

MOSFET - Metal Oxide Silicon Field Effect Transistors

[MOSFET Basics](#)[MOSFET Types](#)[MOSFET Operating Regions](#)[MOSFET as a Switch](#)[MOSFET Applications](#)

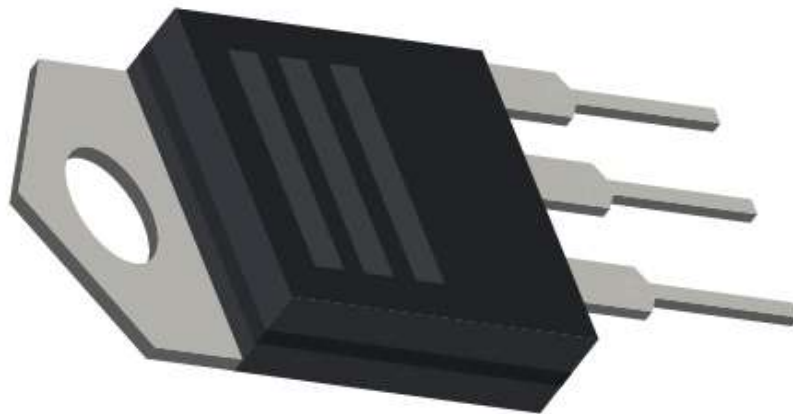
MOSFETs or Metal Oxide Silicon Field Effect Transistors were invented to overcome the disadvantages posed by FETs, such as the slow operation, high drain resistance, and moderate input impedance. In this article, let us learn about the basics of MOSFET.

MOSFET Basics

What is a MOSFET?

Metal Oxide Silicon Field Effect Transistors commonly known as MOSFETs are electronic devices used to switch or amplify voltages in circuits. It is a voltage controlled device and is constructed by three terminals. The terminals of MOSFET are named as follows:

- Source
- Gate
- Drain
- Body

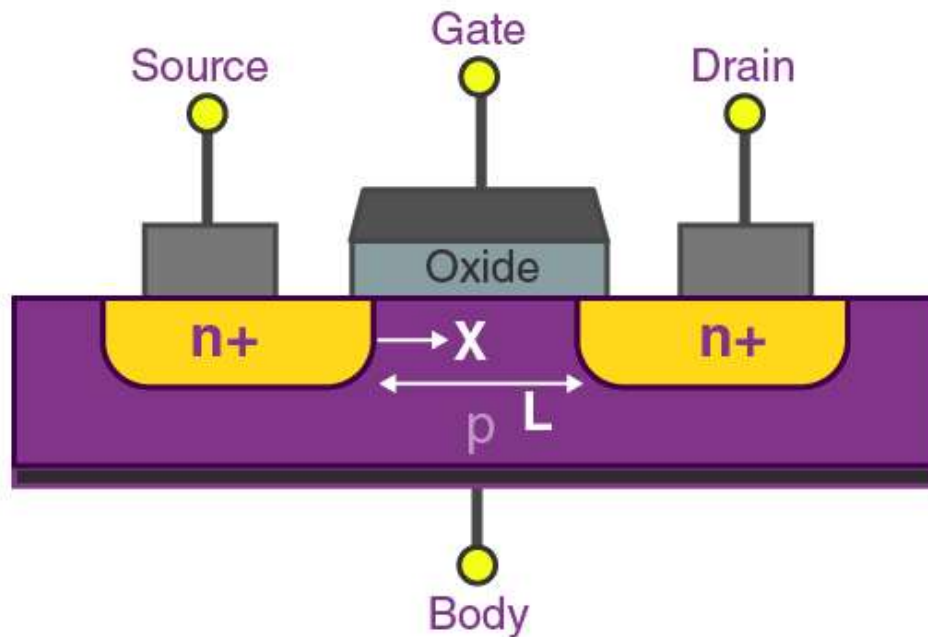


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The figure shows a practical MOSFET.

MOSFET Construction

The circuit of MOSFET is typically represented as follows:



- The p-type semiconductor forms the base of the MOSFET.
- The two types of the base are highly doped with an n-type impurity which is marked as n+ in the diagram.
- From the heavily doped regions of the base, the terminals source and drain originate.
- The layer of the substrate is coated with a layer of silicon dioxide for insulation.
- A thin insulated metallic plate is kept on top of the silicon dioxide and it acts as a capacitor.
- The gate terminal is brought out from the thin metallic plate.
- A DC circuit is then formed by connecting a voltage source between these two n-type regions.

