

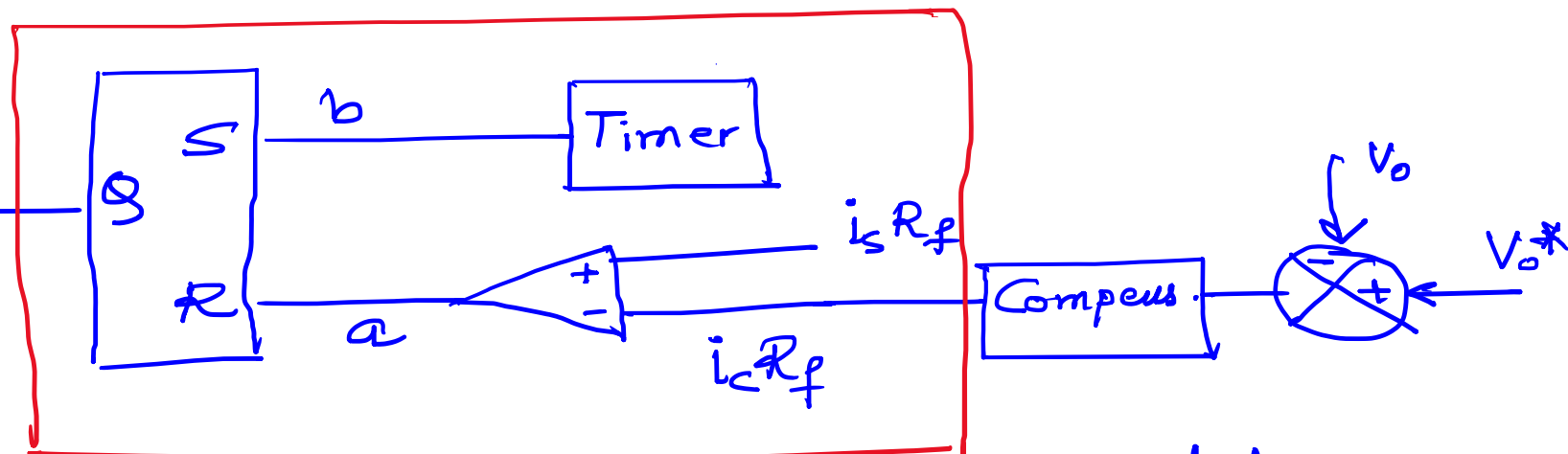
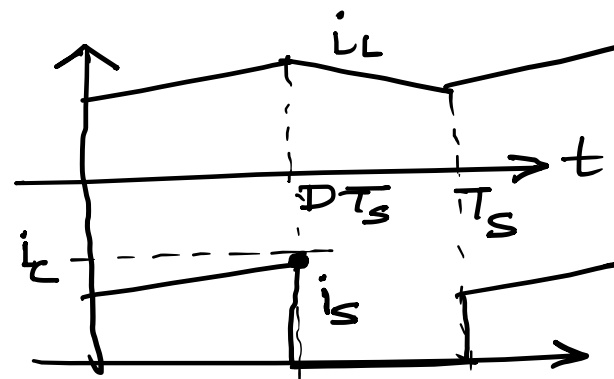
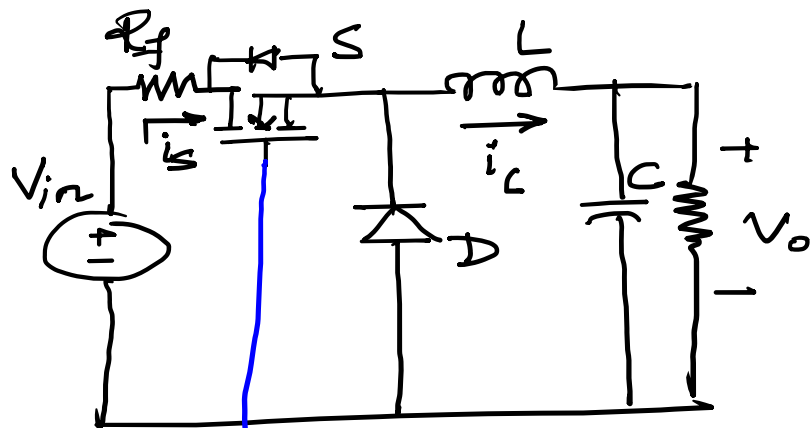
Switched Mode Power Conversion

