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FACULTY OF ENGINEERING AND TECHNOLOGY

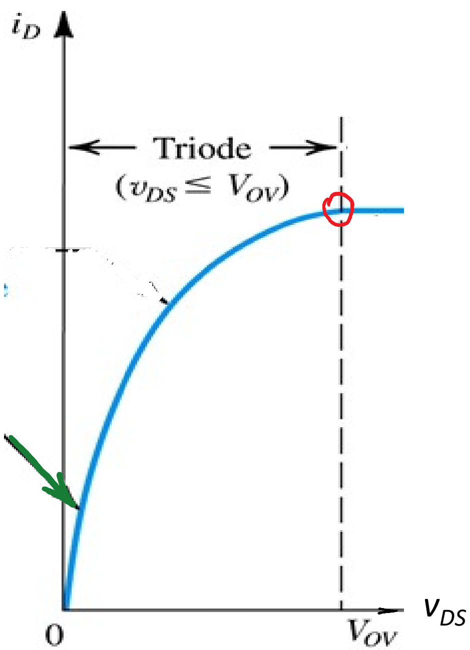
MEC-022

Lecture - 07

N-MOSFET: Triode Region Characteristics

- The expression for i_D is quadratic in v_{DS} with max reached at $v_{DS} = v_{GS} - v_{TN} = v_{OV}$
- For small $v_{DS} << v_{GS} - v_{TN}$, the characteristics i_D vs. v_{DS} appear to be linear (triode region, linear)

$$i_D = K_n \left(v_{GS} - V_{TN} - \frac{v_{DS}}{2} \right) v_{DS}$$



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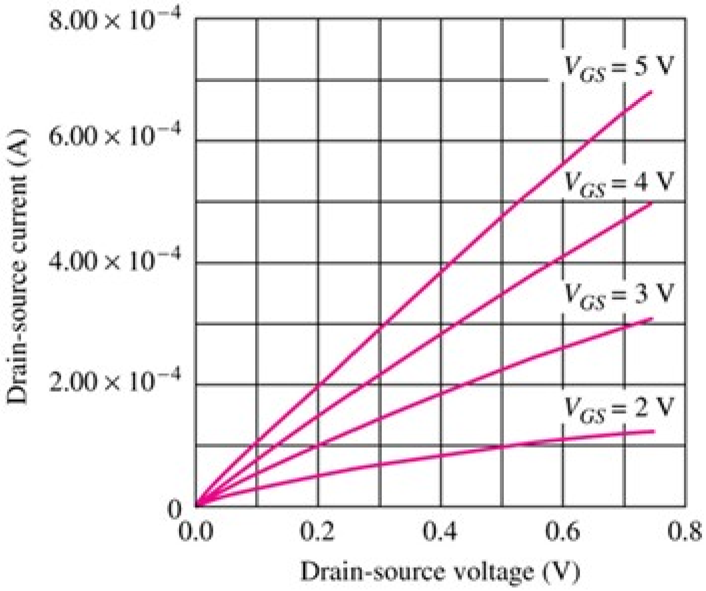

Under this condition, MOSFET behaves like a **gate-source voltage-controlled** resistor between source and drain,

