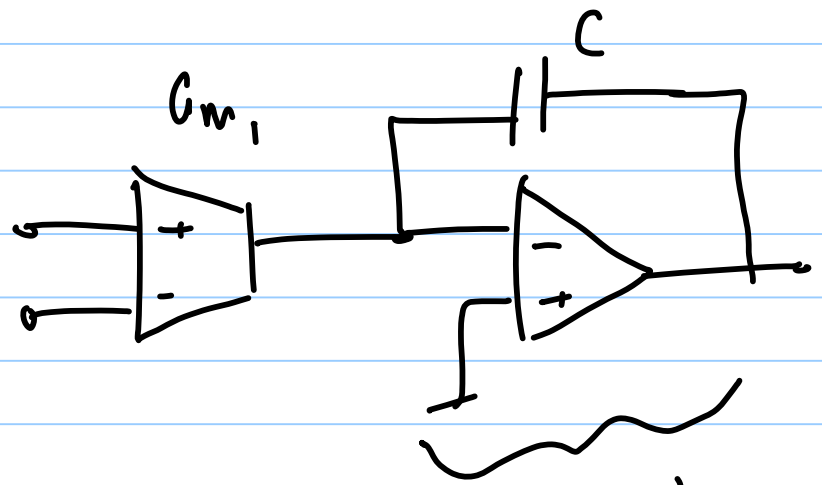
22/10/19

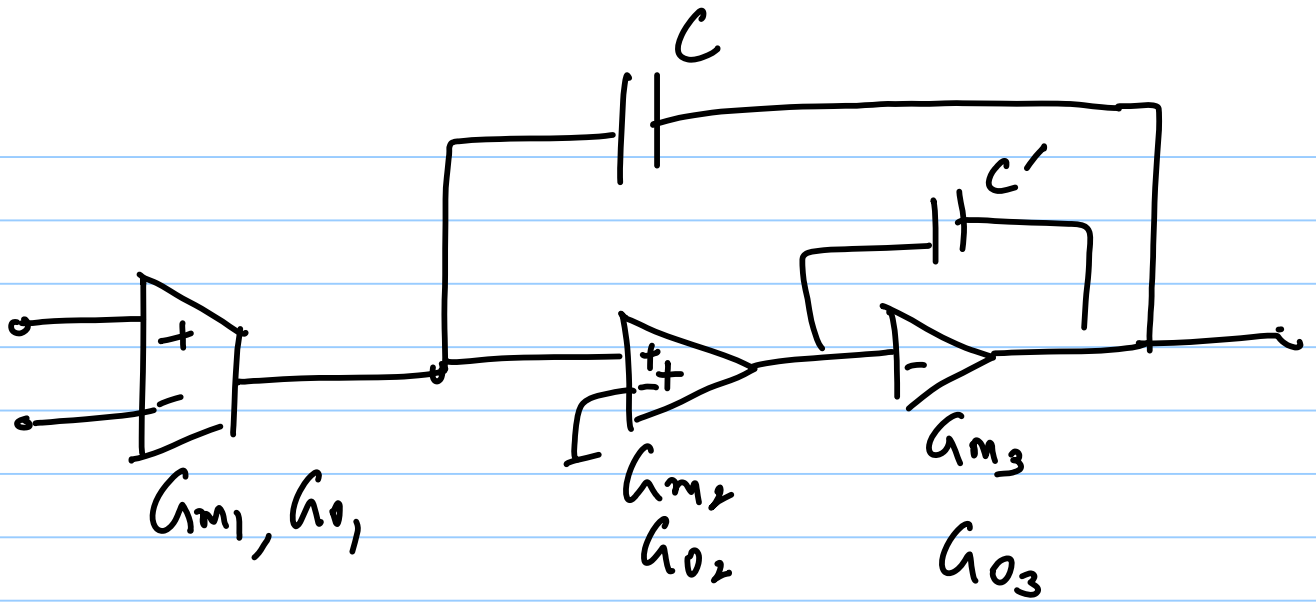
Lec 32.

3- stage opamp : $A_o = \dfrac{G_{m_1} G_{m_2} G_{m_3}}{G_{o_1} G_{o_2} G_{o_3}}$

