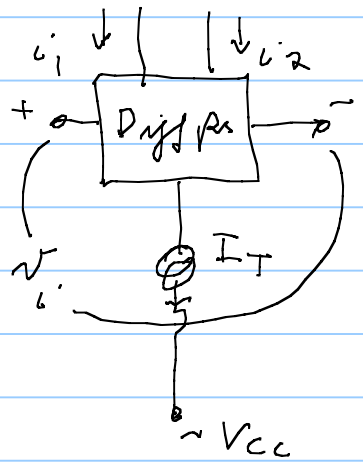
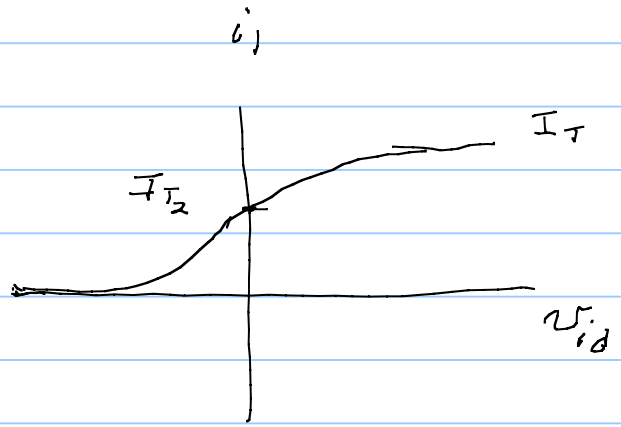
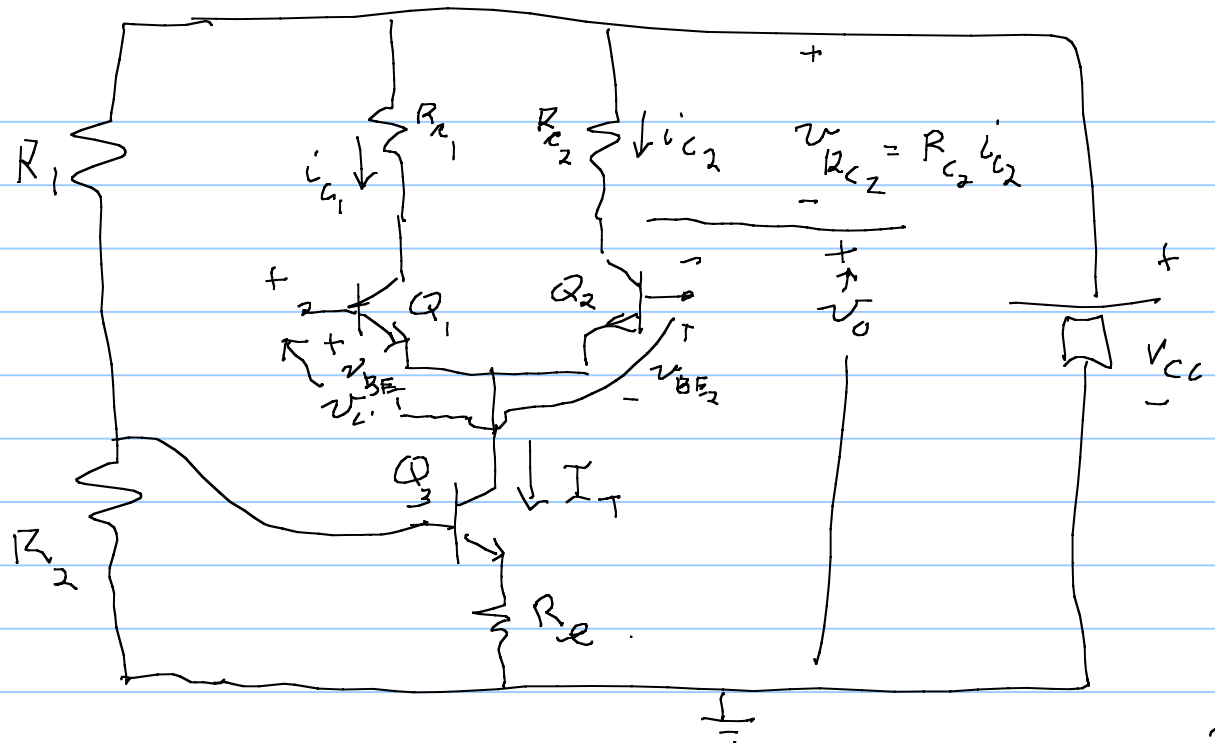
EE 307

