Lecture17: Common-source amplifier (1)

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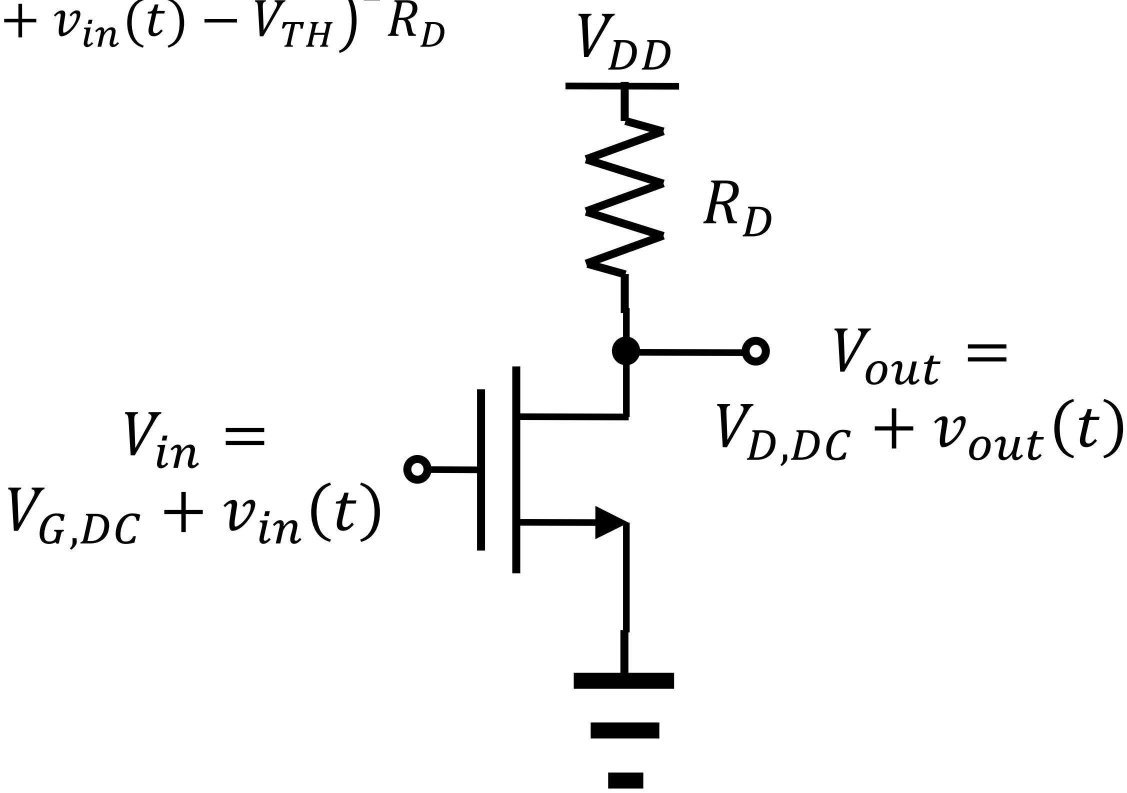
Common-source amplifer

- The source terminal is the reference.
  - The output voltage is $V_{out} = V_{DD} - I_D R_D$.

