V-code: ???

The MOSFET Amplifier (2)

Lecture 8
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V-code: ???

Outline

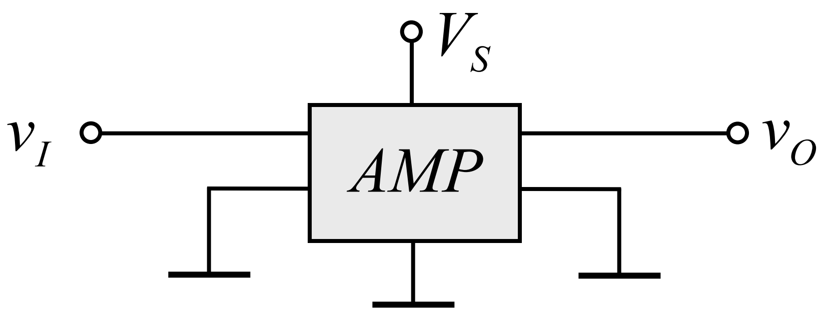
Textbook: 7.5, 7.6, 7.7

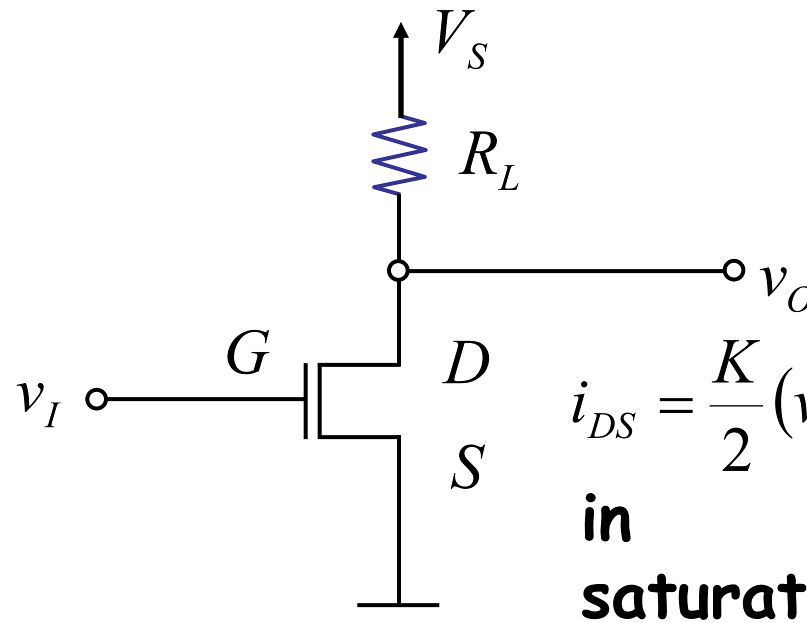
- **The MOSFET Amplifier**
- Large-Signal Analysis of the MOSFET Amplifier
- Operating Point Selection

V-code: ???

The MOSFET Amplifier

- Back to amplifier





$$i_{DS} = \frac{K}{2}\left(v_I - V_T\right)^2$$

in saturation region

To ensure the MOSFET operates as a VCCS, we must operate it in its saturation region only. To do so, we promise to adhere to the

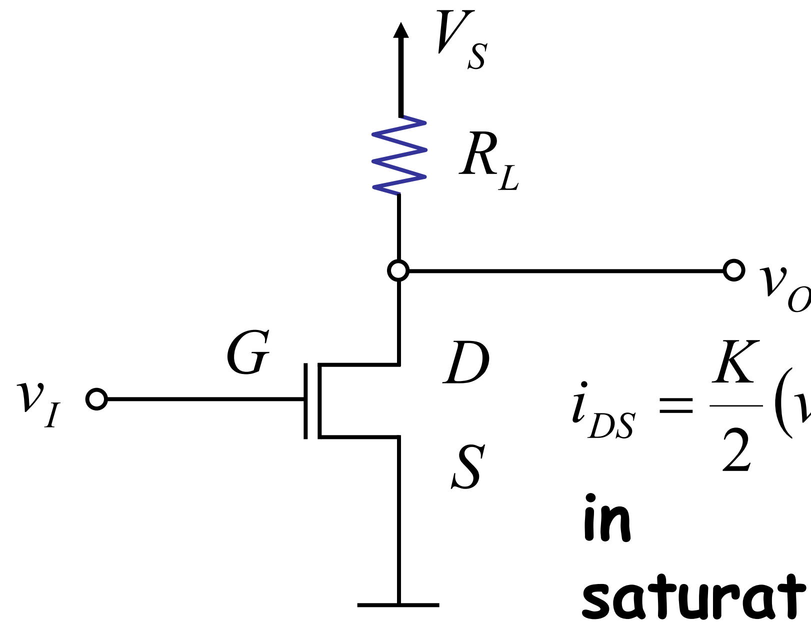
"saturation discipline"

V-code: ???

