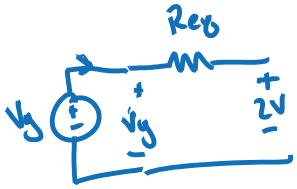
Equivalent Circuit Model

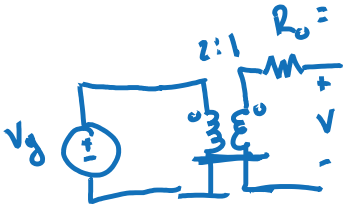
$P_{loss} = C_{fly} f_s (V_g - 2V)^2$

$P_{in} = V_g C_{fly} f_s (V_g - 2V)$

$R_{eq} = \frac{1}{C_{fly} f_s}$



$\Rightarrow$



$R_o = \frac{1}{4 C_{fly} f_s}$

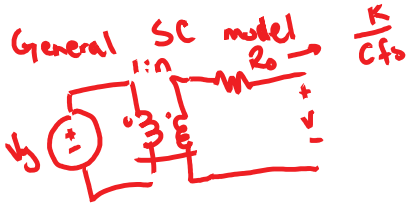
for high η, want small R_o

→ Large C_{fly}, Large f_s

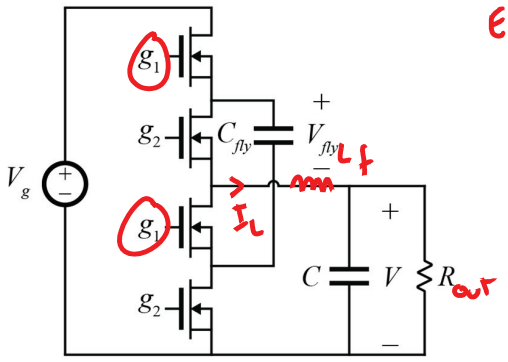
↓

Limit: $t_c \gg \tau$

$\frac{1}{2} \frac{1}{f_s} \gg R C_{fly}$



2:1 – Current Loaded



$E_{loss} = E_{C,i}^{I} + E_{C,i}^{II}$

$= \frac{1}{2} C \left[2 I_L R (V_2 - V_1) \right] + \frac{1}{2} C \left[2 (-I_L) R (V_1 - V_2) \right]$

