EE 303
02/28/07

$$i_{out} = \pm v_{iD} \cdot \sqrt{I_T \left(\frac{W}{L}\right) KP - \frac{1}{4}\left(\frac{W}{L} KP\right) v_{iD}^2}$$

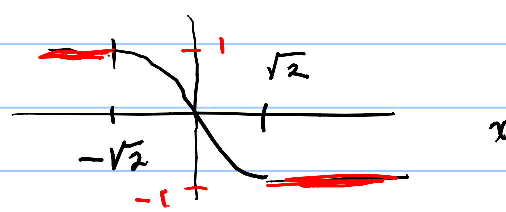
$$\Rightarrow \frac{i_{out}}{I_T} = - v_{iD} \left(\frac{W}{L}\frac{KP}{I_T}\right)^{1/2} \sqrt{1 - \frac{1}{4}\left(\left(\frac{W}{L}\frac{KP}{I_T}\right)^{1/2} v_{iD}\right)^2} \quad ; \quad x = \left(\frac{W}{L}\frac{KP}{I_T}\right)^{1/2} v_{iD}$$

$$i = -x\sqrt{1-\frac{1}{4}x^2} \qquad i = i_{out}/I_T$$

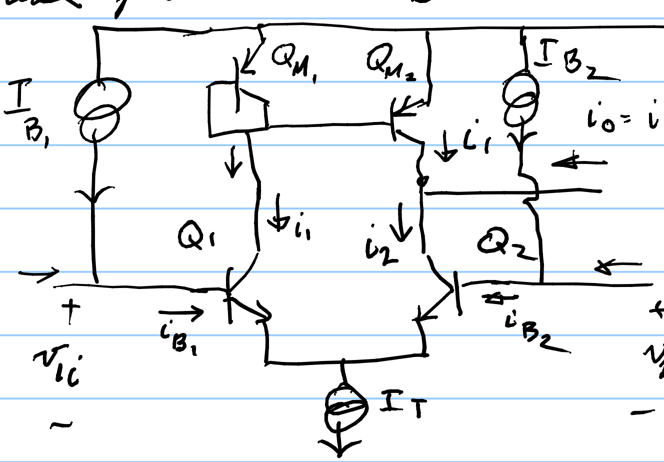
what x gives $i = 1$; $\frac{1}{-x} = \sqrt{1-(x/2)^2} \Rightarrow \frac{1}{x^2} = 1 - \left(\frac{x^2}{4}\right)$

$$1 - x^2 + (x^2)^2/4 = 0 \Rightarrow z = x^2 \Rightarrow z^2 - 4z + 4 = 0$$

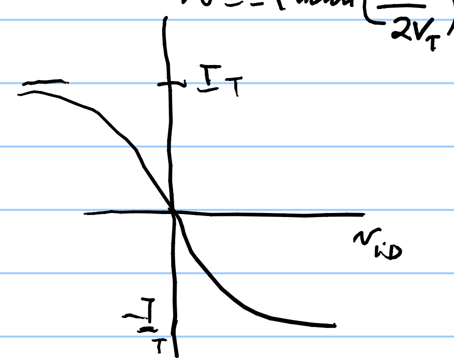
$$z = \frac{4}{2} \pm \frac{1}{2}\sqrt{16 - 4\times 4} = 2, \quad x = \pm\sqrt{2}$$



