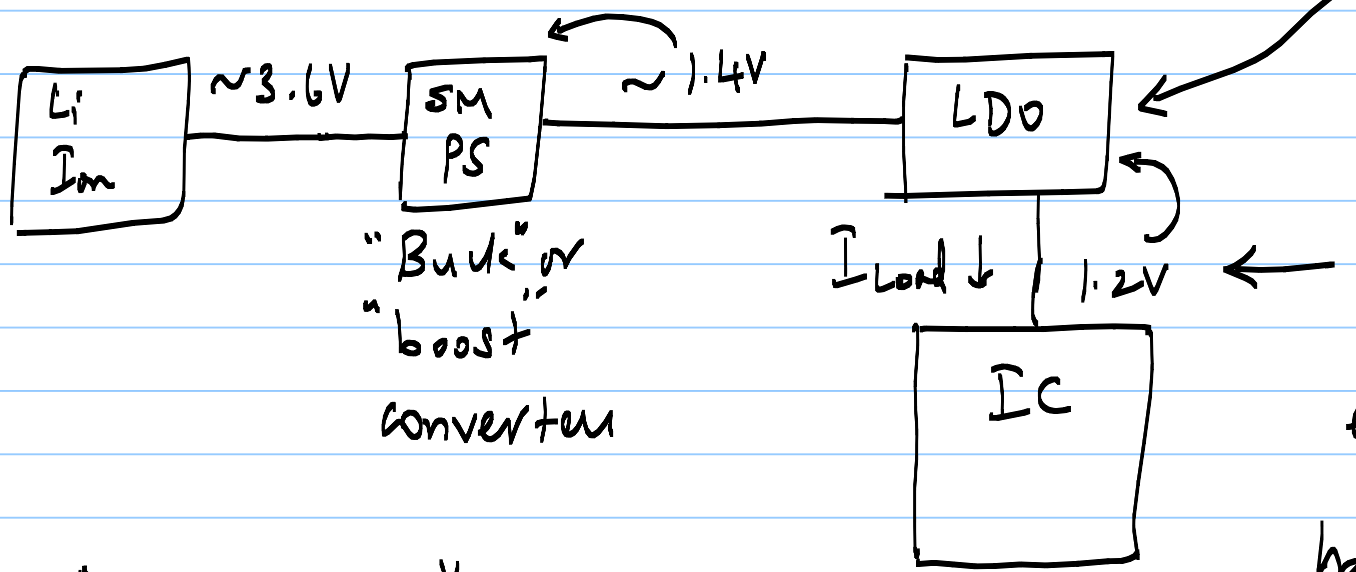
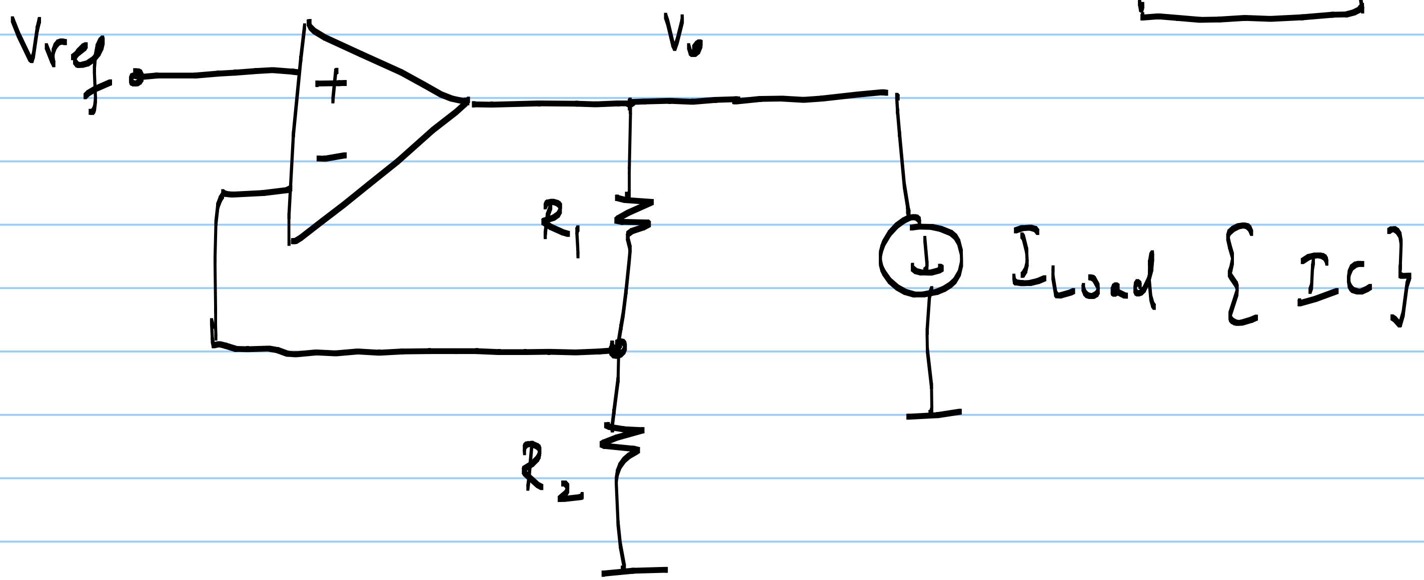
5/11/20

