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EEM 303 Electronics II Laboratory - MOSFET Summary

The metal-oxide-semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a type of field-effect transistor (FET), most commonly fabricated by the controlled oxidation of silicon. It has an insulated gate; whose voltage determines the conductivity of the device. This ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. A metal-insulator-semiconductor field-effect transistor or MISFET is a term almost synonymous with MOSFET. Another synonym is IGFET for insulated-gate field-effect transistor.

The IGFET or MOSFET is a voltage-controlled field effect transistor that differs from a JFET in that it has a "Metal Oxide" Gate electrode which is electrically insulated from the main semiconductor n-channel or p-channel by a very thin layer of insulating material usually silicon dioxide, commonly known as glass.

This ultra-thin insulated metal gate electrode can be thought of as one plate of a capacitor. The isolation of the controlling Gate makes the input resistance of the MOSFET extremely high way up in the Mega-ohms (MΩ) region thereby making it almost infinite.

As the Gate terminal is electrically isolated from the main current carrying channel between the drain and source, *"NO current flows into the gate"* and just like the JFET, the MOSFET also acts like a voltage-controlled resistor where the current flowing through the main channel between the Drain and Source is proportional to the input voltage. Also, like the JFET, the MOSFETs very high input resistance can easily accumulate large amounts of static charge resulting in the MOSFET becoming easily damaged unless carefully handled or protected.

Like in the JFET experiment, MOSFETs are three terminal devices with a Gate, Drain and Source and both P-channel (PMOS) and N-channel (NMOS) MOSFETs are available. The MOSFETs are available in two basic forms:

Depletion Type: the transistor requires the Gate-Source voltage, (VGS) to switch the device "OFF". The depletion mode MOSFET is equivalent to a "Normally Closed" switch.

Enhancement Type: the transistor requires a Gate-Source voltage, (VGS) to switch the device "ON". The enhancement mode MOSFET is equivalent to a "Normally Open" switch.

The symbols and basic construction for both configurations of MOSFETs are shown in Figure 2.

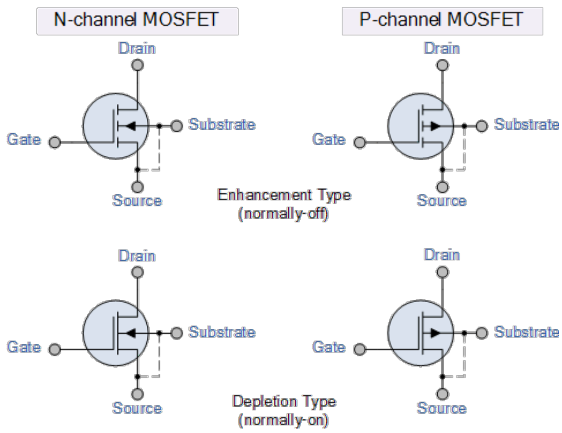

Figure 1: Symbols of MOSFET types

Some MOSFETs are used as drive amplifiers, especially in high power controls. Hence, this type of transistors is called Power MOSFETs which have wider channel structure. The structure is vertical and not planar. Using a vertical structure, it is possible for the transistor to sustain both high blocking voltage and high current. This type of ***Power MOSFET***s is called ***Vertical MOSFETs***, also shortly **V-MOSFETs.**

In general, there are three operating regions for MOSFET

— **Cut-Off Region**

Cut-off region is a region in which the MOSFET will be OFF as there will be no current flow through it. In this region, MOSFET behaves like an open switch and is thus used when they are required to function as electronic switches.

— **Ohmic** or **Linear Region**

Ohmic or linear region is a region where in the current I_{DS} increases with an increase in the value of V_{DS}. When MOSFETs are made to operate in this region, they can be used as amplifiers.

— **Saturation Region** or **Constant-current Region**

In saturation region, the MOSFETs have their I_{DS} constant inspite of an increase in V_{DS} and occurs once V_{DS} exceeds the value of pinch-off voltage V_P. Under this condition, the device will act like a closed switch through which a saturated value of I_{DS} flows. As a result, this operating region is chosen whenever MOSFETs are required to perform switching operations.

The Enhancement mode MOSFET only operates in the enhancement mode.

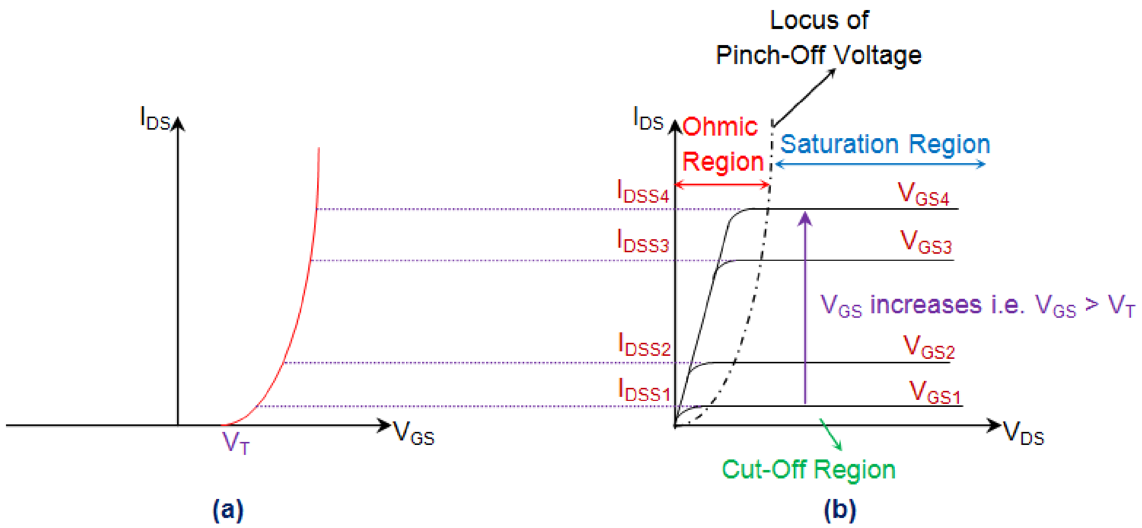

Figure 2: n-Channel Enhancement type MOSFET. (a) Transfer Characteristics, (b) Output Characteristic

— V_{GS} is always positive
— I_{DSS}=0 when $V_{GS} < V_T$
— As V_{GS} increases above V_T, I_D increases
— If V_{GS} is kept constant and V_{DS} is increased, then I_D saturates (I_{DSS})

The behavior of a MOSFET transistor in depletion and enhancement modes depending on the gate voltage is summarized as follows.

MOSFET TYPE	V_{GS} = +VE	V_{GS} = 0	V_{GS} = -VE
N-channel Depletion	ON	ON	OFF
N-channel Enhancement	ON	OFF	OFF
P-channel Depletion	OFF	ON	ON
P-channel Enhancement	OFF	OFF	ON

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