Note Title

EE 303 02/09/11

changes on last page

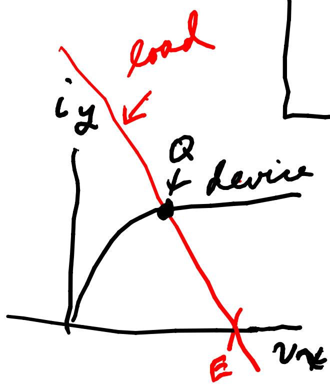
2/9/2011

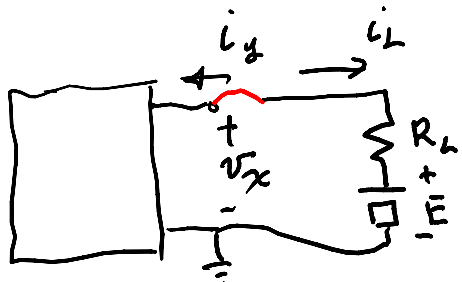
Biasing: p. 390

Π equivalent circuit, p. 410

2-ports appendix C

Load line

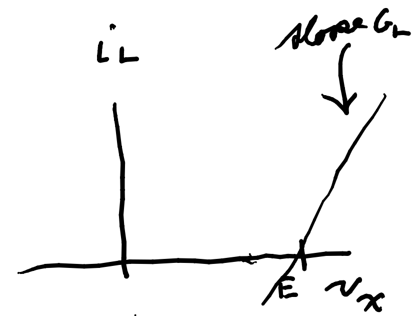




KCL: $0 = -i_y - i_L$

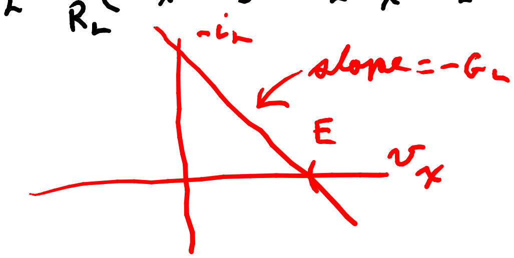
$i_L = -i_y$

when connect

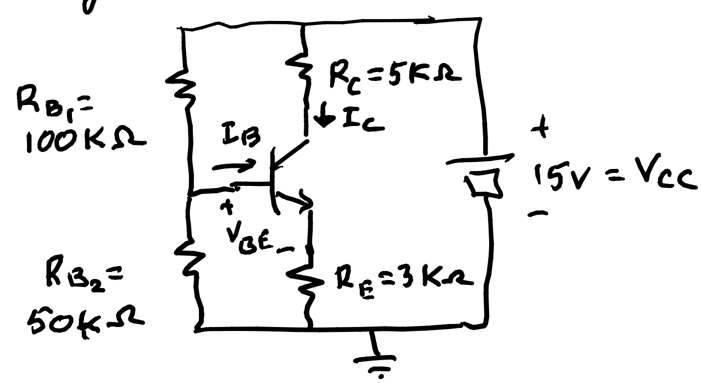


KVL: $0 = R_L i_L + E - v_x$

$i_L = \frac{1}{R_L}(v_x - E) = G_L v_x - G_L E$

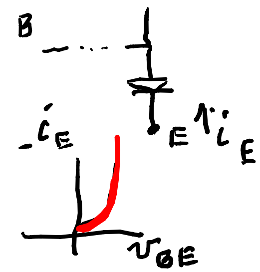


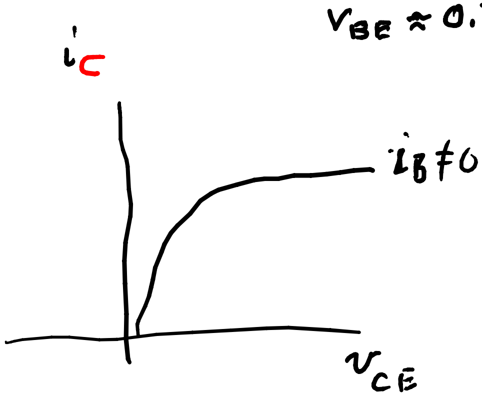
Biasing an npn   p. 390



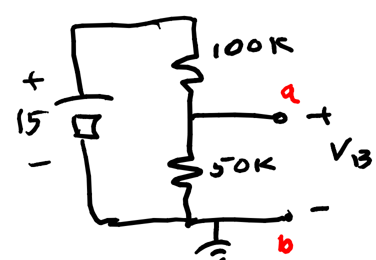
$V_{BE} \approx 0.7$

$\beta = 100 = \frac{I_C}{I_B}$

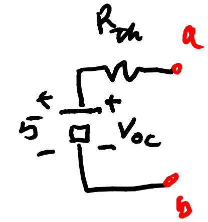




for Base

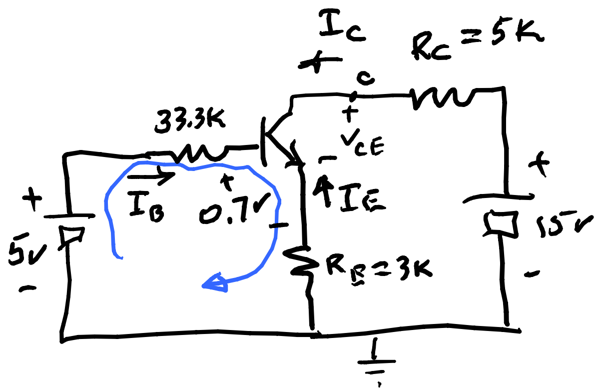


$\Rightarrow$



$V_{oc} = \frac{50K}{150K} \times 15$, $R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{5}{15/100K}$

$= 33.3K\Omega$



