Lecture26:
SPICE results

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SPICE

- Simulation Program with Integrated Circuit Emphasis
  - Originally developed at UC Berkeley (first release in 1971)
  - It was a term project in a graduate course!

Is this SPICE? Not in this context…
(Google Images)

Larry Nagel, the main author of SPICE
(Google Images)

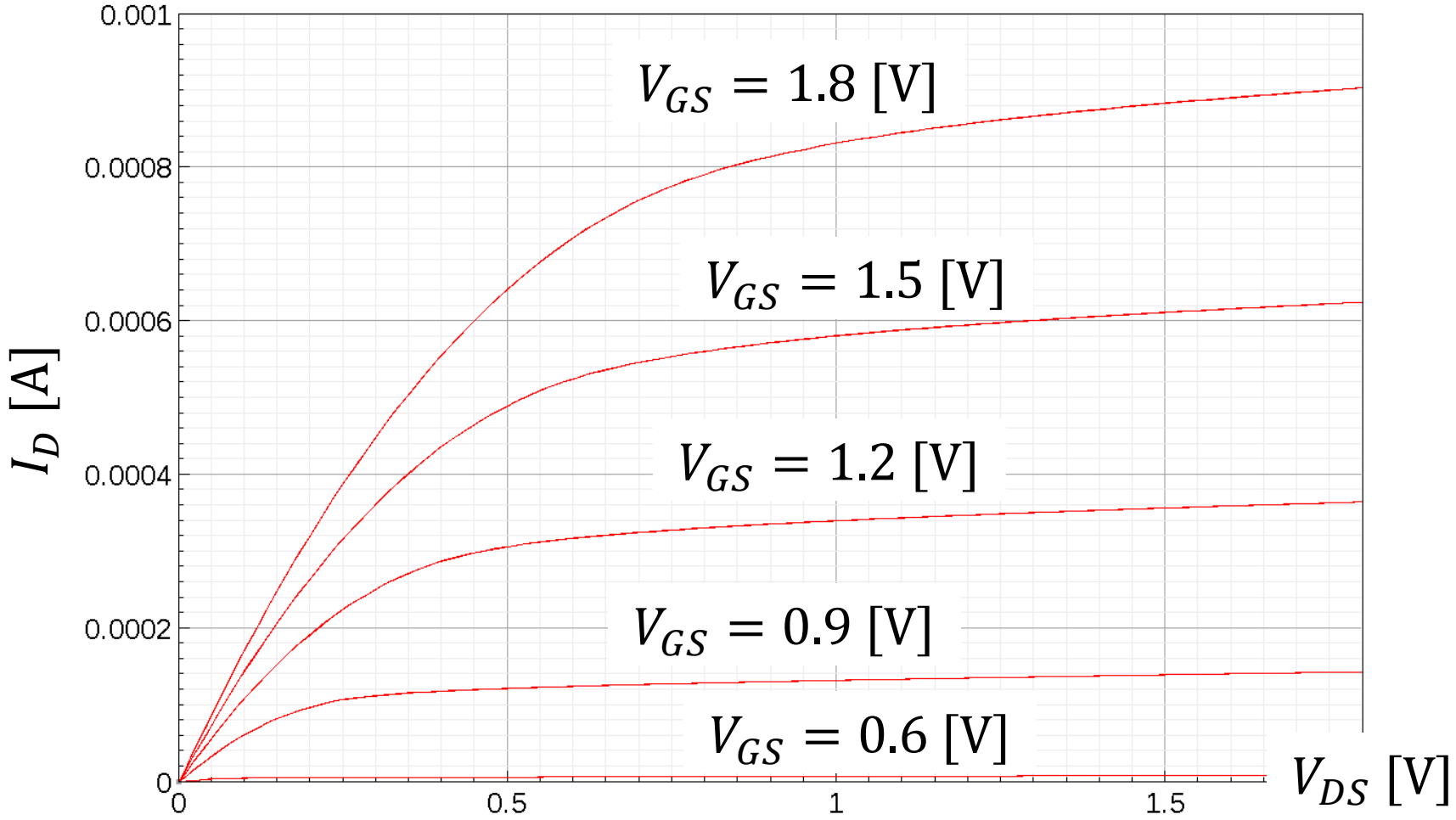
MOS IV (1/3)

Chenming Hu
(Google Images)

- BSIM3 model (NMOS)
  - Tox = 9 [nm]
  - Vth0 = 0.6322 [V] for long-channel devices
- BSIM3 model (PMOS)
  - Tox = 9 [nm]
  - Vth0 = -0.6732829 [V] for long-channel devices
- We will use 1.8 V as the V_{DD}.
- Note that these models also consider many parasitic effects.
  - Perfect agreement with our simple results cannot be expected!

