Lecture19: CMOS amplifiers (6)

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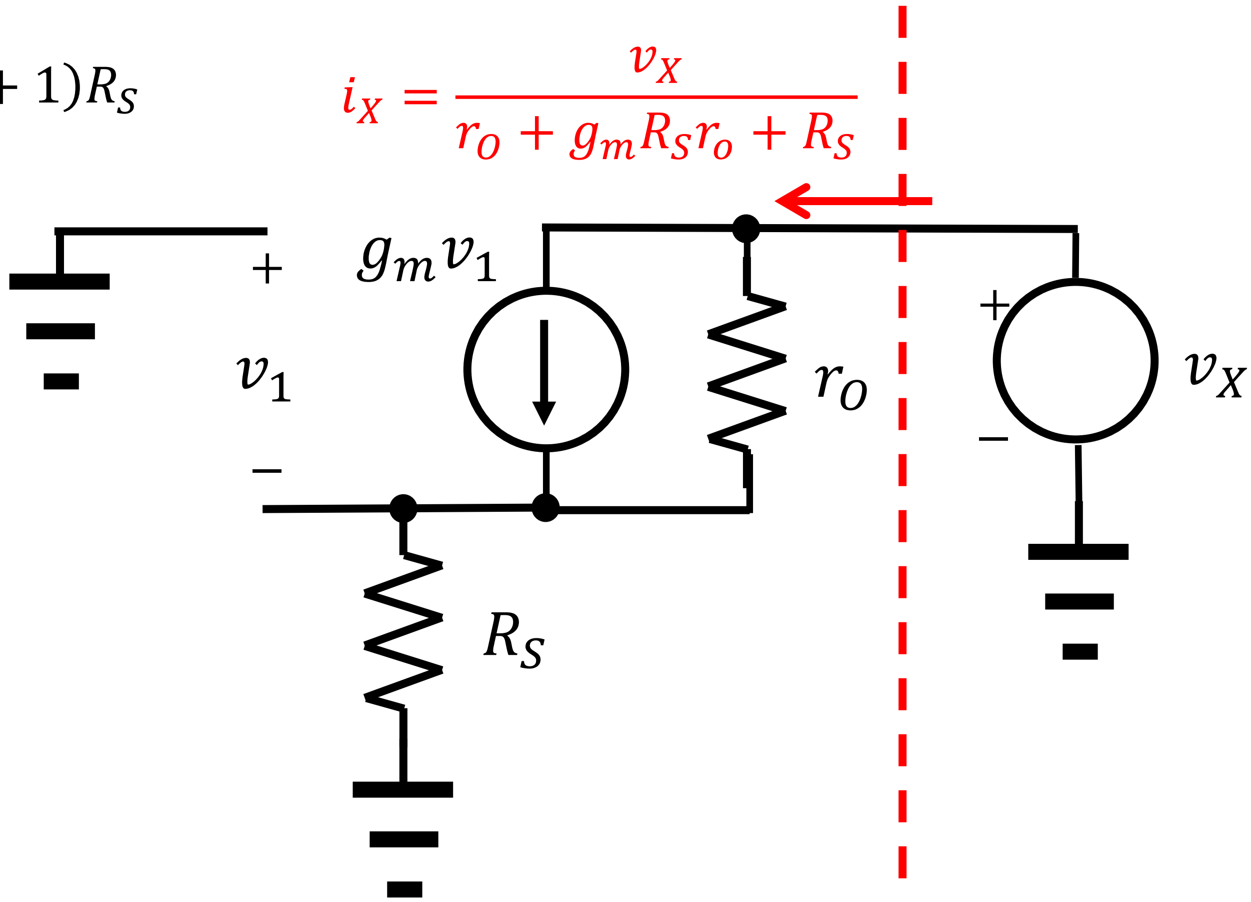
Review of previous lecture