Working Principle of MOSFET

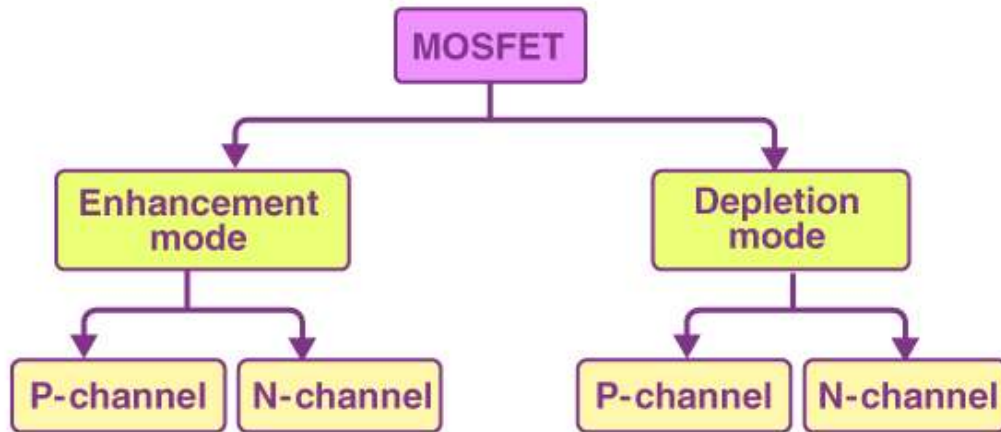
When voltage is applied to the gate, an electrical field is generated that changes the width of the channel region, where the electrons flow. The wider the channel region, the better conductivity of a device will be.

Similar Reading

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MOSFET Types

The classification of MOSFET based on the construction and the material used is given below in the flowchart.



MOSFETs are of two classes: *Enhancement mode* and *depletion mode*. Each class is available as n-channel or p-channel; hence overall they tally up to four types of MOSFETs.

Depletion Mode

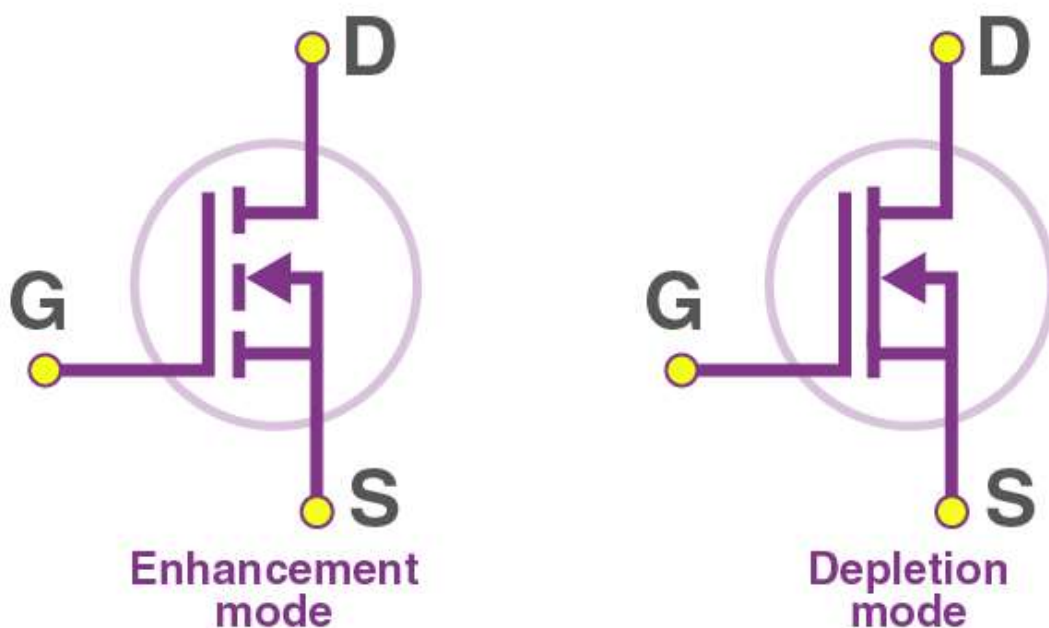
When there is no voltage across the gate terminal, the channel shows maximum conductance. When the voltage across the gate terminal is either positive or negative, then the channel conductivity decreases.

