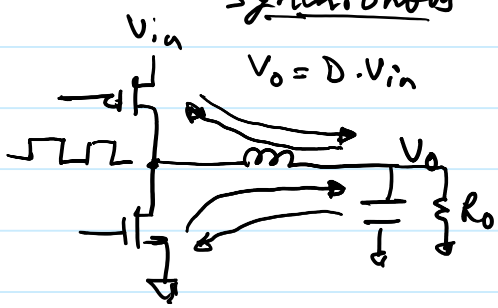
CCM vs. DCM

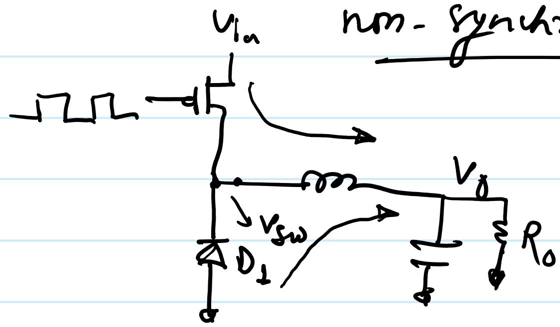
CCM → continuous conduction mode

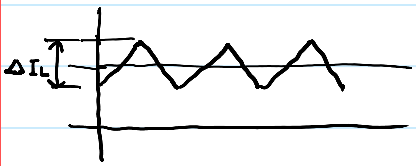
DCM → discontinuous " "

Synchronous

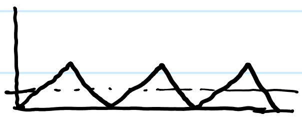


non-synchronous

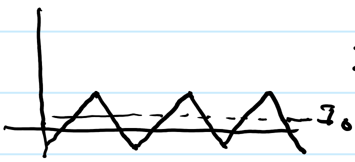




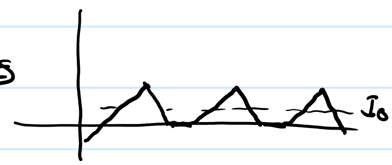
$I_o > \frac{\Delta I_L}{2}$ ⇒ same as synch



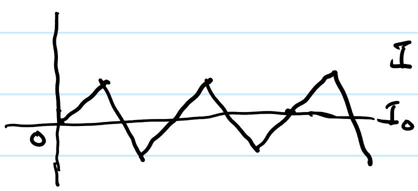
$I_o = \frac{\Delta I_L}{2}$ ⇒ same as synch



$I_o < \frac{\Delta I_L}{2}$ ⇒



D_1 → not conducting



$I_o = 0$

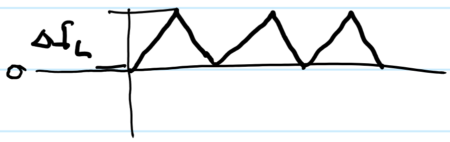
V_{sw} → high-Z

$V_o = D \cdot V_{in}$ becomes invalid in DCM

CCM vs. DCM

CCM	DCM
# Inductor is always conducting $\Rightarrow$ losses are increased	# inductor stops conducting $I_o < 0$ $\Rightarrow$ reduced losses
# output can be regulated for any load current	# output can't be regulated for load current when $D < D_{min}$ unless we reduce F_{sw} $\Rightarrow$ higher output ripple
	# output can't be regulated for $I_o \leq 0$

CCM-DCM Boundary Condition



$$I_o = \frac{\Delta I_L}{2} = \frac{1}{2} \times \frac{V_o(1-D)}{L} \times T_{sw}$$

