

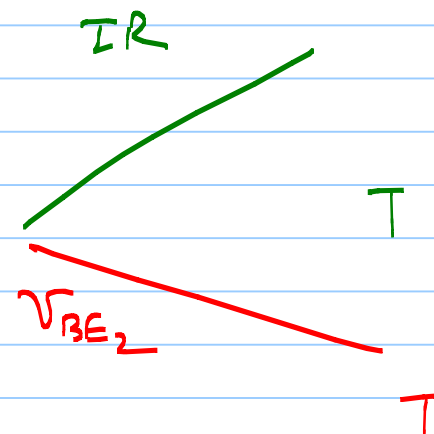
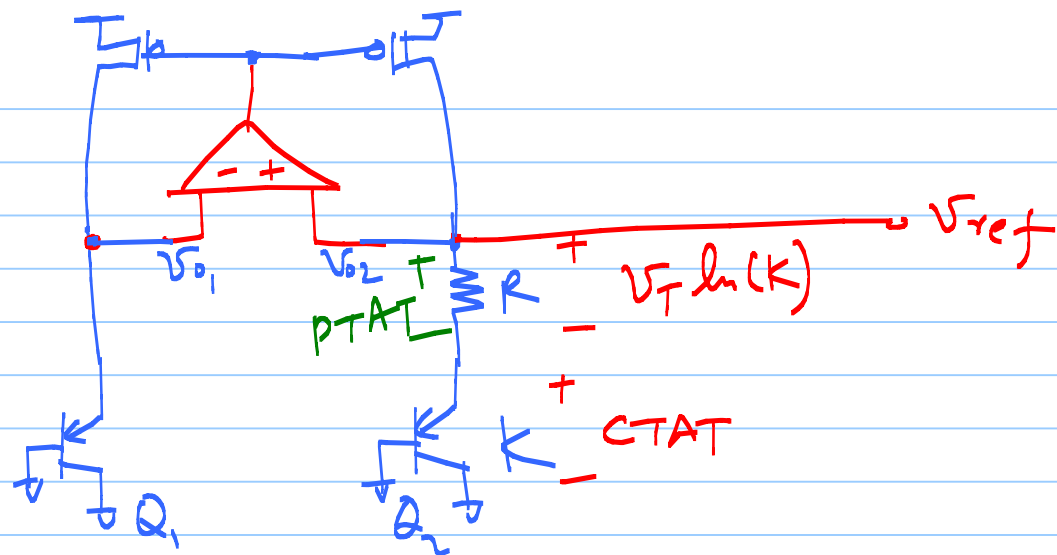
ECE 5411 → Lecture 26.

Note Title

5/4/2011

Final on Monday
May 9th
6-8 pm

A4 / Letter
one side
cheat sheet



$$IR = V_{BE1} - V_{BE2}$$

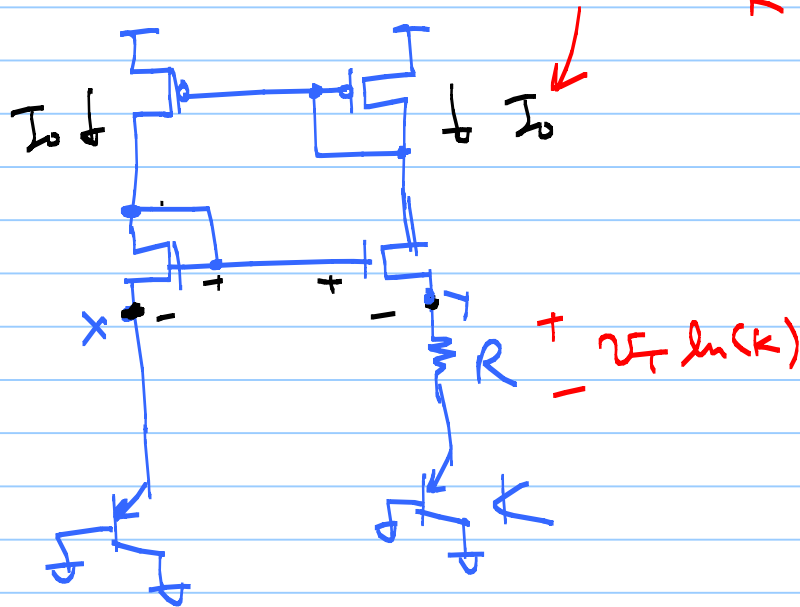
$$= \textcircled{V_T} \ln(K) \leftarrow PTAT$$

