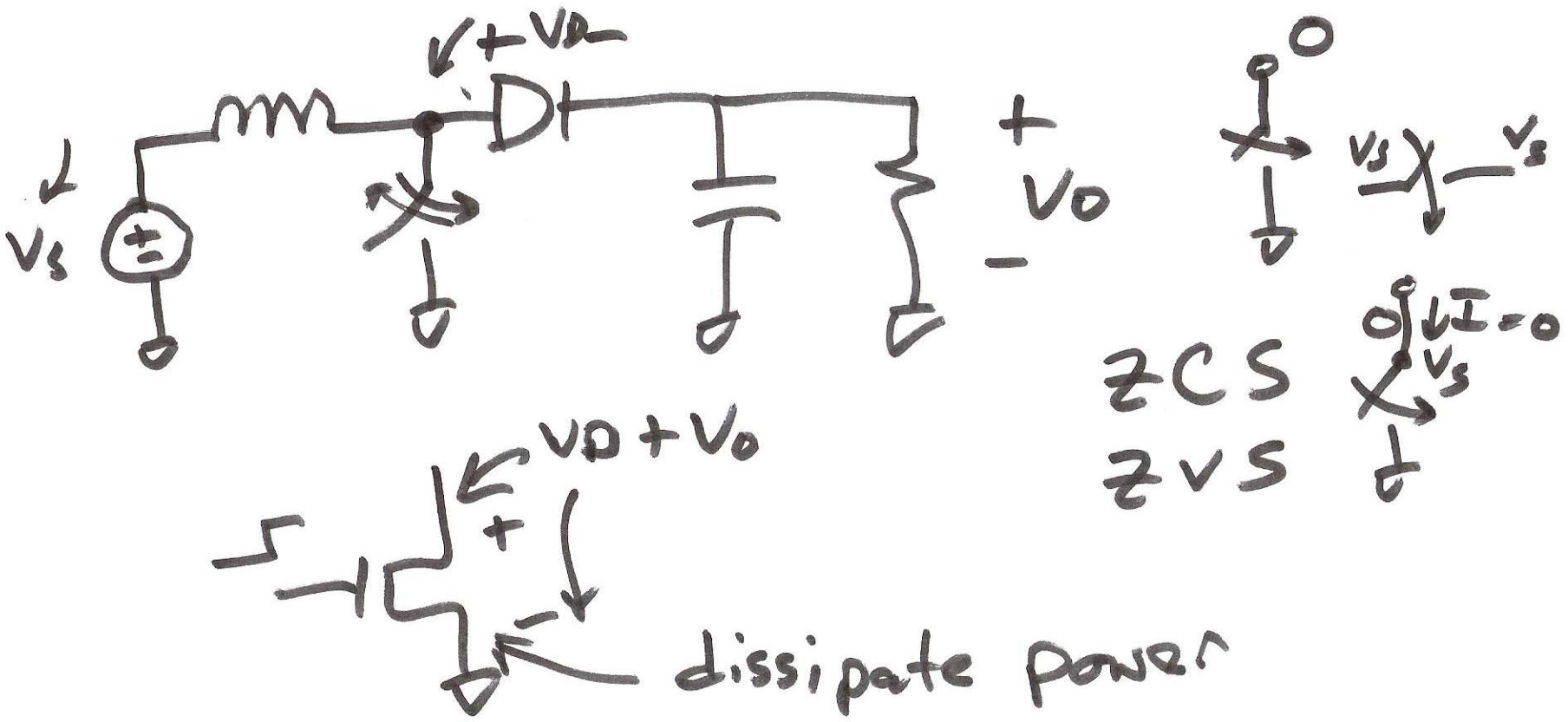
ECE 5/472 Power Electronics

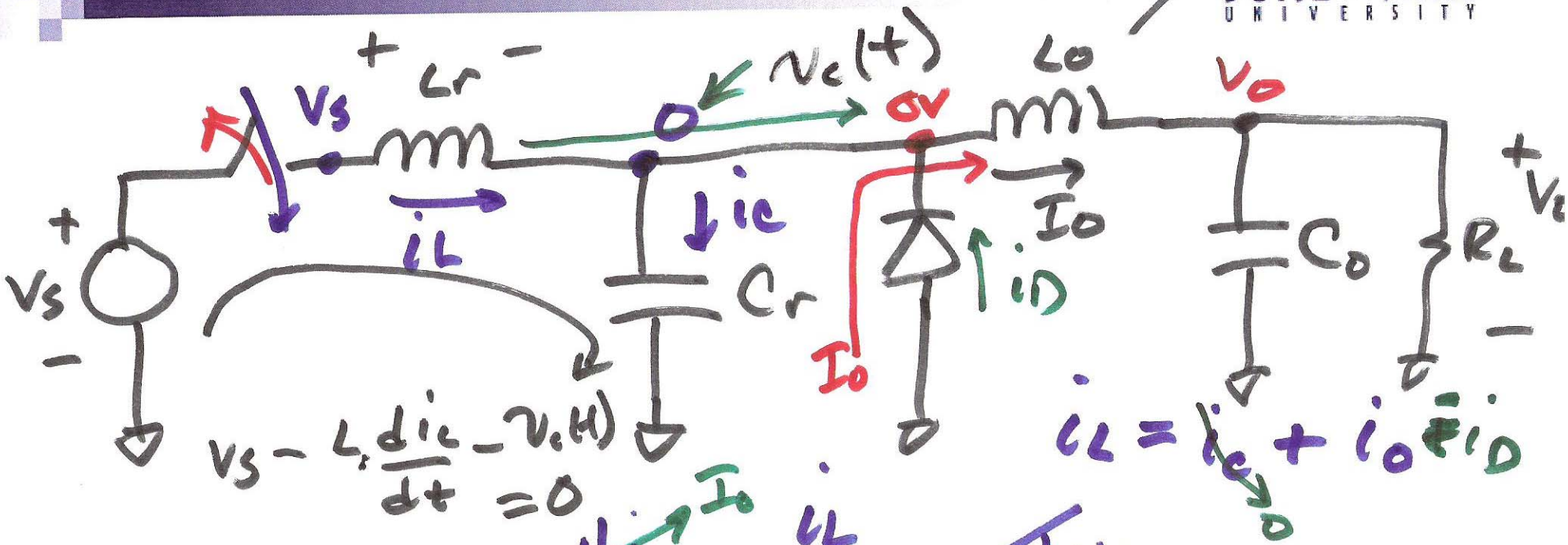
BOISE STATE UNIVERSITY

Sept. 29, 2011

Lecture 11

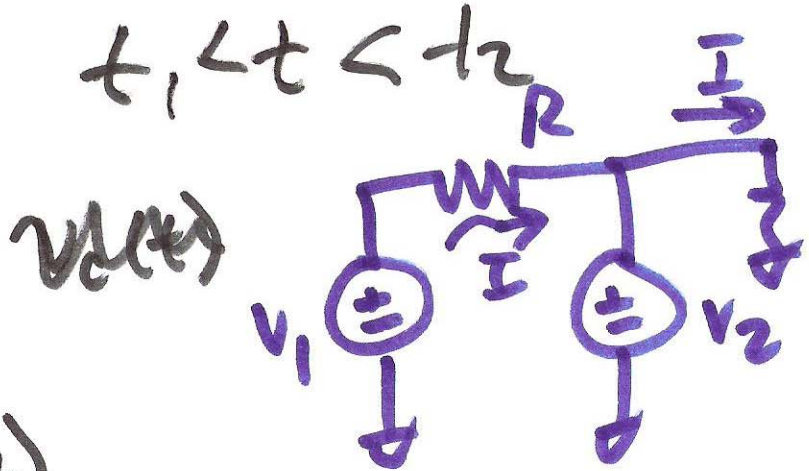


Resonant converters ZVS, ZCS



$$\frac{V_s}{L} = \frac{\Delta i_L}{\Delta t}$$

$t_1 < t < t_2$



$$\frac{I_0 \cdot L}{V_s} = t_1$$ — diode shuts off

$$V_1 - IR - V_2 = 0$$

2)

