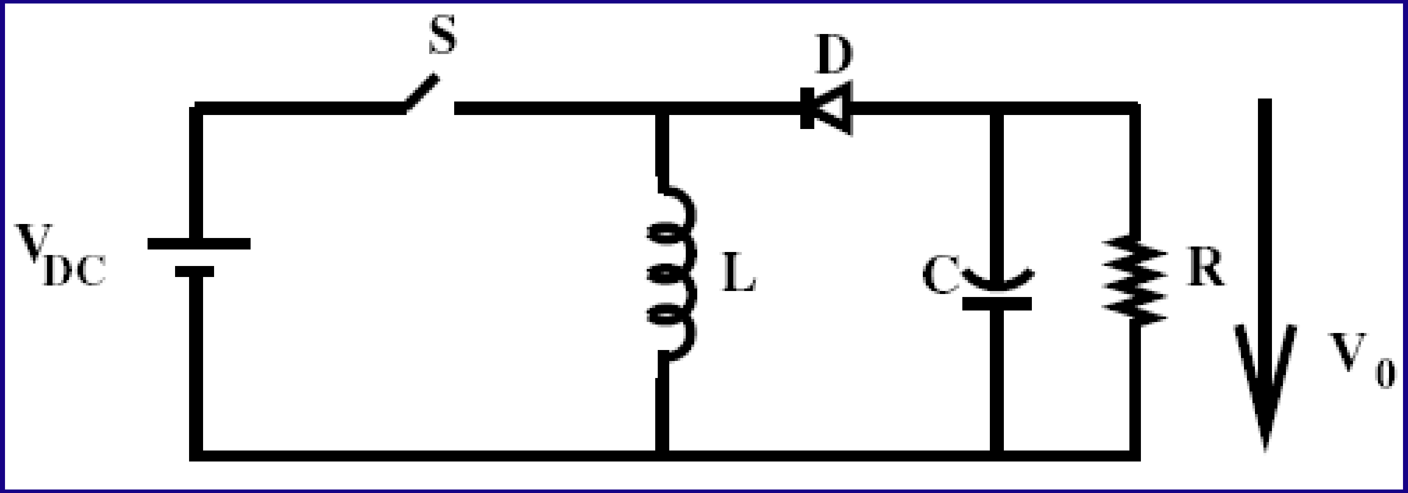
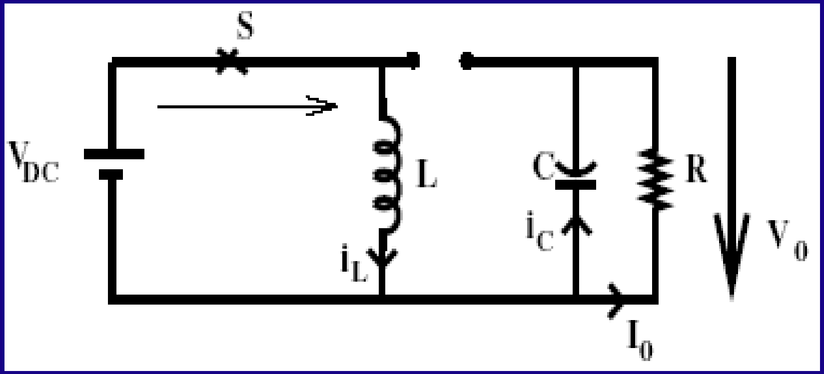
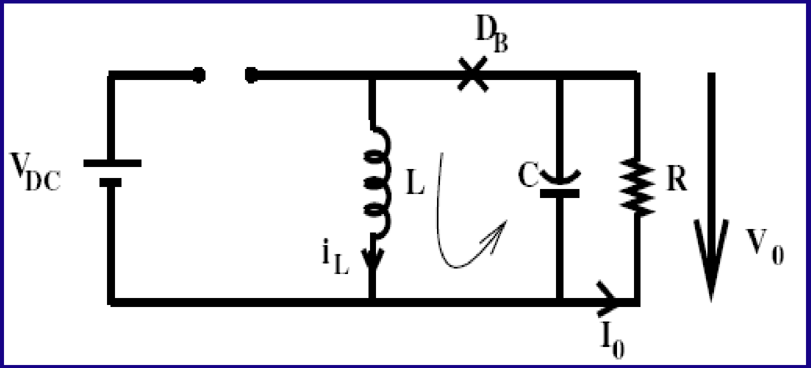
Buck – Boost :



$\Rightarrow$ Can be regarded as cascade connection of Buck + Boost.

