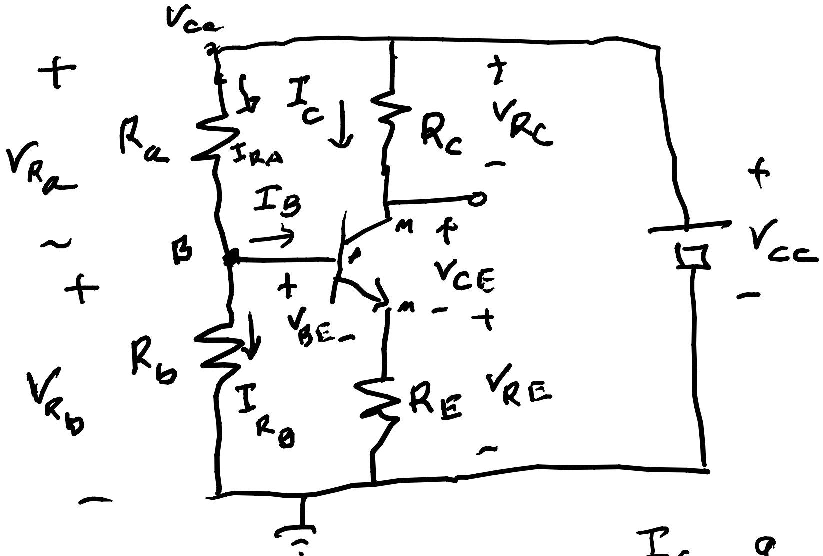
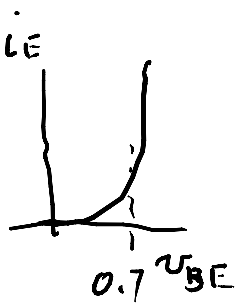
EE303

09/27/12

Note Title 9/25/2012





Ex: $g_m = \frac{I_c}{V_T}$

$V_T = 26\times10^{-3}V$

choose $I_c = 2.6mA$

$g_m = \frac{2.6\times10^{-3}}{2.6\times10^{-4}} = \frac{1}{10}\mho$

$g_o = I_c / V_A$

$g_\pi = \frac{I_c}{\beta V_T} = \frac{g_m}{\beta}$, if $V_A = 130$ = Early voltage

$g_o = \frac{2.6\times10^{-3}}{1.3\times10^{2}} = 2\times10^{-5}\mho$

if $\beta = 100$

$g_\pi = \frac{1}{10^3} = 10^{-3}\mho$

$r_\pi = 1/g_\pi = 10^3\Omega = 1K\Omega$

$r_o = \frac{1}{g_o} = \frac{1}{2}\times10^{5}\Omega = 5\times10^{4}\Omega$
$= 50K\Omega$

$I_B = \frac{I_c}{\beta} = \frac{2.6\times10^{-3}}{10^2} = 26\times10^{-6}A$; $R_E = 1K\Omega$ (choose)

$V_{RE} = R_E\left(\frac{I_c}{\alpha}\right) \approx R_E I_c = 10^3\times2.6\times10^{-3}$
$= 2.6V$

$\alpha = \frac{\beta}{\beta+1}$ from $\beta = \frac{\alpha}{1-\alpha}$

$V_{R_b} = V_{BE} + V_{RE} = \underset{v_{BE}}{0.7} + 2.6 = 3.3V$

$I_{R_b} = \frac{V_{R_b}}{R_b} = \frac{3.3}{R_b}$; $I_{R_a} = I_B + I_{R_b}$ by KCL @ Base

$= 26\times10^{-6} + \frac{3.3}{R_b} = \frac{V_{cc} - V_{R_b}}{R_a}$

Choose $V_{cc} = 9V$ (battery) $\Rightarrow I_{R_a} = \frac{9 - 3.3}{R_a} = \frac{5.7}{R_a}$

