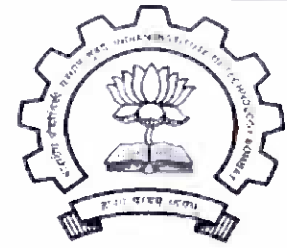


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## Numerical Values of BJT (npn) Parameters (Typical Case)



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Biasing :  $\rightarrow I_c = 1 \text{ mA}$      $V_{CB} = 3 \text{ V}$

$$V_{CS} = 5 \text{ V}$$

Capacitances : 1.  $C_{je0} = 10 \text{ fF}$  ,  $\phi_{0e} = 0.9 \text{ Volts}$  ,  $n_c = 1/2$

2.  $C_{\mu 0} = 10 \text{ fF}$  ,  $\phi_{0c} = 0.5 \text{ V}$  ,  $n_c = 1/3$

3.  $C_{cs0} = 20 \text{ fF}$  ,  $\phi_{0s} = 0.65 \text{ V}$  ,  $n_s = 1/3$

Others :  $\rightarrow \beta_0 = 100$  ,  $\tau_B = 10 \text{ ps}$  ,  $V_A = 20 \text{ V}$

Resistances :-  $r_{bb'} = 300 \Omega$  ,  $r_{es} = 5 \Omega$  ,  $r_c = 50 \Omega$  ,  $r_{\mu} = 10 \beta_0 r_o$

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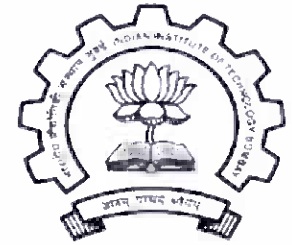
## Evaluations of Parameters

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

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

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

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



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$$5. C_{be} = g_m \tau_B = 38 \times 10^{-3} \times 10 \times 10^{-12} \\ = 0.38 \text{ pf}$$

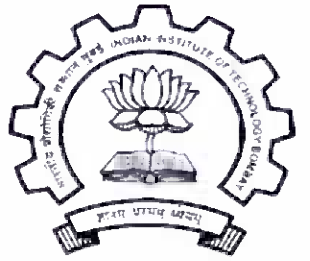
$$6. C_{\pi} = C_{be} + C_{je} = 0.38 \text{ pf} + 0.02 \text{ pf} = 0.4 \text{ pf}$$

$$7. r_{\pi} = \frac{\beta_0}{g_m} = \frac{100}{38 \text{ mA/V}} = 26 \text{ k}\Omega$$

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

$$9. r_{\mu} = 10 \beta_0 r_o = 10 \times 100 \times 20 \text{ k}\Omega = 20 \text{ M}\Omega$$

## BJT (Continued)



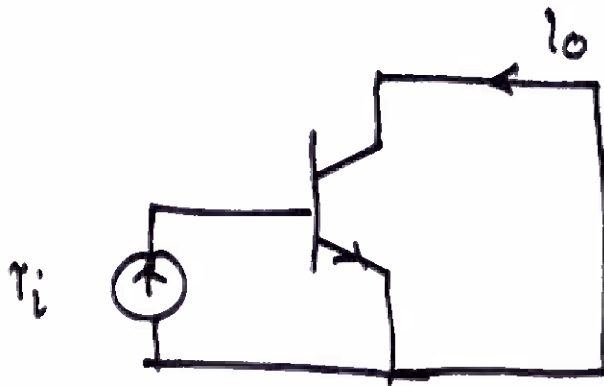
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## Figure of Merit of Transistor

' $f_T$ ' is called Figure of Merit which is also Common Emitter Current Gain falls to 'Unity' as frequency reaches  $f_T$ .