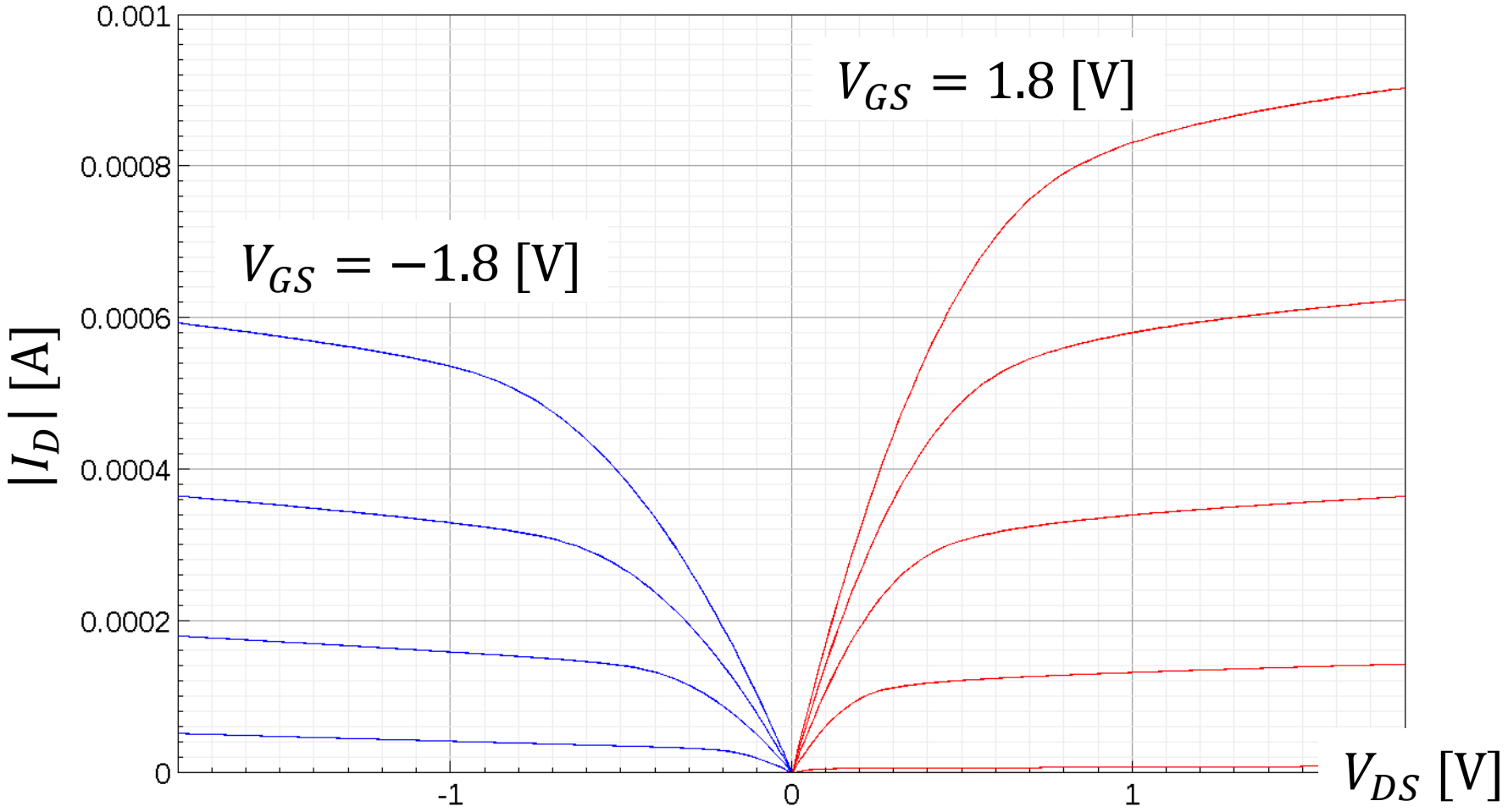
MOS IV (2/3)

- NMOS IV curve (L = 0.5 microns, W = 10 microns)
  - Channel-length modulation is visible.



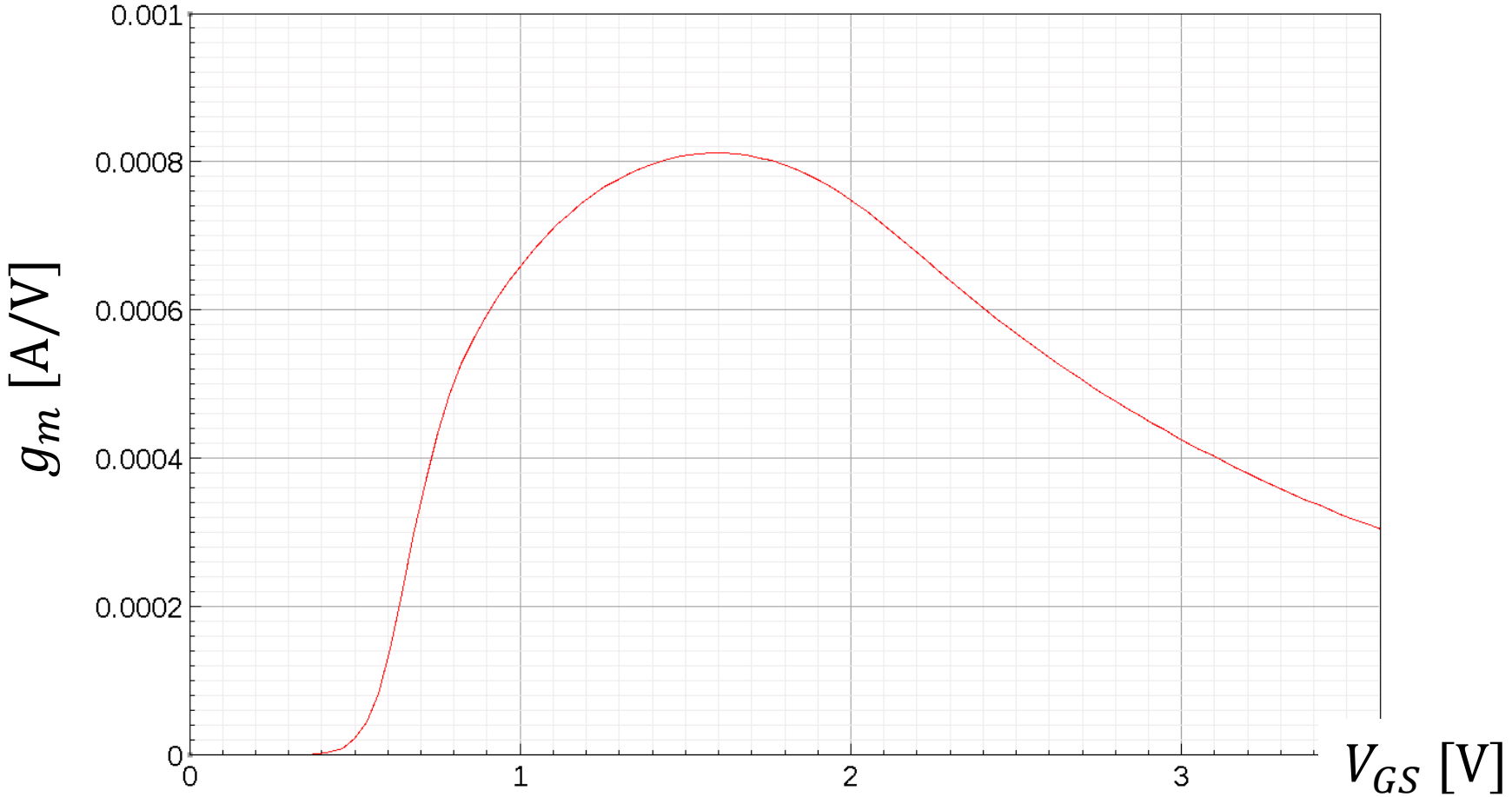
MOS IV (3/3)

- PMOS IV curve (L = 0.5 microns, W = 10 microns)
  - Certainly, its current level is smaller than the NMOS.



