RAMA UNIVERSITY

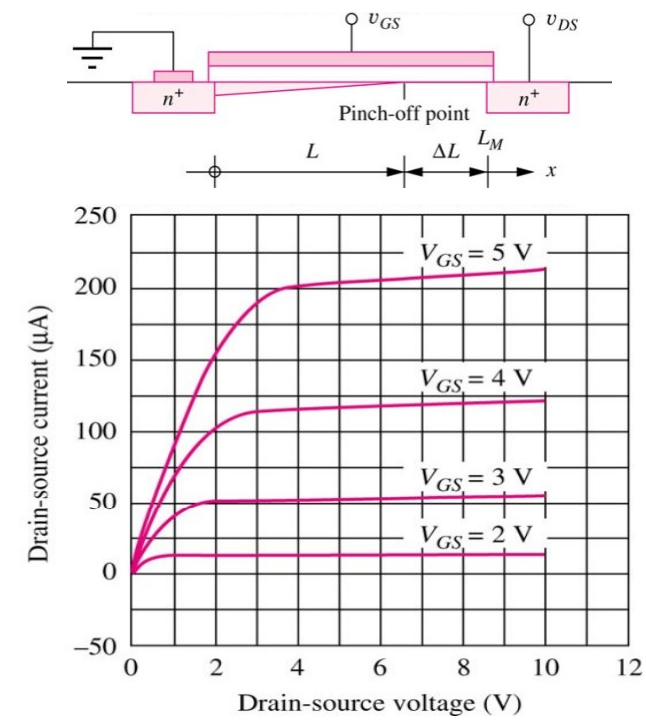
www.ramauniversity.ac.in

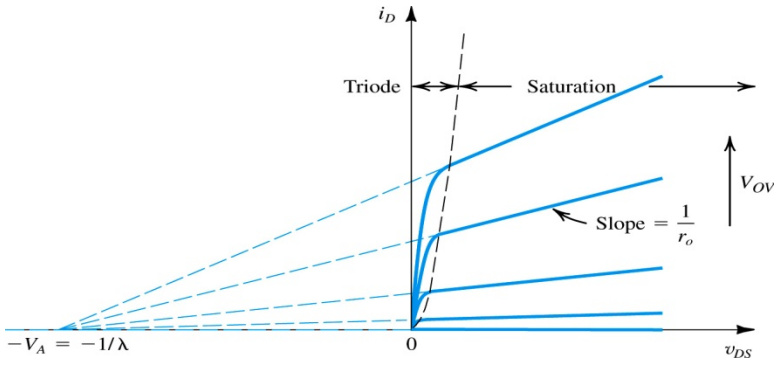
FACULTY OF ENGINEERING AND TECHNOLOGY

MEC-022

Lecture - 09

Channel-Length Modulation





- On the previous *iv*-characteristics, the saturation part was horizontal (the current was constant, as v_{DS} increases). However, it's not exactly so.
- As v_{DS} increases above v_{DSAT} , length of depleted channel beyond pinch-off point, ΔL, increases and actual L decreases.
- Since *L* is in denominator of the current expression, it compensate slightly the general increase of resistivity, which normally makes the curve flat.
- As a result, i_D increases slightly with v_{DS} instead of being constant and we can rewrite equation in the form:

$$i_D = \frac{K_n'}{2}\frac{W}{L}\left(v_{GS} - V_{TN}\right)^2\left(1+\lambda v_{DS}\right)$$

where λ is the channel length modulation parameter, depends on manufacturing and *L*.

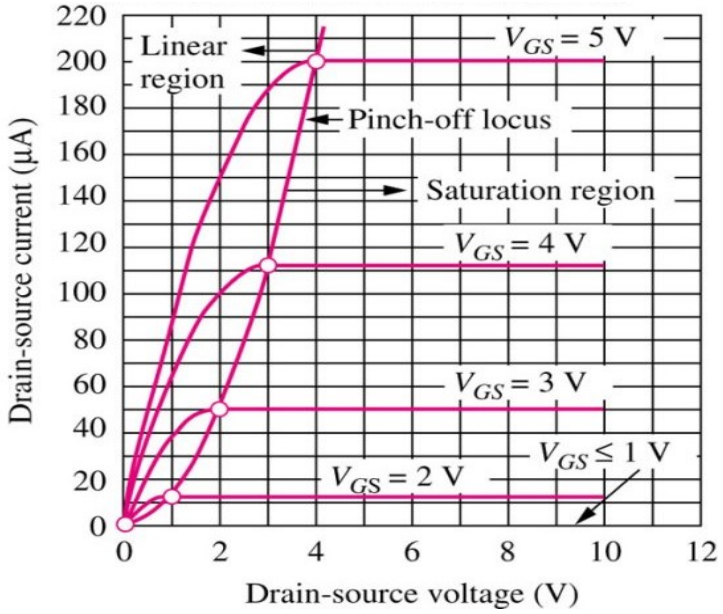
V_a – Early voltage.

