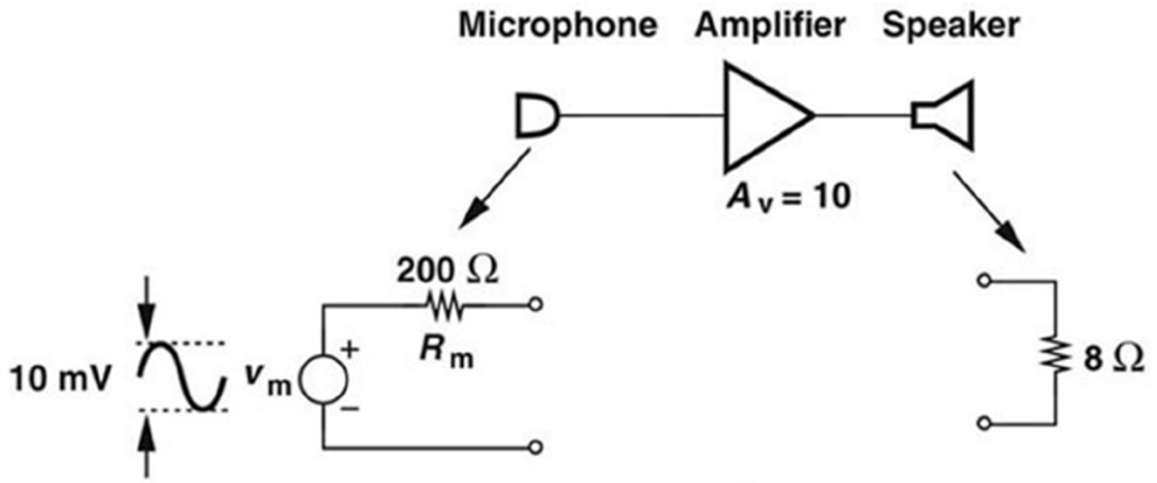
# Lect. 5: CMOS Amplifiers (1) (Razavi 7)



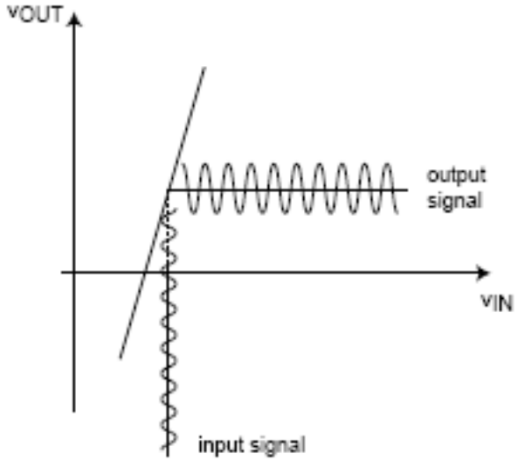

- Amplifier output signal should be **faithful replica** of input signal with desired amount of amplification

➔ Linear (Small-signal operation for MOS transistor)

- Key amplifier parameters:

  Gain

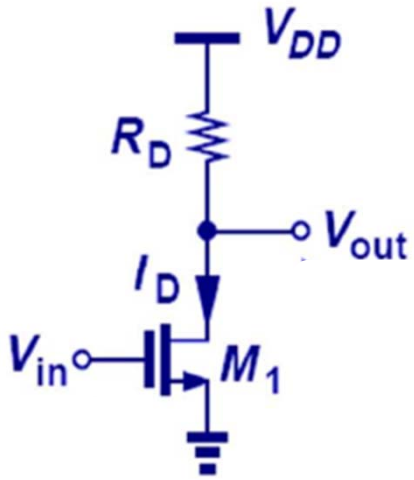
  $R_{in}$ and $R_{out}$

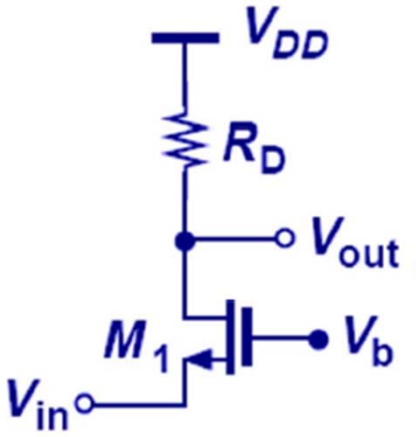


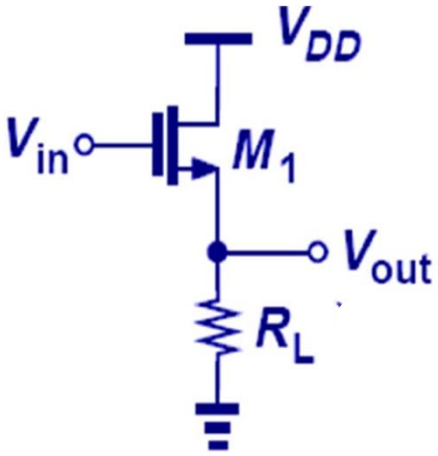
# Lect. 5: CMOS Amplifiers (1) (Razavi 7)

How can make amplifiers with MOS transistors

Three basic configurations: CS, CG, CD (SF)



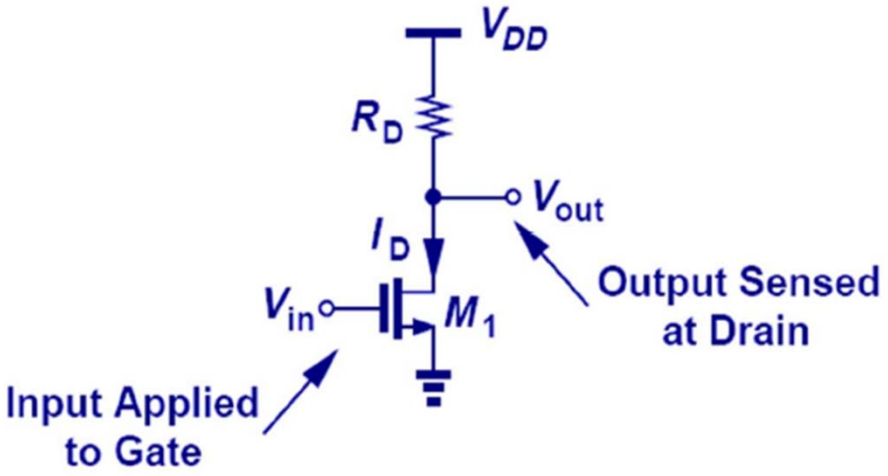



# Lect. 5: CMOS Amplifiers (1) (Razavi 7)

- Common Source

- How does it work?




- Operation in saturation

$$R_D I_D < V_{DD} - (V_{GS} - V_{TH})$$

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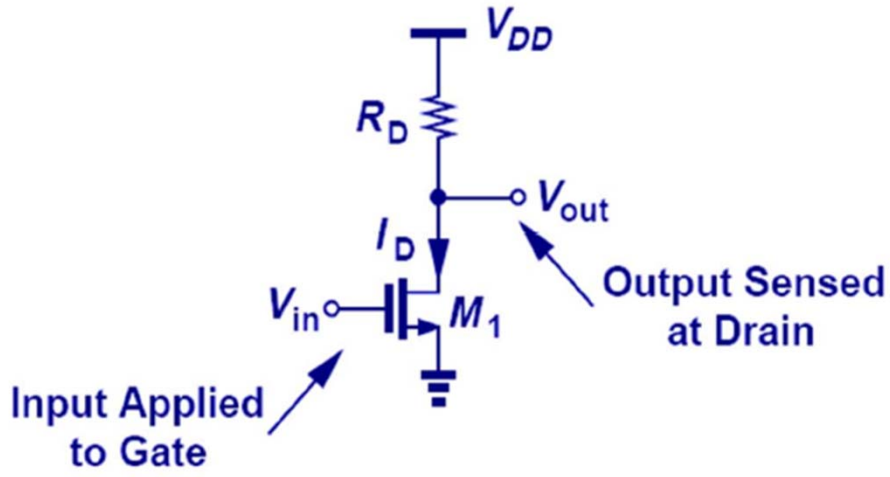
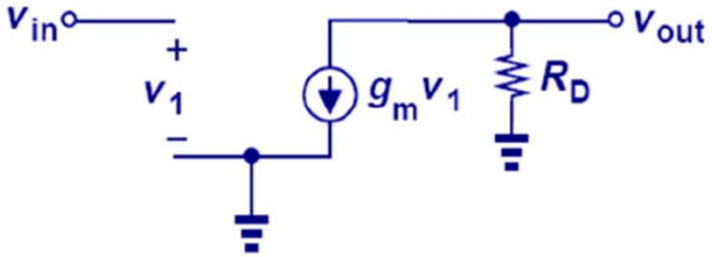
- CS



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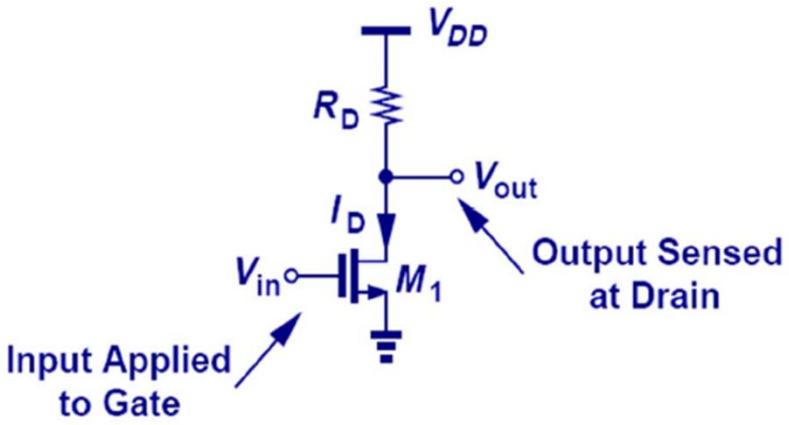
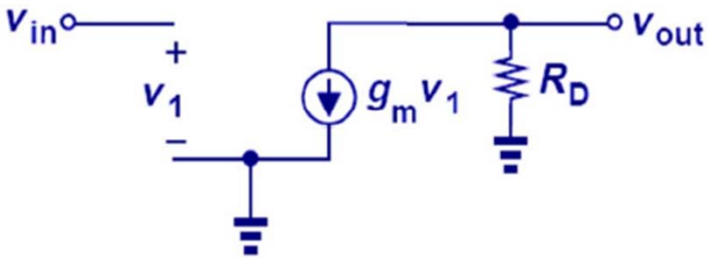
- CS

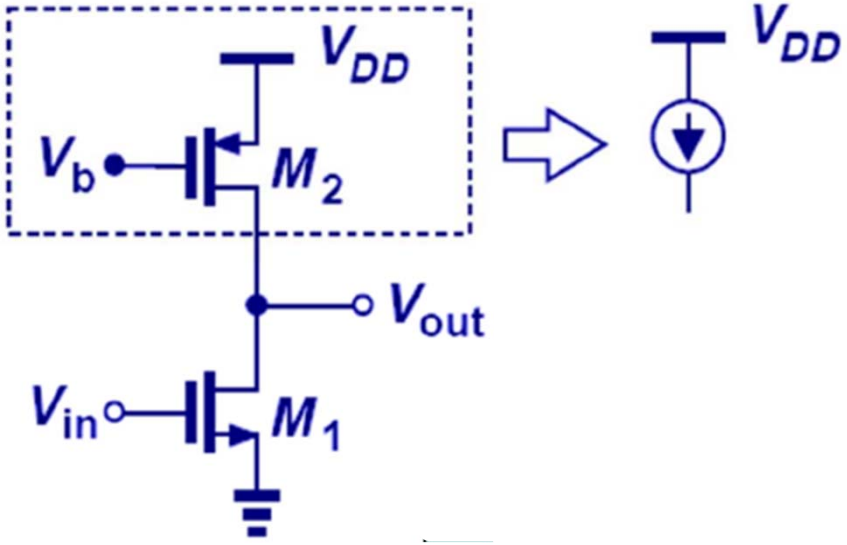


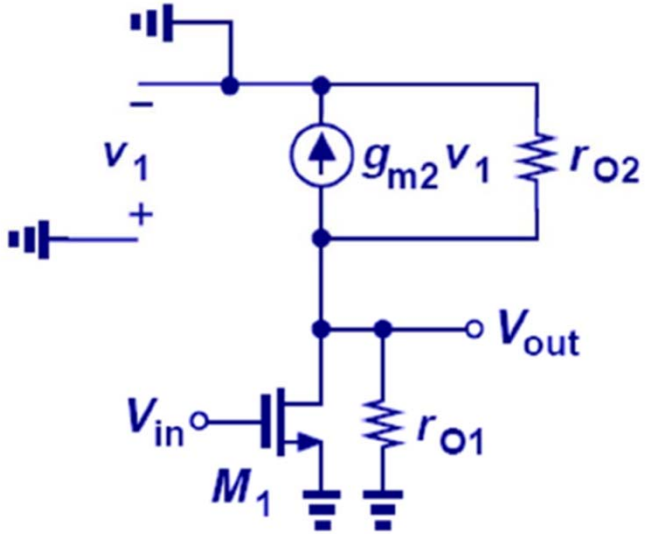




- With channel length modulation

- With a load ($R_L$)

