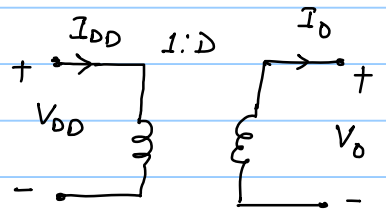


$V_0 = D \cdot V_{dd}$

for ideal transformer

$P_0 = P_{DD}$

$V_{dd} I_{dd} = V_0 \cdot I_0$

$$\boxed{I_{dd} = D \cdot I_0}$$

$V_0 = D \cdot V_{dd}$ is only true under no loss condition

$I_{dd} = D \cdot I_0$ is true for all conditions.

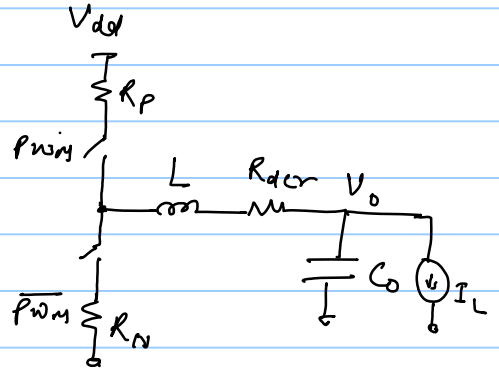
Efficiency of a switching converter

$$\eta = \frac{P_{out}}{P_{in}} = \frac{V_o \cdot I_o}{V_{dd} \cdot I_{dd}}$$

$D_{\_noloss}$ $\quad \frac{1}{D}$

$$\boxed{\eta = \frac{D_{\_noloss}}{D}}$$

True only for conduction losses.



Example:

$V_{dd} = 1.8\,V$

$V_o = 1.5\,V$

$R_P = R_N = 0.05\,\Omega$

$R_{dcr} = 0.05\,\Omega$

$I_L = 1\,A$

$$V_o = D \cdot V_{dd} - V_{loss}$$

$$V_{loss} = I_L \left(D \cdot R_p + (1-D) R_N + R_{dcr} \right)$$

$$= 1A \left(0.05 + 0.05 \right) = 100mV$$

$$1.5 = D(1.8) - 100\,mV$$

$$\Rightarrow D = \frac{1.6}{1.8} = 0.88$$

$$D_{no\text{-}loss} = \frac{1.5}{1.8} = 0.833$$

$$\Rightarrow \Delta D = 0.055 \simeq 5.5\%$$

$$I_{dd} = 0.88 \times 1A = 0.88A$$

$$P_{dd} = 1.8 \times 0.88 = 1.6W$$

$$P_o = 1.5W$$

$$\eta = \frac{1.5}{1.6} = 93.75\%$$

$$\eta = \frac{D_{wlan}}{D} = \frac{0.833}{0.88} \simeq 93.75\%$$

Efficiency of LDO

$$\eta = \frac{1.5}{1.8} = 83.33\%$$

Now assume

$$V_o = 0.9\,V$$

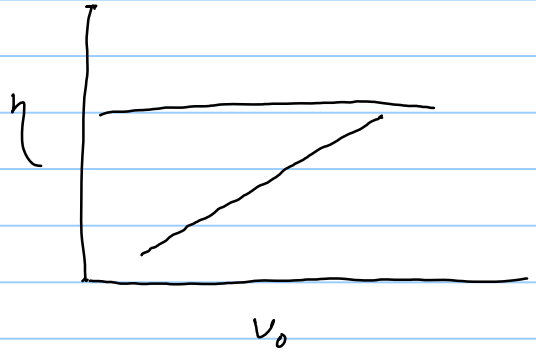
$$0.9 = D(1.8) - 150\,mV$$

$$D = \frac{1}{1.8} = 0.555$$

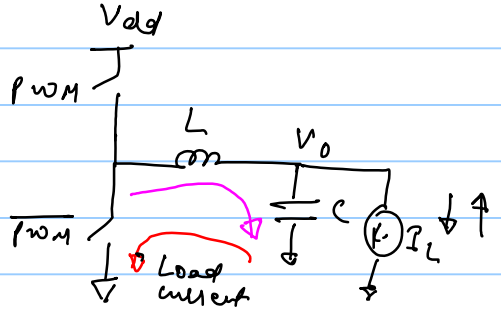
$$\eta = \frac{0.5}{0.555} \simeq 90\%$$

for LDO

$\eta = 50\%$



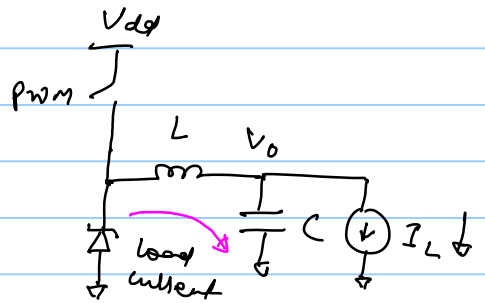
Synchronous Vs. non-synchronous switching Regulator.



Synchronous

↓

Bi-directional



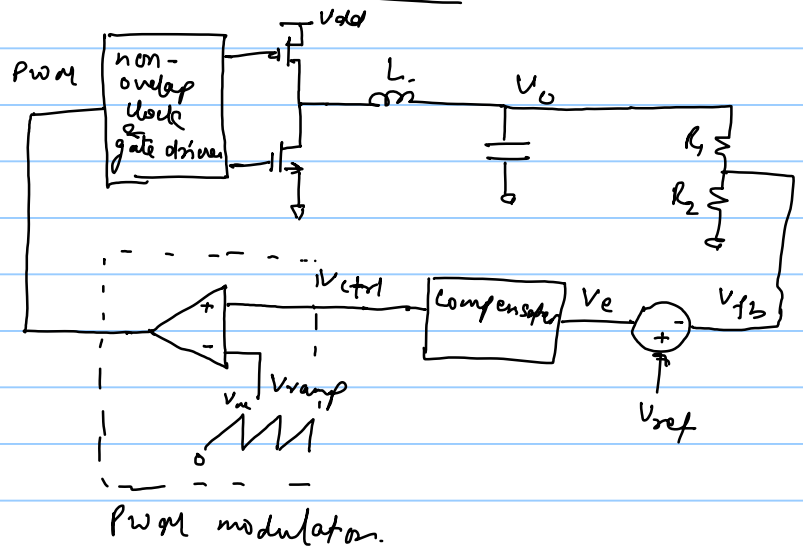
non-synchronous

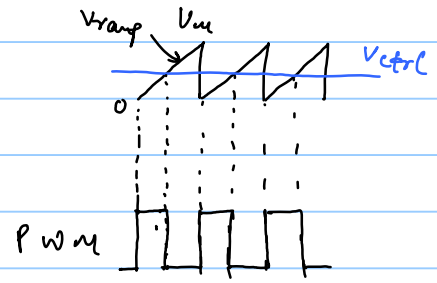
Control Techniques

PWM control → Voltage mode control

→ Current mode control

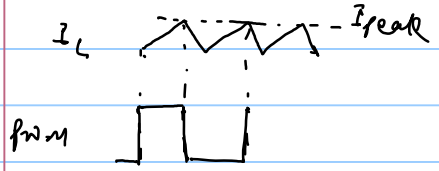
Voltage mode control





$$D = \frac{V_{ctrl}}{V_m}$$

Current mode control



no external Vramp is used.