Enhancement Mode

When there is no voltage across the gate terminal, then the device does not conduct. When there is the maximum voltage across the gate terminal, then the device shows enhanced conductivity.

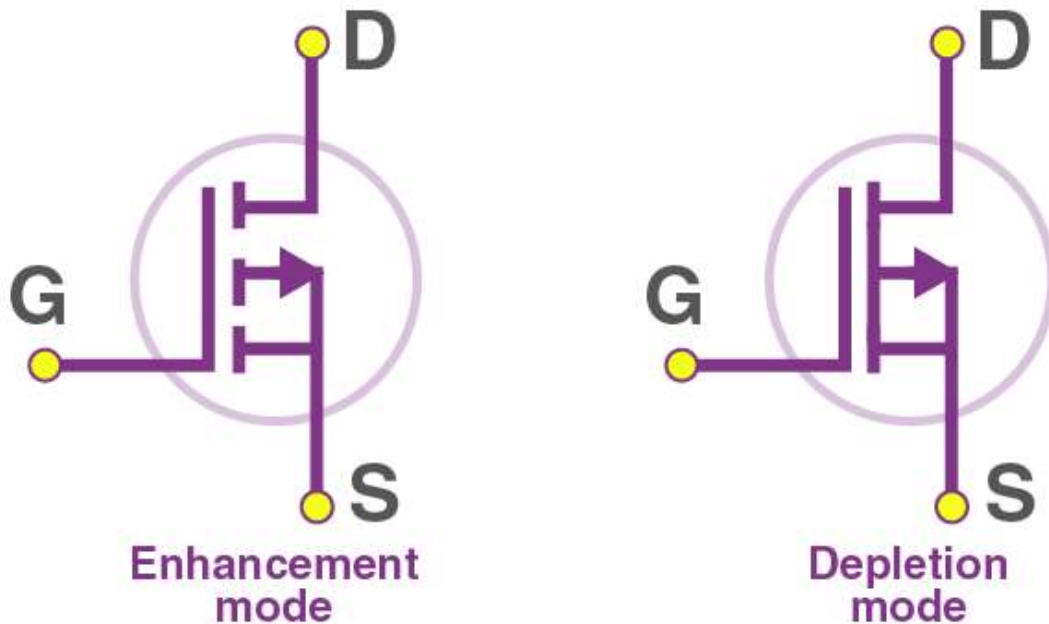
The N-channel MOSFETs are abbreviated as NMOS and are symbolically represented as shown in the figure below:

Symbols of N-Channel MOSFET



Similarly, the P-channel MOSFETs are abbreviated as PMOS and are symbolically represented as follows:

Symbols of P-Channel MOSFET



Operating Regions of MOSFET

A MOSFET is seen to exhibit three operating regions. Here, we will discuss those regions.

Cut-Off Region

The cut-off region is a region in which there will be no conduction and as a result, the MOSFET will be OFF. In this condition, MOSFET behaves like an open switch.