The MOSFET Amplifier

- Back to amplifier

To ensure the MOSFET operates as a VCCS, we must operate it in its saturation region only. To do so, we promise to adhere to the "saturation discipline"



$$i_{DS} = \frac{K}{2}(v_I - V_T)^2$$

in saturation region

In other words, we will operate the amp circuit such that

$v_{GS} \geq V_T$ and $v_{DS} \geq v_{GS} - V_T$, $v_O \geq v_I - v_T$ at all times.

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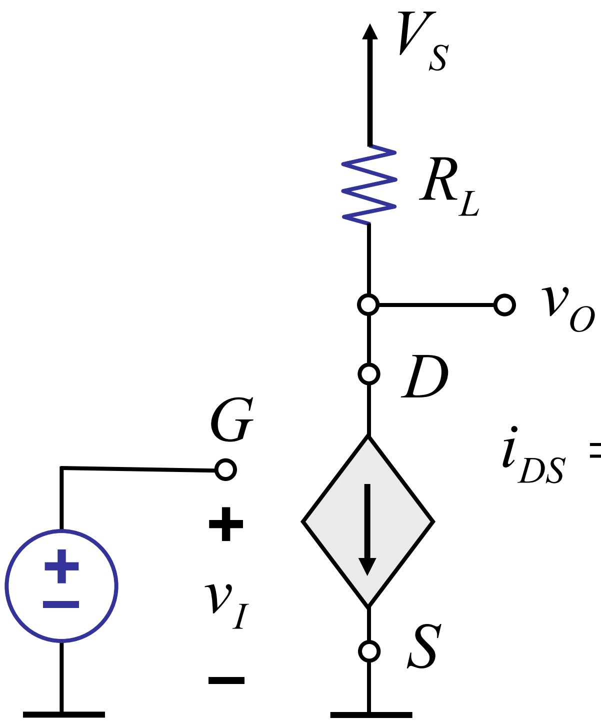
The MOSFET Amplifier

- **Let's analyze the circuit**

First, replace the MOSFET with its SCS model.

$v_{GS} = v_I$



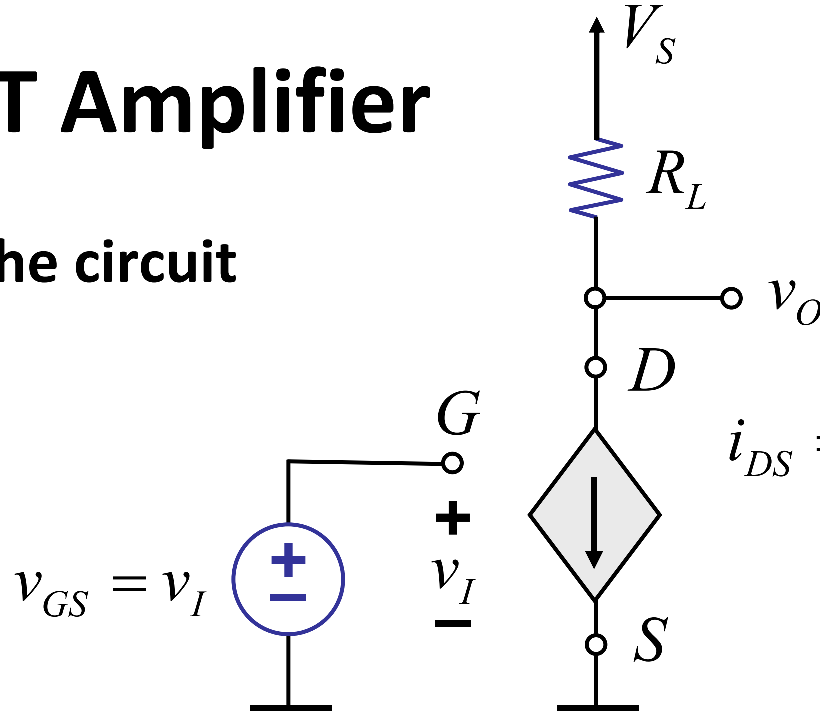
$$i_{DS} = \frac{K}{2}(v_I - V_T)^2$$ A

for $v_O \geq v_I - V_T$

V-code: ???

