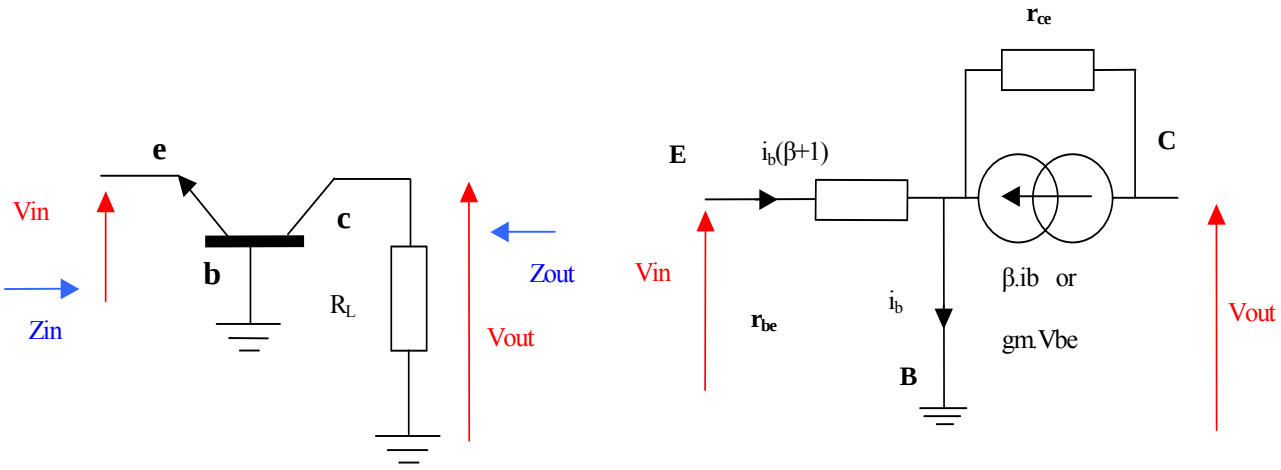
Common-Base/Gate Circuits

Common-Base BJT circuit

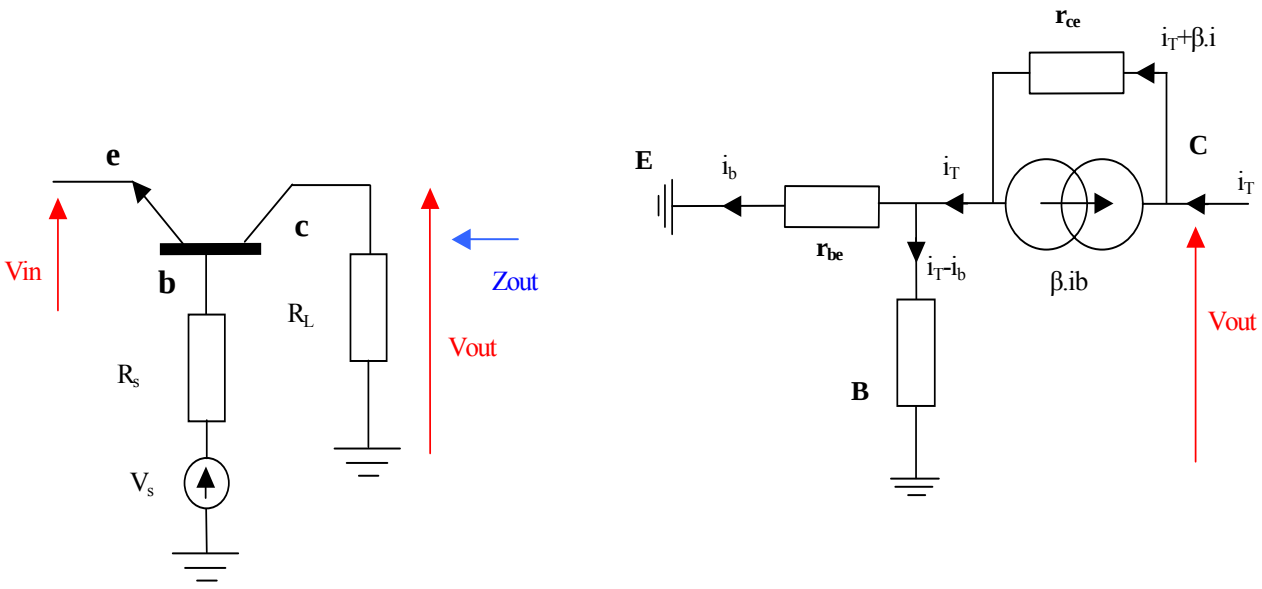
The figure below shows the simplied 'Pi' model of a common-base BJT.



