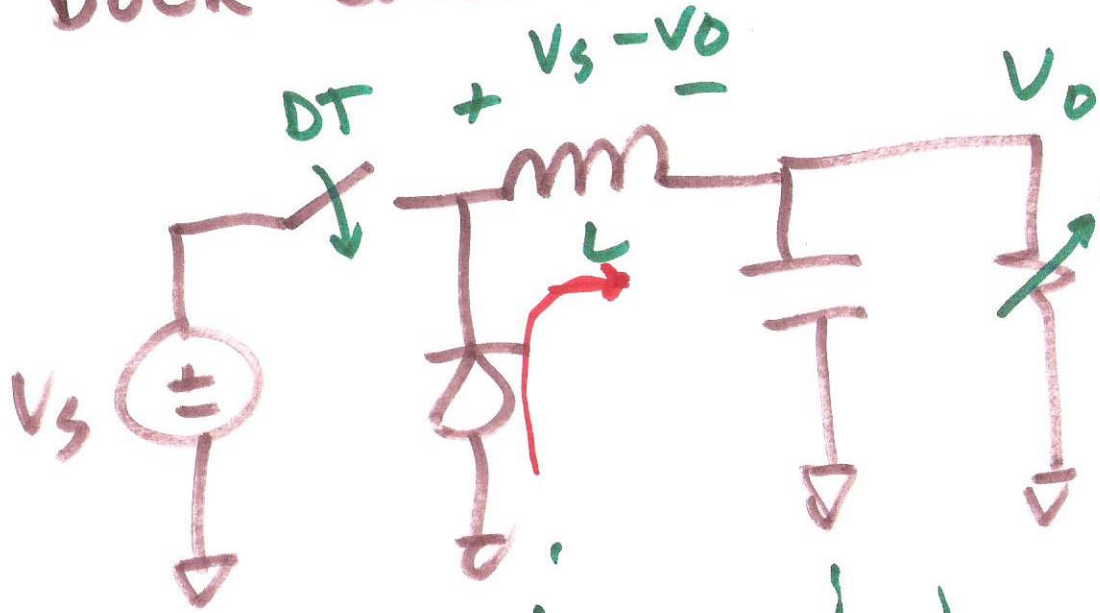
ECE 5/472 Power Electronics

BOISE STATE UNIVERSITY

Lecture 9 Sept. 20, 2011

Buck converter

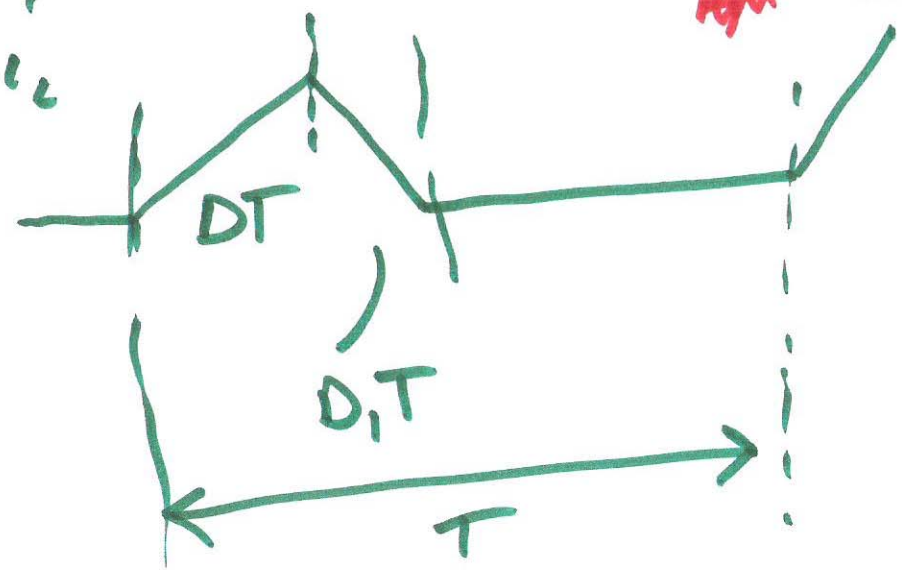


$$V = L\frac{di}{dt}$$

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

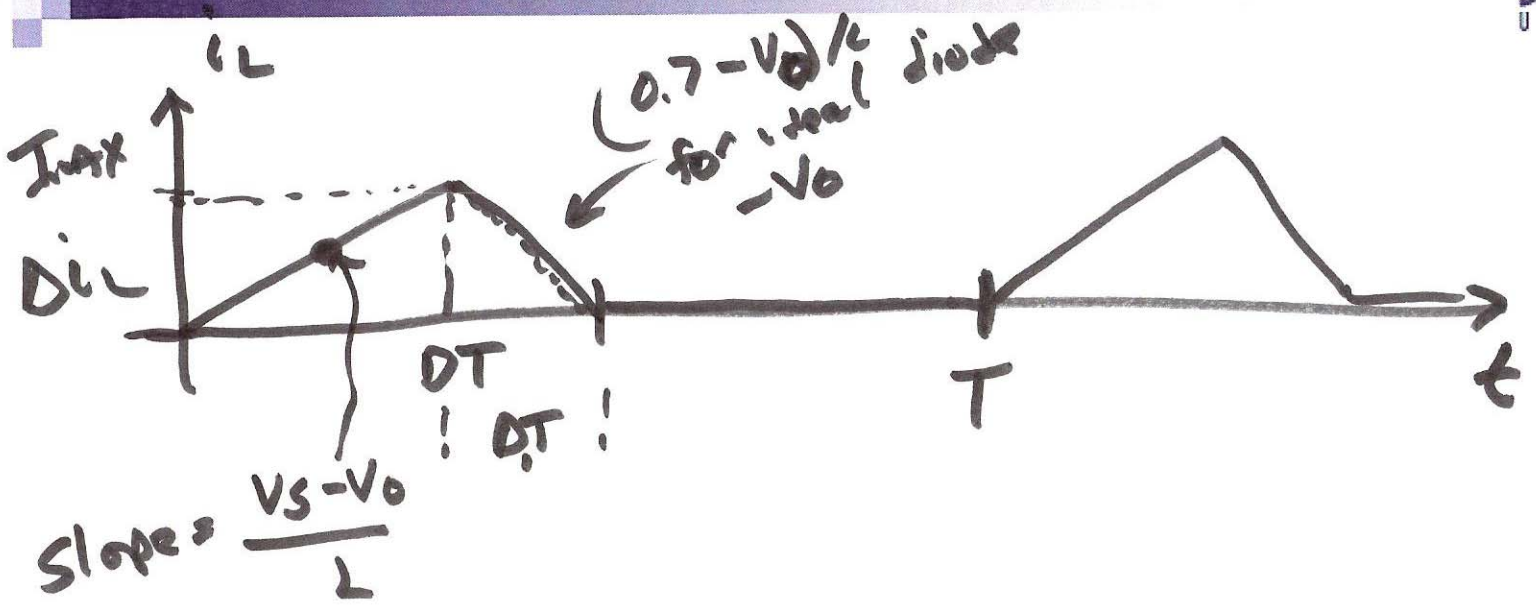
$$\frac{V_o^2}{R} = P_o$$

$W = J/s$



$\frac{V_o^2}{R} \cdot T$

$\frac{V_o^2}{R} T$



$$\frac{V_s - V_o}{L} \cdot DT + D_1 T \frac{0 - V_o}{L} = 0$$

$$(V_s - V_o) D = D_1 V_o$$

$$V_o = V_s \cdot \frac{D}{D + D_1}$$

Load current

$$\frac{V_O}{R} = I_R = I_L$$

$$\frac{V_O}{R} = \frac{1}{T}\left(\frac{I_{MAX}}{2} \cdot DT + \frac{I_{MAX}}{2} \cdot D_1 T\right)$$

$$= \boxed{\frac{1}{2} I_{MAX} (D + D_1) = \frac{V_O}{R}}$$

Δi

Switch Closed → $I_{MAX} = \frac{V_S - V_O}{L} \cdot DT \rightarrow \frac{V}{L} = \frac{di}{dT} = \frac{\Delta I_{MAX}}{DT}$