- Source degeneration

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

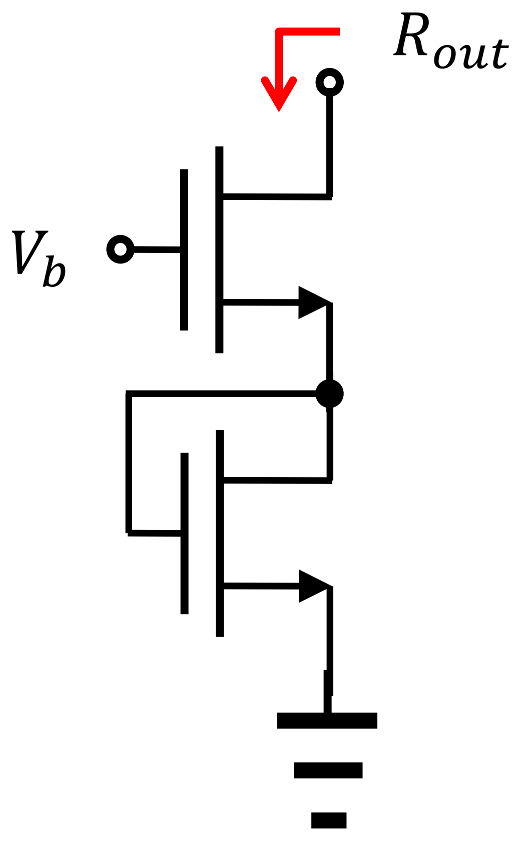
$$R_{out} = r_O + (g_m r_O + 1) R_S$$

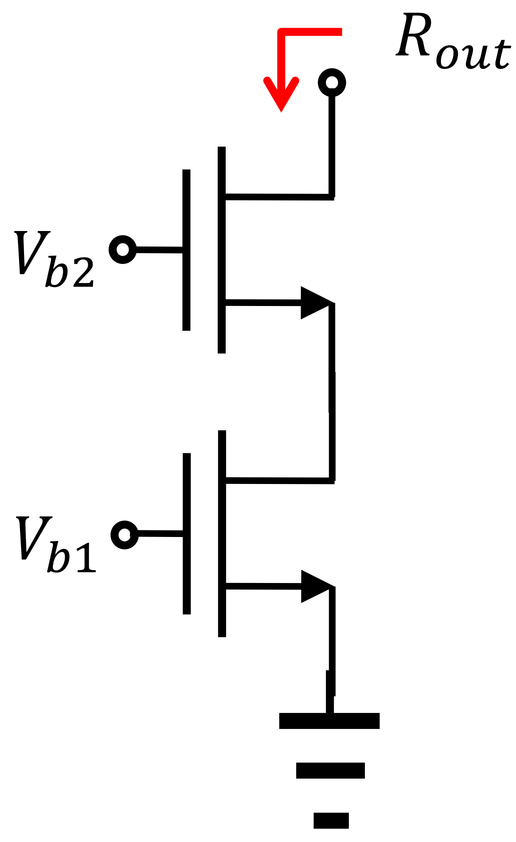
$$i_X = \frac{v_X}{r_O + g_m R_S r_o + R_S}$$