Semester II Academic Year 2025-26

Lecture 28

1st April 2026

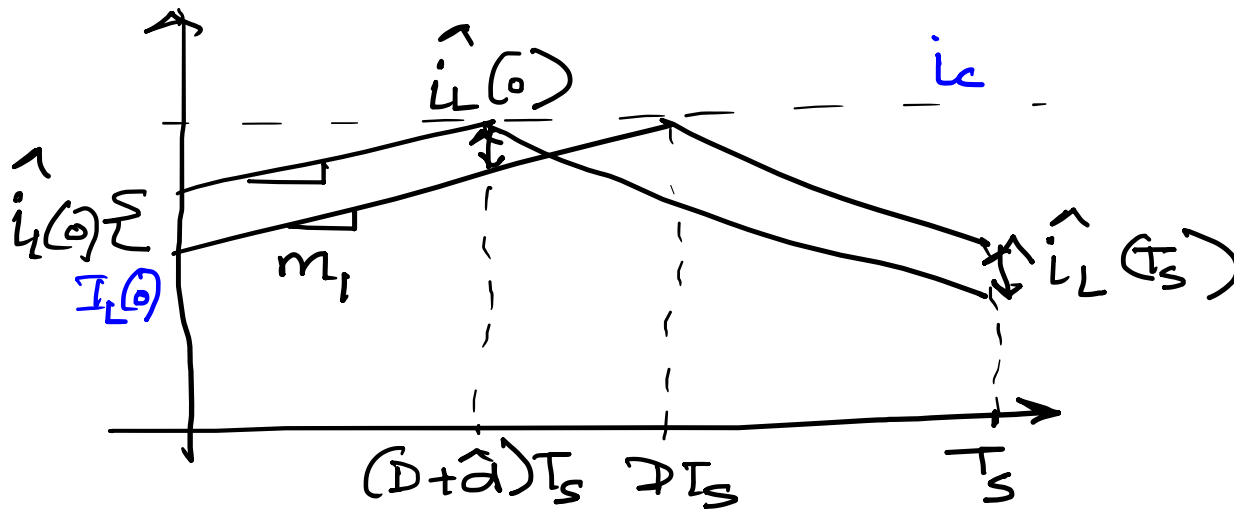
Current Programmed Control



CPM → Simple Implementation

Current Programmed Control

Oscillations



$$i_c = I_L(0) + m_1 D T_s$$

$$i_c = I_L(0) + \hat{i}_L(0) + m_1 (D + \hat{\alpha}) T_s$$

$$\therefore \hat{i}_L(0) = -m_1 \hat{\alpha} T_s$$

$$\hat{i}_L(T_s) = m_2 \hat{\alpha} T_s$$

$$\hat{i}_L(T_s) = \hat{i}_L(0) \left(\frac{-m_2}{m_1} \right)$$

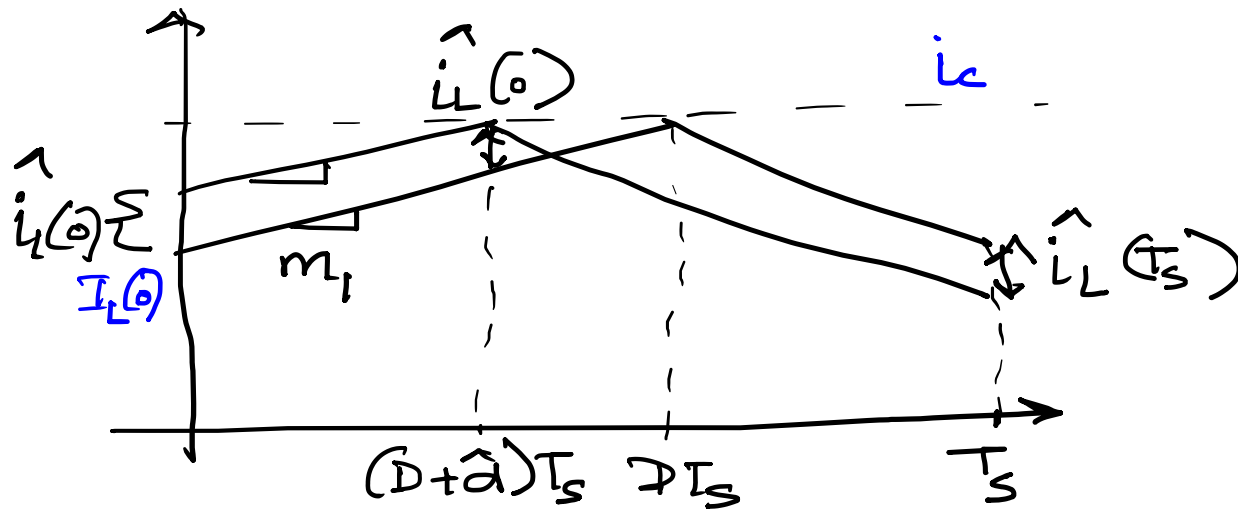
$$\Rightarrow \hat{i}_L(T_s) = \hat{i}_L(0) \left(-\frac{D}{D'} \right)$$