V_{ref}

α from the BMR circuits.

$$\frac{V_T \ln(K)}{R} \quad (\text{PTAT current})$$

$$\lambda = 0$$





$$v_{ref} = v_T \ln(k) \cdot \underbrace{L}_{\alpha_2} + v_{BE3} \cdot \underbrace{\frac{1}{\alpha_1}}$$

$$\frac{\partial V_{ref}}{\partial T} = \underbrace{\left(\frac{k}{q}\right) \ln(k) \cdot L}_{0.085 \text{ mV/K}} + \underbrace{\frac{\partial V_{BE3}}{\partial T}}_{-1.5 \text{ mV/K}} = 0$$

Ex
23.5'

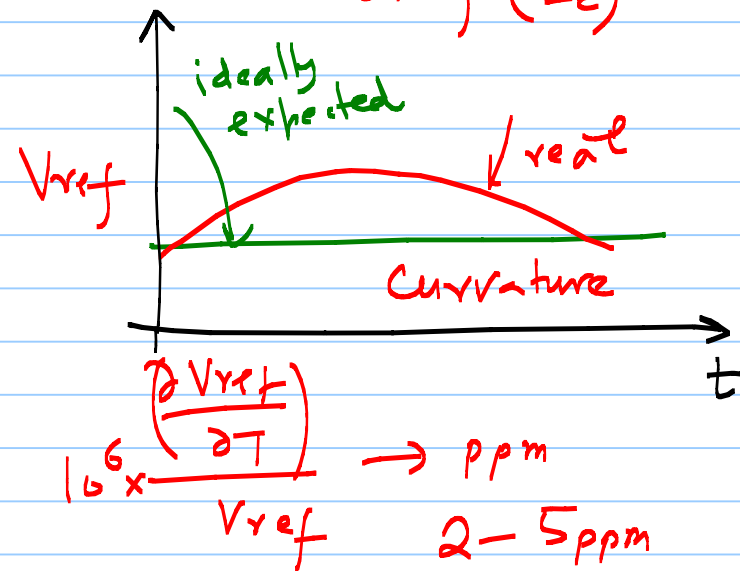
$$\ln(k) \cdot L = \frac{-(-1.5 \text{ mV/K})}{0.085 \text{ mV/K}} = 17.2$$

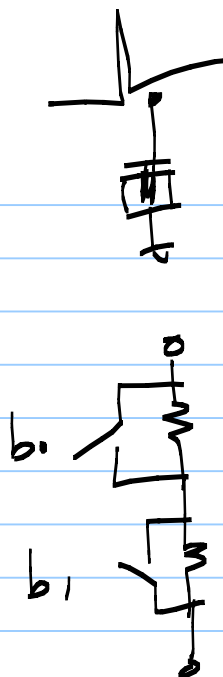
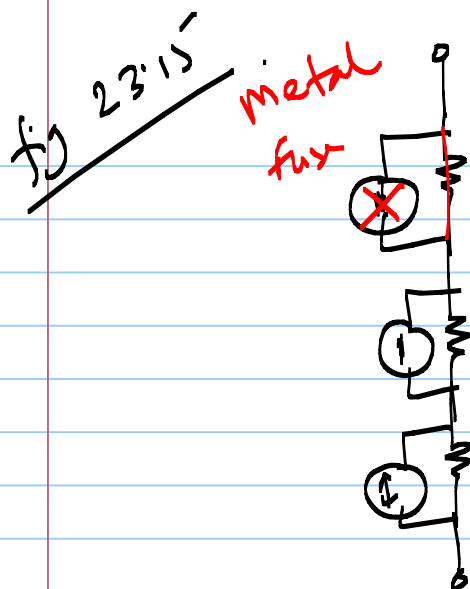
$f(V_{BE})$
 $\Rightarrow f(I_C)$

$K=8$

$$I_0 = 1 \mu A \Rightarrow L = \frac{17.2}{\ln(8)} = \underline{8.4834}$$

$$V_{ref} = \underline{V_{BE3}} + L \cdot V_T \ln(k) = \underline{1.25 \text{ V}}$$