Examples 17.23 and 17.24

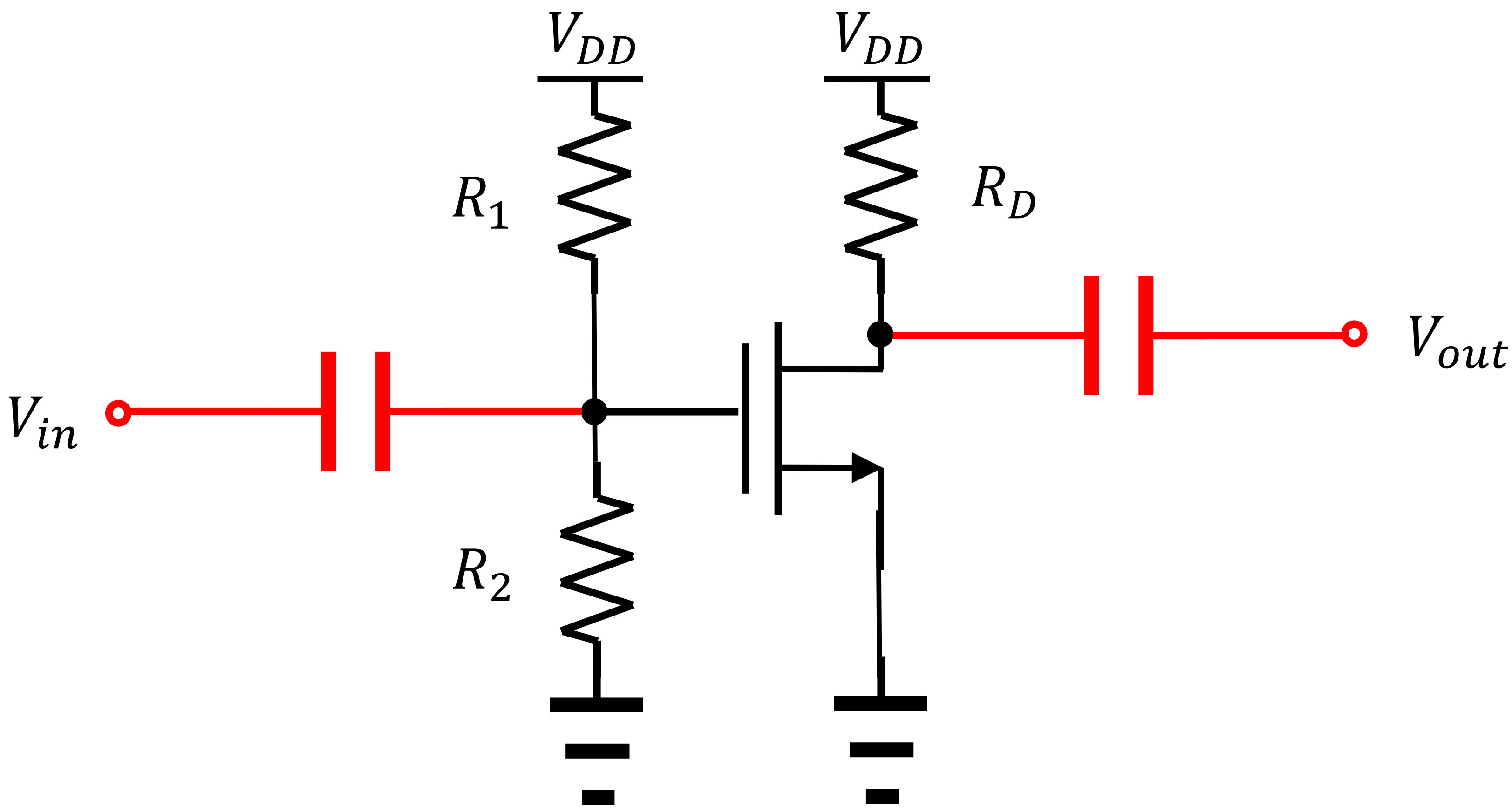
- Compute the output resistance.
  - What is the difference?





CS stage with biasing

- We need capacitive coupling at the input and output.