$$\hat{i}_L(2T_s) = \hat{i}_L(0) \left(-\frac{D}{D'} \right)^2$$

$$\therefore \hat{i}_L(nT_s) = \hat{i}_L(0) \left(-\frac{D}{D'} \right)^n$$

Current Programmed Control

Oscillations



How reduce this oscillation
for $D > 0.5$ with CPM??

Current Programmed Control

Reducing Oscillations

⇒ Device S will turn OFF when

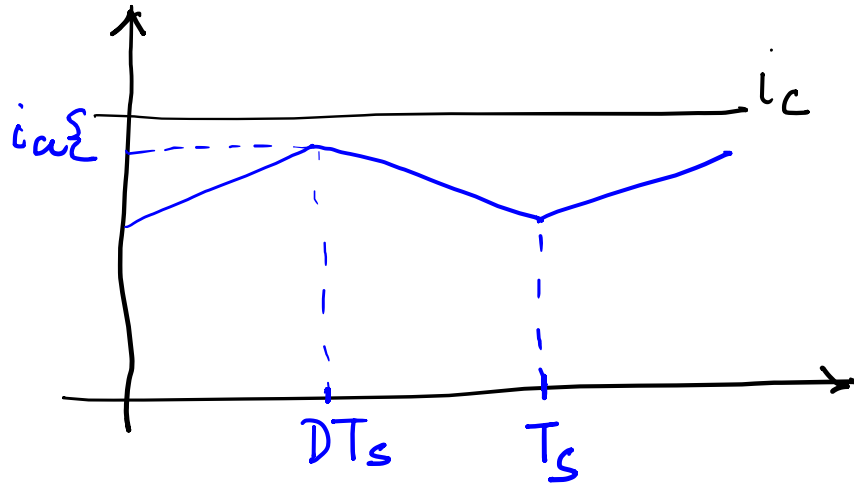
$$i_s + i_a > i_c$$
$$\Rightarrow \boxed{i_s > i_c - i_a}$$

