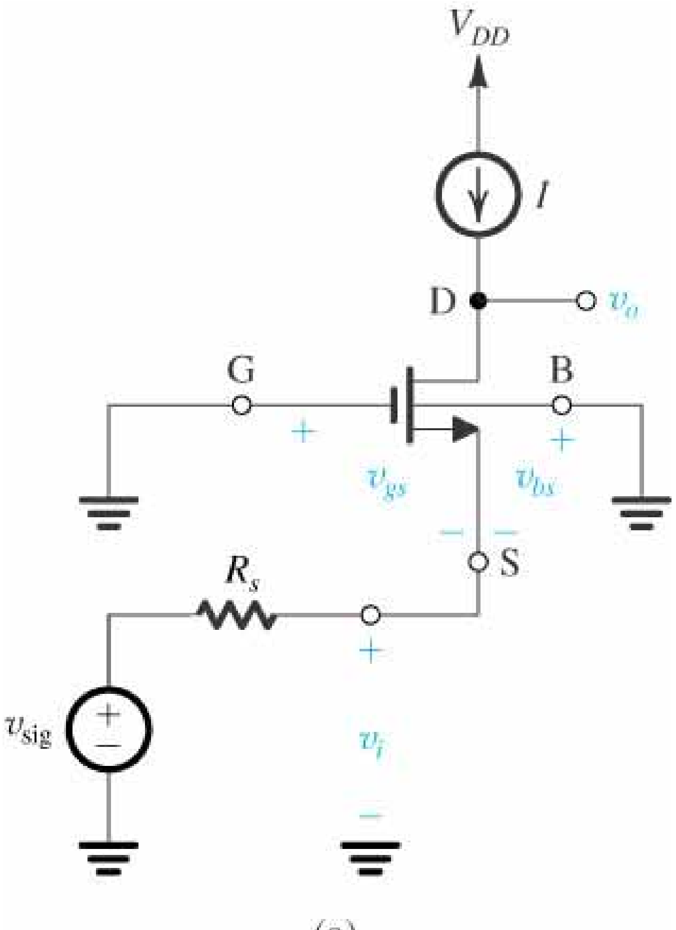
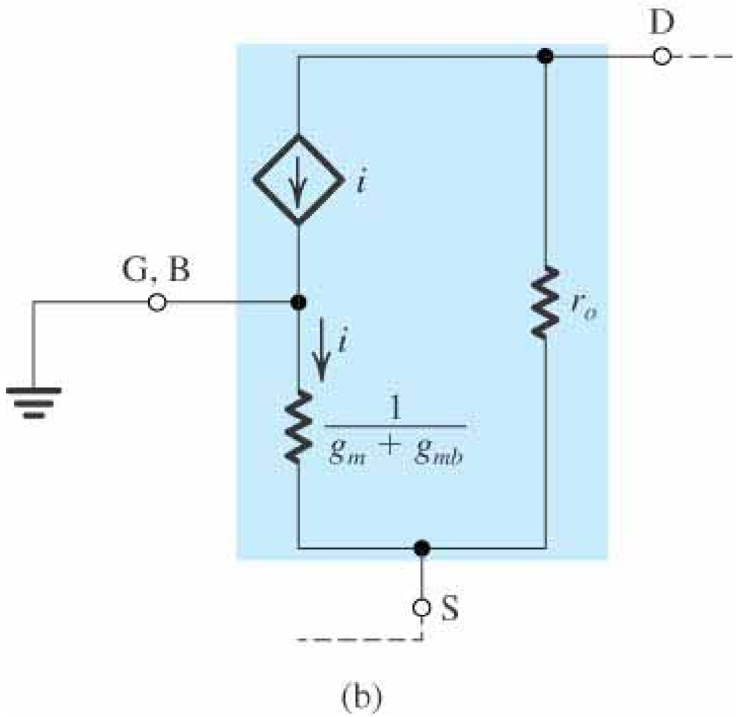
Outline

- Comparison between the MOS and the BJT
- From **discrete** circuit to **integrated** circuit
  - Philosophy, Biasing, …etc.
- Frequency response
- The **C**ommon-**S**ource and **C**ommon-**E**mitter amplifier with active loads
- The **C**ommon-**G**ate and **C**ommon-**B**ase amplifier with active load
- The **S**ource and **E**mitter **F**ollower
- The CS and CE amplifier with **source degeneration**
- Current mirrors with improved performance
- **Cascode** amplifier and **transistor pairings**