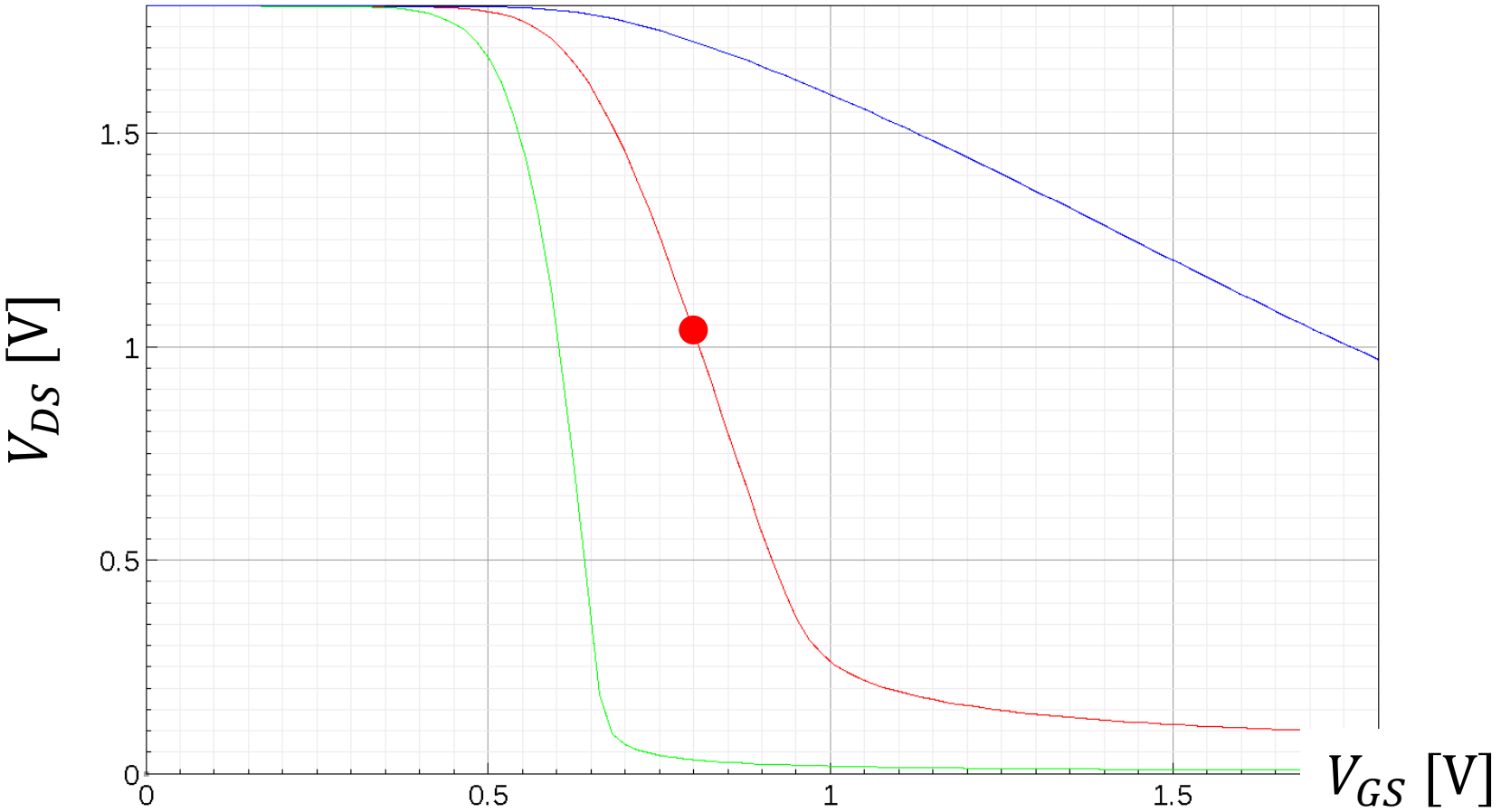
Transconductance

- NMOS g_m (L = 0.5 microns, W = 10 microns)
  - Curve at $V_{DS} = \frac{1}{2}V_{DD}$.



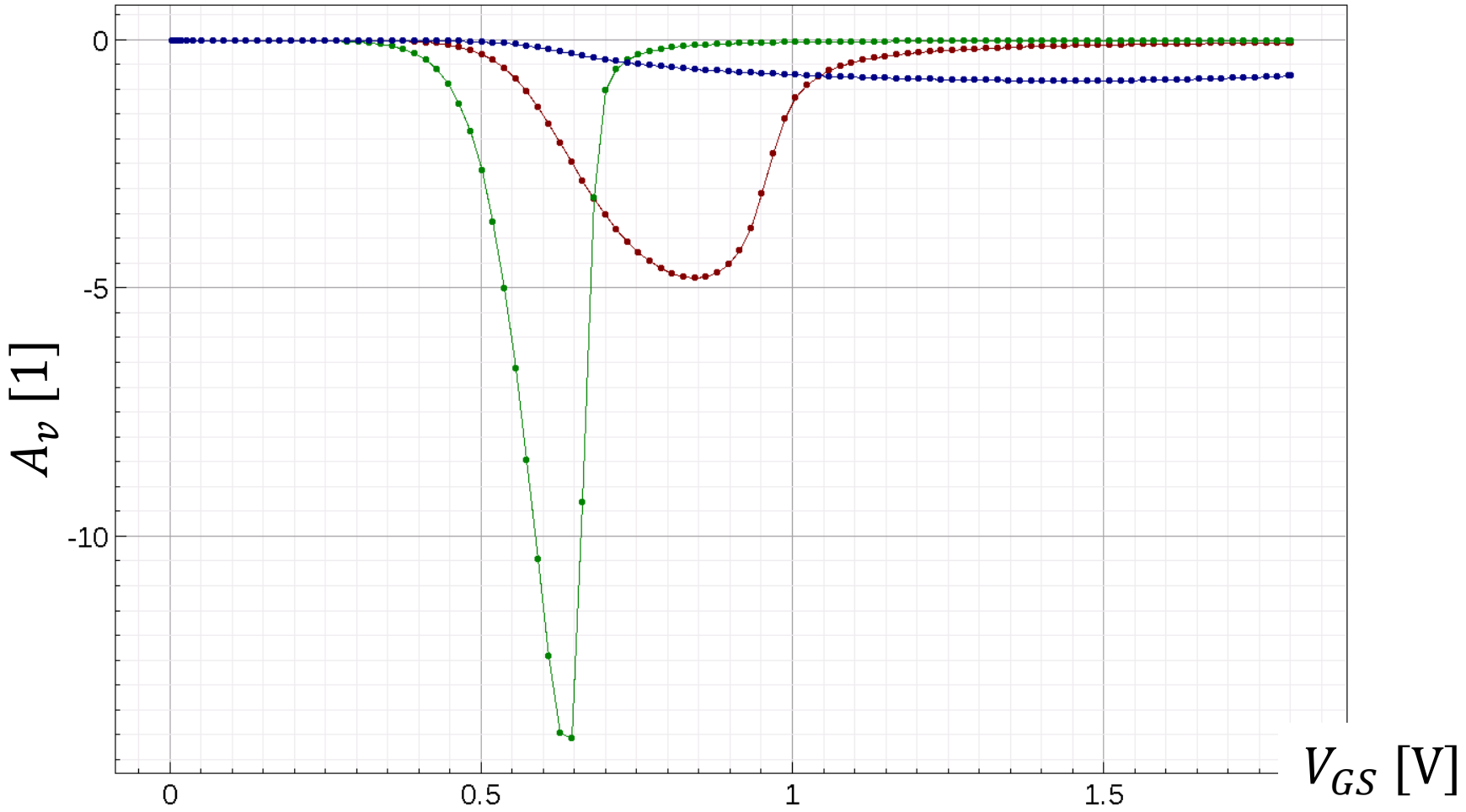
Common-source (1/3)

- Consider a CS stage (L = 0.5 microns, W = 10 microns)
  - The VTC is shown for different load resistances, $1\ \mathrm{k\Omega}$, $10\ \mathrm{k\Omega}$, and $100\ \mathrm{k\Omega}$.



