Lecture14:
CMOS amplifiers (1)

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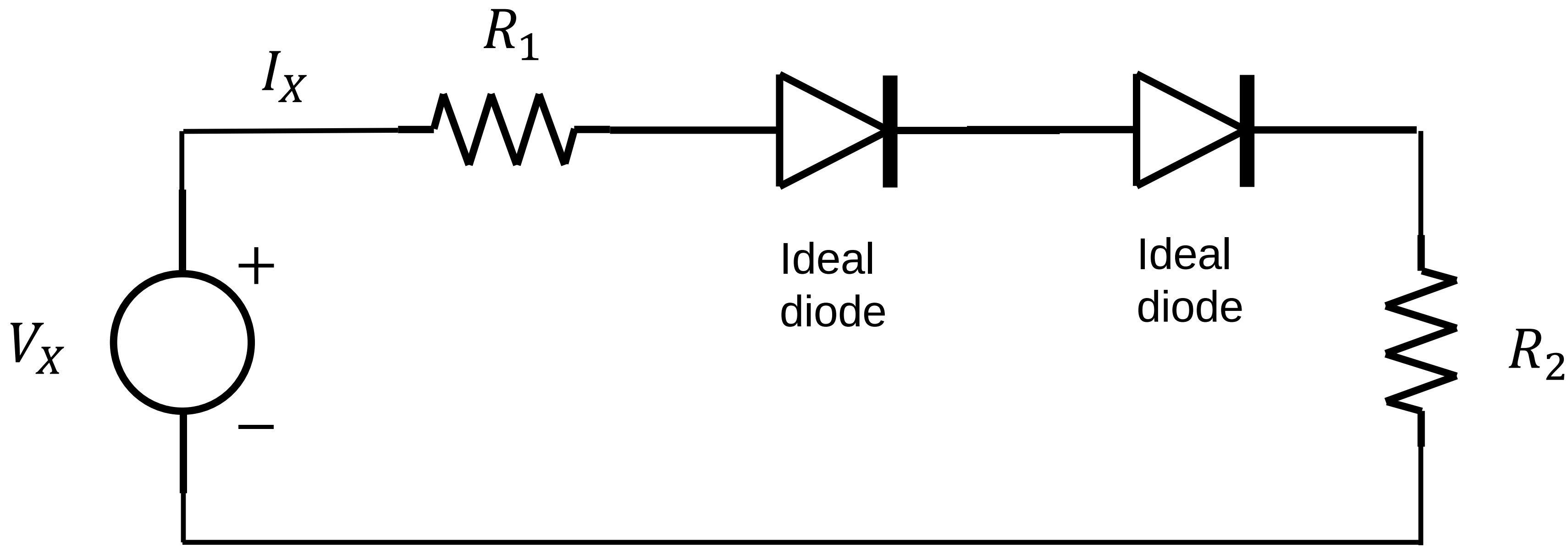
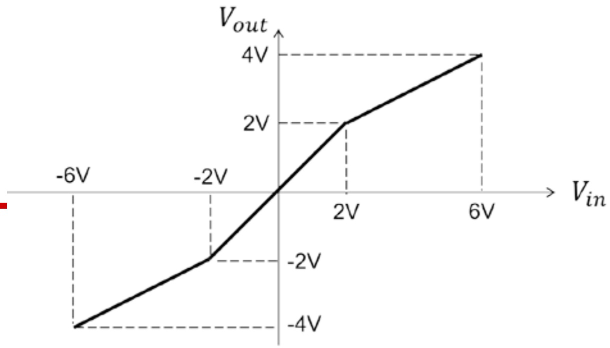
Homework#2-1

- Problem1:
  – Plot the IV characteristics.

