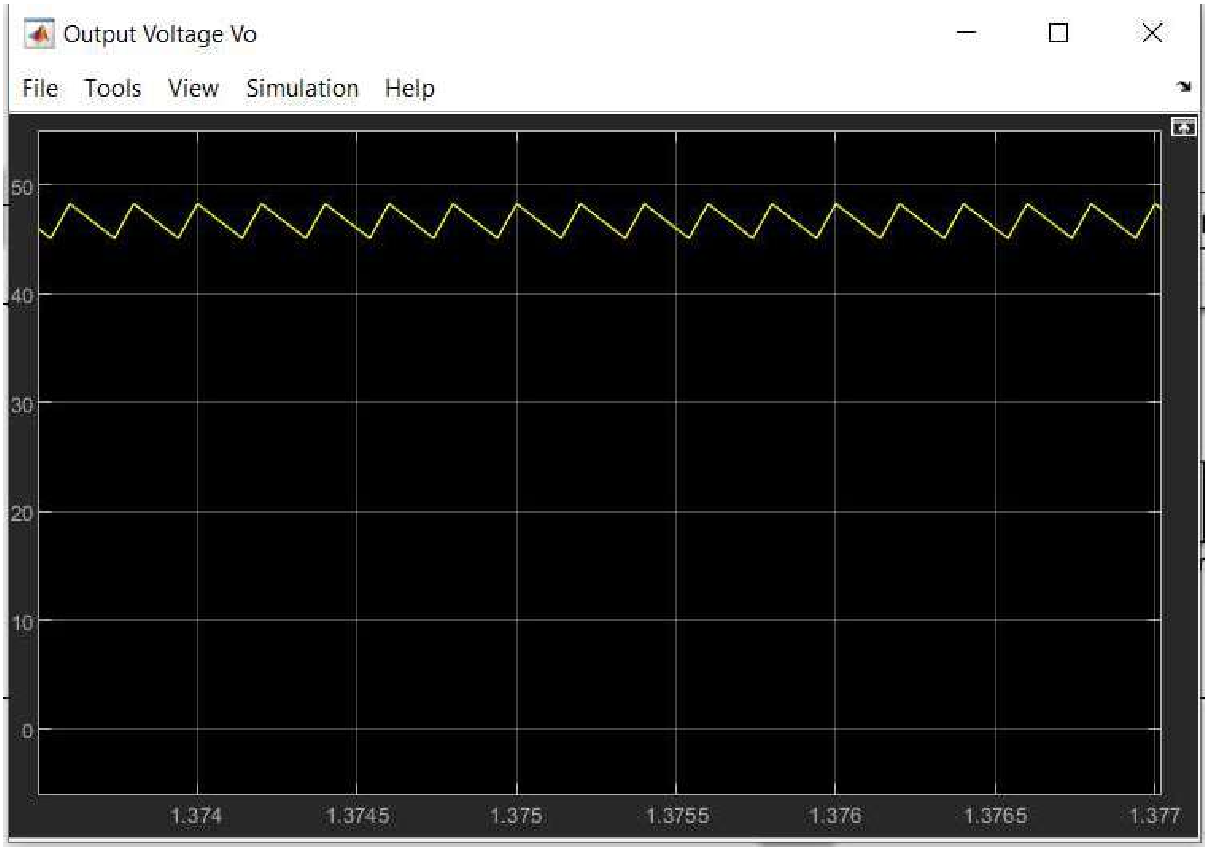


Fig 5 : Output Current waveform (I_o)

