Lab 3 – Introduction to Field-Effect Devices

WATERLOO ENGINEERING

ECE 331

Electronic Devices

Marco Iskander, MASc, EIT
Lab Instructor\Hardware Specialist

Outline

- Intended Learning Outcomes
- Introduction
- Lab Procedure

Lab 3: Introduction to Field-Effect Devices

- **Intended Learning Outcomes:**
  - Experiment the behaviour of a MOSFET (*Metal-Oxide-Semiconductor Field Effect Transistor*) as an electronic device.
    - Gate-to-source as well as drain-to-source voltages are varied to understand their impact on the overall behaviour of the device.
    - A semiconductor parameter analyzer is used to get accurate device characteristic graphs.

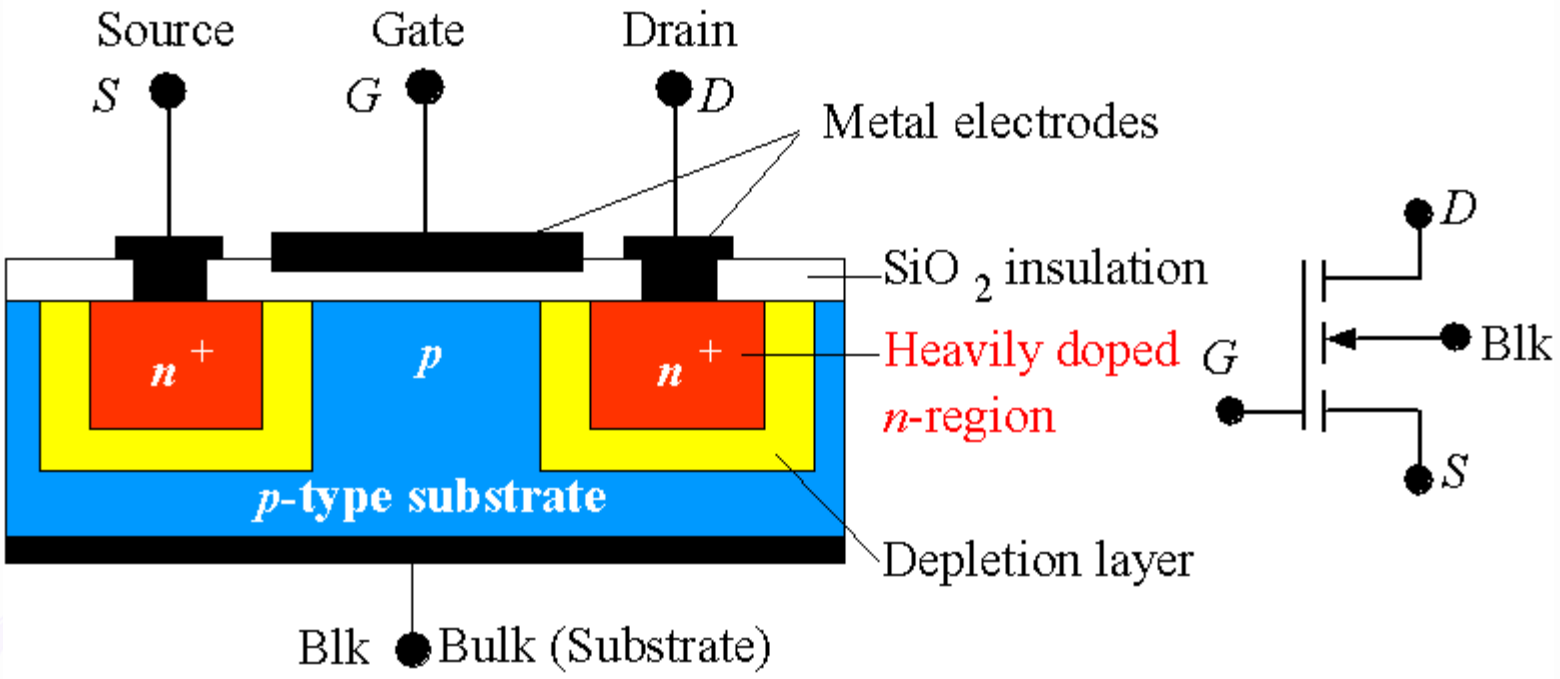
True or False

- **(T or F)** MOSFET has an isolated Gate $I_G \approx 0$ ( )
- **(T or F)** MOSFET has 3 or 4 terminals ( )
- Body Voltage influences the threshold voltage of MOSFET

$$V_T \approx V_{To} + \gamma\left(\sqrt{\varphi - V_{BS}} - \sqrt{\varphi}\right)$$

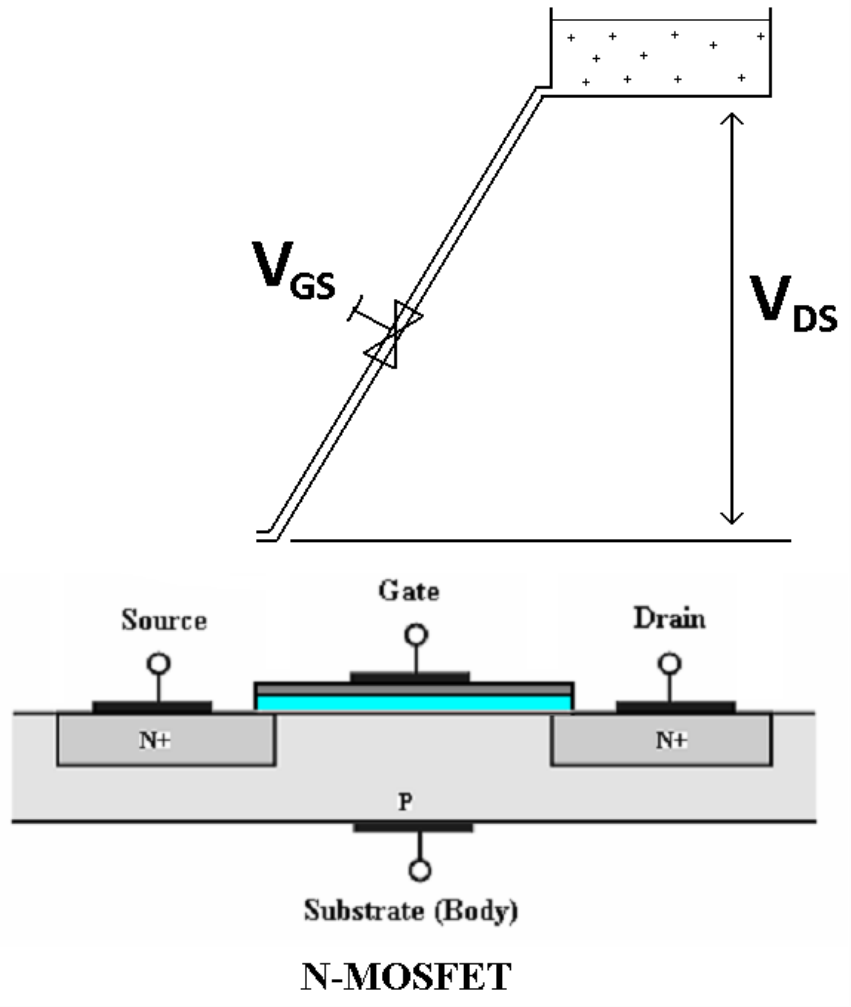
V_{T0} is the threshold voltage at $V_{BS} = 0$
γ and ϕ are model parameters