$t_1 < t < t_2$

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$$v_c(t) = V_S - L\frac{di_L}{dt}, \quad i_c(t) = i_L(t) - I_0$$

$$i_c(t) = C\frac{dv_c(t)}{dt}$$

$$\frac{dv_c(t)}{dt} = -L\frac{d^2 i_L}{dt^2} = \frac{i_c(t)}{C}$$

$$L\frac{d^2 i_L}{dt^2} = \frac{I_0 - i_L}{C}$$

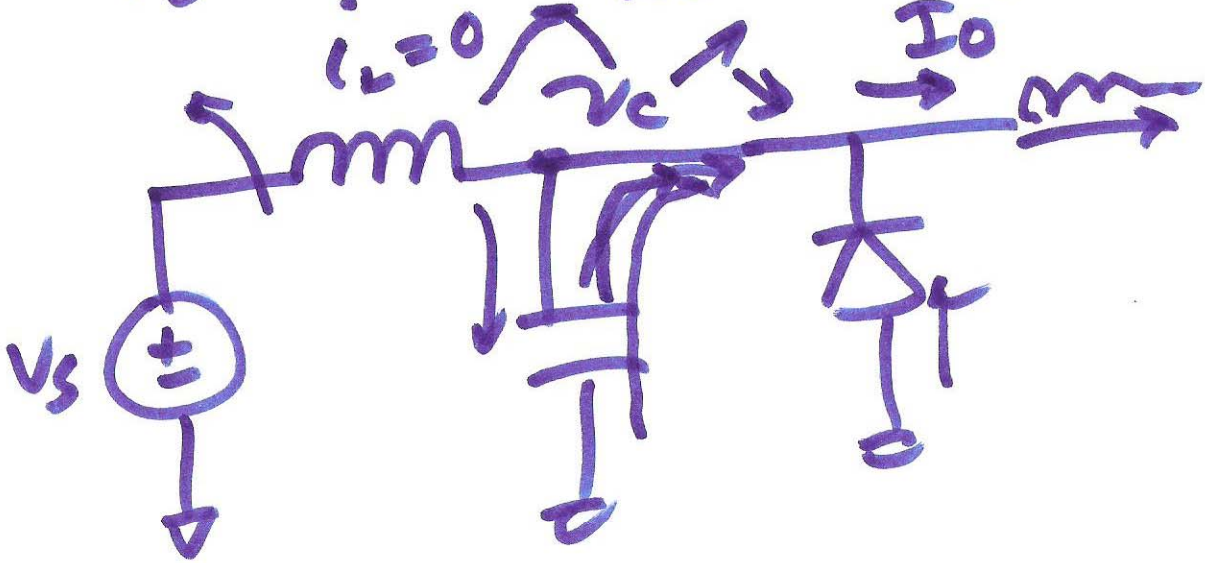
$$\frac{d^2 i_L(t)}{dt^2} + \frac{i_L(t)}{LC} = \frac{I_0}{LC}$$

3)