Low load impedance

- Example 17.27
  - With the load impedance, R_L, the gain becomes

$$A_v = g_m(R_D || r_O || R_L)$$

8 Ω

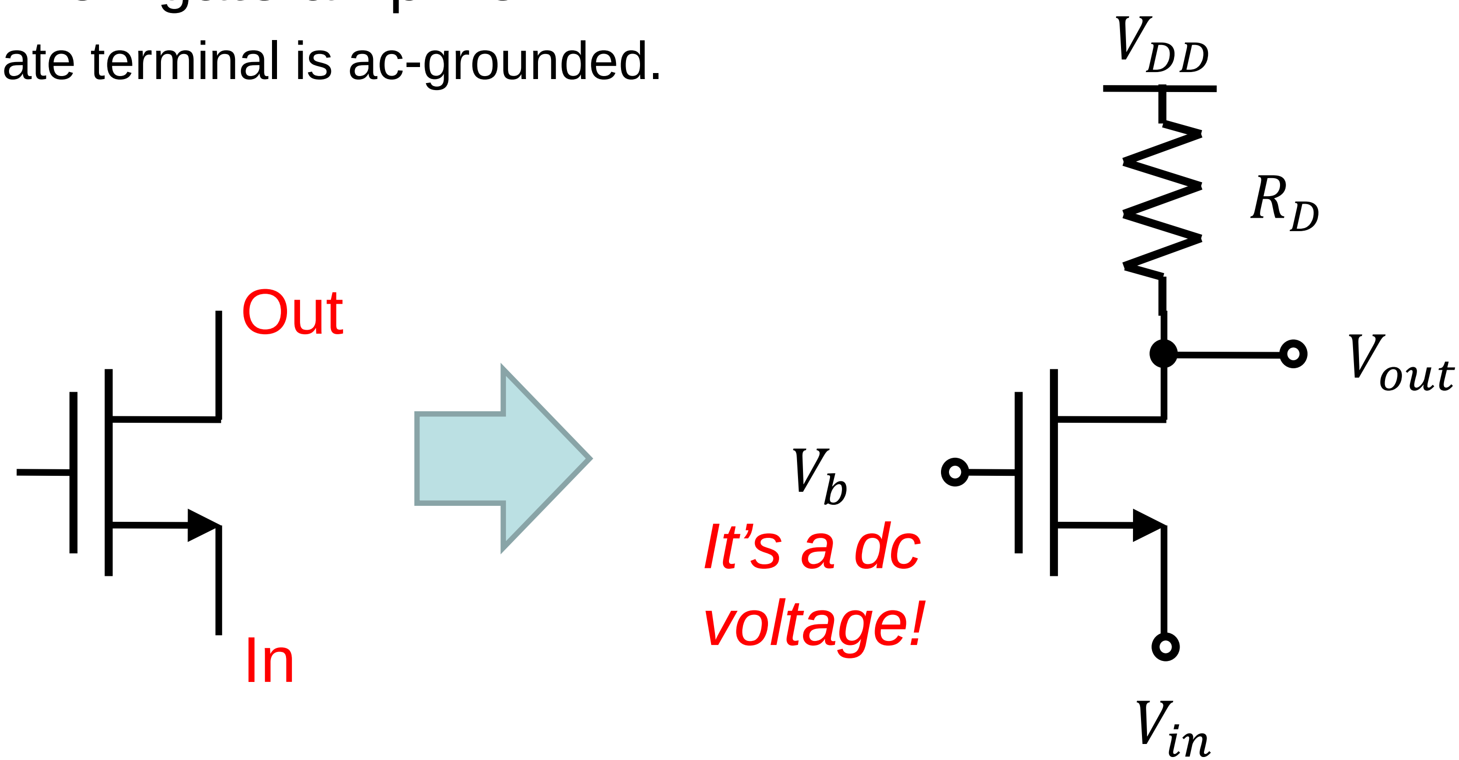
Very large

1 kΩ

  - Low load impedance drops the gain drastically!

