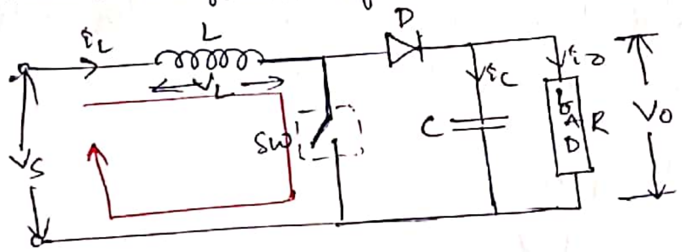
Module - 4

Boost Converter :

- It is also called as boost regulator
- If the input voltage is fixed and the output voltage is greater than the input voltage.

$$\boxed{V_o > V_s}$$

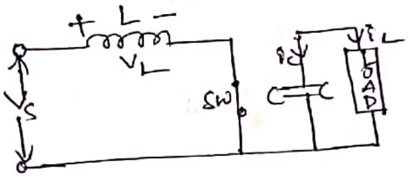
- Circuit diagram of boost converter as shown in figure.



- The boost Converter has two modes of operation.

Mode I : <u>Switch is ON</u>, <u>diode is OFF</u>

- When switch is ON, (at t=0), the input current rises and flow through the inductor.



$$\boxed{V_L = V_s}$$

- charging of inductor increas, capacitor is discharges ($V_C \downarrow$)
- Boost convert in steady state operation for this mode using KVL,

$$V_L = V_s$$

$$V_L = L\frac{di_L}{dt} = V_s$$

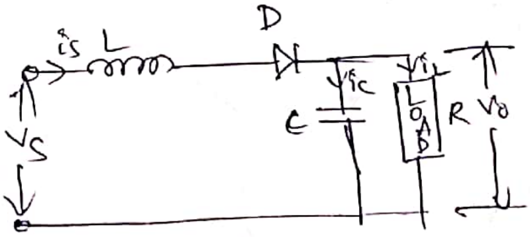
$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{\alpha T} = \frac{V_s}{L}$$

Since the switch is closed for a time $T_{ON} = \alpha T$ we can say that

$$(\Delta i_L)_{closed} = \left(\frac{V_s}{L}\right)\alpha T$$

Mode II : Switch is OFF, diode ON.

- When the switch is OFF at $t>t_1$. Here current flows through the L,C, Load and diode.



- The energy stored in inductor is discharged through load.

$$\boxed{V_L = V_s - V_o}$$

- Inductor discharges i_L decreases, capacitor charges so V_C increases.

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– Boost Converter in steady state operation for mode II using KVL

$$V_s = V_L + V_o$$

$$V_L = V_s - V_o = L\frac{di_L}{dt} \Rightarrow \frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{(1-\alpha)T} = \frac{V_s - V_o}{L}$$

– Since the switch is open for a time $T_{OFF} = T - T_{ON} = T - \alpha T = (1-D)T$, we can say that $\Delta t = (1-\alpha)T$

$$(\Delta i_L)_{open} = \left(\frac{V_s - V_o}{L}\right)(1-\alpha)T$$

– It is already established that the net change of the inductor current over any one complete cycle is zero.

$$(\Delta i_L)_{closed} + (\Delta i_L)_{open} = 0.$$

$$\left(\frac{V_s}{L}\right)\alpha T + \left(\frac{V_s - V_o}{L}\right)(1-\alpha)T = 0$$

$$\left(\frac{V_s}{\cancel{L}}\right)\alpha \cancel{T} = -\left(\frac{V_s + V_o}{\cancel{L}}\right)(1-\alpha)\cancel{T}$$

$$V_s\alpha = -(V_s - V_o)(1-\alpha)$$

$$V_s\alpha = (-V_s + V_o)(1-\alpha)$$

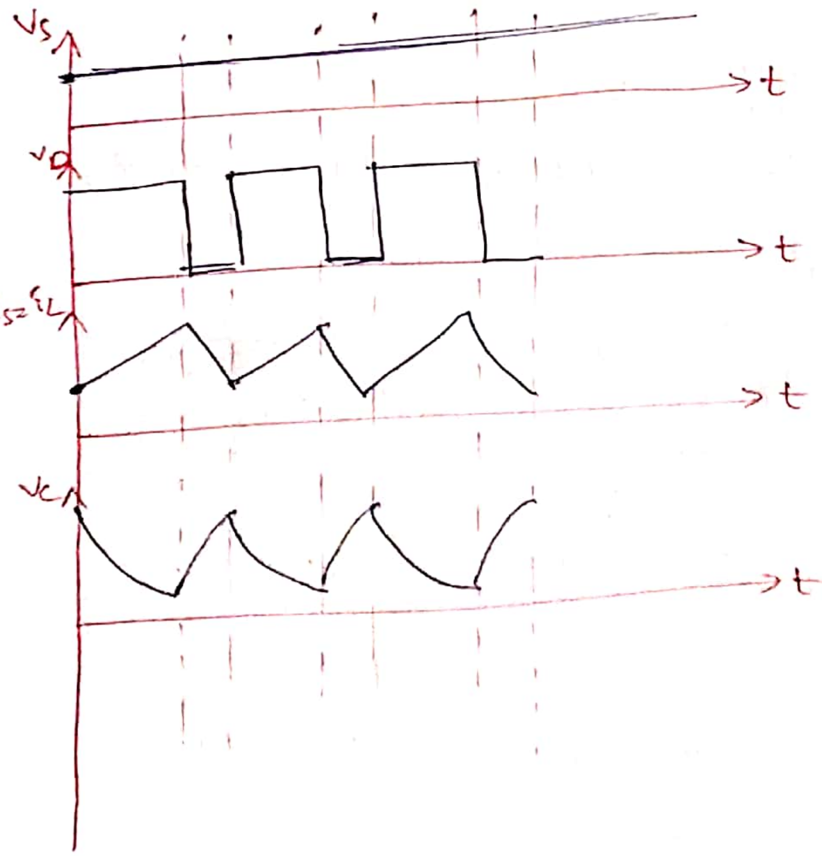
$$V_s\alpha = -V_s + V_o + V_s\alpha - V_o\alpha$$

