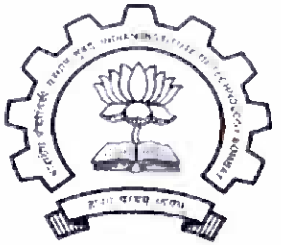
Numerical Values of BJT (npn) Parameters (Typical Case)



Biasing :→ $I_C = 1\,mA$ $V_{CB} = 3V$

$V_{CS} = 5V$

Capacitances : 1. $C_{jeo} = 10\,fF$, $\phi_{oe} = 0.9$ Volts, $\eta_e = 1/2$

2. $C_{\mu o} = 10\,fF$, $\phi_{oc} = 0.5\,V$, $\eta_c = 1/3$

3 $C_{cso} = 20\,fF$, $\phi_{os} = 0.65\,V$, $\eta_s = 1/3$

Others :→ $\beta_o = 100$, $\tau_B = 10\,ps$, $V_A = 20V$

Resistances :– $r_{bb'} = 300\,\Omega$, $r_{es} = 5\,\Omega$, $r_c = 50\,\Omega$, $r_\mu = 10\,\beta_o r_o$

Evaluations of Parameters

1. $C_{je} = 2 \times 10\ fF = 20\ fF$

2. $C_{\mu} = \dfrac{10}{\left(1 + \frac{3}{0.5}\right)^{0.33}} \cong 5.6\ fF$

3. $C_{cs} = \dfrac{20}{\left(1 + \frac{5}{0.65}\right)^{1/3}} \cong 10.5\ fF$

4. $g_m = \dfrac{qI_C}{kT} = \dfrac{10^{-3}}{26\ mV}\ A/V = 38\ mA/V$

5. $C_{be} = g_m \tau_B = 38 \times 10^{-3} \times 10 \times 10^{-12}$

$= 0.38$ pf

6. $C_\pi = C_{be} + C_{je} = 0.38$ pf $+ 0.02$ pf $= 0.4$ pf

7. $r_\pi = \frac{\beta_o}{g_m} = \frac{100}{38\ mA/V} = 26\ k\Omega$

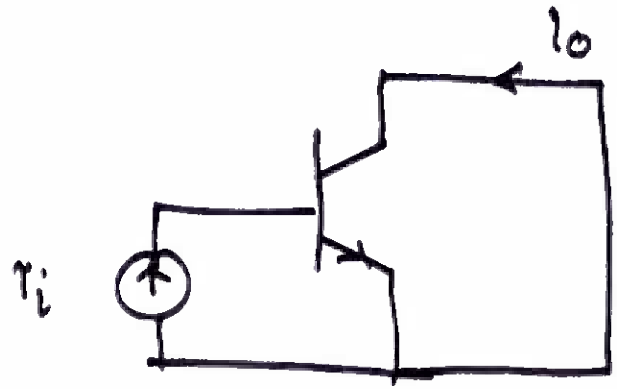
8. $r_o = \frac{V_A}{I_C} = \frac{20}{1 \times 10^{-3}} = 20\ k\Omega$

9 $r_\mu = 10\,\beta_o r_o = 10 \times 100 \times 20\ k\Omega = 20\ M\Omega$

BJT (Continued)