Output and Transfer Characteristics of MOSFETS

- A MOSFET has one output variable – the drain-source current , that depends on two input variables – drain-source voltage and gate-source voltage (V_{GS} is usually is a control variable).
- Two types of iv-curves are used to describe a MOSFET device fully:

  output (drain) curve (DS current vs. DS voltage for a fixed GS voltage)

  (the earlier considered characteristics were drain curves)



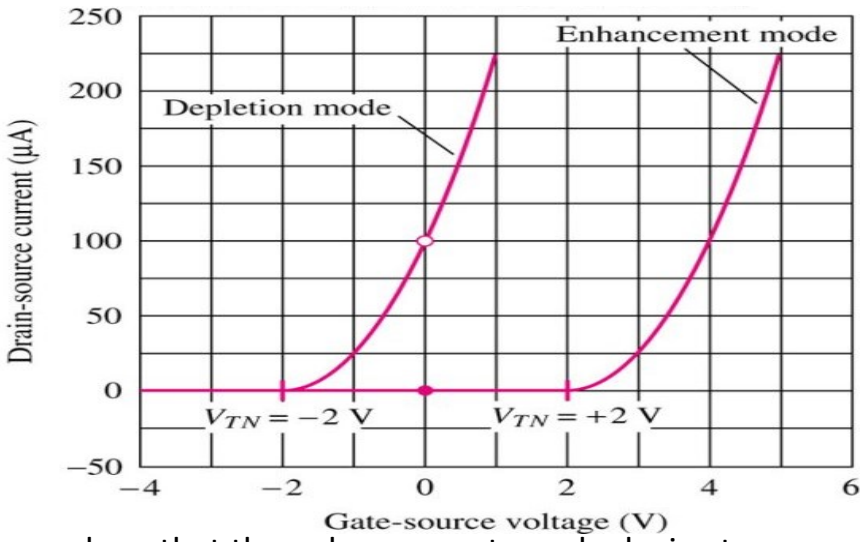
Output and Transfer Characteristics of MOSFETS

- A MOSFET has one output variable – the drain-source current , that depends on two input variables – drain-source voltage and gate-source voltage (V_{GS} is usually is a control variable).
- Two types of iv-curves are used to describe a MOSFET device fully:

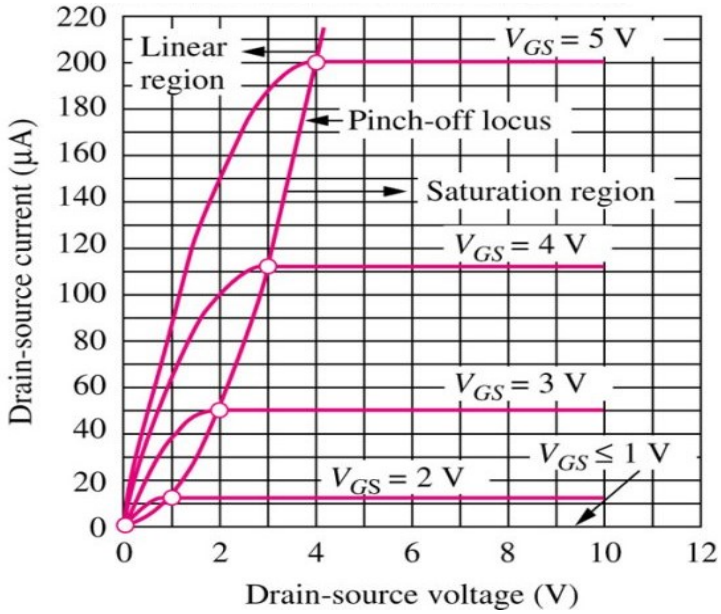
  output (drain) curve (DS current vs. DS voltage for a fixed GS voltage)

  (the earlier considered characteristics were drain curves)

  transfer curve (DS current vs. GS voltage for a fixed DS voltage, *f.i. sat*.)