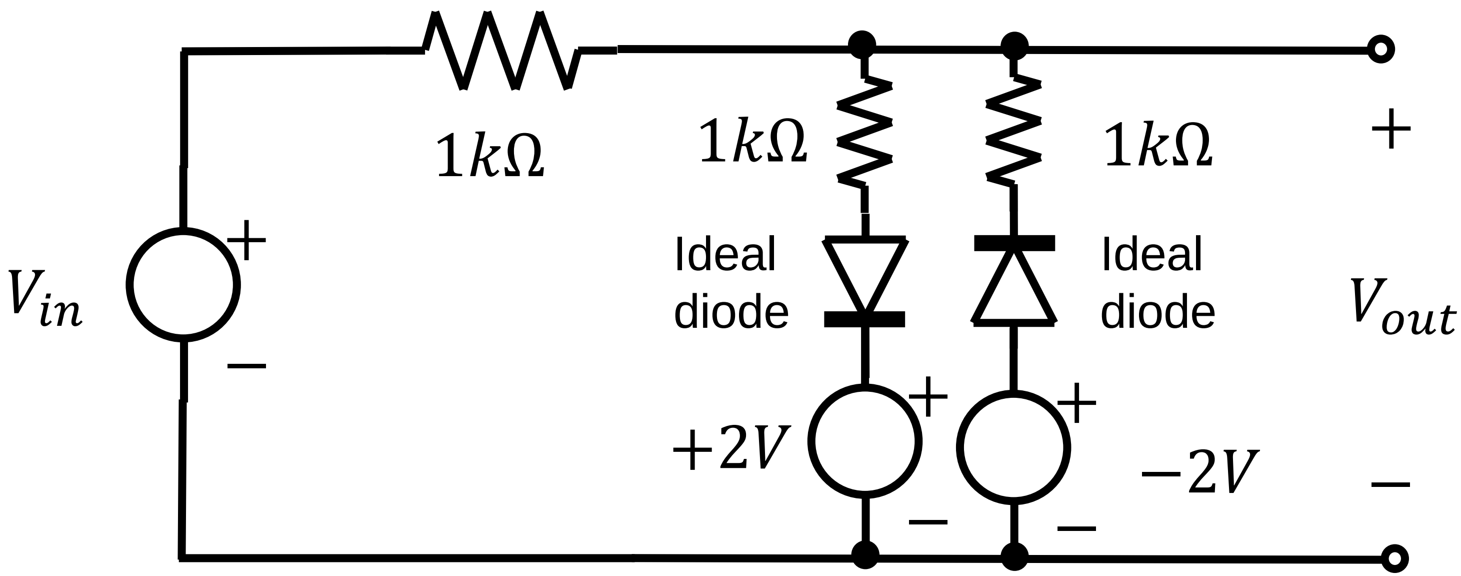


- Answer:
  – For a positive V_X, we have a resistance of $R_1 + R_2$
  – For a negative V_X, we have $I_X = 0$.

Homework#2-2



- Problem1:
  - We wish to design a circuit that exhibits the input/output characteristic shown below. Using 1-kΩ resistors, ideal diodes, and other components, construct the circuit.
- Answer:



Homework#2-3 (1/2)

- Problem3:
  - We studied the depletion approximation for the pn junction.
  - In the MOS structure, we can also consider the depletion region in the p-type substrate, whose acceptor density is N_A.
  - When the electric field ***in the oxide*** is E_{ox}, calculate the length of the depletion region, W_{depl}.
  - Then, what is the potential difference between the interface and the substrate?
  - (Neglect the electrons in this problem.)

Homework#2-3 (2/2)

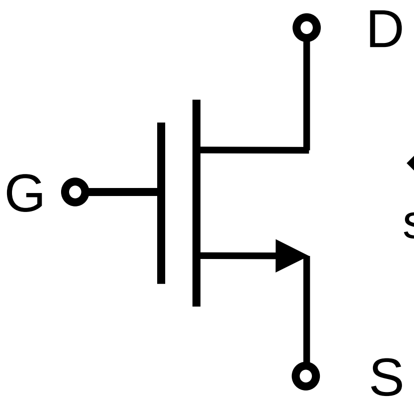
- Answer:
  - When the oxide field is E_{ox}, the surface field (in silicon) is $\frac{\epsilon_{ox}}{\epsilon_{si}} E_{ox}$.
  - The electric field changes in the depletion region, with a ratio of $-q\frac{N_A}{\epsilon_{si}}$.
  - At the end of the depletion region, the electric filed must vanish.
  - Therefore,

$$\frac{\epsilon_{ox}}{\epsilon_{si}} E_{ox} - q\frac{N_A}{\epsilon_{si}} W_{depl} = 0$$

- Comment:
  - Then, how about the potential difference across the depletion region?