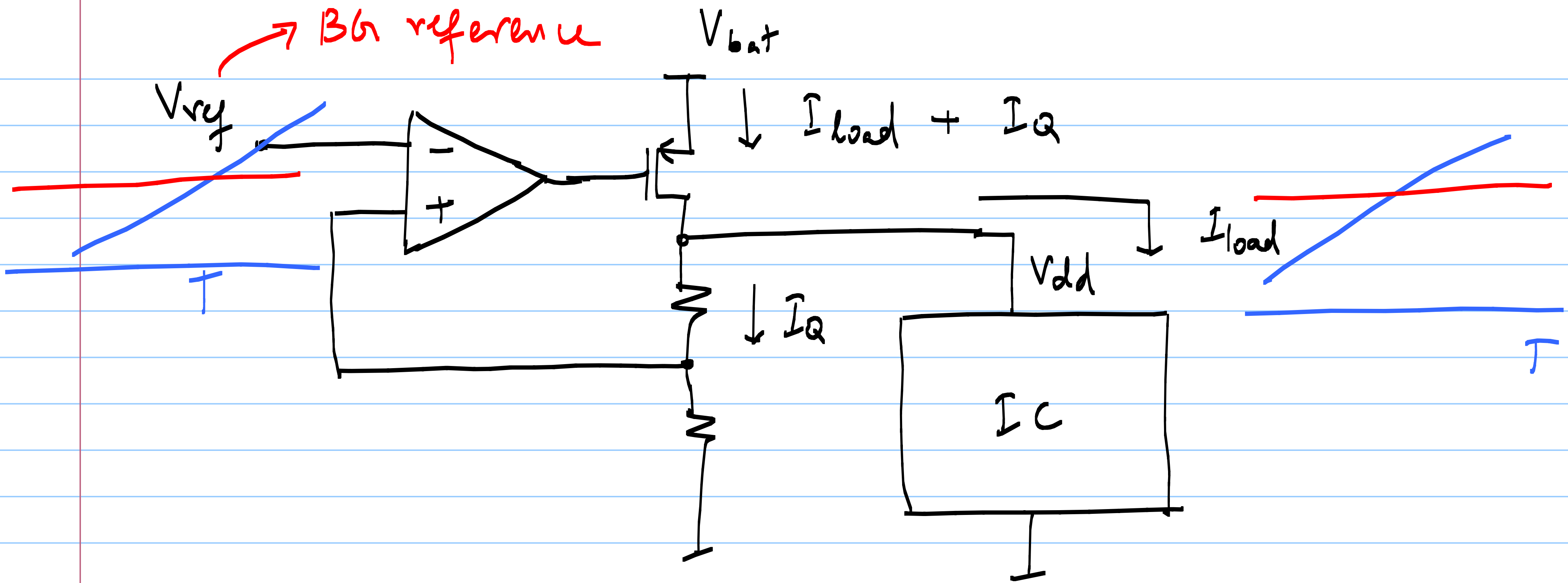
Lecture 50

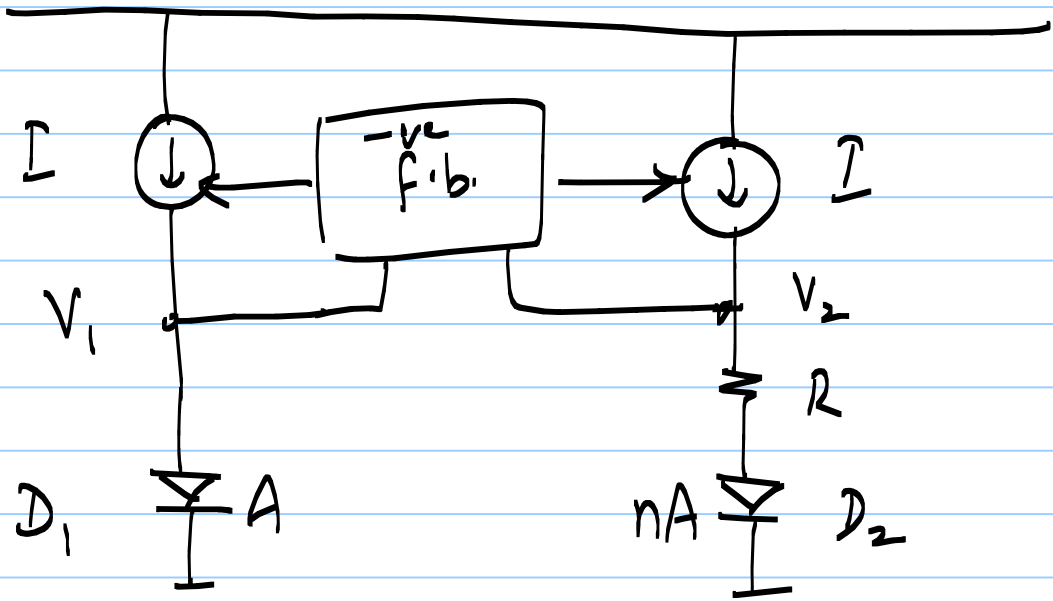
One application of BG reference — Low Dropout regulator