$$I_o = \frac{V_o}{R_o}$$

$$\frac{\cancel{V_o}}{R_o} = \frac{\cancel{V_o}(1-D)T_{sw}}{2L}$$

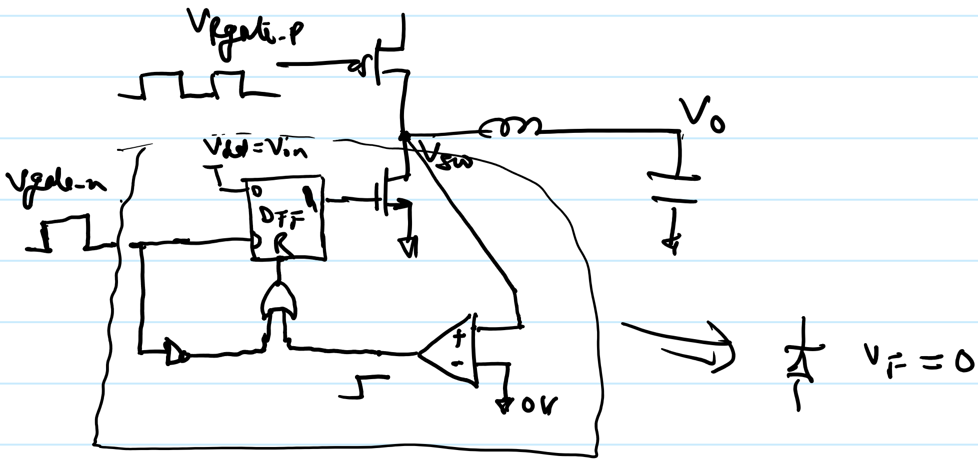
$$1-D = \frac{2L}{R_o T_{sw}} = K$$

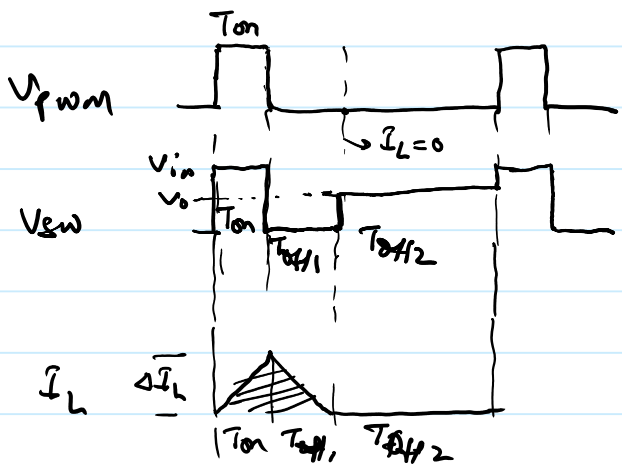
$$1-D = D'$$

$D' > K \rightarrow$ CCM

$D' < K \rightarrow$ DCM

DCM with synchronous buck





$$V_L(\text{avg}) = \frac{(V_{in} - V_o)T_{on} + (-V_o)T_{off_1} + 0}{T_{sw}} = 0$$

$$V_{in} T_{on} = V_o (T_{on} + T_{off_1})$$

$$T_{on} + T_{off_1} = \frac{V_{in}}{V_o} \cdot T_{on} \quad \text{--- (1)}$$

$$I_L(\text{avg}) = \frac{\text{area under } \Delta}{T_{sw}} = \frac{1}{T_{sw}} \times \frac{1}{2} \times (T_{on} + T_{off_1}) \times \frac{V_{in} - V_o}{L} T_{on} \quad \text{--- (2)}$$

Output Regulation in DCM

Solve ① & ② and substitute K

$$\frac{V_O}{V_{IN}} = \frac{2}{1+\sqrt{1+4K/D^2}}$$

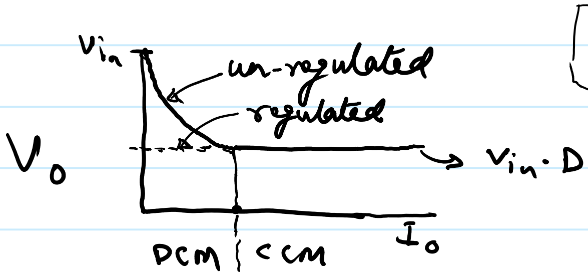
$$K = \frac{2L}{R_O T_{SW}}$$

Valid only for DCM ($D' < K$)

For regulation $\frac{V_o}{V_{in}}$ = const.

$$\frac{K}{D^2} = \text{constant}$$

$$K = \frac{2L}{R_O T_{SW}} \Rightarrow \frac{K}{D^2} = \frac{2L\,T_{SW}}{R_O\, T_{on}^2}$$



$\boxed{R_O \uparrow \; T_{on} \downarrow \text{ for regulation}}$

$T_{on} < T_{on\_min}$

$R_O \uparrow \; T_{sw} \uparrow$ for regulation → PFM