Note Title 2/21/2011

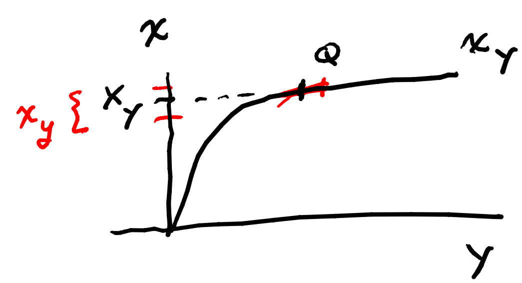
02/21/11
EE303

Notation x_Y = total = bias + signal

X_Y = bias = DC

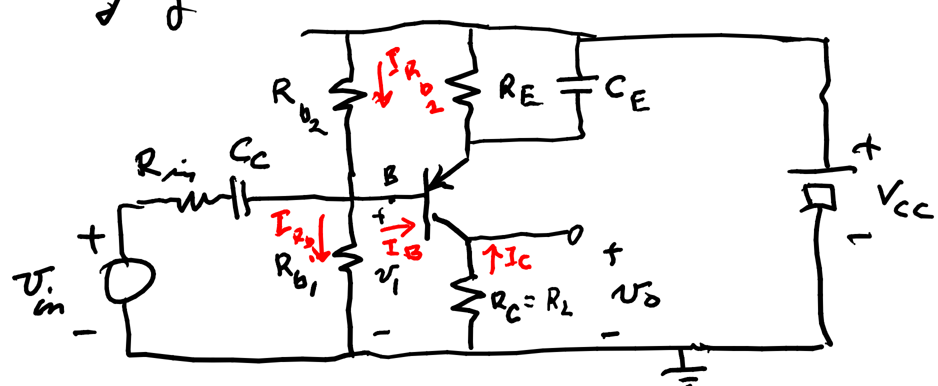
x_y = signal

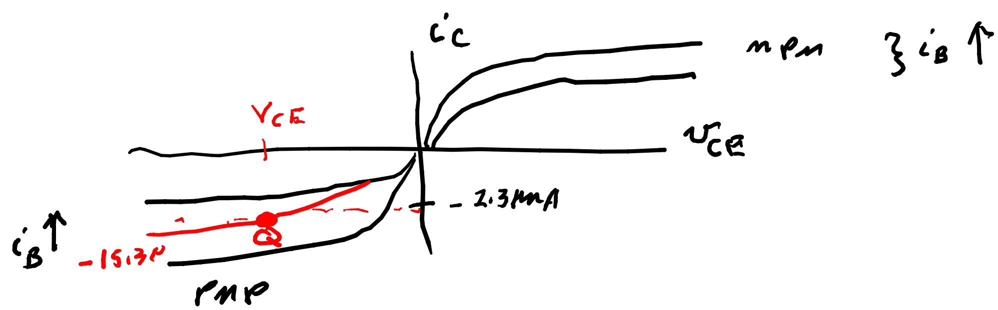
$x_Y = X_Y + x_y$



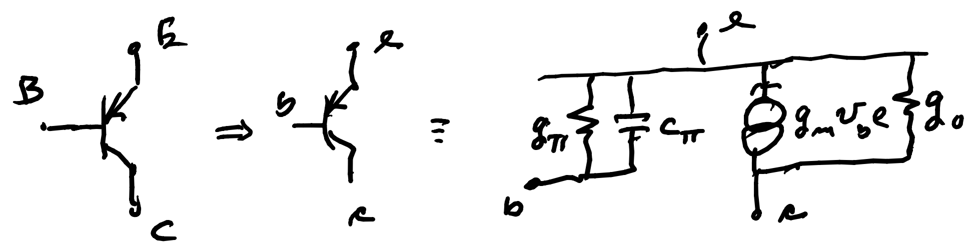
pp. 557–558 table compares MOS & BJT

Biasing of





as all slopes are > 0 then get the same equivalent circuit for the pnp & npn



assume given $A_v = -150$, $R_L = R_C = 1.5\,k\Omega$

$$\frac{v_o}{v_i} = -g_m R_L \Rightarrow g_m = \frac{150}{1.5\times10^3} = \frac{1.5\times10^2}{1.5\times10^3} = \frac{1}{10}$$