Introduction - N-MOSFET



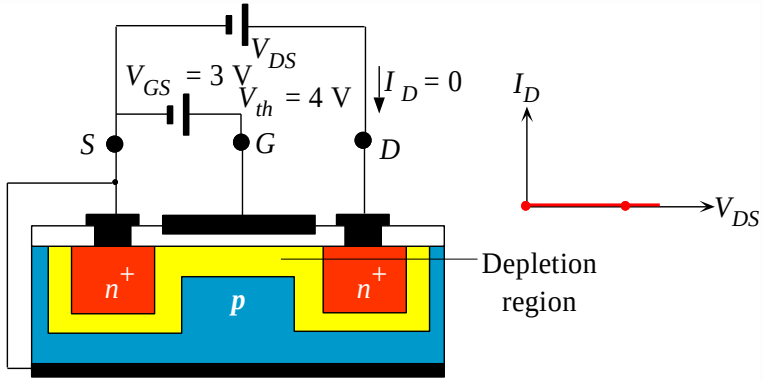
[Principles of Electronic Materials and Devices By: Kasap]

Introduction

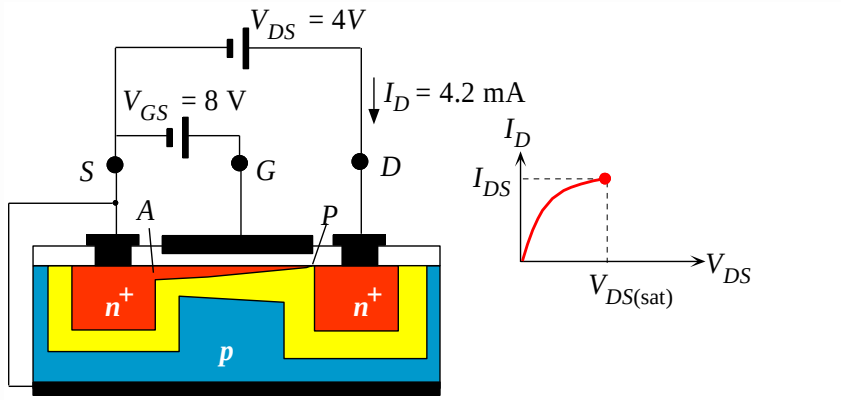


N-MOSFET

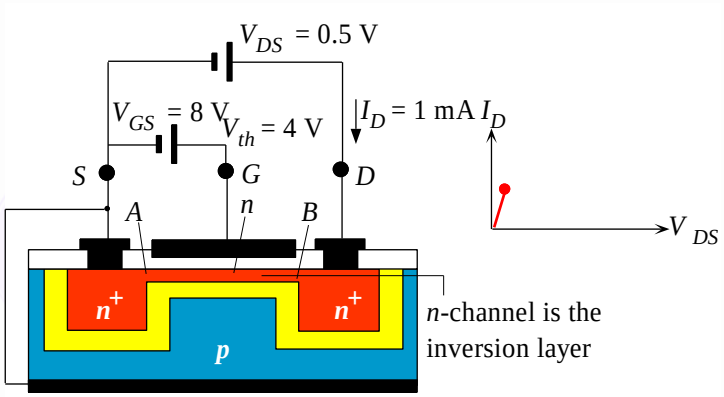
How NMOS works



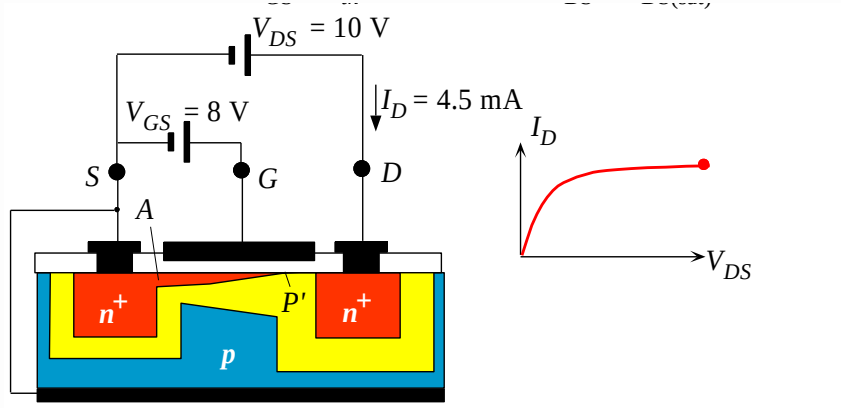
(a) Below threshold $V_{GS} < V_{th}$ and $V_{DS} > 0$