$$\cancel{V_s\alpha} + V_s + V_o - \cancel{V_s\alpha} + V_o\alpha = 0$$

$$V_s + V_o + V_o\alpha$$

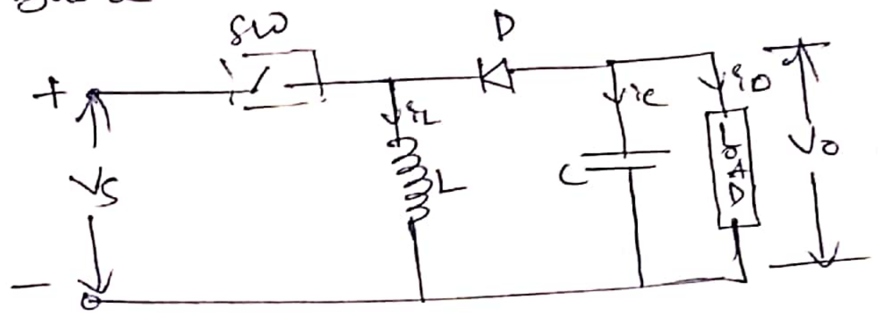
$$V_s = V_o(1-\alpha)$$

$$\boxed{V_o = \frac{V_s}{1-\alpha}}$$



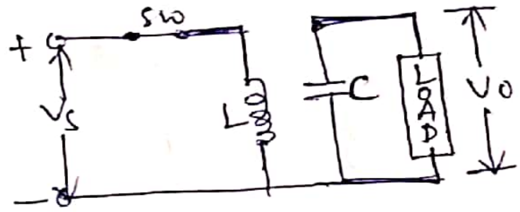
Buck – Boost Converters / Regulator.

- It is a Combination of two Converters, which can perform either of two functions.
- The polarity of output voltage is opposite to that of the input voltage.
- This is also called as inverting or fly wheel regulator
- Circuit diagram of Buck–Boost Converter is shown in figure.



- It operates in two modes.

Mode I: Switch is on, Diode OFF
- when switch is on, current flows through the inductor
- L is charging i_L increases



$$\boxed{V_L = V_s}$$

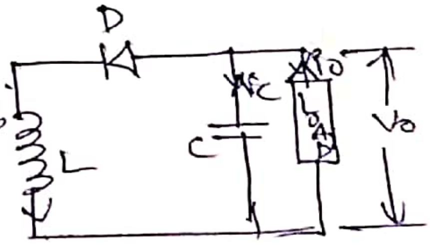
- Buck boost Converter in steady state operation for this mode using KVL

$$V_s = V_L = L\frac{di}{dt} = V_s \Rightarrow \frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{\alpha T} = \frac{V_s}{L}$$

- Since the switched closed for a time $T_{on} = \alpha T$, we can say that $\alpha T = \Delta t$.

$$(\Delta i_L)_{closed} = \left(\frac{V_s}{L}\right)\alpha T. \longrightarrow ①$$

Mode II: Switch is OFF, Diode on



- when switch is off, the current pass through the load and Capacitor.

→ The energy stored in inductor is transferred to load.

$$\boxed{V_L = -V_o}$$

- Buck boost converter in steady state operation for mode II using KVL

$$\therefore V_L = -V_0$$

$$L\frac{di_L}{dt} = -V_0$$

$$\frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{(1-\alpha)T} = \frac{-V_0}{L}$$

- Since the switch is open for a time $T_{OFF} = T - T_{ON} = T - \alpha T = (1-\alpha)T$ we can say $\Delta t = (1-\alpha)T$

$$(\Delta i_L)_{open} = \left(\frac{-V_0}{L}\right)(1-\alpha)T \longrightarrow (2)$$

$$(\Delta i_L)_{closed} + (\Delta i_L)_{open} = 0$$

$$\left(\frac{V_s}{L}\right)\alpha T + \left(\frac{-V_0}{L}\right)(1-\alpha)T = 0$$

$$\left(\frac{V_s}{\cancel{L}}\right)\alpha \cancel{T} = \frac{V_0}{\cancel{L}}(1-\alpha)\cancel{T} = 0$$

$$V_s\alpha = V_0 - V_0\alpha$$

$$\boxed{V_0 = \frac{V_s\alpha}{1-\alpha}}$$

Waveforms: