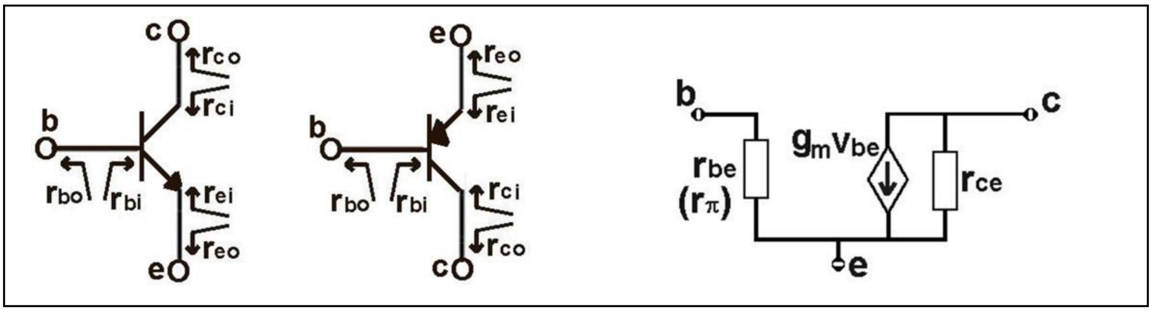


For BJT: $g_m = \dfrac{I_{CQ}}{V_T}$ $\qquad r_{be} = r_\pi = \dfrac{\beta_F}{g_m}$

$$\frac{V_C}{V_b} = -g_m \frac{r_{ce}^2}{g_m r_{eo} r_{ce}^2 + r_{ce}^2 + r_{eo} r_{ce}} (r_{cN}//r_{co})$$

$$r_{cN} = r_{ce} + r_{be}//r_{eo} + g_m (r_{be}//r_{eo}) r_{ce} \qquad (r_{cN} \neq r_{ci}) \qquad (r_{bo} = 0 \to r_{cN} = r_{ci})$$

$$r_{co} << r_{cN} \text{ and } r_{eo} << r_{ce} \to \frac{v_c}{v_b} \cong -\frac{g_m r_{co}}{1 + g_m r_{eo}}$$

**************************************

$$\frac{v_e}{v_b} = g_m \frac{\dfrac{r_{eo}}{1 + g_m r_{eo}} \dfrac{r_{cN}}{r_{cN} + r_{co}} + \dfrac{r_{eo}}{\beta_F}}{1 + g_m \dfrac{r_{eo}}{\beta_F}}$$

$$r_{co} \ll r_{cN} \text{ and } g_m r_{eo} \ll \beta_F \to \frac{v_e}{v_b} \cong \frac{g_m r_{eo}}{1 + g_m r_{eo}}$$

*******************************************

$$\frac{v_c}{v_e} = \left( \frac{g_m}{1 + g_m \dfrac{r_{bo}}{\beta_F}} + \frac{1}{r_{ce}} \right) (r_{ce}//r_{co})$$

$$r_{co} \ll r_{ce} \text{ and } \frac{1}{r_{ce}} \ll \frac{g_m}{1 + g_m \dfrac{r_{bo}}{\beta_F}} \to \frac{v_c}{v_e} \cong \frac{g_m r_{co}}{1 + g_m \dfrac{r_{bo}}{\beta_F}}$$

**********************************************

$$r_{ei} = \left[ \frac{1}{g_m} \frac{\left(1 + g_m \dfrac{r_{bo}}{\beta_F}\right)(r_{ce} + r_{co})}{\dfrac{1}{g_m} + \dfrac{r_{bo}}{\beta_F} + r_{ce}} \right] // [r_{be} + r_{bo}]$$

$$r_{co} \ll r_{ce} \text{ and } \frac{\beta_F + g_m r_{bo}}{\beta_F} \ll g_m r_{ce} \to r_{ei} \cong \frac{1}{g_m} + \frac{r_{bo}}{\beta_F}$$

*************************************************

$$r_{bi} = r_{be} \frac{r_{be} + r_{eo} + \beta_F r_{eo} + g_m r_{ce}^2}{r_{be} + g_m r_{eo} r_{be} - g_m r_{eo} r_{be} \dfrac{r_{CN}}{r_{CN} + r_{co}}}$$

$$r_{co} \ll r_{CN} \text{ and } g_m r_{eo} \ll \beta_F \to r_{bi} \cong \beta_F \left( \frac{1}{g_m} + r_{eo} \right)$$

