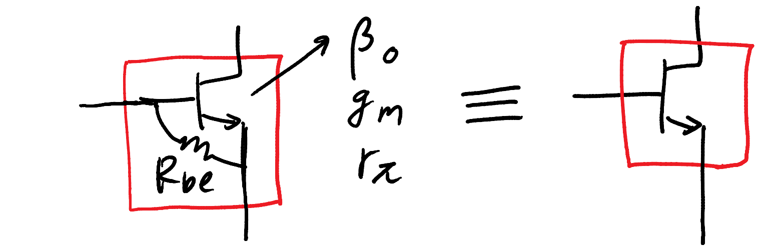
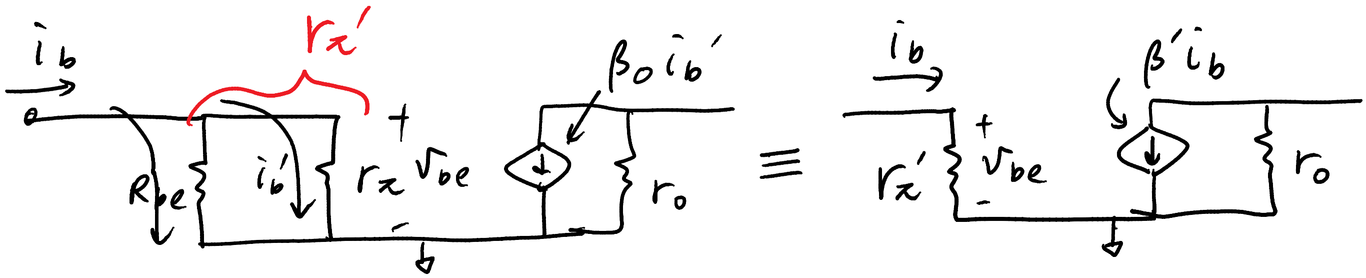
Discussion #2

Monday, February 06, 2012
4:21 AM

Problem: inspection formula for adding R_{be} parallel with r_π



what is the new β', g_m' & r_π'?



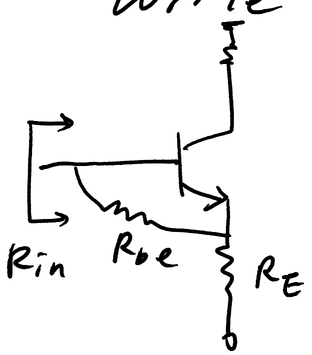
$$\beta' i_b = \beta_o i_b' = \beta_o \frac{R_{be}}{R_{be}+r_\pi} i_b$$

$$\Rightarrow \beta' = \boxed{\frac{R_{be}}{R_{be}+r_\pi}} \beta_o$$

$$r_\pi' = r_\pi \parallel R_{be} = \boxed{\frac{R_{be}}{R_{be}+r_\pi}} \cdot r_\pi$$

$$\underline{g_m r_\pi = \beta_o} \Rightarrow g_m' r_\pi' = \beta' \Rightarrow \boxed{g_m' = g_m}$$

Ex: Write the expression of R_{in} for



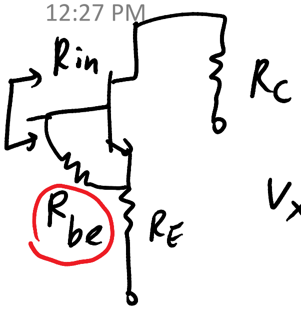
Method 1: small-signal analysis

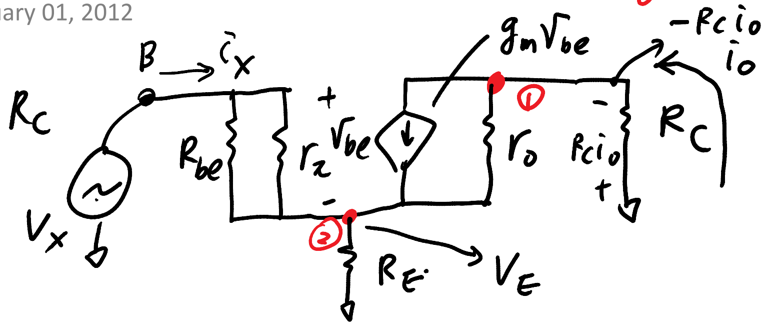
Method 2: use inspection formulas

Wednesday, February 01, 2012
12:27 PM

Method 1

Use Small-signal model





R_{in}'

