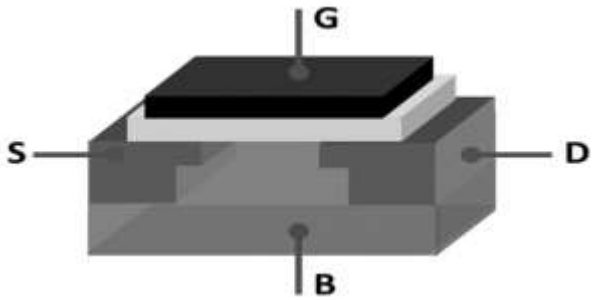
What is a MOSFET : Working and Its Applications

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is a semicc that is widely used for switching purposes and for the amplification of electronic signa devices. A MOSFET is either a core or integrated circuit where it is designed and fabric chip because the device is available in very small sizes. The introduction of the MOSF brought a change in the domain of **switching in electronics**. Let us go with a detailed exp concept.

What is MOSFET?

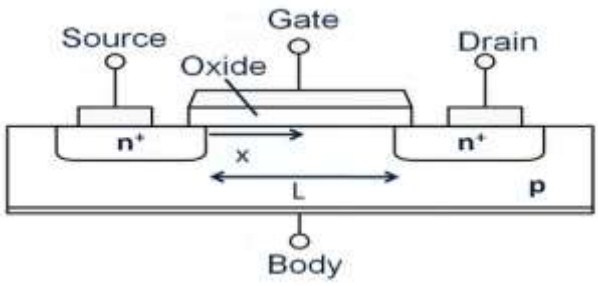
A MOSFET is a four-terminal device having source(S), gate (G), drain (D) and body (B) terr general, The body of the MOSFET is in connection with the source terminal thus forming a t device such as a field-effect transistor. MOSFET is generally considered as a transistor and both the analog and digital circuits. This is the basic **introduction to MOSFET**. And the ger of this device is as below :



MOSFET

From the above **MOSFET structure**, the functionality of MOSFET depends on the electrica happening in the channel width along with the flow of carriers (either holes or electrons). Th carriers enter into the channel through the source terminal and exit via the drain.

The width of the channel is controlled by the voltage on an electrode which is called the gat located in between the source and the drain. It is insulated from the channel near an extrem of metal oxide. The MOS capacity that exists in the device is the crucial section where the e is across this.



MOSFET With Terminals

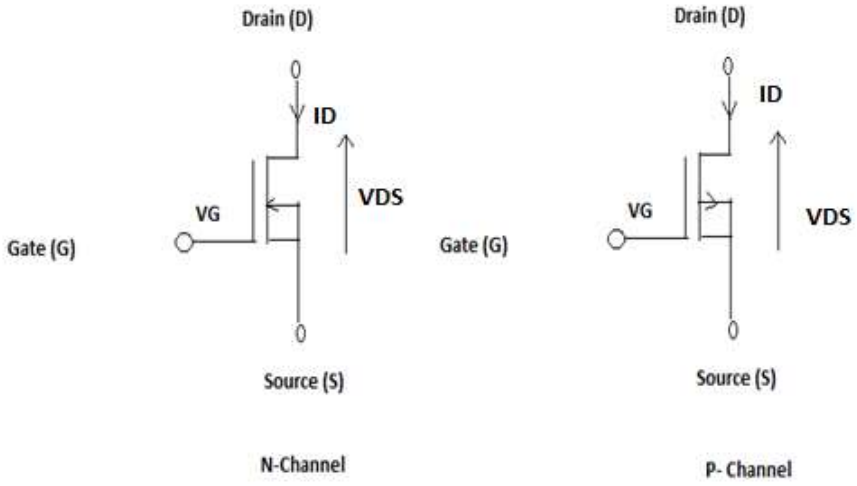
A MOSFET can function in two ways

- Depletion Mode
- Enhancement Mode

Depletion Mode

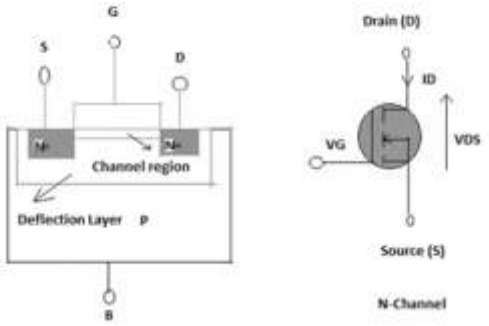
When there is no voltage across the gate terminal, the channel shows its maximum conduc
Whereas when the voltage across the gate terminal is either positive or negative, then the c
conductivity decreases.