Switch open → $-I_{MAX} = \frac{-V_O}{L} \cdot D_1 T$

$$\frac{V_O}{R} = \frac{1}{2} \frac{V_O D_1 T}{L} (D + D_1)$$

3)

$$\frac{V_0}{R} = \frac{1}{2L} V_{GT} \left(D_1 D + D_1^2\right)$$

$$T\frac{D_1^2}{2L} + \frac{D_1 D T}{2L} - \frac{1}{R} = 0$$

$$D_1^2 + D_1 D - \frac{2L}{RT} = 0$$

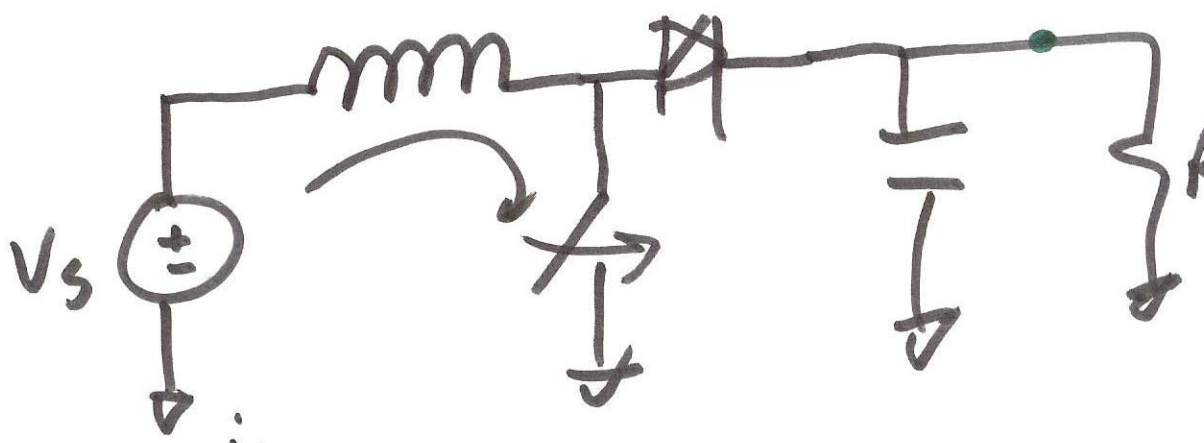
$$D_1 = \frac{-D \pm \sqrt{(D)^2 + 4\frac{2L}{RT}}}{2}$$

$$V_0 = V_S \cdot \frac{D}{D+D_1} = V_S \left[\frac{2D}{D + \sqrt{D^2 + 8L/RT}}\right]$$

4)

BOOST DISCONTINUOS

BOISE STATE UNIVERSITY



Continuos current

$$\frac{\Delta i_L}{DT} = \frac{I_{MAX} - 0}{L} = \frac{V_S - 0}{L}$$

$$\frac{\Delta i_L}{(1-D)T} = \frac{I_{MAX} - I_{MIN}}{(1-D)T} = \frac{V_S - V_O}{L}$$

$$\frac{DT \cdot V_S}{L} = \frac{(V_O - V_S) \cdot D_1 T}{L}$$

$$V_O = V_S \left(\frac{D + D_1}{D_1} \right)$$

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

$$I_{MAX} = DT \cdot \frac{V_S}{L}$$

$$= \frac{V_O - V_S}{L} \cdot D_1 T$$

$$L = \frac{V \cdot S^2}{Q} \frac{V_O}{R} = \frac{1}{T} \left(\frac{DT \cdot V_S}{2L} + \frac{V_O - V_S}{2L_R} \cdot D_1 T \right)$$

AVG. Inductor current

$$\frac{D V_S}{2L} + \frac{V_O - V_S}{2L} D_1 - \frac{V_O}{R} = 0$$

5)

BOISE STATE UNIVERSITY

$V = L \cdot \frac{di}{dT}$ (C/s²) $L = \frac{V \cdot s^2}{C}$, $\frac{V}{L} = \frac{di}{dt}$ (C/s)

