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MOSFET transistors: review

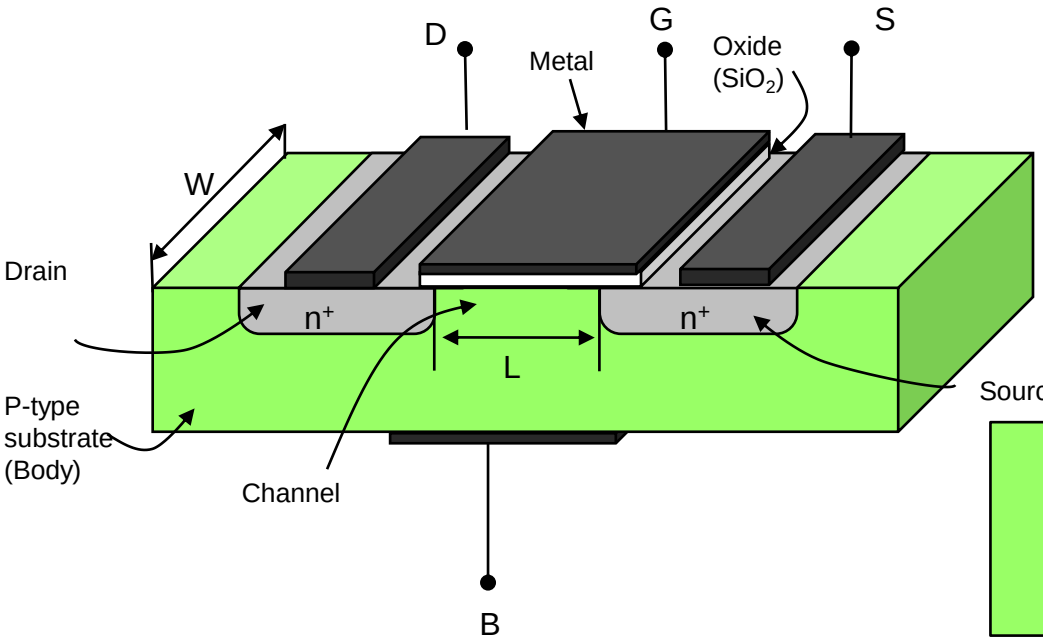
Field effect transistors (FETs)

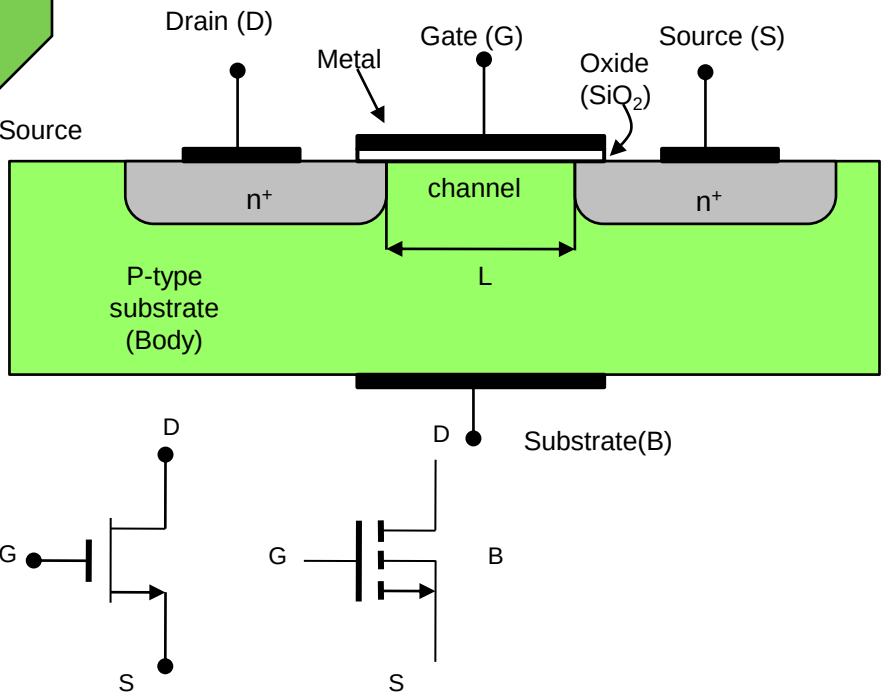
Types	Operation	Channel
MOSFET **(Metal-Oxide Semiconductor FET)**	**Enhancement**	N channel (or N-MOS) P channel (or P-MOS)
	Deplexion	N channel (or N-MOS) P channel (or P-MOS)