For Example



Enhancement Mode

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



Enhancement Mode

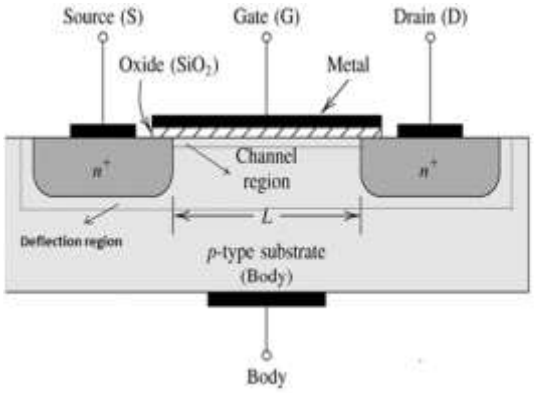
Working Principle of MOSFET

The main principle of the MOSFET device is to be able to control the voltage and current fl
source and drain terminals. It works almost like a switch and the functionality of the device

MOS capacitor. The MOS capacitor is the main part of MOSFET.

The semiconductor surface at the below oxide layer which is located between the so terminal can be inverted from p-type to n-type by the application of either a positive o voltages respectively. When we apply a repulsive force for the positive gate voltage, present beneath the oxide layer are pushed downward with the substrate.

The depletion region populated by the bound negative charges which are associated wi atoms. When electrons are reached, a channel is developed. The positive voltage also at from the n+ source and drain regions into the channel. Now, if a voltage is applied betwee source, the current flows freely between the source and drain and the gate voltage contro in the channel. Instead of the positive voltage, if we apply a negative voltage, a hole channe under the oxide layer.

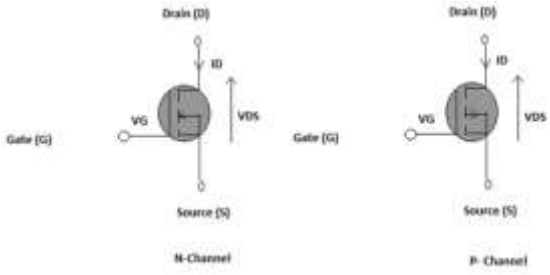


MOSFET Block Diagram

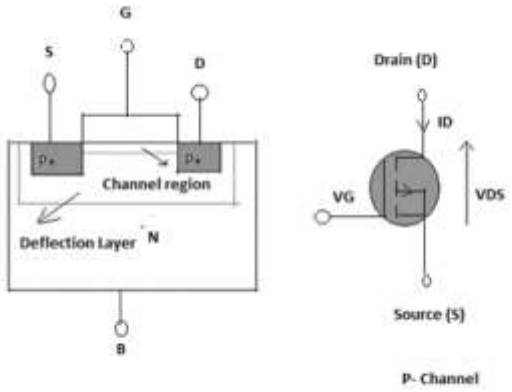
P-Channel MOSFET

The P- channel MOSFET has a P- Channel region located in between the source and drai a four-terminal device having the terminals as gate, drain, source, and body. The drain heavily doped p+ region and the body or substrate is of n-type. The flow of current is in positively charged holes.

When we apply the negative voltage with repulsive force at the gate terminal, then the el under the oxide layer are pushed downwards into the substrate. The depletion region pc bound positive charges which are associated with the donor atoms. The negative gate volta holes from the p+ source and drain region into the channel region.