Current Programmed Control

Reducing Oscillations

⇒ Device S will turn OFF when

$$i_s + i_a > i_c$$
$$\Rightarrow \boxed{i_s > i_c - i_a}$$



Current Programmed Control

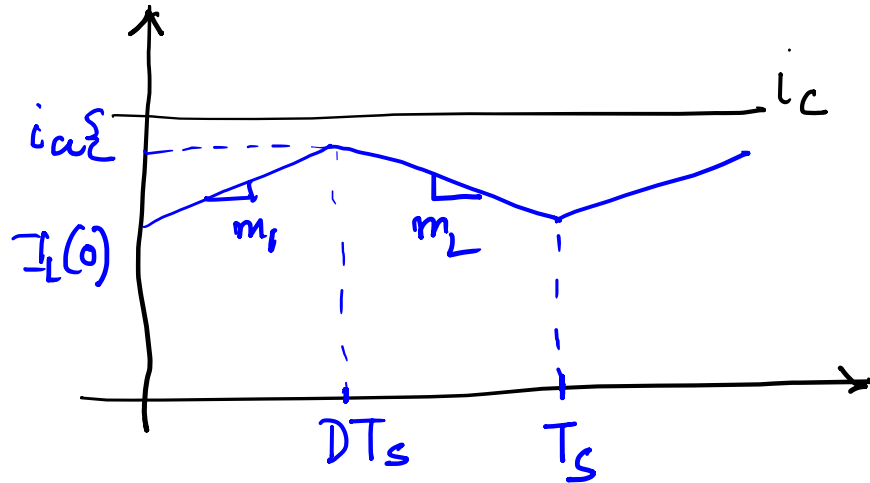
Reducing Oscillations

⇒ Device S will turn OFF when

$$i_s + i_a > i_c$$
$$\Rightarrow \boxed{i_s > i_c - i_a}$$

$$I_c - i_a = I_L(0) + m_1 DT_s$$

$$\Rightarrow I_c = I_L(0) + m_1 DT_s + i_a$$



Current Programmed Control

Reducing Oscillations

⇒ Device S will turn OFF when

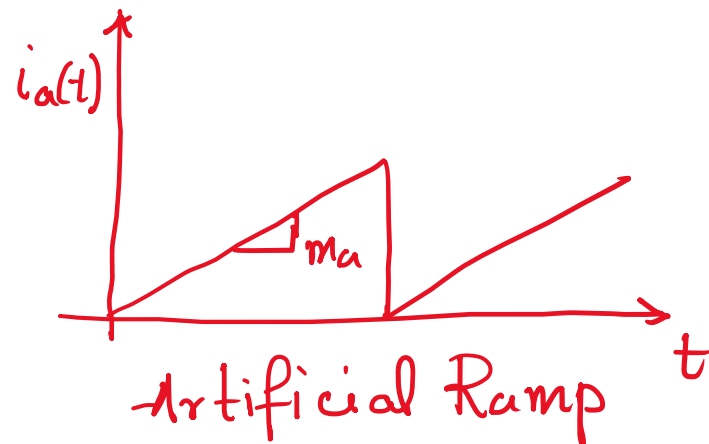
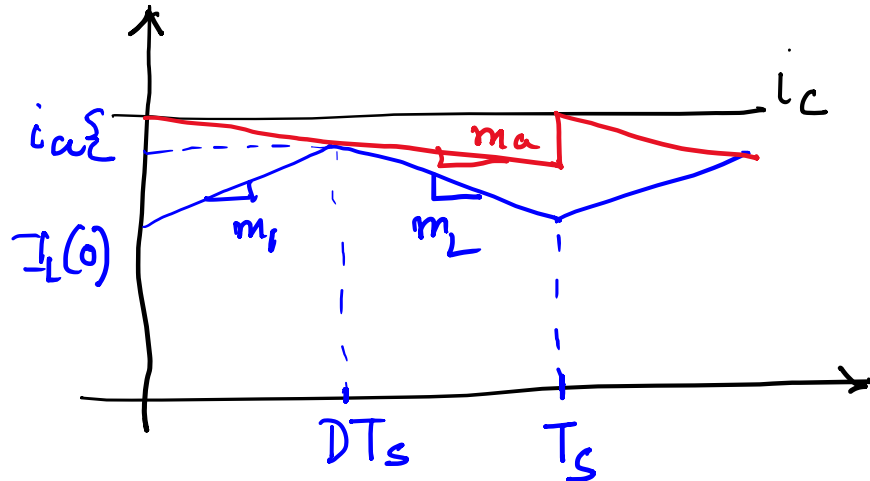
$$i_s + i_a > i_c$$