$\Rightarrow$ Hence the name Buck – Boost.





$$0 < t < DT$$

$$v_L = V_{DC}$$

$$r\,i_L + L\frac{di_L}{dt} = V_{DC}$$

$$C\frac{dv_0}{dt} + \frac{v_0}{R} = 0$$

$$DT < t < T$$

$$v_L = -v_0$$

$$r\,i_L + L\frac{di_L}{dt} + v_0 = 0$$

$$i_L = C\frac{dv_0}{dt} + \frac{v_0}{R}$$

Av. values of v_0 & i_L are V_0 & I_L

$$rI_L + L\left(\frac{di_L}{dt}\right)_{av} + \frac{1}{T}\int_{DT}^{T} V_0 dt = DV_{DC}$$

$$C\left(\frac{dV_0}{dt}\right)_{av} + \frac{V_0}{R} = \frac{1}{T}\int_{DT}^{T} i_L dt$$

At steady state $\left(\frac{di_L}{dt}\right)_{av}$ & $\left(\frac{dv_0}{dt}\right)_{av} = 0$

$$rI_L + (1-D)V_0 = DV_{DC}$$

$$\frac{V_0}{R} = I_L(1-D)$$

$$r\frac{V_0}{R(1-D)}+(1-D)V_0=DV_{DC}$$

$$\therefore V_0=\frac{V_{DC}D(1-D)}{\frac{r}{R}+(1-D)^2}----\rightarrow 1$$

$$I_L=\frac{V_{DC}D}{r+R(1-D)^2}$$

$$\text{if } r\rightarrow 0 \quad V_0=V_{DC}\frac{D}{(1-D)}-----\rightarrow 2$$

$$I_L=V_{DC}\frac{D}{R(1-D)^2}$$

This can also be proved by equating Voltage across the inductor over the cycle $= 0$

$$V_{DC}DT = V_0(1-D)T$$

$$\therefore V_0 = V_{DC}\frac{D}{(1-D)}$$

In eq. -2 $\quad \left|\dfrac{V_0}{V_{DC}}\right| < 1$ for $0 < D < 0.5$

& $\quad \left|\dfrac{V_0}{V_{DC}}\right| > 1$ for $0.5 < D < 1$

$V_0 \to \infty$ as $D \to 1$

$\Rightarrow V_0$ is $-$ve W.R.T. reference point of V_{DC}.

$\Rightarrow$ True in an ideal converter.

In non – ideal converter :

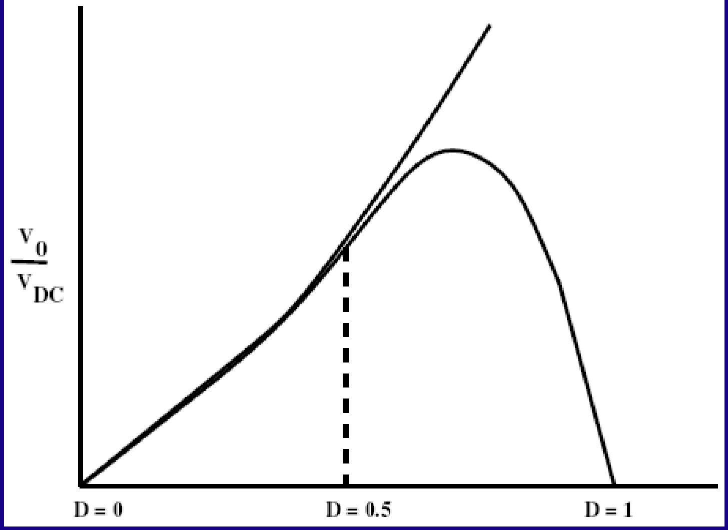
$\frac{V_0}{V_{DC}}$ reaches a peak and then reduces.

