Lecture16:
CMOS amplifier, common-source (3)

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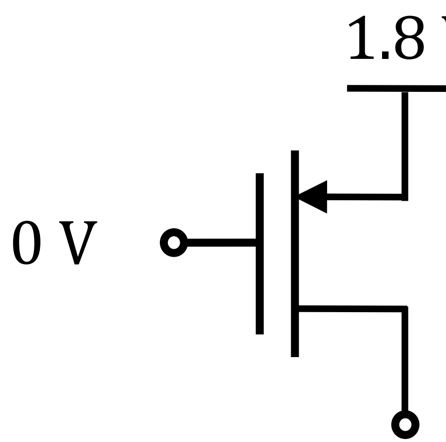
Review

- Voltage gain of a common-source amplifier
  - It is given by $A_v = -g_m(R_D||r_O)$.
  - By using a current source, we can maximize the voltage gain.

- Rule to calculate the input/output impedances

Biasing of PMOS devices

- Use a PMOS as a current source
  - The amount of “gate overdrive” is $1.2\ \mathrm{V}$.
  - It is not $0.6\ \mathrm{V}$.



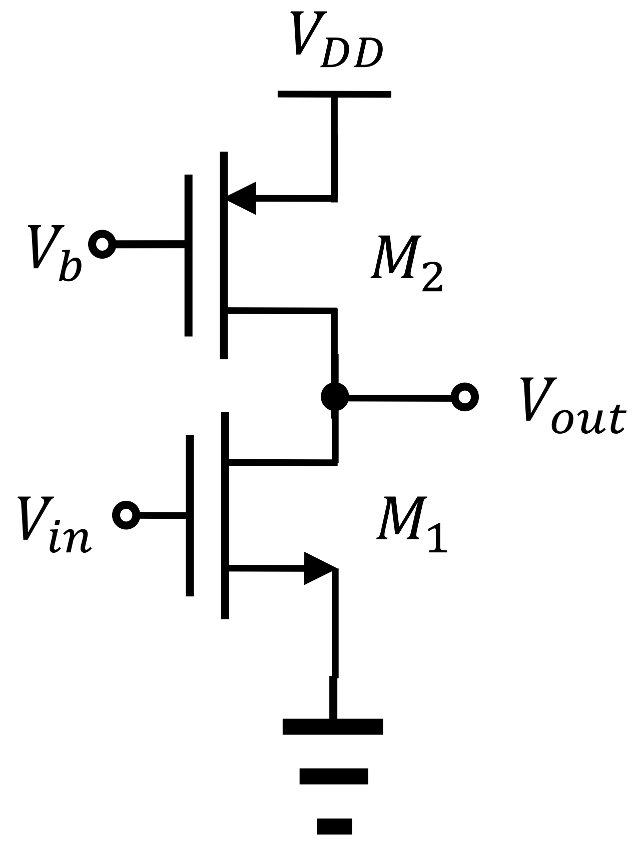
$$V_{TH} = -0.6\ \mathrm{V}$$
$$\mu_p C_{ox} = 75\ \mu\mathrm{A/V}^2$$
$$\frac{W}{L} = 2.0/0.18$$

Real current-source load

- Use a PMOS as a current source.
  - It is not an ideal current source.

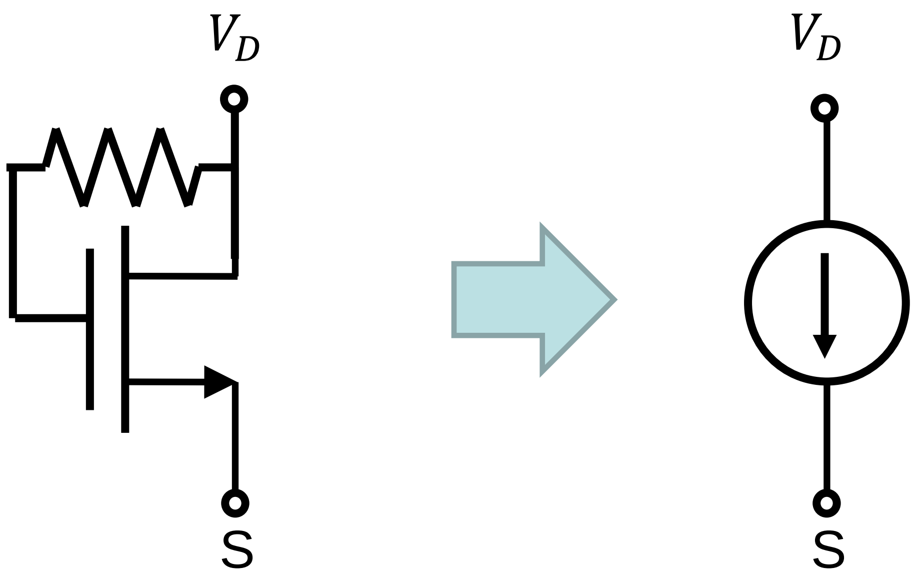
$$v_{out} = -g_{m1}(r_{O1}||r_{O2})v_{in}$$