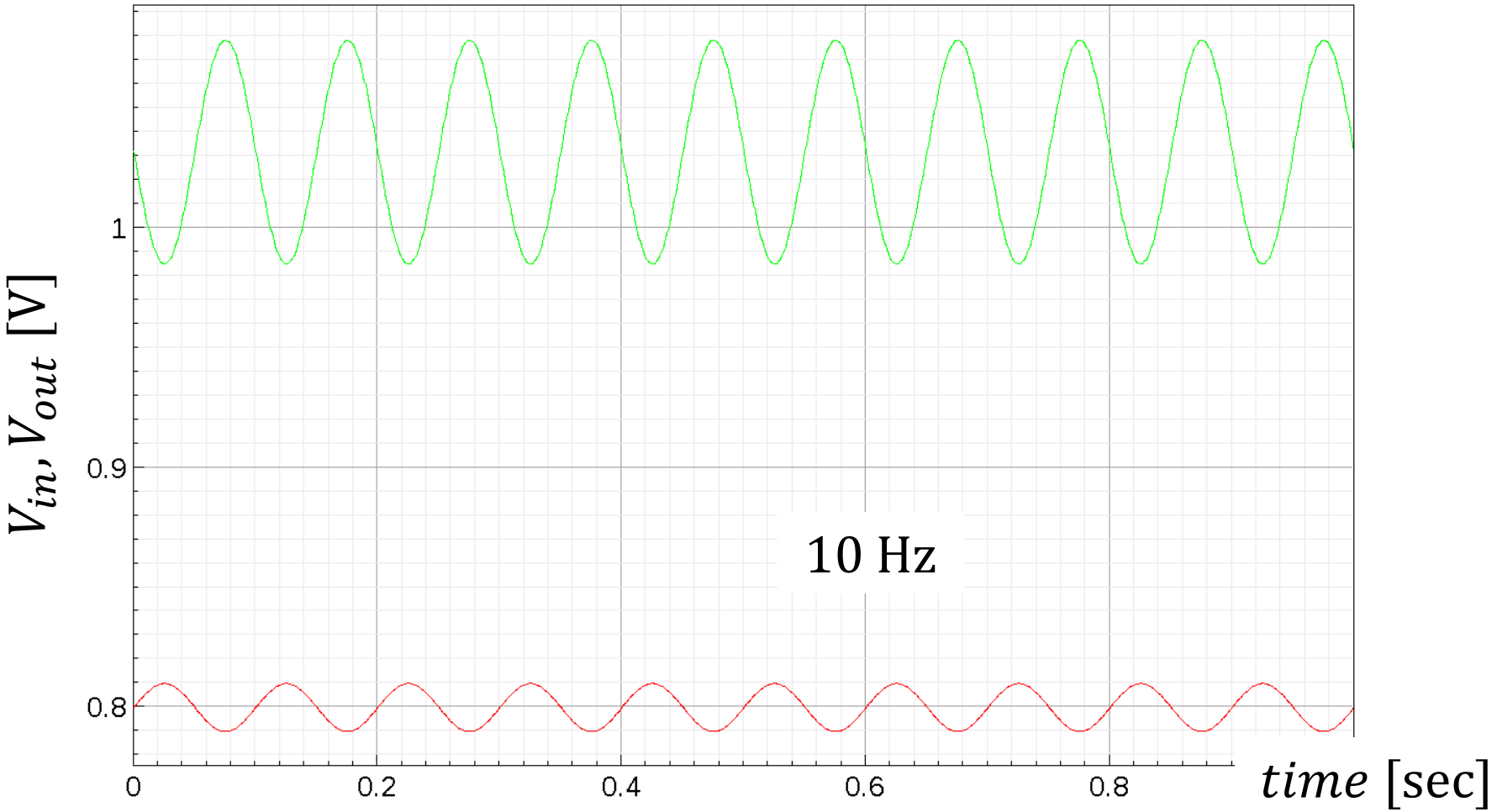
Common-source (2/3)

- From the previous curve,
  - We can calculate the voltage gain.



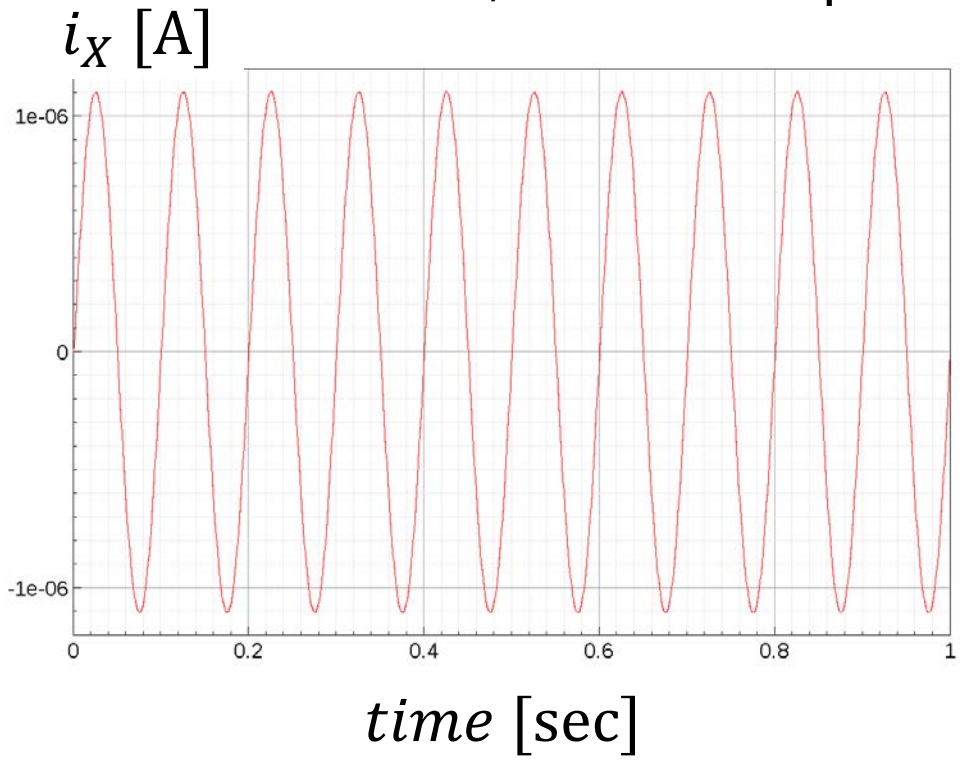
Common-source (3/3)

