EI-27003: Electronics Devices and Circuits
Lecture - 8

Subject Incharge: Mr. Rajesh Khatri
Associate Professor

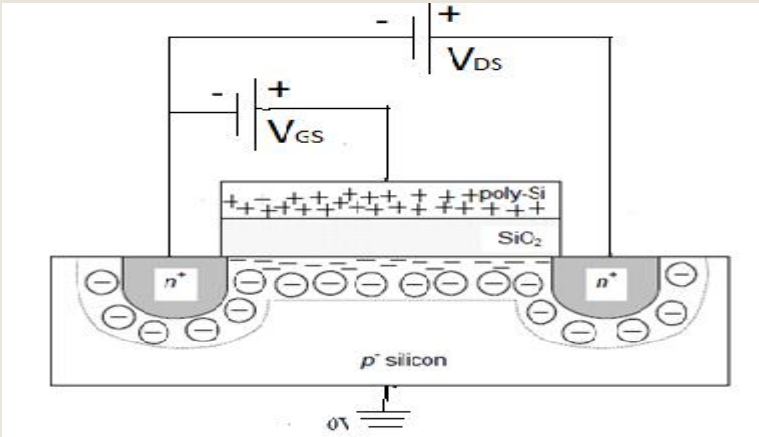
LECTURE - 8

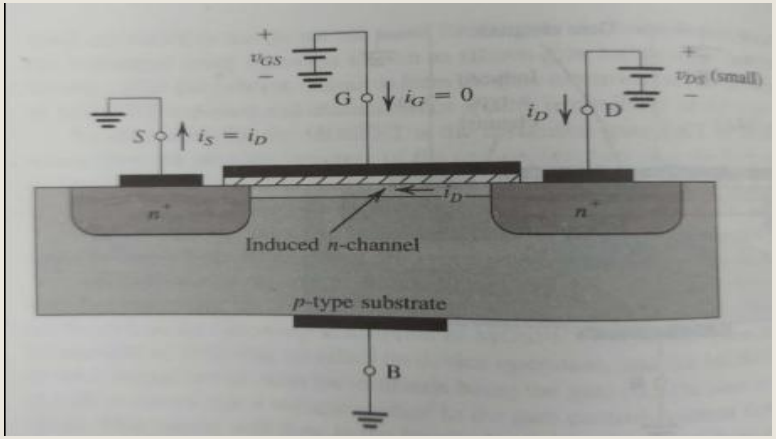
Year: 2020-21

MOS Operation -2

- **Applying a Small V_{DS}.**

➢ In NMOS, if $V_{GS}>V_t$, channel forms.





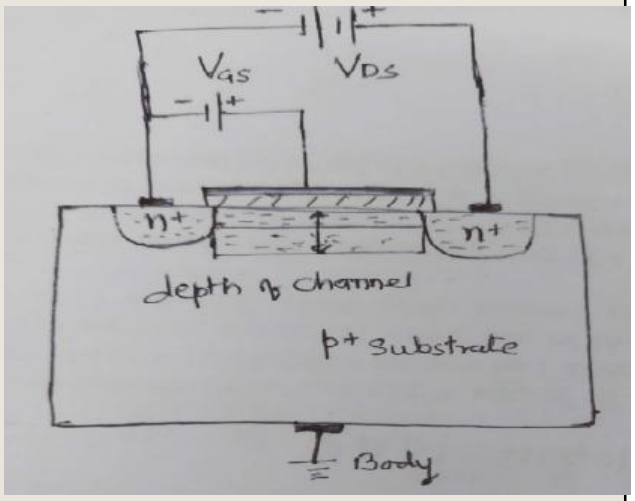
➢ Now consider case where V_{DS} is small. The voltage V_{DS} causes current I_D to flow through induced n channel. Current is carried by free electrons traveling from source to drain (electron current). But the conventional current flows from drain to source ID.

➢ If we further increase V_{DS}, the drain current I_D increases.