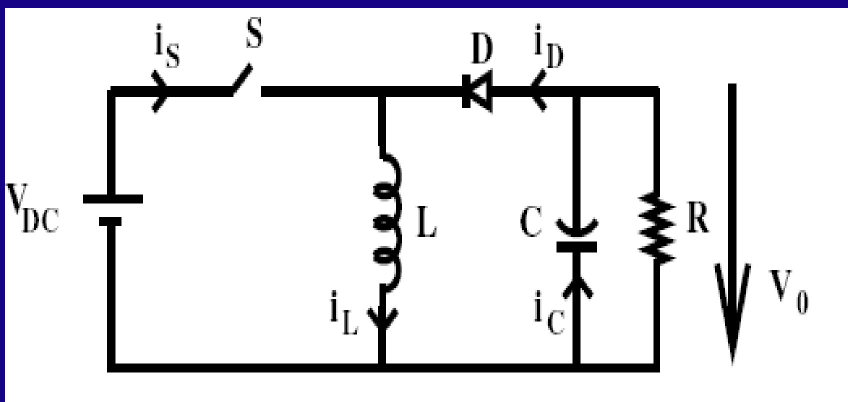
$V_0 = 0$ when $D = 1$

Using eq.1 $\left|\frac{dV_0}{dD}\right|_{=0}$

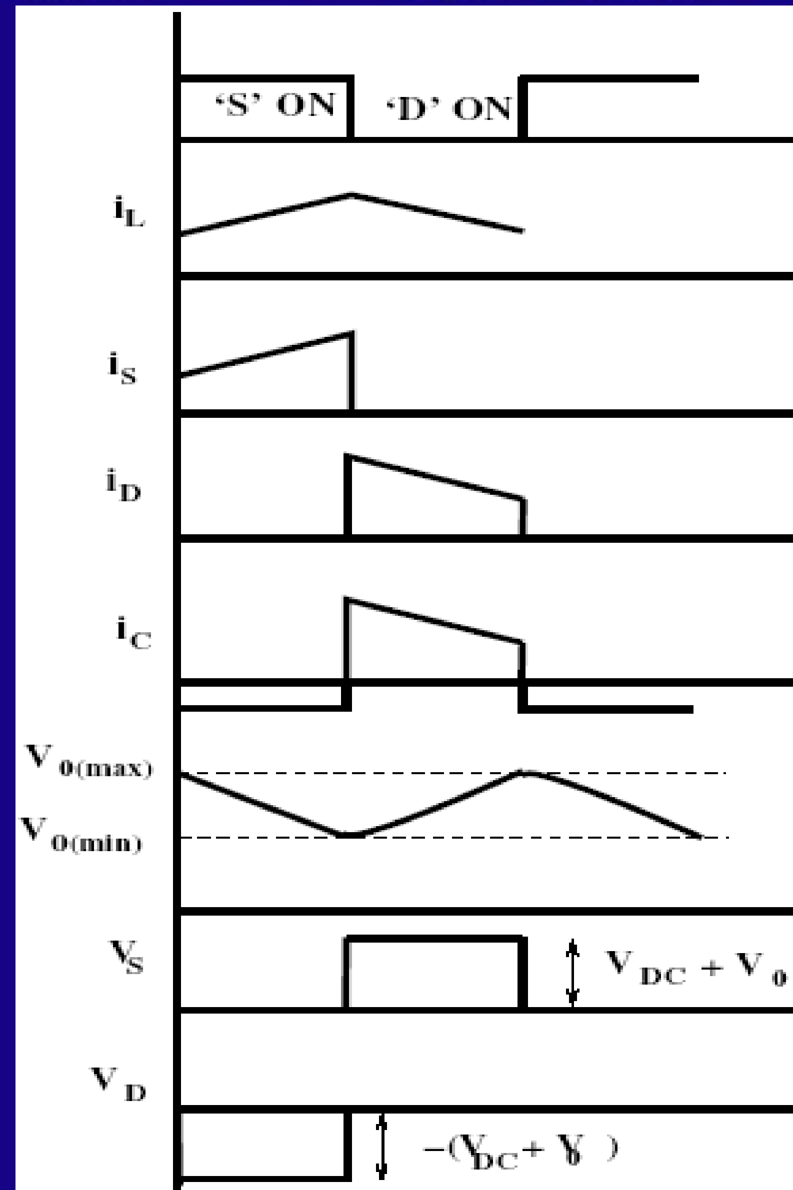
$$D_{max.} = 1 + \frac{r}{R} - \sqrt{\frac{r(1+\frac{r}{R})}{R}}$$