$$i_D = K_n\left(v_{GS} - V_{TN}\right)v_{DS} = \frac{1}{R_{on}} \cdot v_{DS}$$

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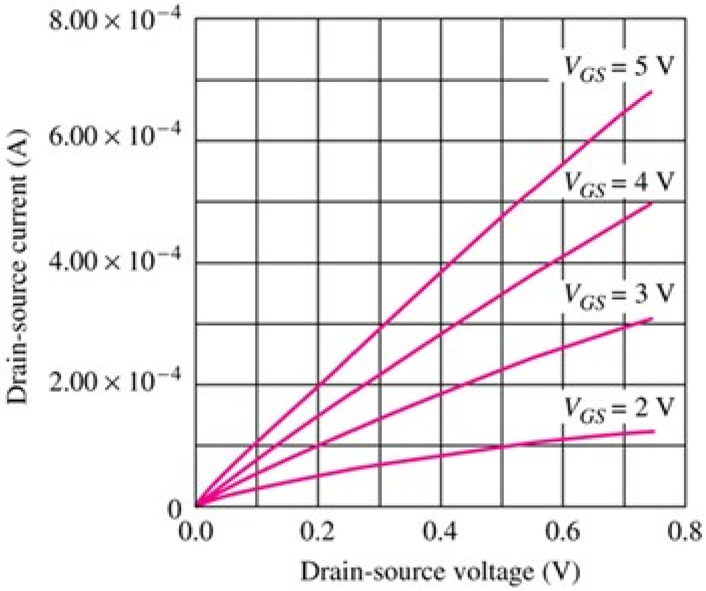

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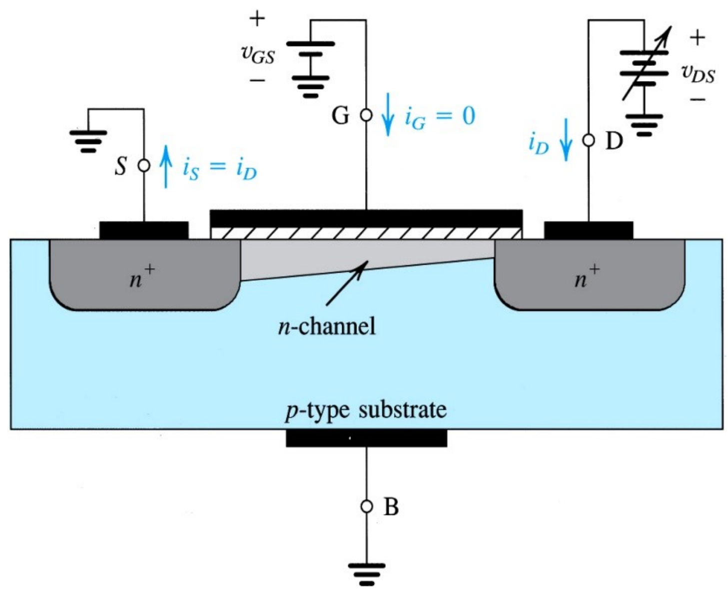
where **on-resistance**:

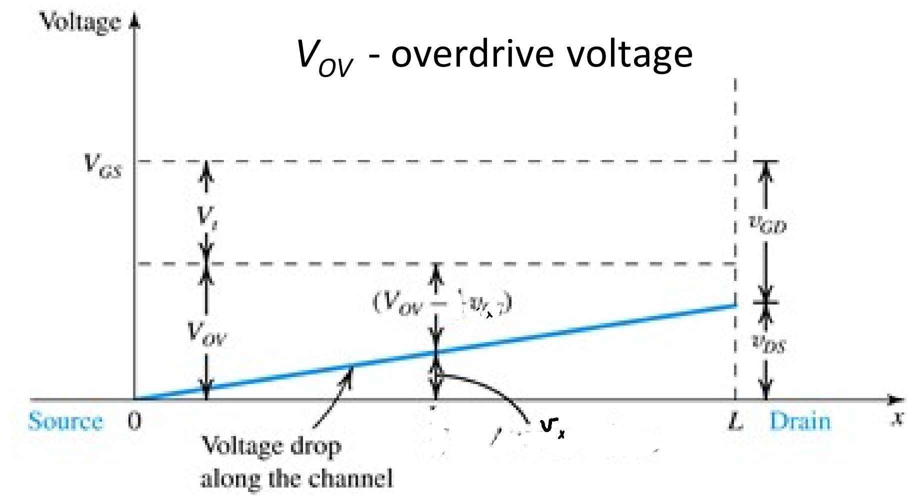
$$R_{on} = \left. \frac{1}{K_n' \frac{W}{L} \left(V_{GS} - V_{TN} - V_{DS} \right)} \right|_{v_{DS} \to 0}$$

$$= \frac{1}{K_n' \frac{W}{L} \left(V_{GS} - V_{TN} \right)} = R_{on}(V_{GS})$$

NMOS Transistor: inversion layer change

If we increase v_{DS} , and it's no more $v_{DS} << V_{GS}$ - V_{TN} = V_{OV} (triode region limit), it starts influencing the depth of induced inversion layer, for which we need V_{GS} > $V_{TN.}$