➢ But the magnitude of drain current is also dependent on voltage V_G on gate.

MOS Operation -2

- If we increase (V_{GS} - V_t), more and more holes in P-substrate will be repelled (pushed back) deep into substrate. And more electrons from drain and source will accumulate in channel.

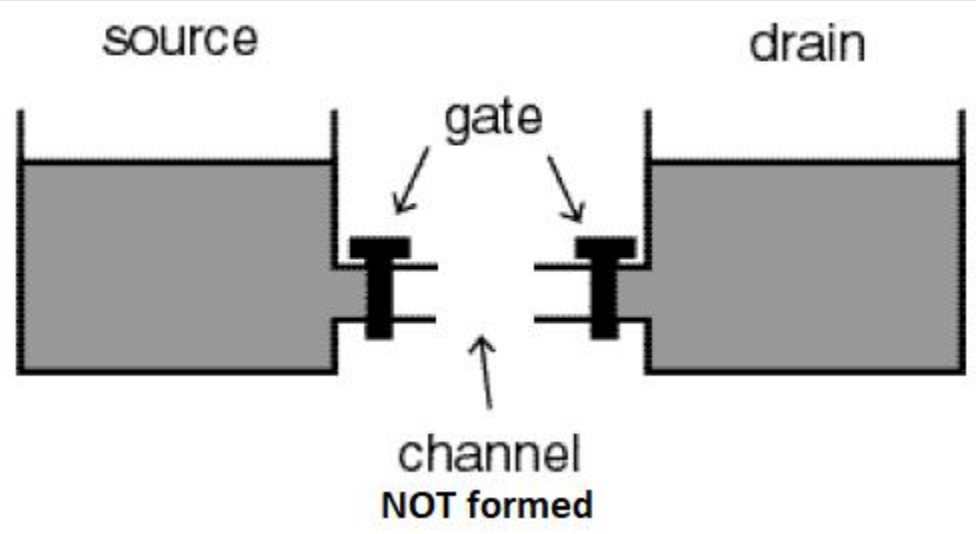


- Thus depth of channel increases. So it follows that the depth of channel is proportional to (V_{GS} - V_t).
- As depth of channel increases, more and more electrons will flow through the channel and hence drain current ID increases.
- Thus drain current is proportional to (function of) V_{DS} and $V_{GS.}$
- Increasing the VGS above the threshold voltage V_t enhances the channel hence it is also called as Enhancement-mode MOSFET

Two Tank Analogy of MOS

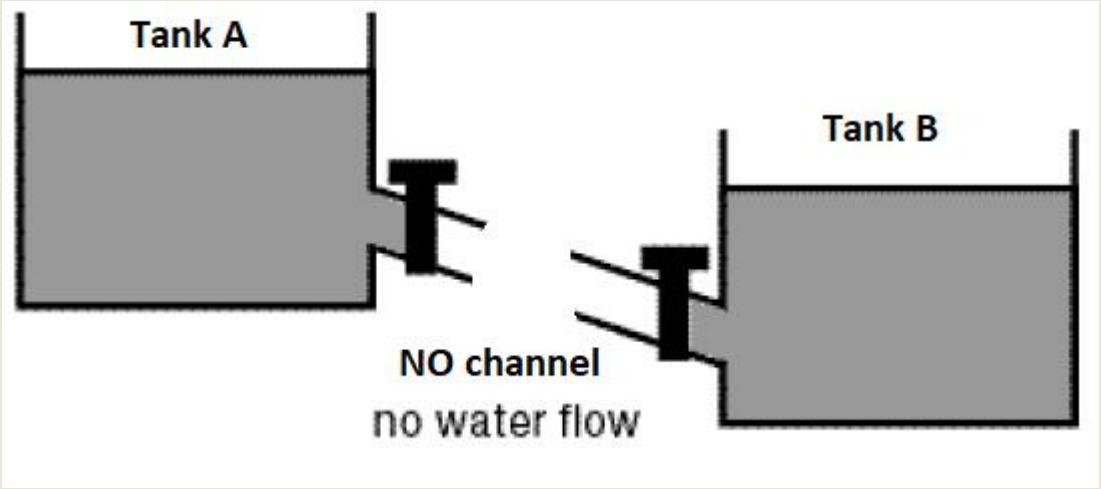
- In NMOS. If $V_{GS}<V_t$, NO channel is formed.
- Also since drain and source (i.e. both tanks) are at same potential

➢ So NO current flows.



