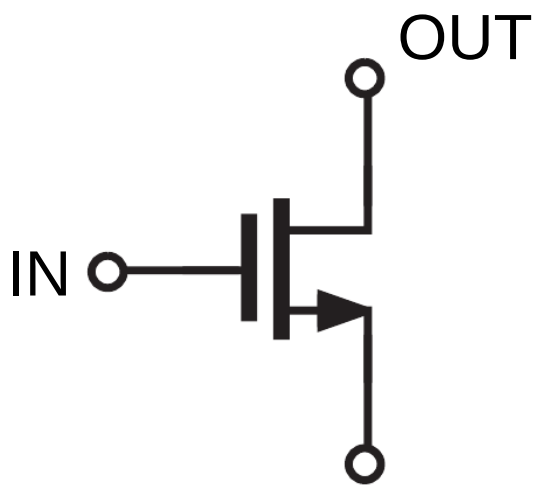
Source Follower

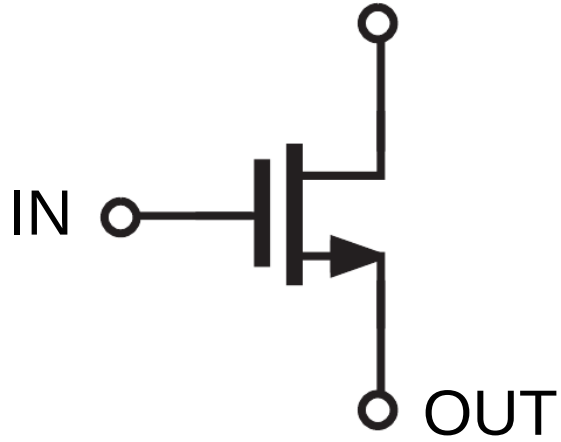
Hanwool Jeong

hwjeong@kw.ac.kr

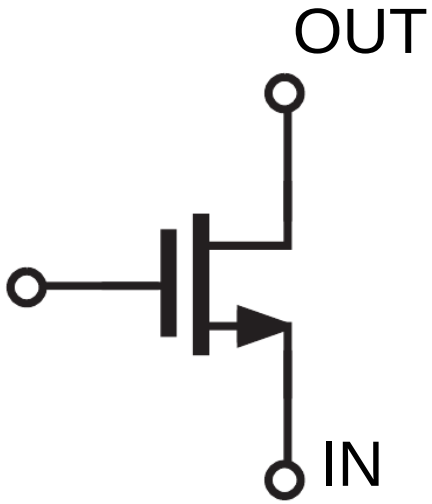
Revisit Possible Amplifier Configuration Using MOSFET



Common Source



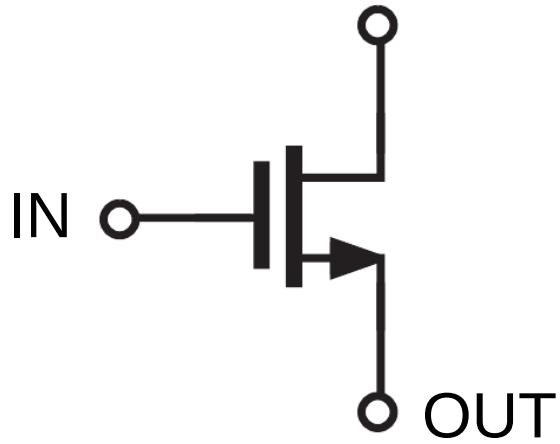
Common Drain
Source Follower



Common Gate

Source Follower

- Why can we use it as an amplifier?
- How the drain voltage be?
- Saturation or linear?
- How can OUT be captured as voltage?



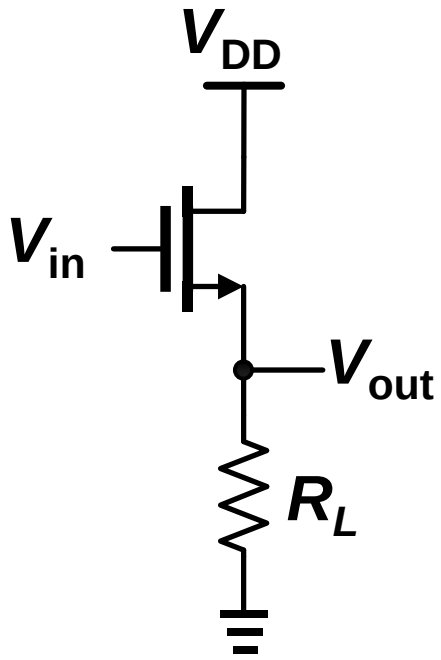
Amplifying Procedure in Source Follower

- In CG, considering $\Delta v_{in} = \Delta V_{GS} \rightarrow \Delta I_{DS} \rightarrow \Delta v_{out}$,

$$\frac{\Delta v_{out}}{\Delta v_{in}} = \frac{\Delta I_{DS}}{-\Delta V_{GS}} \times \frac{\Delta v_{out}}{\Delta I_{DS}} = g_m \times R_D$$

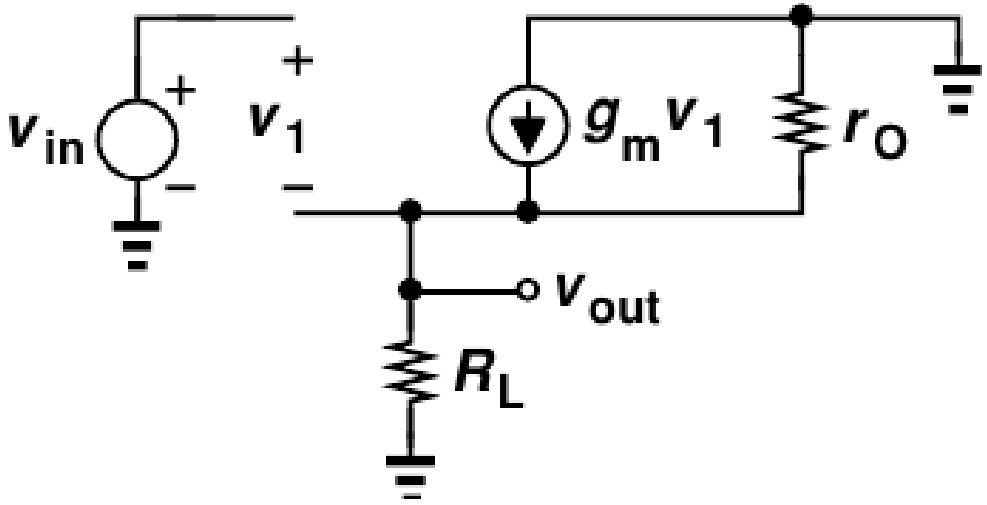
- Can we use the above term?

$$\Delta V_{in} = \Delta V_{GS} \uparrow \rightarrow \Delta I_{DS} \uparrow \rightarrow \Delta V_{out} \uparrow \rightarrow \Delta V_{GS} \downarrow \rightarrow \Delta I_{DS} \downarrow$$



Small Signal Model of Source Follower

- When λ ≠ 0,



Gain of Source Follower

- You see why it is named as “follower”
- The gain is less than 1, why do we use it?

$$\frac{v_{out}}{v_{in}} = \frac{g_m(r_O||R_L)}{1 + g_m(r_O||R_L)}$$

$$= \frac{r_O||R_L}{\frac{1}{g_m} + r_O||R_L}.$$

- What is real “gain” by using SF? Didn’t we miss something?

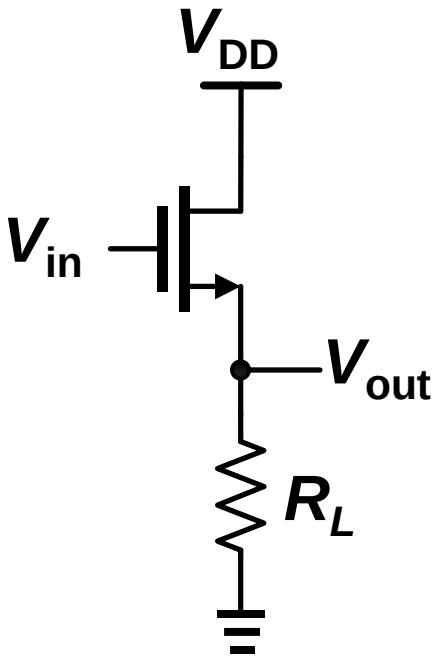
➔ R_{in} & R_{out}

R_{out}

- How do you measure R_{out}?
- What if $\lambda \neq 0$?

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

$$\approx \frac{1}{g_m} || R_L .$$



How was R_{out} of CG or CS?

- In CS, R_D or $R_D//r_{O.}$
- In CG, R_D or R_D // Very large R
- Can we reduce R_D?

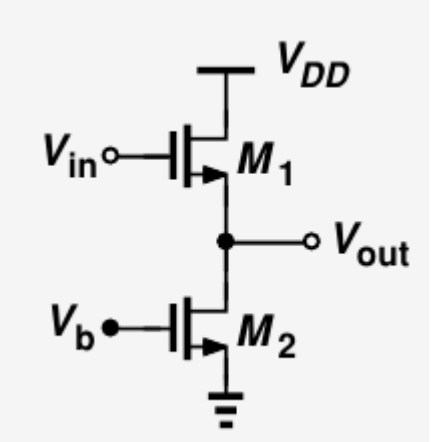
Reason For Using Source Follower

- Gain is less than 1 (but almost 1) but
- Have
  - Very high R_{in}
  - Very small R_{out}
- It can deliver the voltage signal very well

➔ Playing a good rule as a “buffer” stage.

Example 7.16

A source follower is realized as shown in Fig. 7.30(a), where M_2 serves as a current source. Calculate the voltage gain of the circuit.



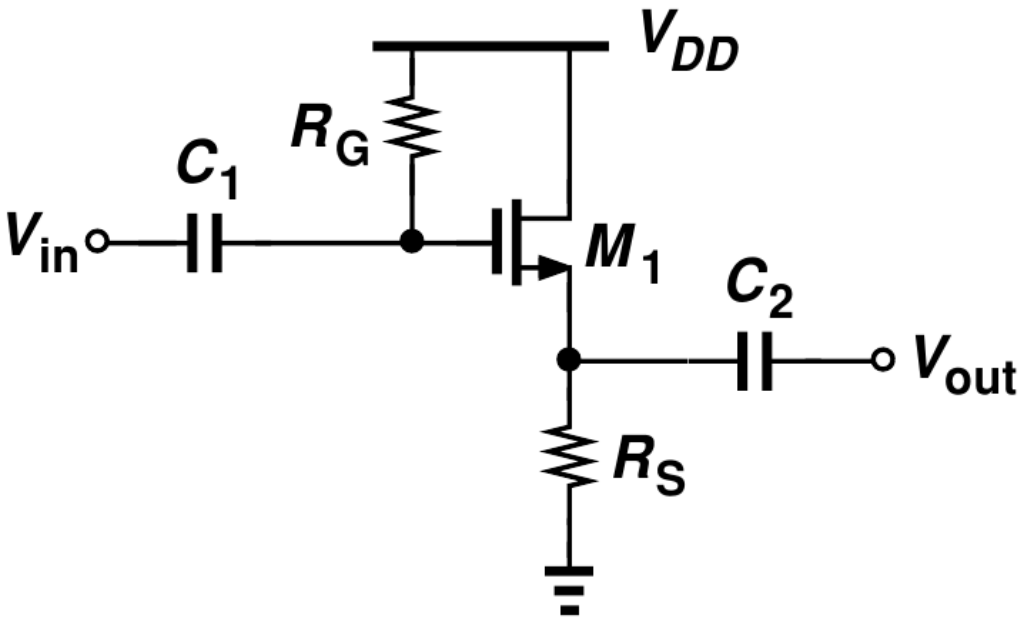
- Assume $\lambda \neq 0$

Example 7.17

Design a source follower to drive a 50-Ω load with a voltage gain of 0.5 and a power budget of 10 mW. Assume $\mu_n C_{ox} = 100\,\mu\text{A/V}^2$, $V_{TH} = 0.5\,\text{V}$, $\lambda = 0$, and $V_{DD} = 1.8\,\text{V}$.

Biasing & Decoupling DC Signal

- Coupling cap is used for only delivering AC signal
- Infinity impedance drops to finite value R_G.



$$V_{GS} + I_D R_S = V_{DD}$$

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2$$

$$= \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{DD} - I_D R_S - V_{TH})^2.$$

Example 7.18

Design the source follower of Fig. 7.32 for a drain current of 1 mA and a voltage gain of 0.8. Assume $\mu_n C_{ox} = 100\,\mu\text{A/V}^2$, $V_{TH} = 0.5\,\text{V}$, $\lambda = 0$, $V_{DD} = 1.8\,\text{V}$, and $R_G = 50\,\text{k}\Omega$.