The MOSFET Amplifier

- Let's analyze the circuit



$$i_{DS} = \frac{K}{2}(v_I - V_T)^2 \longleftarrow \text{A}$$

for $v_O \geq v_I - V_T$

1 **Analytical method:** v_O vs v_I $\quad$ ($v_O = v_{DS}$ in our example)

$$v_O = V_S - i_{DS} R_L \longleftarrow \text{B}$$

or $v_O = V_S - \frac{K}{2}(v_I - V_T)^2 R_L$ for $v_I \geq V_T$, $v_O \geq v_I - V_T$

$v_O = V_S$ for $v_I < V_T$ (MOSFET turns off)

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The MOSFET Amplifier

- **Let's analyze the circuit**

② **Graphical method** v_O vs v_I

From Ⓐ **:** $i_{DS} = \frac{K}{2}(v_I - V_T)^2$,

for $v_O \geq v_I - V_T$

$$\Downarrow$$

$$v_O \geq \sqrt{\frac{2i_{DS}}{K}}$$

$$\Downarrow$$

$$i_{DS} \leq \frac{K}{2} v_O{}^2$$

Ⓑ **:** $i_{DS} = \frac{V_S}{R_L} - \frac{v_0}{R_L}$

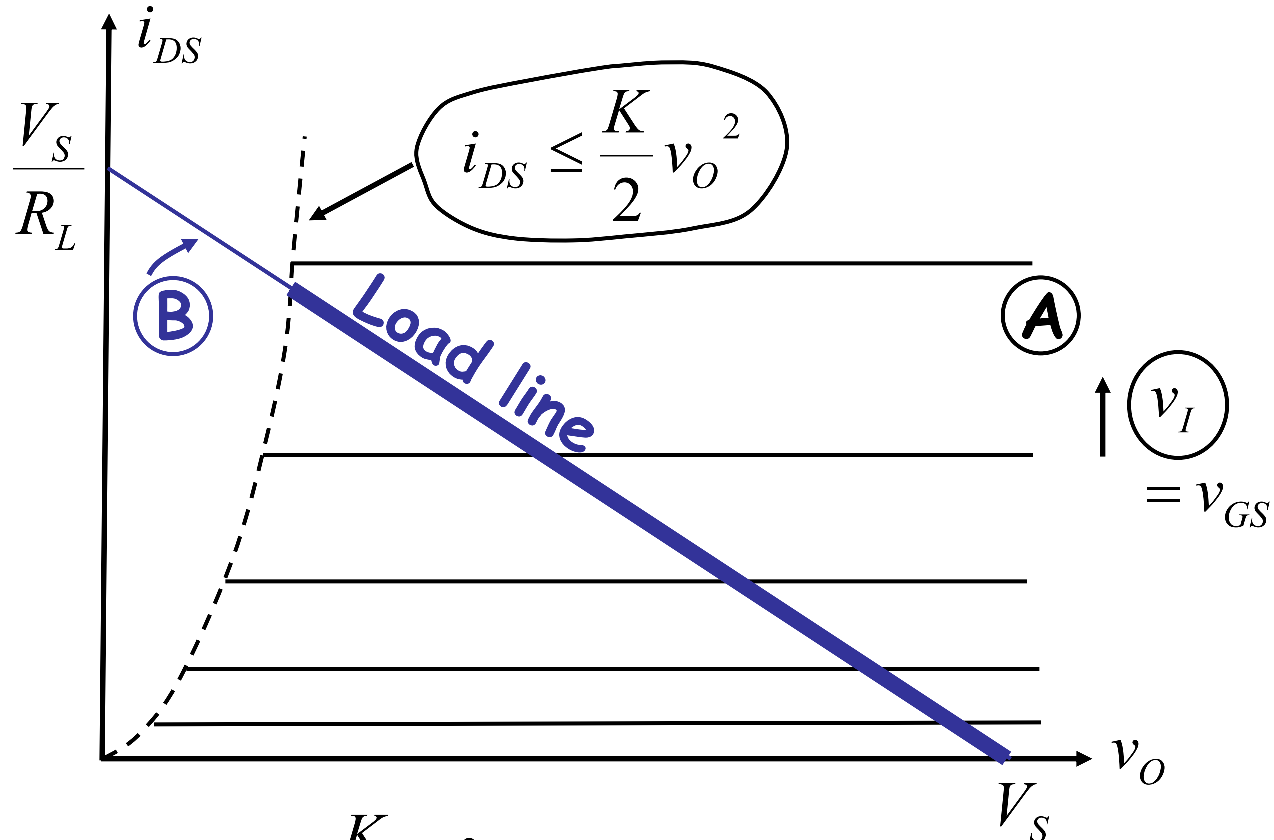
V-code: ???

