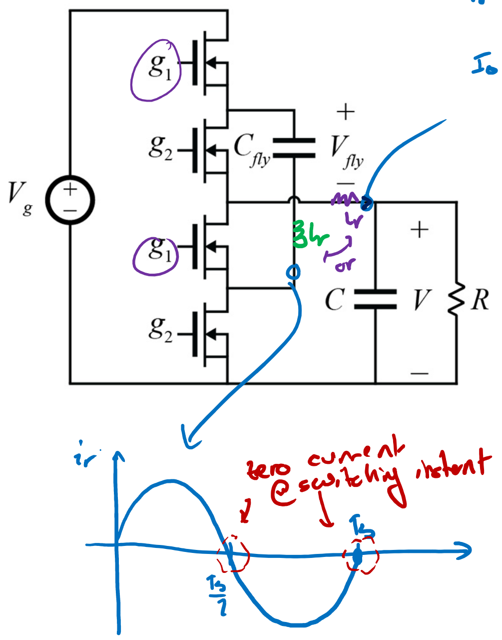
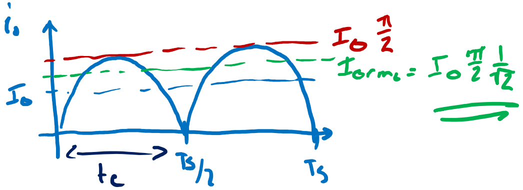
2:1 – Resonant Implementation





$$E_{loss} = 2\cdot\frac{1}{2}C(V_2-V_1)^2\,\frac{\pi^2 RC}{2T_s}$$

$$P_{loss} = \underbrace{C^2(V_2-V_1)^2}_{=\Delta Q^2}\,\frac{\pi^2}{2}f_s^2\,R$$

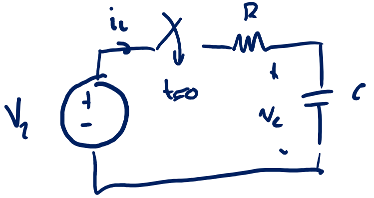
$$\Delta Q = I_o\frac{T_s}{2}$$

$$P_{loss} = \left(\frac{\Delta Q\,\pi\, f_s}{\sqrt{2}}\right)^2 R$$

$$= \left(\frac{I_o T_s\,\pi\, f_s}{2\sqrt{2}}\right)^2 R$$

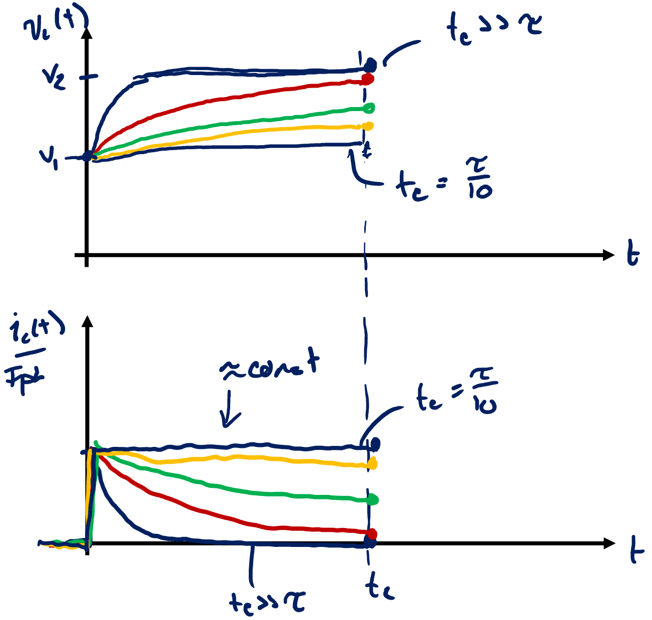
$$P_{loss} = I_{o,rms}^2 R \;, \qquad R = ESR_c + 2R_{on} + R_L$$

Slow and Fast Switching Limits



$v_c(t=0) = V_1$

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



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

$t_c \gg \tau \rightarrow v_c(t_c) \rightarrow V_2$ $\quad i_c \rightarrow \phi$ before end of period

Slow switching Limit (SSL)