Ohmic Region

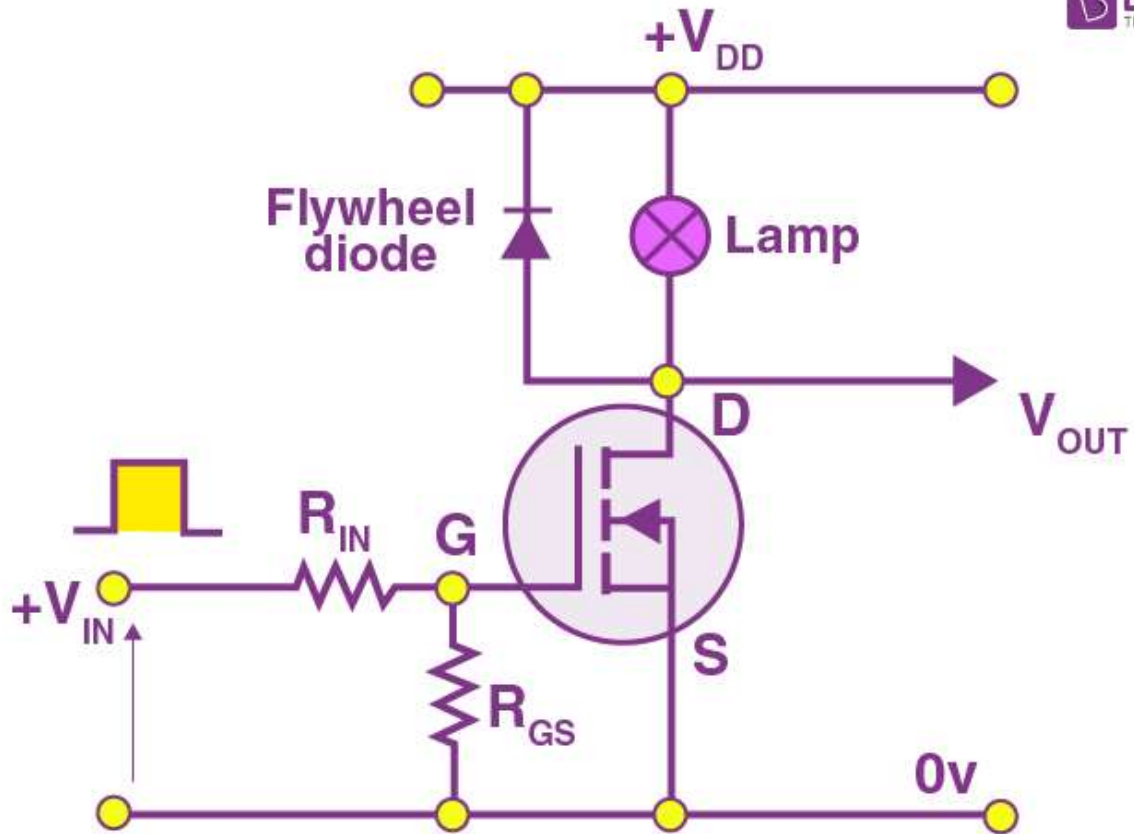
The ohmic region is a region where the current (I_{DS}) increases with an increase in the value of V_{DS} . When MOSFETs are made to operate in this region, they are used as amplifiers.

Saturation Region

In the saturation region, the MOSFETs have their I_{DS} constant in spite 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.

MOSFET as a Switch

MOSFETs are commonly used as switches. The circuit below shows the configuration of MOSFET when it is used as a switch.



In the circuit arrangement, an Enhancement-mode N-channel MOSFET is used to switch a simple lamp “ON” and “OFF.” The input gate voltage V_{gs} is adjusted to an appropriate positive voltage to switch “ON” the device and the voltage level is set to a negative value or zero to turn it “OFF.”

The switching characteristics for both N-channel and P-channel type MOSFET are summarised in the table below:

MOSFET Type	$V_{GS} \ll 0$	$V_{GS} = 0$	$V_{GS} \gg 0$
N-channel Enhancement	OFF	OFF	ON
N-channel Depletion	OFF	ON	ON
P-channel Enhancement	ON	OFF	OFF
P-channel Depletion	ON	ON	OFF

MOSFET vs BJT

In this section, let us discuss some differences between MOSFET and BJT.

MOSFET	BJT
There are two types of MOSFET and they are named: N-type or P-type	BJT is of two types and they are named as: PNP and NPN
MOSFET is a voltage-controlled device	BJT is a current-controlled device
The input resistance of MOSFET is high.	The input resistance of BJT is low.
Used in high current applications	Used in low current applications

MOSFET applications

- Radiofrequency applications use MOSFET amplifiers extensively.
- MOSFET behaves as a passive circuit element.
- Power MOSFETs can be used to regulate DC motors.
- MOSFETs are used in the design of the chopper circuit.

Advantages of MOSFET

- MOSFETs operate at greater efficiency at lower voltages.
- Absence of gate current results in high input impedance producing high switching speed.

Disadvantages of MOSFET

- MOSFETs are vulnerable to damage by electrostatic charges due to the thin oxide layer.
- Overload voltages make MOSFETs unstable.

Frequently Asked Questions on MOSFET

What is a MOSFET?

MOSFET or Metal Oxide Silicon Field Effect Transistors is a voltage-controlled four-terminal device that is used for switching and amplification purposes.

Can MOSFET conduct in both directions?

Yes, MOSFETs are bidirectional.

How many types of MOSFETs are there?

MOSFETs are of two classes: *Enhancement mode* and *depletion mode*. Each class is available as n-channel or p-channel; hence overall they tally up to four types of MOSFETs.

What are the operating regions of MOSFET?

There are three operating regions and they are named as: cut off region, ohmic region and saturation region.

What is the difference between a MOSFET and a BJT?

MOSFET is a voltage-controlled device while a BJT is a current-controlled device.

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