ECE 5/472 Power Electronics

BOISE STATE UNIVERSITY

Lecture 10

Sept. 22, 2011

Derive energy stored in a capacitor & inductor

$\frac{1}{2}Cv^2$ $\quad$ $\frac{1}{2}Li^2$

$$\mathcal{E} = \int P \cdot dt = C \int_0^V v(t)\, dv(t) = \frac{1}{2}CV^2$$

$\mathcal{E} \rightarrow J$

$P \rightarrow W = J/s$

CAP.

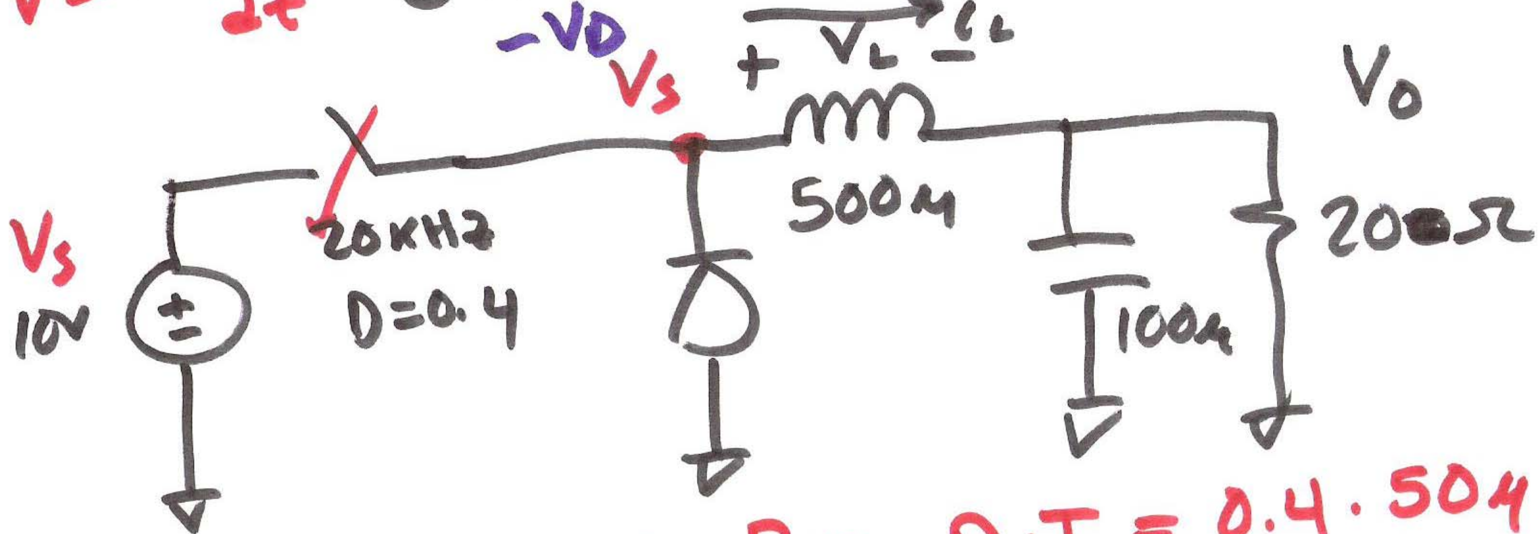
$v(t) \cdot i(t)$

$v(t) \cdot C\frac{dv(t)}{dt}$

$$\left\{ \int \frac{1}{f^2}\, df = -\frac{1}{f} \right\}$$

$v = L \cdot \frac{di}{dt}$

Give DC-DC converter



$V_0 = ?$

$\frac{\Delta V_0}{V_0} = ?$

$\Delta i_L = ?$

$I_{MAX} = ?$

$I_{MIN} = ?$

switch closed for $D \cdot T = 0.4 \cdot 50\mu = 20\mu s$

$$\frac{V_s - V_0}{L} = \frac{\Delta i_L}{D \cdot T}, \quad \Delta i_L = 20\mu s \cdot \frac{10 - 3.58}{500\mu H}$$

switch open for $(1-D)T = 0.6 \cdot 50\mu = 30\mu s$

$$\frac{-V_D - V_0}{L} = \frac{\Delta i_L}{(1-D)T}$$

$$\frac{2\cancel{0} \cdot 6.42}{\cancel{50\cancel{0}}_{25}} \approx \frac{1}{4} A$$

$$\boxed{\Delta i_L = \frac{1}{4} A}$$

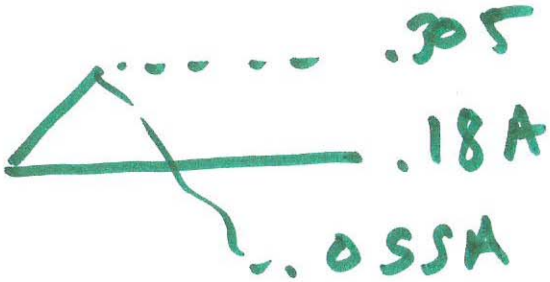
2)