6-5 Common-Gate and Common-Base amplifers with acitive loads

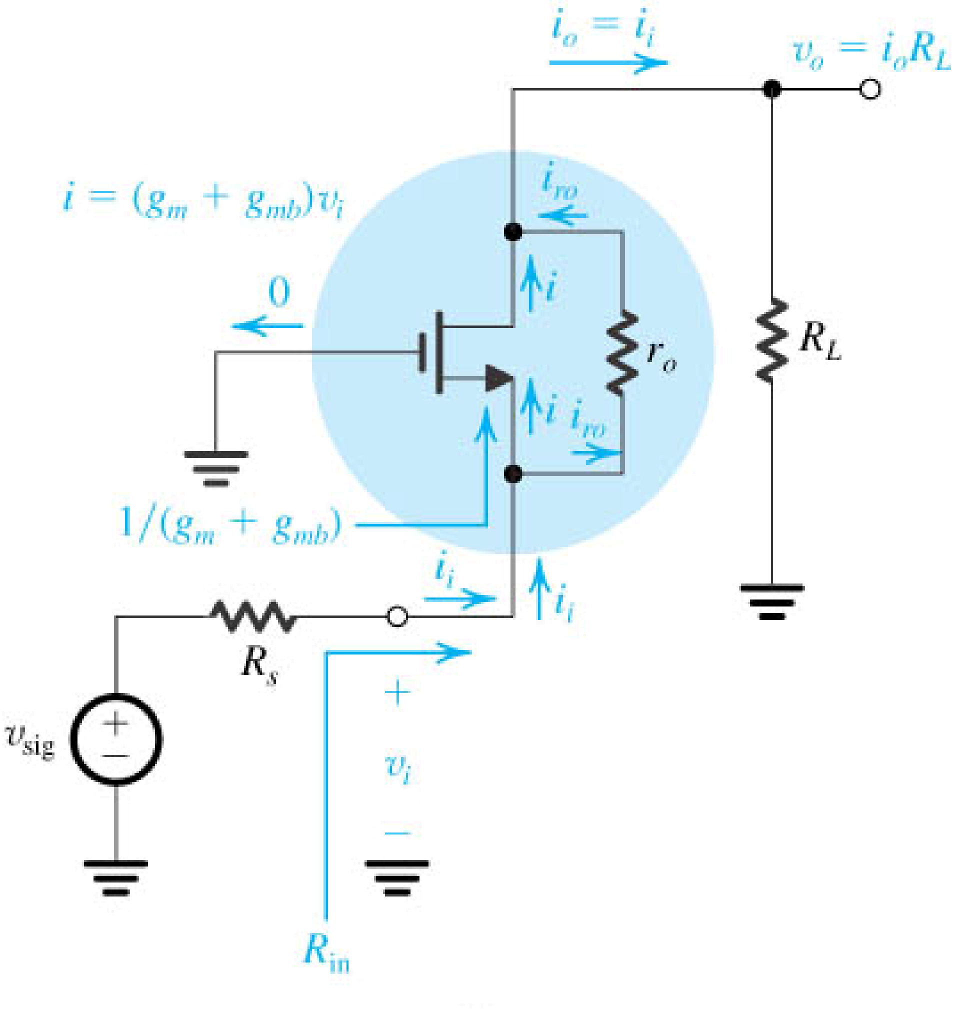


(a)



(b)

Low-frequency characteristics of the CG amplifier



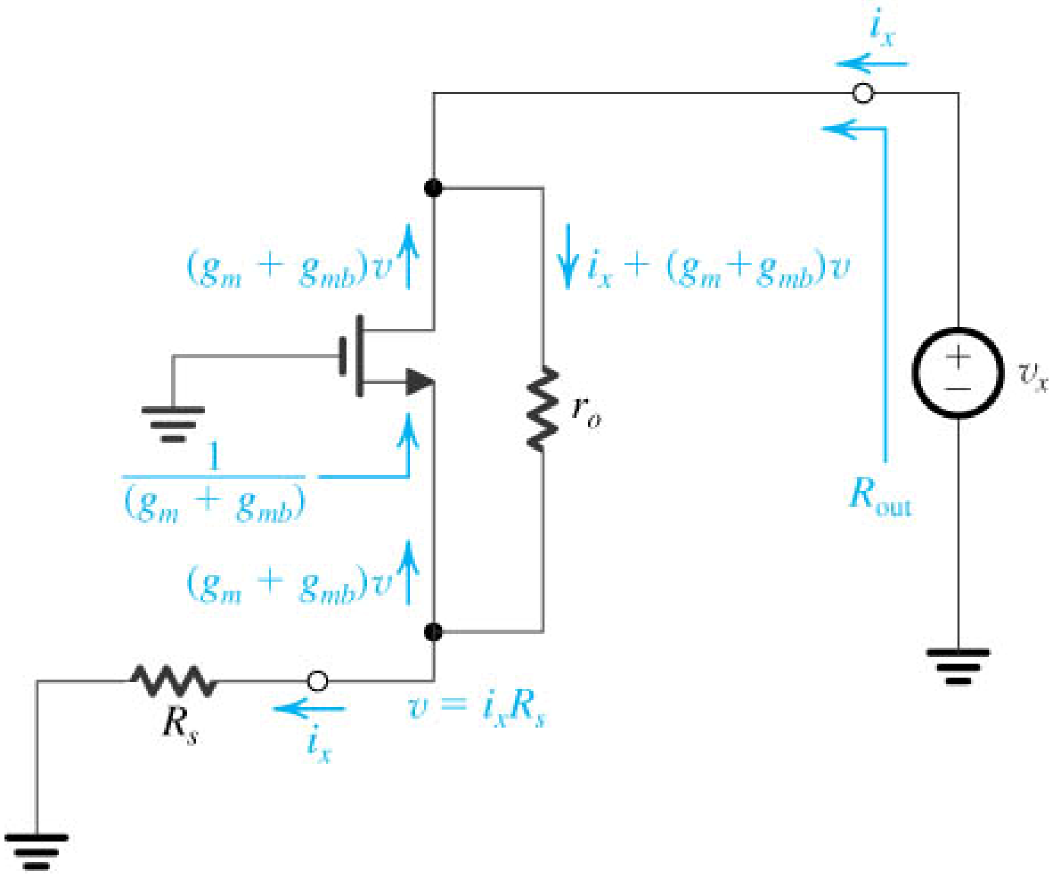
(c)

$$R_{in} \equiv \frac{v_i}{i_i} = \frac{r_o + R_L}{1 + (g_m + g_{mb})r_o}$$

$$A_{vo} = 1 + (g_m + g_{mb})r_o$$

$$R_{in} \cong \frac{1}{g_m + g_{mb}} + \frac{R_L}{A_o}$$

Low-frequency characteristics of the CG amplifier



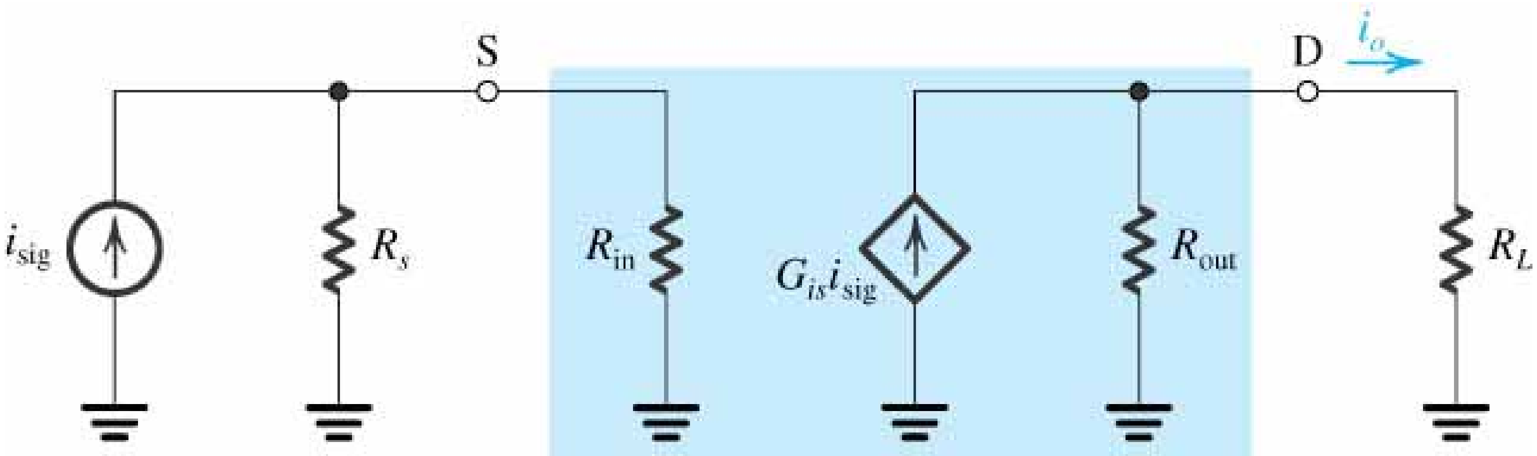
(b)

$$R_{out} = r_o + [1 + (g_m + g_{mb})r_o]R_s$$

Since $g_m \cong 10 g_{mb}$

$$R_{out} \cong r_o + (1 + g_m r_o)R_s$$

CG amplifier can be used as a current buffer

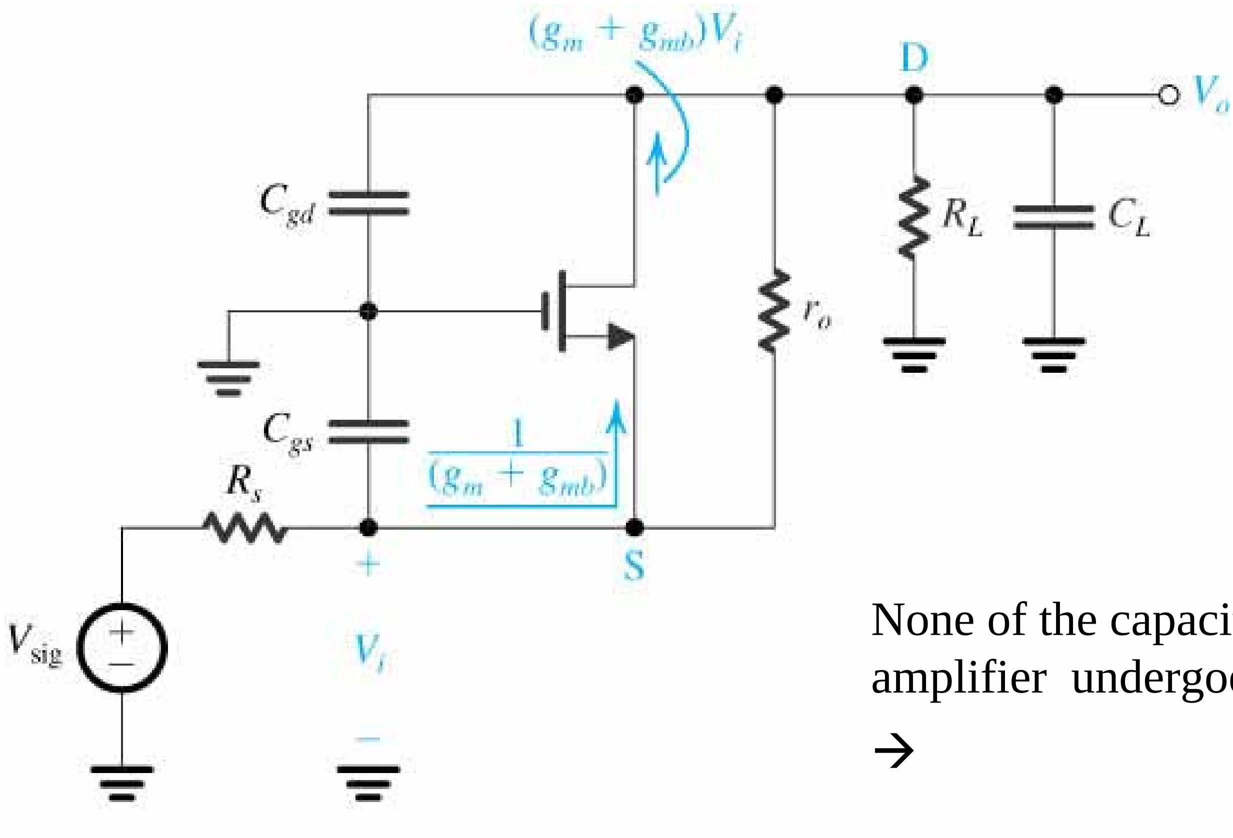


$$R_{in} \cong \frac{1}{g_m + g_{mb}} + \frac{R_L}{A_{vo}}$$

$$R_{out} \cong r_o + (1 + g_m r_o) R_s$$

$$G_{is} = A_{vo} \frac{R_s}{R_{out}} \cong 1$$

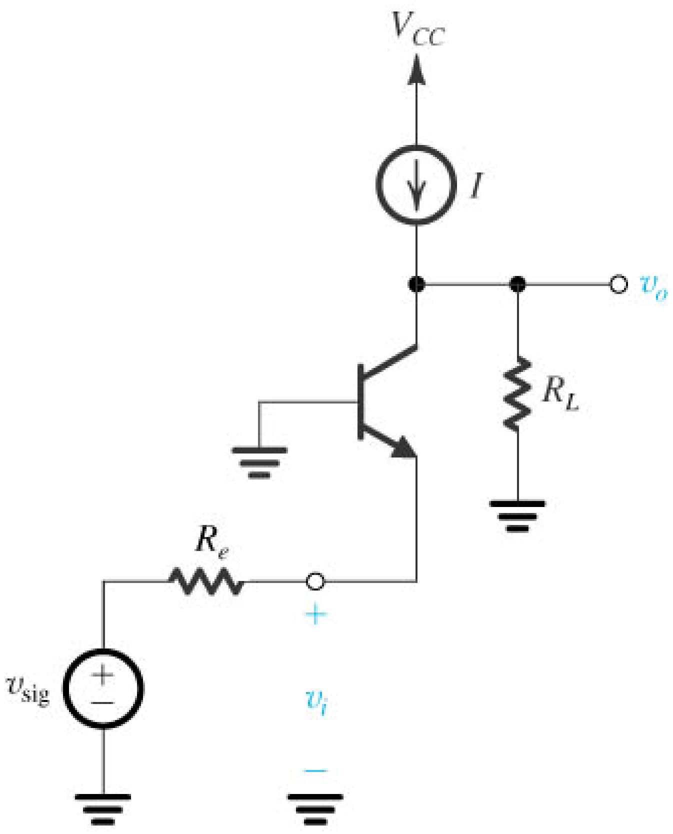
High-frequency response of a CG amplifier



(a)