The MOSFET Amplifier

- **Let's analyze the circuit**

② **Graphical method**

v_O vs v_I



Ⓐ : $i_{DS} = \frac{K}{2}(v_I - V_T)^2$, **for** $i_{DS} \le \frac{K}{2} v_O^{\ 2}$

Ⓑ : $i_{DS} = \frac{V_S}{R_L} - \frac{v_O}{R_L}$

Constraints Ⓐ and Ⓑ must be met

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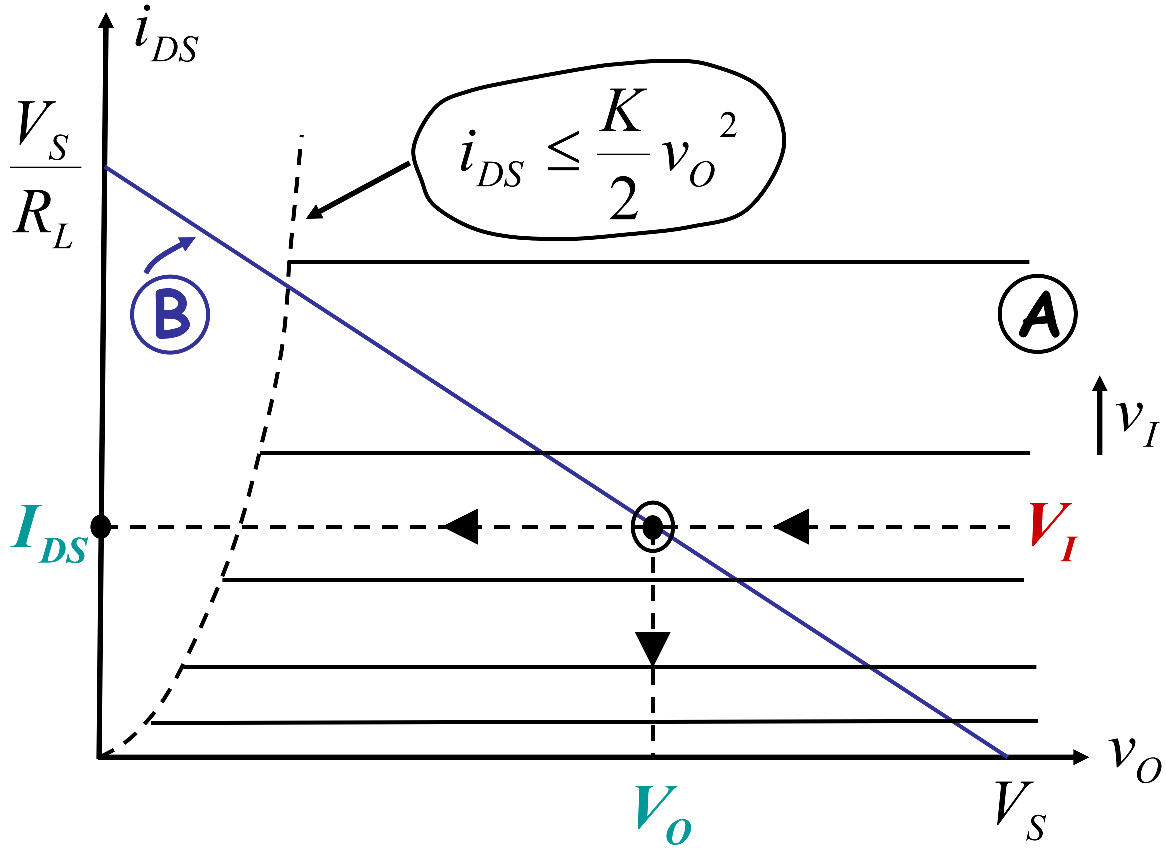
The MOSFET Amplifier

- Let's analyze the circuit

2 Graphical method



Constraints A and B must be met.
Then, given V_I, we can find V_O, I_{DS}.

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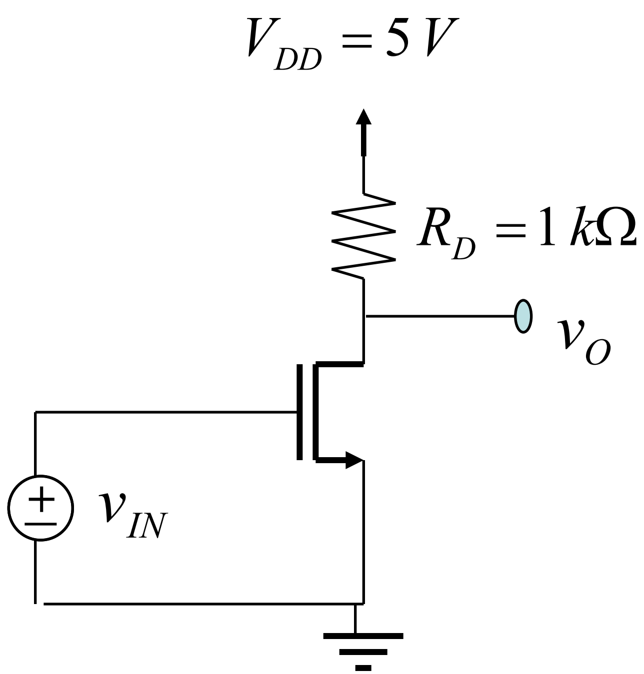
The MOSFET Amplifier