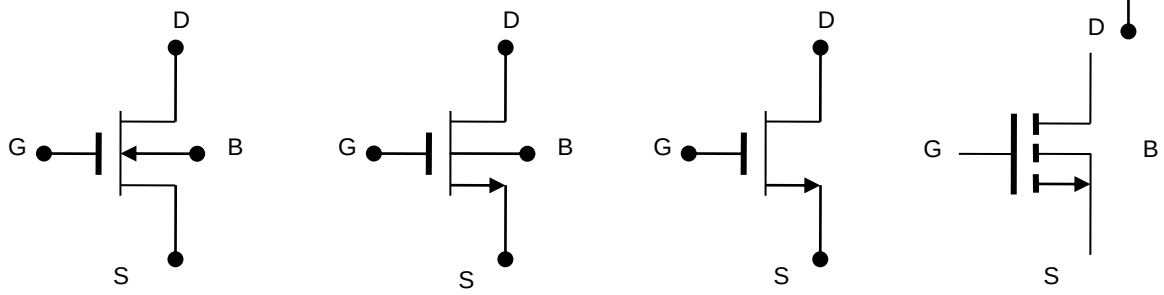
Basic features

- They are unipolar: only one type of carrier
- They control I through V (in bipolars I is controlled through I)
- Three terminals:
  - Source: send carriers
  - Gate: controls the passage of carriers
  - Drain: receives carriers

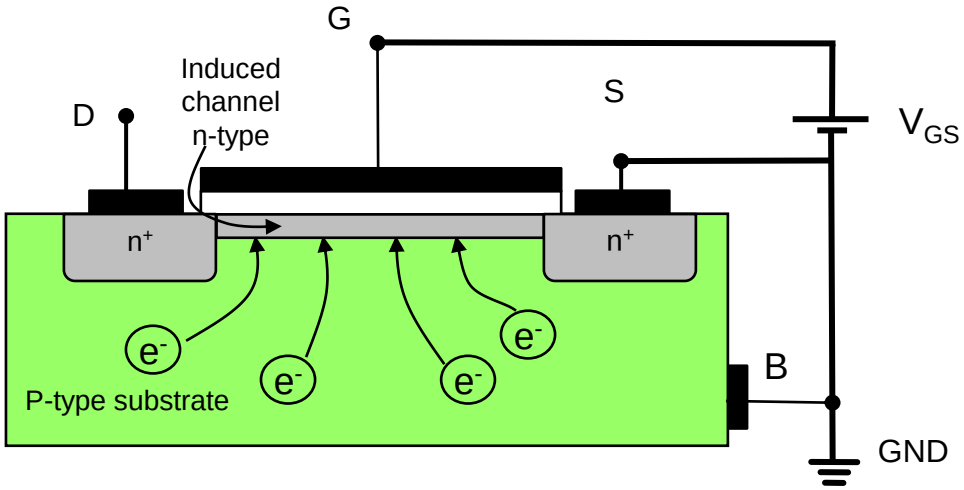
Structure of the Enhancement N-channel MOS Transistor (n-MOS)

