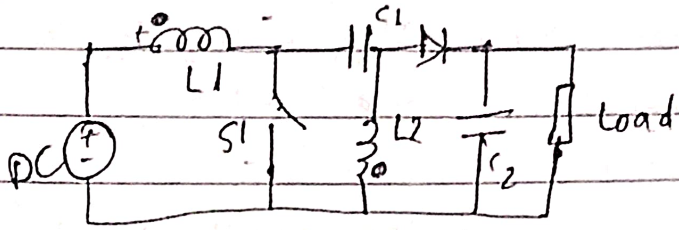
## SEPIC converter

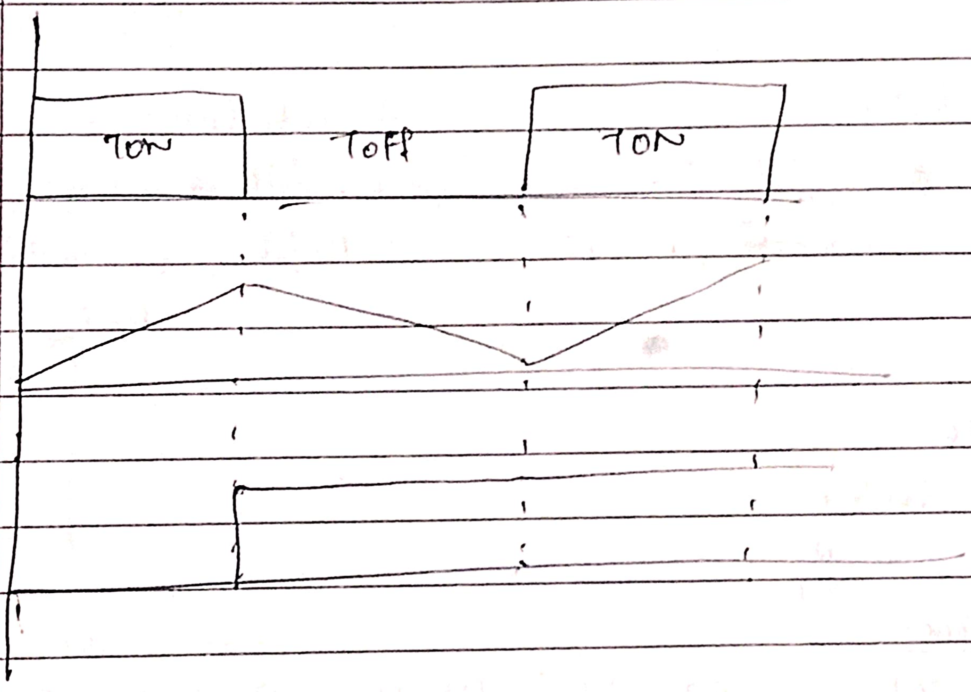



Single ended primary inductance converters

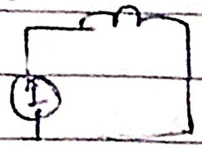
→ switching is easier

→ non-inverting o/p

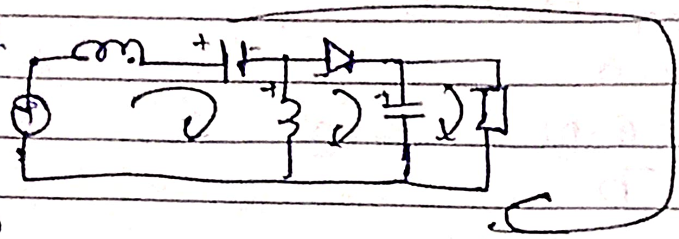
IL1
IL2
Vout



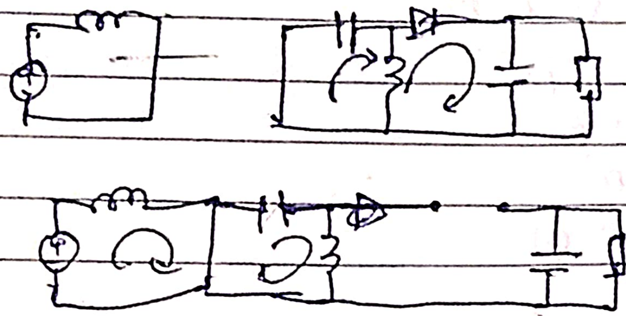
$T_{ON}$ 1



$T_{off}$



$T_{ON}$ 2



$f = 20kHz$

$V_s = 24V$

$D = 0.5$

$\Delta I_L = 30\%$

$\frac{\Delta V_c}{V} = 2\%$

$P_i = 200W$

## Derivations

1) ON state

$V_{L1(ON)} = V_s$

$V_{L2(ON)} = -V_{C1}$

$i_{C1(ON)} = i_{L2}$

$i_{C2(ON)} = -i_o$

2) OFF state

$V_s = V_{L1(OFF)} + V_{C1} + V_o$

$V_{L1(OFF)} = V_s - V_{C1} - V_o$

$V_{L2(OFF)} = V_o$

Volt-sec Rule

① $V_s DT + (V_s - V_{C1} - V_o)(1-D)T = 0$

$V_s - V_{C1}(1-D) - V_o(1-D) = 0$

$$\frac{V_s - V_o(1-D)}{1-D} = V_{C1} \quad — ①$$

② $V_{L2(on)} DT + V_{L2(off)}(1-D)T = 0$

$$-V_{C1} D + V_o(1-D) = 0$$

$$V_{C1} = \frac{V_o(1-D)}{D} \quad — ②$$

$$\therefore \frac{V_s - V_o(1-D)}{1-D} = \frac{V_o(1-D)}{D}$$

$$\frac{V_s}{1-D} = V_o + \frac{V_o(1-D)}{D}$$

$$\frac{V_s}{1-D} = \frac{V_o D + V_o(1-D)}{D}$$

$$\frac{V_s}{1-D} = \frac{V_o}{D}$$

$$\boxed{\therefore V_o = V_s \frac{D}{1-D}}$$

③ Power

$$P_o = P_i$$

$$V_o I_o = V_i I_i$$

$$V_s \frac{D}{1-D} I_o = V_s I_i$$

$$\boxed{\therefore I_o = I_i \frac{1-D}{D}}$$

④ $V_{L1} = L_1 \frac{\Delta I_{L1}}{DT}$

$$V_{L1} = V_s$$

$$\Delta I_{L1} = \frac{V_s DT}{L_1}$$

$$\Delta I_{L2} = \frac{V_s DT}{L_2}$$

⑤ $i_{C2} = -i_o$

$$\Delta V_{C1} = \frac{I_o DT}{C_1}$$