Avg. Diode current

$\frac{V_D}{R} = \frac{1}{T}\left(0 + \frac{V_D - V_S}{L} \cdot D_1 T\right)$

I_{MAX} Amps

switch closed

switch open

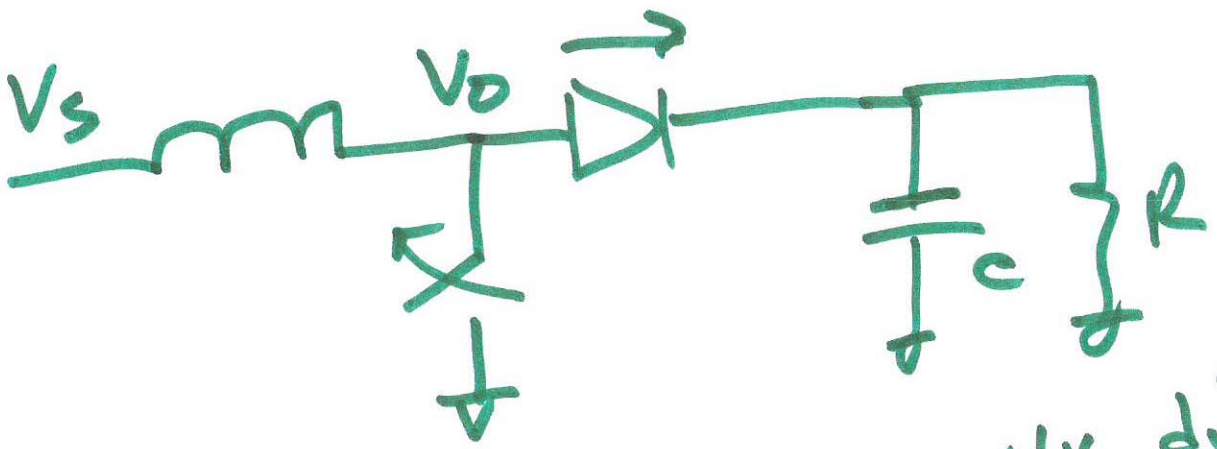
V

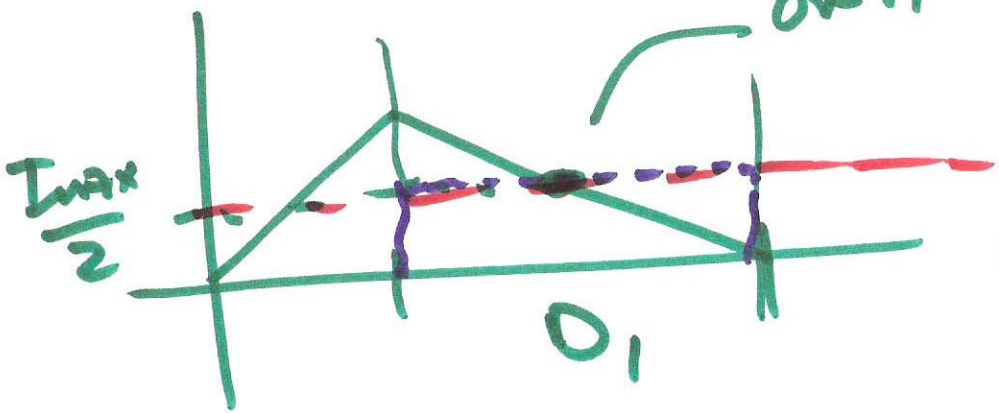
$\frac{V_D}{R}(Amps) = \frac{V_D - V_S}{L} \cdot D_1$

$V \cdot \frac{s^2}{C}$

$\frac{1}{T}\left(I_{MAX} \cdot D_1 T\right)$

6)