03/30/16

Note Title 3/30/2016







$$v_i = v_{BE_1} - v_{BE_2}$$

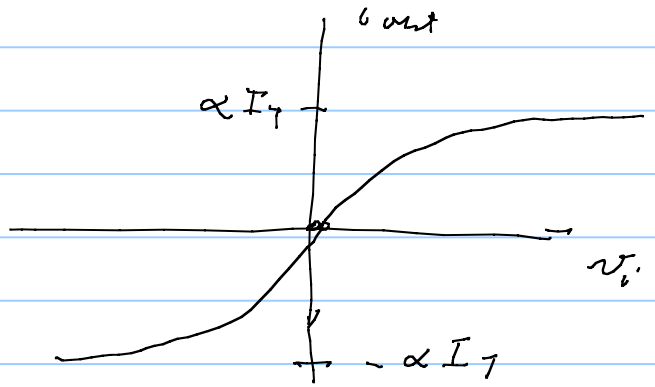
$$I_T = (-i_{E_1}) + (-i_{E_2}) \quad \text{by KCL}$$

$$= \frac{i_{C_1}}{\alpha} + \frac{i_{C_2}}{\alpha} \simeq \frac{I_S e^{v_{BE_1}/V_T}}{\alpha} + \frac{I_S e^{v_{BE_2}/V_T}}{\alpha} = \frac{I_S}{\alpha} e^{v_{BE_2}/V_T} \left(e^{v_i/V_T} + 1 \right)$$

$$i_{C_1} - i_{C_2} \simeq i_{out} \simeq I_S e^{v_{BE_1}/V_T} - I_S e^{v_{BE_2}/V_T} = I_S \cdot e^{v_{BE_2}/V_T} \left(e^{v_i/V_T} - 1 \right)$$

$$i_{out} = I_S e^{v_{BE_2}/V_T}\left(e^{v_i/V_T} - 1\right) = \frac{\alpha I_T}{e^{v_i/V_T}+1} \times \left(e^{v_i/V_T} - 1\right)$$

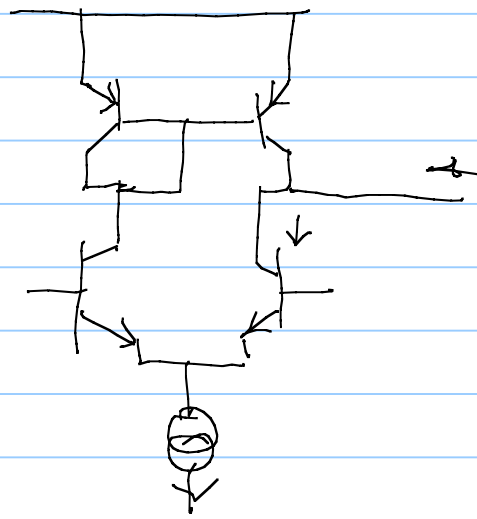
$$= \alpha I_T \left(\frac{e^{v_i/2V_T}}{e^{v_i/2V_T}}\right)\left(\frac{e^{v_i/2V_T} - e^{-v_i/2V_T}}{e^{v_i/2V_T} + e^{-v_i/2V_T}}\right) = \alpha I_T \cdot \tanh\left(\frac{v_i}{2V_T}\right)$$



if output is a current difference

$$g_m = \left.\frac{d\, i_{out}}{d\, v_i}\right|_{v_i=0} = \left.\alpha I_T \cdot \frac{1}{2V_T}\left(1 - \tanh^2\left(\frac{v_i}{2V_T}\right)\right)\right|_{v_i=0}$$

$$\simeq \alpha \cdot \frac{I_T}{2V_T}$$



$i_{C_2} - i_{C_1} = -i_{out}$

v_{out} on R_{C_2} $\Rightarrow$ $v_0 = V_{CC} - R_{C_2} \cdot i_{C_2}$

$$i_{C_2} = I_S e^{v_{BE_2}/V_T} = \alpha I_T \times \frac{1}{e^{v_i/V_T} + 1}$$

$$v_0 = V_{CC} - R_{C_2} \cdot \alpha I_T \times \frac{1}{e^{v_i/V_T} + 1}$$

$$A_v = \frac{dv_o}{dv_i}\bigg|_{v_i=0} = -R_{C_2} \cdot \alpha I_T \cdot \frac{-1}{(e^{v_i/V_T}+1)^2} \times \frac{1}{V_T} e^{v_i/V_T}\bigg|_{v_i=0}$$

$$= \frac{\alpha R_{C_2}}{2} \frac{I_T}{V_T} \times \frac{1}{2} \times 1 = \frac{\alpha R_{C_2}}{2} \cdot \frac{I_T}{2V_T} = R_{C_2} \cdot \frac{g_m}{2}$$

$$= \frac{v_o}{v_1 - v_2}$$

for feedback structure $v_2 = v_o \times \frac{R_{f1}}{R_{f1} + R_{f2}}$

$$A_v \cdot \left(v_i - \frac{v_o R_{f1}}{R_{f1} + R_{f2}}\right) = v_o \quad \approx \quad \frac{v_o}{v_i} \approx 1 + \frac{R_{f1}}{R_{f2}}$$