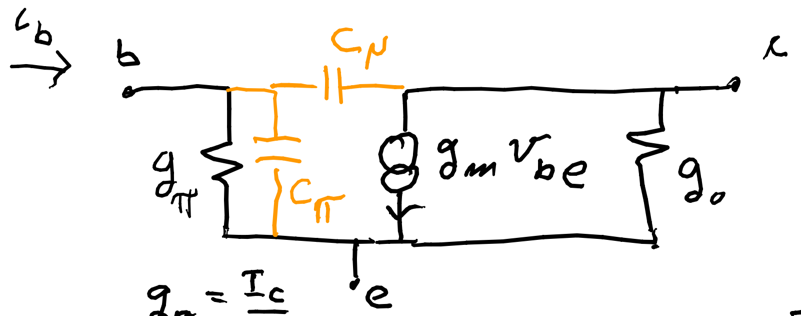
EE303
02/24/06

BJT



$$g_\pi = \frac{I_c}{\beta V_T} = \frac{1}{\beta} g_m$$

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

$$g_o = \frac{I_c}{(V_A+V_{CE})} = \frac{V_T}{(V_A+V_{CE})} \cdot \frac{I_c}{V_T} = \eta_A \cdot g_m$$

V_T = thermal voltage

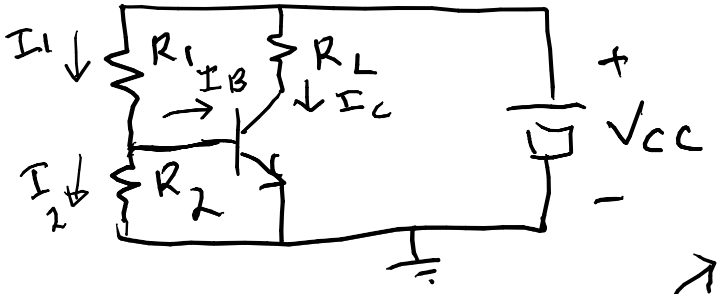
Ex: $\beta = 50$, $I_c = 2\,mA$, $V_A = 100\,V$; $V_T = 0.026$

$$g_m = \frac{I_c}{V_T} = \frac{2\times10^{-3}}{26\times10^{-3}} = 0.077 = 77\,m℧$$

$$g_\pi = \frac{g_m}{\beta} = 0.0015 = 1.5\,m℧;\ r_\pi = 0.67\,K\Omega$$

$$g_o = \frac{I_c}{V_A} = \frac{2\times10^{-3}}{1\times10^{2}} = 0.2\times10^{-6};\ r_o = \frac{1}{g_o} = 5\,meg\,\Omega$$

