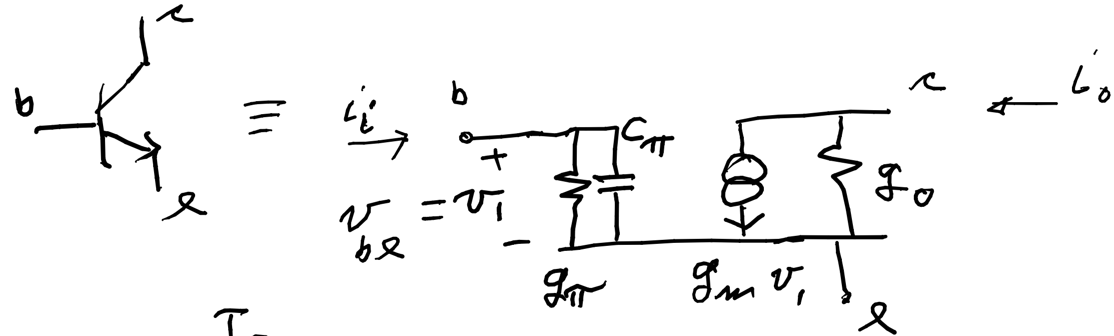
EE 303
02/21/07

small signal npn



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

$$V_T = 0.026 \text{ @ room } T$$

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

$$g_o = \frac{I_c}{V_A} \qquad V_{BE} = 0.7\text{v DC}$$

from data sheet ω_T is known, $\omega_T = 2\pi f_T$

f_T transition frequency:

meaning: $\left|\frac{i_o}{i_i}\right| = 1$ for a short ce (freq. dep.)

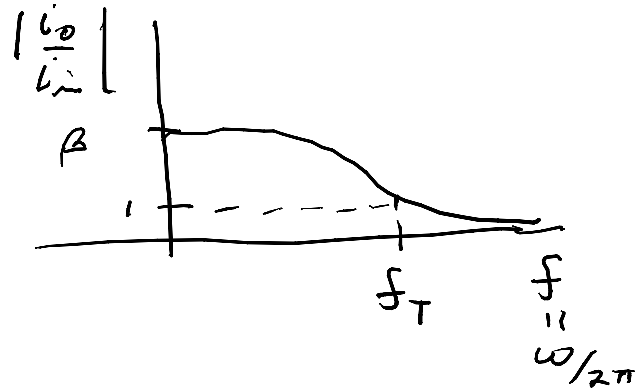
$$i_o = -g_m v_1 \Big|_{\text{short ce}}, \qquad i_i = y_{in} v_1$$

$$= (g_\pi + sC_\pi) v_1$$

$$\frac{i_o}{i_{in}} = -\frac{g_m}{g_\pi + sC_\pi} = \frac{-g_m/g_\pi}{1 + sC_\pi/g_\pi}$$

$$= \frac{-\beta}{1 + sC_\pi/g_\pi} \Rightarrow \left|\frac{i_o}{i_{in}}(\omega)\right| = \frac{\beta}{\sqrt{1^2 + \left(\omega \frac{C_\pi}{g_\pi}\right)^2}}$$

ω_T is where $\left|\frac{i_o}{i_{in}}\right| = 1$



$$1^2 = \frac{\beta^2}{1^2 + \left(\frac{\omega_T C_\pi}{g_\pi}\right)^2}$$

$$\omega_T = \frac{g_\pi}{C_\pi}\sqrt{\beta^2 - 1} \approx \frac{g_\pi}{C_\pi}\cdot\beta \Rightarrow C_\pi = \frac{g_\pi \beta}{2\pi f_T}$$

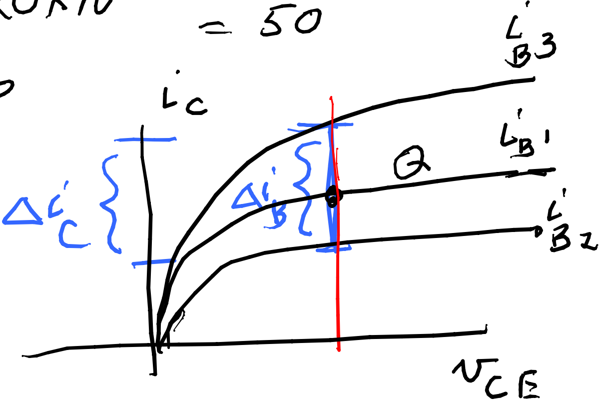
for 2N3904, $f_T = 300\,\text{MEG Hz} = 3\times10^8\,\text{Hz}$ @ 10 ma