$I_C = -\alpha I_E$

$= \beta I_B$

$I_E = -\frac{\beta}{\alpha} I_B$, $\beta = \frac{\alpha}{1-\alpha}$

$\Rightarrow (1-\alpha)\beta = \alpha$

$\beta = \alpha + \beta\alpha \Rightarrow \alpha = \frac{\beta}{1+\beta}$

$- \beta/\alpha \, I_B$

$=$

KVL: $0 = -5 + 33.3\times10^3 I_B + 0.7 + R_E(-I_E)$

$4.3 = (33.3\times10^3 + \frac{\beta}{\alpha} 3\times10^3) I_B$, $\frac{\beta}{\alpha} = \frac{\beta}{\frac{\beta}{1+\beta}} = (1+\beta)$

$4.3 = (33.3\times10^3 + 3\times101\times10^3) I_B$

$I_B = \frac{10^{-3}}{336.3} = 0.013\ mA = 13\ \mu A$

$I_C = \beta I_B = 1.3\ mA$, $I_E = -\frac{100}{101} \times 1.3\ ma = -1.29\ ma$

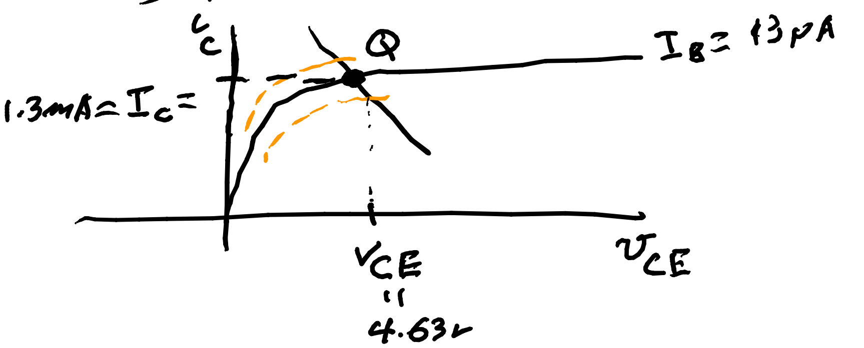
V_E = voltage at emitter $= R_E(-I_E)$

$= 3.87V$

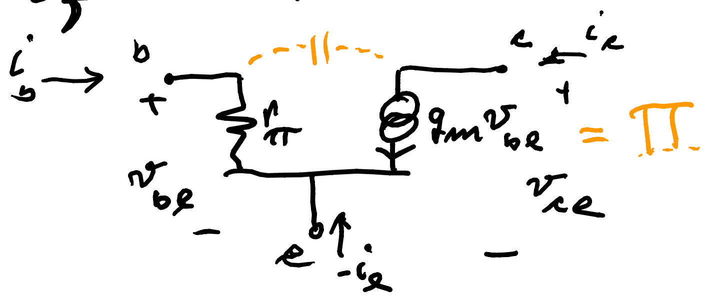
$V_{R_C} = 1.3\times10^{-3} \times 5\times10^3 = 6.5V$

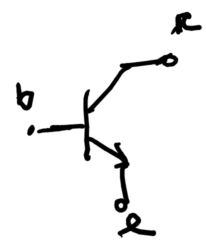
V_C = voltage at collector $= V_{CC} - V_{R_C} = 15 - 6.5 = 8.5$