None of the capacitors in the CG amplifier undergoes the Miller effect →

Common-Base amplifier



(a)

$$R_{in} \cong r_e + \frac{R_L}{A_o}$$

$$R_{out} \cong (1 + g_m R'_e) r_o \qquad \text{where } R'_e \cong r_\pi \parallel R_e$$

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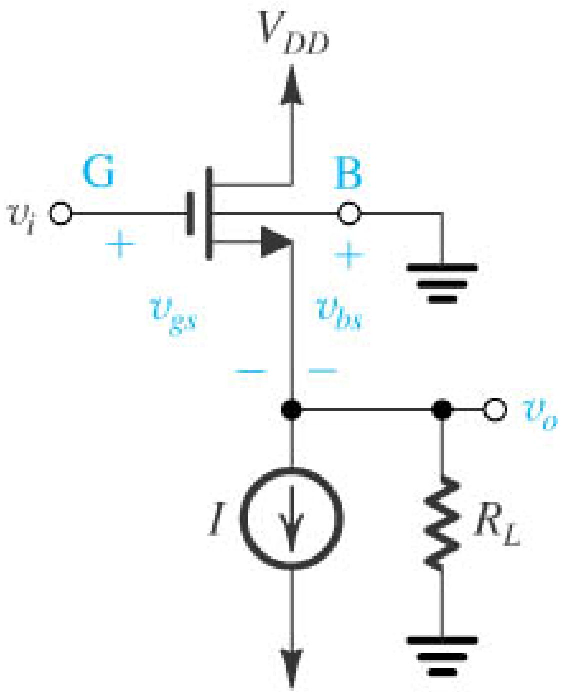
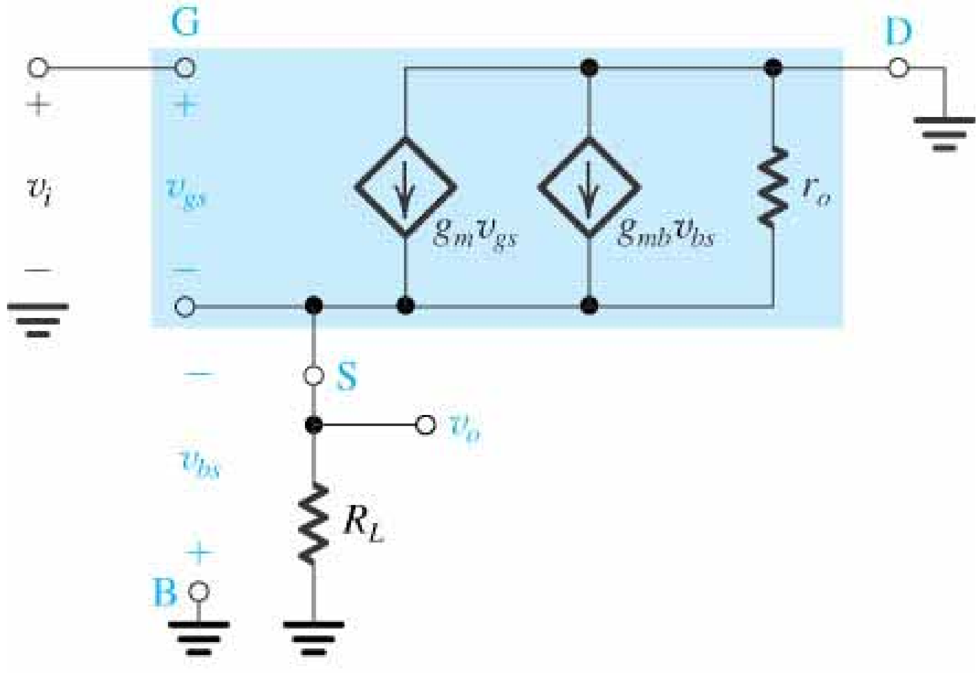
6-6 The Source- and Emitter-follower

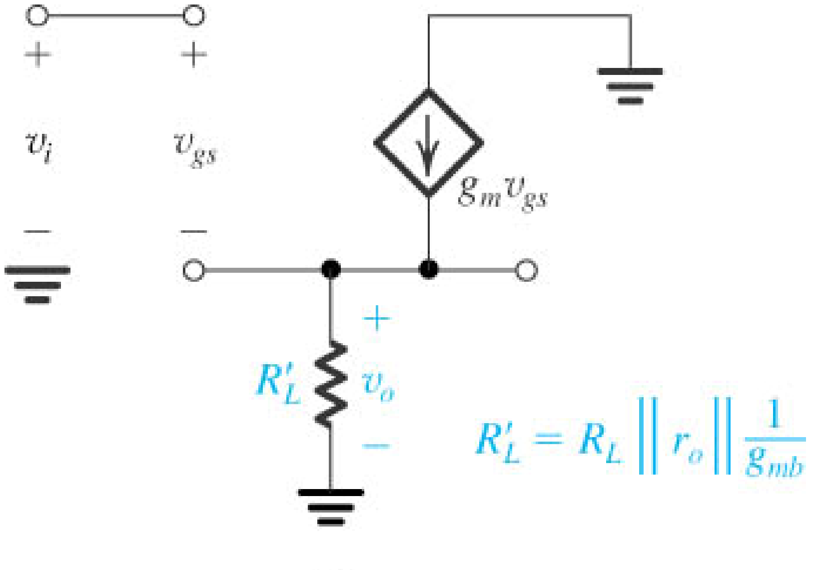


(a)