$g_o = (1 - 40\,\mu℧)$ choose $20\times10^{-6}\,℧$ @ 1 ma

$$= \frac{I_C}{V_A} \Rightarrow V_A = \frac{I_C}{g_o} = \frac{1\times10^{-3}}{20\times10^{-6}} = \frac{1}{2}\times10^{-3}\times10^{5} = 50$$

$\beta = (100 - 400)$ choose 100

$$\beta \approx \left.\frac{\Delta i_C}{\Delta i_B}\right|_{v_{CE} = V_{CE}}$$



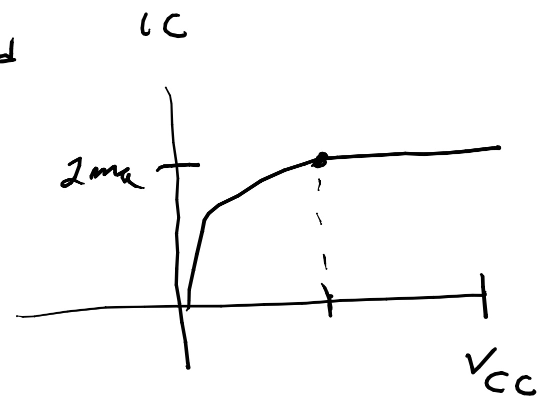
assume bias at $2\,\text{ma} = I_C$

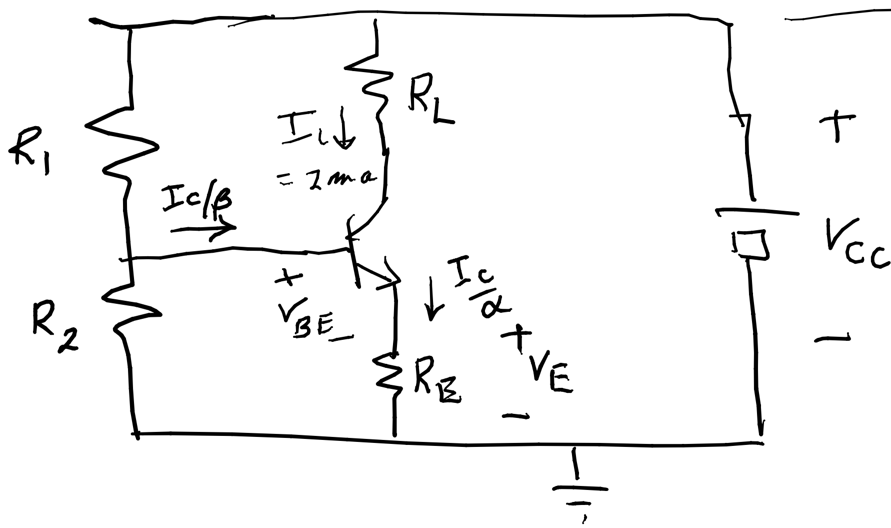
$$g_m = \frac{I_C}{V_T} = \frac{2\times10^{-3}}{26\times10^{-3}} = 1/13$$

$$g_\pi = \beta g_m = 50 g_m = 50/13; \quad g_o = \frac{I_C}{V_A} = \frac{2\times10^{-3}}{50} = 4\times10^{-5}\,℧$$

$$f_T = 3 \times 10^8, \quad C_\pi = \frac{g_\pi \beta}{2\pi f_T} = \frac{(50/13) \times 50}{2\pi \times 3 \times 10^8} = \frac{25}{(13)(6\pi)} \times 10^{-6}$$

$$\approx 10^{-7}\ \text{Fd}$$





$$I_B = \frac{I_c}{\beta} = \frac{2 \times 10^{-3}}{50}$$

$$= 4 \times 10^{-5}$$

$$= 40\,\mu\text{amp}$$