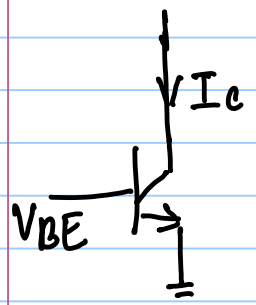
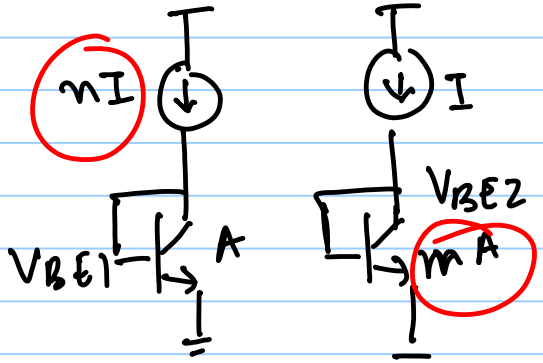
Lecture # 48

Note Title 25-04-2019



$$V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right)$$

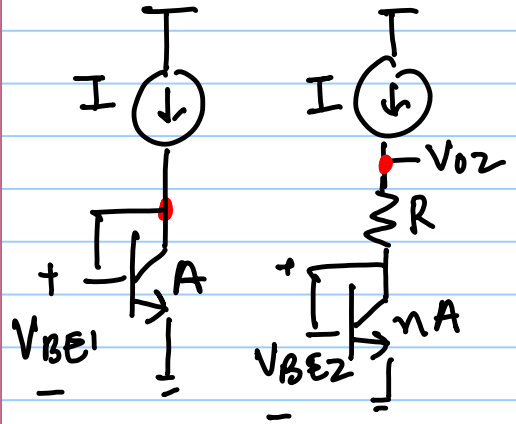
$$\frac{dV_{BE}}{dT} = -1.5\ \text{mV/K}$$



$$\Delta(V_{BE}) = V_T \ln(nm)$$

$$V_{REI} = \alpha_1 V_{BE} + \alpha_2 (\Delta V_{BE})$$

$$= 1 \cdot V_{BE} + \alpha_2 V_T \ln(nm)$$



$$V_{BE1} = V_{BE2} + I.R$$

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

$$= V_T \ln(n)$$

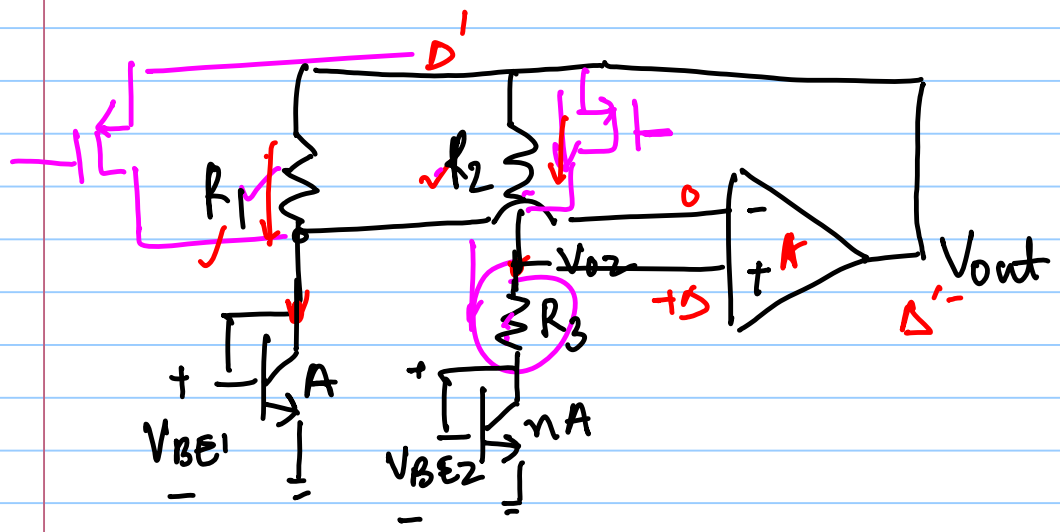
$$V_{O2} = V_{BE1} = V_{BE2} + (V_T \ln(n)) = 0.75 + 0.025 \times 17.2$$

