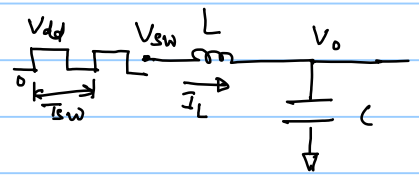
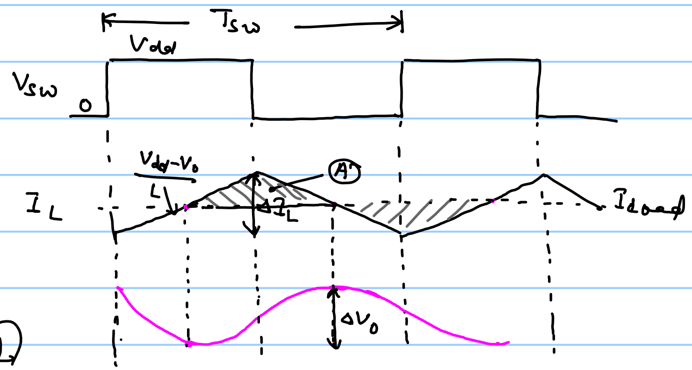
Ripple Voltage of a dc-dc converter





$$\Delta I_L = \frac{V_{dd} - V_o}{L} D \cdot T_{sw}$$

$$\Delta I_L = \frac{V_{dd}(1-D) D \cdot T_{sw}}{L} \quad \text{— (1)}$$

area of triangle (A)

$$Q_o = \frac{1}{2} \times \frac{T_{sw}}{2} \times \frac{\Delta I_L}{2} = \frac{1}{8} \Delta I_L T_{sw}$$

from (1)

$$Q_o = \frac{1}{8} \frac{V_{dd}(1-D) \cdot D}{L} \times T_{sw}^2$$

$$Q_o = C \Delta V_o \Rightarrow \Delta V_o = \frac{Q_o}{C} = \boxed{\frac{1}{8} \frac{V_{dd}(1-D) D}{L C F_{sw}^2}}$$

$\Rightarrow$ output ripple $\propto \frac{1}{F_{sw}^2}$

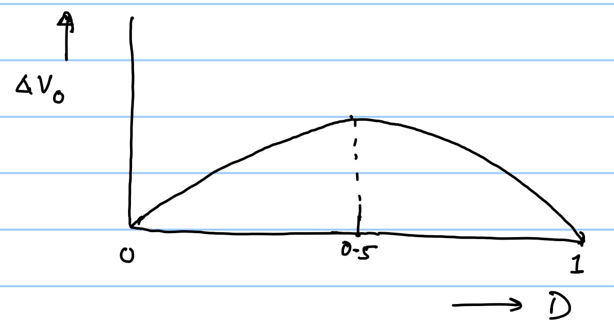
$\Rightarrow \Delta V_o \propto \frac{1}{LC}$

Assume V_{dd} is constant & D is varying (V_o is varying)

$$\Delta V_o = \frac{1}{8} \frac{V_{dd}(1-D)D}{LC F_{sw}^2}$$

$$\frac{d \Delta V_o}{dD} = (1-2D) \frac{1}{8} \frac{V_{dd}}{LC F_{sw}^2} = 0$$

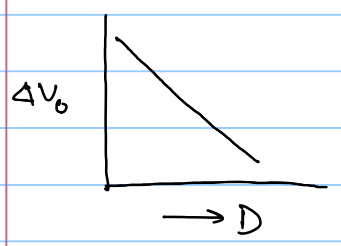
$$\Rightarrow D = \frac{1}{2} = 0.5$$



$$\Delta V_o = \frac{1}{8} \times \frac{V_o (1-D)}{L C F_{sw}^2}$$

$$D \rightarrow \frac{1}{V_{DD}}$$

$\Rightarrow \Delta V_o \rightarrow V_{dd}$ for constant V_o.



How to choose L & C

$$\Delta I_L = \frac{V_{dd} (1-D) D \cdot T_{sw}}{L}$$

$$\Delta V_o = \frac{1}{8} \frac{V_{dd} (1-D) D}{L C F_{sw}^2}$$

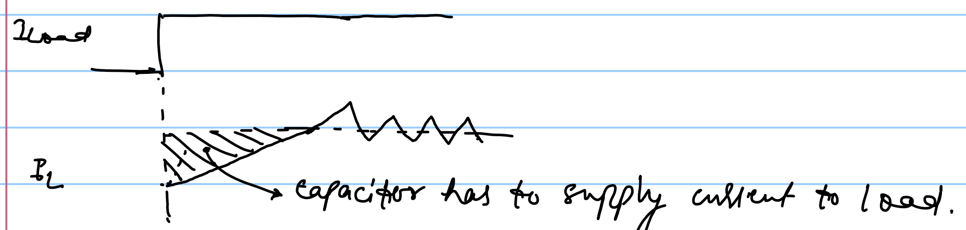
Case-1 L is large & C is small for the same ΔV_0

ΔI_L → small → RMS losses are reduced.

Inductor current slope reduce → slow rise in current

Capacitor is also reduce

⇒ Transient response will be poor.



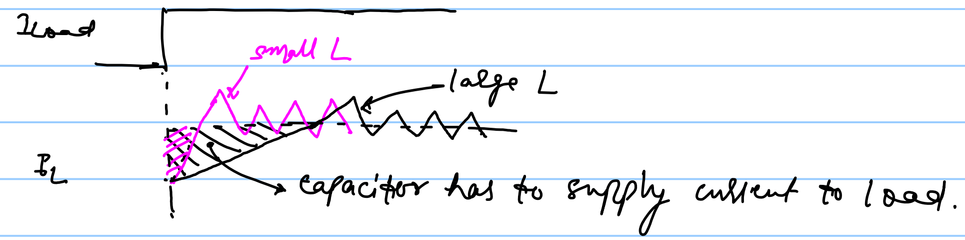
Case-2 L is small & C is large.

ΔI_L is large → higher RMS losses

Inductor current slope increases → fast rise in current

& capacitor is also large → better transient response.

⇒ Require inductor with higher saturation current.



I_{Load}
small L
large L
I_L
capacitor has to supply current to load.