

→ Região Ativa

- Modelo de Pequenos Sinais (Modelagem Linear)

$$I_{C0} = I_S \exp\left(\frac{V_{BE}}{V_T}\right) \left(1 + \frac{V_{CE}}{V_A}\right)$$

$$\frac{1}{r_o} = \frac{\partial I_{C0}}{\partial V_{CE}} = \frac{I_S \exp\left(\frac{V_{BE}}{V_T}\right)}{V_A}$$

Levando-se
em conta o
efeito Early

$$r_o = \frac{V_A}{I_C \exp\left(\frac{V_{BE}}{V_T}\right)} \approx \frac{V_A}{I_C}$$

Resistência Base-Emissor

$$g_{in} = \frac{1}{r_{\pi}} = \frac{\partial I_B}{\partial V_{BE}} = \frac{\partial}{\partial V_{BE}} \left[\frac{I_S}{\beta} \exp\left(\frac{V_{BE}}{V_T}\right) \right]$$

$$g_{in} = \frac{1}{r_{\pi}} = \frac{1}{V_T} \cdot \frac{I_S}{\beta} \exp\left(\frac{V_{BE}}{V_T}\right)$$

$$g_{in} = \frac{1}{r_{\pi}} = \frac{I_B}{V_T} \Rightarrow \boxed{r_{\pi} = \frac{V_T}{I_B}}$$