should be constant even if 3.6V battery voltage changes







$V_1 = V_2 = V_{ref} \sim 1.2V$

↳ $V_1 = V_{BE_1} \sim 1.2V$

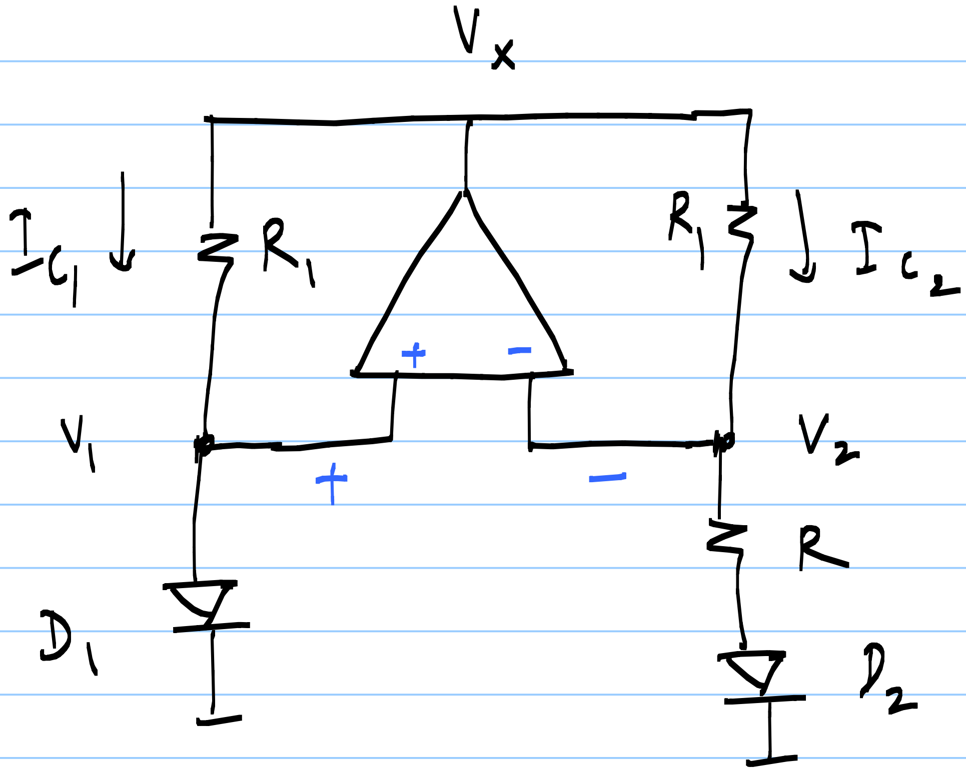
normally

$V_{BE_1} \sim 0.65V$

$$V_{BE_1} = V_t \ln\left(\frac{I_{C_1}}{I_{S_1}}\right) \approx \frac{0.65V}{0.026V} \approx 20.xx$$