(b)

Low-frequency characteristics of a Source follower



(c)

$$R_{in} = \infty$$

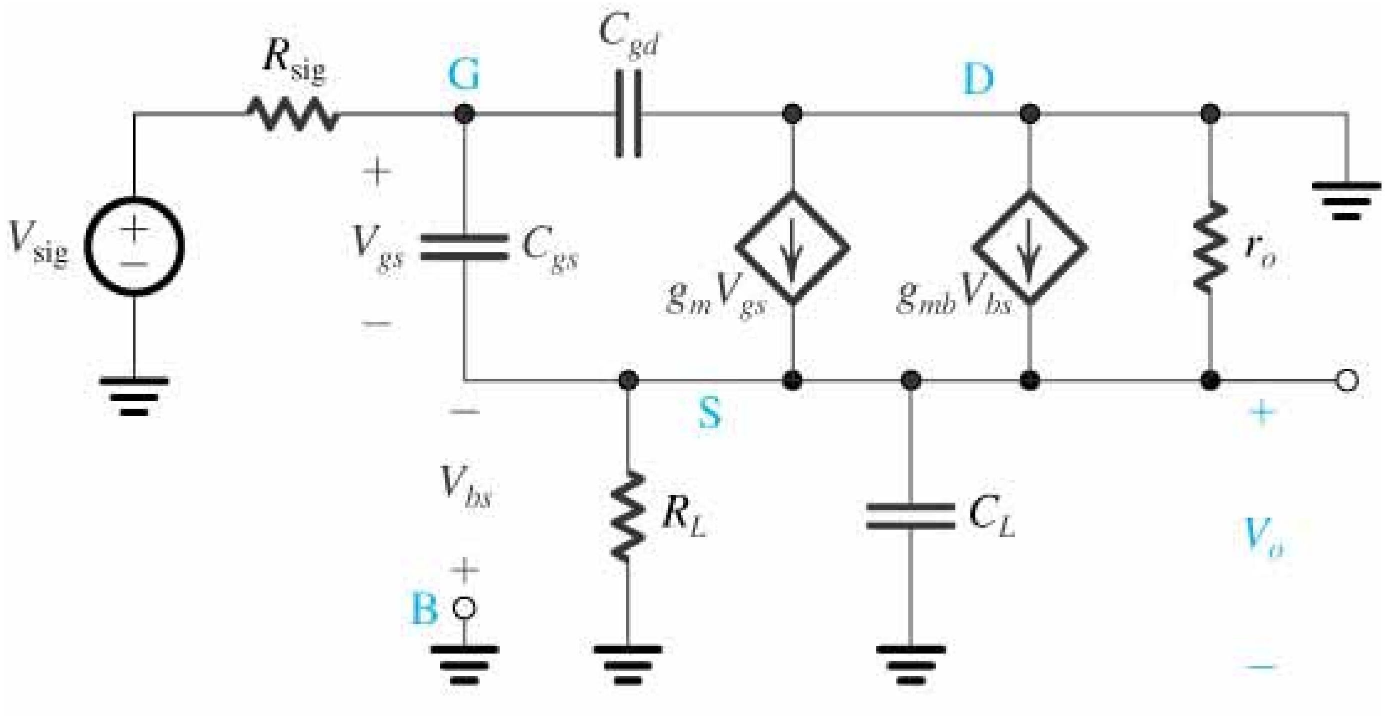
$$R_{out} = \frac{1}{g_m} \,||\, \frac{1}{g_{mb}} \,||\, r_o$$

$$A_{vo} = \left. \frac{g_m R'_L}{1 + g_m R'_L} \right|_{RL=\infty} = \frac{g_m r_o}{1 + (g_m + g_{mb}) r_o}$$