$$A_v = -g_{m1}(r_{O1}||r_{O2})$$



Self-biasing

- Already covered in Example 6.13.
  - Always in the saturation region.



$$\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_D - V_S - V_{TH})^2$$

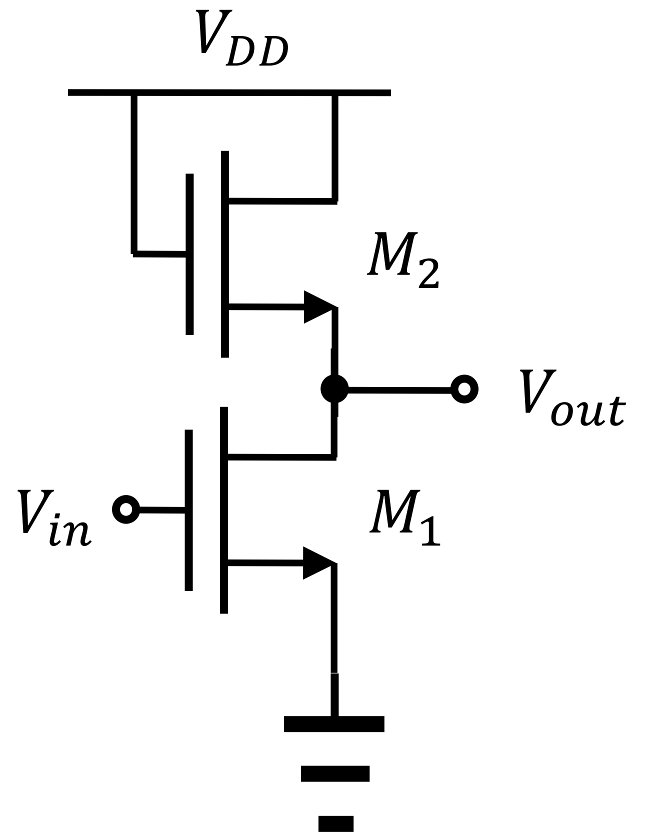
Gate and drain are tied.

Diode-connected load

- Use a diode-connected load.
  - It is not an ideal current source.