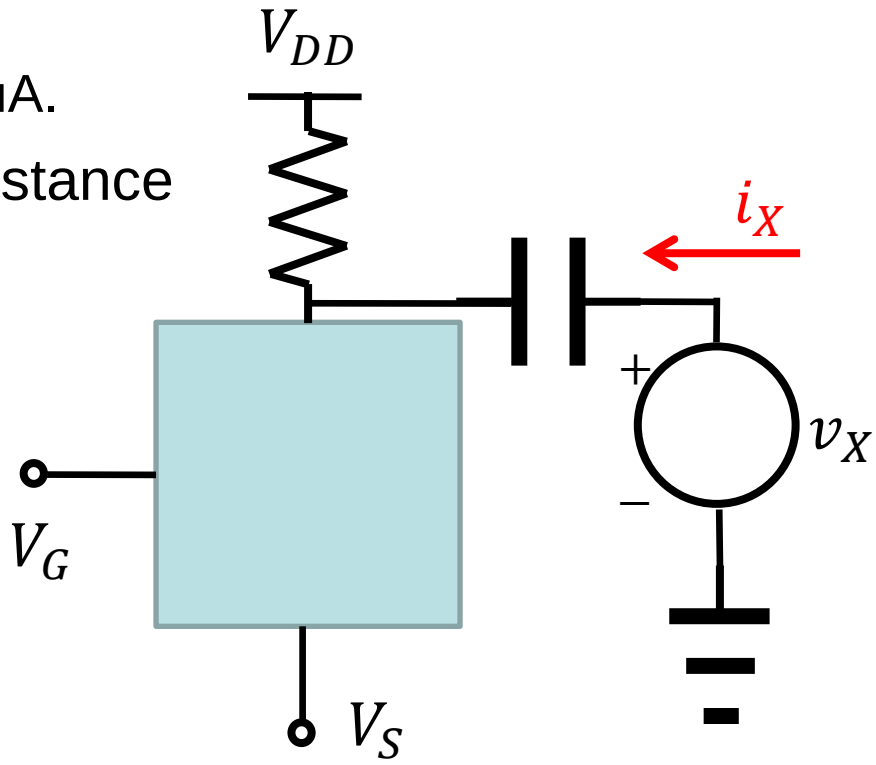
- Checking directly with transient simulation
  - Load resistance of $10\ \mathrm{k\Omega}$ is used. ($V_{GS} = 0.8\ \mathrm{V}$, amplitude of 10 mV)



Measuring impedances

- Applying a small-signal voltage excitation
  - Amplitude was 10 mV.
  - Current has an amplitude of 1.1 μA.
  - Therefore, $9\ \mathrm{k}\Omega$ of output resistance