$$V_{REF} = V_{O2} = V_{BE1} =$$

$$\frac{dV_{BE2}}{dT} < 0 \qquad \frac{dV_T}{dT} > 0$$

$$\frac{dV_{BE1}}{dT} = 0 \Rightarrow \ln(n) = 17.2$$

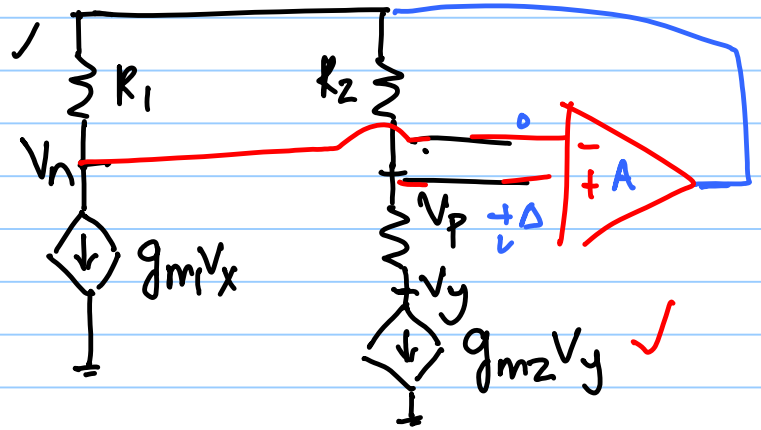
$$-1.5\,mV/K + 17.2 \times 0.087 = 0$$



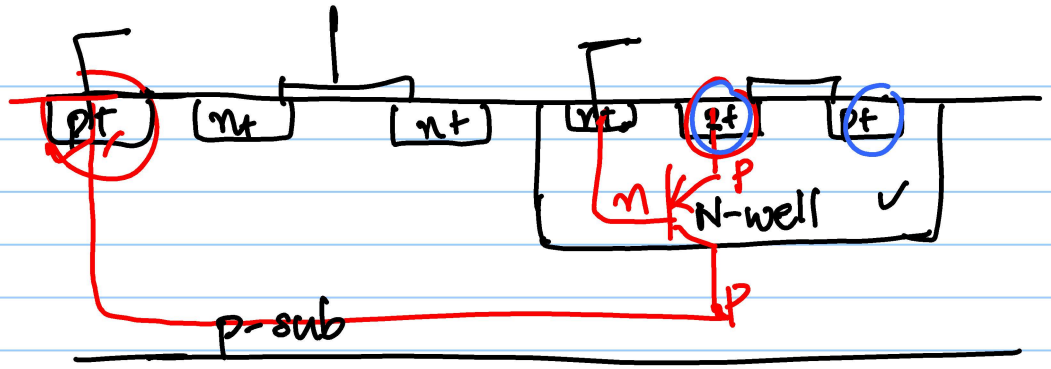
$$V_{out} = V_{BE2} + I(R_2+R_3)$$

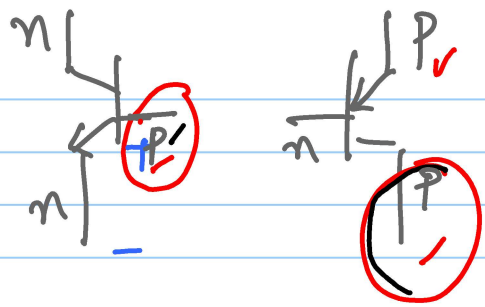
$$= V_{BE2} + \frac{V_T \ln(n)}{R_3}(R_2+R_3)$$

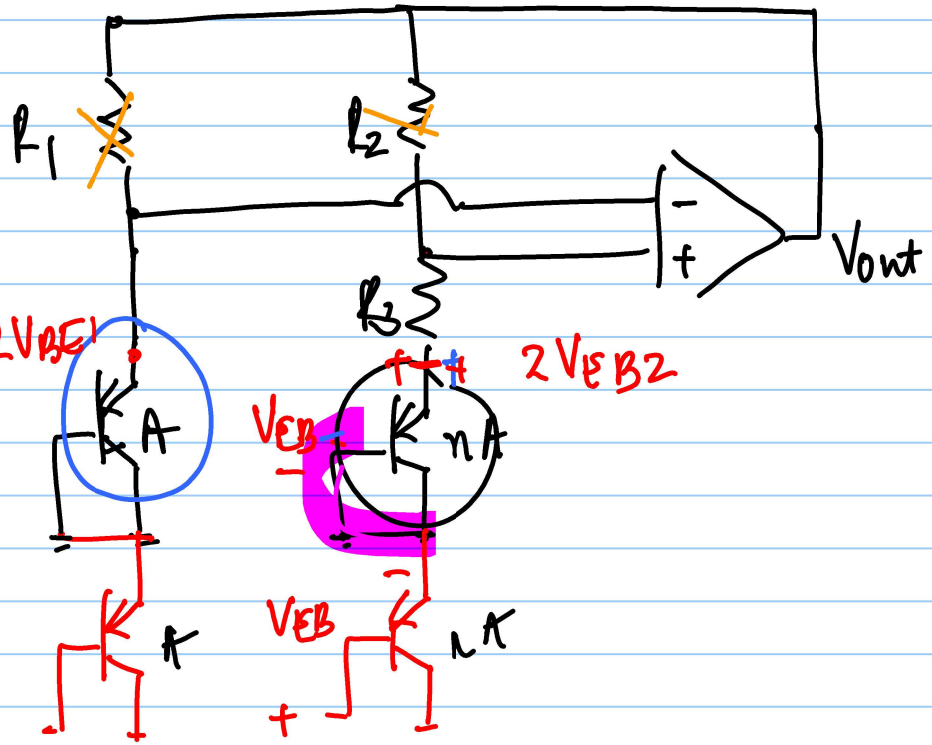
$$= V_{BE2} + V_T\left(1+\frac{R_2}{R_3}\right)\ln(n)$$