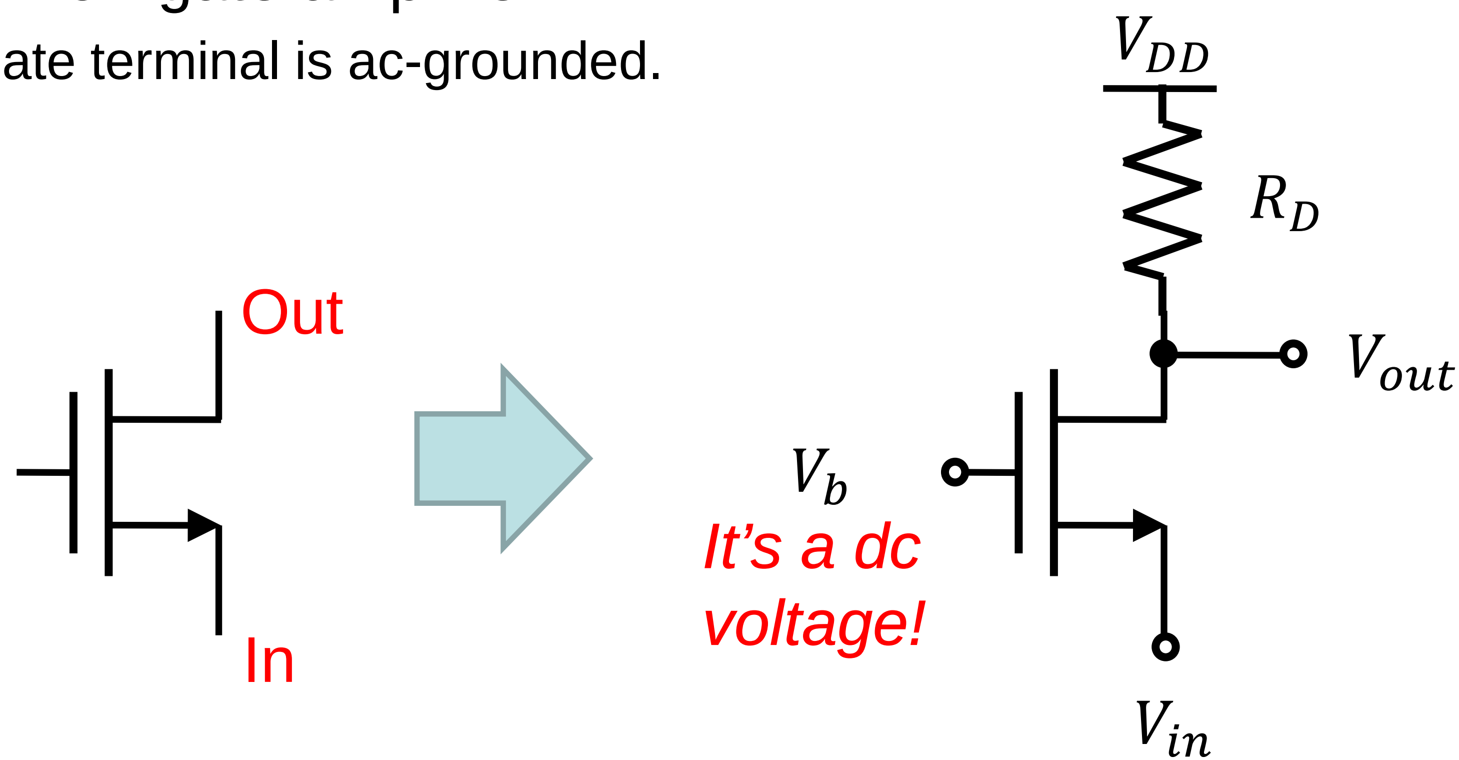
$$v_{out} = -g_{m1}\left(r_{O1}||\frac{1}{g_{m2}}||r_{O2}\right)v_{in}$$