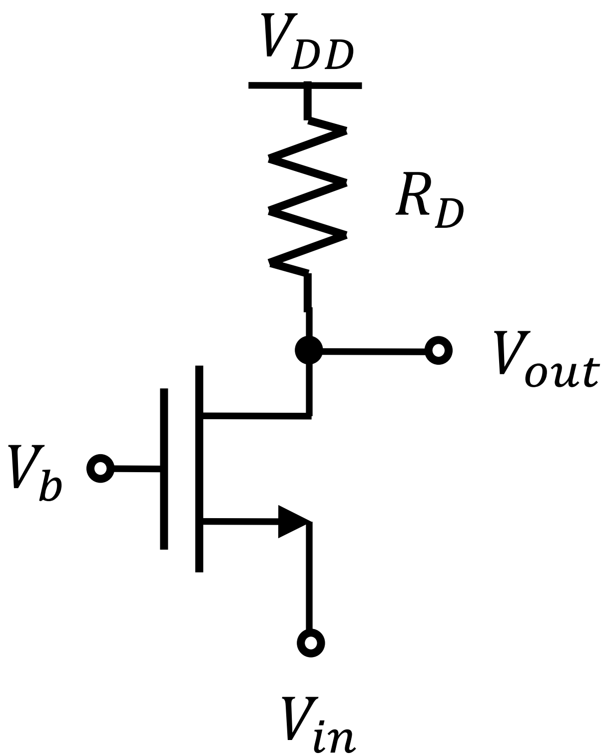
Common-gate amplifier

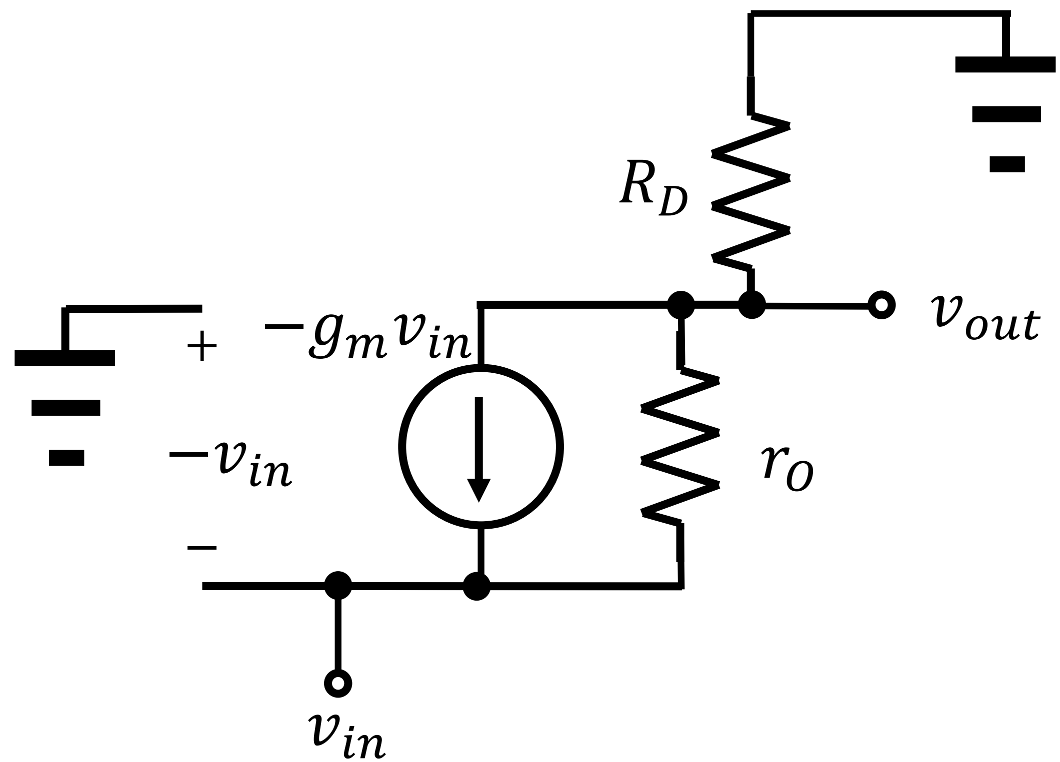
- Why do we study other amplification topologies?
  - Different circuit properties
- Common-gate amplifier
  - Gate terminal is ac-grounded.



