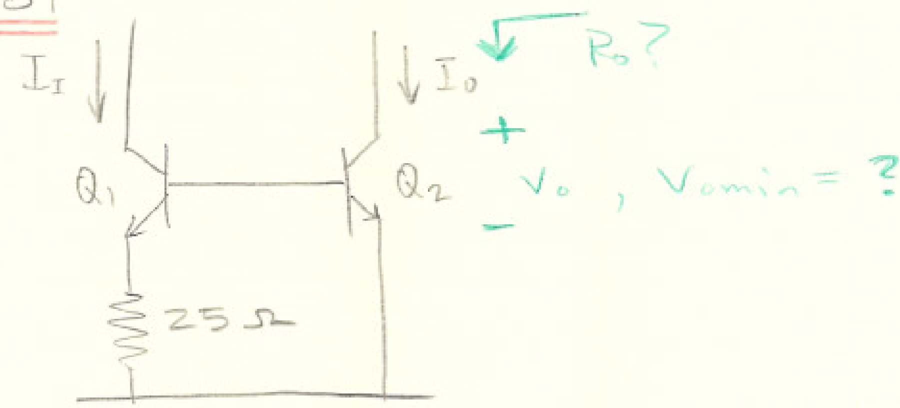
P8.89



$I_I = 700\ \mu A$

$\beta = 100$

$V_A = 75\ V$

$Q_1 = Q_2$

$$V_{BE2} \cong V_{BE1} + I_I R_E$$

$$I_{C2} \cong I_S \exp\left(\frac{V_{BE2}}{V_T}\right)$$

$$I_{C2} = I_o = I_S \exp\left(\frac{V_{BE1} + I_I R_E}{V_T}\right)$$

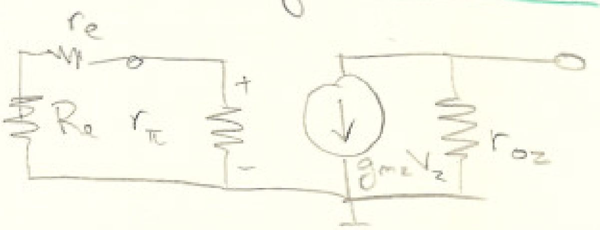
$$= \underbrace{I_S \exp\left(\frac{V_{BE1}}{V_T}\right)}_{I_{C2}} \exp\left(\frac{I_I R_E}{V_T}\right)$$

$$I_o \cong I_I \exp\left(\frac{I_E R_E}{V_T}\right)$$

$\therefore I_o = 1.37\text{mA}$

as assumed $I_o > I_I$

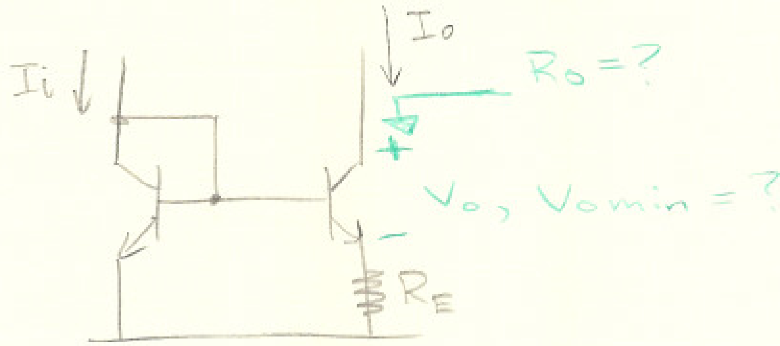
Small signal model



$$\therefore R_o = r_{o2} = \frac{V_A}{I_C} = 54.7\ k\Omega$$

$$V_{omin} = V_{CE2sat} \cong 0.3\ V$$

P8.90 Widlar Current Source



$Q_1 = Q_2$

$\beta = 100$

$V_A = 75\ V$

$I_i = 700\ \mu A$

$$V_{BE1} \cong V_{BE2} + I_o R_E.$$

$$I_I = I_S \exp\left(\frac{V_{BE1}}{V_T}\right)$$

$$I_I = \underbrace{I_S \exp\left(\frac{V_{BE2}}{V_T}\right)}_{I_o} \exp\left(\frac{I_o R_E}{V_T}\right)$$