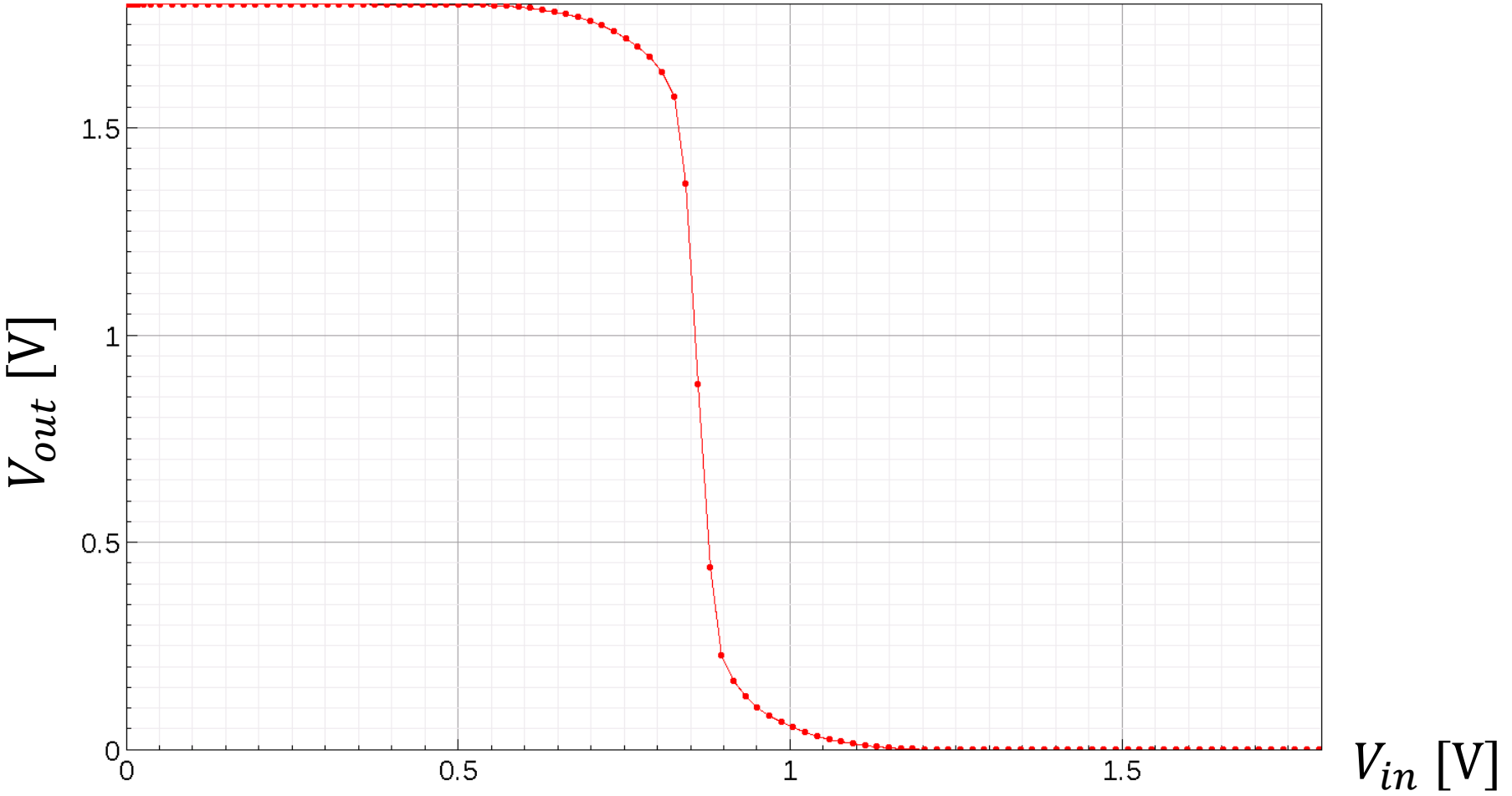




Setting for calculating R_{out}

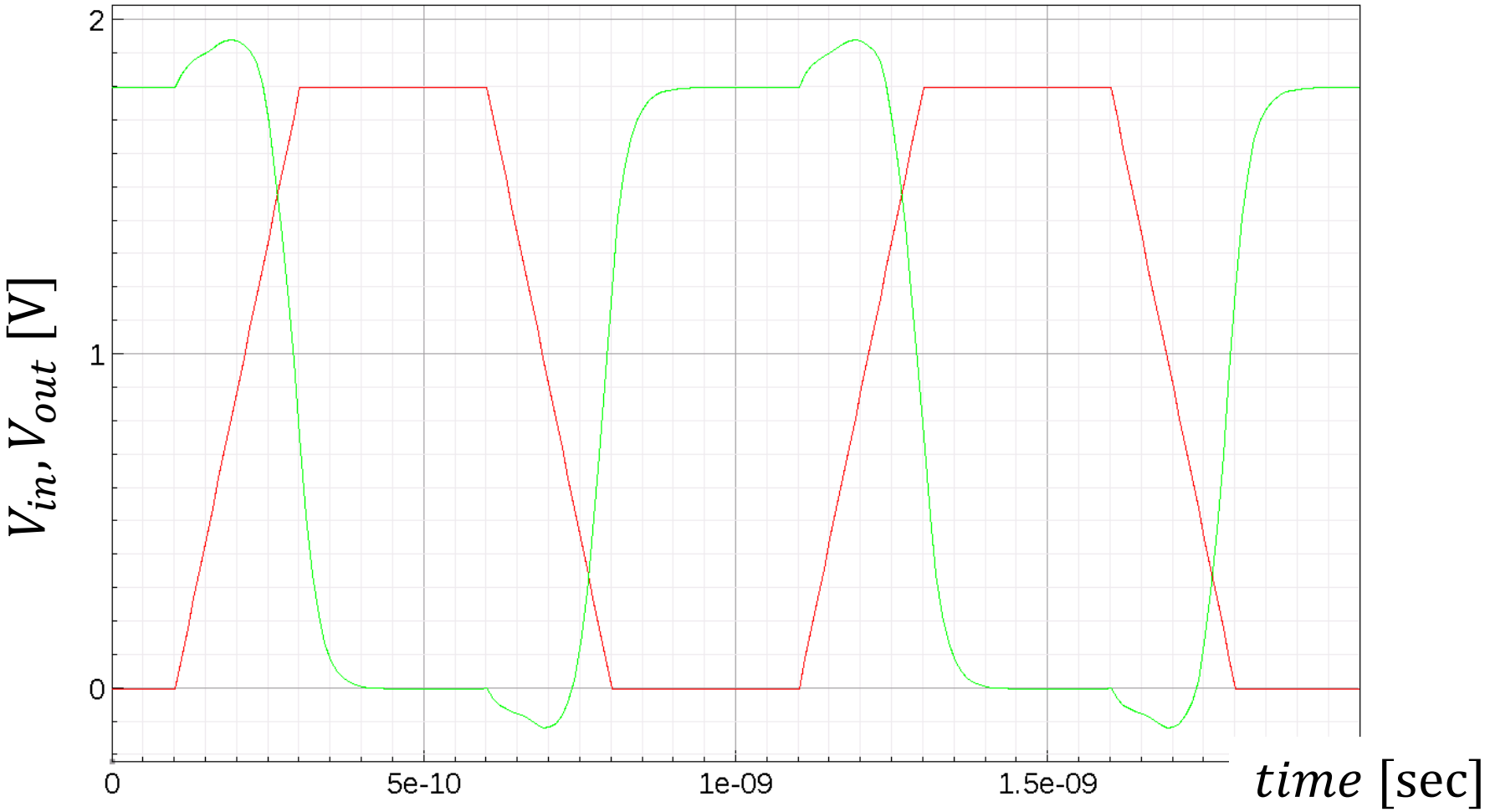
CMOS inverter

- Width ratio = 1:2 (NMOS:PMOS)
  - Improved VTC, as expected



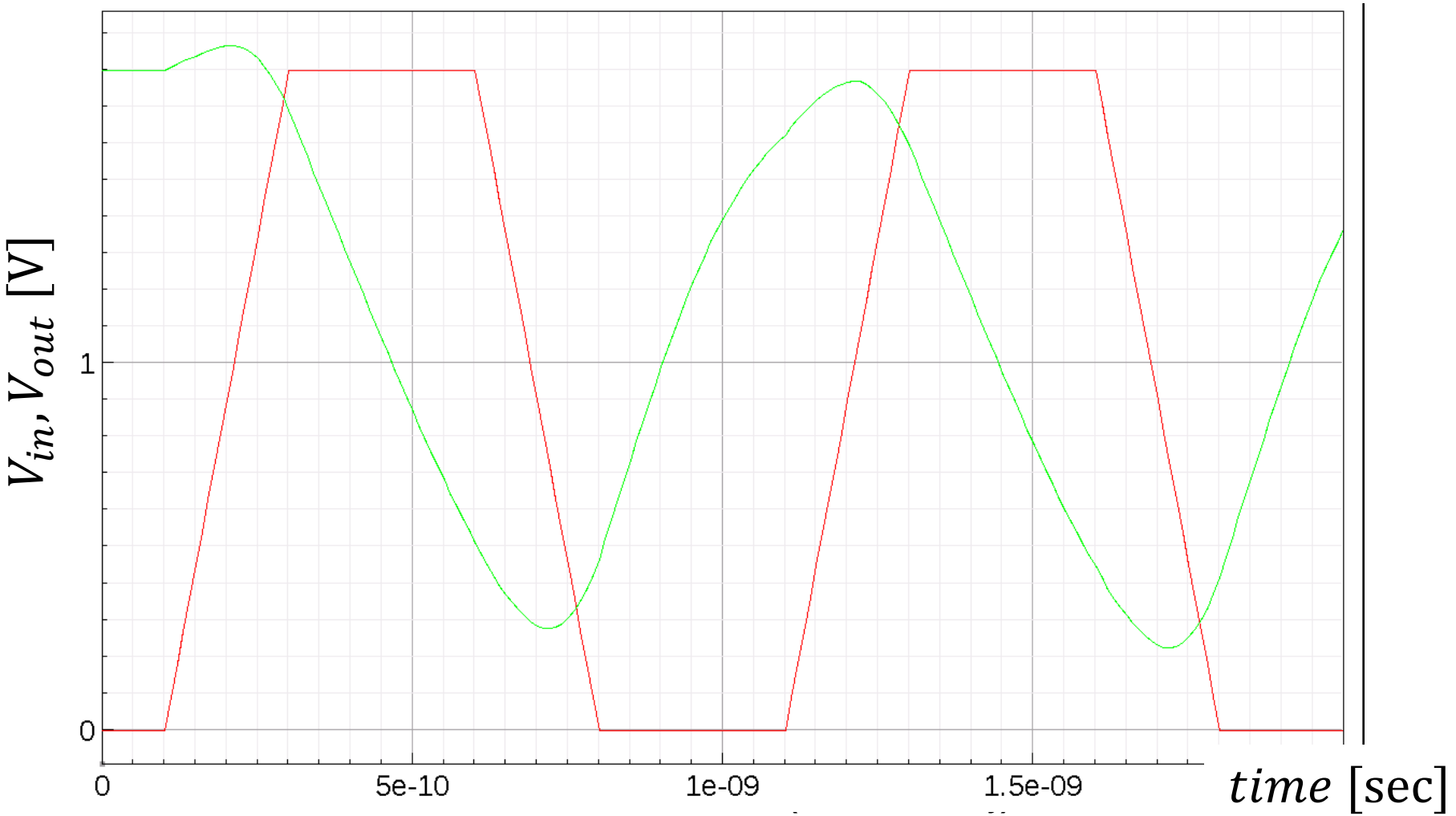
Transient simulation (1/2)

- Load capacitor of 20 fF
  - 1 GHz signal



Transient simulation (2/2)

- Higher value of load capacitance, 200 fF



Final exam.

- The day after tomorrow!
  - June 10 (Wed)
  - PM 01:00 ~ 02:15 (Class time)
  - In this time, we will have an ordinary paper exam.
  - Again, no calculator, no cell phone, …