- **Example 7.7: A MOSFET Amplifier**



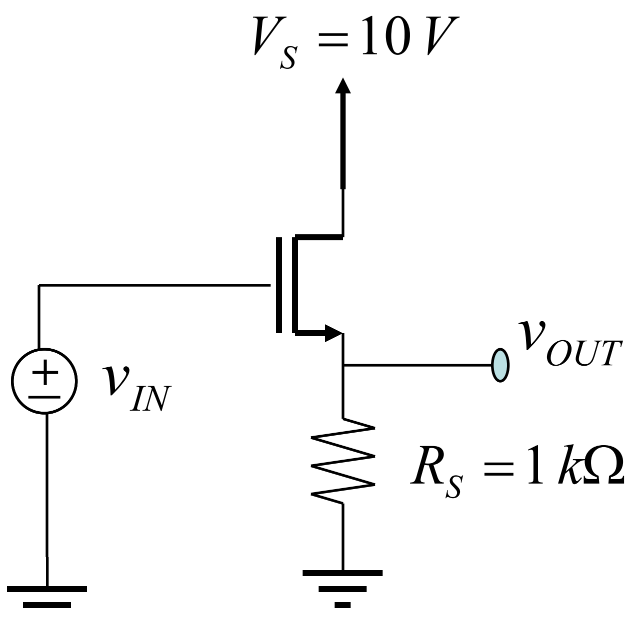
$$V_T = 0.8\,V,\ K = 0.5mA/V^2$$

$$\boldsymbol{v_{in} = 2.5\text{V},\ \ v_o = ?}$$

V-code: ???