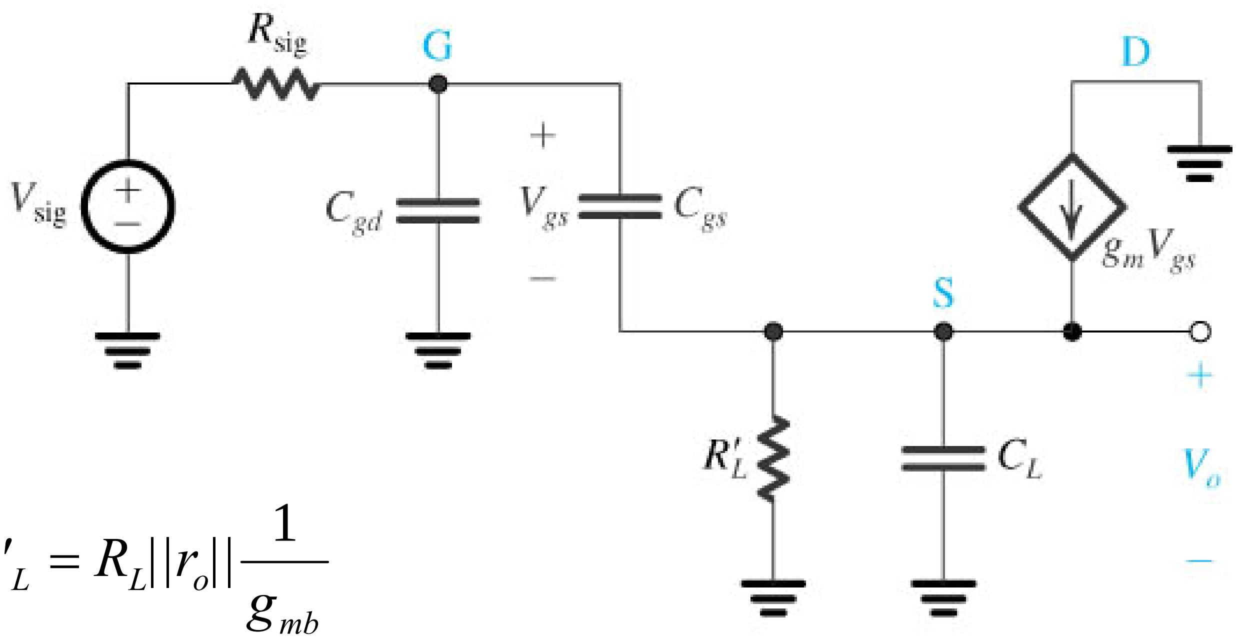
$$\Rightarrow A_{vo} \cong \frac{g_m}{g_m + g_{mb}} = \frac{1}{1 + \chi}$$

$\Rightarrow$ CD amplifier can function as a voltage buffer!!

High-frequency response of a Source Follower



(a)



$$R'_L = R_L || r_o || \frac{1}{g_{mb}}$$

(b)

Zeros:

$$s_Z = -\frac{g_m}{C_{gs}}$$

Dominant pole:

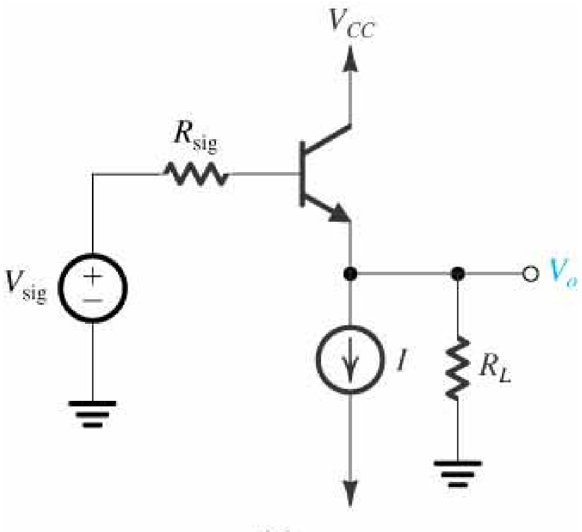
$$R_{gd} = R_{sig}$$

$$R_{CL} = R'_L || \frac{1}{g_m}$$

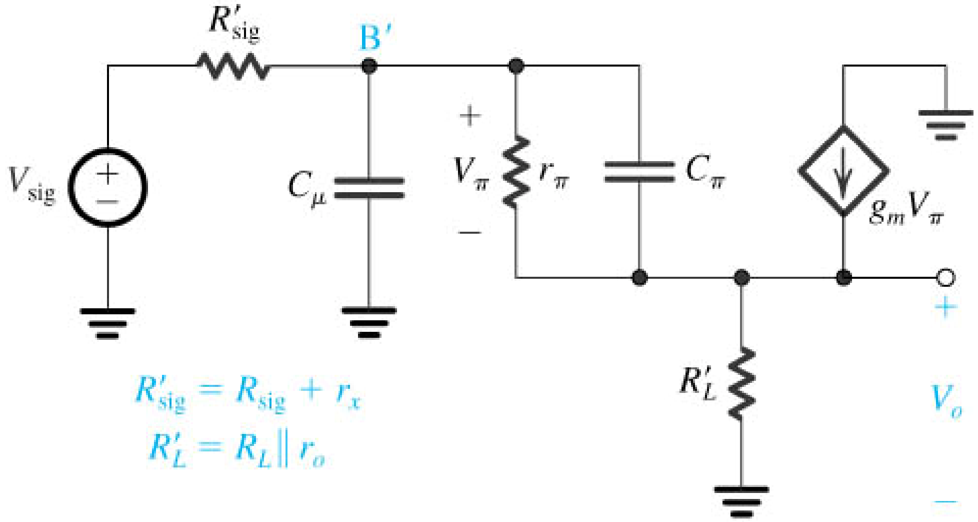
$$R_{gs} = \frac{R_{sig} + R'_L}{1 + g_m R'_L}$$

$$f_H = 1/2\pi(C_{gd}R_{sig} + C_{gs}R_{gs} + C_L R_{CL})$$

The Emitter Follower



(a)