Depletion Mode P Channel



P Channel Enhanced Mode

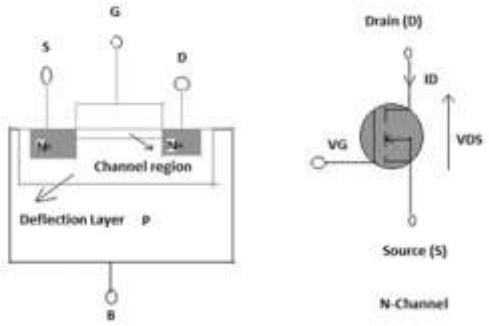
N- Channel MOSFET

The N-Channel MOSFET has an N- channel region located in between the source and drai a four-terminal device having the terminals as gate, drain, source, body. In this type Transistor, the drain and source are heavily doped n+ region and the substrate or body are

The current flow in this type of MOSFET happens because of negatively charged elect apply the positive voltage with repulsive force at the gate terminal then the holes present

layer are pushed downward into the substrate. The depletion region is populated by the charges which are associated with the acceptor atoms.

Upon the reach of electrons, the channel is formed. The positive voltage also attracts electr source and drain regions into the channel. Now, if a voltage is applied between the drain current flows freely between the source and drain and the gate voltage controls the e channel. Instead of positive voltage if we apply negative voltage then a hole channel will b the oxide layer.



Enhancement Mode N Channel

MOSFET Regions of Operation

To the most general scenario, the operation of this device happens mainly in three regions a as follows:

- **Cut-off Region –** It is the region where the device will be in the OFF condition and there current flow through it. Here, the device functions as a basic switch and is so employed a are necessary to operate as electrical switches.
- **Saturation Region –** In this region, the devices will have their drain to source current val without considering the enhancement in the voltage across the drain to source. This happ when the voltage across the drain to source terminal increases more than the pinch-off v this scenario, the device functions as a closed switch where a saturated level of current a to source terminals flows. Due to this, the saturation region is selected when the devices to perform switching.

- **Linear/Ohmic Region –** It is the region where the current across the drain to source tern with the increment in the voltage across the drain to source path. When the MOSFET dev in this linear region, they perform amplifier functionality.

Let us now consider the switching characteristics of MOSFET

A semiconductor too such as MOSFET or Bipolar Junction Transistor is basically functionec two scenarios one is ON state and the other is OFF state. To consider this functionality, let u at the ideal and practical characteristics of the MOSFET device.

Ideal Switch Characteristics

When a MOSFET is supposed to function as an ideal switch, it should hold the below prope are

- In the ON condition, there has to be the current limitation that it carries
- In the OFF condition, blocking voltage levels should not hold any kind of limitations
- When the device functions in ON state, the voltage drop value should be null
- The resistance in OFF state should be infinite
- There should be no restrictions on the speed of operation

Practical Switch Characteristics

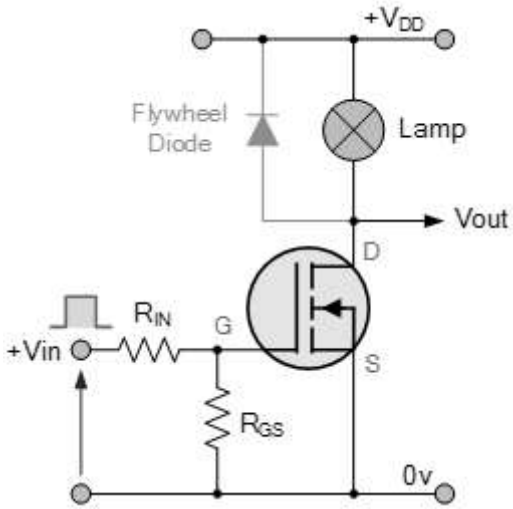
As the world is not just stuck to ideal applications, the functioning of MOSFET is even applic practical purposes. In the practical scenario, the device should hold the below properties

- In the ON condition, the power managing abilities should be limited which means that the conduction current has to be restricted.
- In the OFF state, blocking voltage levels should not be limited
- Turning ON and OFF for finite times restricts the limiting speed of the device and even lin functional frequency
- In the ON condition of the MOSFET device, there will be minimal resistance values wher the voltage drop in forwarding bias. Also, there exists finite OFF state resistance that deli leakage current

- When the device is performing in practical characteristics, it loses power on ON and OFF This happens even in the transition states too.

Example of MOSFET as a Switch

In the below circuit arrangement, an enhanced mode and N-channel MOSFET are being us sample lamp with the conditions ON and OFF. The positive voltage at the gate terminal is a base of the transistor and the lamp moves into ON condition and here V_{GS} =+v or at zero vc device turns to OFF condition where V_{GS}=0.