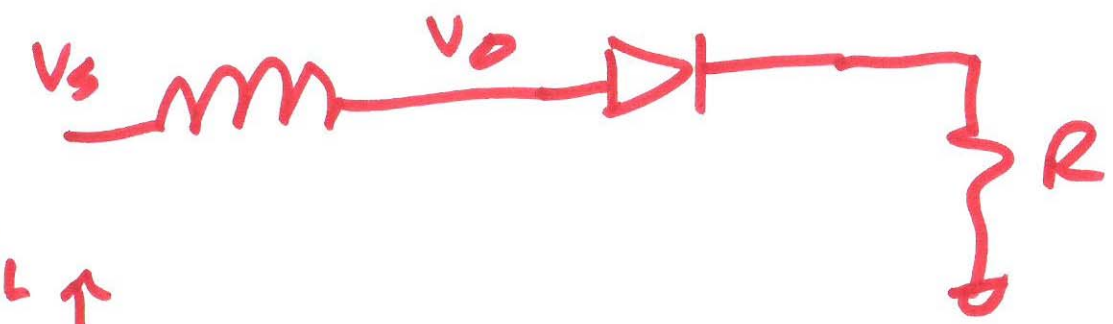


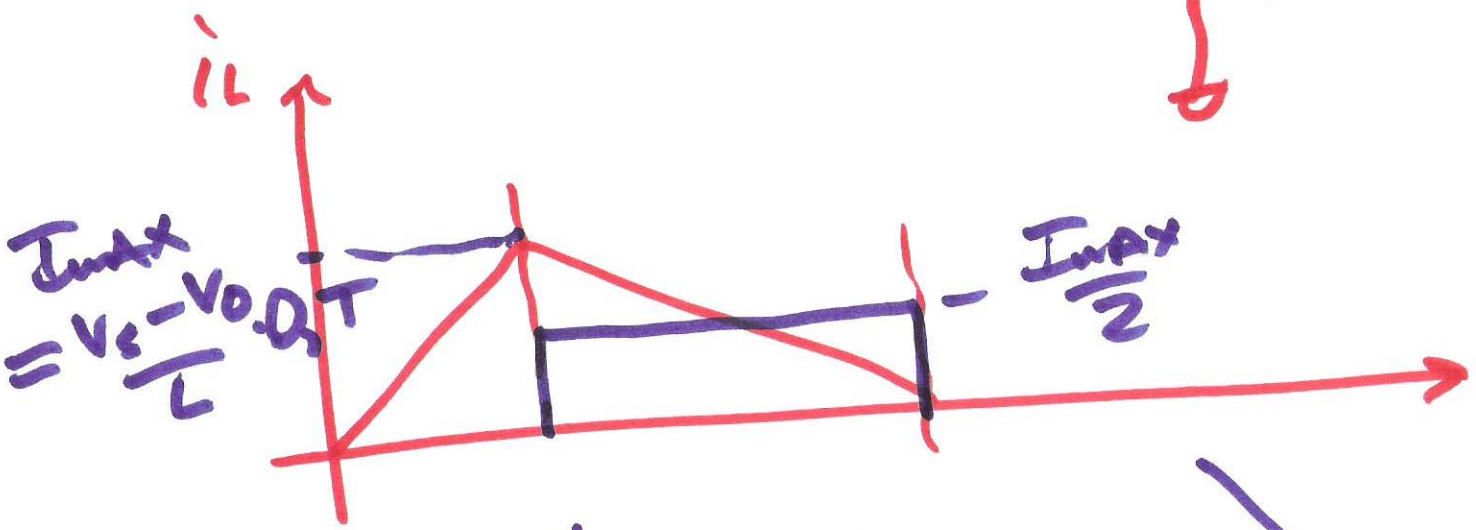
$$I_O = \frac{1}{T}\left(\frac{I_{max}}{2} \cdot D_1 T\right)$$

$$I_{max} = \frac{V_s - V_o}{L} \cdot D_1 T$$

$$I_O = \frac{1}{T}\left(\frac{V_s - V_o}{L} \cdot D_1 T \cdot \frac{1}{2}\right)$$

7)





$$I_{diode\ average} = \frac{1}{T}\left(\frac{V_s - V_o}{2L} \cdot D_1 T \cdot D_1 T\right) = \frac{V_s - V_o}{2L} D_1^2 T$$

$\frac{I_{max}}{2}$

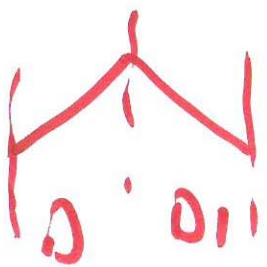
Average diode $= \frac{I_{max}}{2} D_1 F$

8)