We define

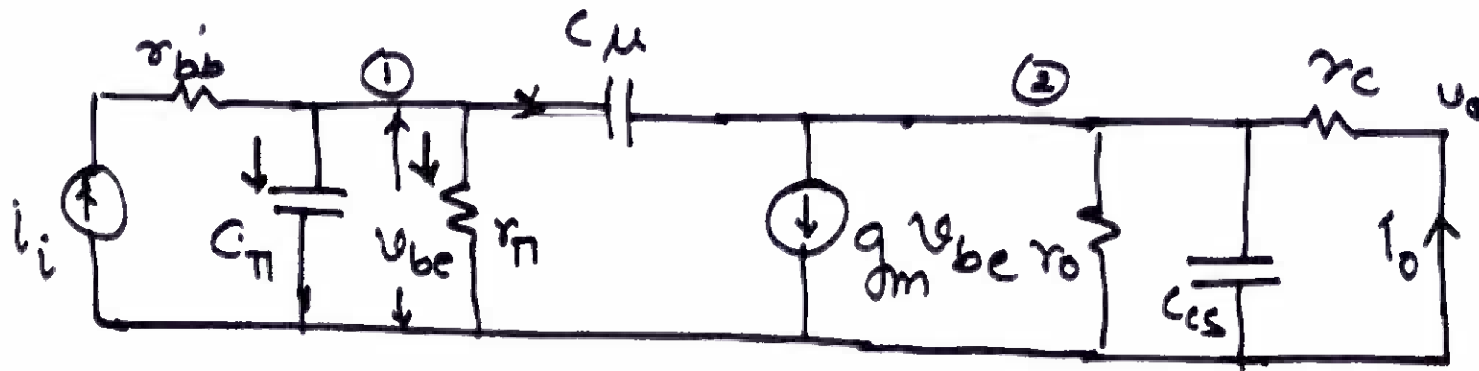
$$\beta(j\omega) = \frac{i_o(j\omega)}{i_i(\omega)}$$