$$R_{IN} = \frac{V_{IN}}{I_{IN}} = \frac{i_b(\beta+1).r_{be}}{i_b(\beta+1)} = r_{be} = \frac{1}{gm} \quad \text{where } gm = \frac{I_{CQ}}{V_T}$$

$$A_V = \frac{V_{OUT}}{V_{IN}} = \frac{\beta.i_b.r_{ce}}{i_b(\beta+1)r_{be}} = \frac{\beta.r_{ce}}{(\beta+1)r_{be}} \approx \frac{r_{ce}}{r_{be}} = \frac{I_{CQ}}{V_T}.\frac{V_A}{I_{CQ}} = \frac{V_A}{V_T} \quad \left(\text{as } \frac{1}{gm} = r_{ce}\right)$$

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



To determine the Output impedance of the circuit we can connect a voltage source (V_s + R_s) to the base and ground the input ie the emitter. We then have to resistances in parallel connected to the current source $\beta.i_b$.

$$R_{OUT} = \frac{V_{OUT}}{i_T}$$

$$V_{OUT} = (i_T + \beta.i_b)r_{ce} + i_b.r_{be}$$

$$\text{Also } i_b = i_T \frac{R_s}{r_{be} + R_s} \quad \text{sub into above equation}$$

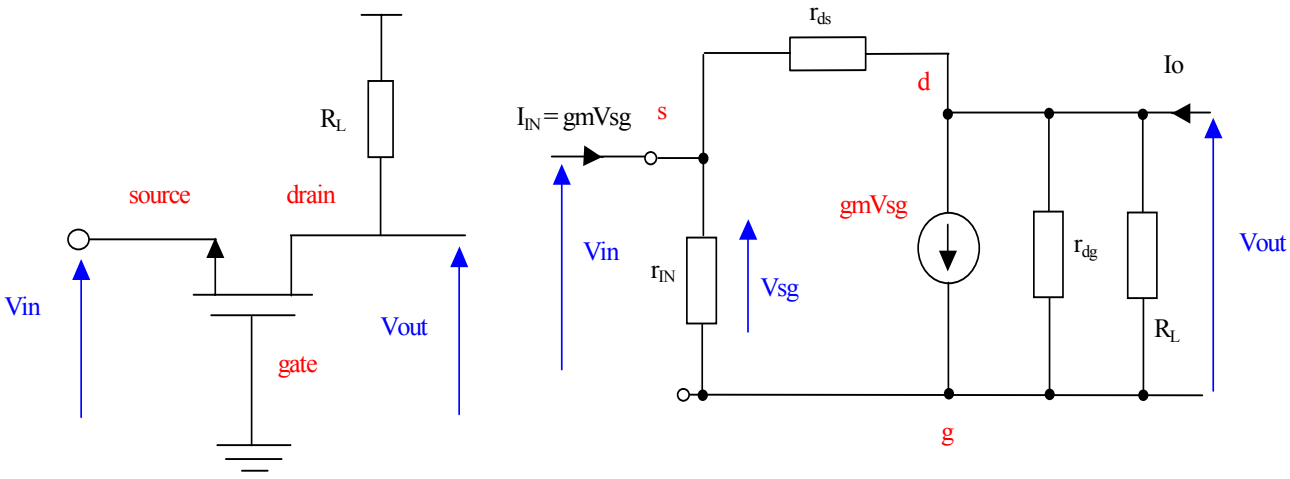
$$V_{OUT} = \left(i_T + \beta.i_T \frac{R_s}{r_{be} + R_s}\right) r_{ce} + i_T \frac{R_s}{r_{ce} + R_s}.r_{be}$$

$$R_{OUT} = \frac{V_{OUT}}{i_T} = r_{ce} + \beta.r_{ce} \frac{R_s}{r_{be} + R_s} + \frac{R_s.r_{be}}{r_{be} + R_s}$$

$$\text{If } R_s = 0 \text{ then } R_{OUT} = r_{ce}$$

$$\text{If } R_s = \text{large then } R_{OUT} = r_{ce} + \beta.r_{ce} + 1 = (\beta + 1)r_{ce}$$

Common-Gate MOSFET Circuit



Voltage Gain A_v

$$A_V = \frac{V_O}{V_{IN}} \qquad V_{IN} = Vsg$$

$$V_O = gmVsg\left(r_{dg} // R_L\right) \quad A_V = gm\left(\frac{r_{dg}.R_L}{r_{dg} + R_L}\right)$$

Input Resistance

$$R_{IN} = \frac{V_{IN}}{I_{IN}} = \frac{Vgs}{gmVgs} = \frac{1}{gm} = I_D\lambda$$

Output Resistance

As the source is low impedance ie close to ground for R_{OUT} – r_{ds} appears to be connected across r_{ds} to ground.

$$R_{OUT} = \frac{V_O}{I_O} = r_{dg} // r_{ds}$$

Current Gain A_i

$A_i = 1$