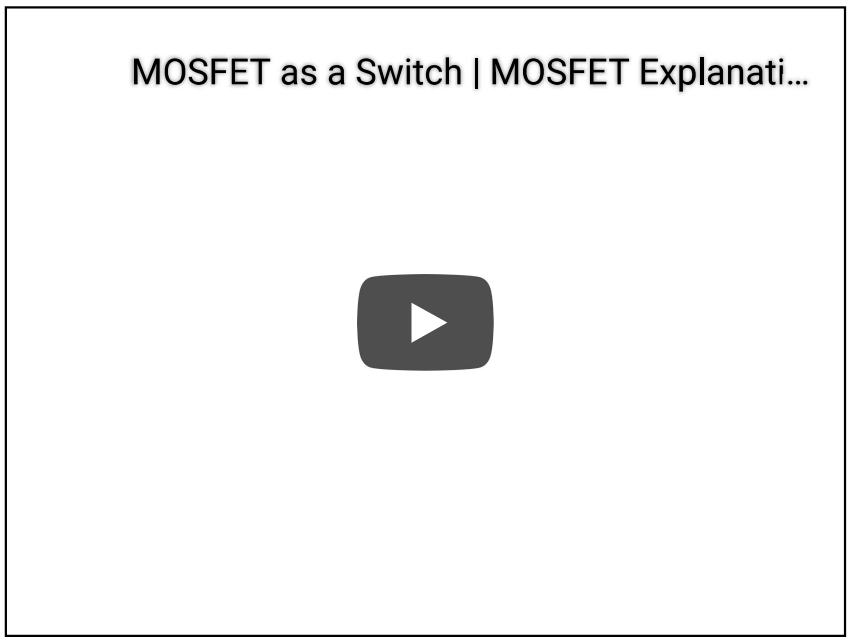


MOSFET As Switch

If the resistive load of the lamp was to be replaced by an inductive load and connected to th diode which is protected to the load. In the above circuit, it is a very simple circuit for switch load such as a lamp or LED. But when using MOSFET as a switch either with inductive loac load, then protection is required for the MOSFET device.

If in the case when the MOSFET is not protected, it may lead to damage of the device. For operate as an analog switching device, it needs to be switched between its cutoff region wh saturation region where V_{GS} =+v.

Video Description



MOSFET can also function as a transistor and it is abbreviated as Metal Oxide Silic Transistor. Here, the name itself indicated that the device can be operated as a transistor channel and N-channel. The device is connected in such a way using the four source, terminals and a resistive load of 24Ω is connected in series with an ammeter, and a v connected across the MOSFET.

In the transistor, the current flow in the gate is in a positive direction and the source termin to ground. Whereas in bipolar junction transistor devices, the current flow is across the path. But in this device, there is no current flow because there is a capacitor at the beginnir just requires only voltage.

This can be happened by proceeding with the simulation process and by switching ON/ switch is ON there is no current flow across the circuit, when the resistance of 24Ω and 0 voltage are connected, then we find the negligible voltage drop across the source because across this device.

The resistance between drain and source is termed as RDS. Due to this RDS, the voltag when there is current flow in the circuit. RDS varies based on the type of the device (it can 0.001, 0.005, and 0.05 based on the type of voltage.

Few of the concepts to learn are :

1). How To Choose MOSFET as Switch?

There are few conditions to be observed while selecting the MOSFET as a switch and those

- Usage of polarity either P or N channel
- A maximum rating of operating voltage and current values
- Increased Rds ON which means that resistance at Drain to Source terminal when the ch completely open
- Enhanced operational frequency
- Packing kind is of To-220 and DPAck and many others.

2). What is MOSFET Switch Efficiency?

The main restriction at the time of operating MOSFET as a switching device is the enhance value that the device can be capable of. It means that RDS in ON condition is the crucial pa decides the switching capability of the MOSFET. It is represented as the ratio of drain-sourc that of drain current. It has to be calculated only in the ON state of the transistor.

3). Why MOSFET Switch is Used in Boost Converter?

In general, a boost converter needs a switching transistor for the operation of the device. So transistor MOSFETs are used. These devices are used to know the current value and voltag considering the switching speed and cost, these are extensively employed.