(c) Above threshold $V_{GS} > V_{th}$ and saturation, $V_{DS} = V_{DS(sat)}$



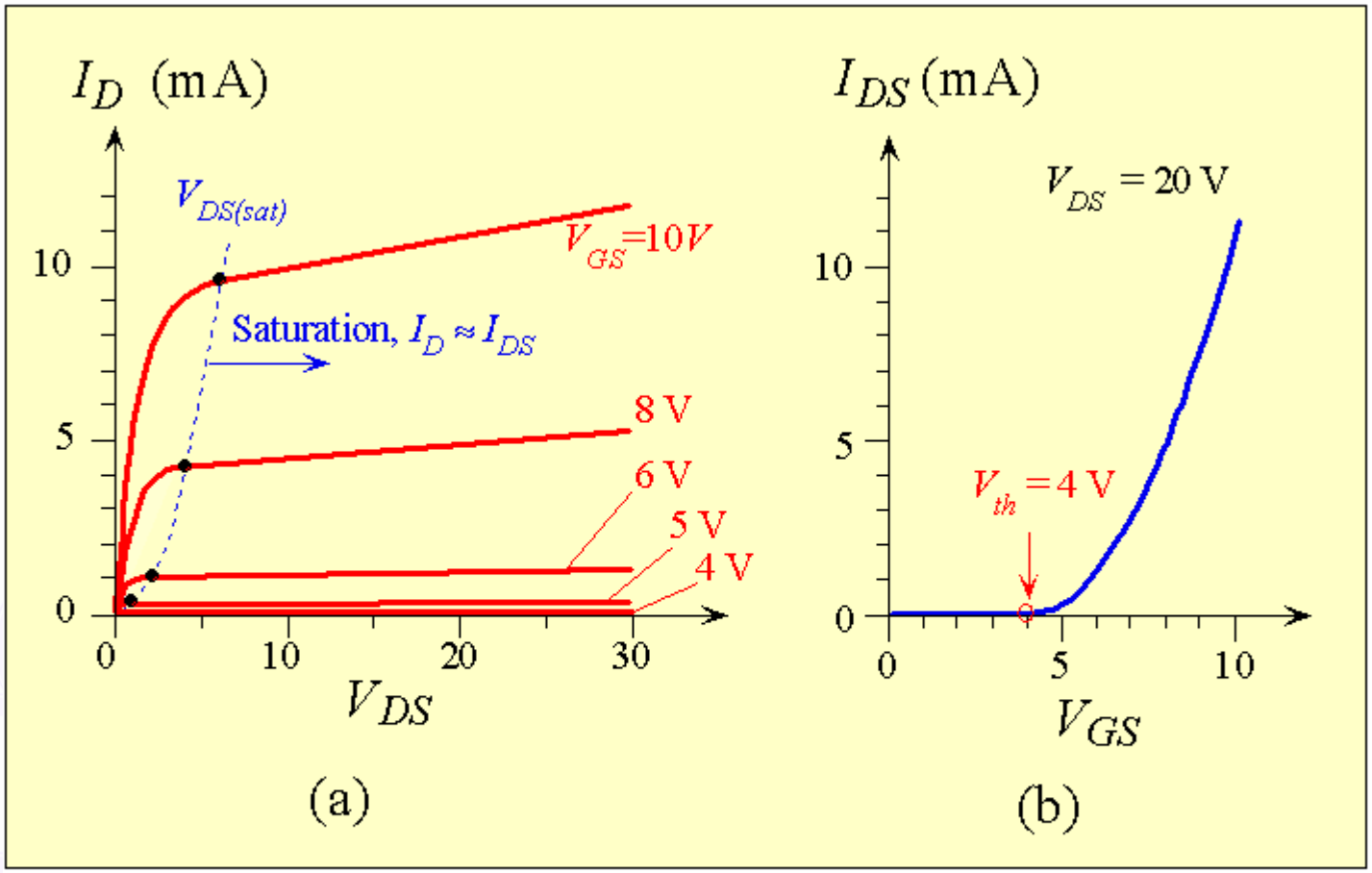
(b) Above threshold $V_{GS} > V_{th}$ and $V_{DS} < V_{DS(sat)}$



(d) Above threshold $V_{GS} > V_{th}$ and saturation region, $V_{DS} > V_{DS(sat)}$

[Principles of Electronic Materials and Devices By: Kasap]

How NMOS works

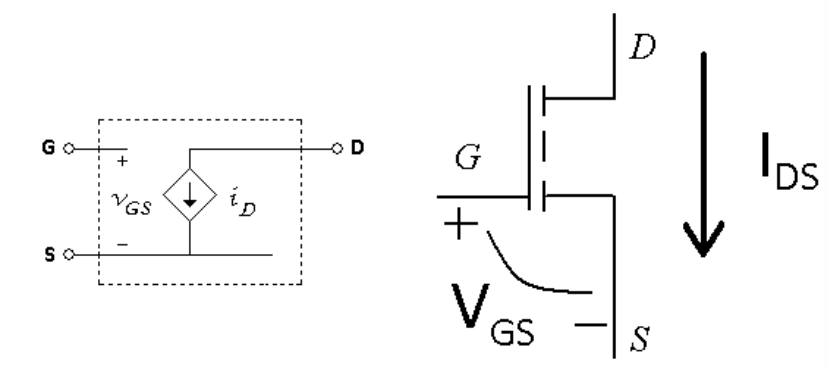


[Principles of Electronic Materials and Devices By: Kasap]

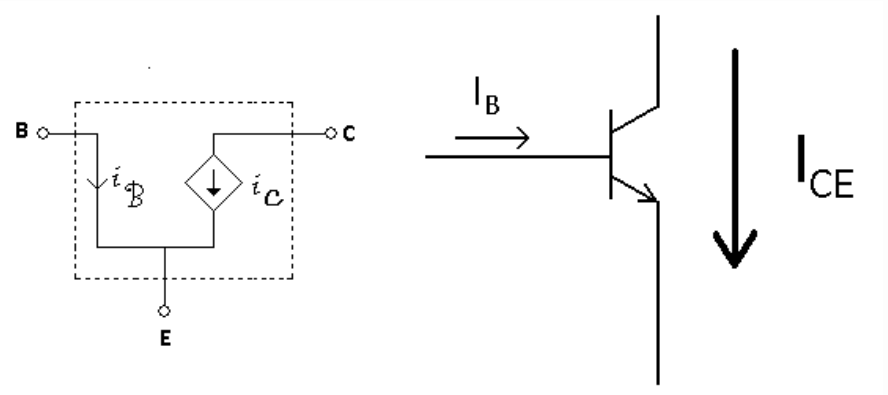
The Q1, Q3, and Q5 transistors are the P-MOSFETs, and the Q2, Q4, and Q6 transistors are the N-MOSFETs.