$$g_m = \frac{|I_C|}{V_T} \Rightarrow I_C = -g_m V_T \quad \text{at room } T$$

$$= -\frac{1}{10}\times 23\,mV \times \frac{I\,\text{unit}}{V} = -2.3\,mA$$

2

assume

$\beta = 150$ is given

$\therefore \quad I_B = \frac{1}{\beta} I_C \Rightarrow \quad I_B = -\frac{2.3 \times 10^{-3}}{1.5 \times 10^{2}} = -1.53 \times 10^{-5} = -15.3\,\mu A$

DC voltage on $R_C \Rightarrow \quad V_C = R_C(-I_C) = 1.5\,k\Omega \times 2.3\,mA$

$= 3.45\,V$

$$\begin{array}{r} 2.3 \\ 1.5 \\ \hline 115 \\ 23 \\ \hline 3.45 \end{array}$$

assume from curves $V_{CE} = -5\,V$

we need $V_{CC} > V_{CE} + V_C = 8.45$

assume get a 12 V battery $\Rightarrow V_{CC} = 12\,V$

now know $V_{R_E} = V_{CC} + V_{CE} + V_{R_C} = 12 - 8.45 = 3.55$

$= R_E \times I_E \,; \quad \alpha I_E = -I_C \,; \quad \alpha = \frac{\beta}{1+\beta} = 0.993 \approx 1$

$R_E = \frac{V_{RE}}{I_E} \approx \frac{3.55}{(2.3/0.993) \times 10^{-3}} = 1.533 \times 10^{3} = 1.53\,k\Omega$

$V_{R_{b_2}} = V_{R_E} + 0.7 = 3.55 + 0.7 = 4.25\,V$

$V_{R_{b_1}} = V_{CC} - V_{R_{b_2}} = 12 - 4.25 = 7.75\,V$

$$I_{R_{b_1}} = I_{R_{b_2}} - I_B = I_{R_{b_2}} - 15.3\mu A$$

$$V_{R_{b_1}} = 7.75 = R_{b_1}(I_{R_{b_2}} - 15.3\mu) \qquad b_1)$$

$$V_{R_{b_2}} = 4.25 = R_{b_2} \cdot I_{R_{b_2}} \qquad b_2)$$

$$b_1)/b_2) \Rightarrow \frac{7.75}{4.25} = \frac{R_{b_1}}{R_{b_2}}\left(1 - \frac{15.3\mu}{I_{R_{b_2}}}\right)$$

$$= 1.824$$

here need $I_{R_{b_2}} > 0$ $\Rightarrow \frac{R_{b_1}}{R_{b_2}} > 1.824$

$$\Rightarrow 15.3 \times 10^{-6} = I_{R_{b_2}}\left(\frac{R_{b_1}}{R_{b_2}} - 1.824\right) \Rightarrow \text{choose } \frac{R_{b_1}}{R_{b_2}} = 3$$

$$= I_{R_{b_2}}(1.176)$$

$$\Rightarrow I_{R_{b_2}} = 13.01\mu A$$

normally choose these large, say Meg Ω s

if choose $R_{b_2} = 1 \times 10^6 \Omega$

$R_{b_1} = 3 \times 10^6 \Omega$

finishes the biasing (turn to Spice to round it as desired).

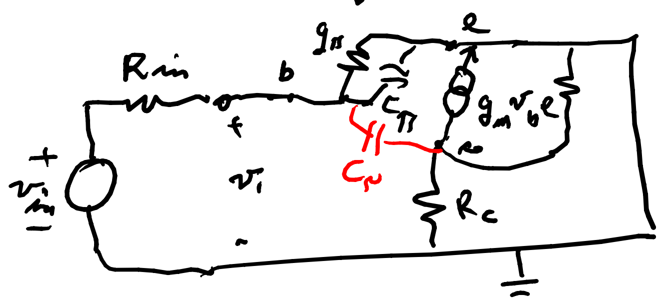
for small signals we know g_m

gives $g_\pi = \frac{g_m}{\beta} = \frac{1}{10} \times \frac{1}{150} = \frac{1}{1.5 \times 10^3} = 0.7$ milli ℧