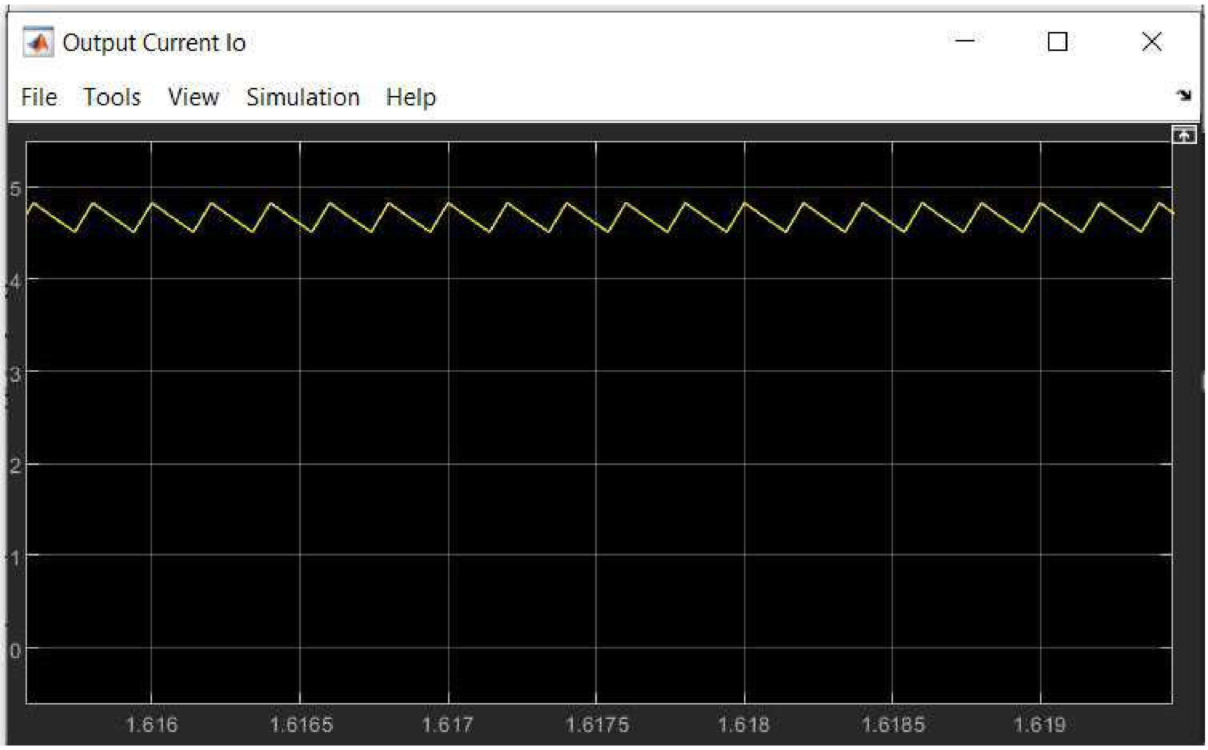


Fig 6 : Voltage across Switch

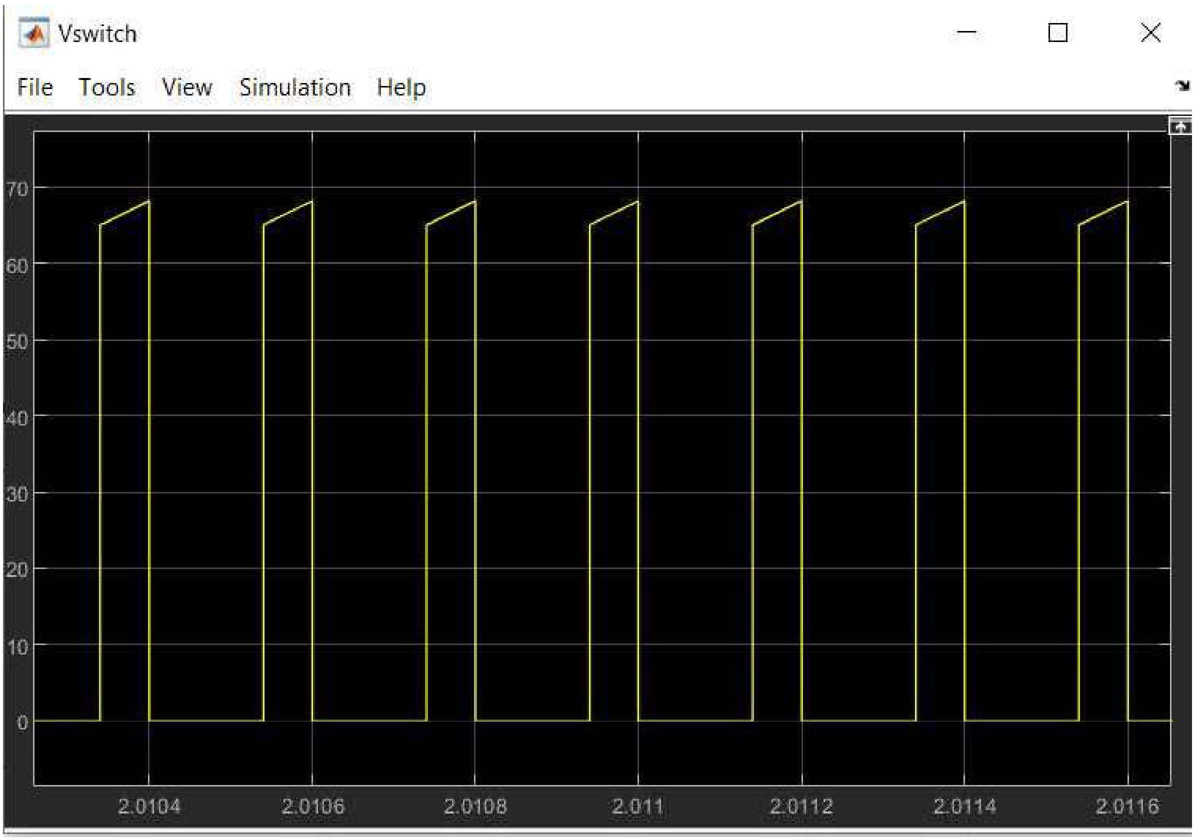


Fig 7 : Voltage across inductor (VL)