$V_{BE_1} \to 0.65V$, $V_t \to 26mV$

I_{C_1} large, I_{S_1} small $\Big) - V_{BE} \sim 1.2V$

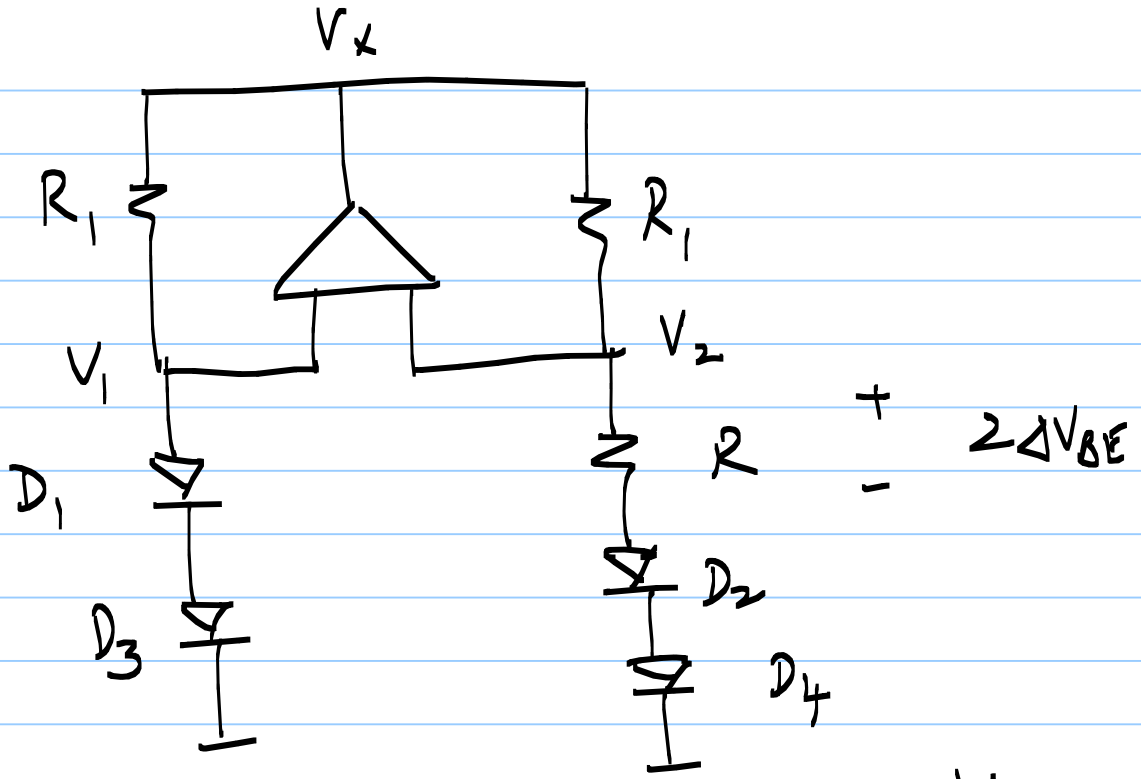


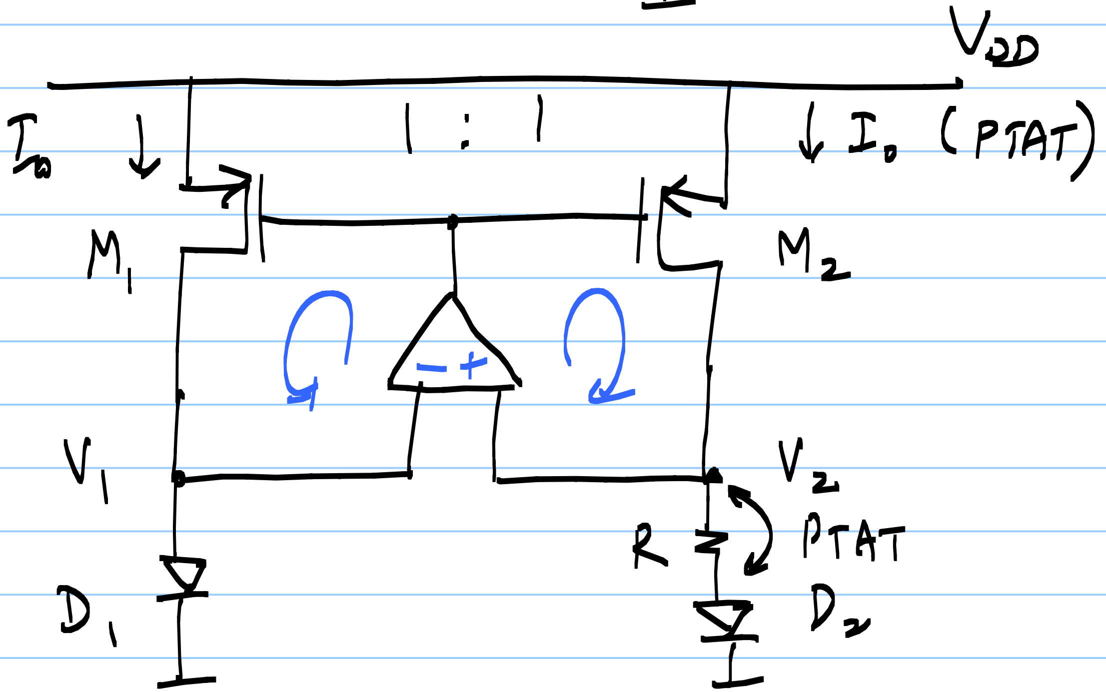
$$I_{C_1} = \frac{V_x - V_1}{R_1}$$

$$I_{C_2} = \frac{V_x - V_2}{R_1} = I_{C_1}$$

* choose signs of opamp so that strength of −ve f.b. > strength of +ve f.b.