MOSFET Vs BJT

- MOSFET as
  - Voltage Controlled Current Source

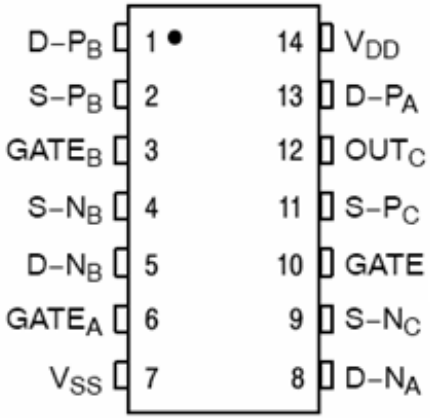


- BJT as
  - Current Controlled Current Source

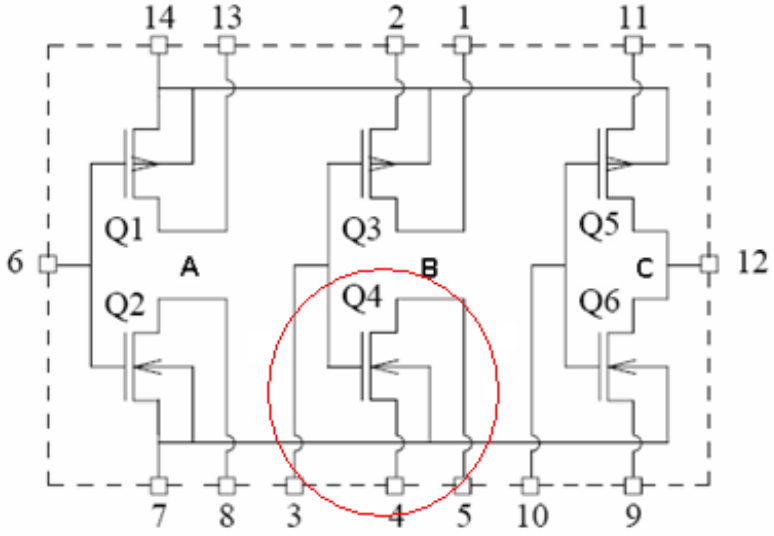


InLAB Devices:

- You will be using a commercial MOSFET device (IC CD4007UBE).
- The Q1, Q3, and Q5 transistors are the **P**-MOSFETs, and the Q2, Q4, and Q6 transistors are the **N**-MOSFETs.

