MOSFET as a Switch

MOSFETs exhibit three regions of operation viz.,
Cut-off,
Linear or Ohmic and
Saturation.

Among these, when MOSFETs are to be used as amplifiers, they are required to be operated in their ohmic region wherein the current through the device increases with an increase in the applied voltage.

On the other hand, when the MOSFETs are required to function as switches, they should be biased in such a way that they alter between cut-off and saturation states. This is because, in cut-off region, there is no current flow through the device while in saturation region there will be a constant amount of current flowing through the device, the MOSFET behavior of an open and closed switch, respectively.

Figure 1 shows a simple circuit which uses an n-channel enhancement **MOSFET as a switch**. Here the drain terminal (D) of the **MOSFET** is connected to the supply voltage V_S via the drain resistor R_D while its source terminal (S) is grounded. Further, it has an input voltage V_i applied at its gate terminal (G) while the output V_o is drawn from its drain.

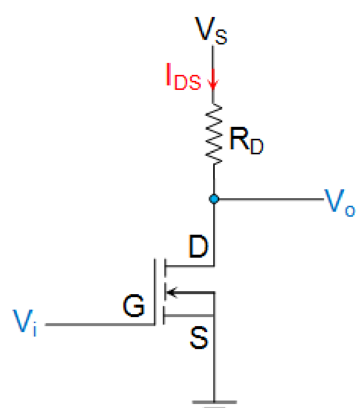
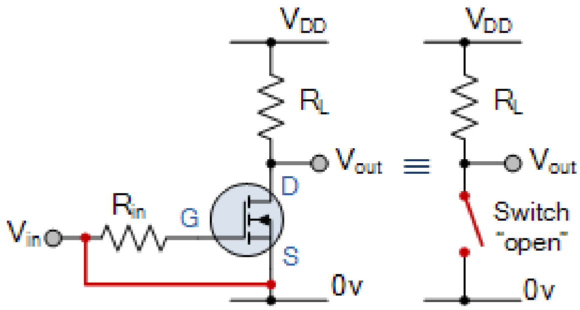


Figure 1 ***n*-Channel Enhancement-type MOSFET Functioning as a Switch**

MOSFET as an OFF Switch

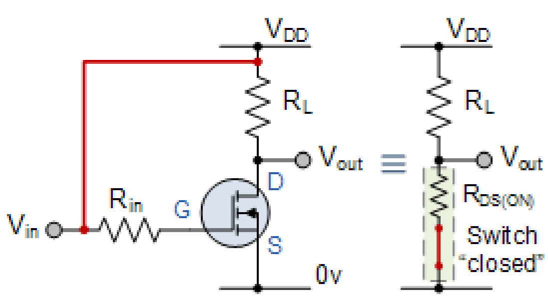
Now consider the case where V_i applied is 0V, which means the gate terminal of the MOSFETis left unbiased. As a result, the MOSFET will be OFF and operates in its cutoff region wherein it offers a high impedance path to the flow of current which makes the I_{DS} almost equivalent to zero. As a result, even the voltage drop across R_D will become zero due to which the output voltage V_o will become almost equal to V_S.



- The input and Gate are grounded (0V)
- Gate-source voltage less than threshold voltage $V_{GS} < V_{TH}$
- MOSFET is "OFF" (Cut-off region)
- No Drain current flows ($I_D = 0$ Amps)
- $V_{OUT} = V_{DS} = V_{DD} =$ "1"
- MOSFET operates as an "open switch"