HW



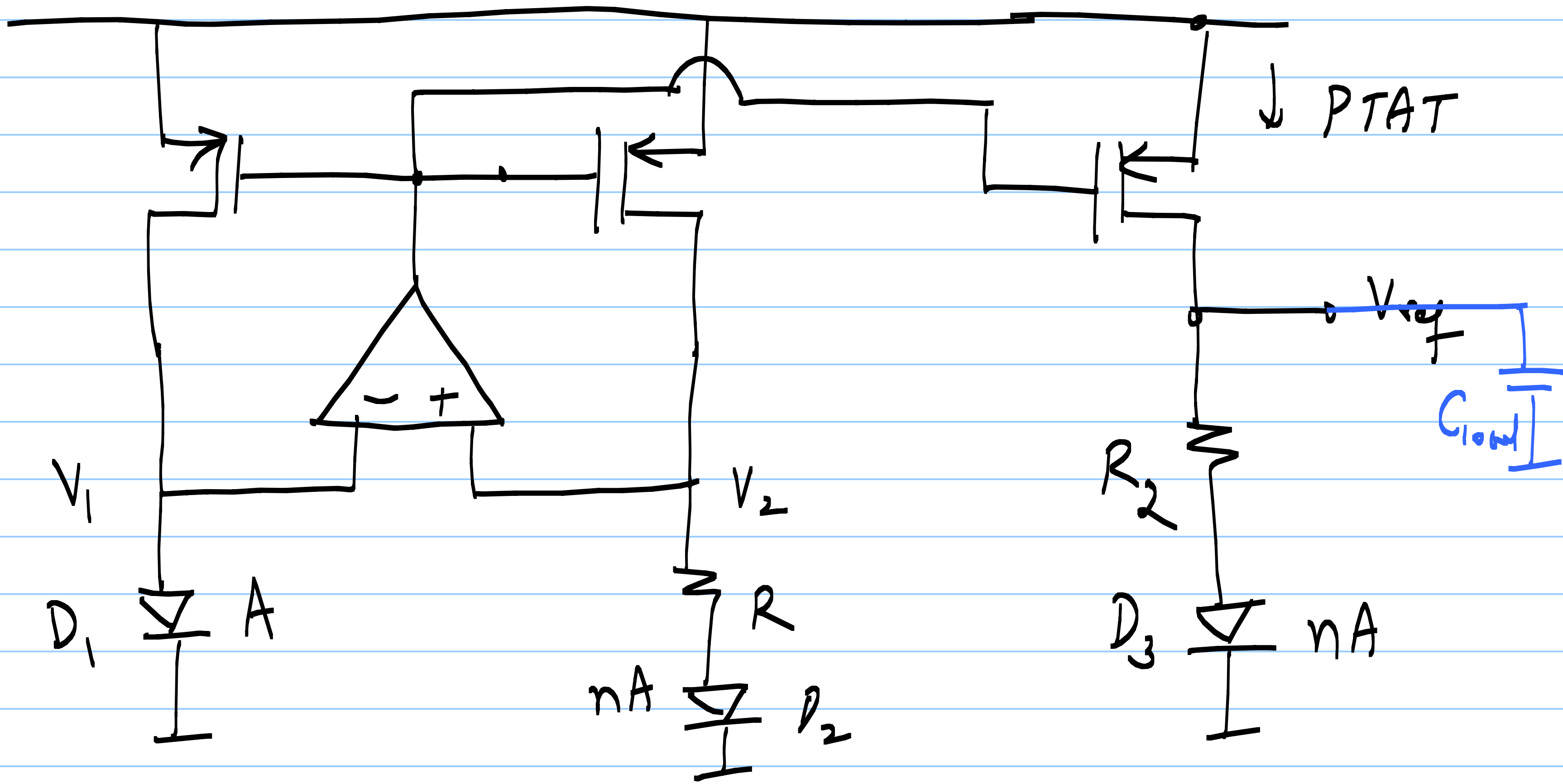


$M_1 \equiv M_2$

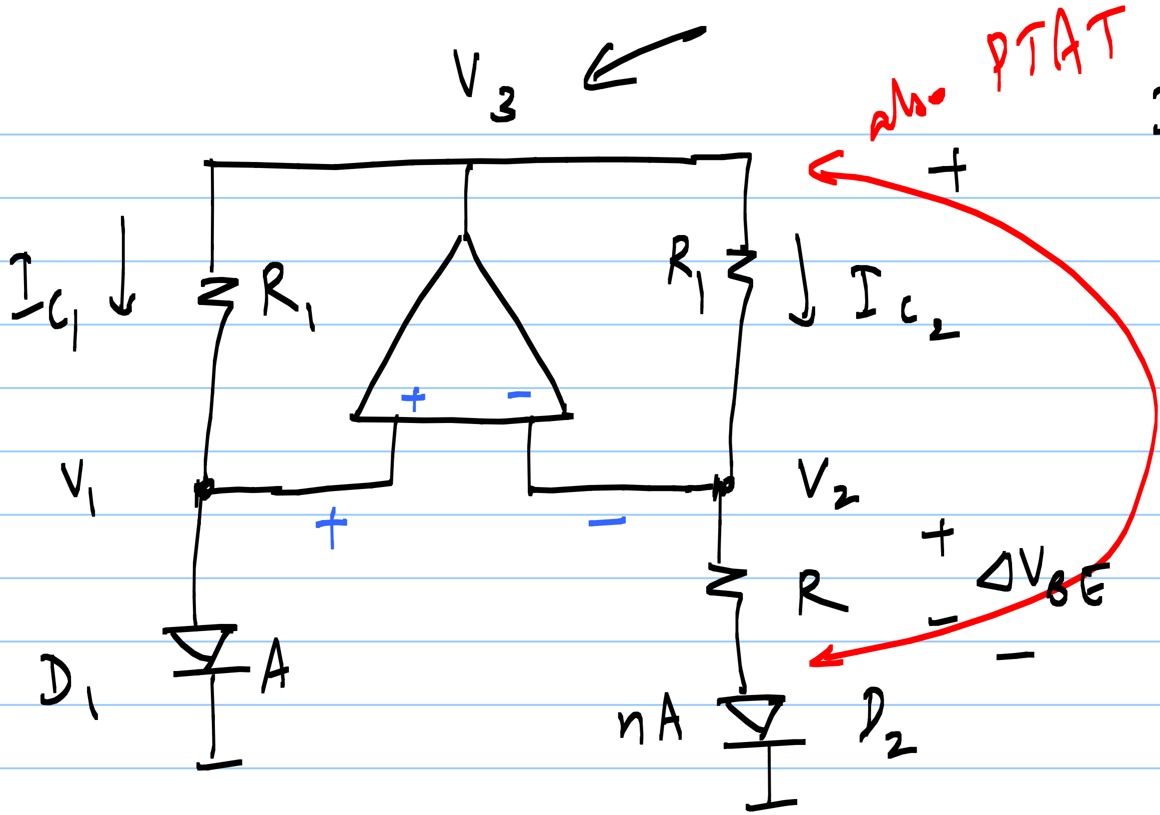
$V_{SG_1} = V_{SG_2}$

$V_{SD_1} = V_{SD_2}$

$I_{D_1} = I_{D_2} = I_o$



PTAT
Vref
Cload
V1
V2
R
R2
D1
A
nA
D2
D3
nA



$$I_{C_1} = I_{C_2} = \frac{V_t \ln(n)}{R}$$

$$V_3 = V_2 + I_{C_2} R_1$$

$$= \underbrace{V_{BE_2} + I_{C_2} R}_{} + I_{C_2} R_1$$

earlier: set this T.C. = 0

Now: Set T.C. of $V_3 = 0$ i.e. $\left.\frac{\partial V_3}{\partial T}\right|_{300K} = 0$

$$V_3 = V_{BE_2} + I_{C_2}(R + R_1)$$

$$= V_{BE_2} + \frac{V_t \ln(n)}{R}(R + R_1)$$

$$V_3 = V_{BE_2} + \left[V_t \ln(n)\right]\left[1 + \frac{R_1}{R}\right]$$

$$\left.\frac{\partial V_3}{\partial T}\right|_{300K} = 0 \Rightarrow \left[1 + \frac{R_1}{R}\right] \ln(n) = 17.2$$

- choose $\frac{R_1}{R}$ so that n is small
- $V_3 = V_{ref}$ {BG ref. voltage)
- V_{ref} depends on (R_1/R) — well controlled over "PVT" variations