$$A_v = -g_{m1}\left(r_{O1}||\frac{1}{g_{m2}}||r_{O2}\right)$$



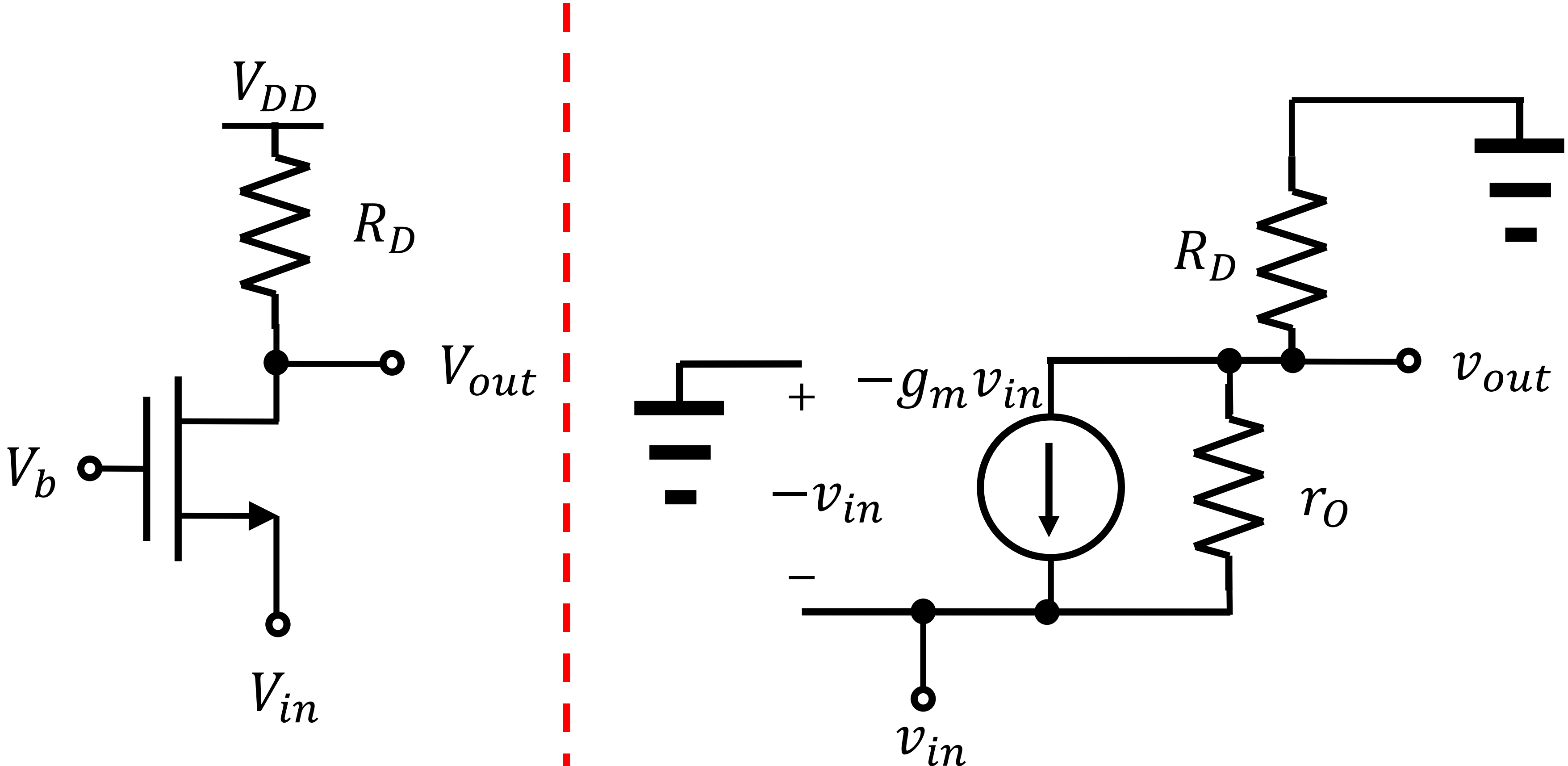
Common-gate amplifier

- Why do we study other amplification topologies?
  - Different circuit properties
- Common-gate amplifier
  - Gate terminal is ac-grounded.



Small-signal model

- Let's draw the small-signal model together!