Small-signal model

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





Gain and input impedance

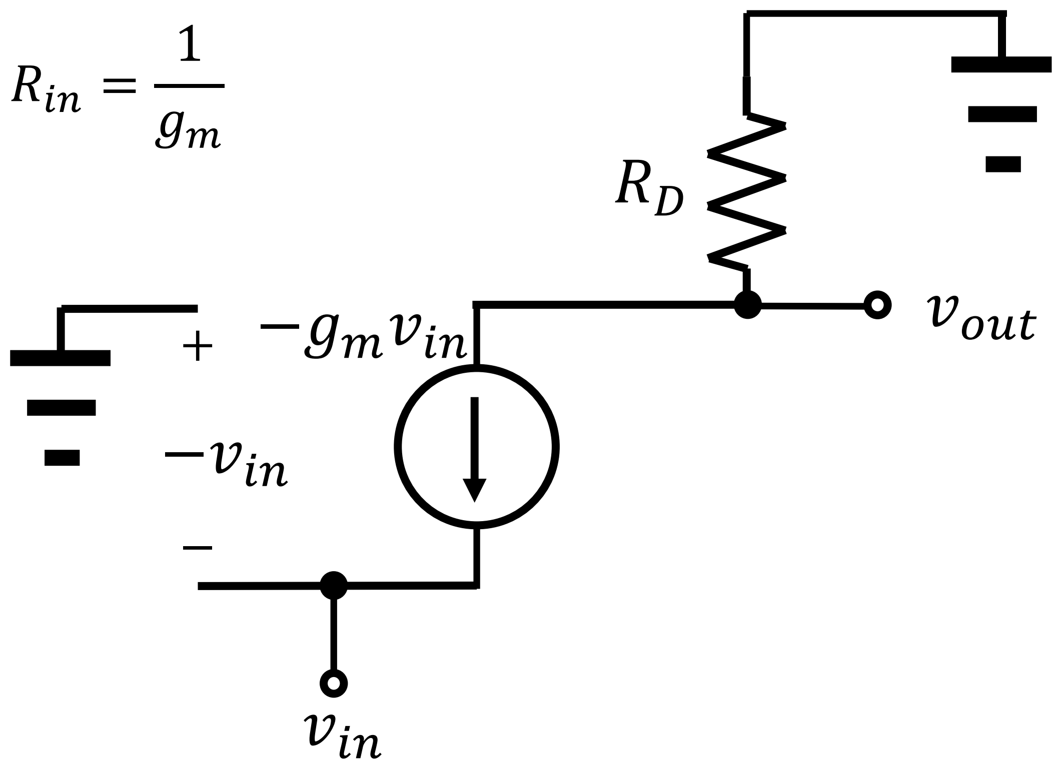
- Neglect the output resistance, r_O.
  - Voltage gain

$$A_v = +g_m R_D$$

  - Input impedance

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

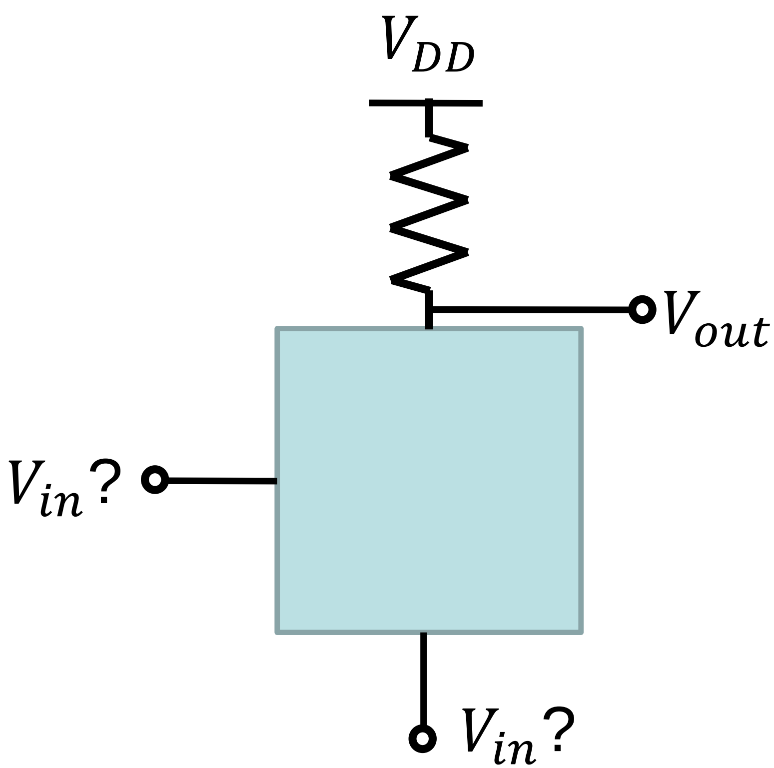
It's small!