Figure of Merit of Transistor

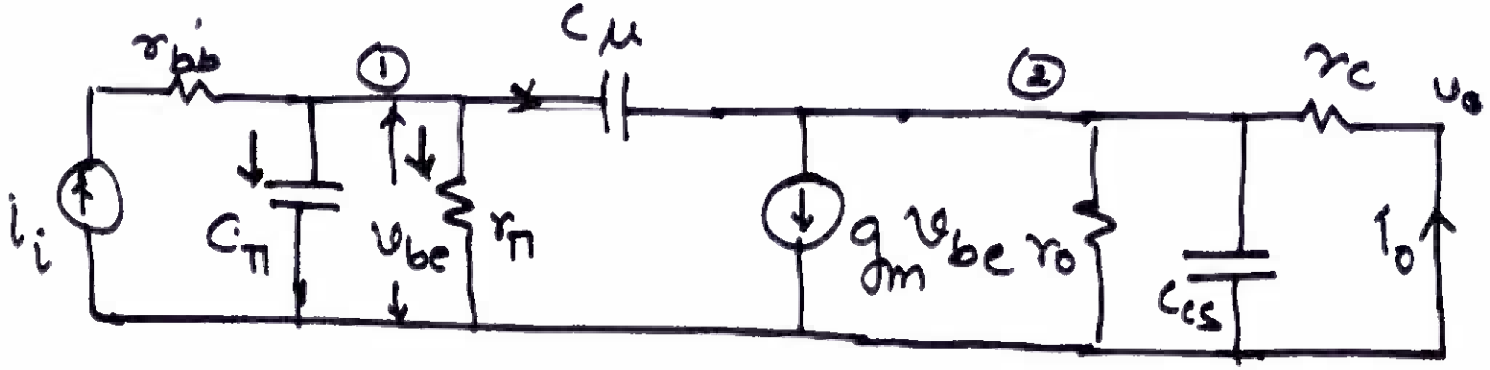
'f_T' is called Figure of Merit which is also common Emitter current gain falls to 'Unity' as frequency reaches f_T.



We define

$$\beta(j\omega) = \frac{I_o(j\omega)}{I_i(\omega)}$$

Equivalent Circuit



At node ② $\quad i_o = g_m v_{be} \qquad (v_o = 0)$

At node ① $\quad i_i = v_{be} \cdot j\omega C_\pi + v_{be} j\omega C_\mu + \dfrac{v_{be}}{r_\pi}$

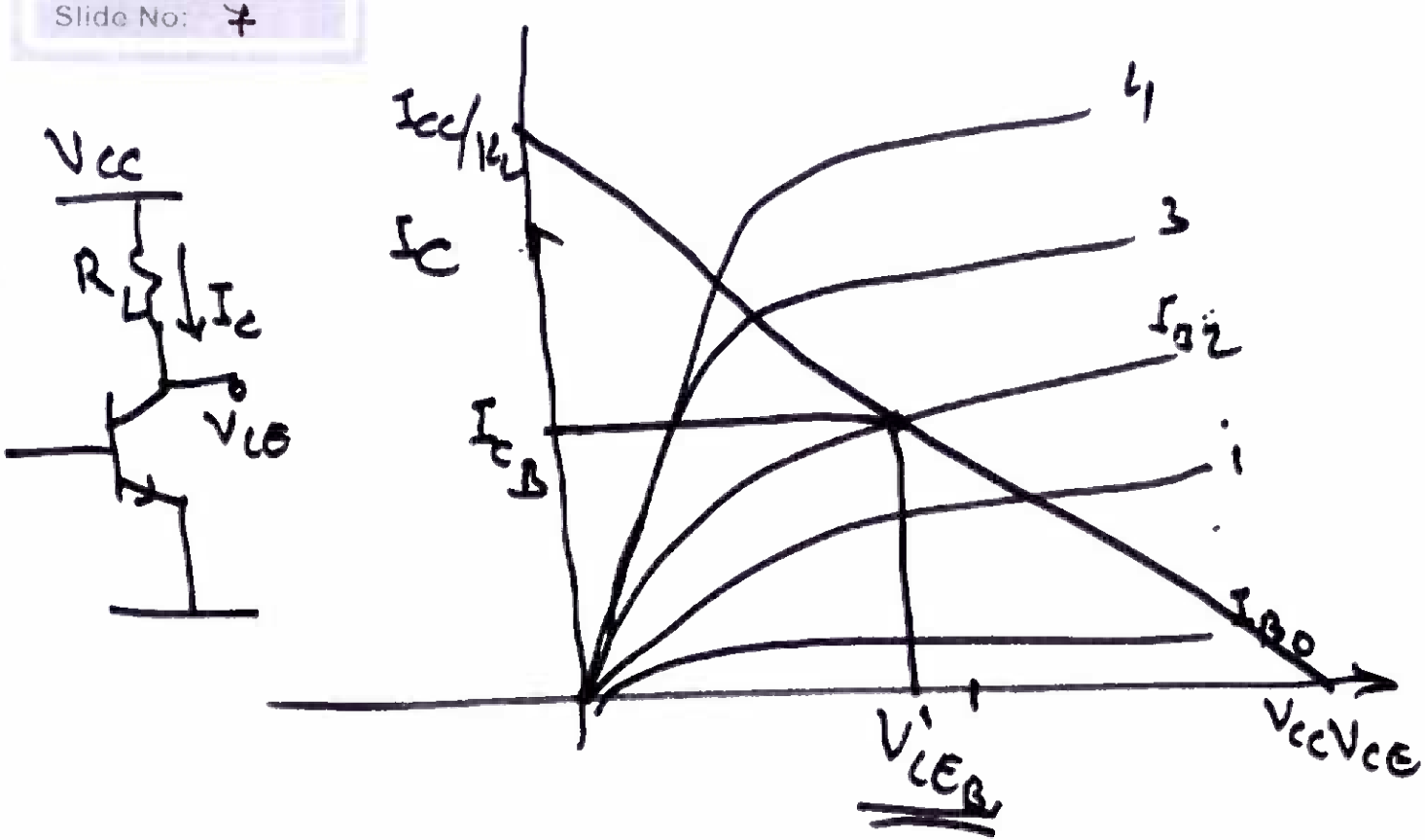
$$\therefore \quad \frac{i_o}{i_i} = \beta(j\omega) = \frac{g_m r_\pi}{1 + r_\pi (C_\pi + C_\mu) j\omega}$$