$$\Rightarrow \boxed{i_s > i_c - i_a}$$

$$I_c - i_a = I_L(0) + m_1 DT_s$$

$$\Rightarrow I_c = I_L(0) + m_1 DT_s + i_a$$

$$\Rightarrow I_c = I_L(0) + DT_s (m_1 + m_a)$$



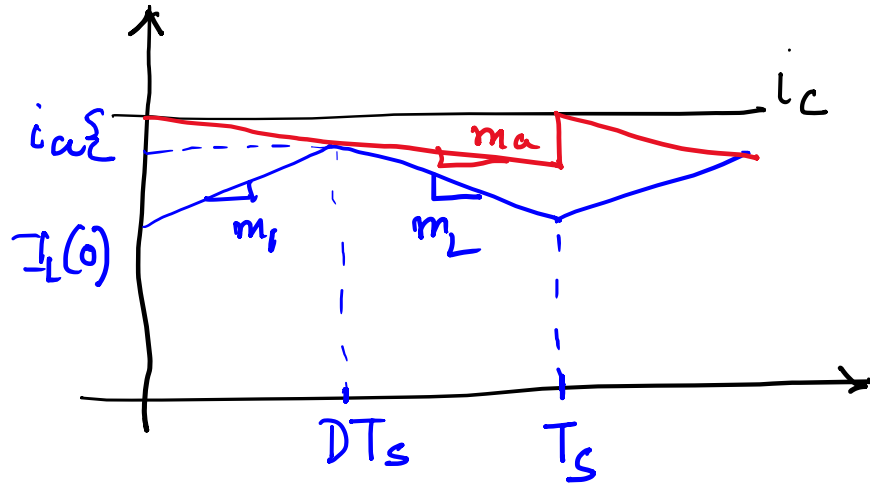
Current Programmed Control

Reducing Oscillations

⇒ Device S will turn OFF when

$$i_s + i_a > i_c$$

$$\Rightarrow \boxed{i_s > i_c - i_a}$$



$$I_c - i_a = I_L(0) + m_1 DT_s$$

$$\Rightarrow I_c = I_L(0) + m_1 DT_s + i_a$$

$$\Rightarrow I_c = I_L(0) + DT_s (m_1 + m_a)$$

$$I_c = (I_L(0) + \hat{i}_L(0)) + (\hat{D} - \hat{d}) T_s (m_1 + m_a)$$

$$\therefore \hat{i}_L(0) = -\hat{d} T_s (m_1 + m_a)$$

$$\hat{i}_L(T_s) = -\hat{d} T_s (m_a - m_2)$$

$$= \hat{i}_L(0) \left[-\frac{m_2 - m_a}{m_1 + m_a} \right]$$

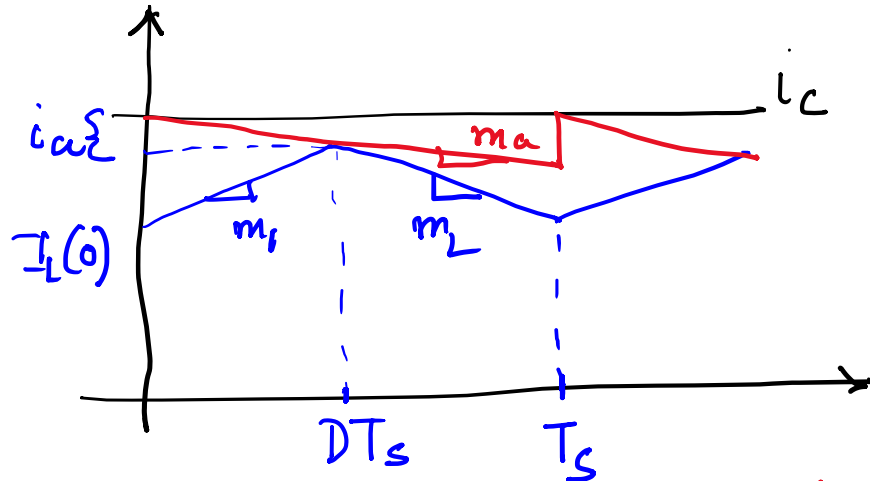
Current Programmed Control

Reducing Oscillations

⇒ Device S will turn OFF when

$$i_s + i_a > i_c$$

$$\Rightarrow \boxed{i_s > i_c - i_a}$$



Deadbeat control ⇐

$$\hat{i}_L(nT_s)$$

$$= \hat{i}_L(0) \left[-\frac{m_2 - m_a}{m_1 + m_a} \right]^n$$

$$= \hat{i}_L(0) \alpha^n$$

For avoiding oscillations,

$$|\alpha| < 1$$

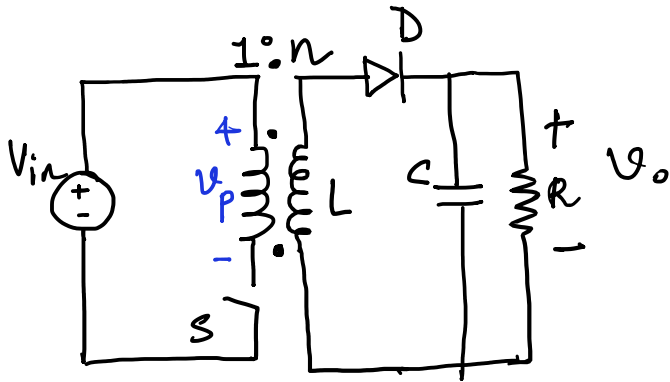
$$\Rightarrow \left| -\frac{m_2 - m_a}{m_1 + m_a} \right| < 1$$