- CS with Current-Source Load

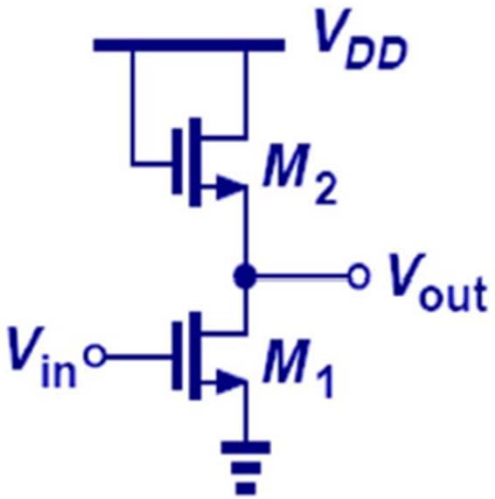


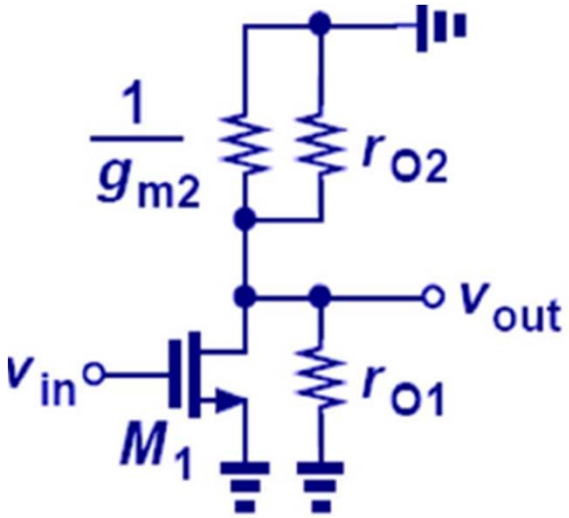




$$A_v = -g_{m1}(r_{O1} \| r_{O2})$$

$$R_{out} = r_{O1} \| r_{O2}$$

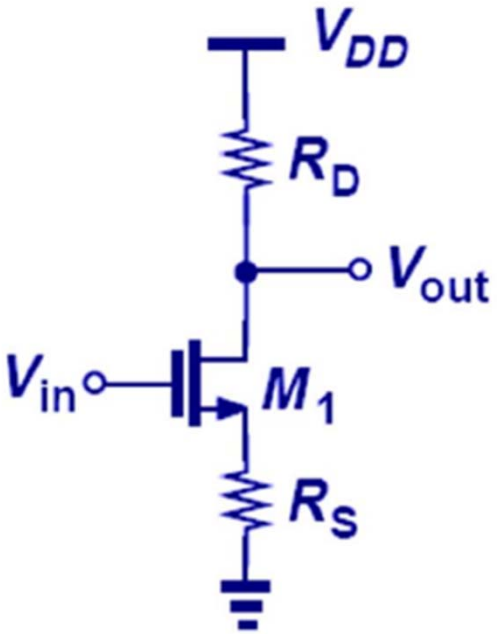
- CS with Diode-Connected Load

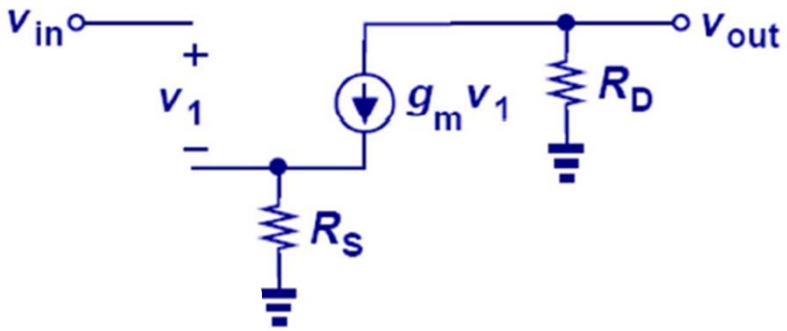



$$A_v = -g_{m1}\left(\frac{1}{g_{m2}} \| r_{O2} \| r_{O1}\right)$$

- CS with Degeneration



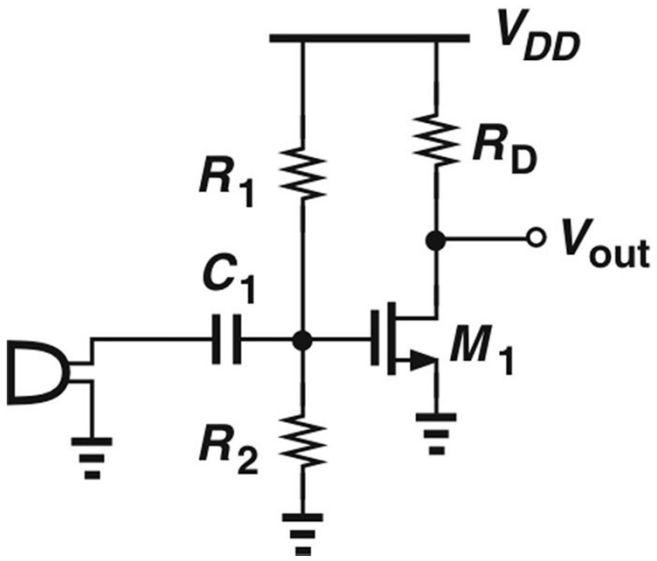




$$A_v = -\frac{R_D}{\frac{1}{g_m} + R_S}$$

# Lect. 5: CMOS Amplifiers (1) (Razavi 7)

- Why source degeneration?