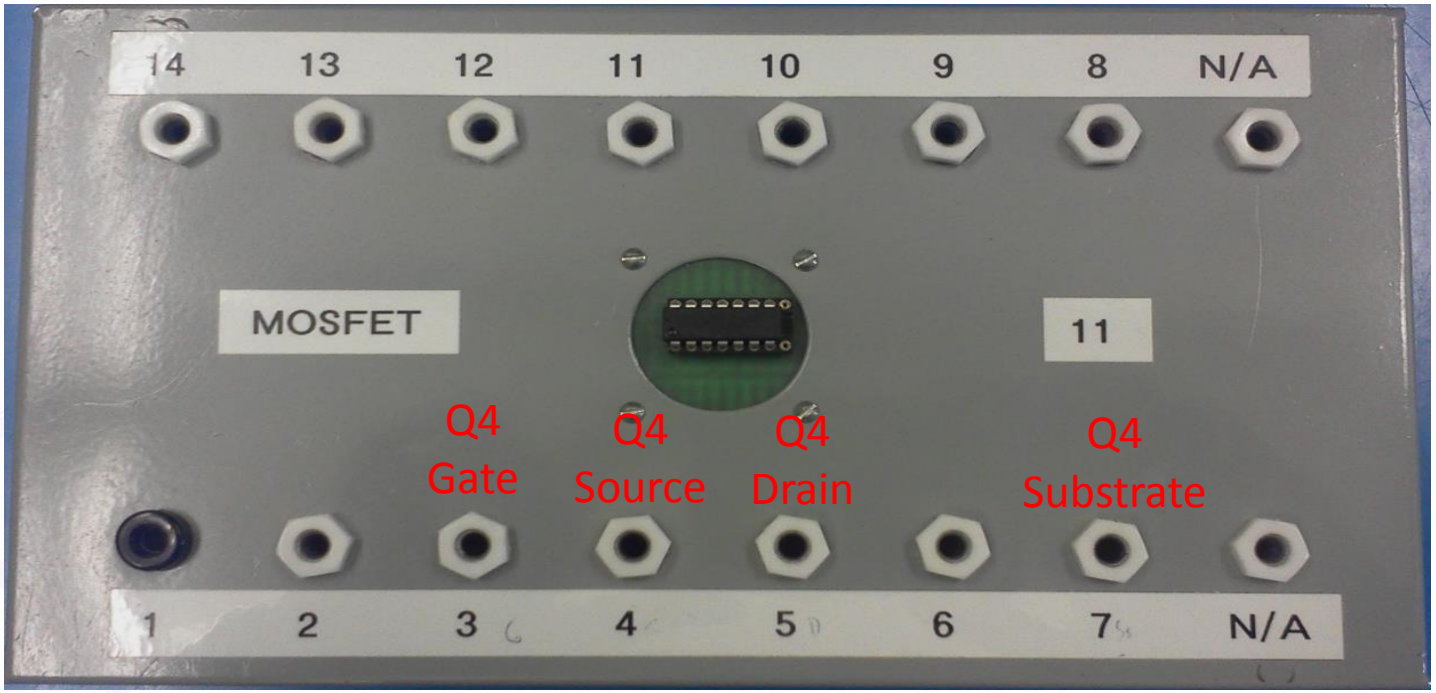


Pin	Function
1	Q3 drain
2	Q3 source
3	Q3 gate & Q4 gate
4	Q4 source
5	Q4 drain
6	Q1 gate & Q2 gate
7	Q2 source & N substrates (Vss)
8	Q2 drain
9	Q6 source
10	Q5 gate & Q6 gate
11	Q5 source
12	Q5 drain & Q6 drain
13	Q1 drain
14	Q1 source & P substrate (Vdd)

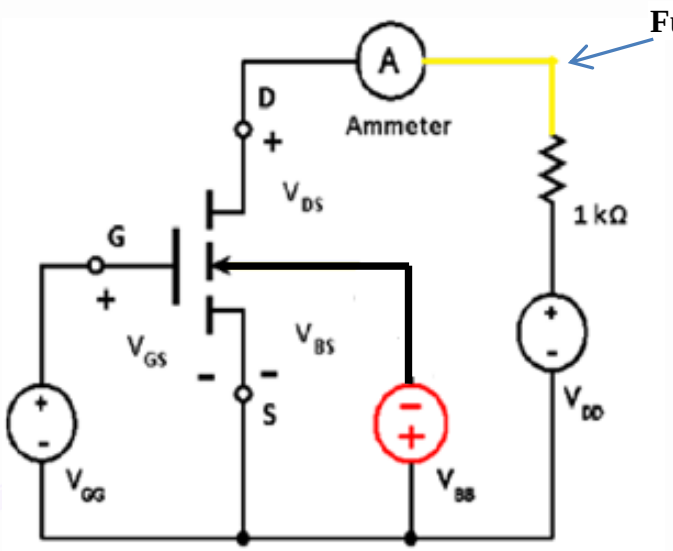


InLAB Devices:

- During this lab, we will use only Q4 (NMOS transistor).