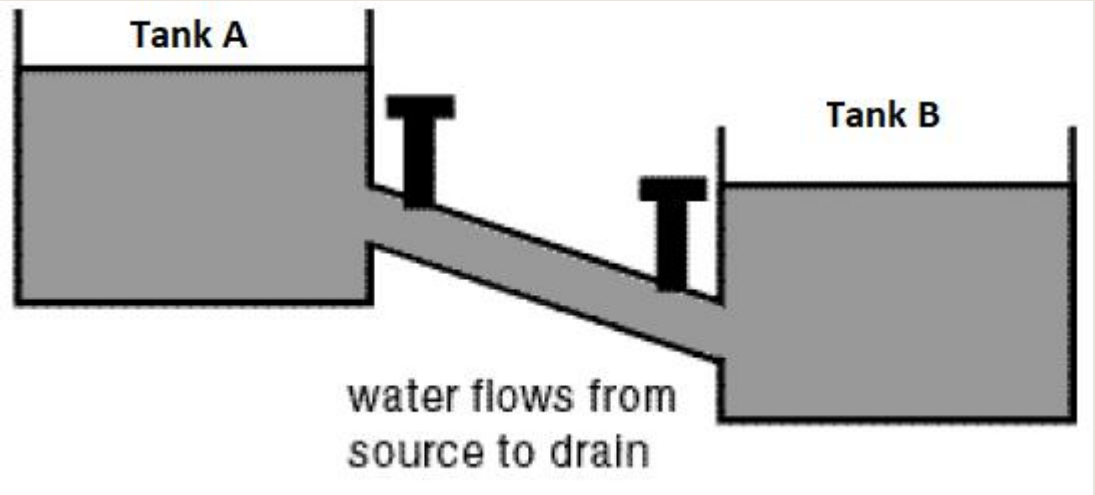
Two Tank Analogy of MOS

- Now still $V_{GS}<V_t$, channel is not formed.
- Tank A in at higher level than tank B, but since NO channel is formed, water(current) does not flow.