- Bias stabilization




- $R_1$, $R_2$ provide bias for M1

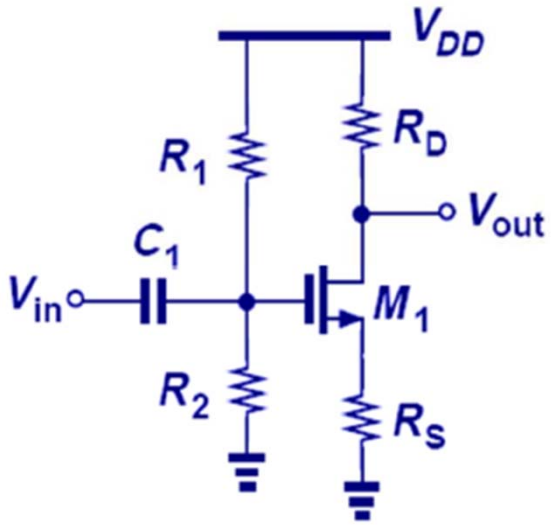
- Why $C_1$?

- What happens if $R_1$, $R_2$ fluctuate?

# Lect. 5: CMOS Amplifiers (1) (Razavi 7)

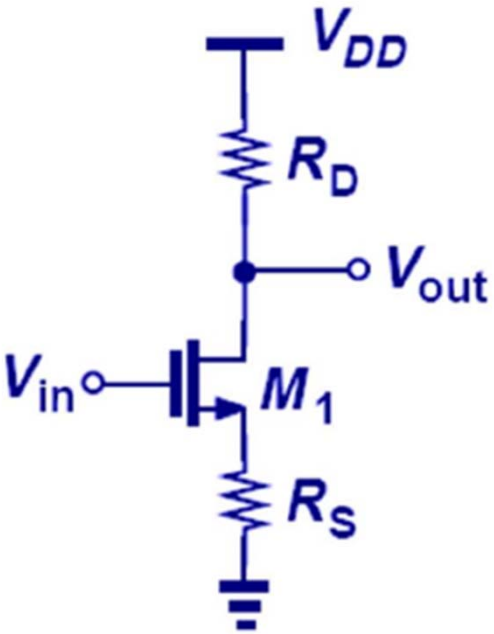
- Why source degeneration?

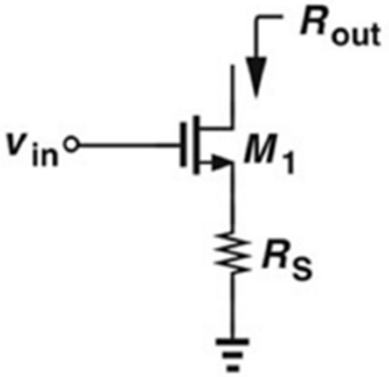
- Bias stabilization

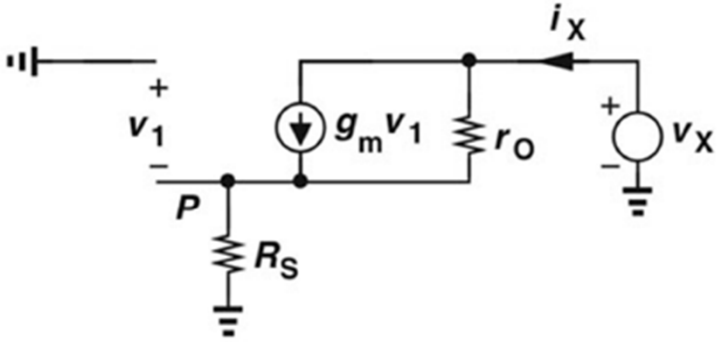



- Any fluctuation in M1 gate voltage is stabilized by $R_S$ (Negative feedback)

- Output Impedance for CS with Degeneration




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

$R_{out}$ for CS with Degeneration?

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- Homework

Prob. 7.17. 7.19 (Assume $\lambda = 0$) in Razavi