4.1 MOSFET Threshold Voltage



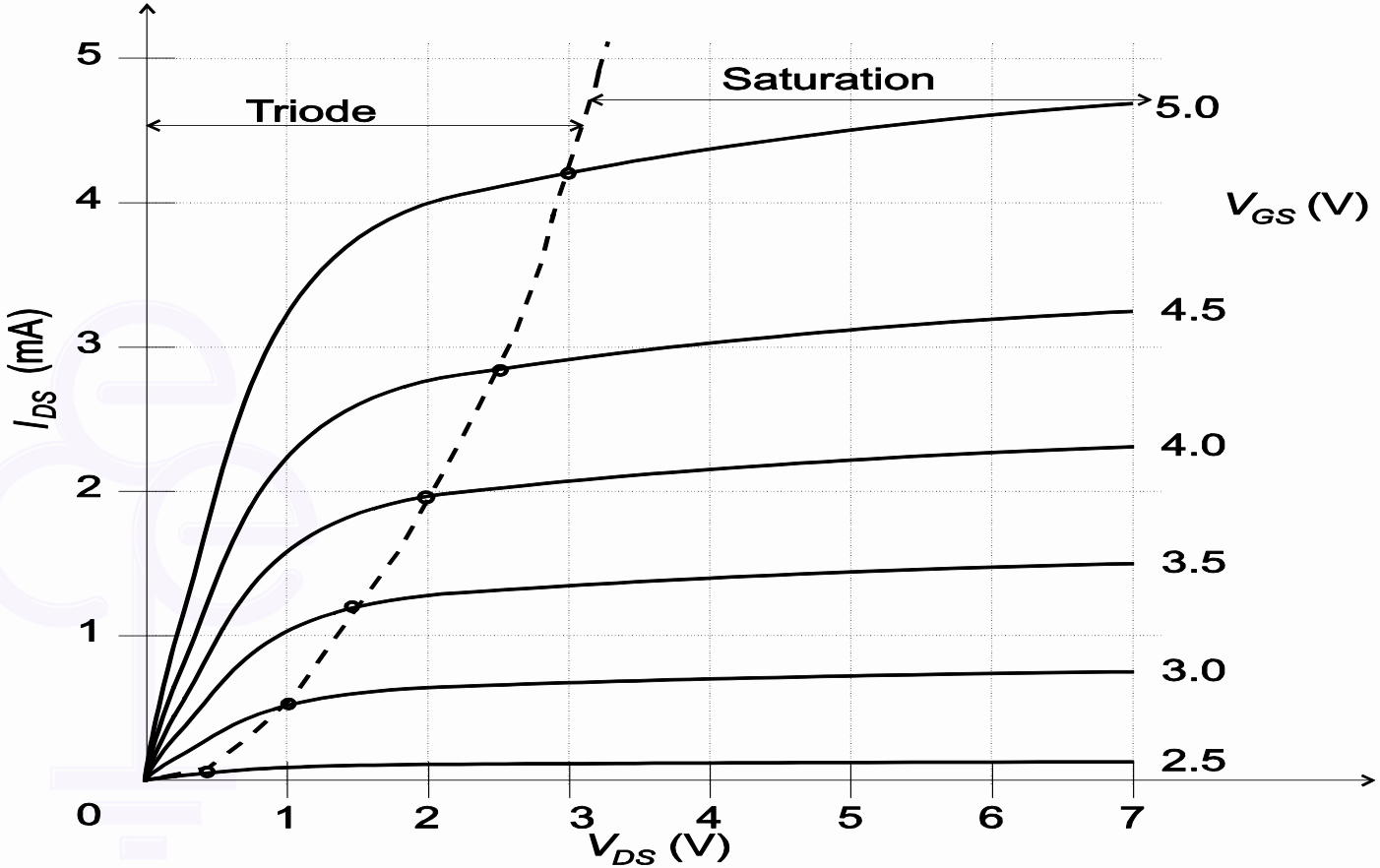
- Keep VDs at 6V.
- Change VGS to get current IDS of 1,2,3,4, and 5 mA
- Repeat for VSB =0, -2, -6, and -10

Figure 6. Circuit to study the effect of body bias on MOSFET threshold voltage.

V_{GG} V_{BB} V_{DD}

4.2 Semiconductor Parameter Analyzer

- Using Q4 (on the MOSFET chassis) and the Agilent parameter analyzer obtain a trace for the MOSFET characteristics of the



End of the lab session

- Do not forget to submit your Data3 to the Learn
- Any question – ask
- Have Fun !!!!