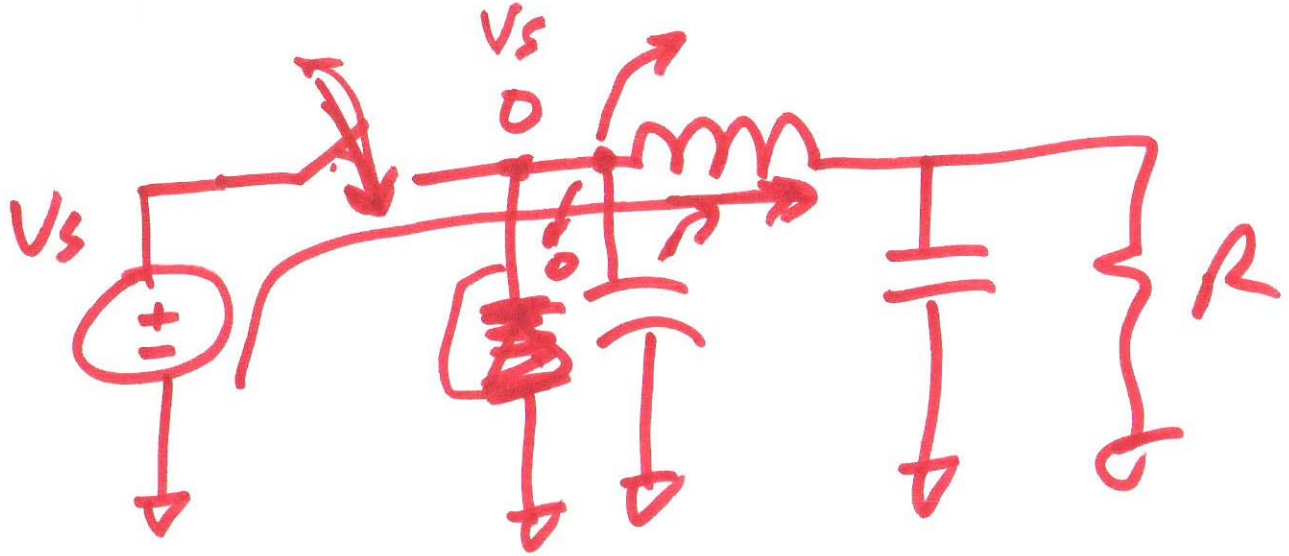
$$I_D = \frac{1}{2}\left(\frac{V_s D T}{L}\right) D_1 = \frac{V_o}{R}$$

$$D_1 = \left(\frac{V_o}{V_s}\right) \cdot \frac{2L}{RDT}$$

$$\frac{V_o}{V_s} = \frac{1}{2}\left(1 + \sqrt{1 + \frac{2D^2RT}{L}}\right)$$



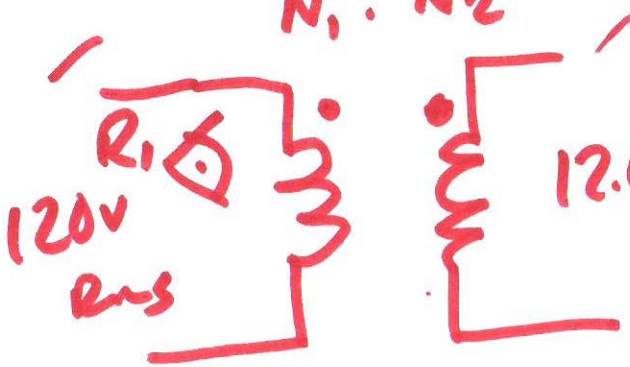
Resonant



Zero-voltage switching

BOISE STATE UNIVERSITY

Modeling Xfmers



$$\frac{V_1}{I_1} = \frac{V_2}{I_2} \cdot \frac{N_1^2}{N_2^2} = \frac{V_2}{I_2}\cdot\frac{1}{N^2}$$

$$\underbrace{\frac{I_1}{R_1}} \quad \underbrace{\frac{I_2}{R_2}}$$

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \sqrt{\frac{L_1}{L_2}} = \frac{1}{N}$$

inductance of the primary = 1mH

$$\frac{120}{12.6} = 9.52 = \sqrt{\frac{1mH}{L_2}} \qquad \frac{1mH}{9.52^2}$$

$$L_2 =$$

$$= 11\,\mu H$$