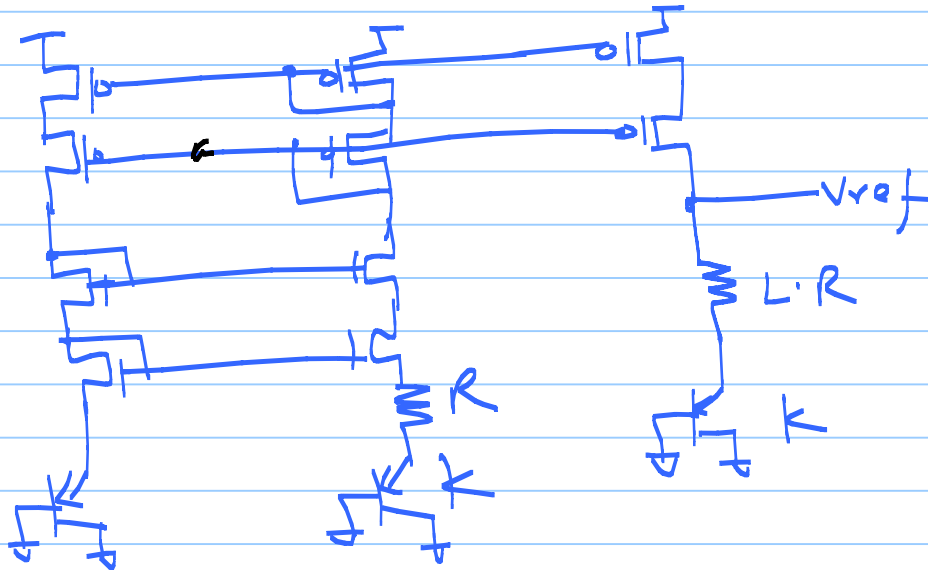




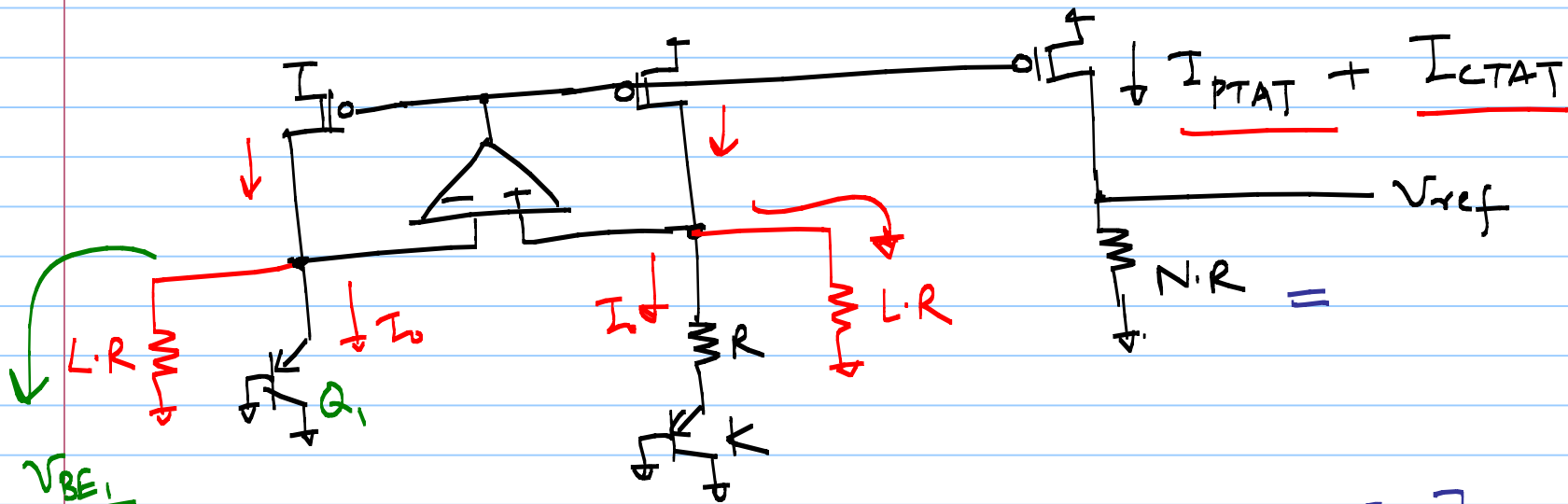
$R_{high} \leftarrow$ leakage

$R_{low} \longleftrightarrow$ Anti-fuse

- * Use Cascoding to improve matching
- * error amplifier in short-channel (regulated drain)