$= 2 I_L R (V_2 - V_1) C$

$\Delta Q = I_L \frac{T_s}{2}$

$E_{loss} = I_L R \left(I_L \frac{T_s}{2} \right) = I_L^2 R T_s$

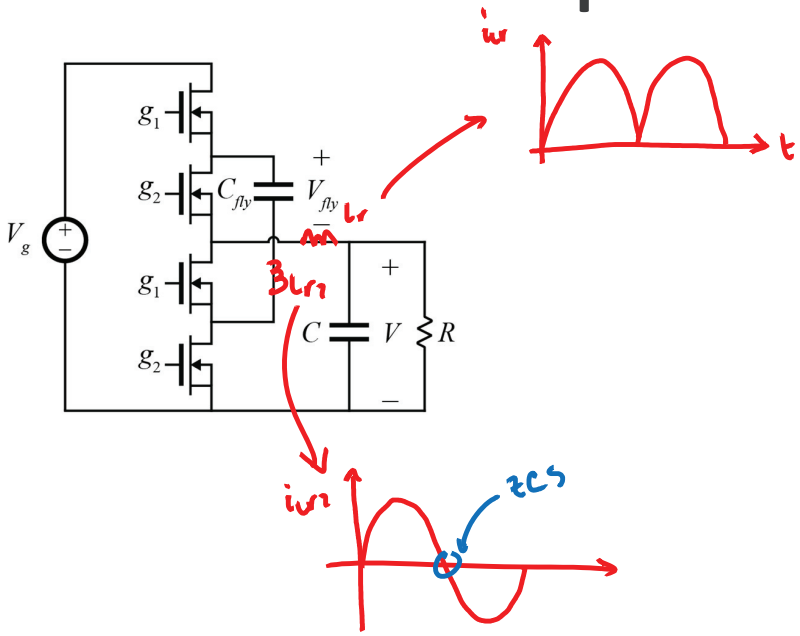
$R = 2 r_{on} + R_L + ESR_C$

This topology no longer has any charge-sharing

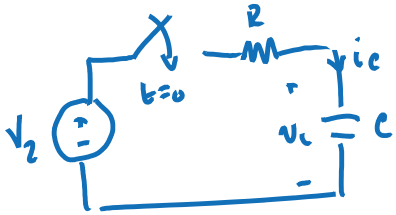
3-level Buck

- Down regulation possible

2:1 – Resonant Implementation

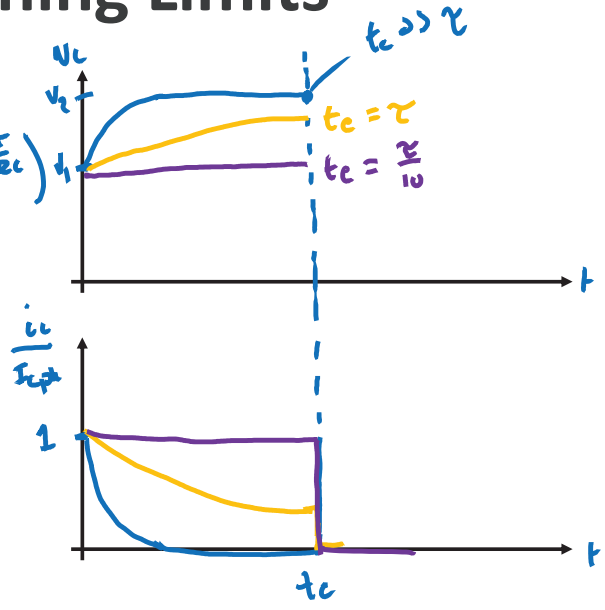


Slow and Fast Switching Limits



$v_c(t=0) = V_1$

$v_c(t>0) = V_1 + (V_2 - V_1)(1 - e^{-\frac{t}{RC}})$



$\frac{t_c}{\tau}$	$\frac{v_c(t_c)}{V_2 - V_1}$
1/10	9.5%
1/2	39%
1	63%
3	95%
∞	100%

SSL → $t_c \gg \tau$
Slow switching Limit

FSL → $t_c \ll \tau$
Fast Switching Limit

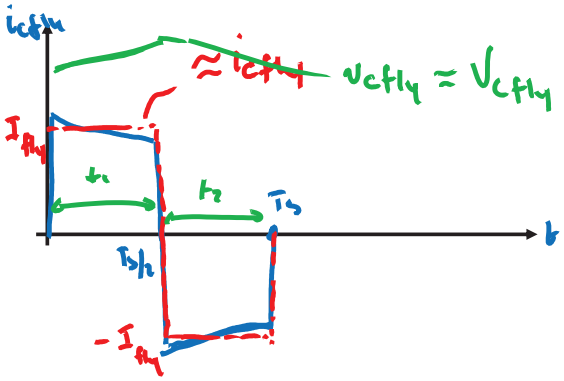
2:1 SC – FSL Model

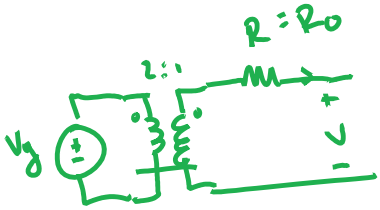
$$P_{out} = V\left[\frac{V_g - V_{cfly} - V}{R}\cdot\frac{t_1}{T_s} + \frac{V_{cfly} - V}{R}\frac{t_2}{T_s}\right]$$

$$t_1 = t_2 = \frac{T_s}{2}$$

$$P_{out} = \frac{V}{R}\left[\frac{V_g}{2} - V\right]$$

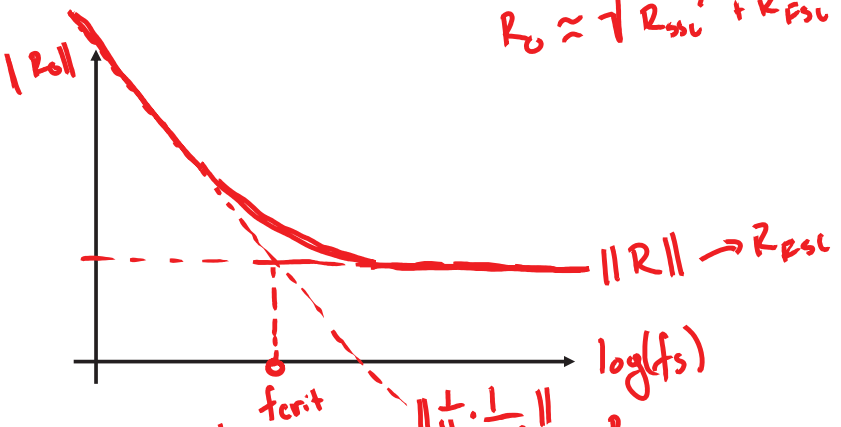
$$= V\,\frac{\left(\frac{V_g}{2} - V\right)}{R}$$





SSL and FSL

$$R_o \approx \sqrt{R_{SSL}^2 + R_{FSL}^2}$$



$$R > \frac{1}{4C_{fly}f_s}$$

$$f_s = \frac{1}{4C_{fly}R}$$

$$\frac{1}{T_s} = \frac{1}{2t_c} = \frac{1}{4C_{fly}R}$$

$$t_c = 2C_{fly}R = 2\tau \quad @\ f_{crit}$$