Gain and input impedance

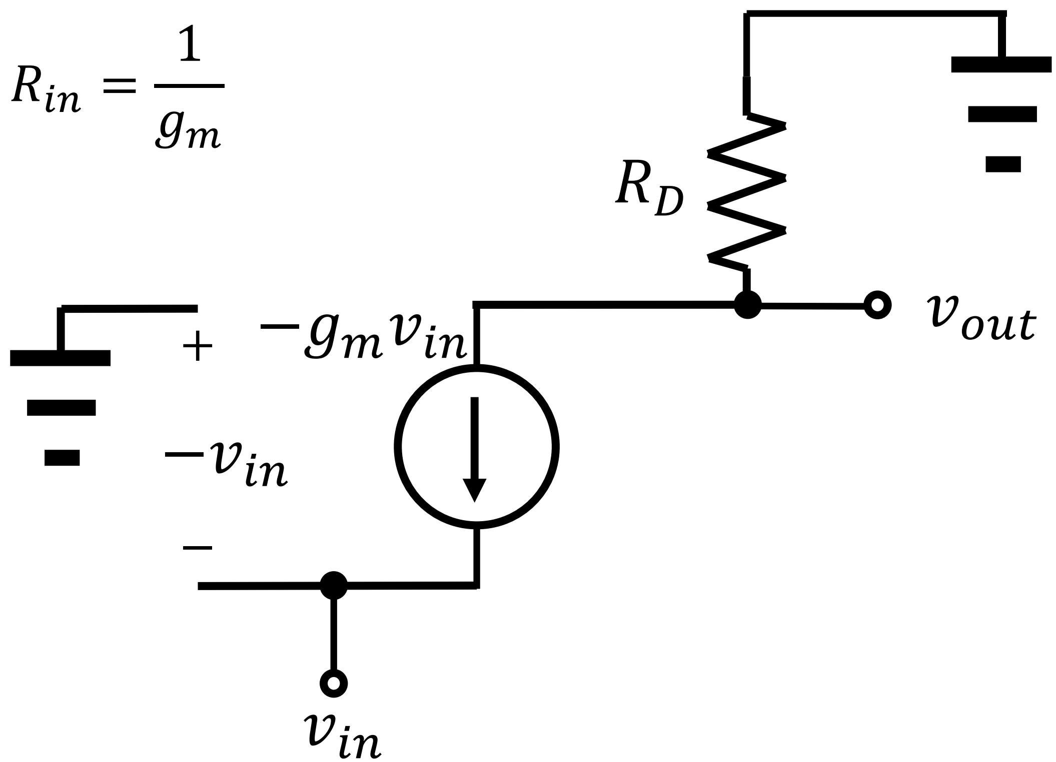
- Neglect the output resistance, r_O.
  - Voltage gain

$$A_v = +g_m R_D$$

  - Input impedance

$$R_{in} = \frac{1}{g_m}$$

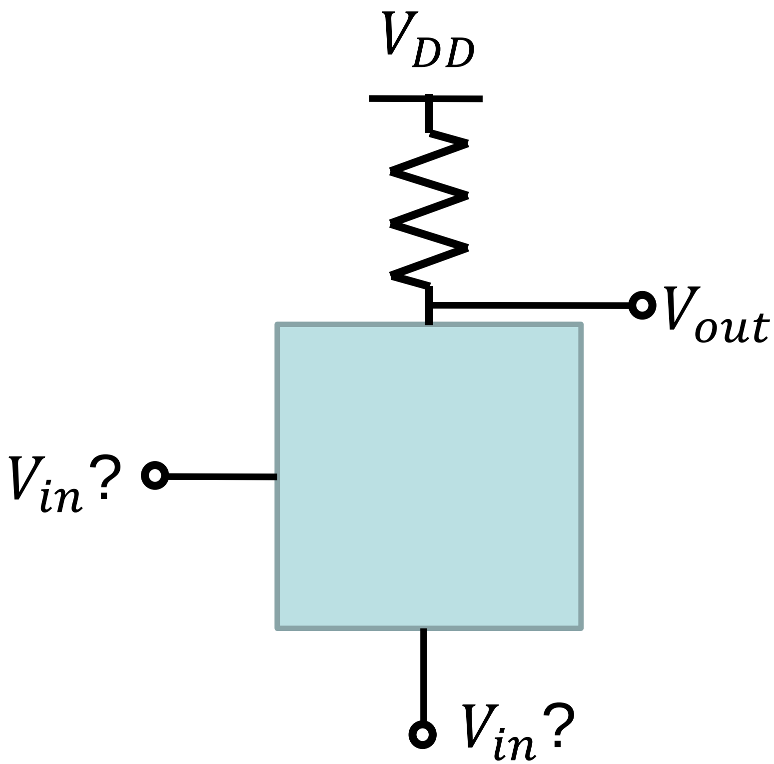
It's small!