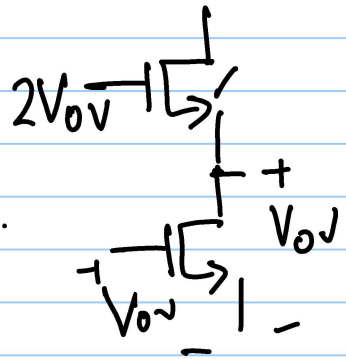
$V_p - V_n = +\Delta \longrightarrow$







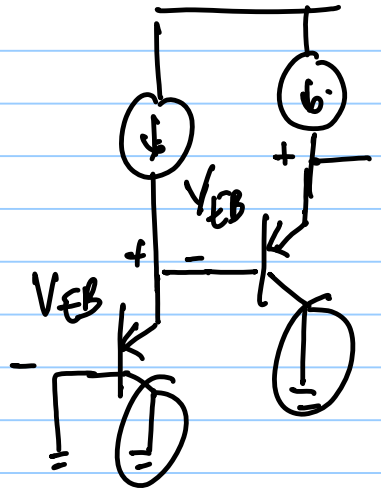
$$2\times\left[V_{EB}+V_T\ln(n)\left(1+\frac{R_2}{R_3}\right)\right]$$

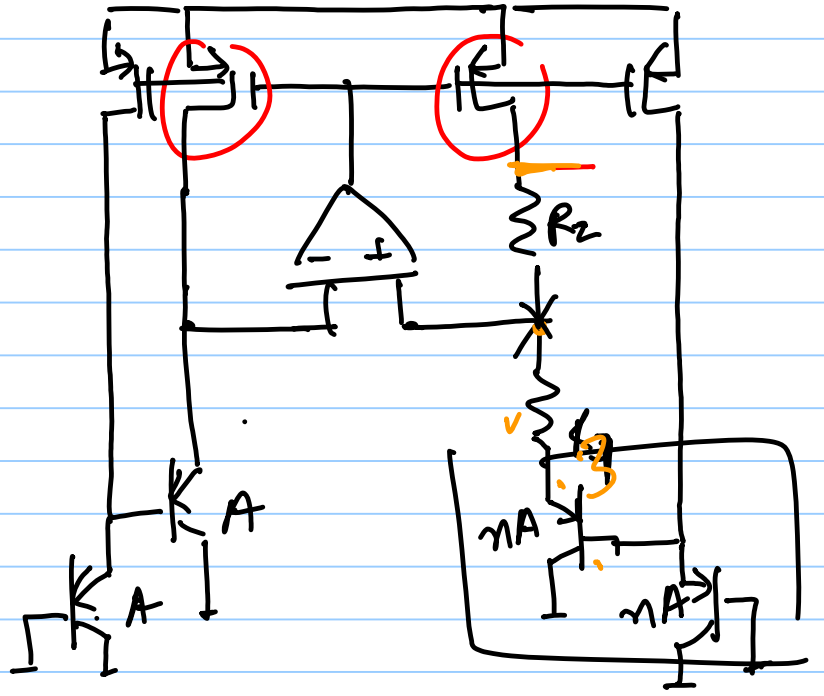


$$2V_{EB1} = 2V_{EB2} + I \cdot R_3$$

$$I = \frac{2(V_{EB1} - V_{EB2})}{R_3} = \frac{2\,V_T \ln(n)}{R_3}$$

$$V_{out} = 2V_{EB2} + \frac{2\,V_T \ln(n)}{R_3}\,(R_2 + R_3)$$





PTAT Current Source

$$2V_{BE2} + \frac{V_T \ln(n)}{R_3} \times (R_3 + R_2)$$