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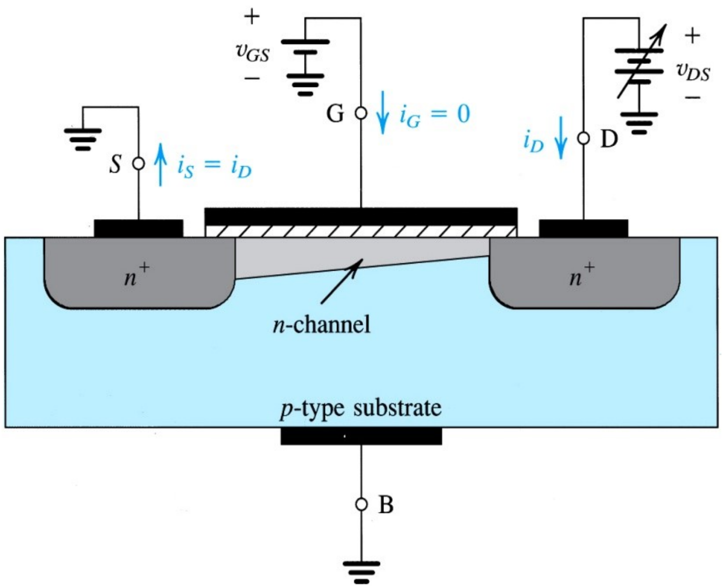
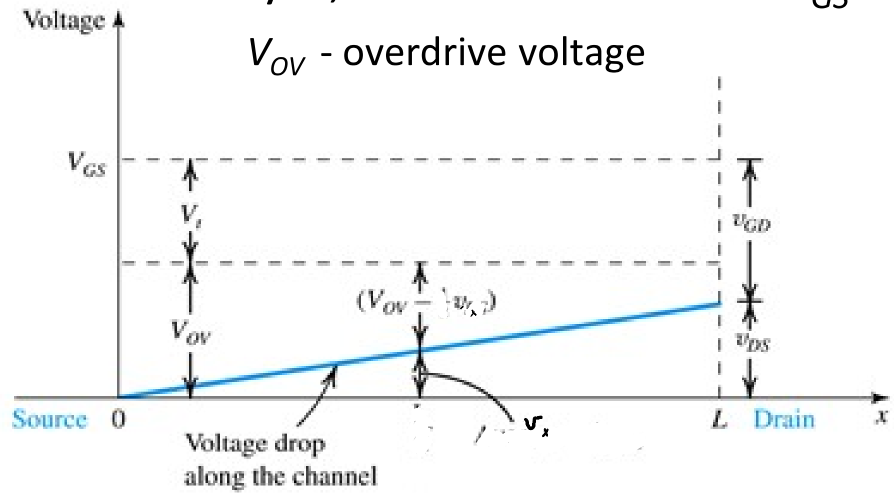
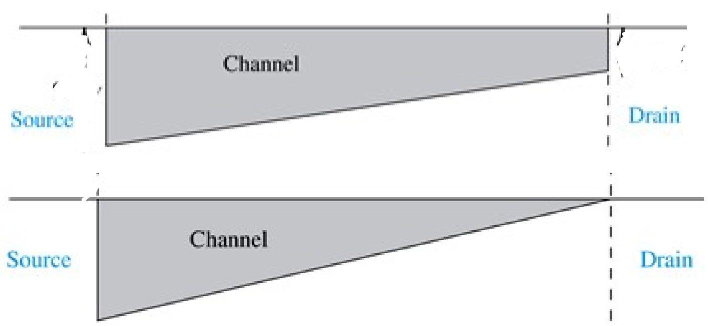
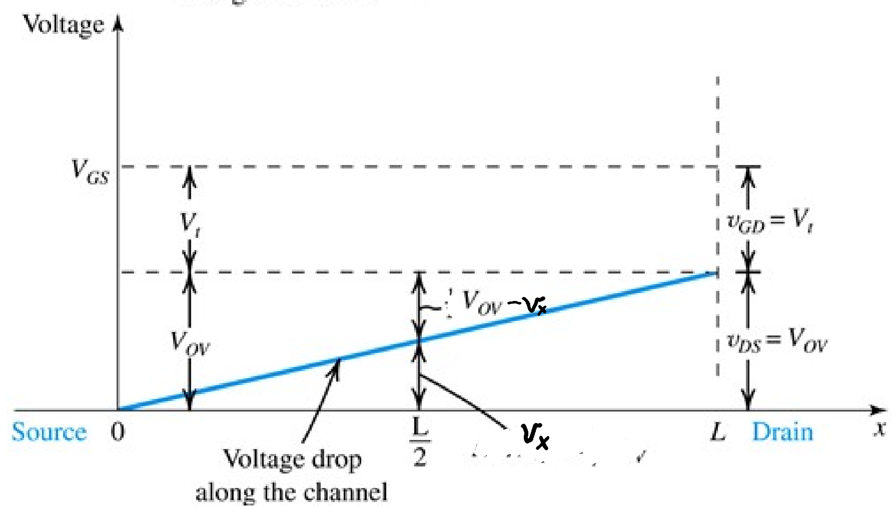