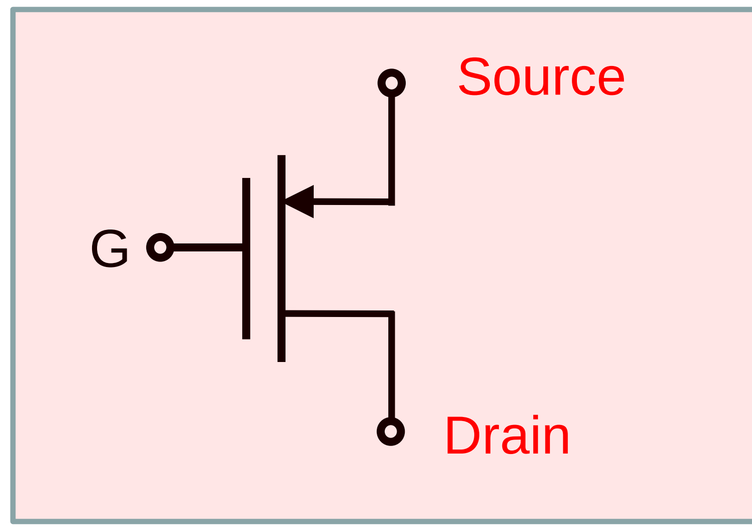
CMOS

- 9’s complementary of 123?
  - 876
- Complementary MOS
  - Here we have an NMOSFET.
  - A device where the transport is dominated by holes



← NMOSFET symbol

PMOSFET symbol →



- Why is it important?

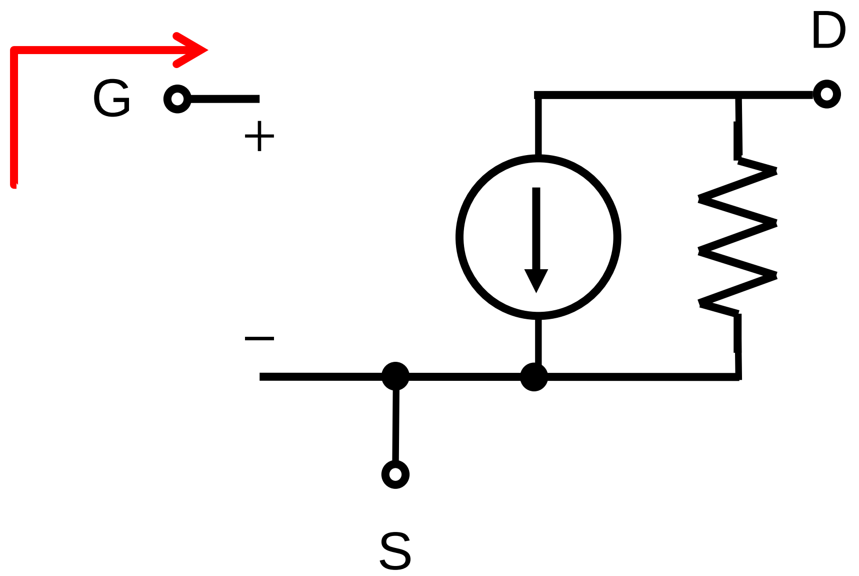
Why amplifiers?

- Signal amplification
  - Usually, signals are “weak.” (in the $\mu\mathrm{V}$ or mV range)
  - It is too small for reliable processing.
  - If the signal magnitude is made larger, processing is much easier.

- Desirable properties
  - Low power consumption
  - High speed operation
  - Low noise