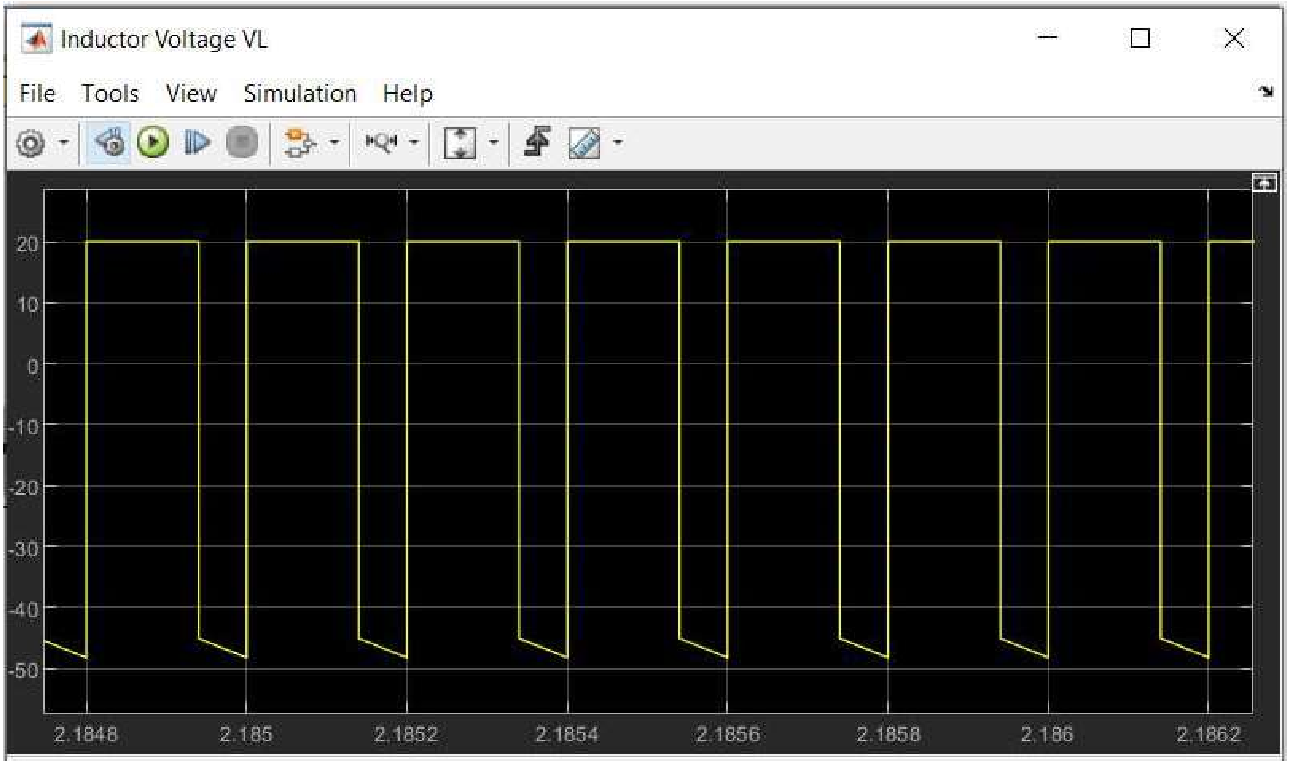