The MOSFET Amplifier

- **Example 7.8: A MOSFET Source-Follower Circuit**



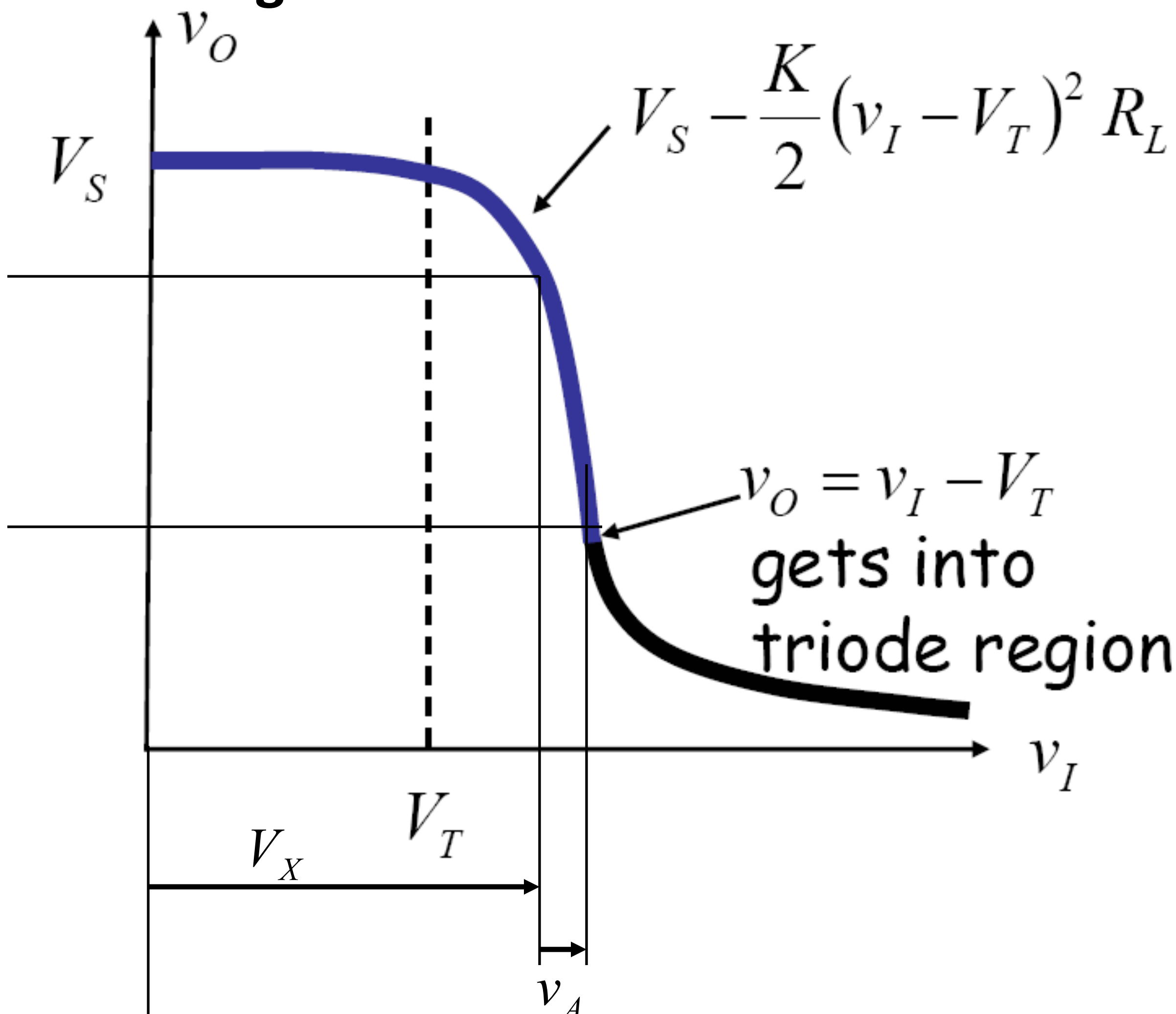
$V_T = 1\,V,\ K = 2\,mA/V^2$

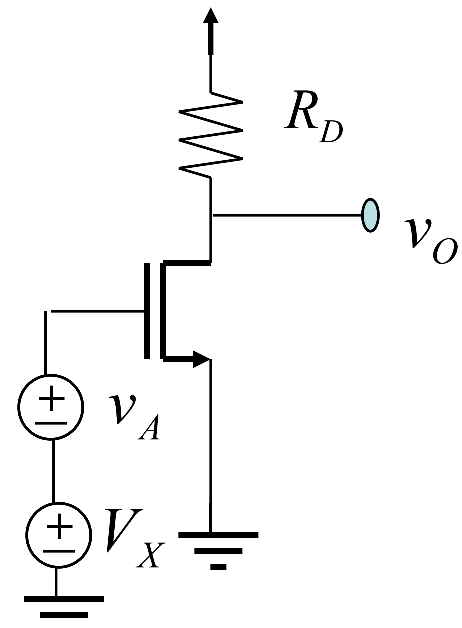
$\boldsymbol{v_{in} = 2\mathrm{V},\ v_o = ?,\ i_D = ?}$

V-code: ???

The MOSFET Amplifier

- **Biasing the Circuit**





V-code: ???

Outline

Textbook: 7.5, 7.6, 7.7

- The MOSFET Amplifier
- **Large-Signal Analysis of the MOSFET Amplifier**
- **Operating Point Selection**

V-code: ???

Large-Signal Analysis

- Large signal analysis of amplifier
  (under Saturation Discipline)

