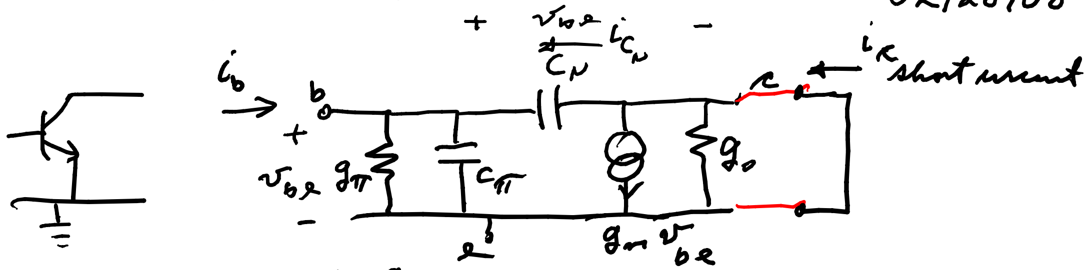
EE 303
02/28/08

f_T = transition frequency



$$g_\pi = \frac{g_m}{\beta_o} \qquad g_m = \frac{I_C}{V_T}$$

$$\frac{i_c}{i_b} = \beta(s)$$

$$i_c = g_m v_{be} + (-sC_\mu v_{be}) = (g_m - sC_\mu) v_{be}$$

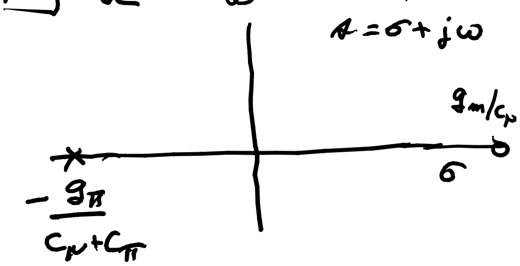
$$i_b = g_\pi v_{be} + sC_\pi v_{be} + sC_\mu v_{be}$$

$$= [g_\pi + s(C_\pi + C_\mu)] v_{be}$$

$$= \frac{g_m - sC_\mu}{g_\pi + s(C_\mu + C_\pi)}$$

$$= \frac{g_m}{g_\pi}\left[\frac{1 - s(C_\mu/g_m)}{1 + s((C_\mu + C_\pi)/g_\pi)}\right]$$

$$= \beta_o\left[\frac{1 - s/s_o}{1 + s/s_p}\right] \approx \frac{\beta_o}{1 + s\left[\frac{C_\mu + C_\pi}{g_\pi}\right]}$$



$$\beta(s) = \frac{\beta_o}{1 + s/\omega_p} \; ; \; \beta(j\omega) = \frac{\beta_o}{1 + j\frac{\omega}{\omega_p}} \Rightarrow \beta(j\omega_p) = \frac{\beta_o}{1 + j1}$$

$$|\beta(j\omega_p)| = \frac{\beta_o}{\sqrt{2}}$$

ω_T is where $|\beta(j\omega_T)| = 1$

$$|\beta(j\omega)| = \frac{\beta_o}{\sqrt{1 + \left(\frac{\omega}{\omega_p}\right)^2}} \Rightarrow 1 \approx \frac{\beta_o}{\left(\frac{\omega_T}{\omega_p}\right)} \Rightarrow \omega_T = \beta_o \times \omega_p$$

$$= \beta_o \cdot \frac{g_\pi}{C_\mu + C_\pi}$$

$$= 2\pi f_T$$

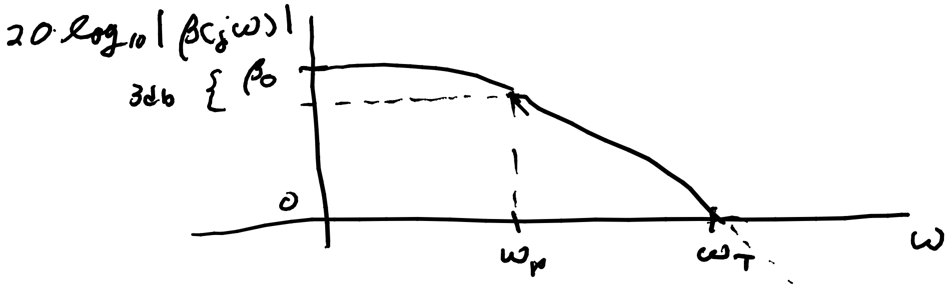
$$f_T = \frac{1}{2\pi} \times \beta_o \times \frac{g_\pi}{C_\mu + C_\pi} = \frac{1}{2\pi}\,\beta_o \cdot \frac{g_m}{\beta_o(C_\mu + C_\pi)}$$

$$= \frac{1}{2\pi} \cdot \frac{|I_C|/V_T}{C_\mu + C_\pi}$$

; Ex: $I_C = 2\,mA$, $C_\pi = 18\,pF$, $C_\mu = 2\,pF$
$V_T = 26\,mV$

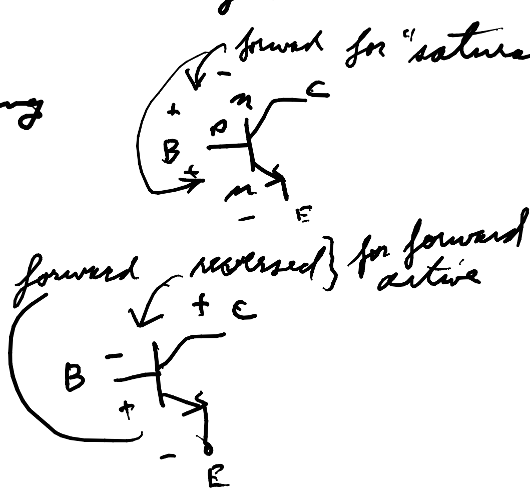
$$f_T = \frac{1}{2\pi} \times \frac{2\times 10^{-3}}{26\times 10^{-3}} \times \frac{1}{20\times 10^{-12}} \approx \frac{10^{12}}{80\times 20} = \frac{1}{1.6}\times 10^{11}$$ Hz