Buck $V_s > V_o$

$$\left(\frac{V_s - V_o}{\cancel{L}}\right)(D\cancel{T}) + (1-D)\cancel{T} \cdot \frac{-V_D - V_o}{\cancel{L}} = 0$$

$$V_s \cdot D - V_o \cdot D - V_D(1-D) - V_o(1-D) = 0$$

$$V_s \cdot D - V_D(1-D) = V_o$$



$$V_o = 10 \cdot .4 - 0.7(0.6)$$

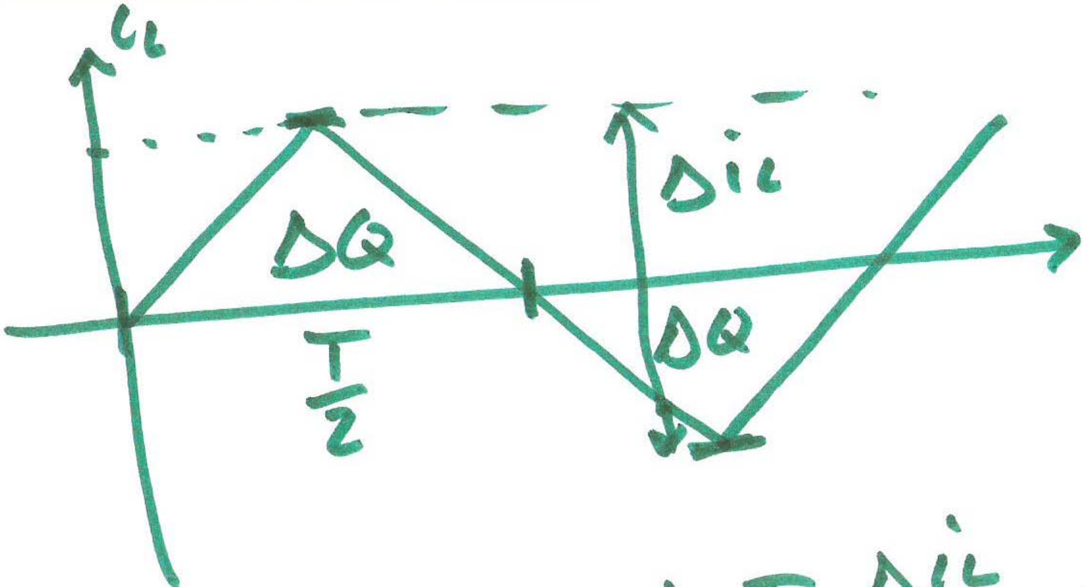
$$= 4 - .42 = \underline{\underline{3.58V}} = \underline{\underline{V_o}}$$

$$I_{MAX} = \frac{\Delta i_L}{2} + \frac{V_o}{R} = \frac{1}{8}A + .18A = \underline{\underline{.305A}}$$

$$I_{MIN} = .18 - \frac{1}{8}A = .055A = \underline{\underline{55mA}}$$

$.18 \qquad .125$

3)



$CV = Q$

$$\Delta V_o = \frac{\Delta Q}{C}$$

$C = 100\mu F$

$$\Delta Q = \frac{1}{2}\frac{T}{2}\frac{\Delta i_L}{2} = \frac{T \cdot \Delta i_L}{8}$$