$$V_{0(max.)} = \frac{V_{DC}}{2}\left(\sqrt{1+\frac{R}{r}} - 1\right)$$



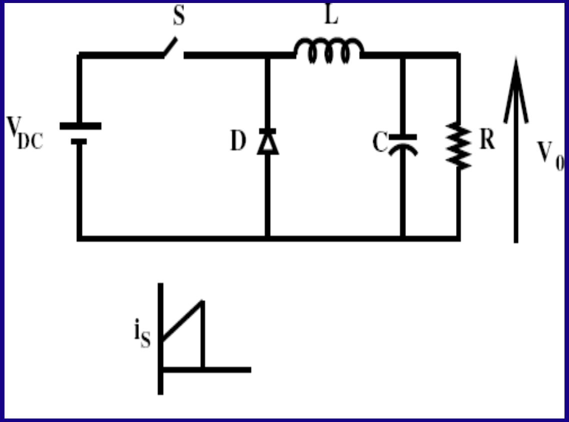


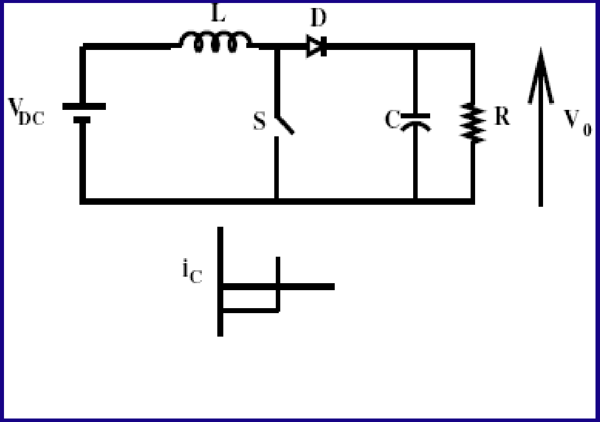
i_S
S
D
i_D
V_{DC}
L
C
R
V_0
i_L
i_C

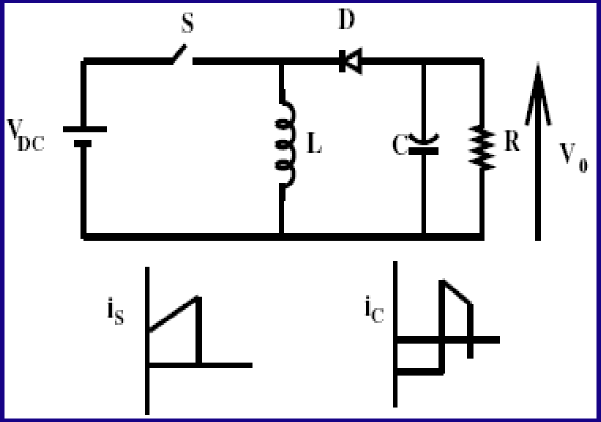


'S' ON
'D' ON
i_L
i_S
i_D
i_C
$V_{0(max)}$
$V_{0(min)}$
V_S
$V_{DC} + V_0$
V_D
$-(V_{DC} + V_0)$

Cuk' Converter:

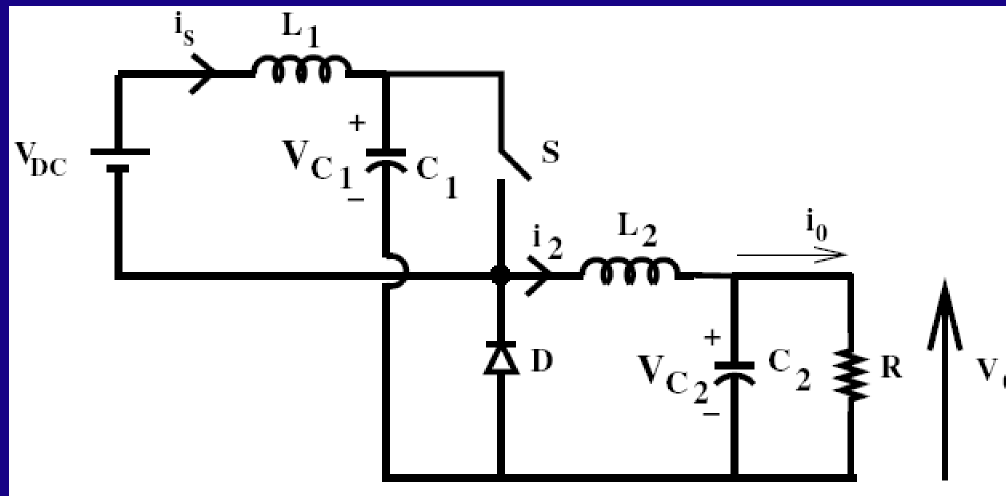




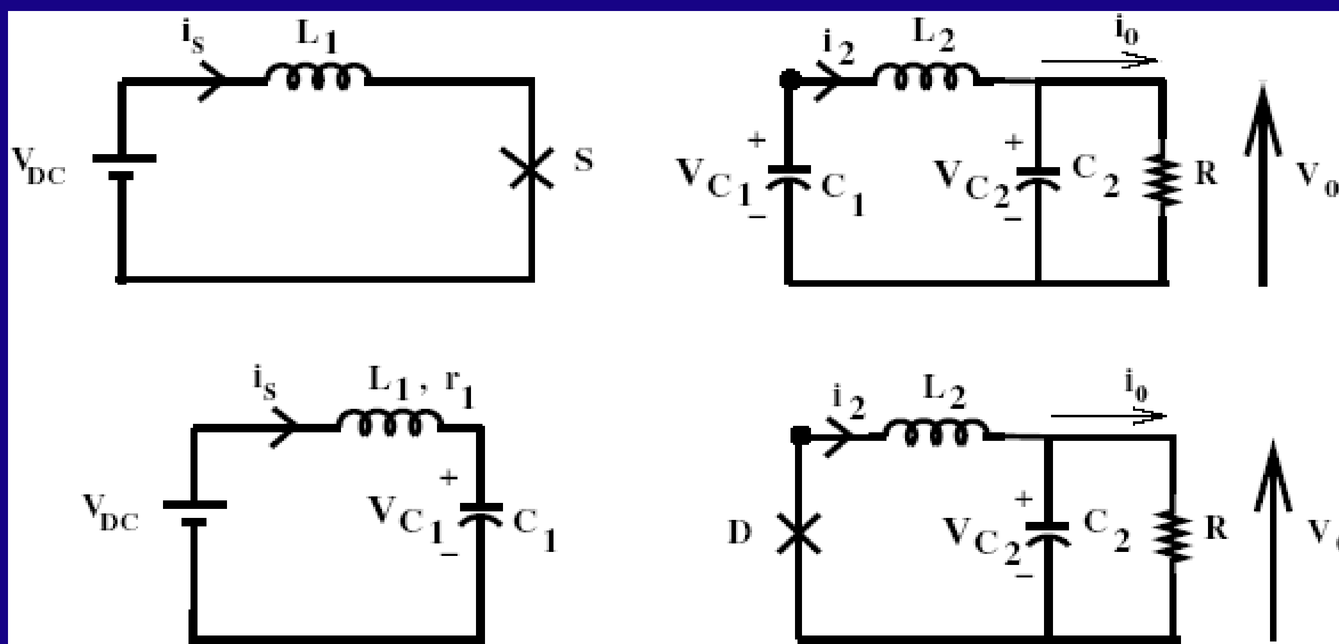


Load is current source. Source is current source.

⇒ Current source both at input & source side are desirable.