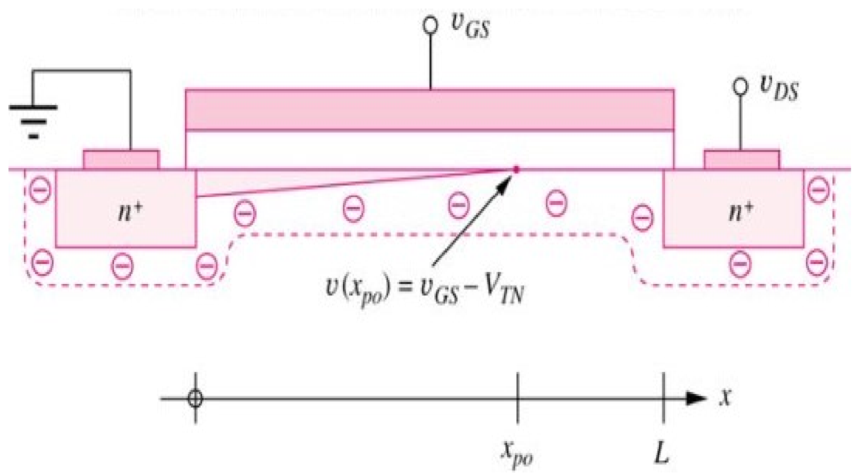






$v_{DS} = V_{OV}$ - pinch-off voltage, saturation region begins

NMOS Transistor: Saturation Region

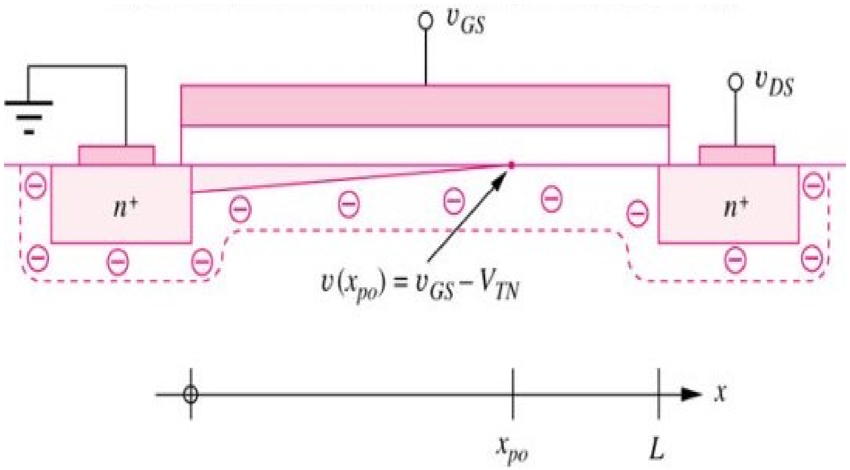


- When v_{DS} increases above triode region limit, channel region akmost disappears, MOSFET also said to be pinched-off.
- Current saturates at (almost) constant value, independent of $v_{DS.}$