$$\underline{\underline{V_{ref}}} = \overset{L}{\alpha_2} V_T \ln(K) + \underset{\alpha_1 < 1}{\alpha_1} V_{BE} \quad \overset{\Delta}{=} \frac{E_g}{2} + (m+4) V_T$$



$$v_{ref} = (I_{PTAT} + I_{CTAT}) \cdot NR = \left[\frac{V_T \ln(K)}{R} + \frac{\sqrt{BE_1}}{L \cdot R} \right] NR$$

$$\Rightarrow V_{ref} = \underset{\alpha_2}{(N)} V_T \ln(K) + \underset{\alpha_1}{\left(\frac{N}{L}\right)} V_{BE1}$$

$$\frac{\partial V_{ref}}{\partial T} = 0 \Rightarrow L = \frac{1.5}{\ln(K) \cdot 0.085} \leftarrow \text{indep of 'N'}$$

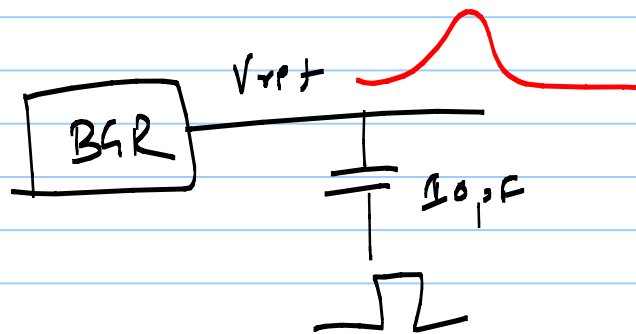
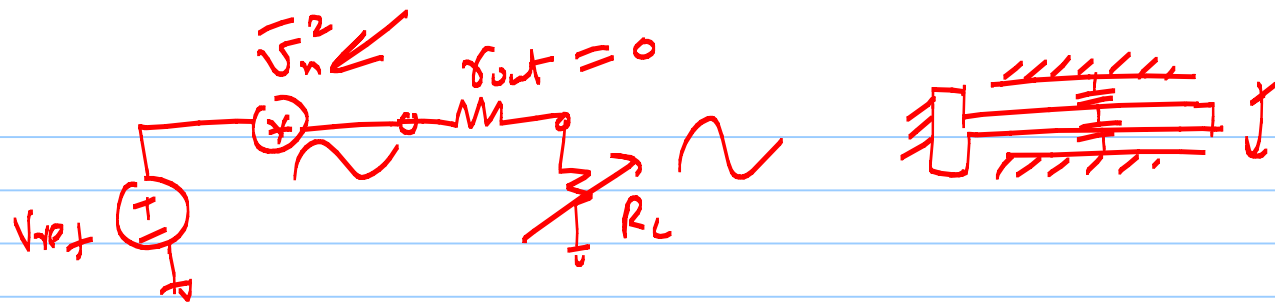
$$\begin{matrix} (L, K) \rightarrow TC = 0 \\ \swarrow \quad \searrow \\ 8.4834 \quad 8 \end{matrix}$$

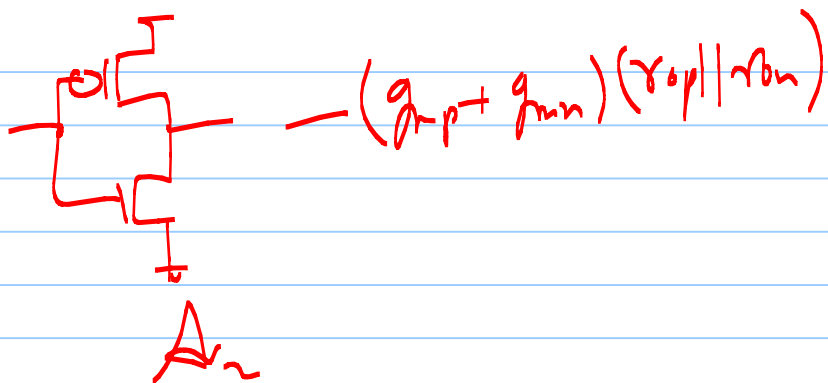
$$\underset{\substack{\uparrow \\ 0.5}}{V_{ref}} = V_T \ln(K) + \frac{N}{L} \underset{0.7}{V_{BE1}}$$

The circuit needs a minimum V_{DD} set by V_{BE} and V_{SG} .