******************************************************

$$r_{ci} = r_{ce} + \frac{g_m r_{ce} r_{be} r_{eo}}{r_{eo} + r_{be} + r_{bo}} + \frac{r_{eo}(r_{be} + r_{bo})}{r_{eo} + r_{be} + r_{bo}}$$

$$r_{eo} \ll (r_{be} + r_{bo}) \to r_{ci} \cong r_{ce} + \frac{g_m r_{ce} r_{be} r_{eo}}{r_{be} + r_{bo}} + r_{eo}$$

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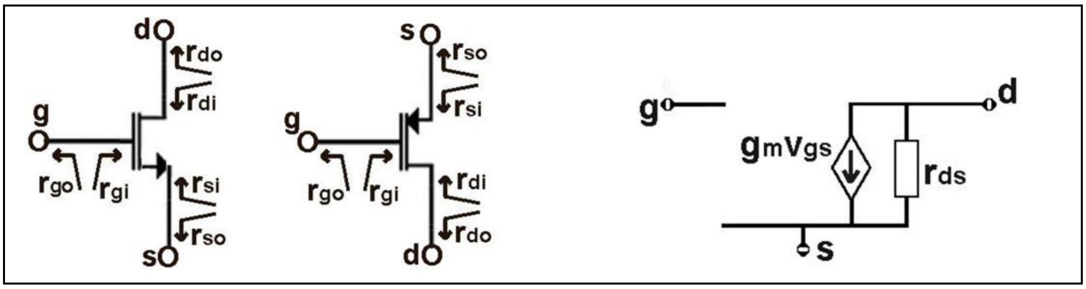


$$For\ MOSFET: g_m = \sqrt{2\beta I_{DQ}} \qquad r_{gs} = \infty$$

$$d \leftrightarrow c, \quad s \leftrightarrow e, \quad b \leftrightarrow g$$

$$(\beta_F = \infty), (r_{gs} \equiv r_{be}), (r_{ds} \equiv r_{ce}), (r_{gi} \equiv r_{bi}), (r_{go} \equiv r_{bo}), (r_{si} \equiv r_{ei}), (r_{so} \equiv r_{eo}), (r_{di} \equiv r_{ci}), (r_{do} \equiv r_{co})$$

$$\frac{V_d}{V_g} = -g_m \frac{r_{ds}^2}{g_m r_{so} r_{ds}^2 + r_{ds}^2 + r_{so} r_{ds}} (r_{di}//r_{do})$$

$$r_{di} = r_{ds} + r_{so} + g_m r_{so} r_{ds}$$

$$r_{do} << r_{di} \text{ and } r_{so} << r_{ds} \rightarrow \frac{v_d}{v_g} \cong -\frac{g_m r_{do}}{1 + g_m r_{so}}$$

***************************************

$$\frac{v_s}{v_g} = \frac{g_m r_{so}}{1 + g_m r_{so}} \frac{r_{di}}{r_{di} + r_{do}}$$

$$r_{do} \ll r_{di} \rightarrow \frac{v_s}{v_g} \cong \frac{g_m r_{so}}{1 + g_m r_{so}}$$

********************************************

$$\frac{v_d}{v_s} = \left(g_m + \frac{1}{r_{ds}}\right)(r_{ds}//r_{do})$$

$$r_{do} \ll r_{ds} \text{ and } \frac{1}{r_{ds}} \ll g_m \rightarrow \frac{v_c}{v_e} \cong g_m r_{do}$$

***********************************************

$$r_{si} = \left[\frac{1}{g_m} \frac{(r_{ds} + r_{do})}{\frac{1}{g_m} + r_{ds}}\right]$$

$$r_{do} \ll r_{ds} \text{ and } \frac{1}{g_m} \ll r_{ds} \rightarrow r_{si} \cong \frac{1}{g_m}$$

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$$r_{gi} = \infty$$

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$$r_{di} = r_{ds} + g_m r_{so} r_{ds} + r_{so}$$

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