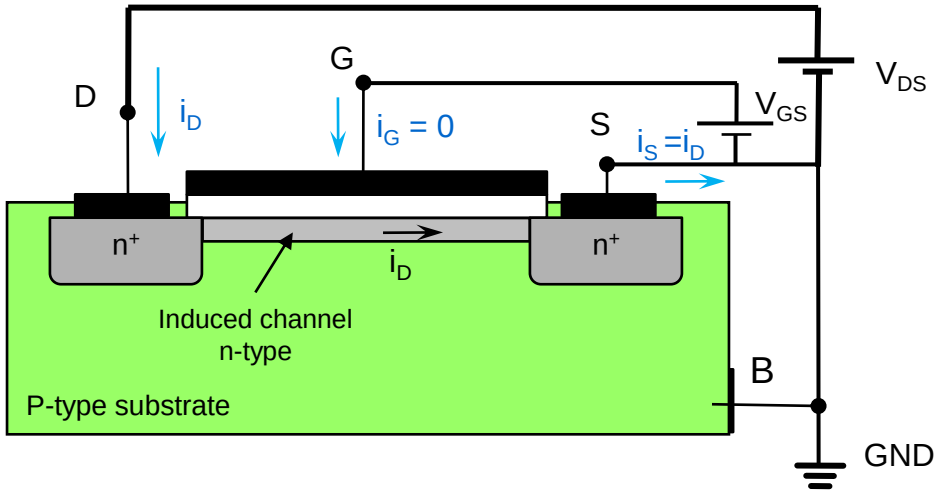




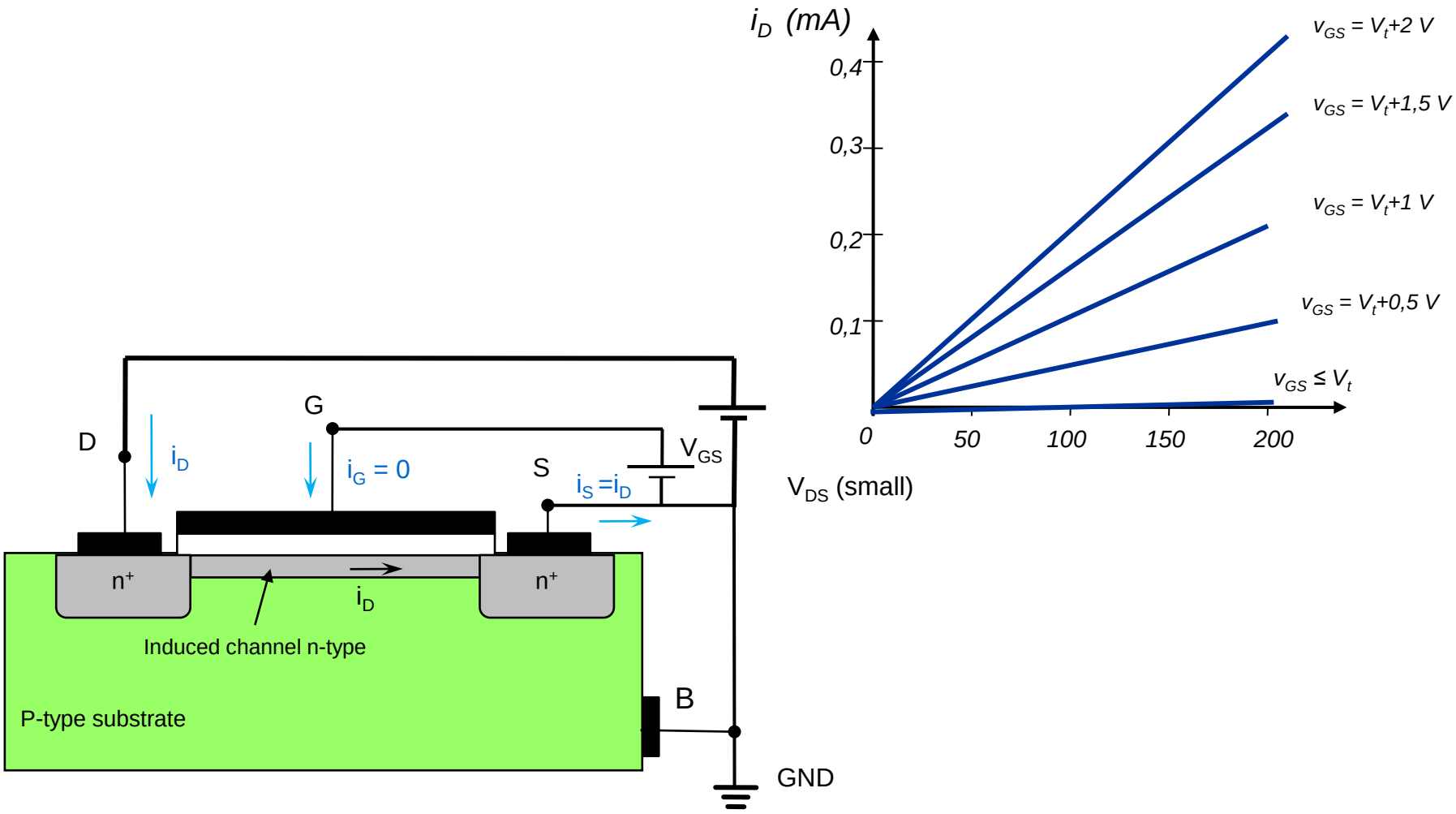


Operation

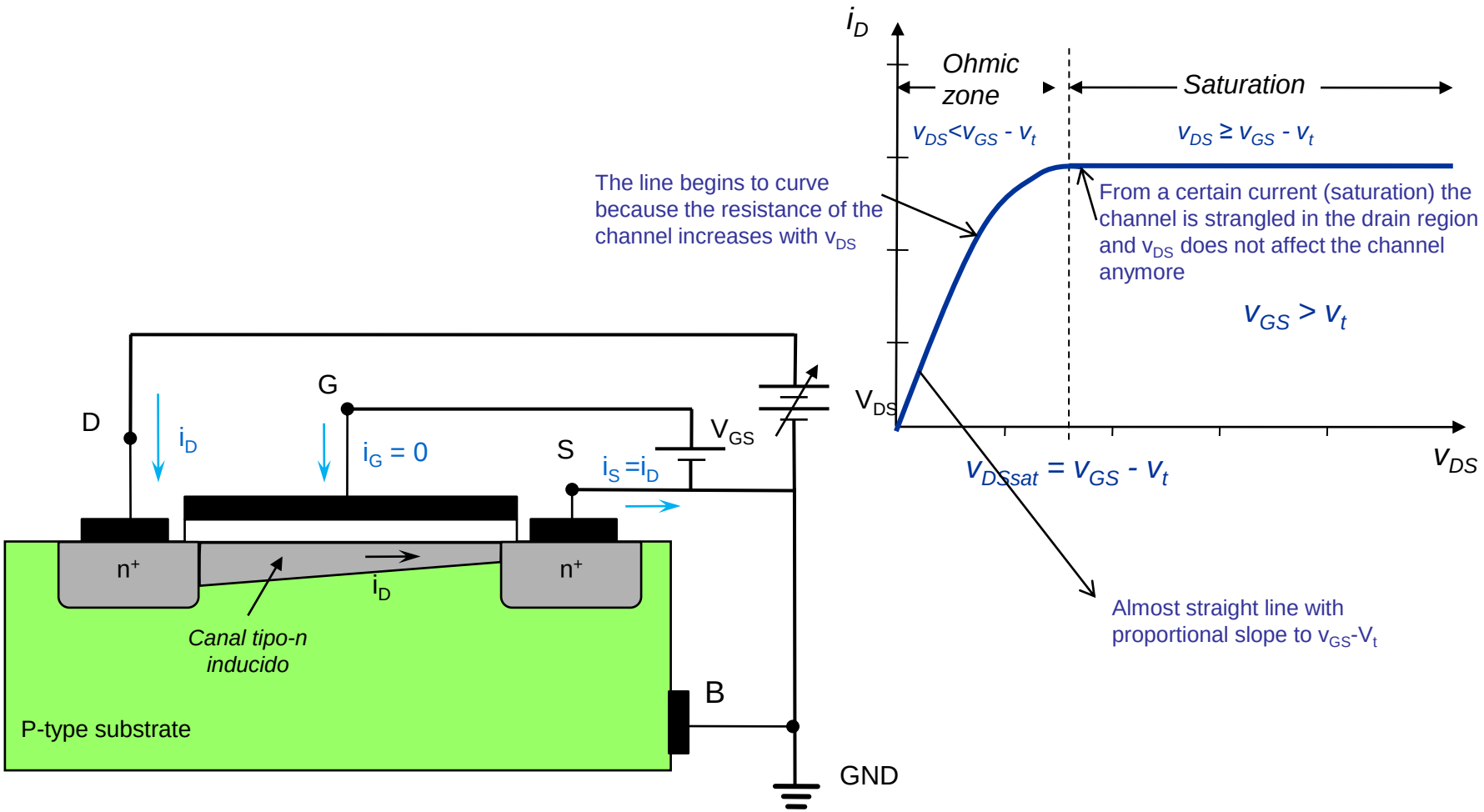