$$\Delta i_L = DT \cdot \left(\frac{V_s - V_o}{L}\right)$$

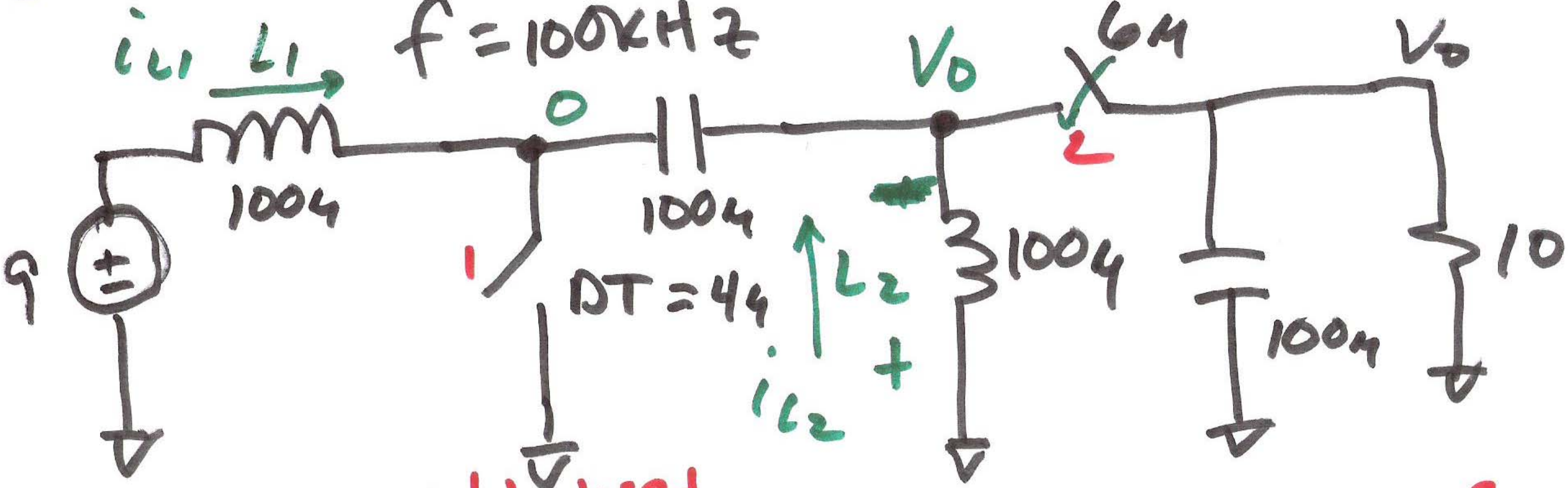
$$\Delta V_o = \frac{T}{8} \cdot \frac{DT}{C} \cdot \frac{V_s - V_o}{L} = \frac{\cancel{50\mu} \cdot \cancel{50\mu} \cdot .4 \cdot 6.42}{8 \cdot \underset{10}{\cancel{100\mu}} \cdot \cancel{500\mu} \cdot 2}$$

$$= \frac{2.5}{160} \approx 18mV$$

$$\frac{\Delta V_o}{V} = \frac{.18}{3.58} \approx .5$$

4)

$V = L\cdot\frac{di}{dT}$



$V_0 = ?$

Switch 1 closed

$$\Delta i_{L1} = \frac{V_S}{L_1}\cdot DT = \frac{9}{100u}\cdot 4u = \frac{9}{25}\ A$$

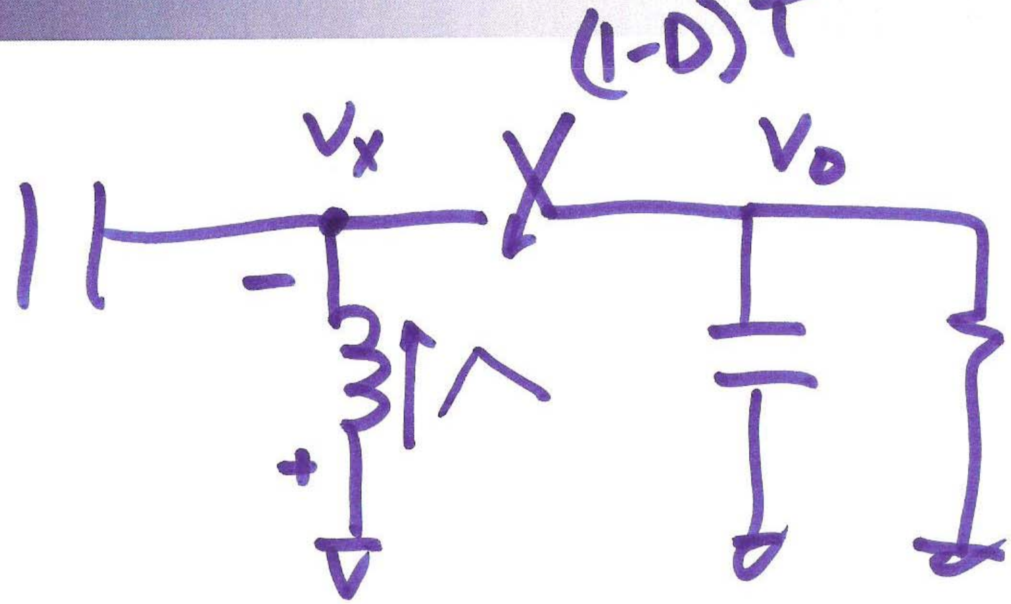
Switch 2 closed

$$\Delta i_{L2} = \frac{-V_0}{L_2}\cdot(1-D)T =$$

$$V_S \cdot i_{L1} = \frac{V_0^2}{R}$$

$$\cancel{\frac{V_S}{L_1}\cdot DT + -\frac{V_0}{L_2}(1-D)T = 0}$$

5)