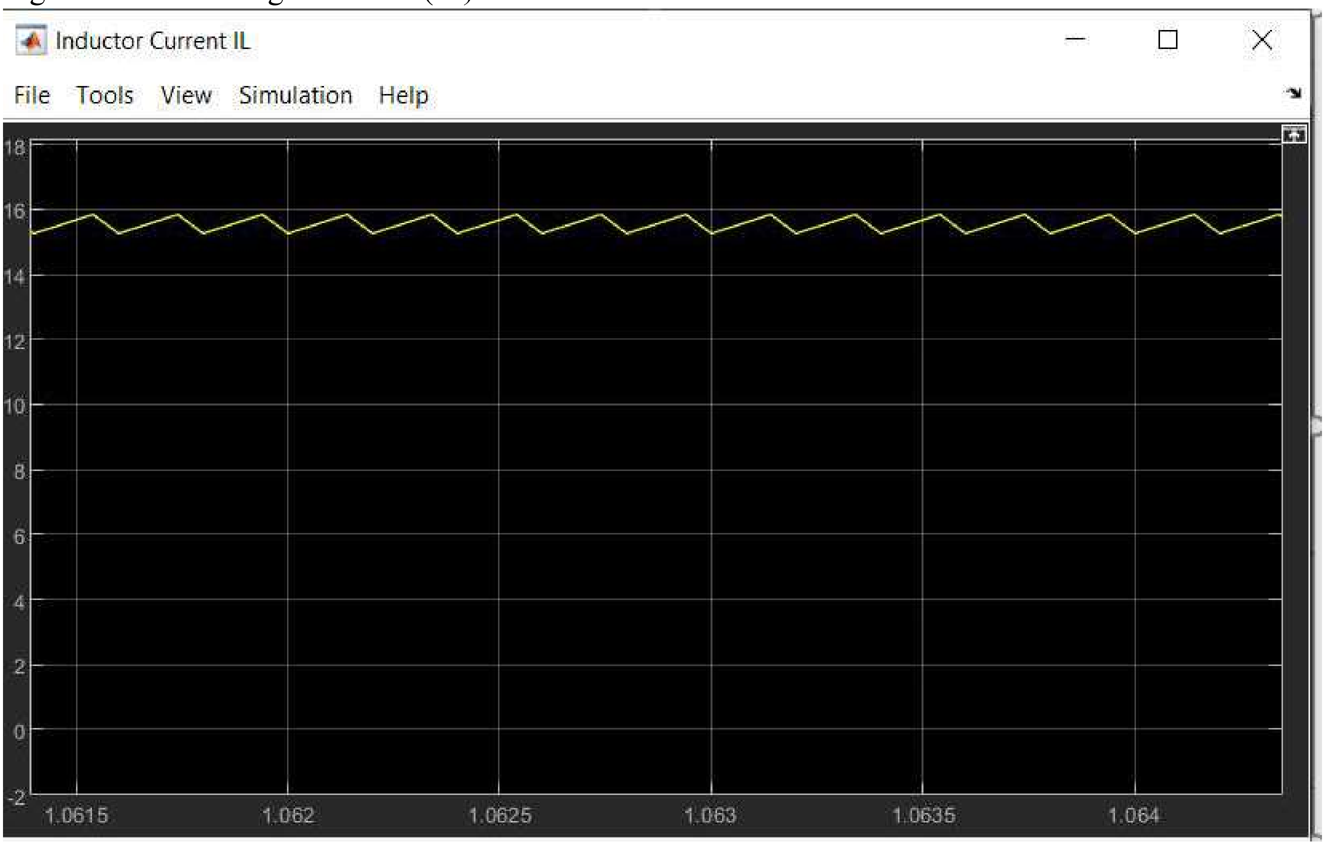


