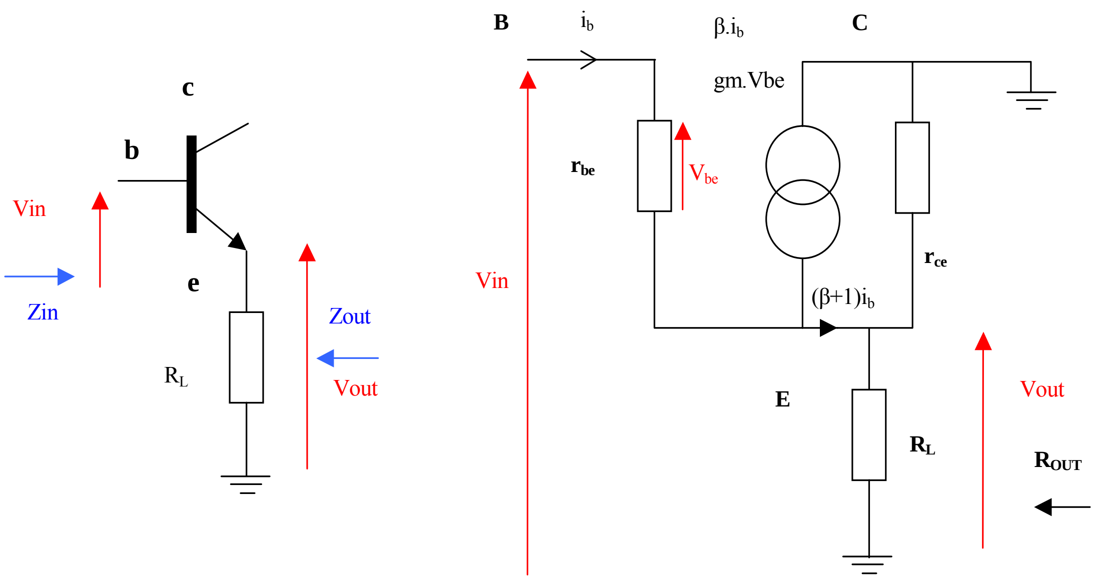
Common-Collector/Drain Circuits

Common-Collector Drain BJT Circuit

Figure 1 below shows the simplied ‘Pi’ model of a common-collector BJT.



$$R_L' = \frac{rce.R_L}{rce + R_L} \qquad \frac{1}{R_L'} = \frac{1}{rce} + \frac{1}{R_L} = go + g_L$$

$$R_{IN} = \frac{V_{IN}}{I_{IN}} = \frac{V_{be} + V_{RL}}{I_{IN}} = \frac{r_{be}.I_b + R_L'(\beta+1).I_b}{I_b} = r_{be} + R_L'(\beta+1) \approx \beta.R_L'$$

$$R_{OUT} = \frac{V_{OUT}}{I_{OUT}} = \frac{(\beta+1).i_b.R_L'}{(\beta+1).i_b} = R_L' = \frac{rce.R_L}{rce + R_L} \quad \text{if } R_L << rce \text{ then } R_{OUT} \approx rce$$

$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{R_L'(\beta+1).I_b}{r_{be}.I_b + R_L'(\beta+1).I_b} = \frac{R_L'(\beta+1)}{r_{be} + R_L'(\beta+1)} \quad \text{divide top \& bottom by } (\beta+1)$$

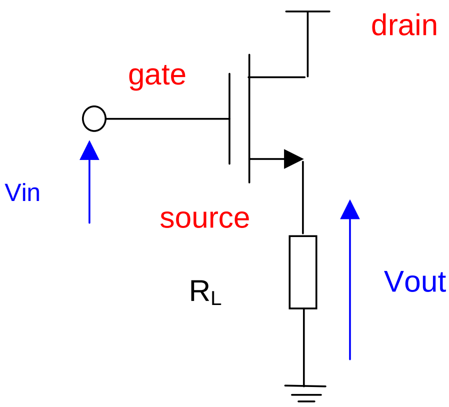
$$A_V = \frac{R_L'}{\frac{r_{be}}{(\beta+1)} + R_L'} \qquad r_{be} = \frac{\beta}{gm} \quad \therefore A_V = \frac{R_L'}{\frac{1}{gm}.\frac{\beta}{(\beta+1)} + R_L'} \quad \text{from above } \frac{1}{R_L'} \approx go + g_L$$

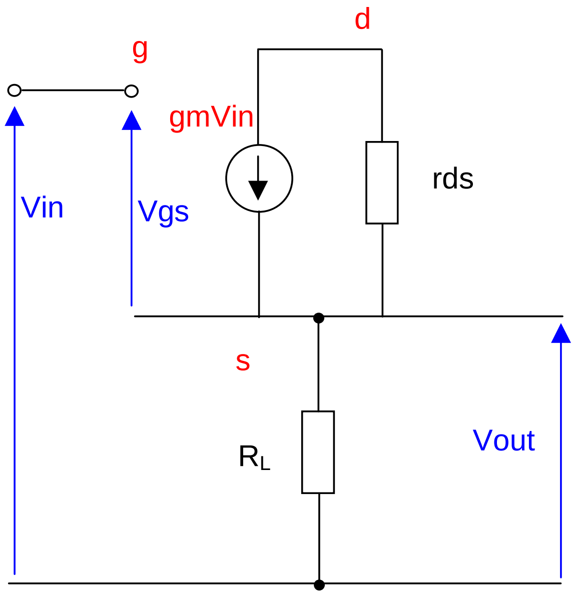
$$A_V = \frac{\frac{1}{go+g_L}}{\frac{go+g_L}{gm}.\frac{\beta}{(\beta+1)} + \frac{1}{go+g_L}} \quad \text{Multiply top \& bottom by } go+g_L \quad = \frac{1}{\frac{go+g_L}{gm}.\frac{\beta}{(\beta+1)} + 1}$$

Let $\alpha = \dfrac{\beta}{\beta + 1}$ and let $\delta = \dfrac{go + g_L}{gm}$ $\quad A_V = \dfrac{1}{1 + \alpha.\delta}$

$$A_i = \frac{I_{OUT}}{I_{IN}} = \frac{(\beta + 1).i_b}{i_b} = (\beta + 1) \approx \beta$$

Common-Drain MOS FET Circuit





Voltage Gain A_v

$$Av = \frac{V_o}{V_{IN}} = \frac{V_O}{V_{gs} + V_O}$$

$Vo = gmV_{gs}(r_{ds}//R_L)$ $\quad Av = \dfrac{gmVgs(r_{ds}//R_L)}{Vgs + gmVgs(r_{ds}//R_L)}$ divide top & bottom by Vgs

$Av = \dfrac{gm(r_{ds}//R_L)}{1 + gm(r_{ds}//R_L)}$ $\quad Av = gm(r_{ds}//R_L)$ Therefore, $Av = \dfrac{A}{1 + A} \approx 1$

Input Resistance

$R_{IN} = \infty$

Output Resistance

$$R_{OUT} = \frac{V_O}{I_O} = \frac{1}{gm}$$

Current Gain A_i

$A_i = \infty$