$= 26\times10^{-6} + \frac{3.3}{R_b} = \frac{5.7}{R_a}$

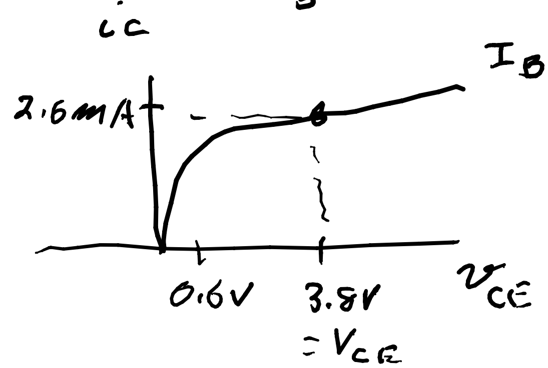
Choose R_a = large = 1 Meg Ω $\Rightarrow 26\times10^{-6} + \frac{3.3}{R_b} = 5.7\times10^{-6}$

then $\frac{3.3}{R_b} = (5.7-26)\times 10^{-6} < 0 \Rightarrow$ can't do with $R_a = 1M\Omega$

$\therefore$ choose R_a smaller $\Rightarrow$ $R_a = 100k\Omega = 10^5\Omega$

$$\frac{5.7}{10^5} = 57\times 10^{-6} = 26\times 10^{-6} + \frac{3.3}{R_b} \Rightarrow \frac{3.3}{R_b} = 31\times 10^{-6}$$

or $R_b = \frac{3.3}{3.1}\times 10^5\,\Omega$



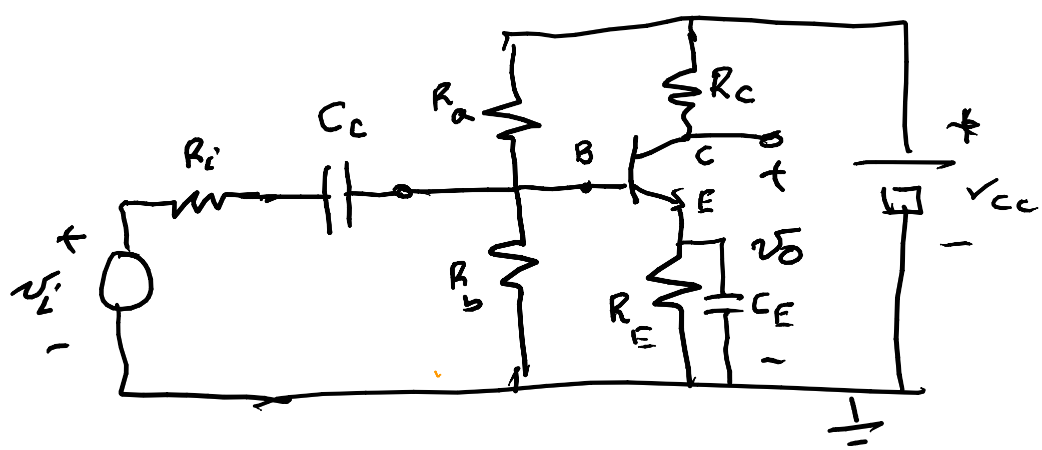
Choose R_c such that

$$A_v\big|_{ideal} = -g_m R_c \approx -100 \Rightarrow R_c = \frac{100}{g_m} = 1000 = 1K$$

at $I_c = 2.6mA$, $V_{R_c} = R_c I_c = 2.6\times 10^{-3}\times 10^3 = 2.6V$

KVL:
$$V_{CE} = V_{CC} - V_{R_c} - V_{R_E} \approx 9 - 2\times 2.6 = 9 - 5.2 = 3.8V$$