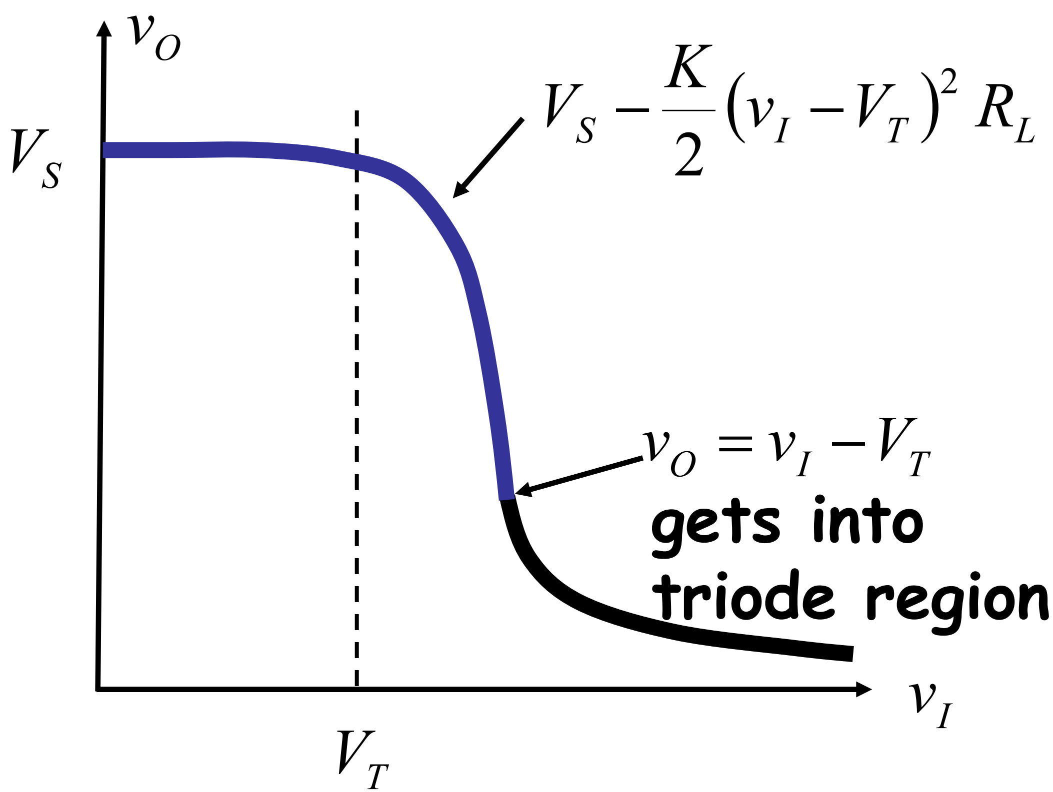
① v_O versus v_I

② Valid input operating range and
valid output operating range

V-code: ???

Large-Signal Analysis

① v_O **versus** v_I



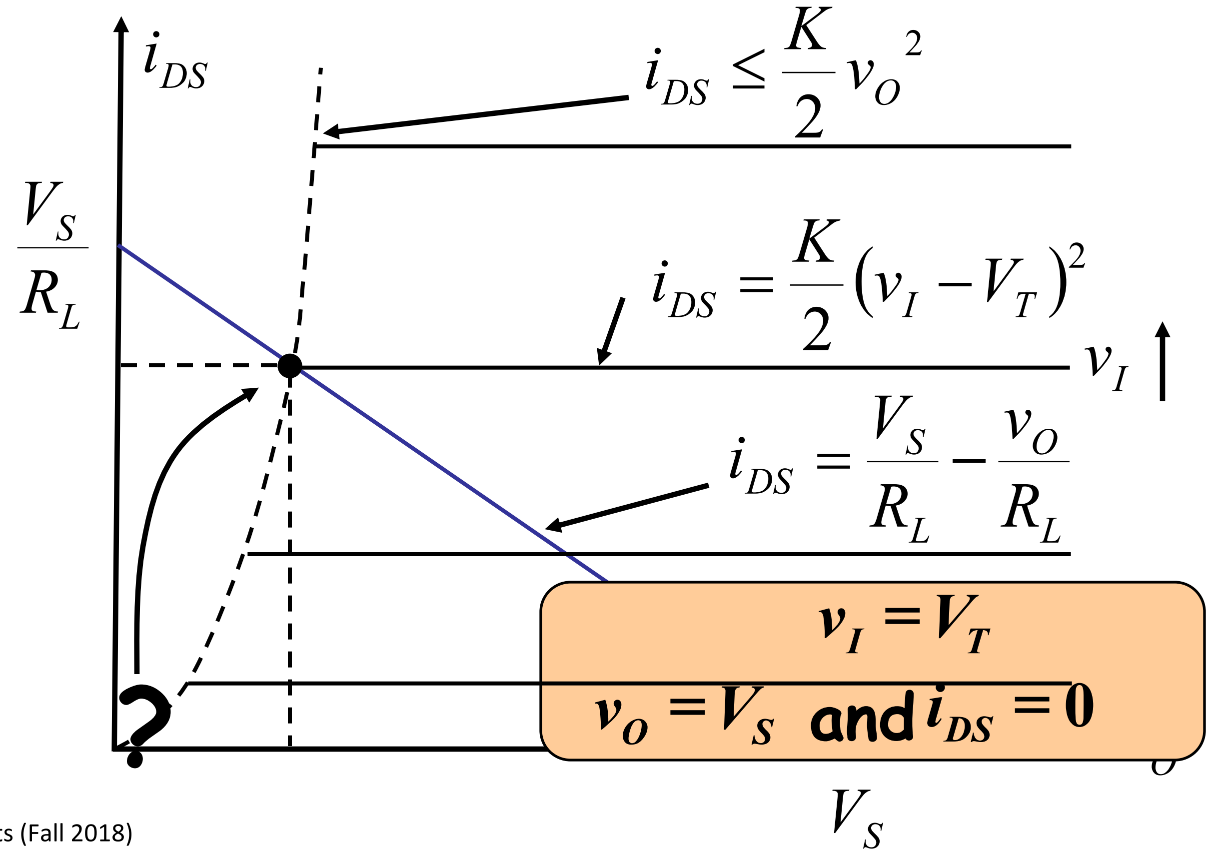
V-code: ???

