14.12.2023

The MOSFETs

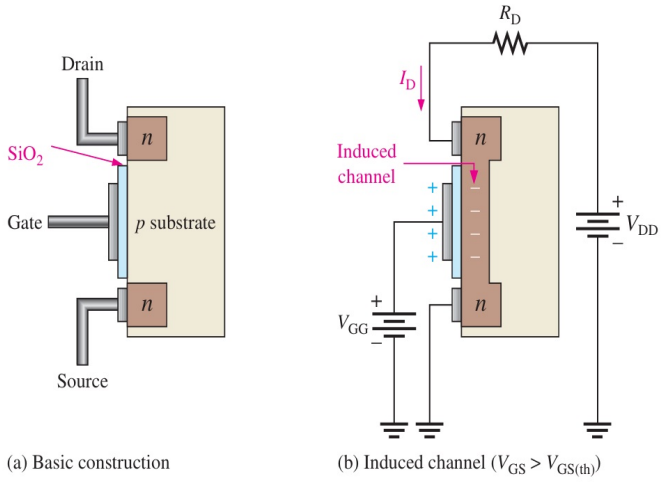
- No p-n junction in the device structure.
- The gate (G) is insulated from the channel by a Silicondioxide.

MOSFETs →
- Enhancement (E) MOSFETs — No physical channel
- Depletion (D) MOSFETs — Physical channel

'Enhancement' & 'Depletion' are the mode of operation.

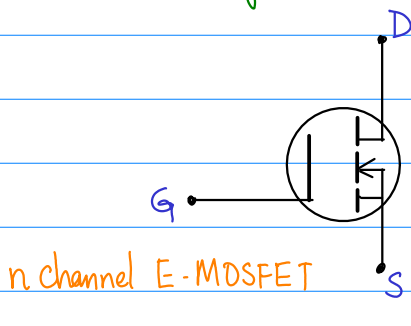
1) E-MOSFETs :

- Operates only in the enhancement mode.
- It has NO structural channel.

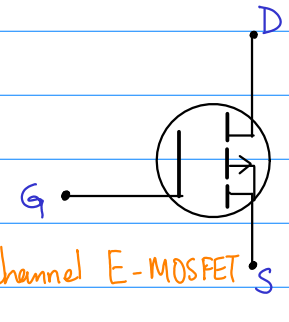


- The substrate extends completely to the SiO_2 layer.
- When $V_{GS} > V_{GS(Threshold)}$, a channel is induced by creating a thin layer of negative charges in the substrate region adjacent to SiO_2 layer.

Circuit Symbol :



n channel E-MOSFET

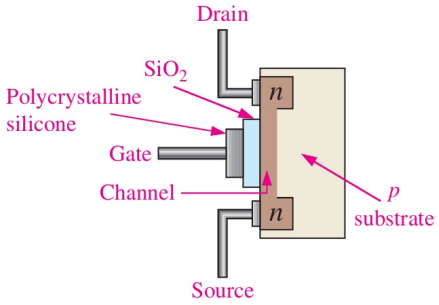


p channel E-MOSFET

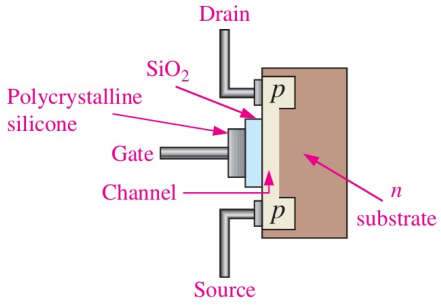
Broken lines symbolize absence of physical channel in E-MOSFETs.

2) D-MOSFET :

- Physical channel is present.
- Can be operated in either depletion or enhancement mode.