Problem is to bias



given I_c & β

$$I_B = \frac{I_c}{\beta}$$

$V_{BE} \approx 0.7$

↳ choose R_2, large, $\Rightarrow I_2 \Rightarrow I_1$ ↗ $I_1 = I_2 + I_B$

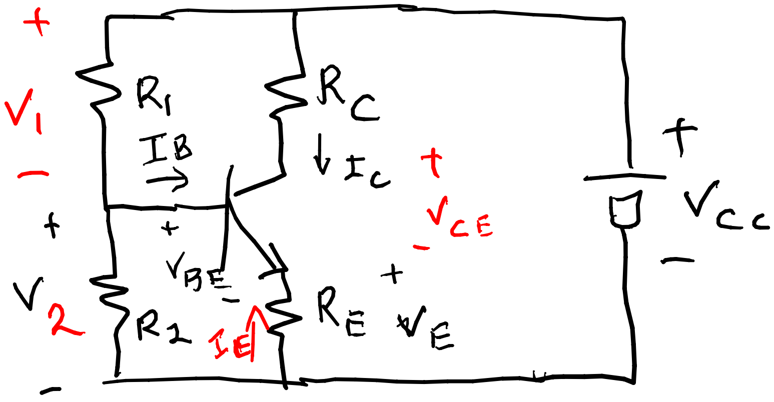
$\sim e^{\left(V/kT/q\right)}$

very dependent on temperature

$''$ V_{BE}/R_2

$\downarrow$ $R_1 = \dfrac{V_{CC} - V_{BE}}{I_1}$

actual bias uses



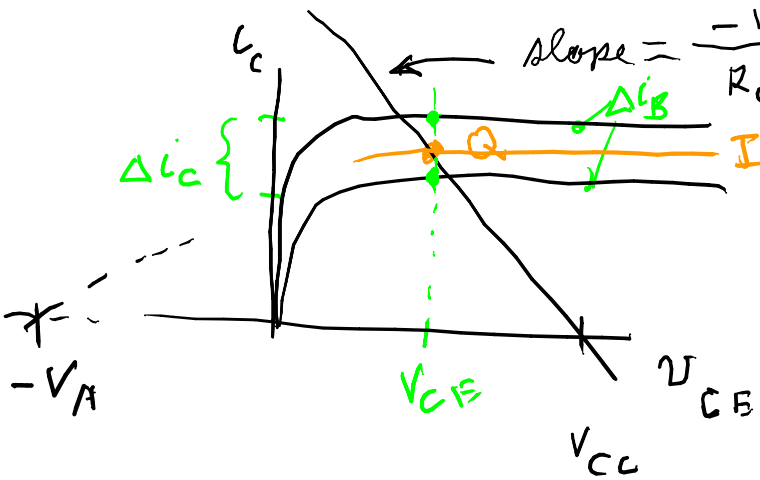
if $I_C\uparrow \rightarrow V_E\uparrow$

if $V_2 = \text{const}$

$\rightarrow V_{BE} = V_2 - V_E\downarrow$

$\rightarrow I_E\downarrow \rightarrow I_C\downarrow$

$I_E = -\dfrac{I_C}{\alpha}$; $V_E = R_E\left(\dfrac{I_C}{\alpha}\right) = \left(\dfrac{R_E}{\alpha}\right) I_C$



slope $= \dfrac{-1}{R_C + \frac{R_E}{\alpha}}$

$\beta = \left.\dfrac{\partial i_c}{\partial i_B}\right|_Q$

$\alpha = \dfrac{\beta}{\beta+1}$

if choose R_E (say 1 kΩ) the load line fixes R_C

after we get $\beta \rightarrow \alpha = \beta/\beta+1$ & Q point fixes I_C

Choose R_2 large (say 1 meg Ω); V_E fixed by α, I_C, R_E

$$V_2 = I_2 \cdot R_2 \Rightarrow I_2 = \frac{V_2}{R_2} = \frac{V_{BE} + V_E}{R_2} \approx \frac{0.07 + (\frac{I_c}{\alpha})R_E}{R_2}$$

know I_B (= Q pt base current)

& I_2

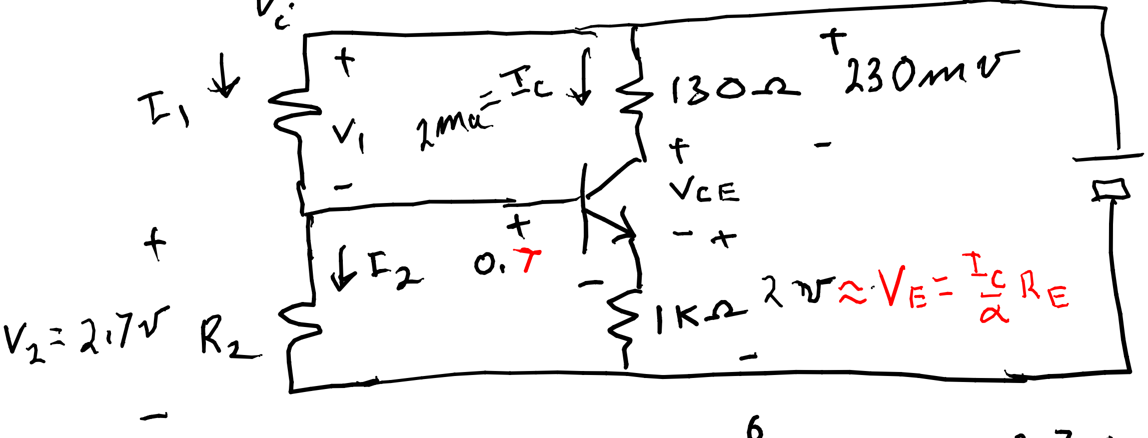
$$I_1 = I_2 + I_B \Rightarrow R_1 = \frac{V_{cc} - V_2}{I_1}$$

R_c normally fixed by gain; $\frac{V_o}{V_i} = -g_m R_c$

- - - - assume we desire $\frac{V_o}{V_i}$ = open circuit voltage gain = −10

and $I_c = 2\,ma$; $\Rightarrow R_C = 10/g_m = 10 \times 13 = 130$

note if $\frac{V_o}{V_i} = -100$, $R_c = 1.3\,K\Omega$



note 5v may not give this Q - best turn to Spice

choose $R_2 = 1\,meg\,\Omega = 10^6\,\Omega$; $I_2 = \frac{2.7v}{10^6} = 2.7\,\mu\,amp$

$I_B = \frac{I_c}{\beta} = \frac{2 \times 10^{-3}}{100} = 20\,\mu A > I_2$; $I_1 = 22.7\,\mu\,amp$

$V_1 = 5 - 2.7v = 2.3v$

$\alpha = \frac{\beta}{\beta+1} = \frac{100}{101} = 0.9901$

$R_1 = \frac{V_1}{I_1} \approx \frac{2.3}{23} \times 10^{+6} = 0.1 \times 10^6\,\Omega$