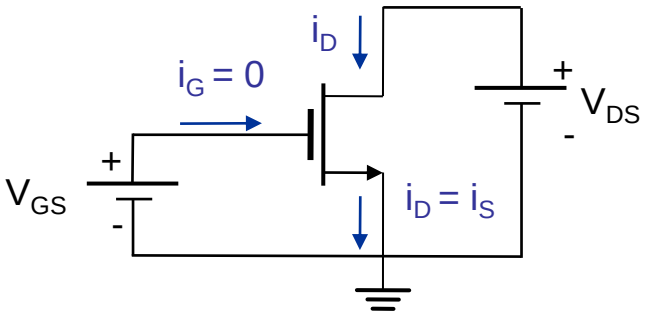
Operation

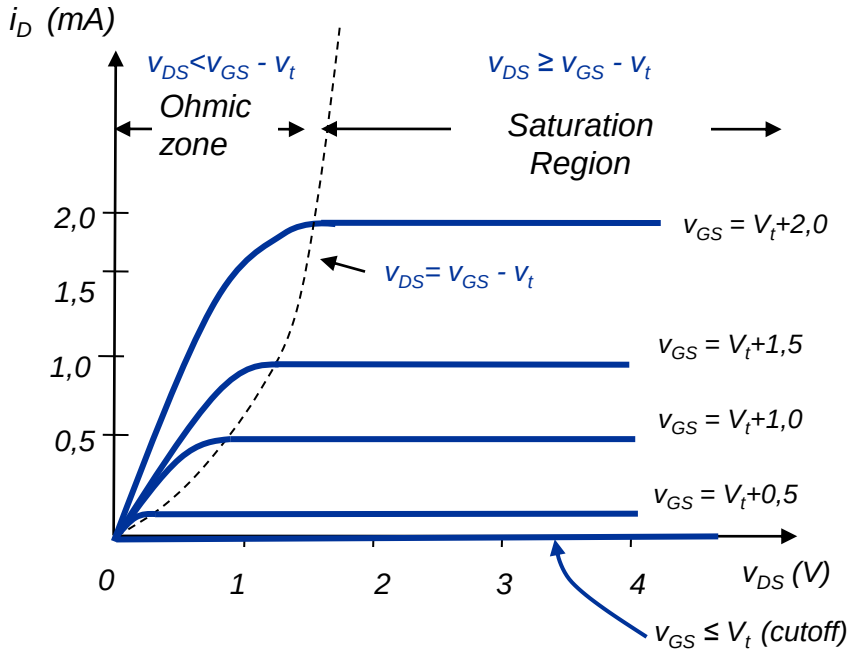


Operation



