Lecture10: MOSFET, transconductance

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Summary

- When $V_G < V_{TH}$,
  - No drain current!

$$I_D = 0$$

- When $V_G > V_{TH}$,
  - Triode mode ($V_{DS} < V_G - V_{TH}$)

$$I_D = \mu_n C_{ox} \frac{W}{L}\left[(V_G - V_{TH})V_{DS} - \frac{1}{2}V_{DS}^2\right]$$

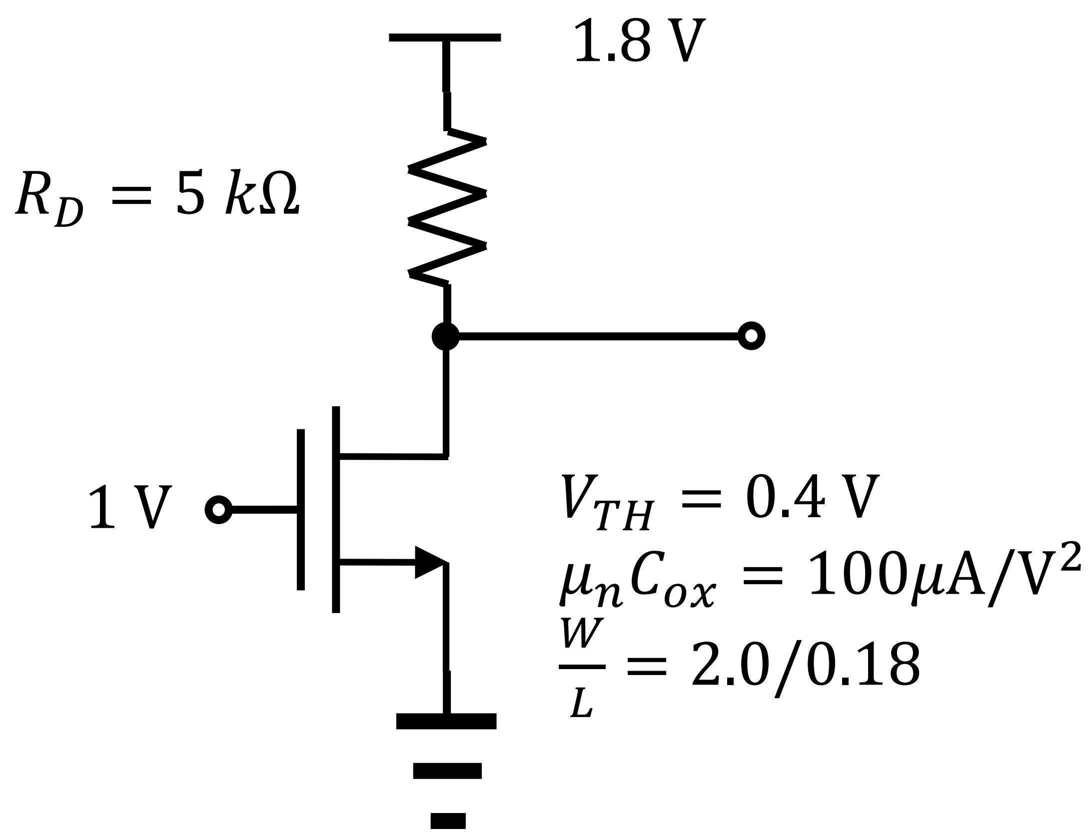
  - Saturation mode ($V_{DS} > V_G - V_{TH}$)

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

  - For a short channel device, I_D increases slightly as V_{DS} increases.

Example 6.6 (Razavi)

- Assume the saturation region.
  - Then, the saturation current becomes $200\ \mu\text{A}$.



V_{out} versus V_{in}

- A table

V_{in} (V)	V_{out} (V)
0.0	1.8
<0.4	1.8
0.7	1.55
1.0	0.8
X	$X - 0.4$
1.8	Y

  – What are the values of X and Y?

MOS transconductance

- "conductance" of a simple resistor
  - It means $\frac{I}{V}$.
- "trans" + "conductance"
  - Between different terminals

$$g_m = \frac{\partial I_D}{\partial V_{GS}} \tag{6.44}$$

  - For the saturation region,

$$g_m = \mu_n C_{ox} \frac{W}{L}(V_{GS} - V_{TH})$$

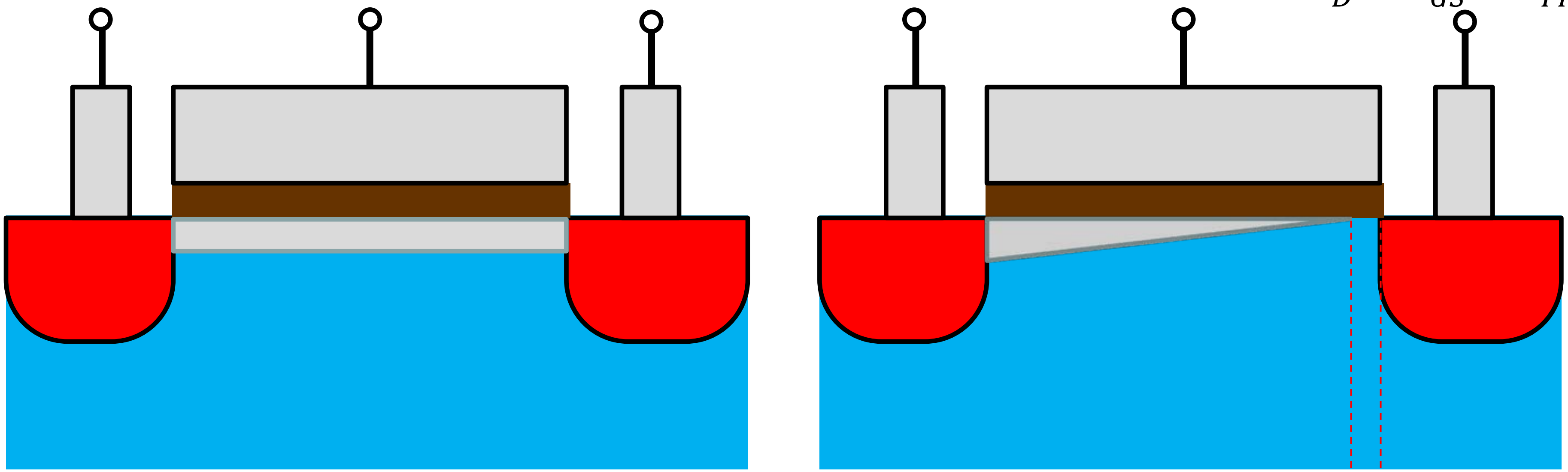
$$g_m = \sqrt{2\mu_n C_{ox} \frac{W}{L} I_D}$$

$$g_m = \frac{2I_D}{V_{GS} - V_{TH}}$$

Channel length modulation

- Channel length modulation

$V_D > V_{GS} - V_{TH}$



- Output resistance?

$$r_O = \frac{\Delta V_{DS}}{\Delta I_D}$$