Now use it as an amplifier, AC couple



C_c & C_E large

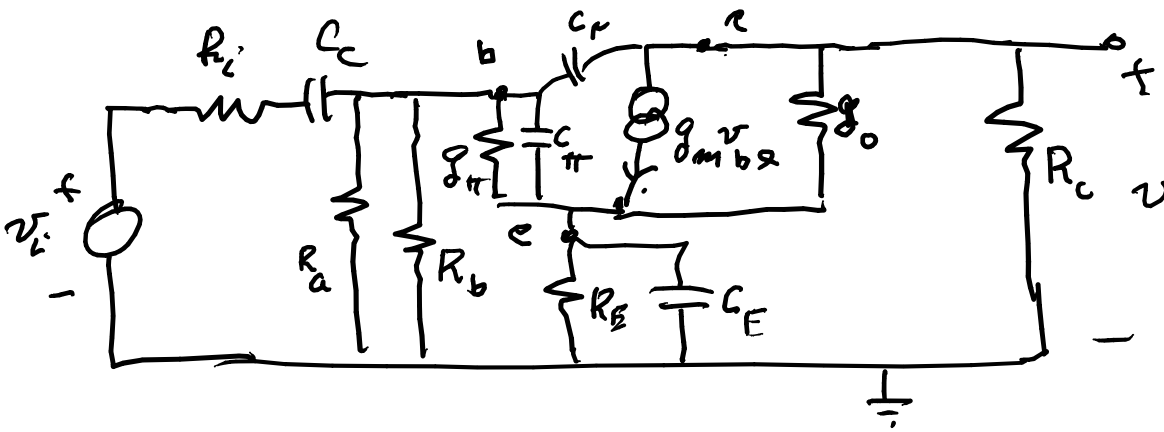
$i = C\frac{dv}{dt}$

if $v = Ve^{st}$

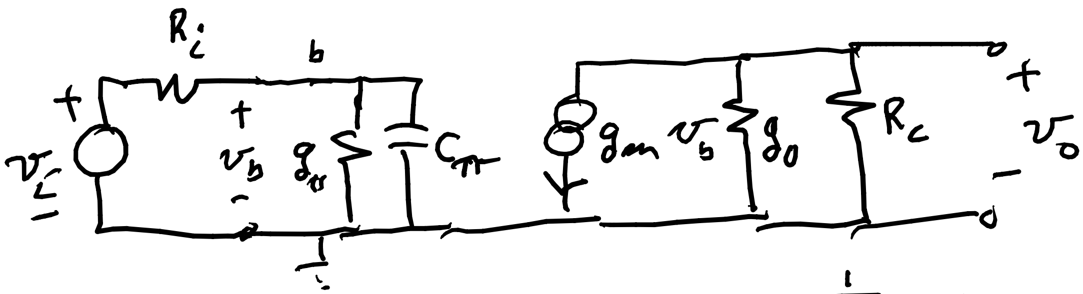
$i = CsVe^{st}$

if $s = j\omega$

for small signals, use
small signal equivalent circuit for the transistor



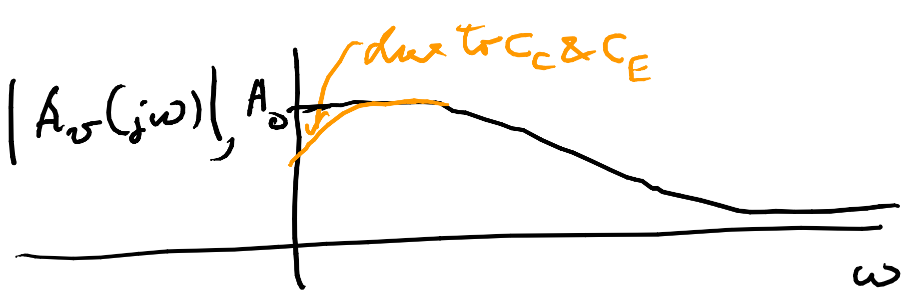
approximate by ($C_E = C_c = C_\mu = 0$, $R_a = R_b = \infty$, R_E bypassed $= 0$)



$$A_i = \frac{v_o}{v_i} \; ; \qquad v_b = v_i \cdot \frac{\frac{1}{g_\pi + sC_\pi}}{R_i + \frac{1}{g_\pi + sC_\pi}} = \frac{1}{(1 + R_i g_\pi) + sR_iC_\pi} \cdot v_i$$

$$v_o = -g_m v_b \left(\frac{r_o R_c}{r_o + R_c} \right) = \frac{-g_m\left(\frac{r_o R_c}{r_o + R_c}\right)}{(1 + R_i g_\pi) + sR_iC_\pi} \cdot v_i$$

$$A_v = \frac{-g_m\left(\frac{r_o R_c}{r_o + R_c}\right)}{(1 + R_i g_\pi) + sR_iC_\pi} \; ; \qquad A_v(j\omega) = \frac{-g_m\left(\frac{r_o R_c}{r_o + R_c}\right)}{(1 + R_i g_\pi) + j\omega R_iC_\pi} = \frac{-A_o}{1 + j\omega \frac{R_iC_\pi}{1 + R_i g_\pi}}$$



gives a low-pass characteristic

also

$$\left[(1 + R_i g_\pi) + sR_iC_\pi\right] v_o = -g_m\left(\frac{r_o R_c}{r_o + R_c}\right) \cdot v_i$$

which is the differential equation

$$R_i C_\pi \frac{dv_o}{dt} + (1 + R_i g_\pi) v_o(t) = -g_m \left(\frac{r_o R_c}{r_o + R_c} \right) v_i(t)$$