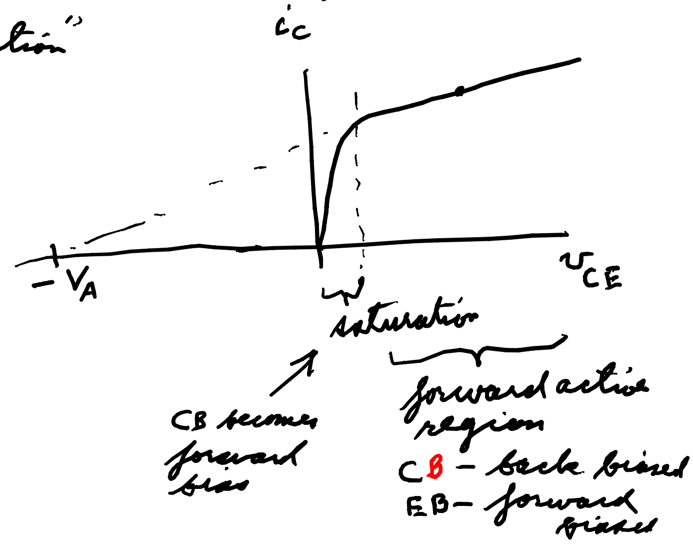
this is where β falls to 1 in magnitude

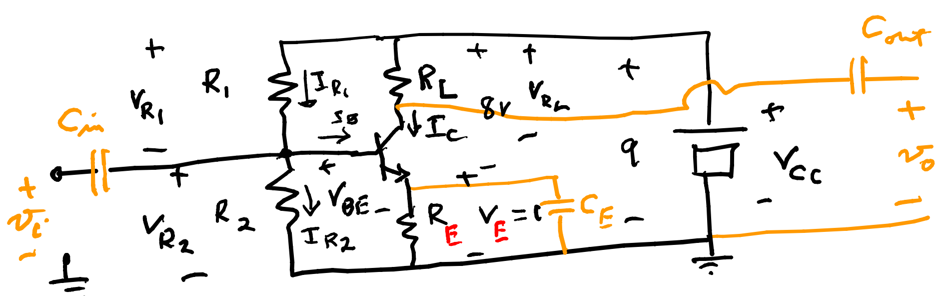


$\beta_0 = h_{fe}$ = (2,1) entry of the H parameters for a "grounded" emitter in the "forward" direction

Biasing







1st choose $g_m = \dfrac{I_C}{V_T}$; $\alpha = \dfrac{\beta_0}{\beta_0+1}$; $|I_E| \approx I_C$; $I_C = -\alpha I_E$

fix R_C to give $V_E \approx 1V$; $V_{R_2} = V_{BE} + V_E = 0.7 + V_E$

$V_{R_1} = V_{CC} - V_{R_2}$; if we know β_0 & I_C we know I_B

$I_B = I_C/\beta_0$

$I_c = 2\,ma$, $\beta_0 = 100 \Rightarrow I_B = \frac{2\times10^{-3}}{10^{+2}} = 20\times10^{-6} = 20\mu\,amp$

$I_{R_1} = I_B + I_{R_2}$, $V_{R_2} = 0.7 + V_E$; choose $V_E = 1.3V$

$\alpha = \frac{\beta}{1+\beta} = \frac{100}{101} \approx 1$ $\quad R_E = \frac{V_E}{|I_E|} = \frac{1.3V}{2ma} = 0.65k\Omega = 650\Omega$

$V_{R_2} = 0.7 + 1.3 = 2V$

choose V_{cc} a battery of 9v

$V_{R_1} = V_{cc} - V_{R_2} = 9 - 2 = 7v$

choose $R_2 = 1MEG\Omega$; $I_{R_2} = \frac{V_{R_2}}{R_2} = \frac{2V}{1MEG} = 2\times10^{-6}A$

$I_{R_1} = 2\times10^{-6} + 20\times10^{-6} = 22\mu\,amp$

$V_{R_1} = 7v \Rightarrow$ $\quad R_1 = \frac{7}{22\mu} = \frac{70\times10^{-1}}{22\times10^{-6}} \approx 3\times10^{5} = 30\,0k\Omega$

choose $I_c = 2ma$, $g_m = \frac{I_c}{V_T} = \frac{2\times10^{-3}}{26\times10^{-3}} = \frac{1}{13}$

$\frac{v_o}{v_i} = G =$ Voltage gain $\approx -g_m R_L = -\frac{1}{13}R_L$ if $G = -10 \Rightarrow R_L = 130$

$V_{R_L} = R_L \times I_c = 130\times2\times10^{-3} = 260\times10^{-3} = 0.26V$

$V_{CE} = V_{cc} - V_E - V_{RL} = 8 - 0.26 = 7.74$