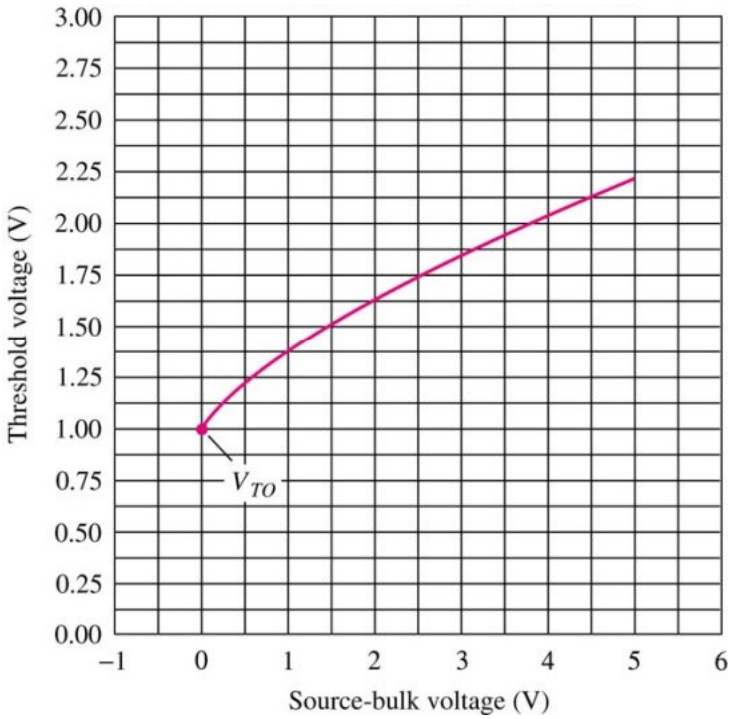


Curves show that the enhancement mode device turns on at V_{GS} = 2, while the depletion mode device turns on at V_{GS} = -2.



Body Effect or Substrate Sensitivity

So far it was assumed that the source-bulk voltage v_{SB} , is zero, which means that a MOSFET is a three terminal device. Quite often v_{SB} , especially in ICs is not zero.



- Non-zero v_{SB} changes threshold voltage.
- This is called substrate sensitivity and is modeled by

$$V_{TN} = V_{TO} + \gamma\left(\sqrt{v_{SB} + 2\phi_F} - \sqrt{2\phi_F}\right)$$