Large-Signal Analysis

Our Constraints

$$v_I \geq V_T$$
$$v_O \geq v_I - V_T \longrightarrow i_{DS} \leq \frac{K}{2} v_O^2$$

② What are valid operating ranges under the saturation discipline?



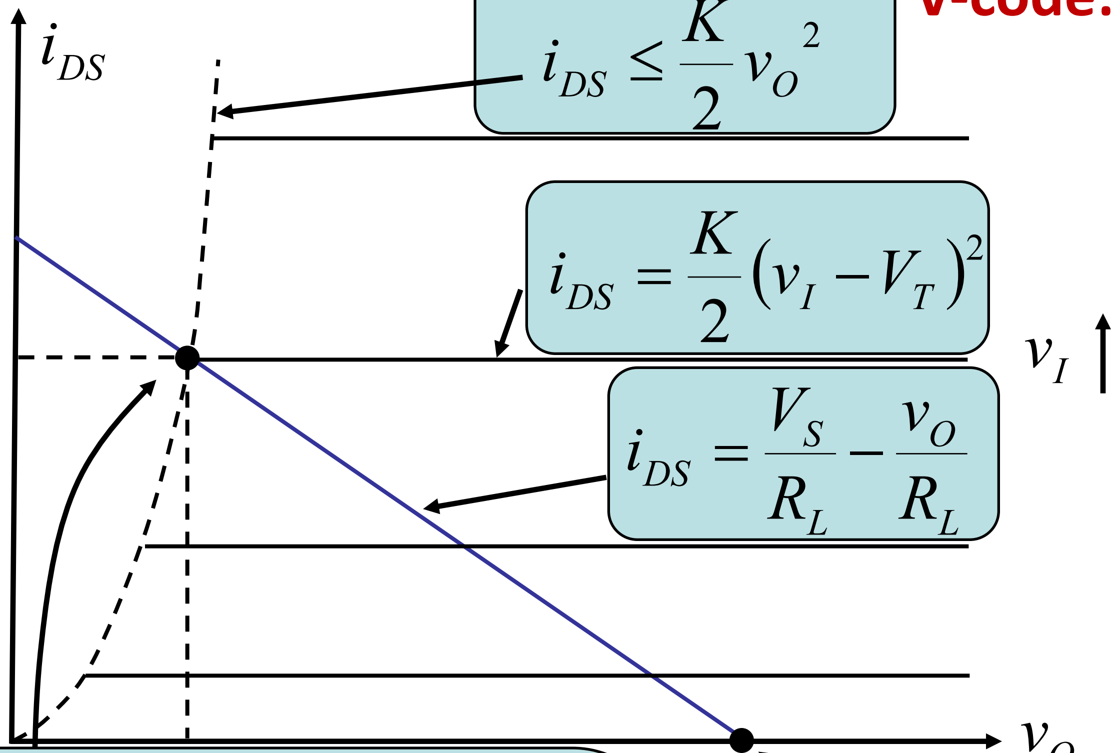
$v_I = V_T$

$v_O = V_S$ and $i_{DS} = 0$

Large-Signal Analysis

V-code: ???

② What are valid operating ranges under the saturation discipline?



$$i_{DS} \le \frac{K}{2} v_O^{\,2}$$

$$i_{DS} = \frac{K}{2}(v_I - V_T)^2$$

$$i_{DS} = \frac{V_S}{R_L} - \frac{v_O}{R_L}$$

$$v_I = V_T + \frac{-1+\sqrt{1+2KR_LV_S}}{KR_L}$$

$$v_O = \frac{-1+\sqrt{1+2KR_LV_S}}{KR_L}$$

$$i_{DS} = \frac{V_S}{R_L} - \frac{v_O}{R_L}$$

$v_I = V_T$

$v_O = V_S$ and $i_{DS} = 0$

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Large-Signal Analysis

- **Large-Signal Analysis: Summary**

1 v_O versus v_I

$$v_O = V_S - \frac{K}{2}(v_I - V_T)^2 R_L$$

2 Valid operating ranges under the saturation discipline?

Valid input range:

$$v_I: \quad V_T \quad \text{to} \quad V_T + \frac{-1+\sqrt{1+2KR_L V_S}}{KR_L}$$

corresponding output range:

$$v_O: \quad V_S \quad \text{to} \quad \frac{-1+\sqrt{1+2KR_L V_S}}{KR_L}$$