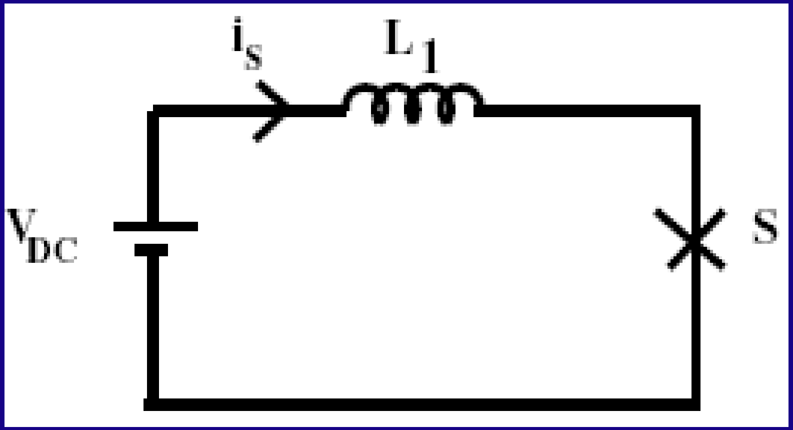


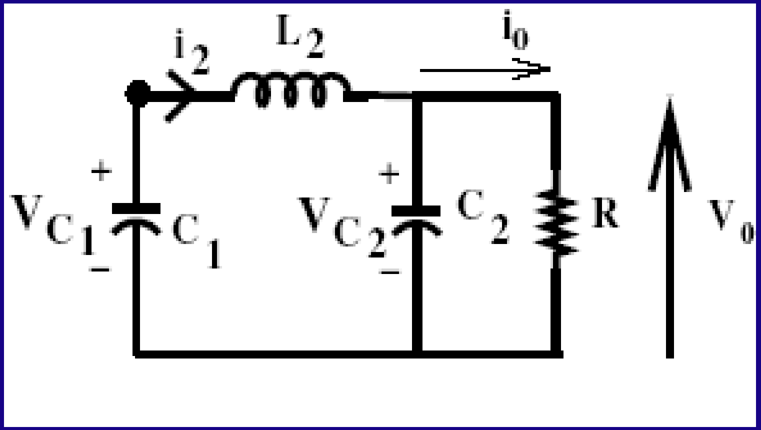
i_s
L_1
V_{DC}
V_{C_1}
C_1
S
i_2
L_2
i_0
D
V_{C_2}
C_2
R
V_0



i_s
L_1
V_{DC}
S
i_2
L_2
i_0
V_{C_1}
C_1
V_{C_2}
C_2
R
V_0
i_s
L_1, r_1
V_{DC}
V_{C_1}
C_1
i_2
L_2
i_0
D
V_{C_2}
C_2
R
V_0

'S' Closed





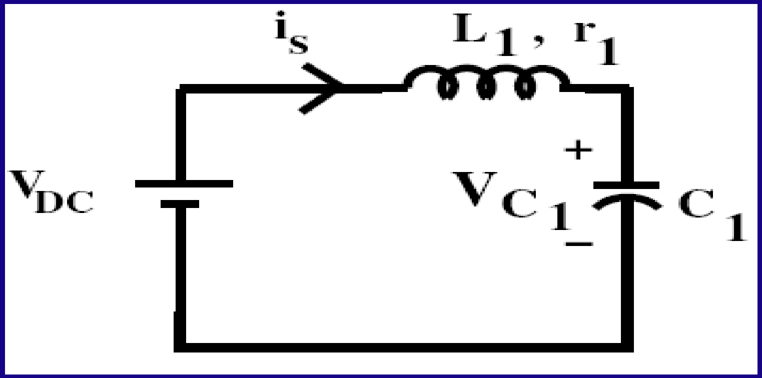
$$V_{DC} = L_1 \frac{di_S}{dt} + r_1\, i_S$$

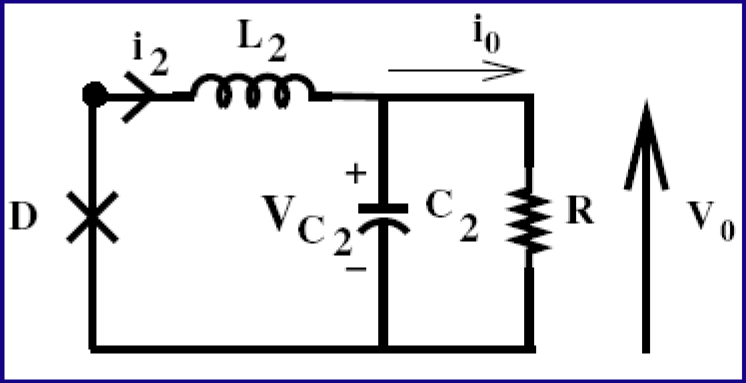
$$V_{C1} = L_2 \frac{di_2}{dt} + r_2\, i_2 + v_0$$

$$i_2 = C \frac{dv_0}{dt} + \frac{v_0}{R}$$

$$C_1 \frac{dV_{C1}}{dt} = -i_2, \qquad 0 < t < DT$$

'S' open:





$$V_{DC} = r_1\, i_S + L_1 \frac{di_S}{dt} + v_{C1}$$

$$r_2 i_2 + L_2 \frac{di_2}{dt} + v_0 = 0$$

$$C_1 \frac{dv_{c1}}{dt} = i_S$$

$$i_2 = C\frac{dV_0}{dt} + \frac{V_0}{R}$$

$$\int_0^{DT} V_{DC} = \int_0^{DT} r_1\, i_S + \int_0^{DT} L_1 \frac{di_S}{dt} \qquad 0 \le t \le DT$$