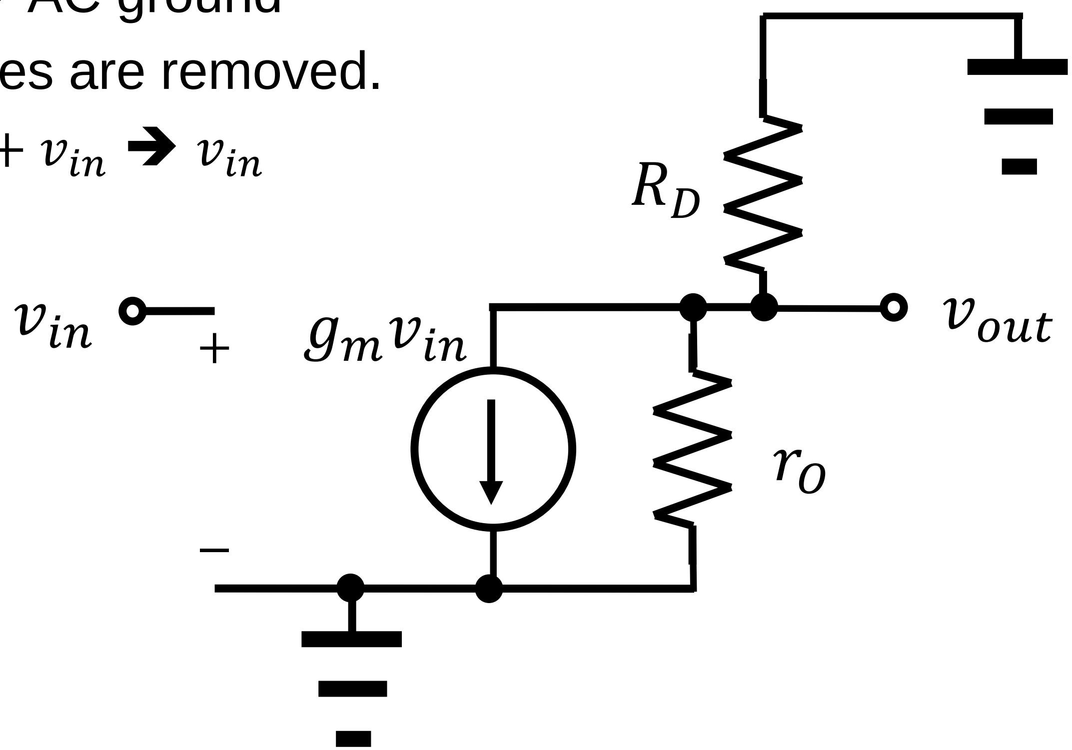
$V_{out}(t) =$

$$V_{DD} - \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(V_{G,DC} + v_{in}(t) - V_{TH}\right)^2 R_D$$



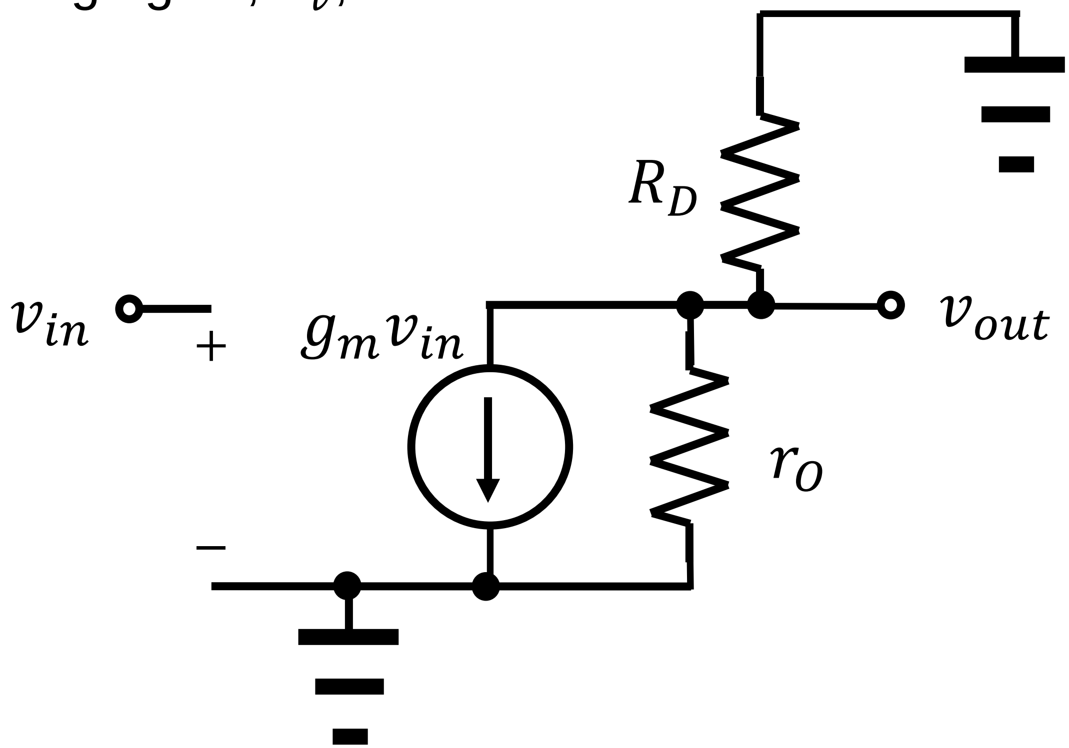
Small-signal model

- Let's draw its small-signal model together!
  - A transistor small-signal model is introduced.
  - Resistors ➔ resistors
  - Ground ➔ AC ground
  - DC voltages are removed.
  - Ex) $V_{G,DC} + v_{in}$ ➔ v_{in}



Gain

- Now, calculate the v_{out}.
  - KCL for the v_{out} node gives
  $v_{out} = -g_m(R_D||r_O)v_{in}$
  - Therefore, the voltage gain, A_v, is
  $A_v = -g_m(R_D||r_O)$



Increasing the gain

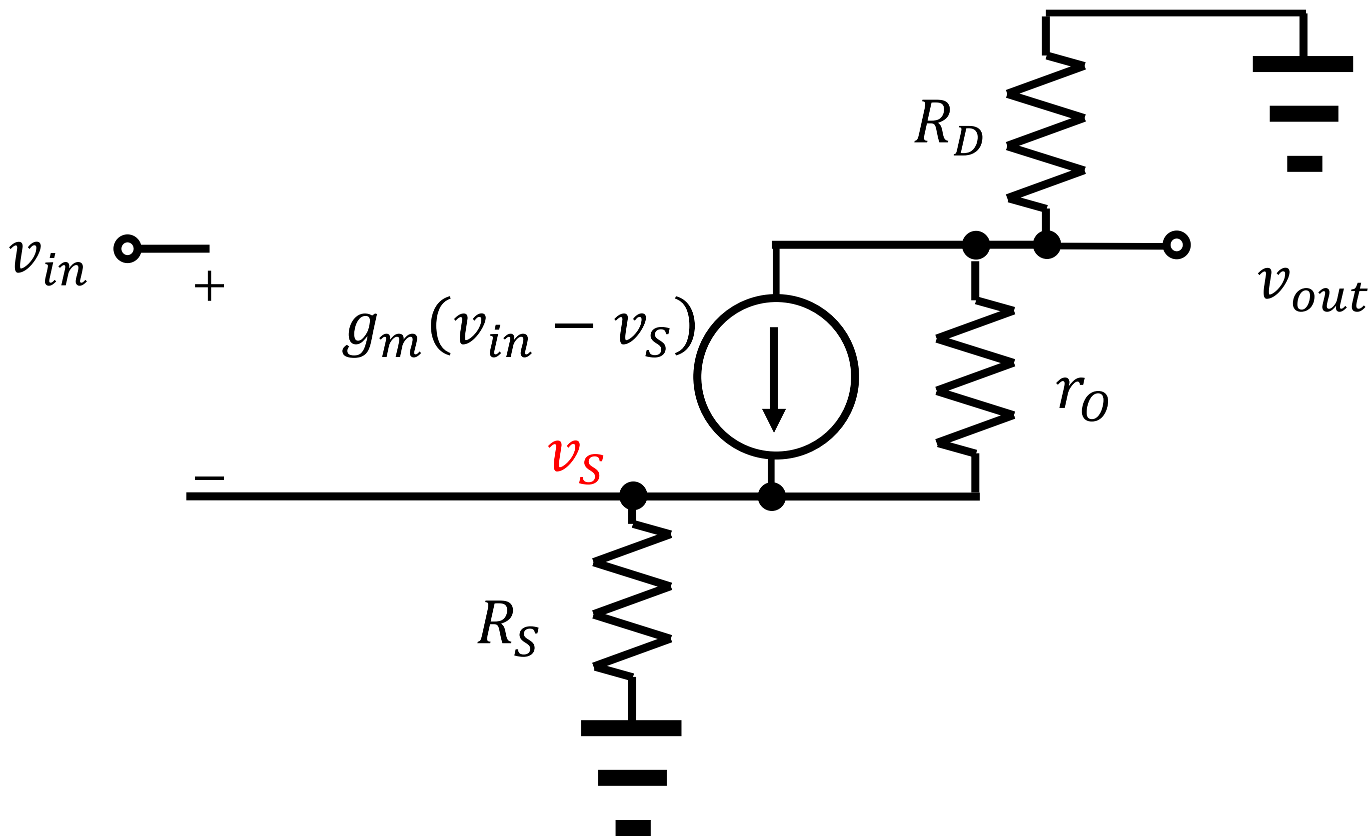
- The voltage gain has two factors.
  - Transconductance(g_m): Selecting W, L, and V_{GS} to maximize the transconductance
  - Resistance($R_D||r_O$): A large R_D value is desirable. However, there is a restrction.