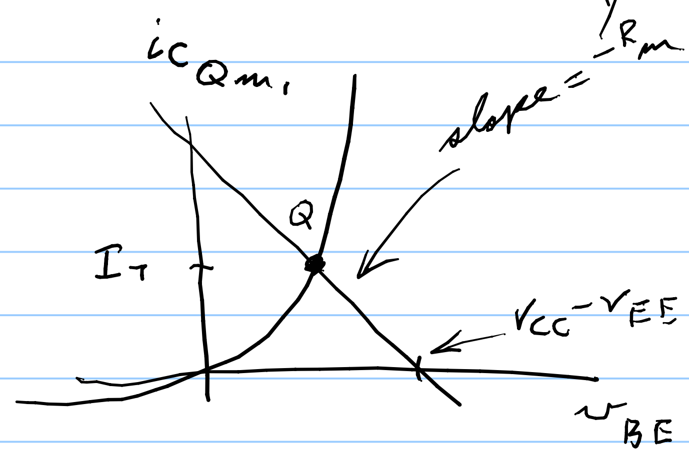
differential pair with BJT



$$i_o = I_T \tanh\left(\frac{v_{iD}}{2V_T}\right)$$



to make I_T



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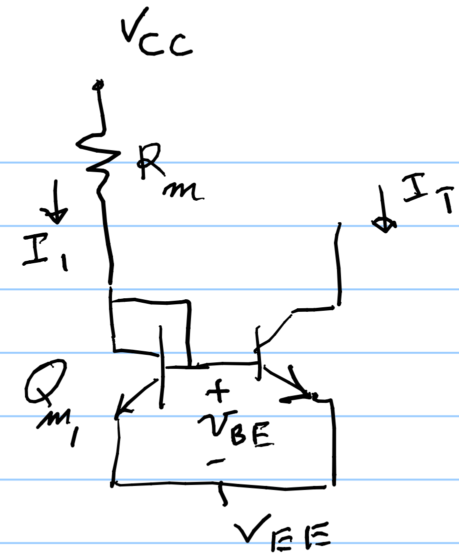
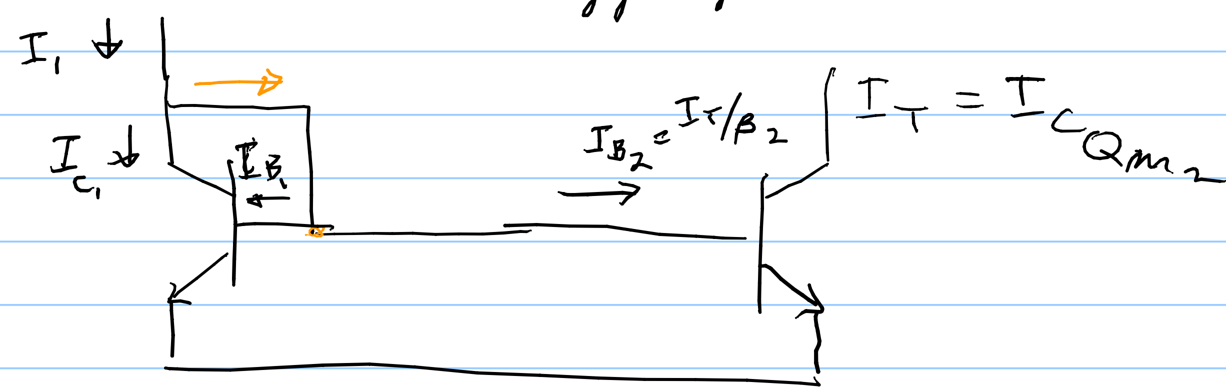


ignored base current   bigger picture uses base current



$I_T = I_{C_{Qm_2}}$

KCL: $I_1 = I_{C_1} + (I_{B_1} + I_{B_2}) = I_{C_1} + \frac{I_{C_1}}{\beta_1} + \frac{I_T}{\beta_2}$

$$= \left(\frac{\beta_1 + 1}{\beta_1}\right) I_{C_1} + \frac{I_T}{\beta_2}$$

By the same voltage, v_{BE}, on both transistors $I_{C_1} = I_T$ if the transistors are equal.

$$\therefore \quad I_1 = \left(\frac{\beta_1 + 1}{\beta_1} + \frac{1}{\beta_2}\right) I_T = \left(\frac{1}{\alpha_1} + \frac{1 - \alpha_2}{\alpha_2}\right) I_T = \left(\frac{\alpha_1 + \alpha_2 - \alpha_1 \alpha_2}{\alpha_1 \alpha_2}\right) I_T$$

$$= \left(\frac{2}{\alpha} - 1\right) I_T \quad \text{if } \alpha_1 = \alpha_2$$