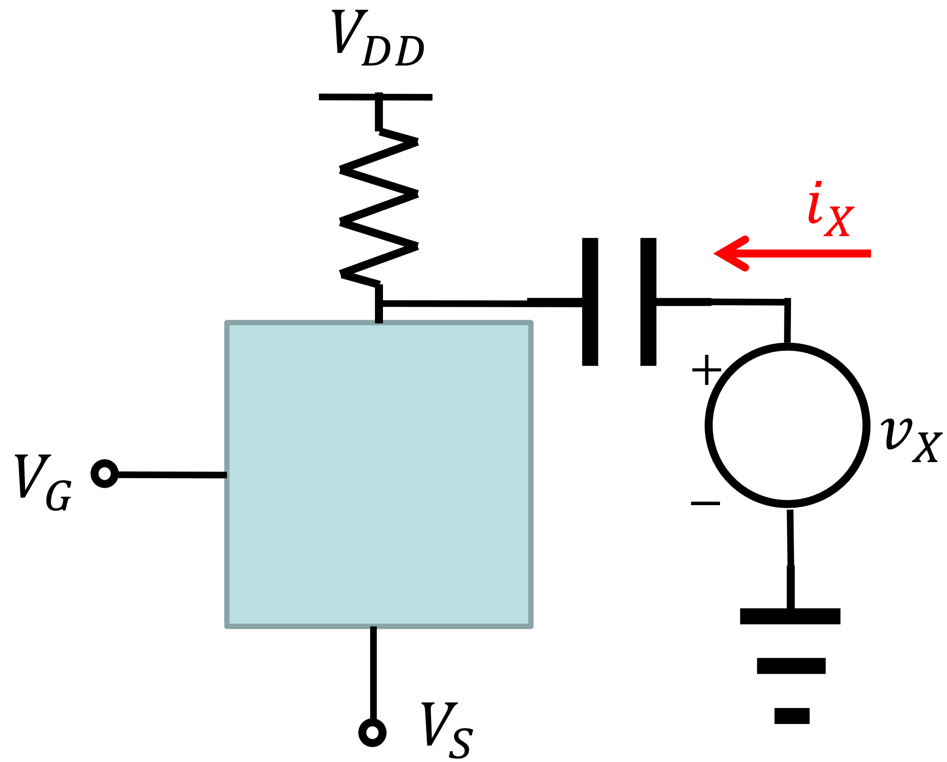
Output impedance

- Same with the CS stage

$$R_{out} = r_O \,||R_D$$



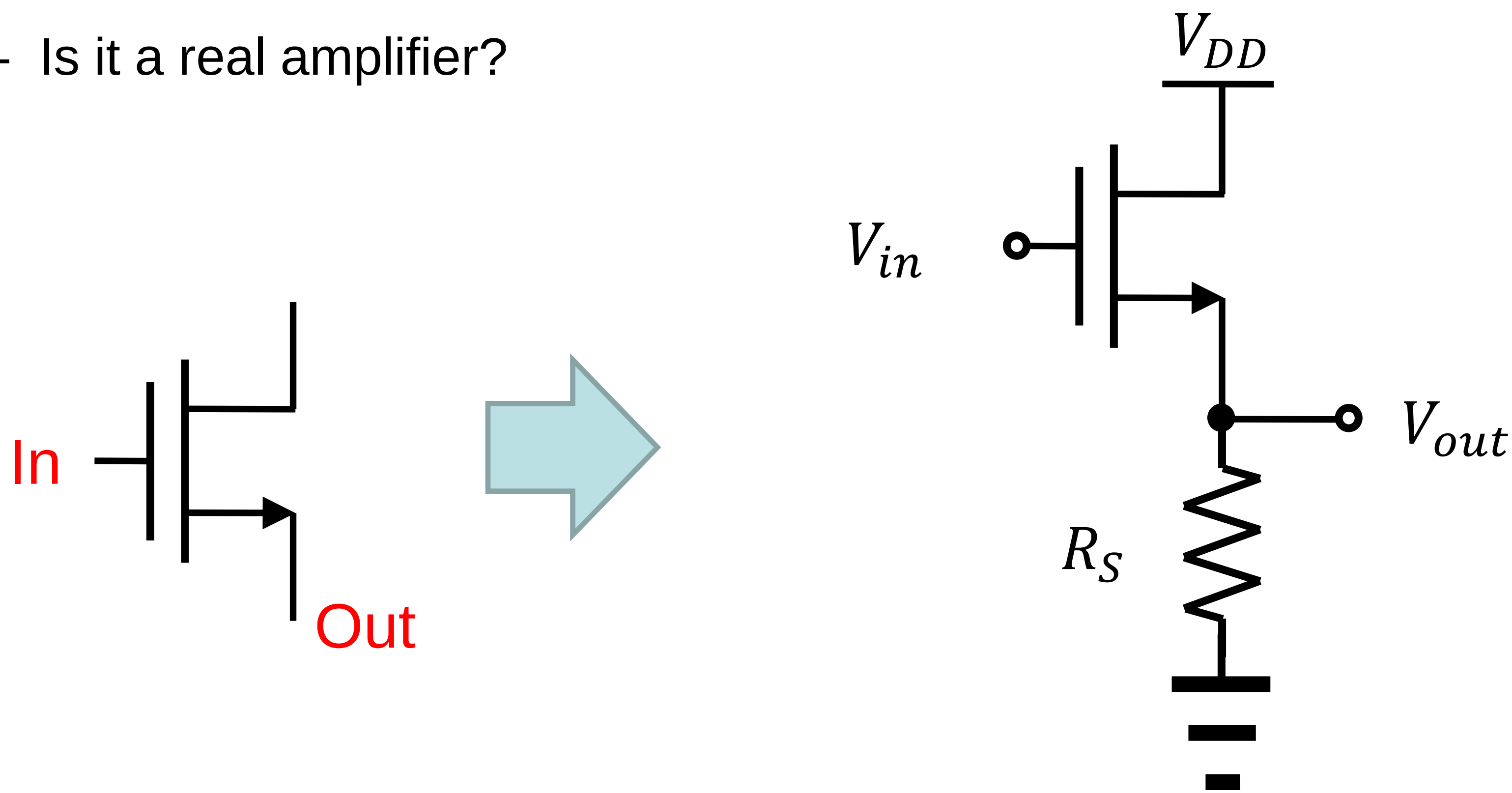
Generic form of CS and CG stages



Setting for calculating R_{out}

Source follower

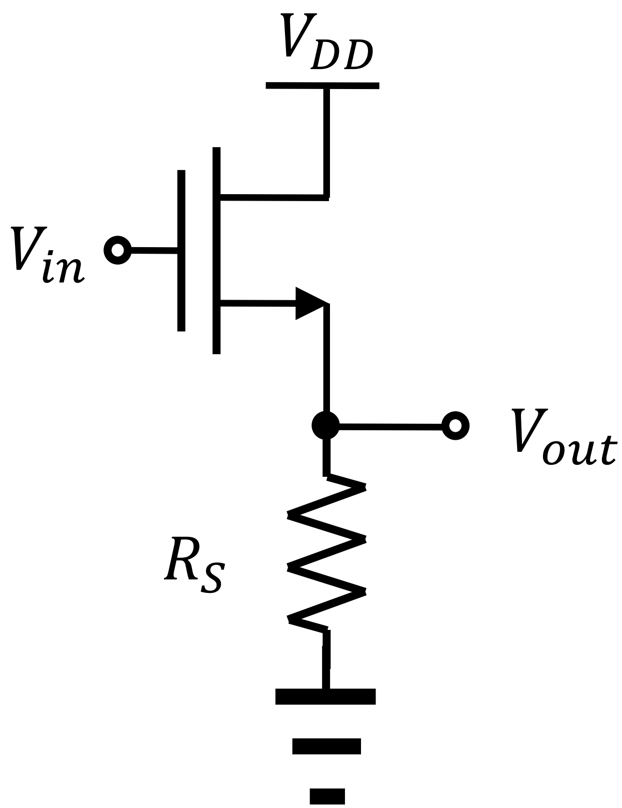
- Also called the “common-drain” stage
  - The drain is ac ground.
- Wait a minute!
  - Is it a real amplifier?



Its core

- Gain is less than 1??

$$A_v = +\frac{g_m R_S}{1 + g_m R_S}$$



You should be able to draw the small-signal model.

Useless?

- Calculate the input and output impedances.
  - Since the gate is the input terminal, the input impedance is very high at low frequencies.
  - How about the output impedance?

$$R_{out} = \frac{1}{g_m} || r_O || R_S$$

  - It is relatively low.

- High input imp., low output imp.
  - They can serve as good “buffers.”