$$\int_{DT}^{T} V_{DC} = \int_{DT}^{T} r_1\, i_S + \int_{DT}^{T} L_1 \frac{di_S}{dt} + \int_{DT}^{T} v_{C1} \qquad DT \le t \le T$$

$$\therefore\ V_{DC} = r_1\, I_S + L_1 \left(\frac{di_S}{dt}\right)_{av} + \frac{1}{T}\int_{DT}^{T} v_{C1}\, dt$$

$$\text{similarly, } r_2\, I_2 + L_2 \left(\frac{di_2}{dt}\right)_{av} + V_0 = \frac{1}{T}\int_{0}^{DT} v_{C1}\, dt$$

$$I_2 = C\left(\frac{dv_0}{dt}\right)_{av} + \frac{V_0}{R}$$

$$C\left(\frac{dv_{C1}}{dt}\right)_{av} = \frac{1}{T}\int_{0}^{DT} (-i_2)dt + \frac{1}{T}\int_{DT}^{T} i_S\, dt$$

In steady state $\left(\frac{di_s}{dt}\right)_{av} = 0$, $\left(\frac{di_2}{dt}\right)_{av} = 0$

$$\left(\frac{dV_0}{dt}\right)_{av} = 0 \;\&\; \left(\frac{dV_c}{dt}\right)_{av} = 0$$

Also neglecting ripple in V_{c1} , i_2 & i_s

$$V_{DC} = r_1 I_s + (1-D) V_{c1} ----------------(1)$$

$$r_2 I_2 + V_0 = DV_{c1} -------------------(2)$$

$$I_2 = \frac{V_0}{R} ---------------------(3)$$

$$0 = -DI_2 + (1-D) I_s ----------------(4)$$

$$i_s = \frac{D}{(1-D)} I_2 \rightarrow \text{Av. load I} \quad \because \text{av. I through C} = 0$$

$$r_2 \frac{V_0}{R} + V_0 = D\,V_{c1}$$

$$\therefore V_{c1} = \frac{V_0}{DR}(r_2 + R)$$

$$V_{DC} = r_1 I_s + (1-D)\frac{I_2 R}{DR}(r_2 + R)$$

$$= r_1 I_s + (1-D) I_s \frac{(1-D)}{D^2}(r_2 + R)$$

$$\therefore I_s = \frac{V_{DC}}{r_1 + \left(\frac{1-D}{D}\right)^2 (r_2 + R)} \rightarrow \text{av. source I in terms of } V_{DC} \text{ \& } D$$

$$V_0 = I_2 R = \left(\frac{1-D}{D}\right) R\, I_s = \left(\frac{1-D}{D}\right) R \frac{V_{DC}}{r_1 + \left(\frac{1-D}{D}\right)^2 (r_2 + R)}$$

$$\therefore V_0 = \frac{V_{DC}}{\frac{r_1}{R}\frac{D}{(1-D)} + \left(\frac{1-D}{D}\right)\left(\frac{R+r_2}{R}\right)} \rightarrow \text{av. } V_0 \text{ in terms of } V_{DC} \text{ \& } D$$

$$V_{c1} = \frac{V_0}{DR}(r_2 + R) = \frac{V_{DC}}{(1-D) + \frac{r_1}{(r_2+R)} * \frac{D^2}{(1-D)}}$$

If r_1 & $r_2 = 0$

$$I_s = \frac{D}{(1-D)} I_2 = \left(\frac{D}{1-D}\right)^2 \frac{V_{DC}}{R}$$

$$V_{c1} = \frac{V_{DC}}{(1-D)} \qquad V_0 = V_{DC}\frac{D}{(1-D)}$$

$$\text{'OR'}\ V_0 = \underline{\underline{DV_{c1}}}$$

$$V_{DC}DT = (V_{c1} - V_{DC})(1-D)T$$

$$\therefore V_{c1} = \frac{V_{DC}}{(1-D)}$$

$$\therefore V_0 = DV_{c1} \text{ (is buck converter with } V_{c1} \text{ as the input voltage)}$$

$$\therefore V_0 = \frac{DV_{DC}}{(1-D)}$$

$\Rightarrow$ **Buck Boost converter.**

$\Rightarrow$ **Both I/P & O/P 'I' waveform are quite smooth.**