$$+\; i_L(t) = I_0 + \frac{V_s}{Z_0}\sin\omega_0(t-t_1)$$

$$Z_0 = \sqrt{\frac{L}{C}} \qquad \omega_0 = \frac{1}{\sqrt{LC}}$$

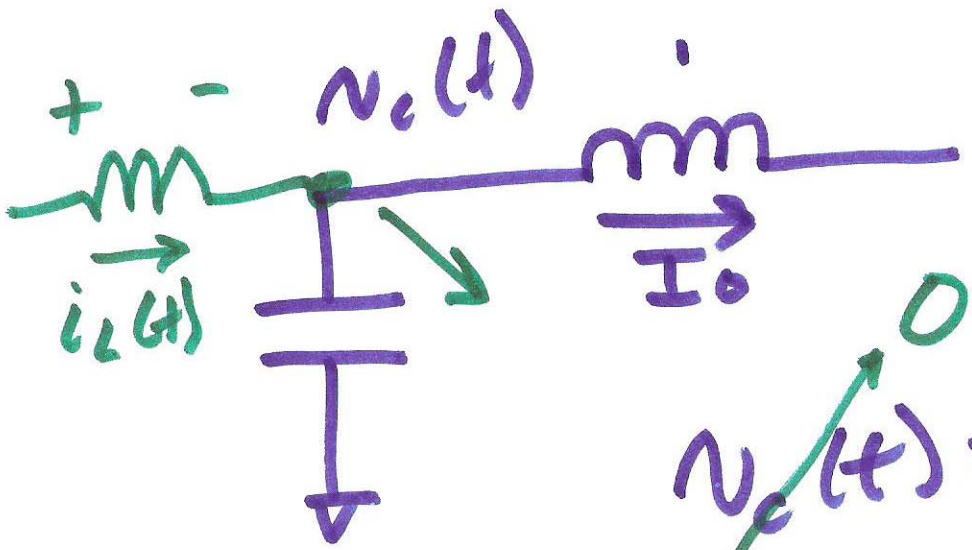
$$t_2 - t_1 = \frac{1}{\omega_0}\sin^{-1}\left(\frac{-I_0 Z_0}{V_s}\right)$$



$t_2 < t < t_3$ Cap discharges

diode off

$t_3 \rightarrow$ diode on!



$$v_c(t) = \frac{1}{C}\int_{t_2}^{t_3} i_L(t)\cdot dt + v_c(t_2)$$

($i_L(t) \rightarrow -I_0$)

$$= -\frac{I_0}{C}(t_3 - t_2) + v_c(t_2)$$

$$v_L(t) = V_S - L\cdot\frac{di_L}{dt}$$

($v_c(t) \rightarrow 0$)

$$t_3 - t_2 = \frac{v_c(t_2)\cdot C}{I_0}$$

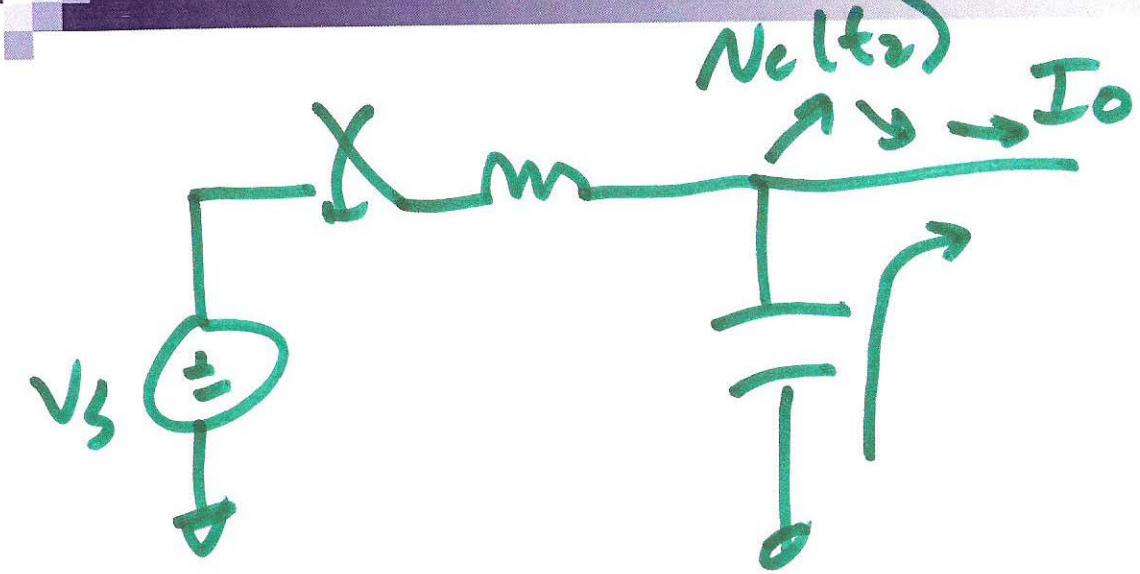
$$\frac{L\cdot\sqrt{\frac{C}{L}}}{\sqrt{\frac{L}{C}}\sqrt{\frac{C}{L}}}$$