In the same way, MOSFET can also be used in multiple ways. and those are

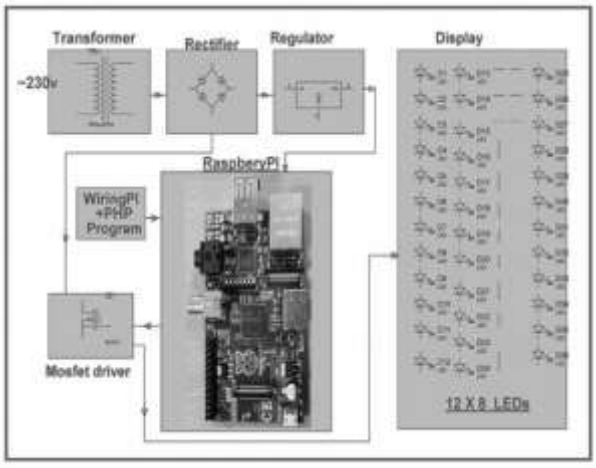
- MOSFET as a switch for LED
- remove_circle_outline
- MOSFET as a switch for Arduino
- MOSFET switch for ac load
- MOSFET switch for dc motor

- MOSFET switch for negative voltage
- MOSFET as a switch with Arduino
- MOSFET as a switch with a microcontroller
- MOSFET switch with hysteresis
- MOSFET as switch diode and active resistor
- MOSFET as a switch equation
- MOSFET switch for airsoft
- MOSFET as switch gate resistor
- MOSFET as a switching solenoid
- MOSFET switch using an optocoupler
- MOSFET switch with hysteresis

Application of MOSFET as a Switch

One of the foremost examples of this device is it is used as a switch is automatic brightness street lights. These days, many of the lights that we observe on highways consist of high-int discharge lamps. But using HID lamps consumes increased energy levels.

The brightness cannot be limited based on the requirement and because of this there has to for the alternative lighting method and it is LED. Using of LED system will overcome the disa high-intensity lamps. The main concept behind the construction of this was to control the lig highways by making use of a microprocessor.



MOSFET Application as Switch

This can be achieved just by modifying the clock pulses. Based on the necessity, this device switching lamps. It consists of a raspberry pi board where it is included with a processor for Here, LEDs can be substituted in the place of HIDs and these have a connection with the pi through MOSFET. The microcontroller delivers corresponding duty cycles and then switches to provide a high level of intensity.

Advantages

Few of the advantages are :

- It generates enhanced efficiency even when functioning at minimal voltage levels
- There is no presence of gate current this creates more input impedance which further pro increased switching speed for the device
- These devices can function at minimal power levels and uses minimal current

Disadvantages

Few of the disadvantages are :

- When these devices are functioned at overload voltage levels, it creates instability of the
- As because the devices have a thin oxide layer, this may create damage to the device wh by the electrostatic charges

Applications

The applications of MOSFET are

- Amplifiers made of MOSFET are extremely employed in extensive frequency applications
- The regulation for DC motors are provided by these devices
- As because these have enhanced switching speeds, it acts as perfect for the construction amplifiers
- Functions as a passive component for various electronic elements.

In the end, it can be concluded that the transistor requires current whereas MOSFET requir The driving requirement for the MOSFET is much better, much simpler as compared to a B.

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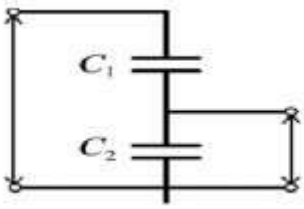

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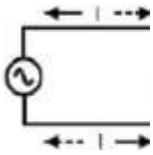

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19 Comments

B.R. Says:

at

Hi !
Very interesting and clear article even for someone who is not familiar with eletronics. I was wondering in which e
electronic devices we could find MOSFET… Maybe vacuum cleaner and/or hairdryer for example?

> **Tarun Agarwal** Says:
>
> at
>
> Hi B.R
> MoSFET is a voltage controlled device. It is mostly used in electronics circuits as switching and amplifier.

Ayushi Malhotra Says:

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What is the use of metal in MOSFET.

> **Tarun Agarwal** Says:
>
> at
>
> Hi Ayushi
> Copper and aluminum are the metals used to make MOSFET interconnects

---

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Can you please explain where mosfet uses for amplifying. I’m also an electronic student. Please reply

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very use for all

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