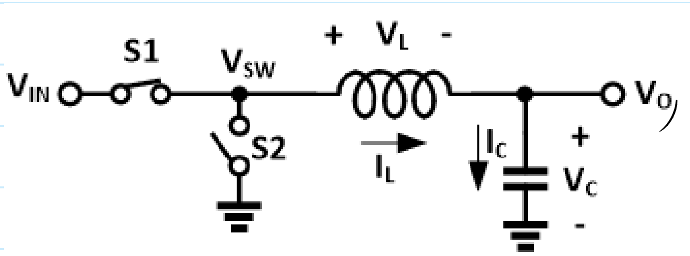
Inductor Ripple Current vs. D



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

$$\Delta I_L = \frac{V_o(1-D)}{L}\cdot\frac{1}{F_{sw}} \quad \text{— (2)}$$

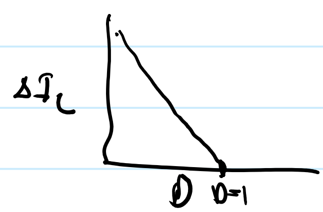
From (1)

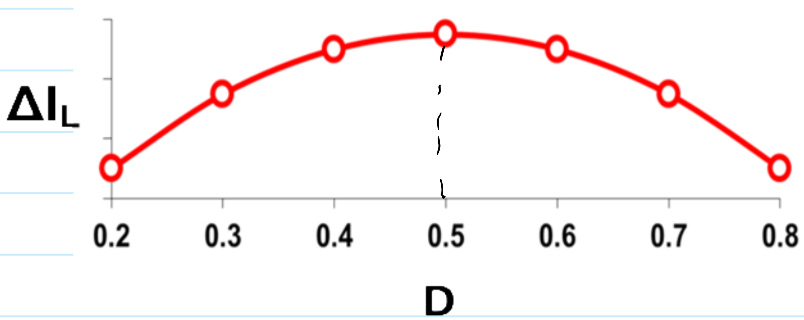
$$\frac{\partial \Delta I_L}{\partial D} = \frac{V_{in}(1-2D)}{L} \times \frac{1}{F_{sw}} = 0 \quad (V_{in} = \text{constant})$$

$\Rightarrow D = 0.5$

From (2) V_o = constant

$\Delta I_L \propto (1-D)$





Example

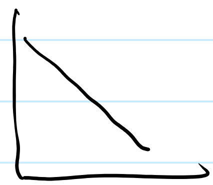
$$\Delta I_L = \frac{V_o (1-D)}{L} \times \frac{1}{F_{sw}}$$

$L = 1\ \mu H, \quad F_{sw} = 1\ MHz$

$V_o = 1V$

$V_{in} = 5\ V \Rightarrow D = \frac{1}{5} = 0.2$

$$\Delta I_L = \frac{(1 - 0.2)}{} = 0.8\ A$$

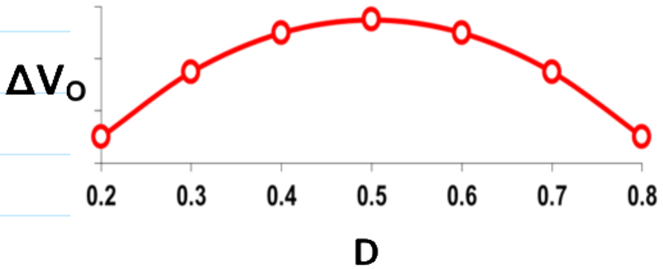


$V_{in} = 2V \Rightarrow D = 0.5$

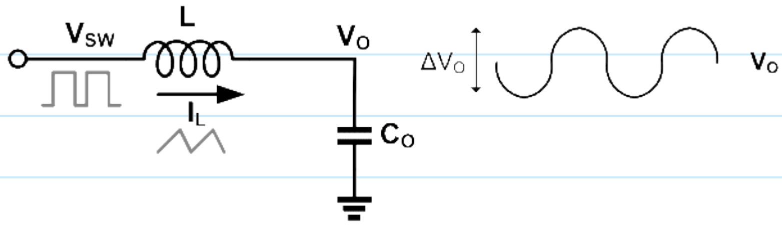
$\Delta I_L = 0.5\ A$

Output Voltage Ripple vs. D

$$\Delta V_O = \frac{V_{IN} \cdot D \cdot (1-D)}{8 \cdot L \cdot C \cdot F_{SW}^{2}}$$



Fsw vs. L & C size



Output Ripple :

$$\Delta V_O \propto \frac{1}{F_{SW}^2} \cdot \frac{1}{LC_O}$$

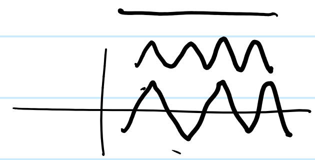
Fsw = 1MHz Fsw ≃ 3MHz Fsw > 5MHz

Source: Micrel

Increasing F_{SW}

Choosing L & C

$$\Delta V_o \propto \frac{1}{F_{sw}^2} \times \frac{1}{L \times C}$$

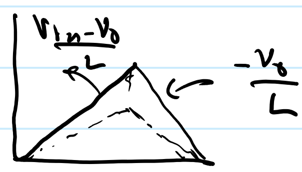


Higher L & lower C

\# ΔI_L is small → RMS losses are reduced. (good)

\# current slew rate is reduced (Poor transient response - Bad)

$$\Delta I_L \propto \frac{V_{in} - V_o}{L}$$



\# smaller cap → poor transient response.

$$\Delta V_{uv/ov} \propto I_{load}^2$$

Lower L & Higher C

\# ΔI_L is large → higher RMS losses (bad)

\# Inductor current slew rate is increased.
→ better transient response (good)

\# Larger cap → improved transient response.

\# Inductor peak current is large
⇒ high saturation current