At $\omega = \omega_T$ $\quad \beta(j\omega) = 1$

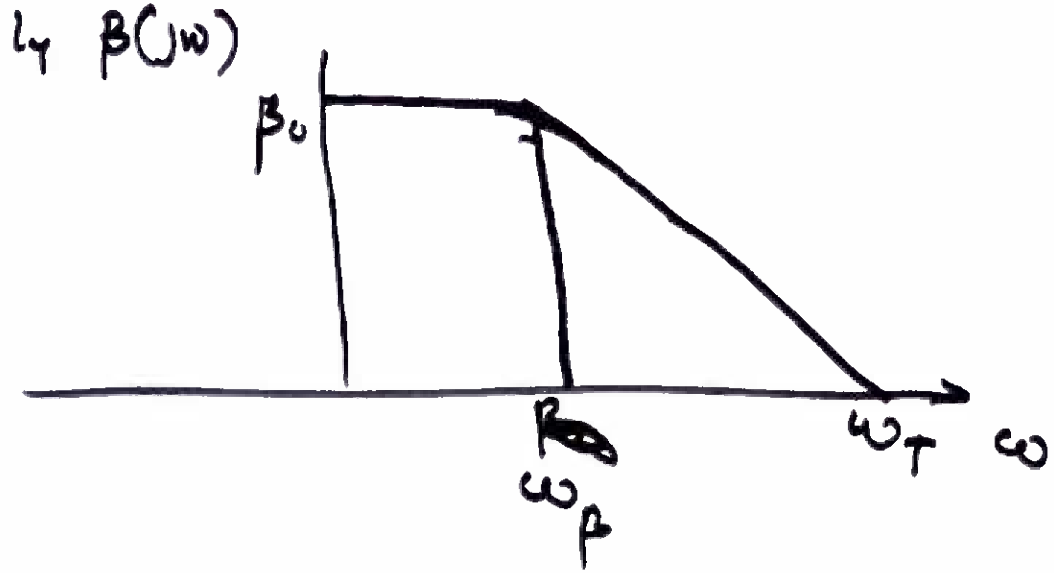
$$r_\pi (C_\pi + C_\mu)\omega_T = g_m r_\pi$$

$$\omega_T = \frac{g_m r_\pi}{r_\pi (C_\pi + C_\mu)} = \frac{\beta_0}{r_\pi (C_\pi + C_\mu)}$$

$$\omega_T = \frac{g_m}{(C_\pi + C_\mu)} = \frac{kT}{qI_C} \cdot \frac{qI_C/kT}{C_\pi + C_\mu} = \frac{g_m}{C_\pi}$$



$$V_{CE} = V_{CC} - I_C R_L$$



$$\omega_T \cong \beta_0 \omega_\beta$$