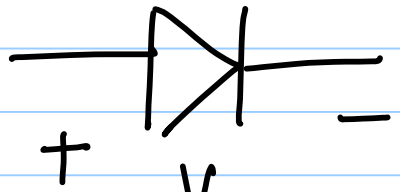


2-stage opamp

Nested Miller Compensation



Bandgap References

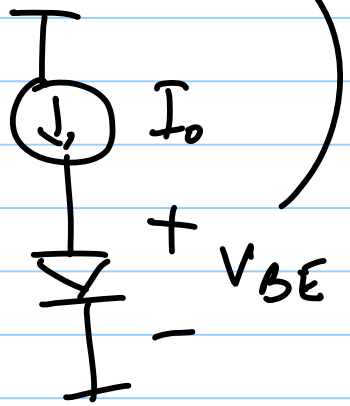


$V_{BE} \simeq 0.75\,V$

$$V_{BE} = V_T \ln\left(\frac{I_0}{I_s}\right)$$

V_T: $f(T)$; $\left(\frac{I_0}{I_s}\right)$: $f(T)$

$$\frac{\partial V_{BE}}{\partial T} \simeq -1.5\,mV/K \quad @\ RT$$

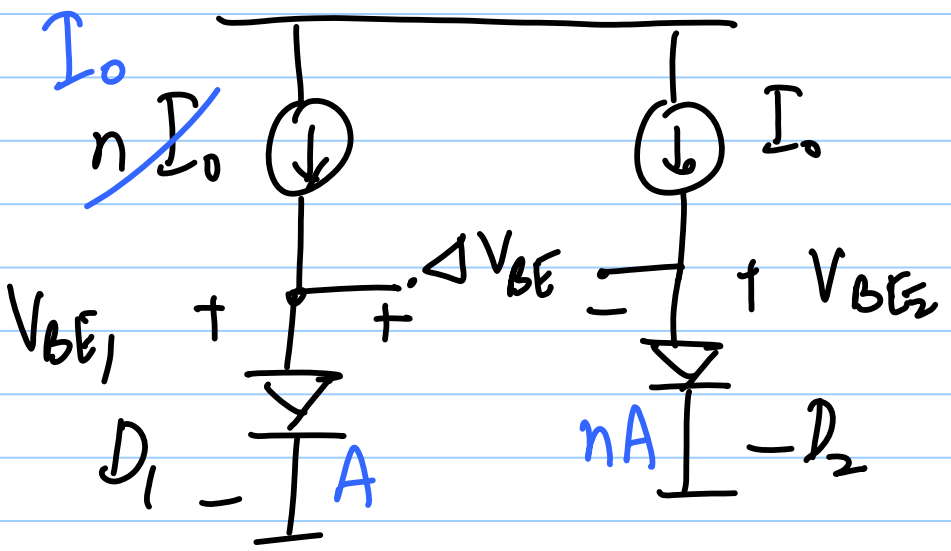


$$V_{ref} = \alpha_1 V_1 + \alpha_2 V_2$$

$\alpha_1 V_1$: $-ve$ T.C

$\alpha_2 V_2$: $+ve$ TC

$$\left.\frac{\partial V_{ref}}{\partial T}\right|_{RT} = 0$$



$$\Delta V_{BE} = V_{BE1} - V_{BE2}$$

$$= V_T \ln\left(\frac{nI_0}{I_S}\right) - V_T \ln\left(\frac{I_0}{I_S}\right)$$

$\equiv$

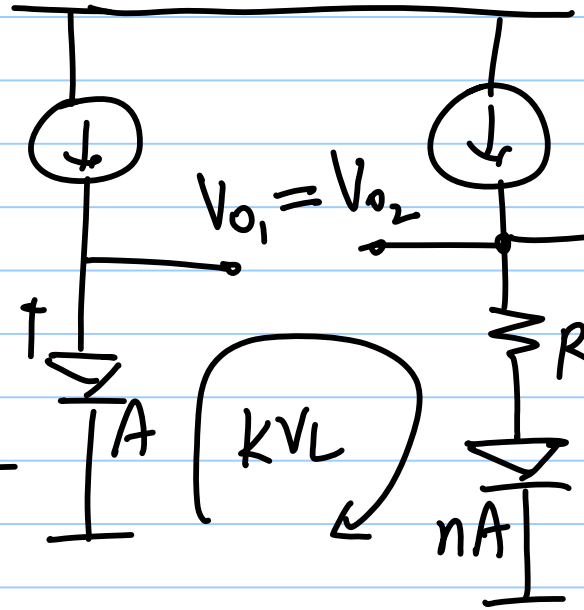
$$= V_T \ln(n)$$

$$= \frac{kT}{q} \ln(n) \quad \propto T$$

+ve T-c

"PTAT"

exact value of I_0 does not matter



Force $V_{O1} = V_{O2}$

$V_{O1} = V_{O2} = V_{BE_2} + V_R$

$+ V_R = \Delta V_{BE}$

$= V_{BE_2} + \Delta V_{BE}$

$V_{ref} = V_{O2} = V_{BE_2} + V_T \ln(n)$ ← Set $T.C. = 0$ @ R_T

$$\left.\frac{\partial V_{mf}}{\partial T}\right|_{300k} = 0 \Rightarrow$$ Calculate n

$$\ln(n) = 17.2$$