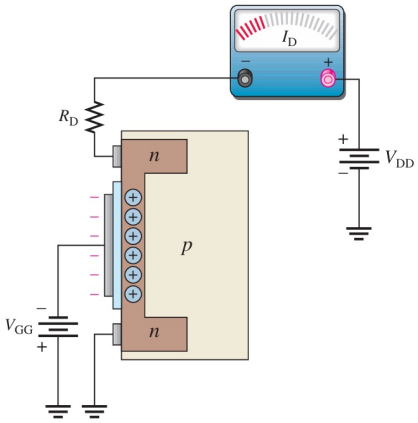
(a) n channel



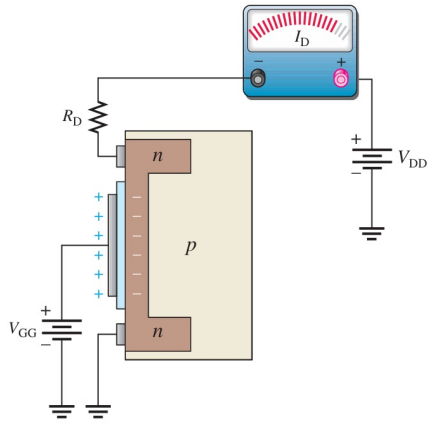
(b) p channel

- V_{GS} = negative (Depletion mode of operation)
  V_{GS} = positive (Enhancement mode of operation)

- Visualize the gate as one plate of a parallel-plate capacitor and channel as the other plate. The SiO_2 is an insulating layer.



(a) Depletion mode: V_{GS} negative and less than $V_{GS(off)}$



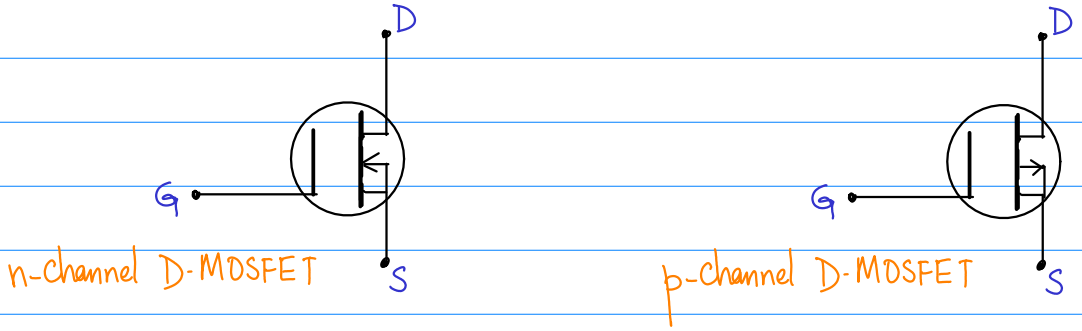
(b) Enhancement mode: V_{GS} positive

- When $V_{GS} < 0$ (Negative gate-voltage)
  - the electrons in n-channel are repelled leaving +ve ions.
  - as a consequence the n-channel is depleted with mobile charge-carriers.
  - Therefore, the channel conductivity decreases.
  - At sufficient negative gate-to-source voltage ($V_{GS(OFF)}$), the channel is completely depleted with mobile charge carriers. $\Rightarrow I_D = 0$

- Similar to n-channel JFET, the n-channel D-MOSFET conducts I_D for $-V_{GS(OFF)} < V_{GS} < 0$

- When $V_{GS} > 0$ (positive gate voltage)
  - As gate voltage is positive, more electrons are attracted into the n-channel.
  - Therefore, the channel conductivity is enhanced.