$V_{CE} = V_C - V_E = 8.5 - 3.87 = 4.63V$



π Equivalent circuits, p. 410





$i_c = f(v_{CE}, i_B) \qquad -i_E = I_{SE}\, e^{v_{BE}/V_T}, \quad V_T = \frac{kT}{|q|} \approx 0.026V$

$$= I_C + \left.\frac{\partial f}{\partial v_{CE}}\right|_Q (v_{CE} - V_{CE}) + \left.\frac{\partial f}{\partial i_B}\right|_Q (i_B - I_B) + \cdots$$

$$\text{signal} = i_c = \left.\frac{\partial i_C}{\partial v_{CE}}\right|_Q v_{ce} + \left.\frac{\partial i_C}{\partial i_B}\right|_Q i_b = g_o \cdot v_{ce} + \beta i_b$$

$$-i_E = I_{SE} e^{v_{BE}/V_T} = I_{SE} \cdot e^{V_{BE}/V_T} + \left.\frac{\partial(-i_E)}{\partial v_{BE}}\right|_Q \cdot (v_{BE} - V_{BE})$$

$$= -I_E + \frac{I_{SE}}{V_T} \cdot e^{V_{BE}/V_T} \cdot v_{be}$$

$$= -I_E - \frac{I_E}{V_T} \cdot v_{be} \qquad \text{but } i_E = -\frac{\beta}{\alpha} i_B$$

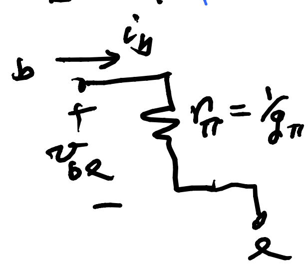
$$i_B = I_B + \frac{\partial i_b}{\partial v_{BE}} \cdot v_{be} = -\frac{\alpha}{\beta} \cdot i_E$$

$$= \frac{\alpha}{\beta} I_E + \frac{I_E}{V_T}\left(\frac{\alpha}{\beta}\right) \cdot v_{be}, \quad I_c = \alpha I_E$$

$$i_b = \frac{1}{\beta}\left(\frac{I_C}{V_T}\right) \cdot v_{be}$$

$$= g_\pi \cdot v_{be}$$

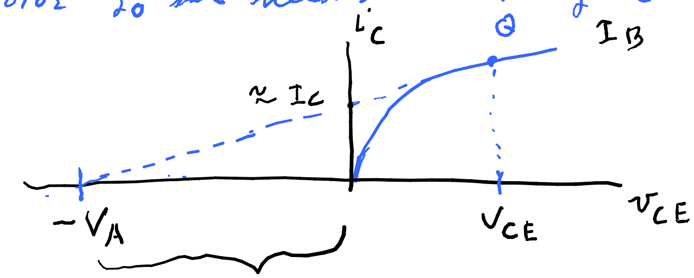
$$r_\pi = \frac{1}{g_\pi} = \beta \frac{V_T}{I_C}$$



$$i_c = g_o v_{ce} + \beta i_b = g_o v_{ce} + \underbrace{\beta\left[\frac{1}{\beta}\cdot\frac{I_c}{V_T}\right]}_{g_m} v_{be}$$

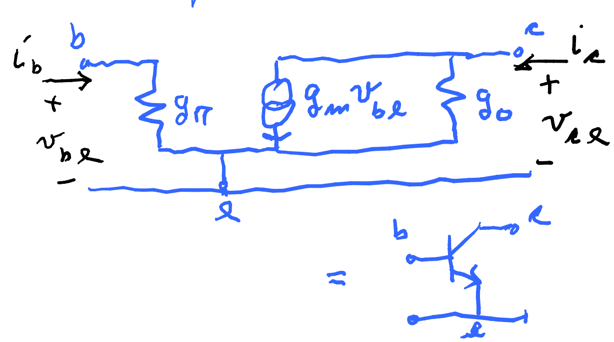
$$\Rightarrow \quad g_m = \frac{I_c}{V_T}, \quad g_\pi = \frac{g_m}{\beta}$$

For g_o we need the slope of i_c vs v_{CE} at I_B



$$\text{slope} \approx \frac{(I_C - 0)}{(0-(-V_A))} = \frac{I_C}{V_A} = \frac{I_C}{V_T}\cdot\frac{V_T}{V_A} = \frac{V_T}{V_A}\cdot g_m$$

2-port equivalent & Y matrix, grounded emitter



$$\begin{bmatrix} i_b \\ i_c \end{bmatrix} = \begin{bmatrix} g_\pi & 0 \\ g_m & g_o \end{bmatrix} \begin{bmatrix} v_{be} \\ v_{ce} \end{bmatrix}$$