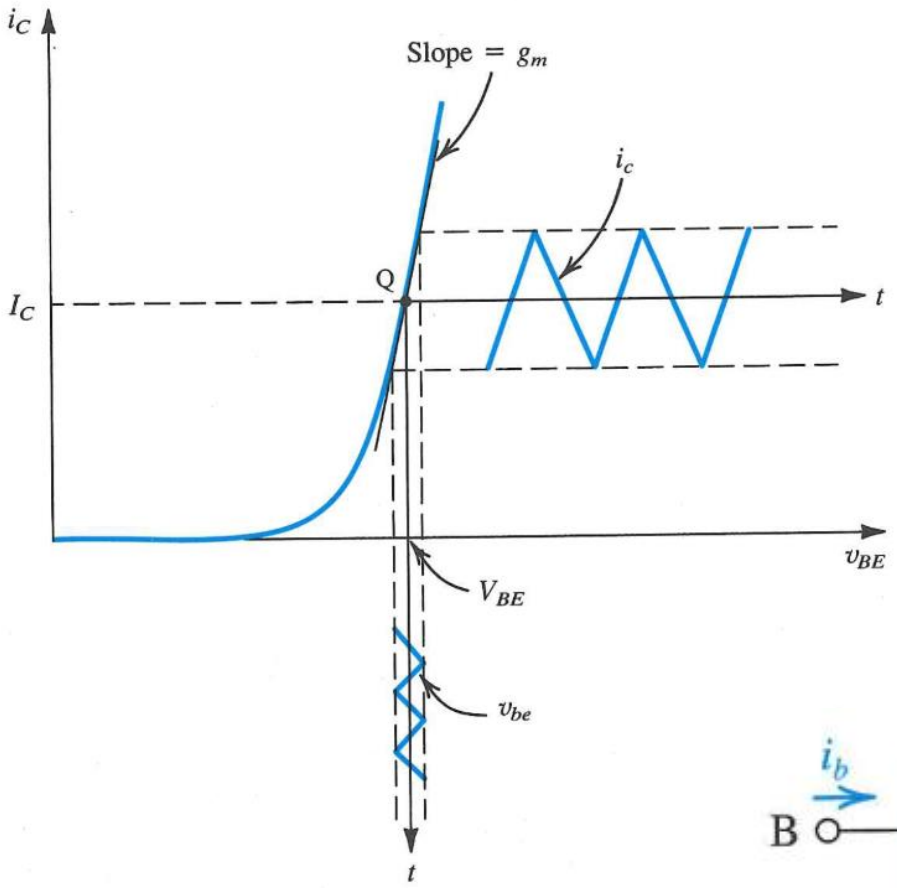


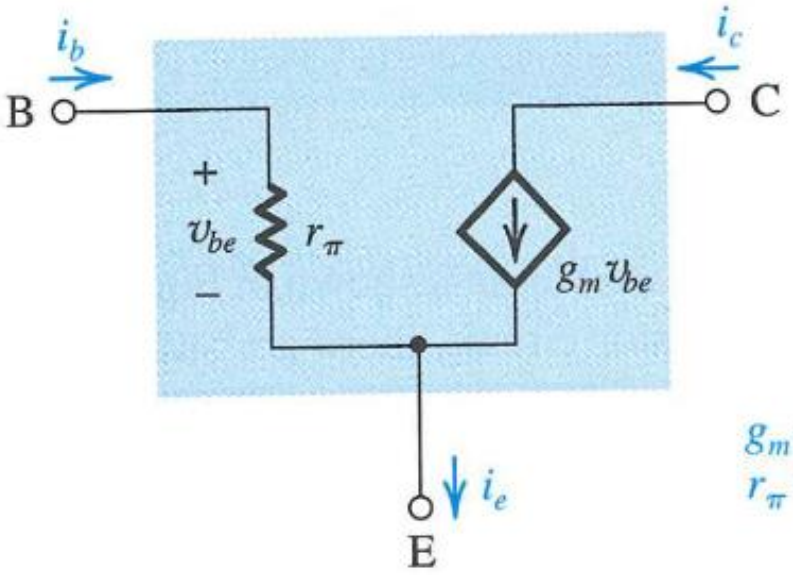
$$i_C = I_S e^{v_{BE}/V_T}$$

$$i_B = \frac{i_C}{\beta} = \left(\frac{I_S}{\beta}\right) e^{v_{BE}/V_T}$$

$$i_E = \frac{i_C}{\alpha} = \left(\frac{I_S}{\alpha}\right) e^{v_{BE}/V_T}$$

$$g_m = \left.\frac{\partial i_C}{\partial v_{BE}}\right|_{i_C = I_C}$$

Small-Signal Model for BJT (FA)



$$g_m = I_C/V_T$$

$$r_\pi = V_T/I_B = \beta/g_m$$

Ref: Sedra-Smith