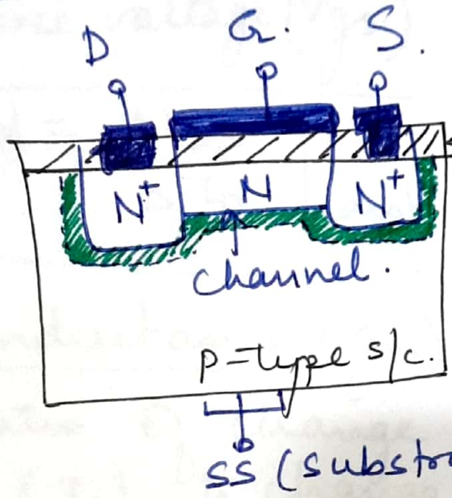
MOSFET

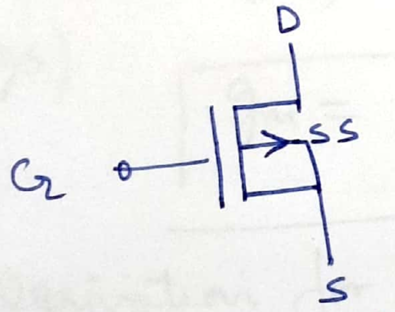
(Metal-Oxide-S/c-Field-Effect Transistor).

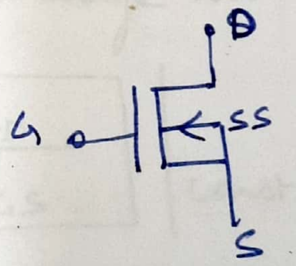
1) N-Channel MOSFET (Depletion type).

Construction.

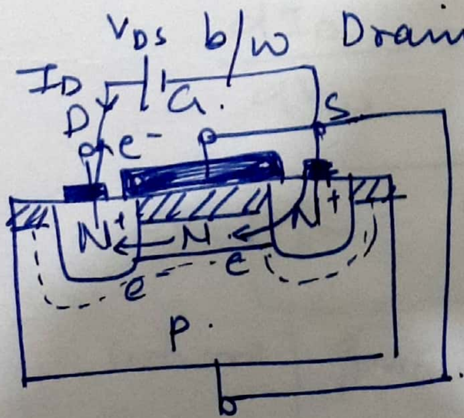


SiO_2 layer.
(acts a insulating material to increase the i/p resistance).



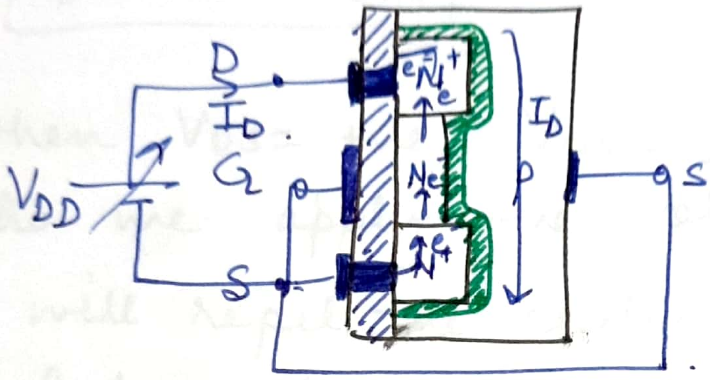


Working 1) When we apply only V_{DS} = +ve. voltage V_{DS} b/w Drain and Source.



Current I_D will start flowing from Drain to Source. and I_D increases with the voltage V_{DS}.

Working of N-channel Depletion-type MOSFET.

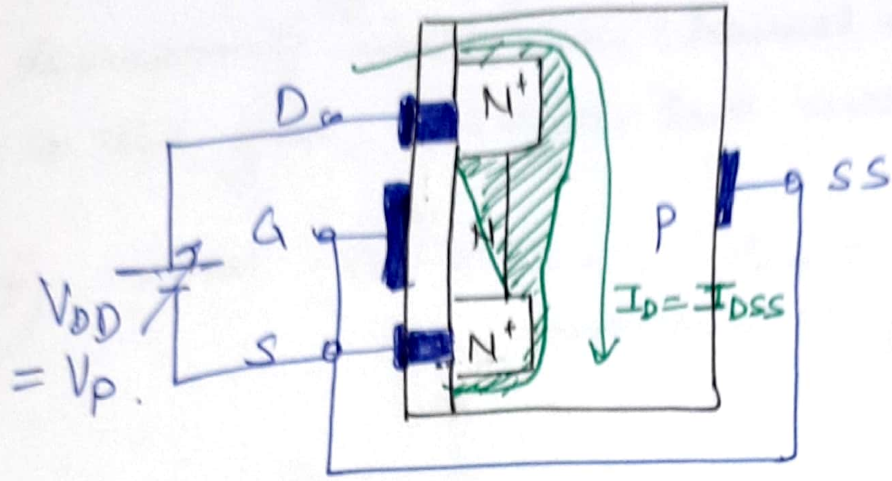


1) when $V_{DS} = +ve$, $V_{GS} = 0V$.