$v_{DSAT} = v_{GS} - V_{TN}$ is also called **saturation or pinch-off voltage**.

What is the current in saturation region?

NMOS Transistor: Saturation Region



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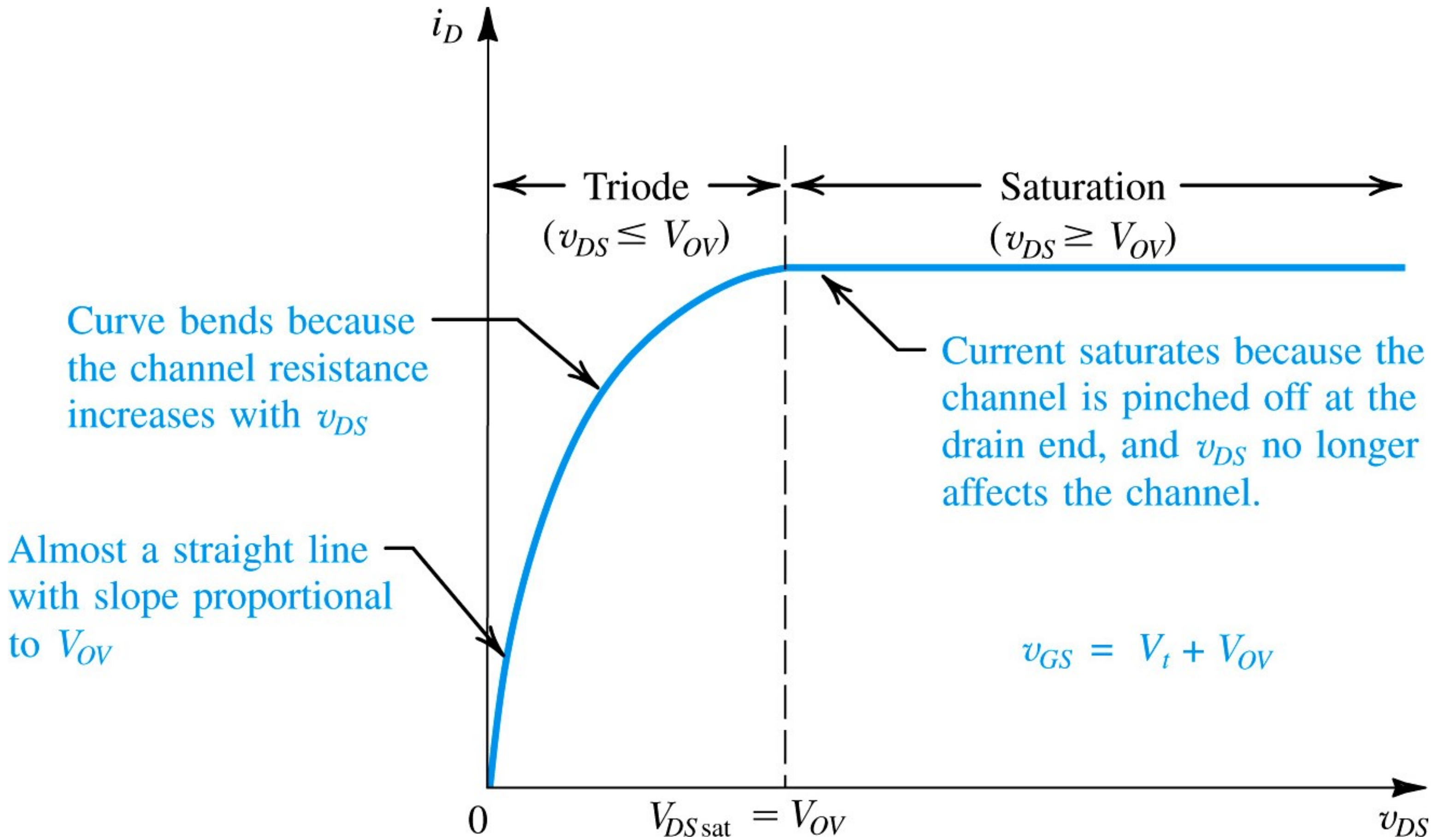
Substituting $v_{DS} = v_{GS} - V_{TN}$ into previous equation for drain current, we get

