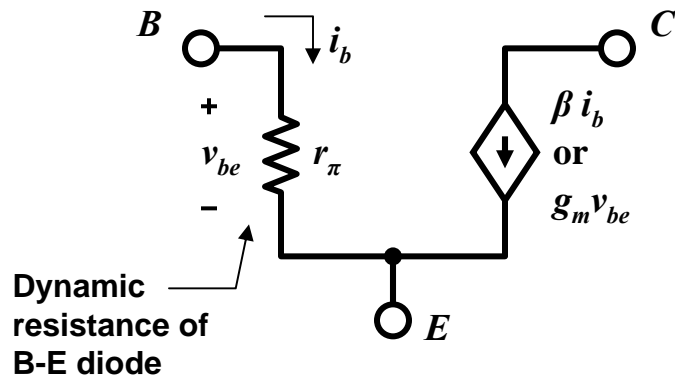
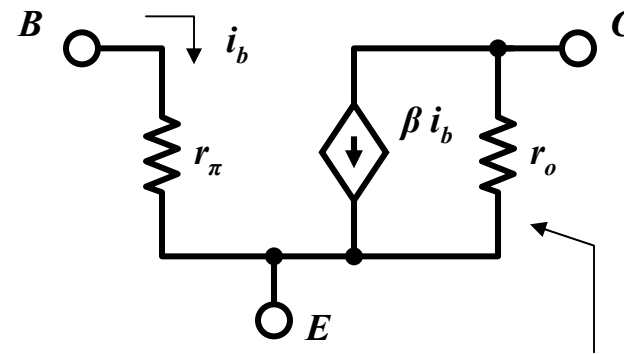


## Low-Frequency Model Linearized around bias-point in saturation

Ideal Case



With Output Resistance



$$r_{\pi} = \frac{V_T}{I_b} \quad V_T = \frac{k_B T}{q} \approx 25 \text{ mV at } 290\text{K}$$

DC bias current

$$r_o = |V_A| / I_c$$

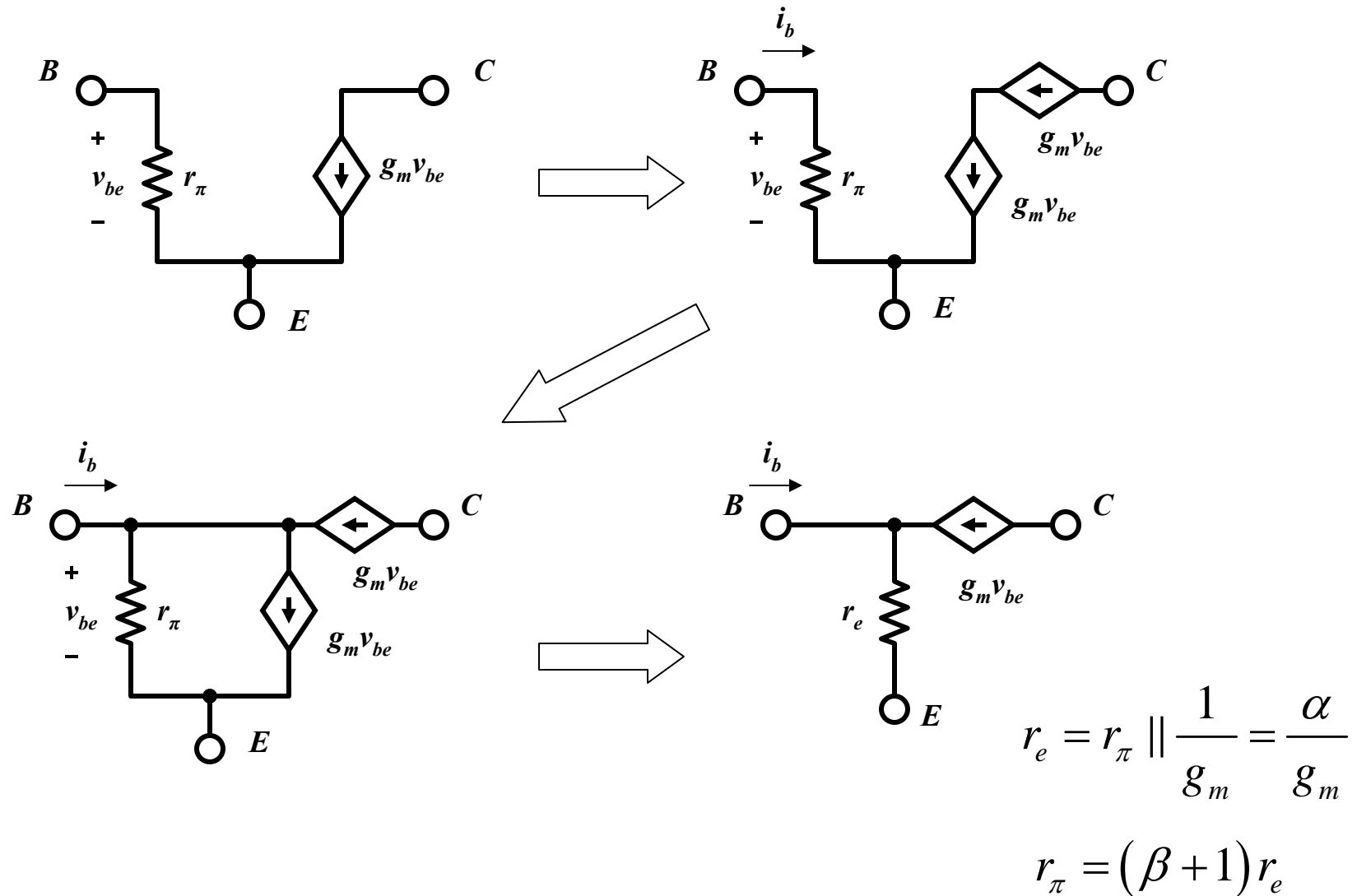
$$\beta i_b = \beta \frac{v_{be}}{r_{\pi}} = g_m v_{be} \quad g_m = \frac{\beta}{r_{\pi}} = \frac{I_c}{V_T}$$

$$I_C = \beta I_B = \alpha I_E$$

$$I_E = I_C + I_B = (\beta + 1) I_B$$

$$\alpha = \frac{\beta}{\beta + 1} \iff \beta = \frac{\alpha}{1 - \alpha}$$

# BJT T-model



# BJT Small-Signal Models (HF)