## Equivalent Circuit



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

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

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

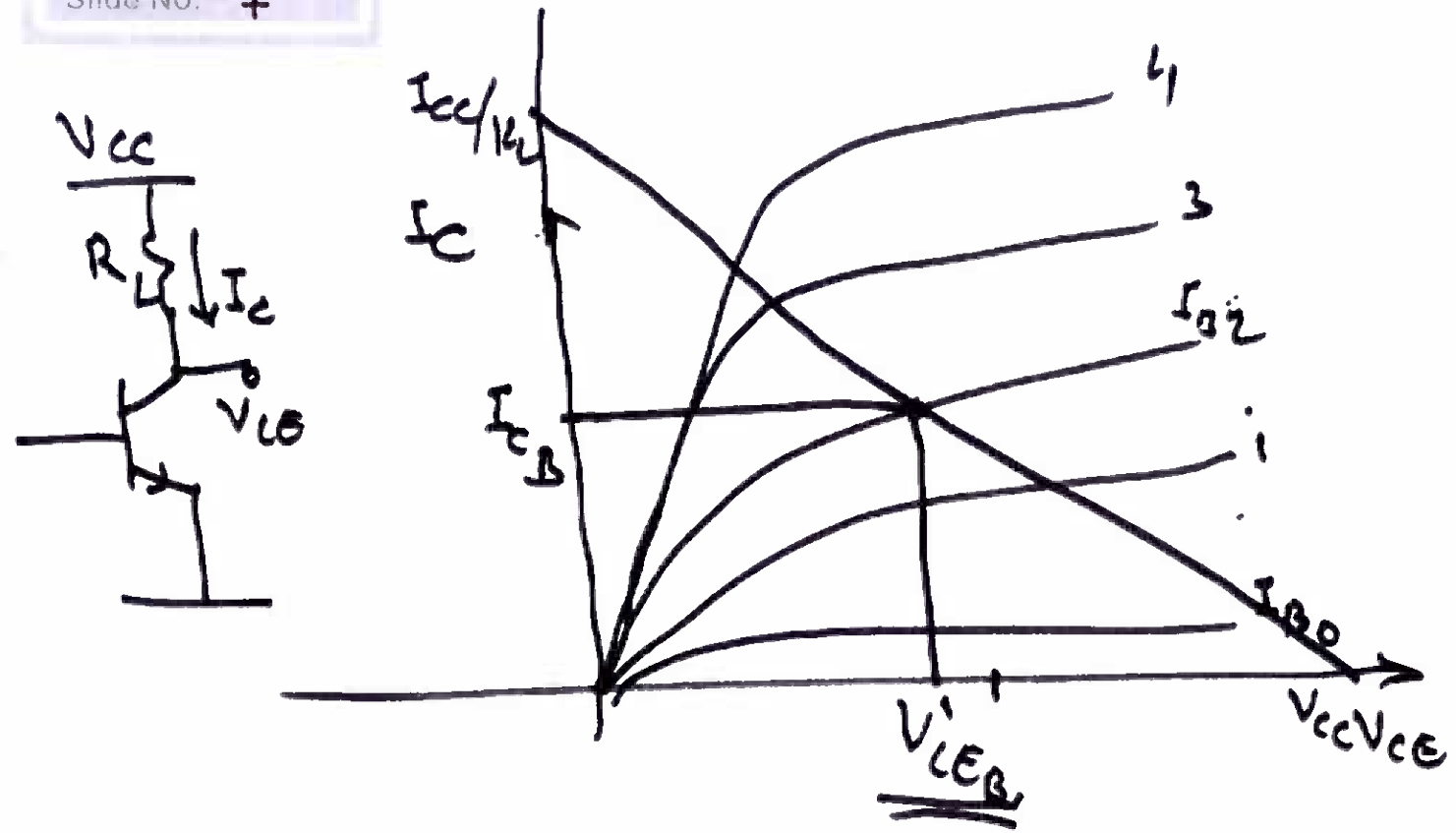


$$\text{At } \omega = \omega_T \quad |B(j\omega)| = 1$$

$$\cancel{1} \cdot r_{\pi} (C_{\pi} + C_{\mu}) \omega_T = g_m r_{\pi}$$

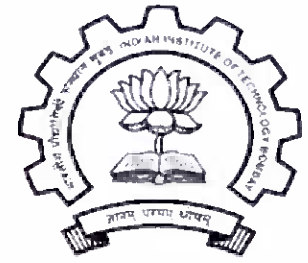
$$\omega_T = \frac{g_m r_{\pi}}{\cancel{1} r_{\pi} (C_{\pi} + C_{\mu})} = \frac{\beta_0}{r_{\pi} (C_{\pi} + C_{\mu})}$$

$$\omega_T = \frac{g_m}{(C_{\pi} + C_{\mu})} = \cancel{\frac{g_m}{C_{\pi} + C_{\mu}}} = \frac{g_m}{C_{in}}$$

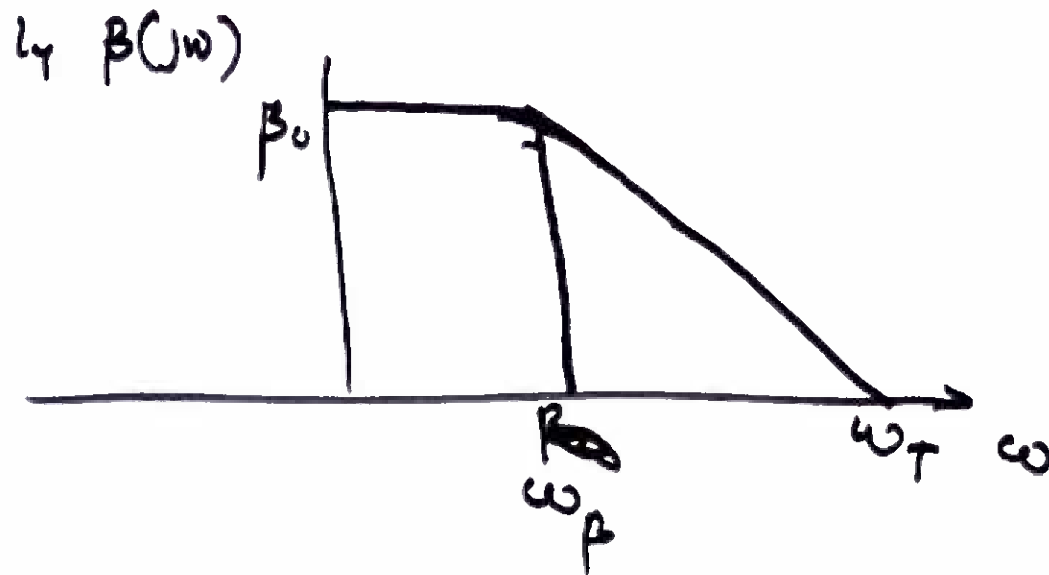


$$V_{CE} = V_{CC} - I_C R_L$$

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$$\omega_T \cong \beta_0 \omega_p$$

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