(c)

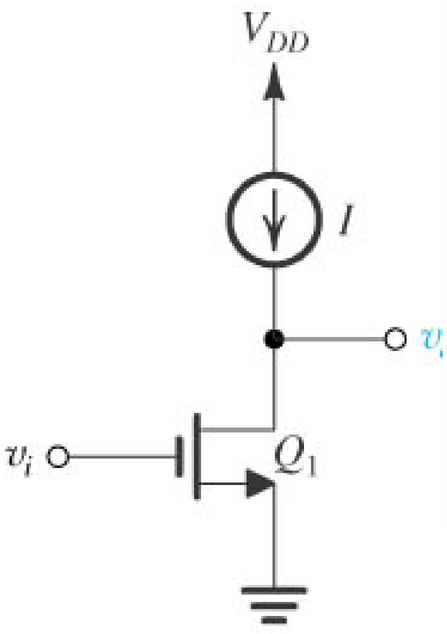
$$s_z = -\frac{1}{C_\pi r_e}$$

$$R_\mu = R'_{sig} \| [r_\pi + (\beta+1)R'_L]$$

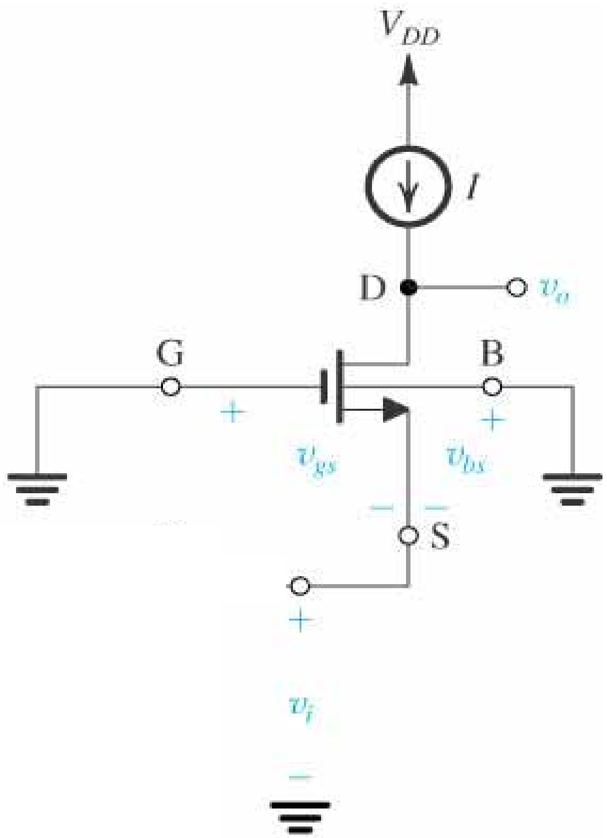
$$R_\pi = \frac{R'_{sig} + R'_L}{1 + \frac{R'_{sig}}{r_\pi} + \frac{R'_L}{r_e}}$$

$$f_H = 1/2\pi(C_\mu R_\mu + C_\pi R_\pi)$$

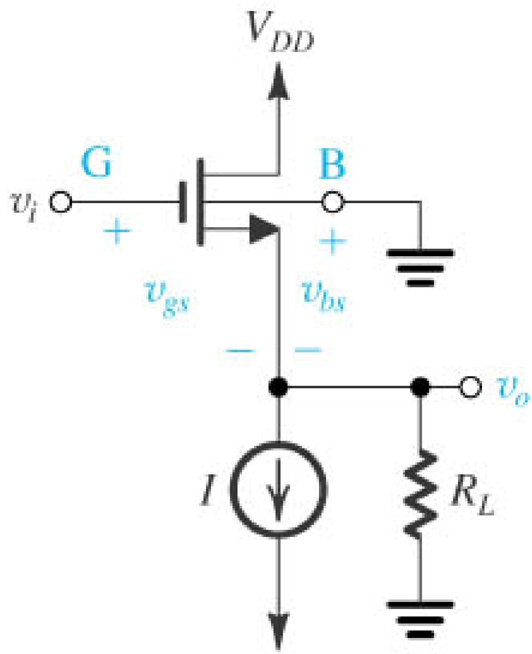
Summary – the intuition for various single-stage amplifiers



(a)



(a)



(a)