$$= \frac{C}{I_0}V_S\left(1 - \frac{L\omega_0}{Z_0}\cos(\omega(t - t_1))\right)$$

($\frac{L\omega_0}{Z_0} \rightarrow 1$)

5)

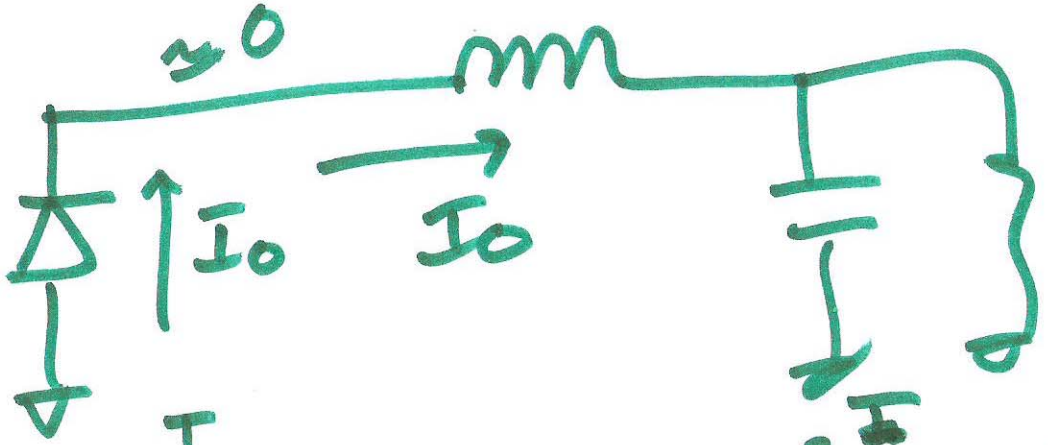
$t_2 < t < t_3$



$$V_c(t_2) = V_s - L\frac{di_L}{dt}$$

$$V_s - L\left(\frac{V_s}{Z_0}\omega_0 \cos(\omega_0(t-t_1)\right)$$

6)



