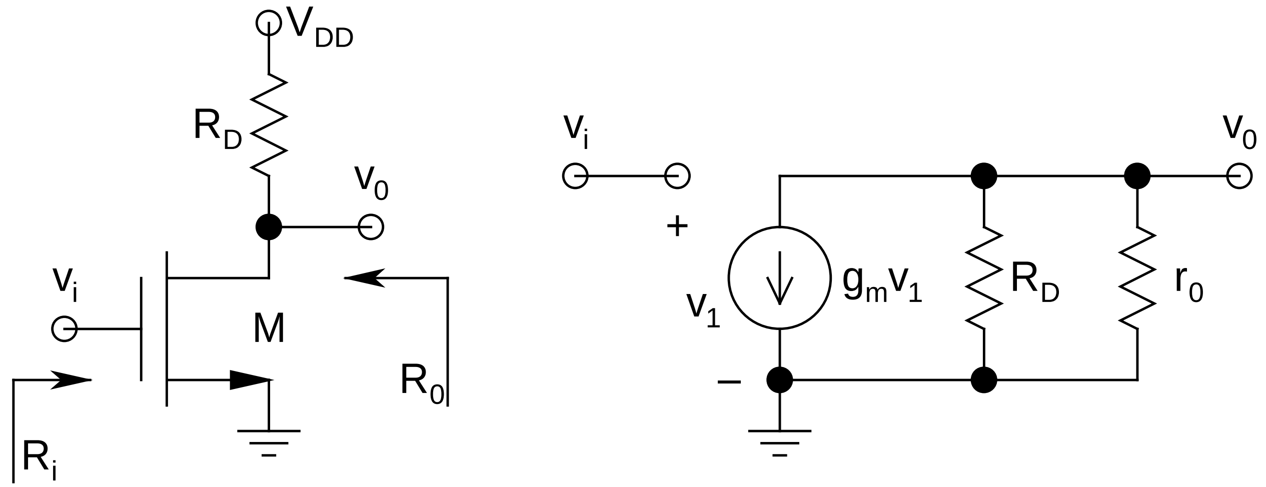
- ***Common-Source*** (CS):



ac Schematic **ac Low-Frequency Equivalent**

- ***Biasing circuit not shown***
- ***Body at ground*** $\Rightarrow$ ***No body effect***

- By inspection, ***Voltage Gain***:

$$A_v = \frac{v_0}{v_i} = \frac{-g_m v_1 \left(R_D \parallel r_0\right)}{v_i} = -g_m \left(R_D \parallel r_0\right)$$

- The ***negative sign*** in front implies ***180° phase shift*** between v_i and v_0
  - ***v_i and v_0 are exactly out of phase***
- For ***discrete circuits***, in general, $R_D << r_0$

  $\Rightarrow A_v = -g_m R_D$ (***moderate***)
- ***Input Resistance***: $R_i \rightarrow \infty$
- ***Output Resistance***: $R_0 = R_D \| r_0 \approx R_D$
- ***Note the remarkable similarity with CE stage***

- If $R_D >> r_0$:

  $A_v = -g_m r_0 = -k_N V_{GT}/(\lambda I_D) = -2/[\lambda(\Delta V)]$

  (***assuming $\lambda V_{DS} < 0.1$***)

- Thus, ***for small λ and small ΔV***, ***A_v can be large***

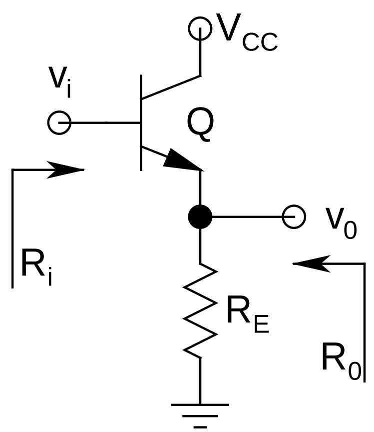
  - Keep in mind that ***$\Delta V(min) = 3V_T$***

- Also, $A_v \propto 1/\sqrt{I_D}$

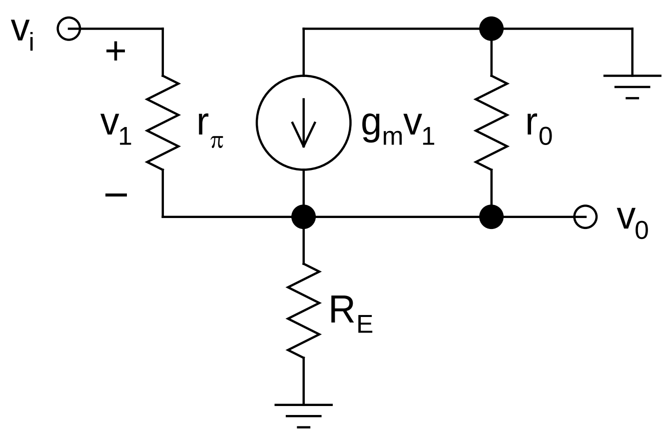
  $\Rightarrow$ ***Lower I_D***, ***higher A_v***

- ***Recall***: For ***CE stage***, A_v(max) was ***independent of I_C***, and ***dependent only on T***

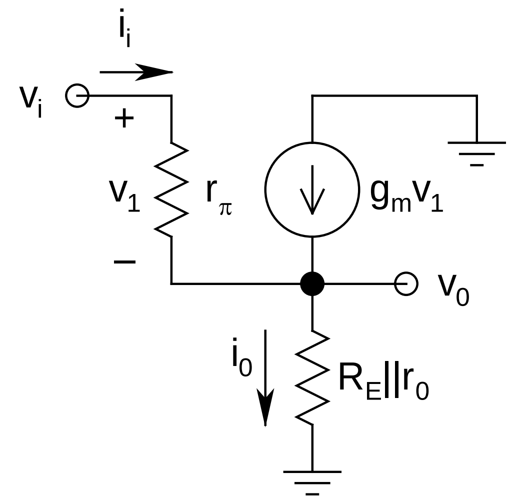
- ***Common-Collector*** (CC):
  - Also known as ***Emitter-Follower***



ac Schematic



ac Low-Frequency Equivalent



Simplified ac Low-Frequency Equivalent

- ***Biasing circuit not shown***

- ***Voltage Gain***:

$$A_v = \frac{v_0}{v_i} = \frac{i_0\left(R_E \parallel r_0\right)}{v_1 + v_0} = \frac{\left(\beta+1\right)i_i\left(R_E \parallel r_0\right)}{i_i r_\pi + \left(\beta+1\right)i_i\left(R_E \parallel r_0\right)}$$

$$= \frac{R_E \parallel r_0}{r_\pi/\left(\beta+1\right) + \left(R_E \parallel r_0\right)} = \frac{R_E \parallel r_0}{r_E + \left(R_E \parallel r_0\right)}$$

- Now, in general, $r_0 >> R_E$

  $\Rightarrow A_v = R_E/(r_E + R_E)$

- ***Two important observations***:
  - ***$A_v \leq 1$***
  - ***No phase shift between v_i and v_0***