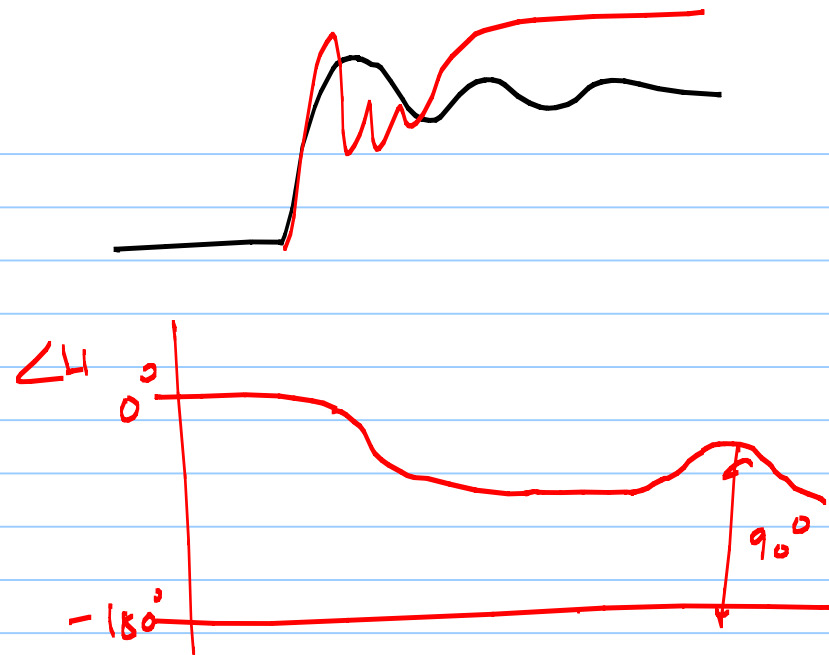
23.32

$$N = \frac{V_{ref}}{V_T \ln(k) + \frac{V_{BE1}}{L}} = 3.91$$

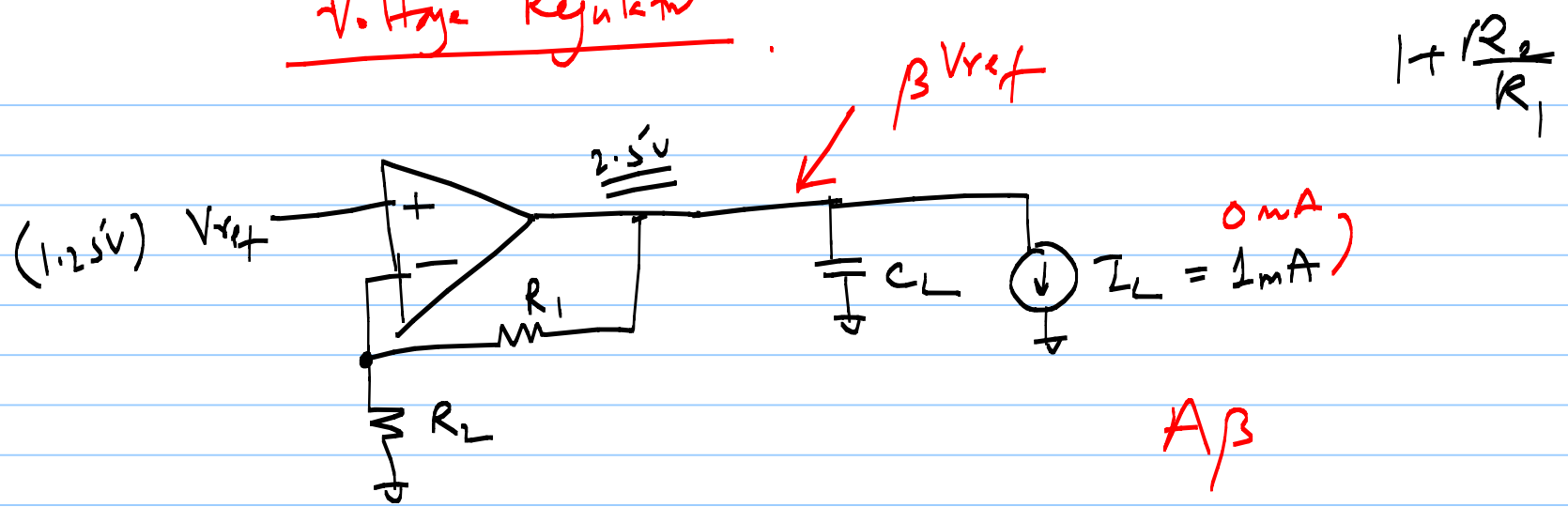


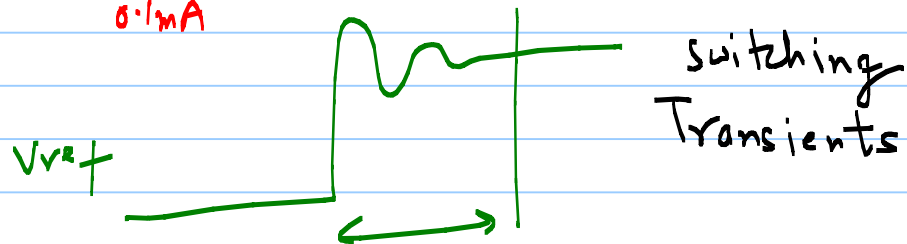