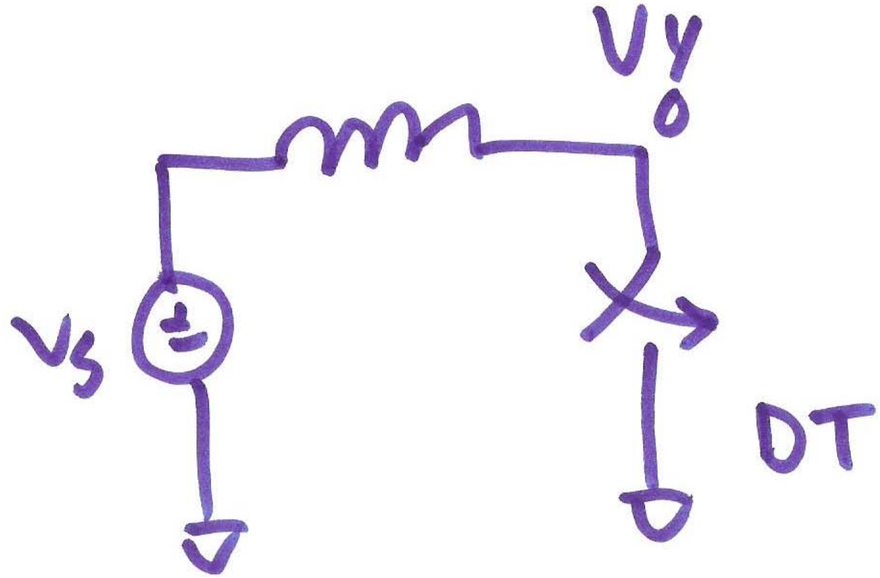


$$\Delta i_L = (1-D)T \cdot \frac{V_o}{L}$$

$$-\Delta i_L = DT \cdot \frac{-V_x}{L}$$

6)

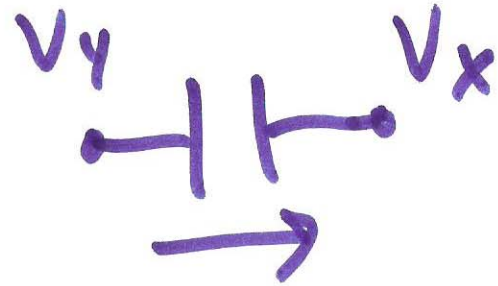
$$\frac{v}{L} = \frac{di}{dt}$$



$$\Delta i_L = DT \cdot \frac{V_s}{L}$$

$$= (1-D)T \cdot \frac{V_s - V_y}{L}$$

$$I = C\frac{dv}{dT}$$

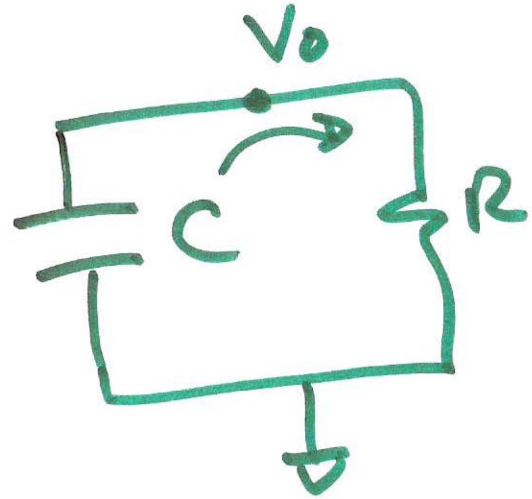


$$I = \frac{V_o}{R} = \frac{V_y - V_x}{DT}$$

2)

* Energy problems
* Study EX6. 6-1 to 6-9
* Really understand Buck & Boost
* Questions about operation of converters.
* Study homework problems
* Derive relationship between V_o and V_s for Buck or Boost operating with Discontinuous inductor current

8)



estimate the ripple

$$I = C\frac{dV}{dt}$$

$$\frac{V_o}{R} = \frac{\Delta V_o}{\Delta t} \cdot C$$