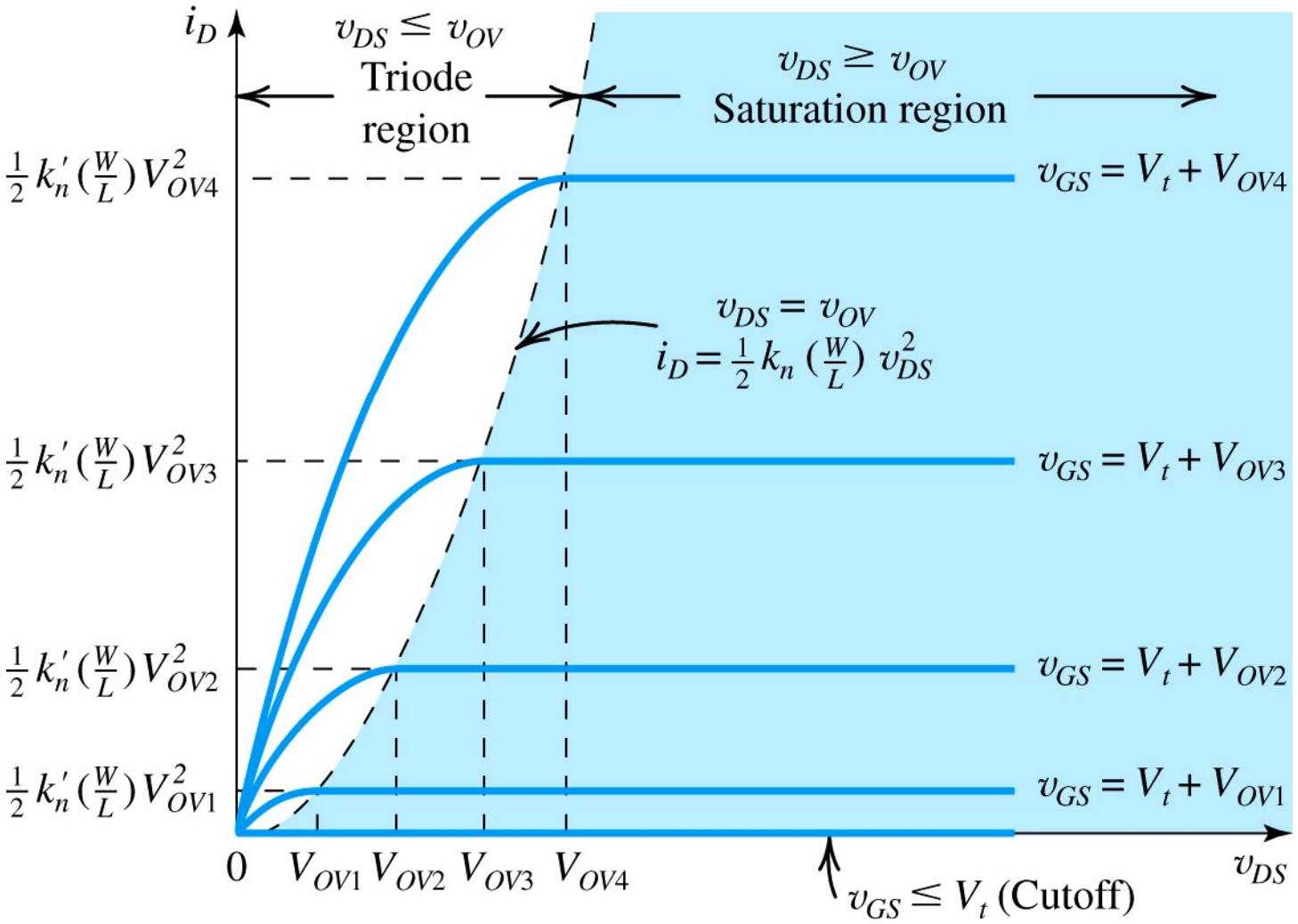
where

V_{TO} - zero substrate bias for V_{TN} (V)

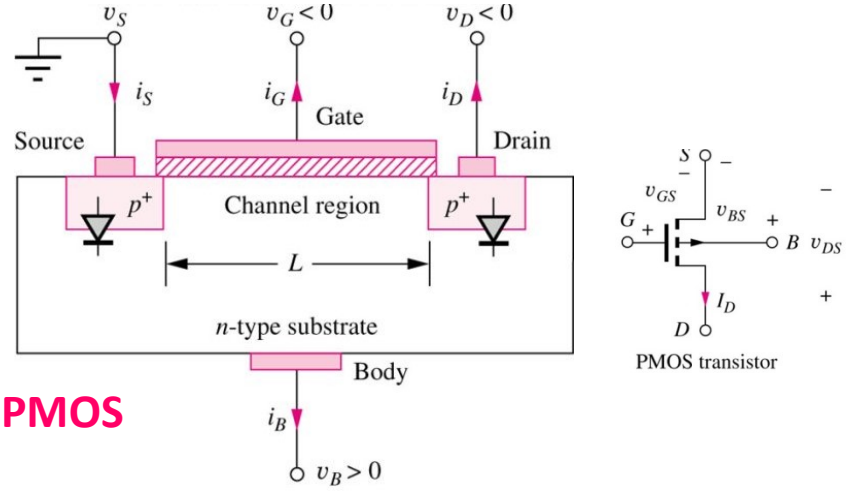
γ – body-effect parameter ($\sqrt{V}$)μ, determines the intensity of the body effect

$2\Phi_F$ - surface potential parameter (V), typically 0.6V.

NMOS Summary (output characteristics)

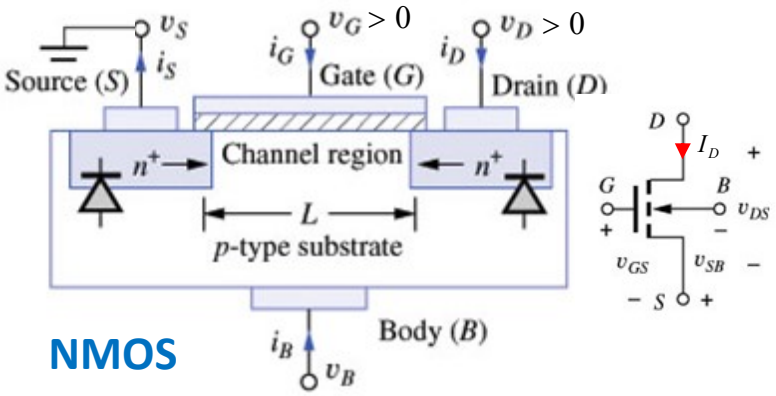


PMOS Transistors Structure (Enhancement-Mode)



PMOS

- *p*-type source and drain regions in *n*-type substrate.



NMOS

- *n*-type source and drain regions in *p*-type substrate.


Thank You!