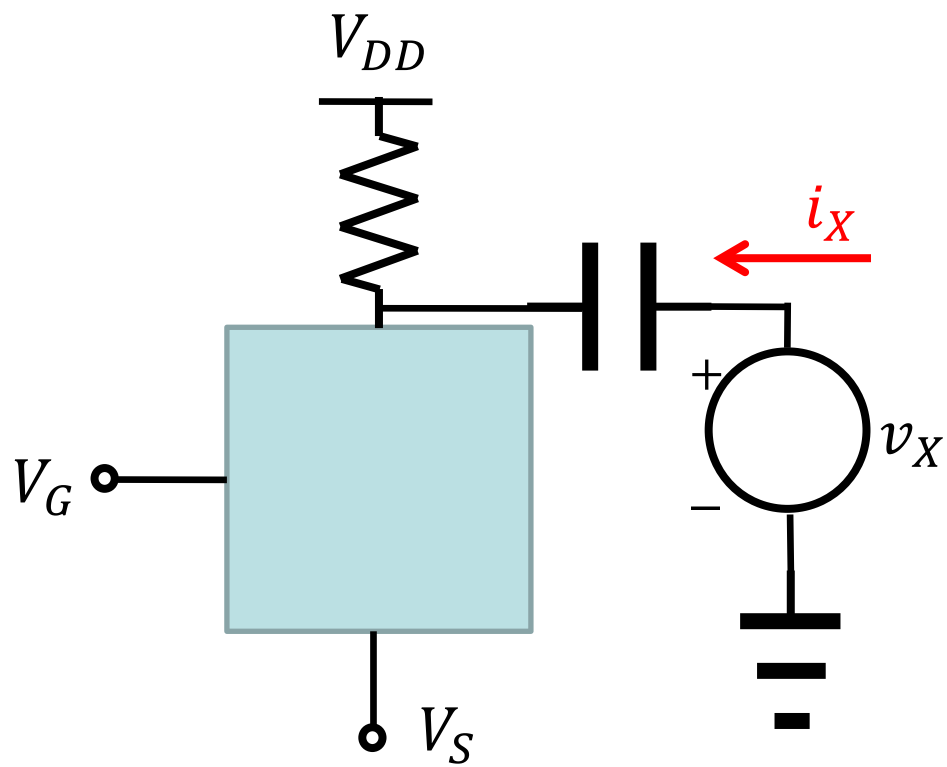
Output impedance

- Same with the CS stage

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



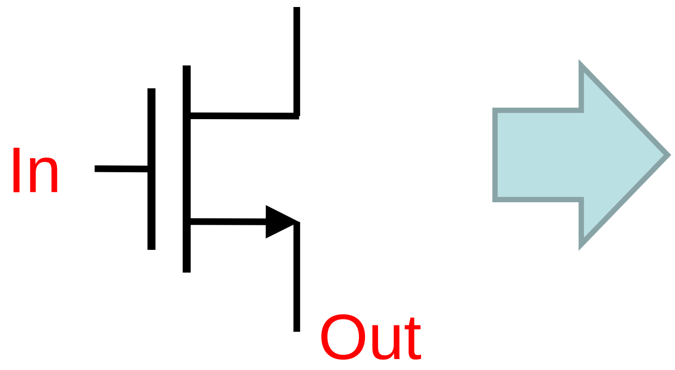
Generic form of CS and CG stages

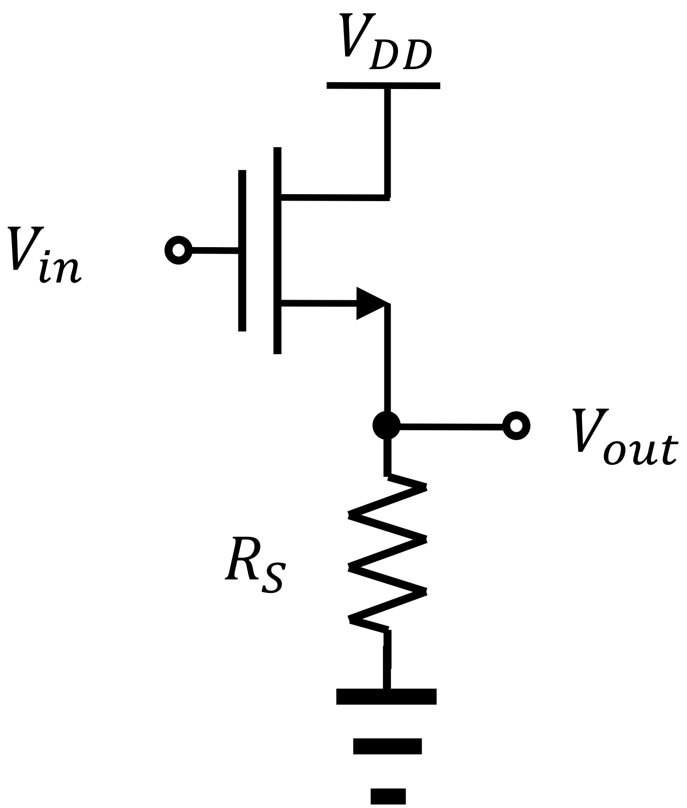


Setting for calculating R_{out}

Source follower