Characteristic curves





- *Ohmic zone*

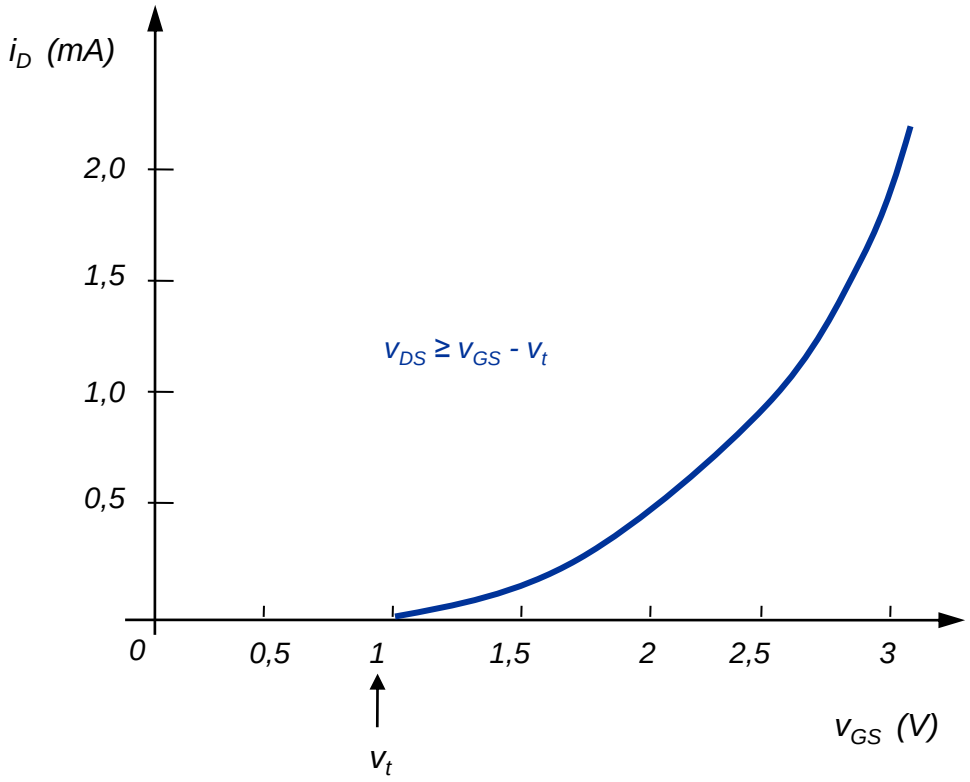
$$i_D = K\left[2(V_{GS} - V_t)V_{DS} - V_{DS}^{\ 2}\right]$$