$$i_D = \frac{K'_n}{2}\frac{W}{L}\left(v_{GS} - V_{TN}\right)^2$$

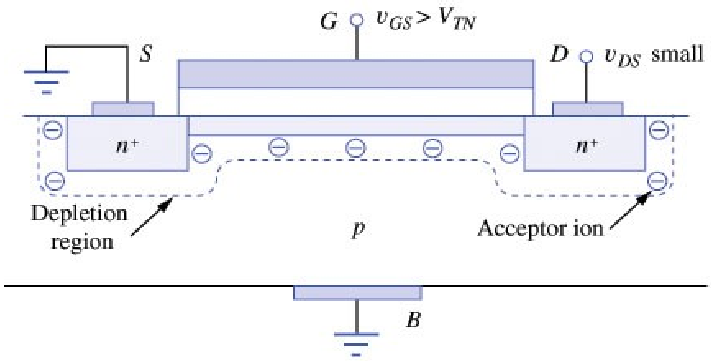
$$\text{for } v_{DS} \geq v_{GS} - V_{TN}$$

- Saturation region operation mostly used for analog amplification.

NMOS Transistor: *iv*-characteristic

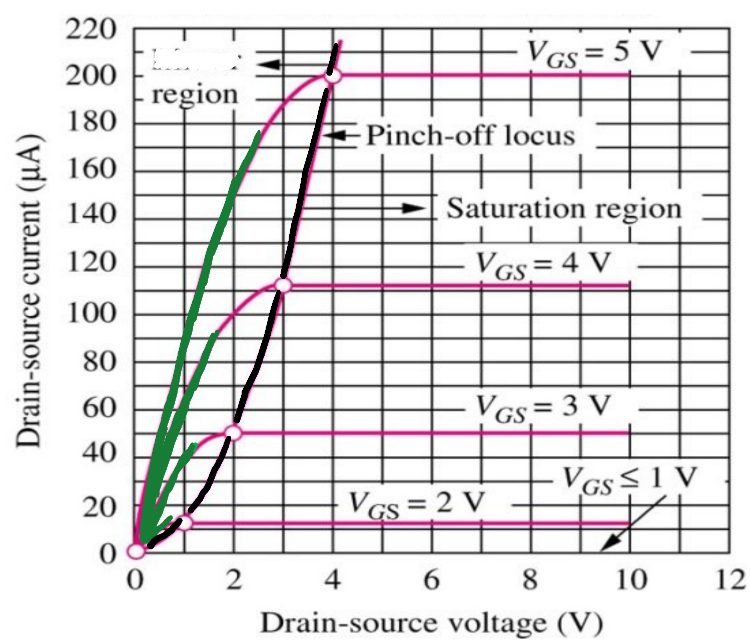


NMOS Transistor: Region Summary



- If v_{DS} **<<** V_{GS} - V_{TN} MOSFET is in **linear portion of the triode region**

Triode




Thank You!