Small Signal Model

Notation.

$i_B(t)$ = total current $v_{BE}(t)$ = total Voltage

I_B = DC part

$i_b(t)$ = AC part

$i_B(t) = I_B + i_b(t)$

Sinusoids

$i_b(t) = I_b e^{j\omega t}$ or $i_b(t) = I_b \cos(\omega t + \phi)$

AC part, complex peak current, real peak, Phase

Base-Emitter Circuit

$$i_B(t) = \frac{I_s}{\beta} e^{v_{BE}(t)/V_T}$$

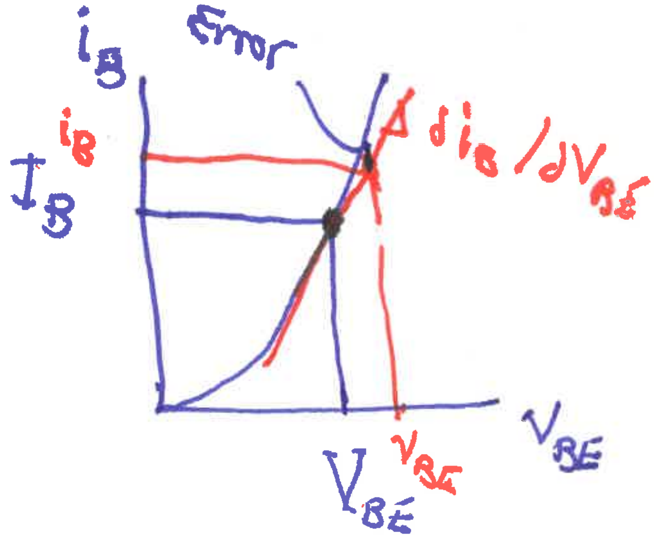
$$v_{BE} = V_{BE} + v_{be}(t)$$

AC part (small)

$$i_B(t) = \frac{I_s}{\beta} e^{V_{BE}/V_T} e^{v_{be}(t)/V_T}$$

$$= \frac{I_s}{\beta} e^{V_{BE}/V_T} \left(1 + \frac{v_{be}(t)}{V_T}\right)$$

T/



$$i_B(t) = I_B\left(1 + \frac{\cancel{I_B}\,1}{V_T} v_{be}(t)\right)$$

$$\cancel{I_B} + i_b(t) = \cancel{I_B} + \frac{I_B}{V_T} v_{be}(t)$$

For AC the "be" circuit looks like

$$r_\pi = \frac{V_T}{I_B} = \frac{\beta V_T}{I_C}$$

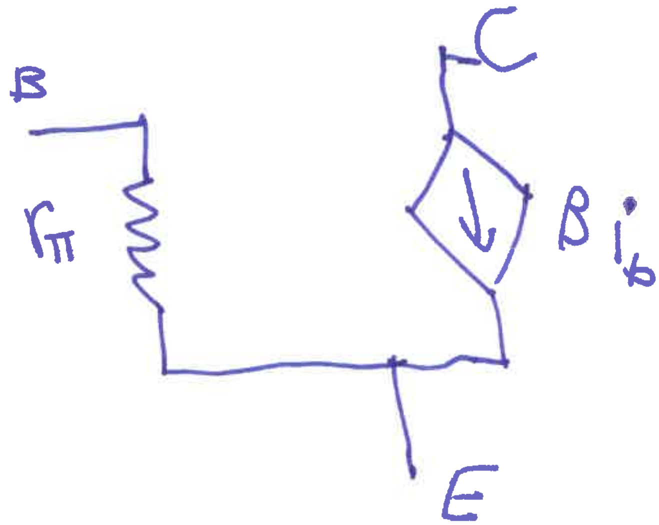
Collector current

$$i_C(t) = \beta\, i_B(t)$$

$$\underbrace{I_C + i_c(t) = \beta I_B}_{=} + \beta\, i_b(t)$$

$$i_c(t) = \beta\, i_b(t)$$

Pi model

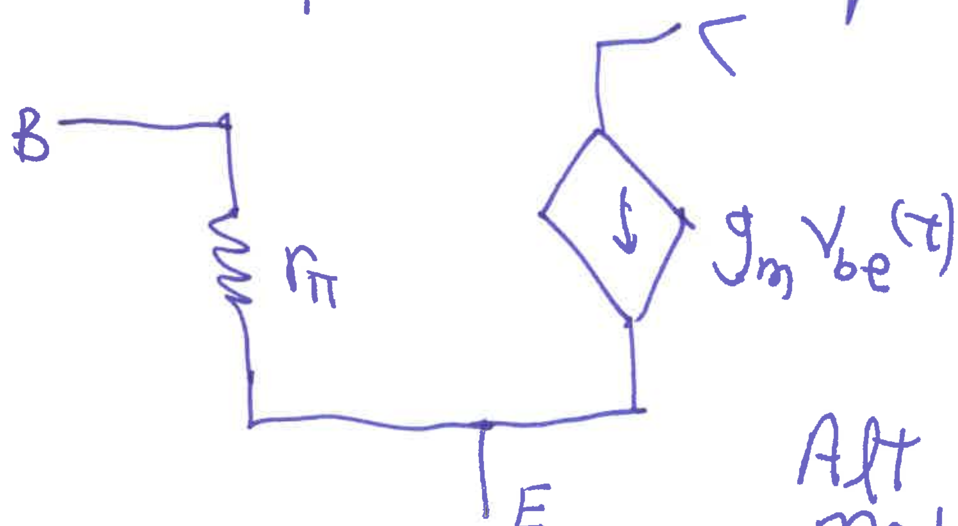


$$i_b(t) = \frac{v_{be}(t)}{r_\pi} \qquad i_c(t) = \frac{\beta}{r_\pi} v_{be}(t)$$

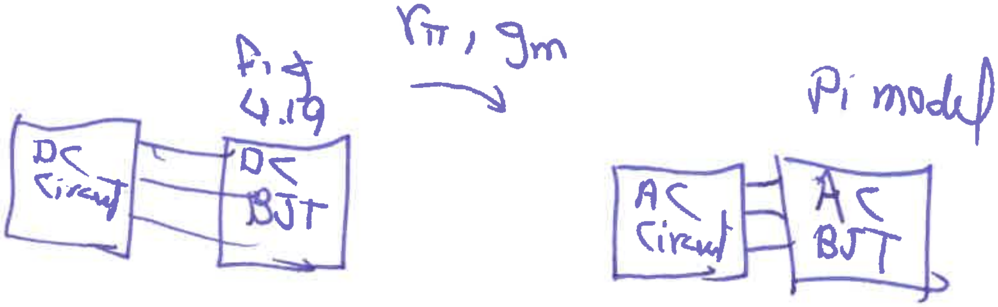
Transconductance

$$i_c(t) = g_m v_{be}(t) \qquad g_m = \frac{\beta}{r_\pi}$$

$$g_m = \frac{I_c}{V_T}$$ Independent of β, I_s



Alt Pi model



Numbers

$$g_m = \frac{I_C}{V_T} = \frac{1\,mA}{25\,mV} = 0.04\,\frac{A}{V}$$

$$r_\pi = \frac{\beta V_T}{I_C} = \frac{100 \times 25\,mV}{1\,mA} = 2.5K$$

AC Circuits

Common Emitter Amplifier