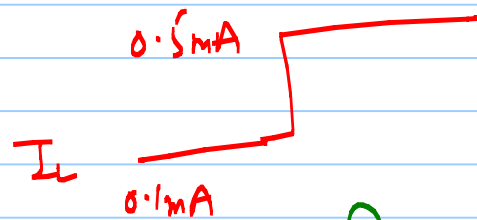
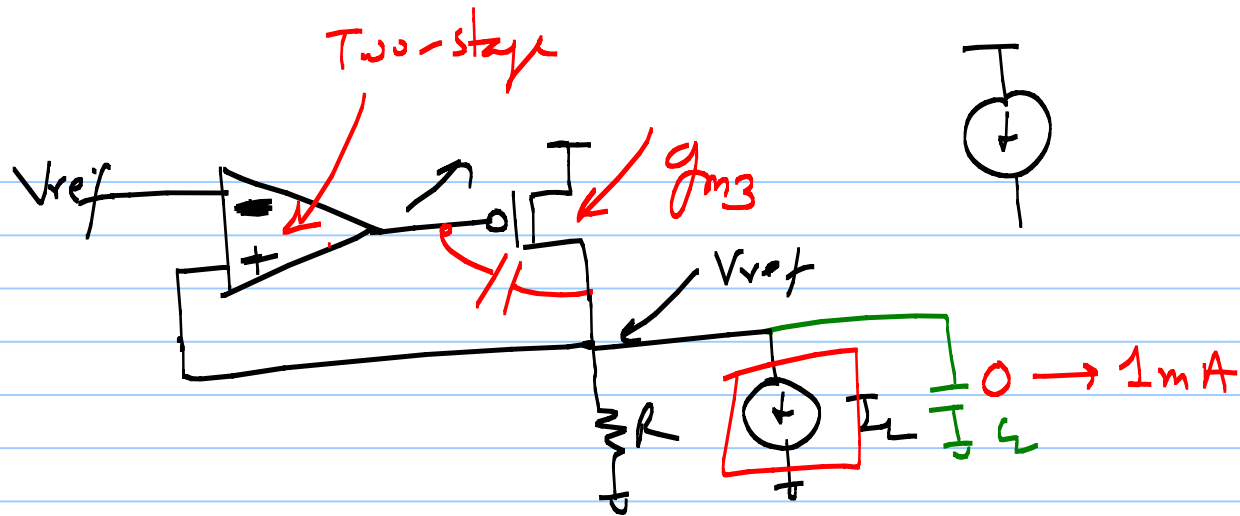


$$-(g_{mp} + g_{mn})(r_{op} || r_{on})$$



Voltage Regulator





Power Management
Circuits