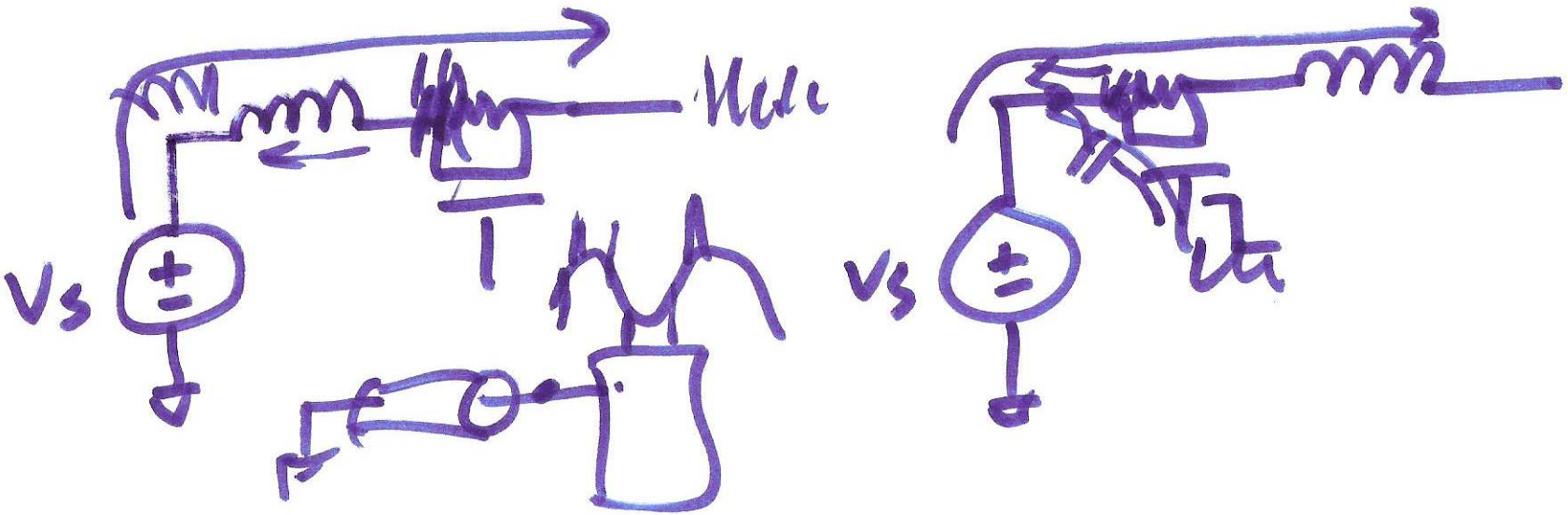
$$\mathcal{E}_s = \int_0^T P_s(t)\,dt = V_s \int_0^T i_L(t)\cdot dt$$

$$\mathcal{E}_L = \int_0^T P_o(t)\cdot dt = V_o \cdot I_o \cdot T = \frac{V_o \cdot I_o}{f}$$

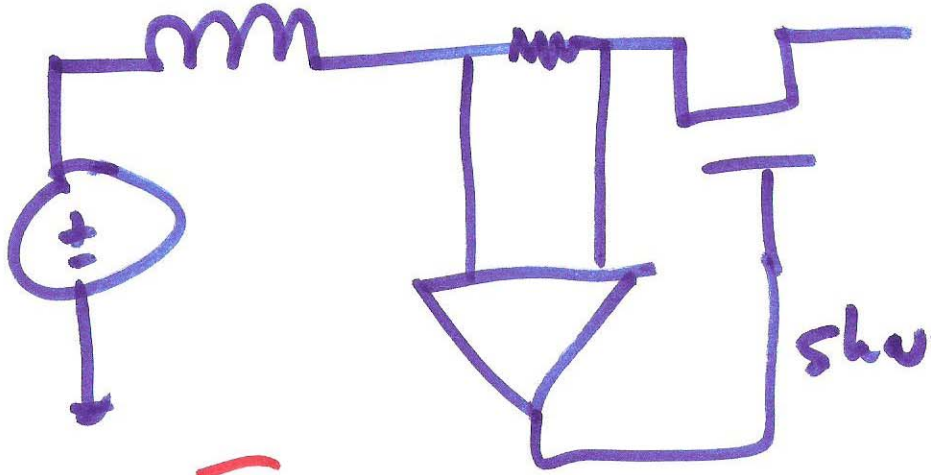
$$\int_0^T i_L(t)\,dt = \int_0^{t_1} \frac{V_s \cdot t}{L}\cdot dt + \int_{t_1}^{t_2} \left[I_o + \frac{V_s}{Z_o}\sin\omega(t-t_1)\right]\cdot dt$$

7)

$$V_o = V_s \cdot f_s \left[\frac{t_1}{2} + (t_2 - t_1) + \frac{V_s C_r}{I_o} \cdot \left[1 - \cos(\omega_o (t_2 - t_1)) \right] \right]$$



How to measure zero current



zero voltage switching

shut off

ZVS

ZFS ↑ field

$$V_o = V_s f_s \left[\frac{t_1}{2} + (t_2 - t_1) + (t_3 - t_2) \right]$$