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

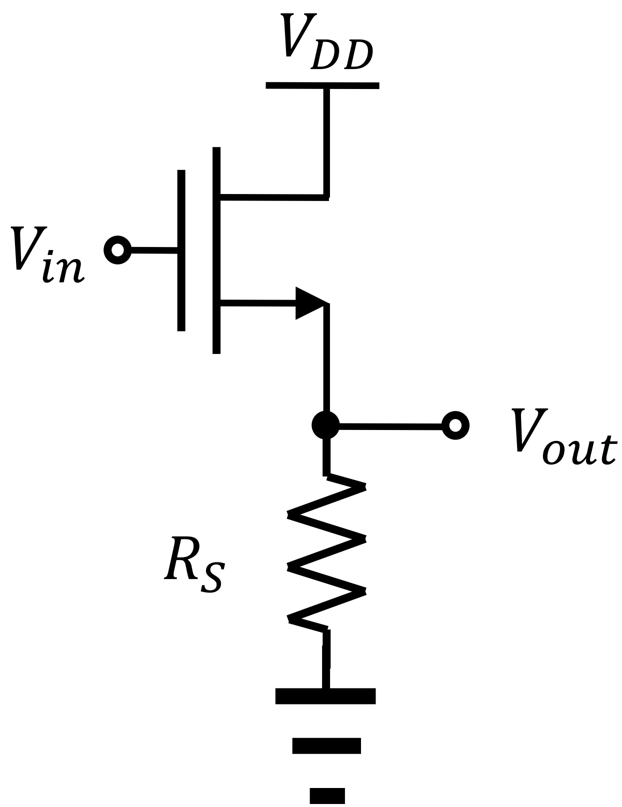




Its core

- Gain is less than 1??

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



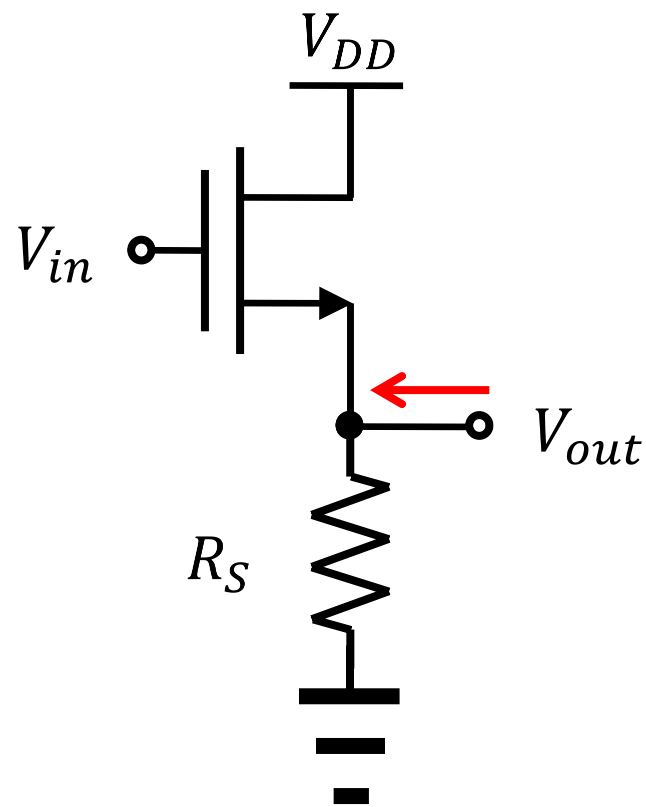
You should be able to draw the small-signal model.

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."