$$m_2 = m_a \quad \alpha = 0$$

Perturbations become zero after one cycle

Current Programmed Control

Flyback Converter Model



[Flyback Converter]

$$\langle v_L \rangle = v_{in} D - \frac{v_o}{n} (1-D) = 0$$

$$\begin{aligned} \langle I_c \rangle &= -\left(\frac{v_o}{R}\right) D + \left(\frac{I_L}{n} - \frac{v_o}{R}\right) D' \\ &= \frac{I_L}{n} D - \frac{v_o}{R} = 0 \end{aligned}$$

$$\langle I_{in} \rangle = I_L D$$

$$\bar{v}_L + \hat{v}_L = (\bar{v}_{in} + \hat{v}_{in})(\bar{D} + \hat{d}) - \frac{(\bar{v}_o + \hat{v}_o)(\bar{D}' + \hat{d}')}{n}$$

$$\text{o.o } \hat{v}_L = \bar{v}_{in} \hat{d} + \bar{D} \hat{v}_{in} + \frac{\bar{v}_o}{n} \hat{d} - \bar{D}' \frac{\hat{v}_o}{n}$$

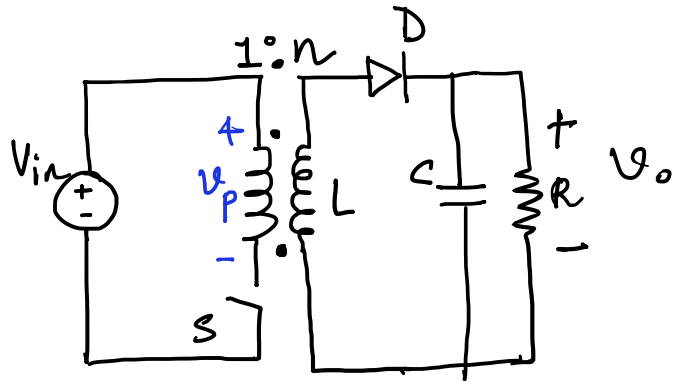
$$\Rightarrow L \frac{d\hat{i}_L}{dt} = \bar{D} \hat{v}_{in} + (\bar{v}_{in} + \frac{\bar{v}_o}{n}) \hat{d} - \frac{\bar{D}'}{n} \hat{v}_o$$

$$C \frac{d\hat{v}_C}{dt} = \bar{D}' \frac{\hat{i}_L}{n} - \frac{\bar{I}_L}{n} \hat{d} - \frac{\hat{v}_o}{R}$$

$$\hat{i}_{in} = \hat{i}_L \bar{D} + i_L \hat{d}$$

Current Programmed Control

Flyback Converter Model

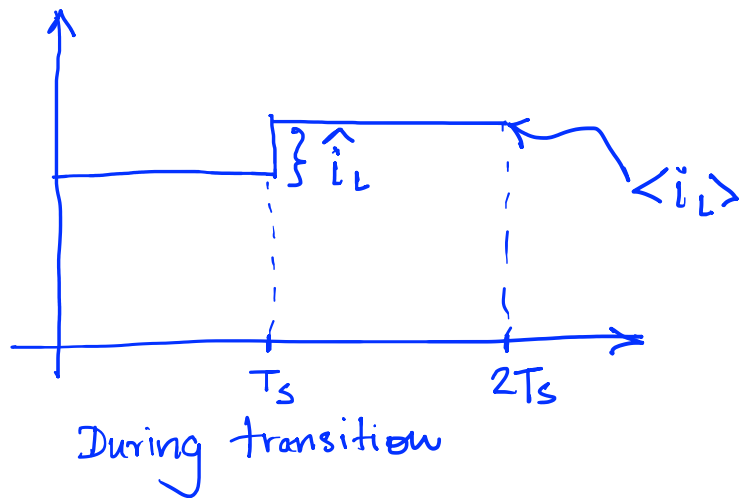


[Flyback Converter]