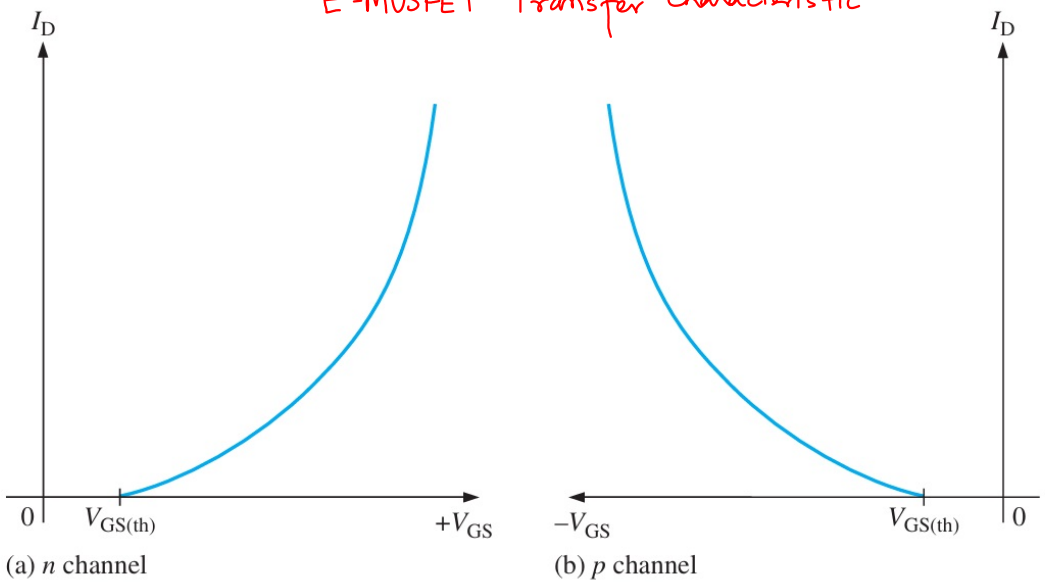
Circuit Symbol:



MOSFET Characteristics and parameters:

- The discussion done for JFET characteristics & parameters applies equally to MOSFETs.

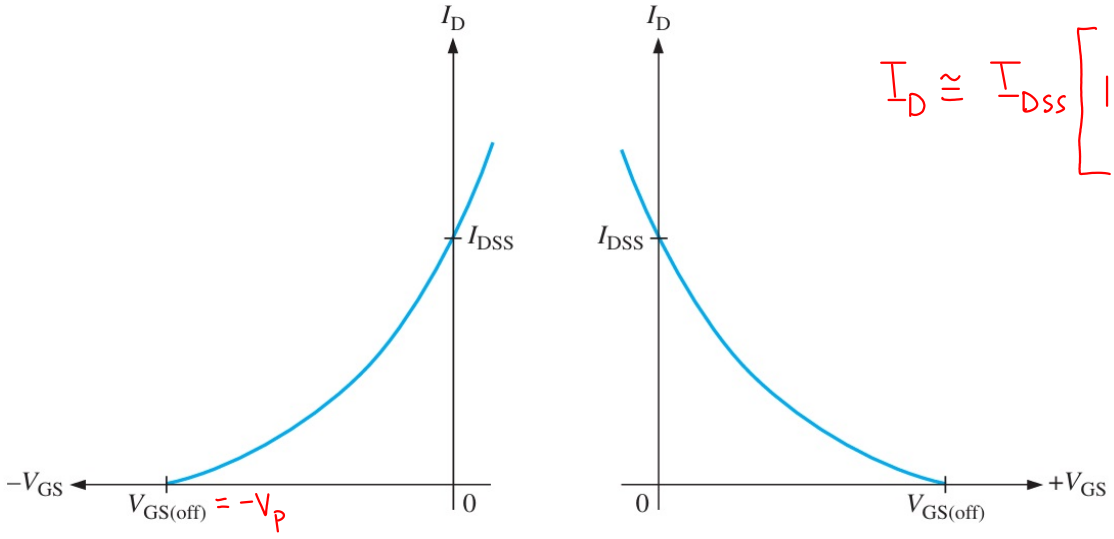
E-MOSFET Transfer characteristic



$V_{GS(th)}$ is the minimum voltage required to induce channel in the device.

$$I_D = K(V_{GS} - V_{GS(th)})^2$$ where K = constant

D-MOSFET Transfer Characteristic



$$I_D \cong I_{DSS}\left[1 - \frac{V_{GS}}{V_{GS(OFF)}}\right]^2$$

MOSFET Biasing :

(a) Voltage-Divider Bias :

$$V_{GS} = \frac{R_2}{R_1+R_2} V_{DD} \quad -(1)$$

$$V_{DS} = V_{DD} - I_D R_D \quad -(2)$$

$$I_D = K\left(V_{GS} - V_{GS(th)}\right)^2 \quad -(3)$$