- Saturation Region (I_D does not depend on V_{DS})

$$i_D = K(V_{GS} - V_t)^2$$

$$K = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}$$

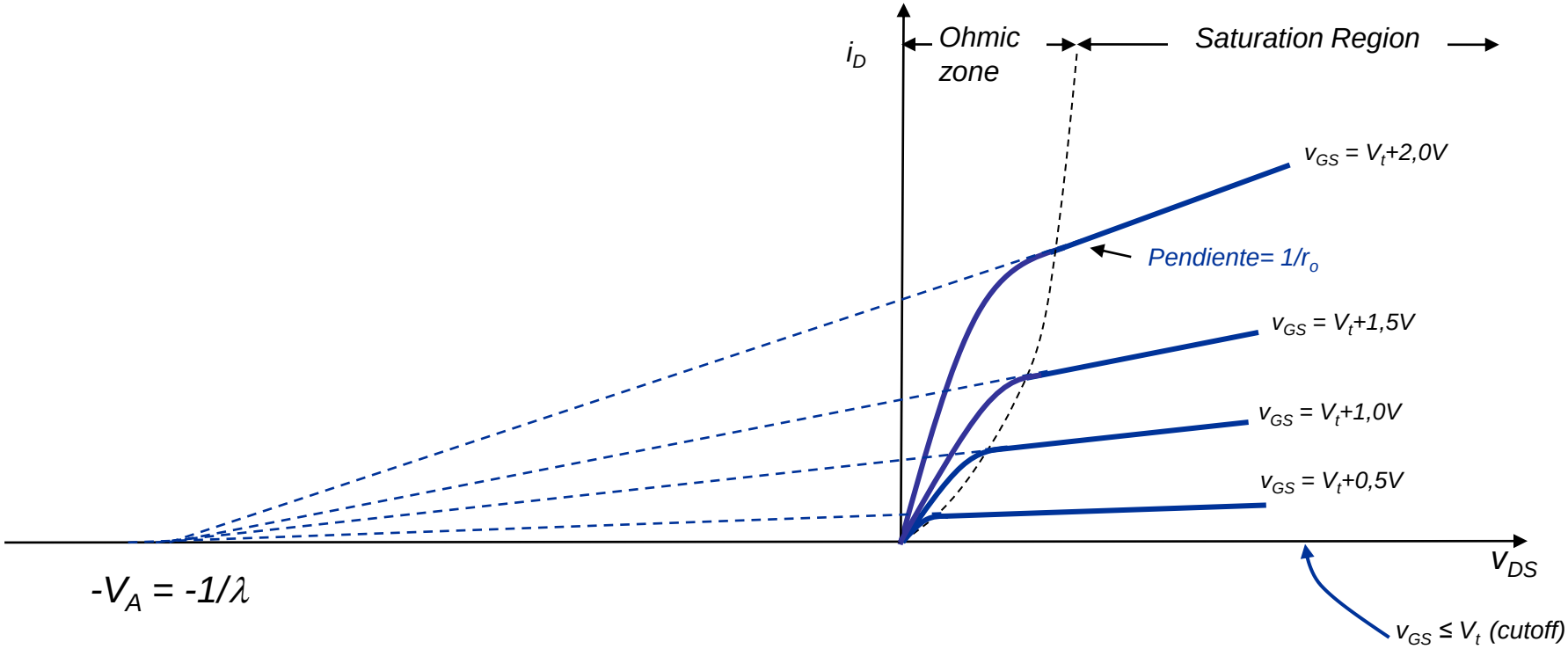
Characteristic curves: saturation



- Saturation Region (I_D does not depend on V_{DS})