$$V_{D,DC} = V_{DD} - R_D I_{D,DC}$$

  - A too large value of R_D reduces $V_{D,DC}$ too much. The triode mode is not suitable for the amplification due to its smaller transconductance.
  - A drain load other than a simple resistor can be tried.

Impact of R_S

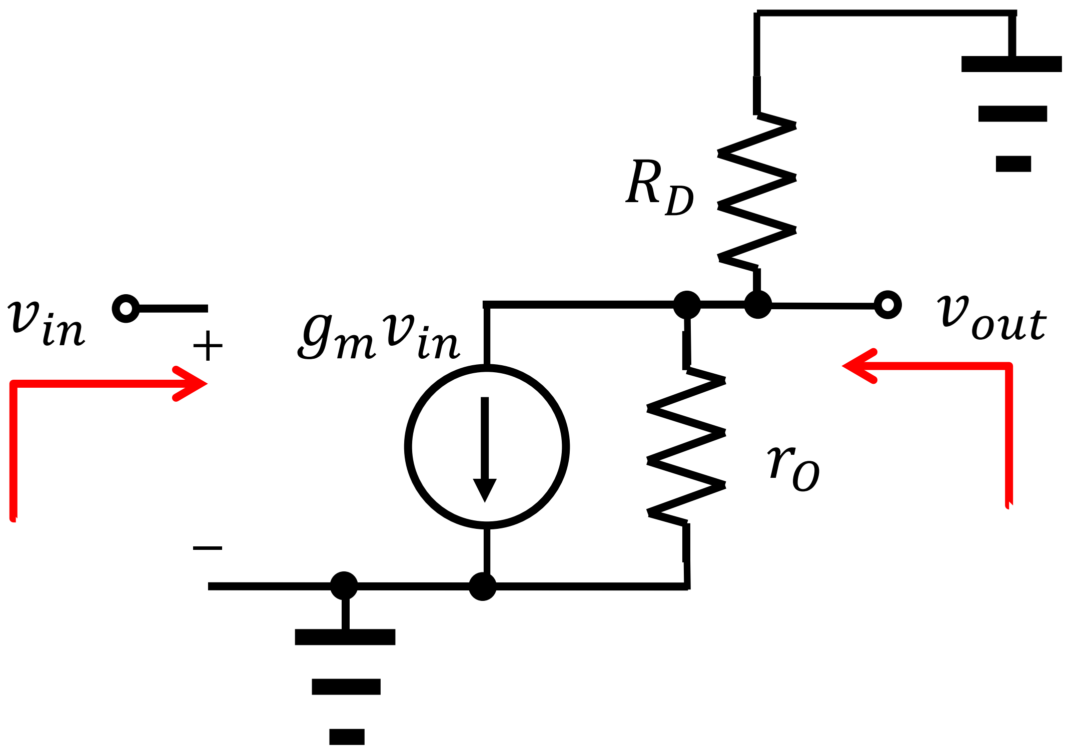
- Consider a source resistance, R_S.
  - Repeat the previous slide.



Input/output impedances

- When calculating the impedance, the voltage sources at other terminals are neglected.
- Input and output impedances

$$R_{in} = \infty$$
$$R_{out} = R_D || r_O$$



Homework#8

- Due: 09:00, **May 13 (Mon)**
- Design the common-source state.
  - A voltage gain is 5 and an output impedance is $1\ k\Omega$. Bias the transistor so that it operates 100 mV away from the triode region. Assume the capacitors are very large and $R_D = 10\ k\Omega$.