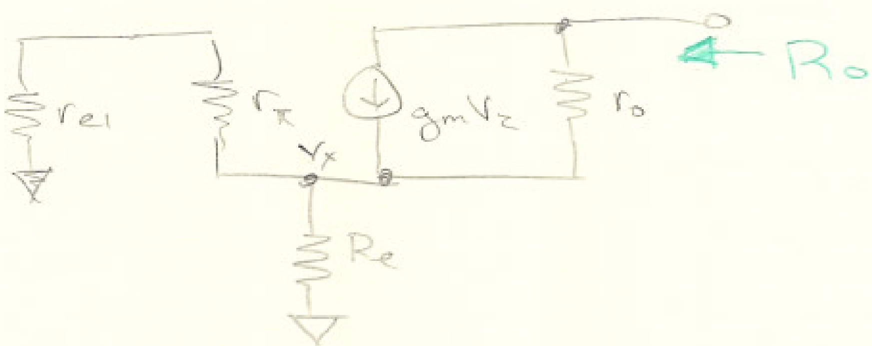
$$I_o = \exp\left(\frac{-V_{BE2}}{V_T}\right)$$

$\therefore I_o = 94.7\ \mu A$

$I_o < I_I$

$$\therefore \; I_o = \frac{V_T}{R_e} \ln\left(\frac{I_I}{I_o}\right)$$

note: hence, if there is variations in the the input current, these variations will be compressed by the log function.



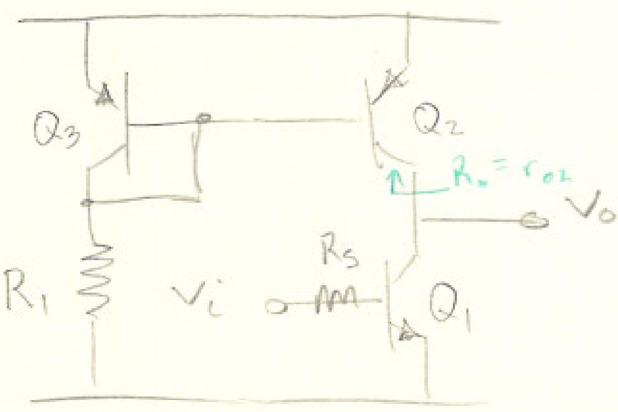
$$V_x = i_{test} \left(R_e \,//\, (r_{e1} + r_\pi) \right) \approx i_{test} R_e$$

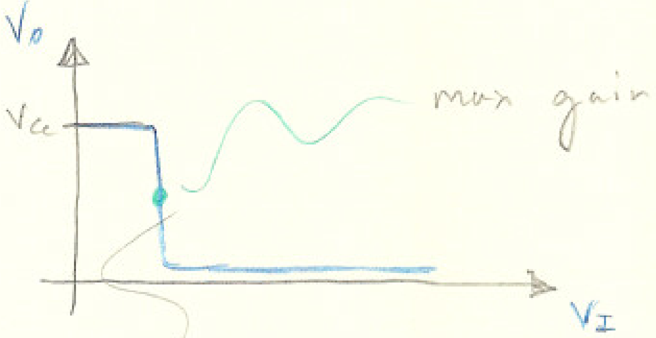
$$i_{test} = g_{m2} V_2 + \frac{V_{Test} - V_x}{r_{o2}}$$

$$V_2 = -V_x \frac{r_{\pi 2}}{r_{\pi 2} + r_{e1}} \approx -V_x$$

$$i_{test} = g_{m2}(-V_x) + \frac{V_{Test}}{r_{o2}} - \frac{V_x}{r_{o2}}$$

Active load

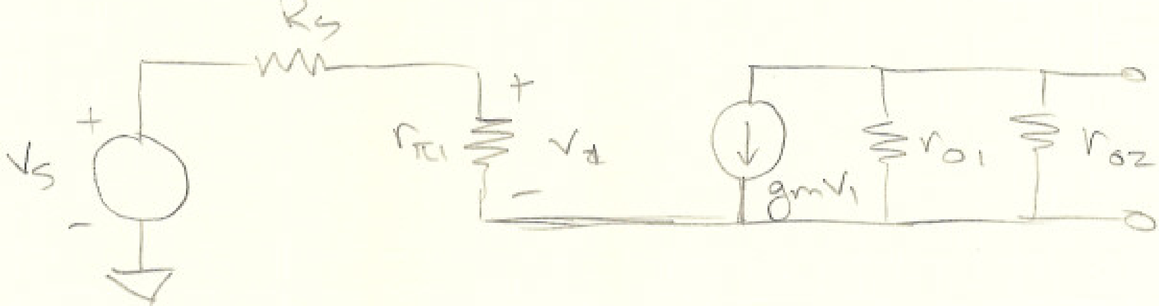




$$\frac{\partial V_o}{\partial V_i} \Big\} \text{ small sig gain.}$$

Assume V_I keeps Q_1 with $I_{C1} = I_I$ and

$$V_{CE1} = \frac{V_{cc}}{2}$$



$$\frac{V_o}{V_1} = -g_m \left(r_{o1} \,\|\, r_{o2} \right)$$

$$a_v = \frac{V_o}{V_S} = \frac{r_\pi}{R_s + r_\pi} \left(-g_m \left(r_{o1} \,\|\, r_{o2} \right) \right)$$