$$L \frac{d\hat{i}_L}{dt} = \bar{D} \hat{v}_{in} + \left(\bar{v}_{in} + \frac{\bar{v}_o}{n} \right) \hat{d} - \frac{\bar{D}}{n} \hat{v}_o$$

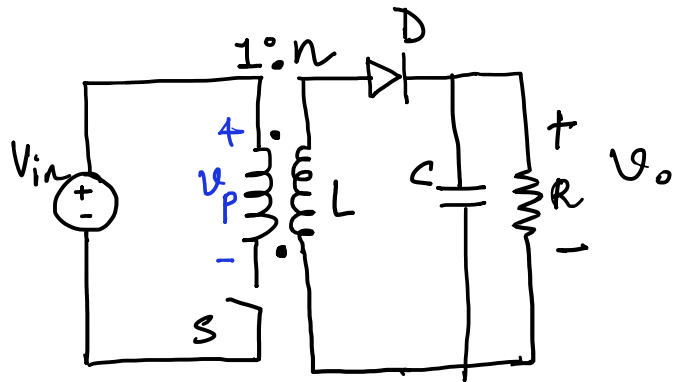
$$C \frac{d\hat{v}_c}{dt} = \bar{D} \frac{\hat{i}_L}{n} - \frac{\bar{i}_L}{n} \hat{d} - \frac{\hat{v}_o}{R}$$

$$\hat{i}_{in} = \hat{i}_L \bar{D} + \bar{i}_L \hat{d}$$



Current Programmed Control

Flyback Converter Model

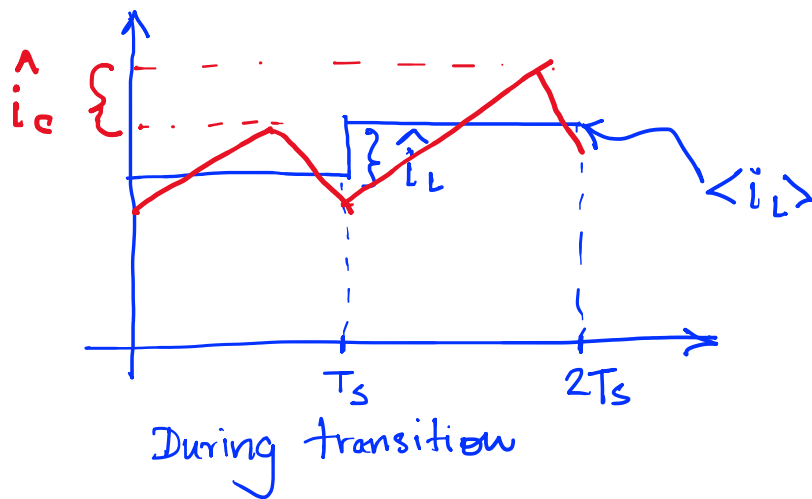


[Flyback Converter]

$$L \frac{d\hat{i}_L}{dt} = \bar{D} \hat{v}_{in} + (\bar{v}_{in} + \frac{\bar{v}_o}{n}) \hat{d} - \frac{\bar{D}'}{n} \hat{v}_o \quad \text{--- (1)}$$

$$C \frac{d\hat{v}_c}{dt} = \bar{D} \frac{\hat{i}_L}{n} - \frac{\bar{I}_L}{n} \hat{d} - \frac{\hat{v}_o}{R} \quad \text{--- (2)}$$

$$\hat{i}_{in} = \hat{i}_L \bar{D} + i_L \hat{d} \quad \text{--- (3)}$$



Assuming that Δi_L doesn't change much appreciably during transients,

$$\hat{i}_c \approx \hat{i}_L$$

Substituting this in 1, 2, 3