β'

g_m'

① $g_m v_{be} = i_o + (V_E + R_C i_o) g_o$

② $\dfrac{V_x - V_E}{r_\pi'} + i_o = \dfrac{V_E}{R_E}$

② $i_o = V_E g_E - (v_x - v_E)\cdot g_\pi'$ — ③

$r_\pi' = r_\pi \| R_{be}$

$\Downarrow$

$$v_E g_o + (R_C g_o + 1)\left[v_E g_o - (v_x - v_E) g_\pi'\right] = g_m (v_x - v_E)$$

$$v_E\left[g_o + (1+g_o R_C) g_E + (1+g_o R_C) g_\pi' + g_m\right] = v_x\left[g_m + g_\pi'(1+g_o R_C)\right]$$

$v_E = \square\, v_x$

$$\square = \frac{g_m + g_\pi'(1+g_o R_C)}{g_o + (1+g_o R_C) R_E + (1+g_o R_C) g_\pi'}$$

$$R_{in} = \frac{V_x}{i_x} = \frac{v_x}{(v_x - v_E) g_\pi'}$$

$$= \frac{v_x}{(v_x - \square v_x) g_\pi'}$$

$$= \frac{1}{(1-\square) g_\pi'}$$

$$1 - \square = \frac{\dfrac{g_o}{1+g_o R_C} + g_E + g_m}{\dfrac{g_o + g_m}{1+g_o R_C} + g_m + g_\pi'}$$

if $r_o \to \infty$

$g_o \to 0$

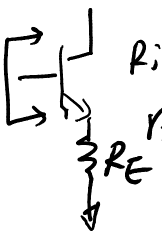
$$\frac{g_E}{g_m + g_E + g_\pi'}$$

Monday, February 06, 2012
4:20 AM

$$R_{in} = \frac{r_\pi'}{1-\square} = r_\pi' \cdot \frac{g_m + g_E + g_\pi'}{g_E}$$

$$= r_\pi' \left(\frac{g_m}{g_E} + 1 + \frac{g_\pi'}{g_E} \right)$$

$$= r_\pi' \left(1 + g_m R_E + g_\pi' \cdot R_E \right)$$



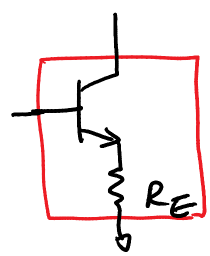
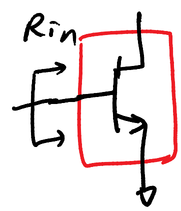
$R_{in} = r_\pi + (1+\beta) R_E$

$$= r_\pi' + g_m R_E r_\pi' + R_E$$

$$= r_\pi' + (1 + \underline{g_m r_\pi'}) R_E \quad \text{———} \quad (*)$$

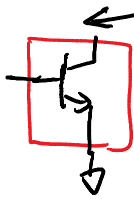
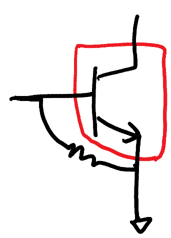
where $r_\pi' = r_\pi \,//\, R_{be}$

Method 2: use inspection formulas

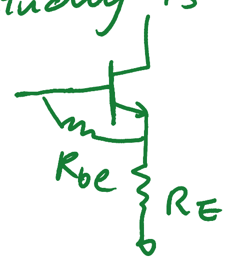
 g_m, β, r_π +  R_E =  $\equiv$ 

(HW#2)

However, we know $\boxed{R_{in} = r_\pi + (1+\beta) R_E}$

Then use  +  = 

actually is



adding R_{be} yields
$$\left.\begin{aligned} \beta' &= \frac{R_{be}}{R_{be}+r_\pi} \beta_o \\ r_\pi' &= \frac{R_{be}}{R_{be}+r_\pi} r_\pi \end{aligned}\right\} \text{inspection formulas}$$

$\Rightarrow R_{in} = r_\pi' + (1+\beta') R_E$ —— same result as $(*)$