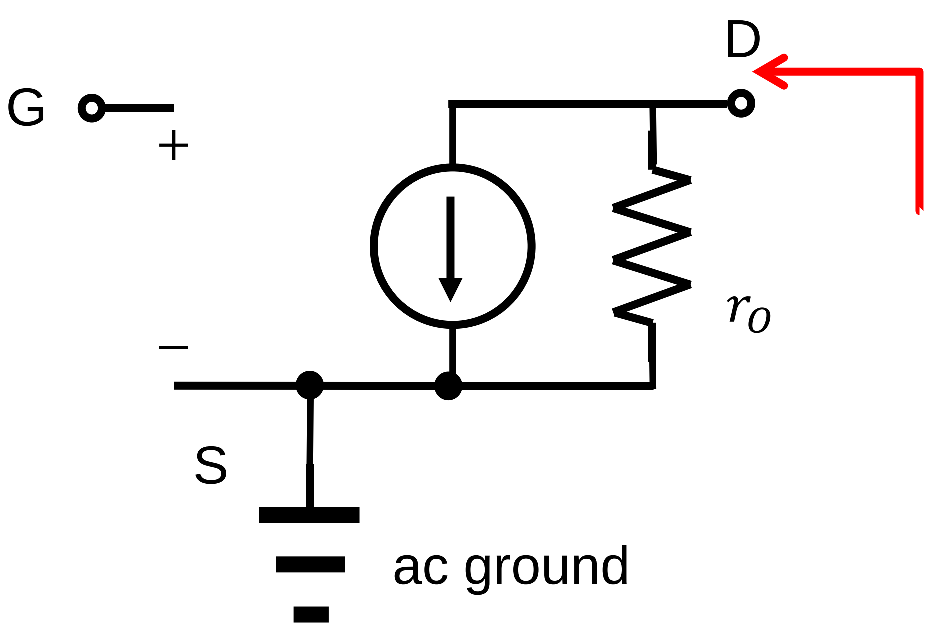
Impedances (1/3)

- A MOSFET with three terminals
  - Looking into the gate, we see the infinite impedance.
  - (Strictly valid at the low-frequency range)



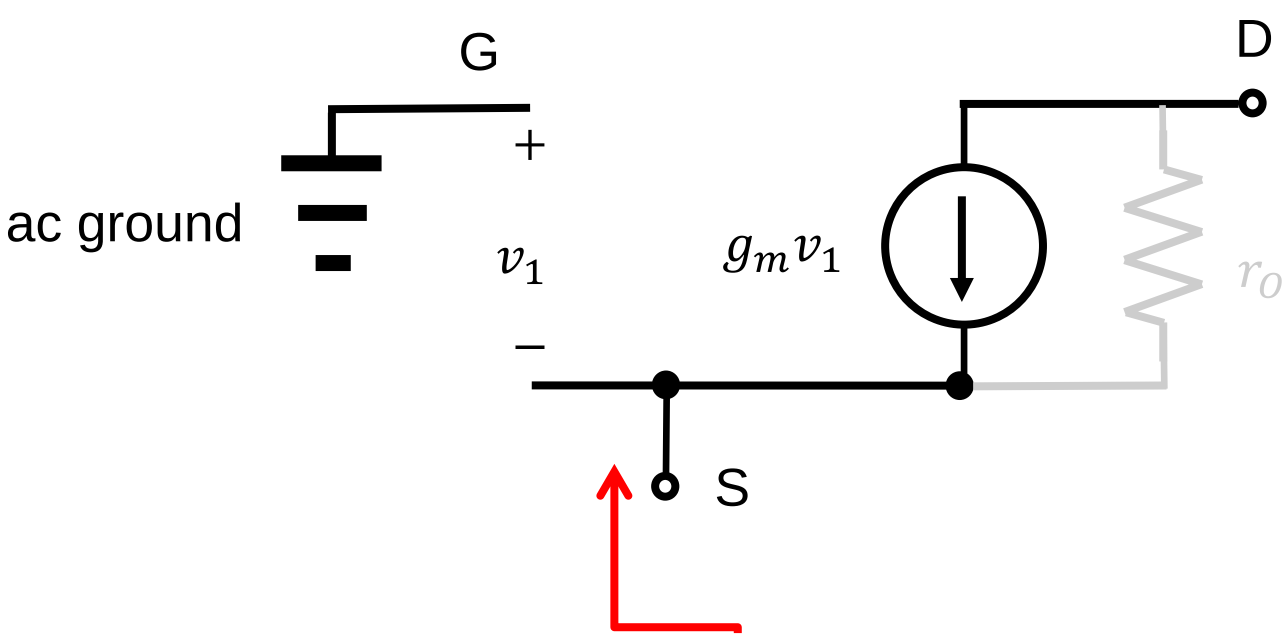
Impedances (2/3)

- A MOSFET with three terminals
  - Looking into the drain, we see r_o if the source is ac grounded.



Impedances (3/3)

- A MOSFET with three terminals
  - Looking into the source, we see $1/g_m$ if the gate is ac grounded and channel-length modulation is neglected.



Reading your textbook

- Sec. 17. 1 has been partially covered.

- On April 27, we will cover Sec. 17. 2.
  - Operating point analysis and design
  - Up to p. 759