for g_o need V_A = Early voltage, assume ≈ 100V

Then $g_o \approx \frac{|I_C|}{V_A} = \frac{2.5 \times 10^{-3}}{100} = 2.5 \times 10^{-5} = 25 \times 10^{-6} = 25\ \mu$℧

small signal equivalent



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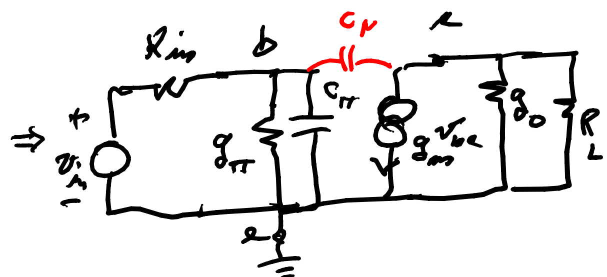
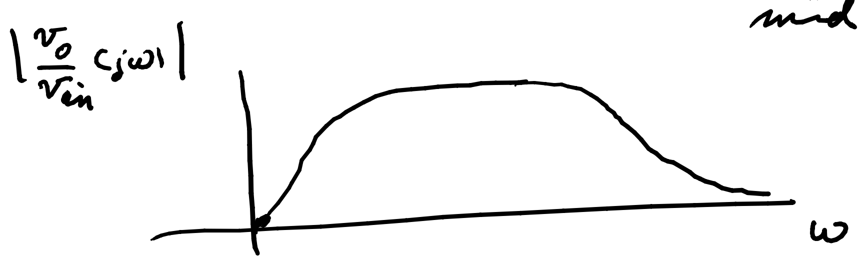
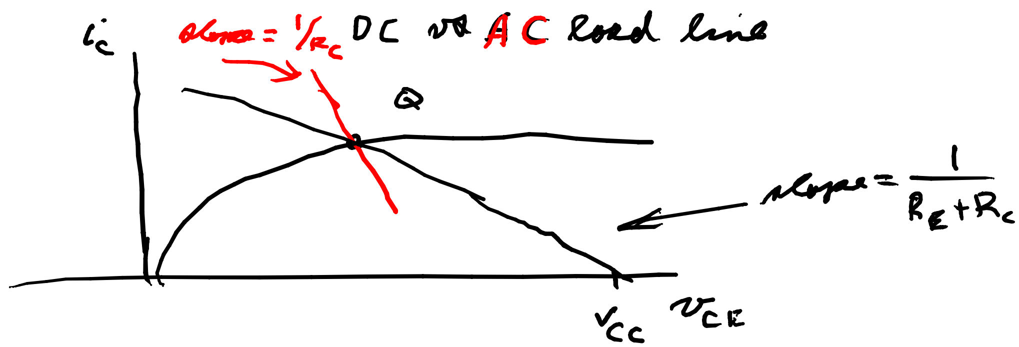


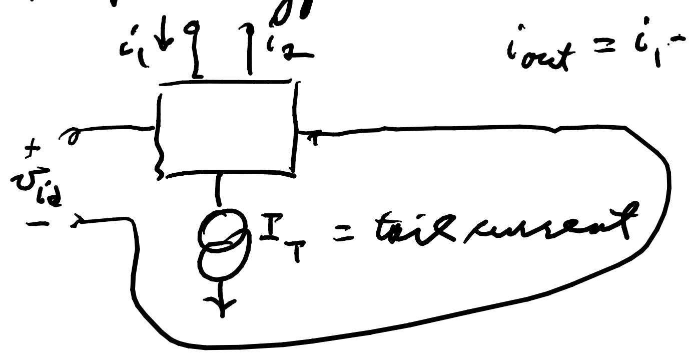
mid band





For emitter follower take signal off of emitter resistor which gives a voltage gain less than 1.

Next topic differential pairs, p. 613



$i_{out} = i_1 - i_2$, $I_T = i_1 + i_2$