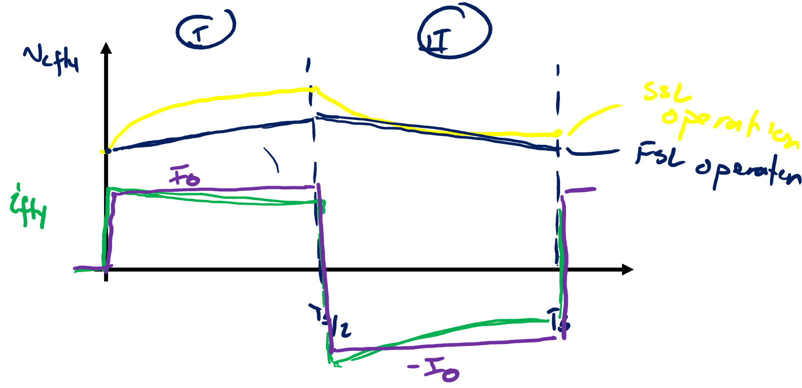
$t_c \ll \tau \rightarrow$ Current ≈ constant through entire interval

$\Delta v_c < V_2 - V_1$

Fast switching Limit (FSL)

2:1 SC – FSL Model

FSL : assume $t_c = \frac{T_s}{2} \ll RC = \tau$

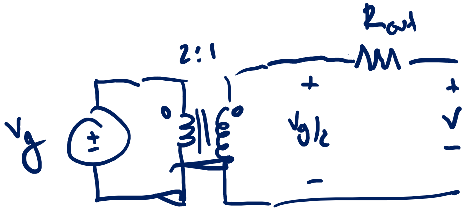


$$P_{out} = V \cdot I_o$$

$$= V \frac{1}{T_s} \int_0^{T_s} i_o(t)\,dt$$

$$= V \cdot \frac{1}{T_s} \left[\underbrace{\frac{V_g - V_{fly} - V}{R}}_{\text{I}} \cdot \frac{T_s}{2} + \underbrace{\frac{V_{fly} - V}{R}}_{\text{II}} \frac{T_s}{2} \right]$$

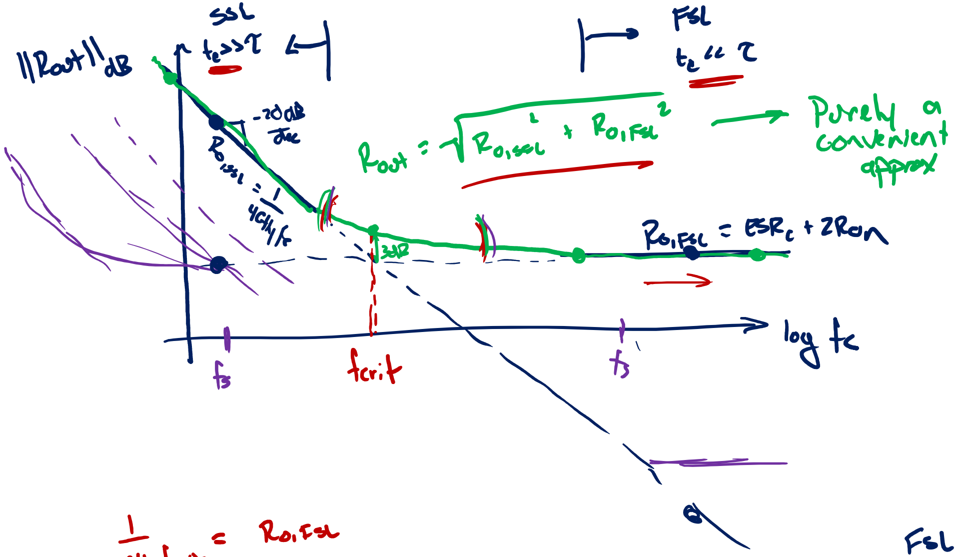
$$= V \cdot \frac{1}{2} \left[\frac{V_g - 2V}{R} \right] = V \cdot \underbrace{\left[\frac{V_g/2 - V}{R} \right]}_{I_o}$$



$$R_{out} = ESR_c + 2R_{on} + \ldots$$

$$\begin{cases} R_{out,SSL} = \dfrac{1}{4 C_{fly} f_s} \\ R_{out,FSL} = ESR_c + 2R_{on} \end{cases}$$

SC Output Resistance



$$\frac{1}{4C_{fly} f_{crit}} = R_{o,FSL}$$

$$f_{crit} = \frac{1}{4C_{fly} R_{o,FSL}}$$

$$\frac{1}{T_s} = \frac{1}{4C_{fly} R_{o,FSL}}$$

$$\frac{1}{2t_c} = \frac{1}{4C_{fly} R_{o,FSL}}$$

$$t_c = 2C_{fly} R = 2\tau$$

→ R_{out} ↓ @ higher f_s

want high f_s for small "conduction" losses

But switching losses aren't included

FSL & SSL equiv model:

$$R_{out} \approx \sqrt{\left(\frac{k}{C_{fly} f_s}\right)^2 + (R_{eq})^2}$$