MOSFET as an ON Switch

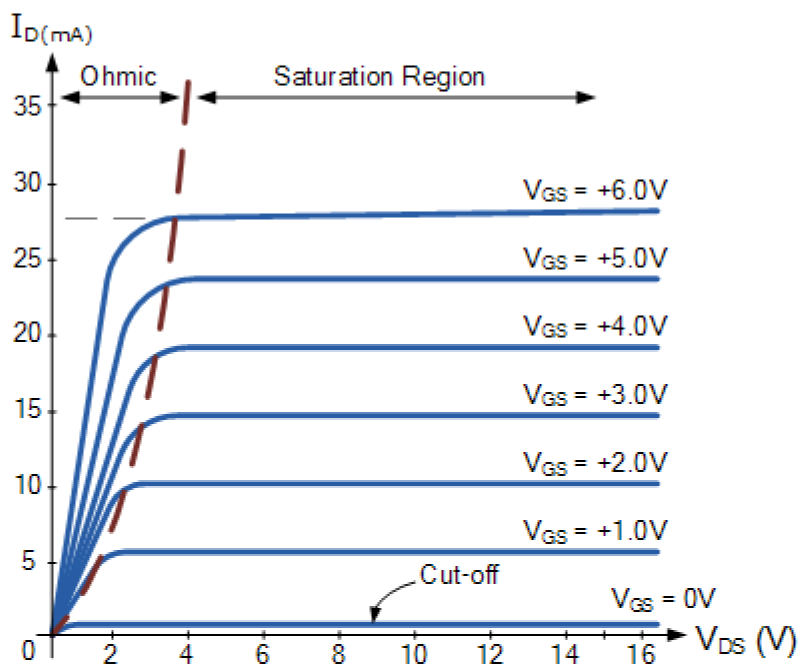
Next, consider the case where the input voltage V_i applied is greater than the threshold voltage V_T of the device. Under this condition, the MOSFET will start to conduct and if the V_S provided is greater than the pinch-off (ohmic region) voltage V_P of the device then the MOSFET starts to operate in its Non saturation region. This further means that the device will offer low resistance path for the flow of constant I_{DS}, almost acting like a short circuit. As a result, the output voltage will be pulled towards low voltage level, which will be ideally zero.



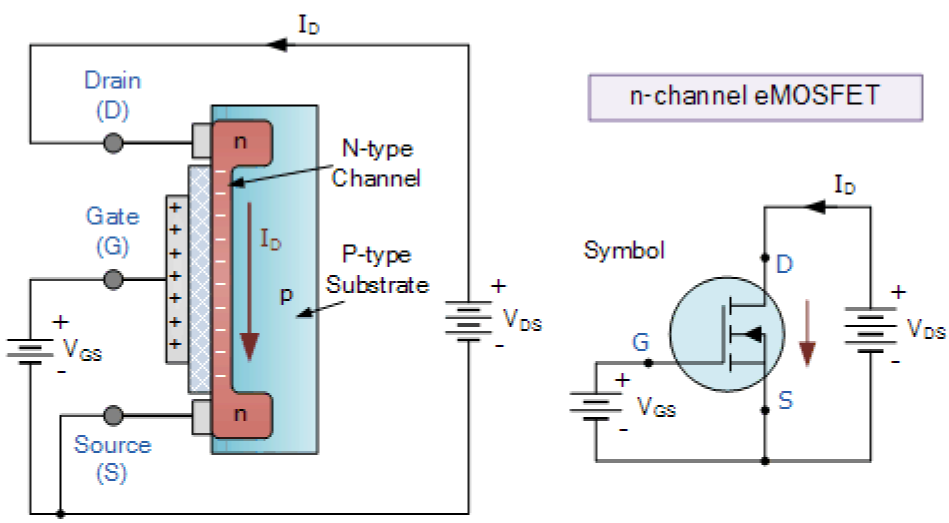
- The input and Gate are connected to V_{DD}
- Gate-source voltage is much greater than threshold voltage $V_{GS} > V_{TH}$
- MOSFET is "ON" (Non saturation region i.e. ohmic region)
- Max Drain current flows ($I_D = V_{DD} / R_L$)
- MOSFET operates as a low resistance "closed switch

MOSFET Amplifier

The main goal of a MOSFET amplifier, is to produce an output signal that is a faithful reproduction of its input signal but amplified in magnitude. This input signal could be a current or a voltage, but for a MOSFET device to operate as an amplifier it must be biased to operate within its saturation region



The saturation region of a MOSFET device is its constant-current region above its threshold voltage, V_{TH}. Once correctly biased in the saturation region the drain current, I_D varies as a result of the gate-to-source voltage, V_{GS} and not by the drain-to-source voltage, V_{DS} since the drain current is called saturated.



Enhancement MOSFET, or eMOSFET, can be classed as normally-off (non-conducting) devices, that is they only conduct when a suitable gate-to-source positive voltage is applied

An enhancement MOSFET does not conduct when the gate-source voltage, V_{GS} is less than the threshold voltage, V_{TH} but as the gates forward bias increases, the drain current, I_D will also increase, making the eMOSFET ideal for use in MOSFET amplifier circuits.