$$i_D = K(V_{GS} - V_t)^2$$

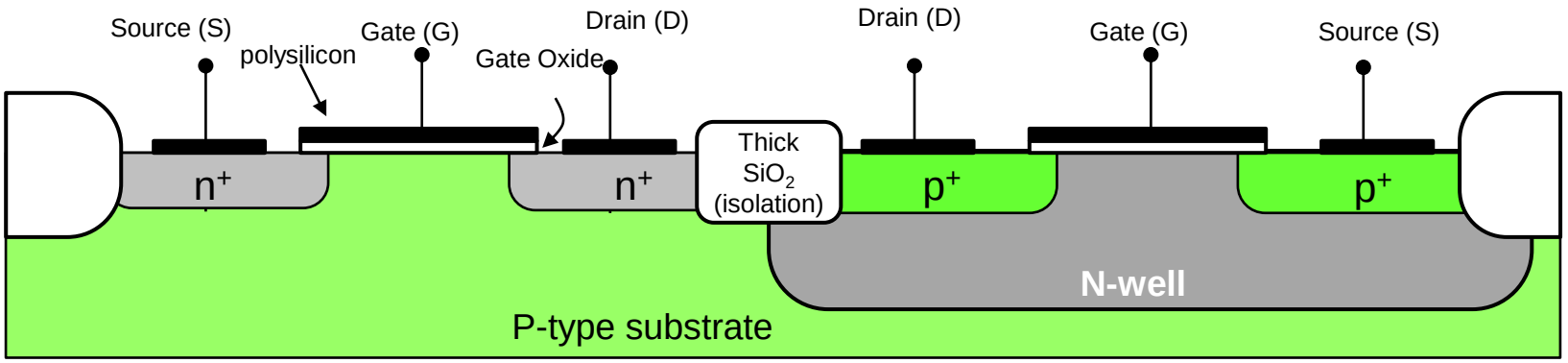
Characteristic curves



V_A is the modulation voltage of the channel, produces an effect similar to the Early voltage in BJTs. Considering it:

$$i_D = K(V_{GS} - V_t)^2(1+\lambda V_{DS})$$

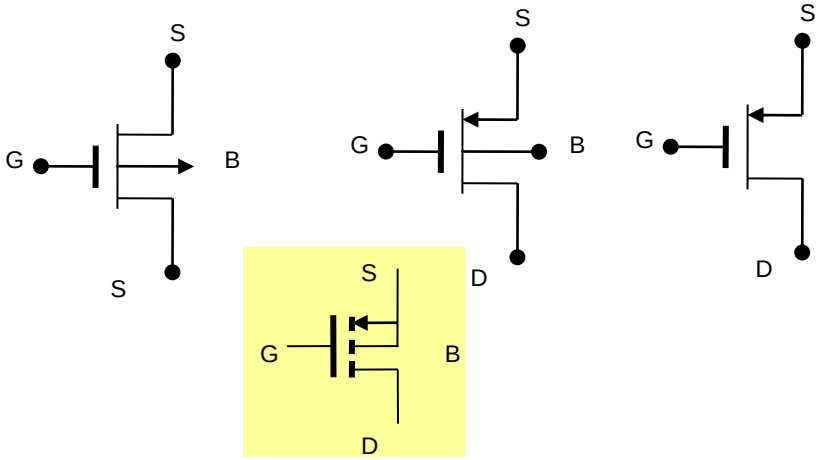
MOSFET with channel p (P-MOS)



- In enhancement pmos,there is a channel if: $V_{GS} \leq V_t < 0$

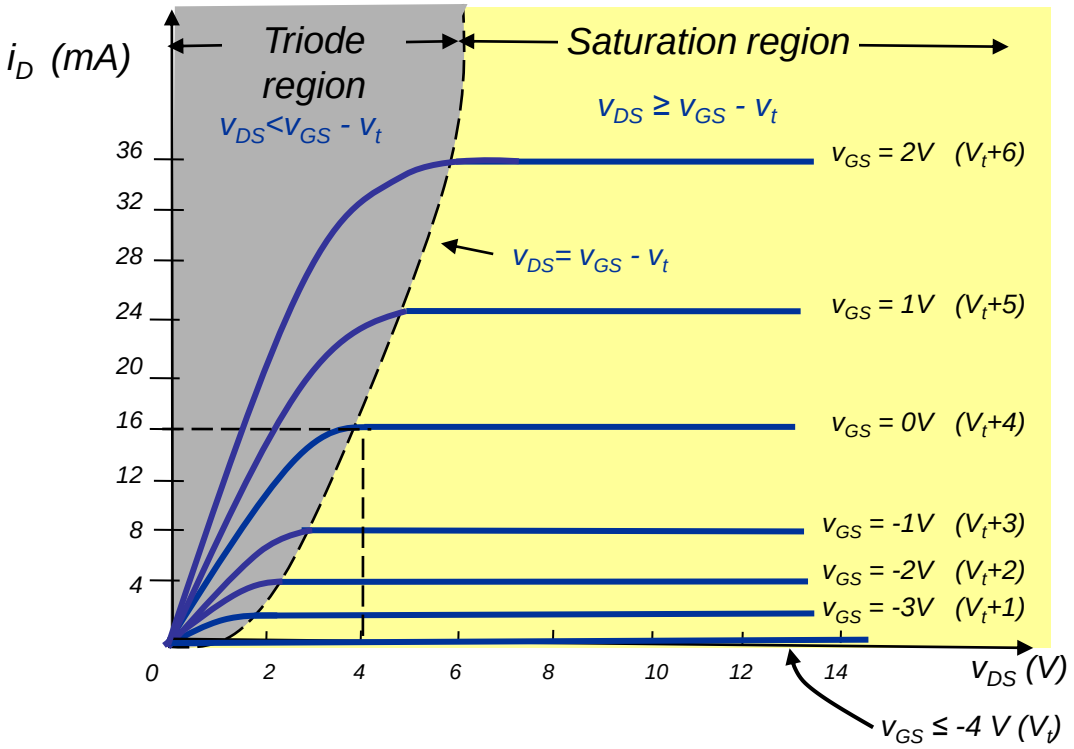
$V_{DS} \geq V_{GS} - V_t$ In ohmic zone