$$\Delta V_{C2} = \frac{i_o DT}{C_2}$$

(6) Critical Inductance

$$I_{L_1} - \frac{\Delta I_L}{2} = 0$$

$$I_{L_2} - \frac{\Delta I_{L_2}}{2} = 0$$

$$I_{L_1} = \frac{\Delta I_L}{2}$$

$$I_{L_2} = \frac{\Delta I_L}{2}$$

$$I_{L_1} = \frac{V_s D T}{2 L_1}$$

$$i_{L_1} = i_s$$

$$I_{L_2} = \frac{V_s D T}{L_2}$$

$$L_1 = \frac{V_s}{i_s} \frac{DT}{2}$$

$$I_{L_2} = I_o$$

$$L_1 = \frac{V_o}{I_o} \frac{(1-D)^2}{D} \frac{T}{2}$$

$$L_2 = \frac{V_s}{I_o} DT$$

$$\boxed{L_1 = R \frac{(1-D)^2}{D} \frac{T}{2}}$$

$$\boxed{L_2 = R (1-D) \frac{T}{2}}$$

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## Designing a SEPIC

$V_i = 24V$ $f = 20\,kHz$ $\frac{\Delta V_c}{V} = 2\%$

$D = 0.5$ $\frac{\Delta I_L}{I} = 30\%$ $P_i = 200W$

1) $\therefore V_o = V_s \frac{D}{(1-D)}$

$\therefore V_o = V_s = 24V.$

2) $P_i = V_i I_i$

$200 = 24 I_i$

$I_i = 8.333A.$

$D = 0.5$

So $I_o = I_i$

3) $\Delta I_L = \frac{V_{in} D}{L f_s}$ Since $D = 0.5$ $L_1 = L_2$

$L = \frac{V_{in} D}{\Delta I_L f_s}$

$= \frac{24 \times 0.5}{0.3 \times 8.33 \times 20 \times 1000}$

$= 0.240\ mH$

$\therefore L_1 \geq L_2 \geq 0.240 mH$

4) $i_c = C_1 \frac{\Delta V_c}{DT}$

$i_c = i_o$

$C_1 = \frac{DT\ i_o}{\Delta V_c}$

$C_1 = \frac{D \times i_o}{f_s \times \Delta V_c}$

$= \frac{0.5 \times 8.333}{20 \times 1000 \times 0.02 \times 24}$

$= 0.434027\ mF$

$\therefore C_1 \geq C_2 \geq 0.434027\ mF$

5) $R = ?$

$L_1 = \frac{R(1-D)^2}{D} \frac{T}{2}$

$R = \frac{0.5 \times 0.240 \times 10^{-3} \times 2 \times 20 \times 1000}{(1-0.5)^2} = 20\Omega$