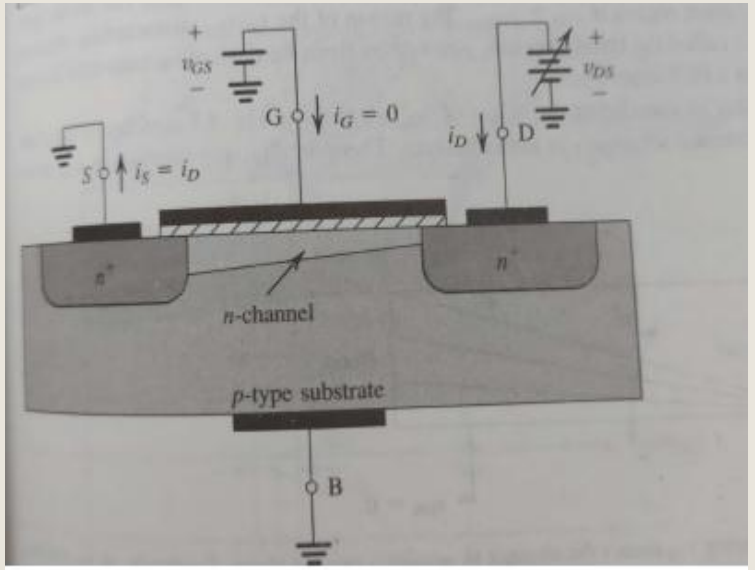
Two Tank Analogy of MOS

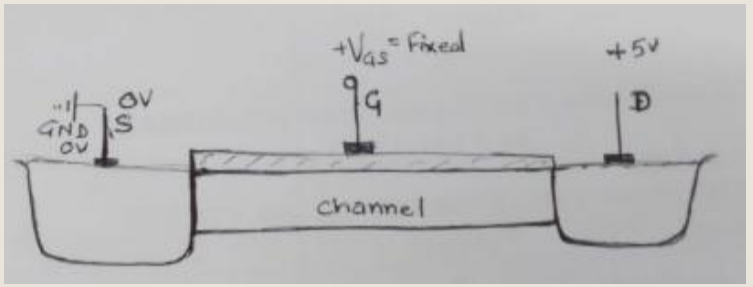
- Now $V_{GS} > V_t$, channel is formed.
- Tank A is at higher level than tank B
- Hence water(current) flows



MOS Operation -2

- Operation as V_{DS} id Increased.
  - Now consider that V_{DS} is further increased. But (V_{GS} - V_t) is kept constant.
  - As we travel along the channel from source to drain, the voltage measured relative to source increases from 0 to V_{DS} (5V).
  - Let V_{GS}=5V and V_{DS} is varying from 0 to 5V.
  - So V_G=5V, V_S=0V and let initially V_D=1V.
  - Hence voltage between gate and points along the channel decreases from V_{GS} at source end to (V_{GS}-V_{DS}) at the drain end.





i.e. At source end 5-0=5V and at drain end 5-1=4V.

- As we have seen, depth of channel is proportional to voltage at Gate VG.
- Hence channel is deepest at source end and shallowest at drain end.
- Thus channel is tapered as shown in fig.

MOS Operation -2

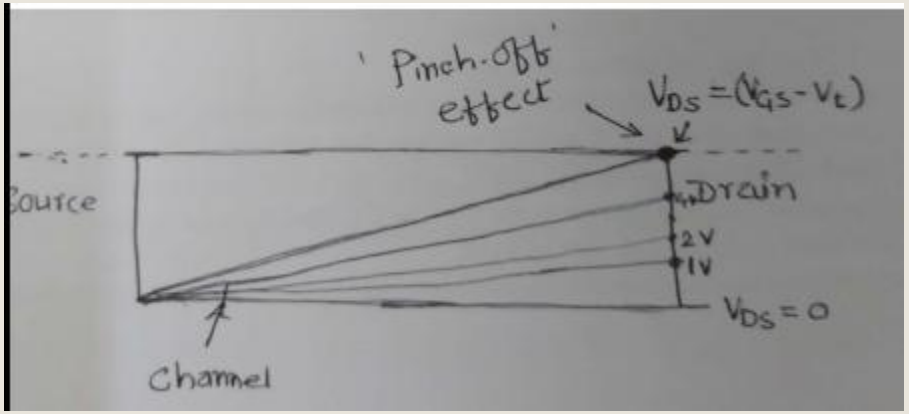
For Example:

Let $V_G=V_{GS}-V_t=5V$ -- fixed

We know $V_S=0V$

Now start increasing V_{DS} from 0 to 5V.

Suppose now $V_{DS}=1V$.



Hence voltage at source end $V_G-V_S=5-0=5V$

voltage at drain end $V_G-V_D=5-1=4V$

Suppose now $V_{DS}=2V$: voltage at drain end $V_G-V_D=5-2=3V$

for $V_{DS}=3V$: voltage at drain end $V_G-V_D=5-3=2V$

Similarly at $V_{DS}=5V$: voltage at drain end $V_G-V_D=5-5=0V$ i.e. depth of channel becomes Zero.

This condition at which $V_{DS}=(V_{GS}-V_t)$ is called at Pinch-off condition.

Its Quiz Time

https://forms.gle/yKDzpCHZs1eJ43pH9