Fig 8 : Current through inductor (IL)



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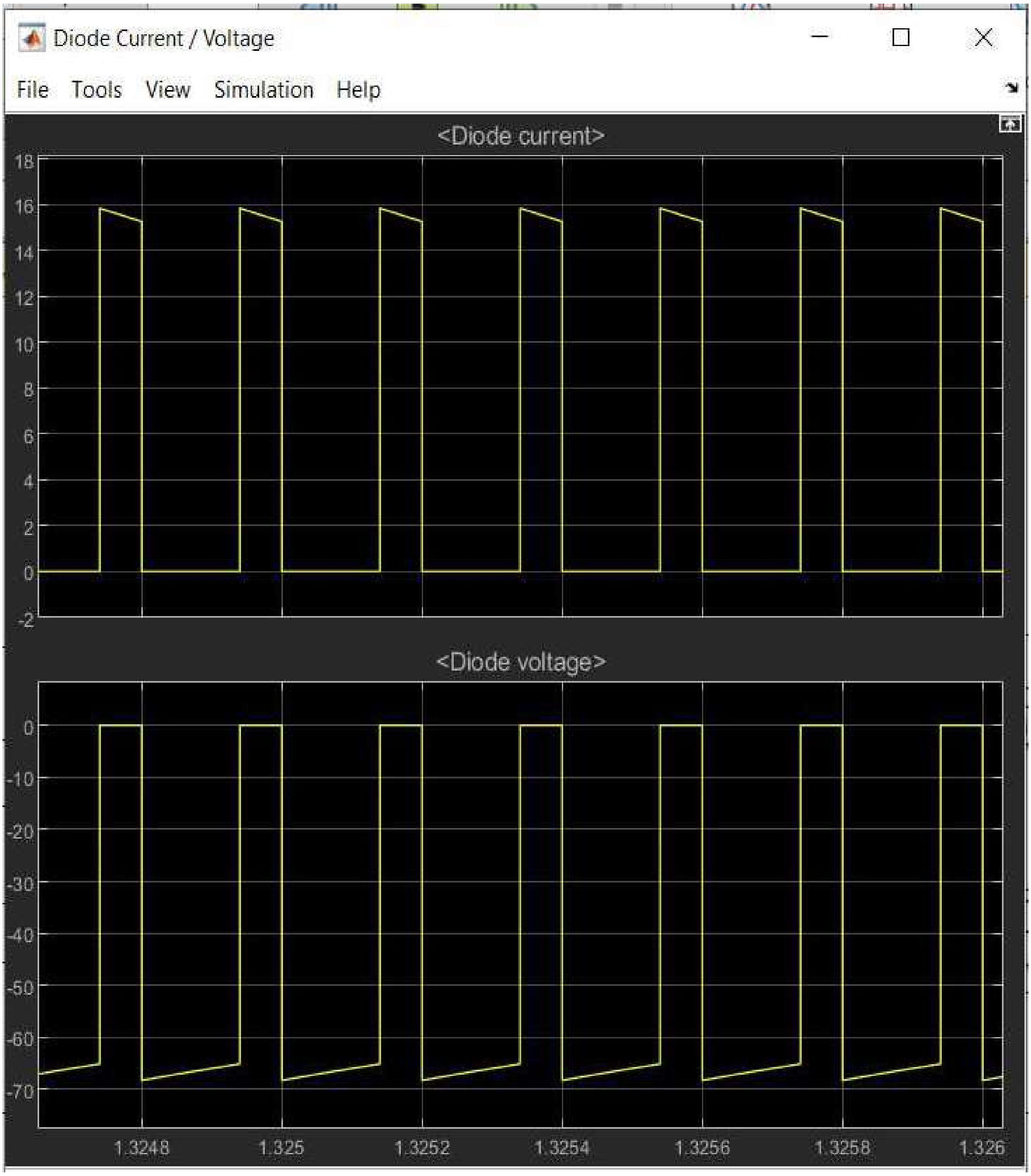
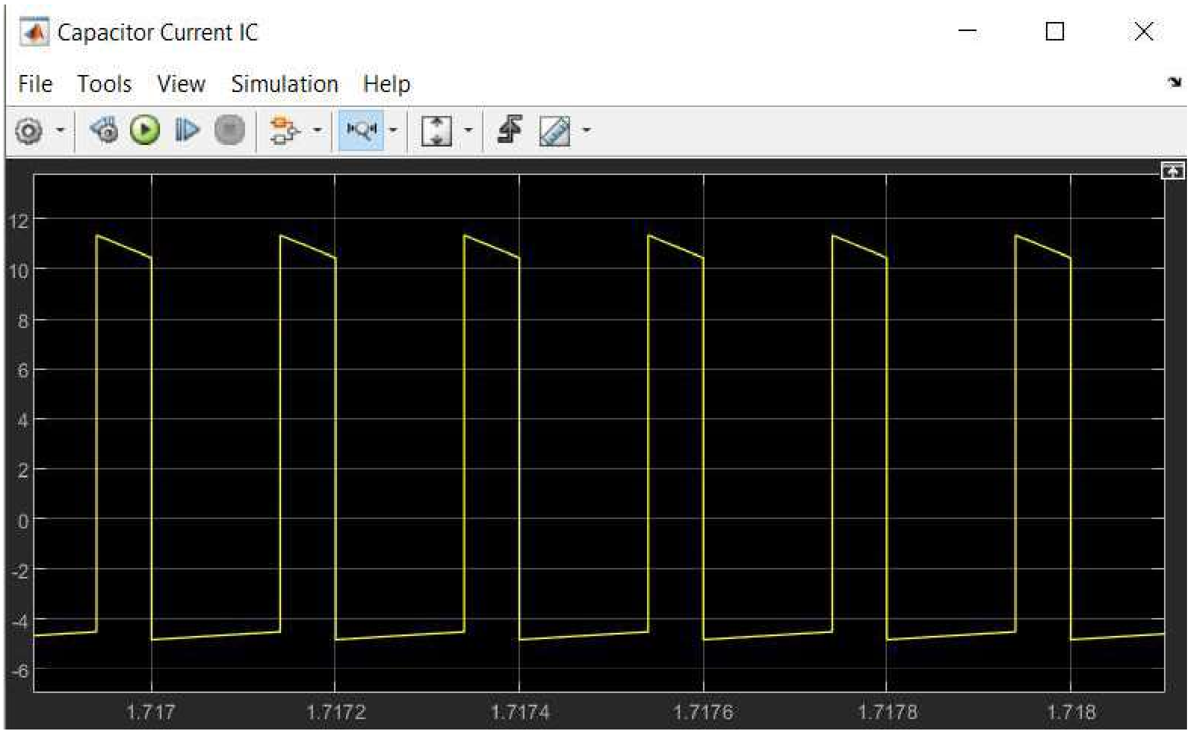


Fig 10 : Current through capacitor (I_C)



Conclusion :

Buck-Boost converter is simulated in Matlab as buck converter is visualized with d=0.3 and boost converter is visualized with d=0.7 and output waveforms are obtained.