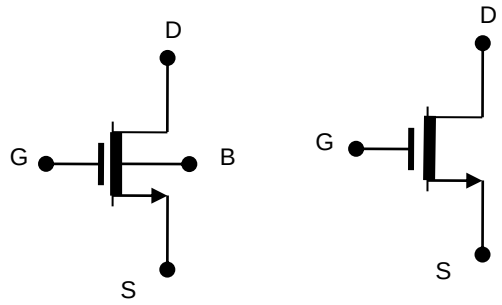
$V_{DS} \leq V_{GS} - V_t$ in saturation

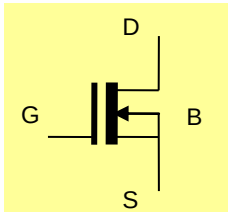


Deplexion MOSFET

- Similar, but with the channel already manufactured:
  - You have to apply a tension $V_{GS}<0$ to remove the channel (the e- move away from the door)
  - If $V_{GS} \leq V_t < 0$ Then there is no channel (cutoff)
- Otherwise, it works the same as enhancement:







Summary

- In the enhancement nmos, there is a channel if: $V_{GS} \geq V_t > 0$

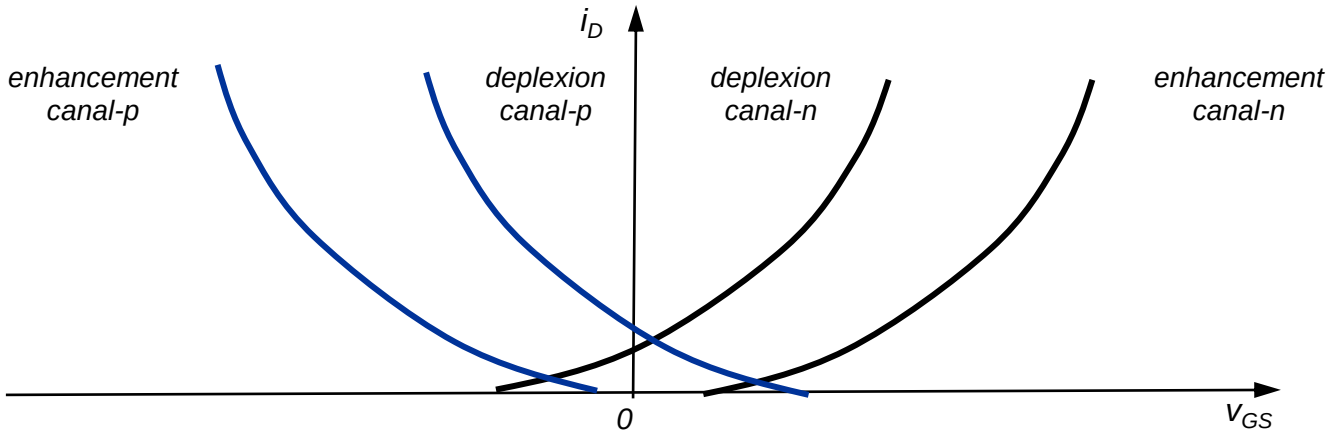
  $V_{DS} \leq V_{GS} - V_t$ In ohmic zone

  $V_{DS} \geq V_{GS} - V_t$ in saturation

- In the enhancement pmos, there is a channel if: $V_{GS} \leq V_t < 0$

  $V_{DS} \geq V_{GS} - V_t$ In ohmic zone

  $V_{DS} \leq V_{GS} - V_t$ in saturation



- In the deplexion nmos, there is a channel if: $V_{GS} \geq V_t, \; V_t < 0$

  $V_{DS} \leq V_{GS} - V_t$ In ohmic zone

  $V_{DS} \geq V_{GS} - V_t$ in saturation

- In the deplexion pmos, there is a channel if: $V_{GS} \leq V_t, \; V_t > 0$

  $V_{DS} \geq V_{GS} - V_t$ In ohmic zone

  $V_{DS} \leq V_{GS} - V_t$ in saturation