* As we apply +ve voltage (V_{DS}) to the Drain to Source (electrons will start moving from source to drain) and hence the current flows through the Drain to Source.

* As we keep on increasing V_{DS} the current I_D also increases and in addition to that the depletion layer in the channel also increases. and a point will come at which channel gets pinched off

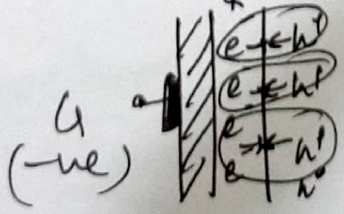
at the drain side



This condition is known as pinch off condition and the current becomes constant as $\boxed{I_D = I_S = I_{DSS}}$.

2) when V_{DS} = +ve, V_{GS} = -ve.

* As we apply -ve voltage to the gate it will repel the electrons of the ~~holes~~ channel towards substrate and attract the holes of p-type substrate. Due to this holes and electrons will recombine and forms the depletion layer.

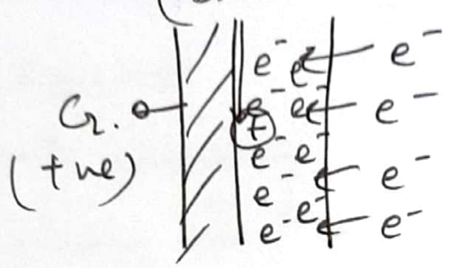


Hence we will say that the V_{GS} (-ve) will help in increase of depletion layer and hence the current decreases.

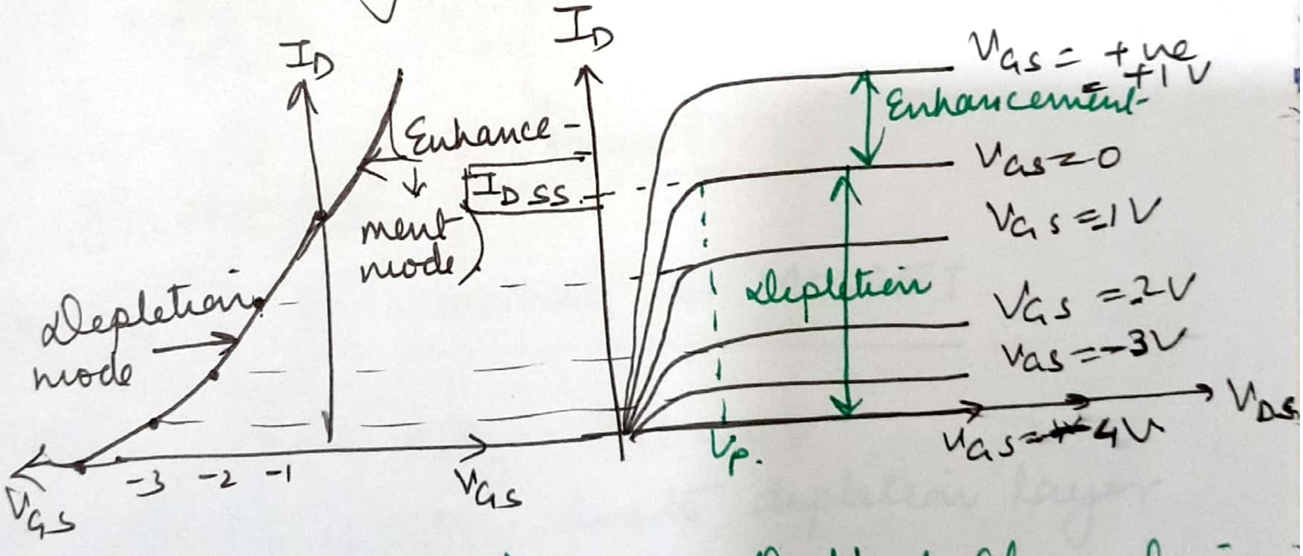
* ~~on the~~ In another way, we can say that as the no. of charge carriers (electrons) are decreasing inside the channel due to -ve voltage on the gate, therefore the current I_D decreases.

3) when V_{DS} = +ve, V_{GS} = +ve.

(bonds break hence no. of electrons increases)



Thus we can say that as the +ve voltage on the gate increases, the current I_D also increases as the no of charge carriers are increasing inside the channel.



Transfer Characteristics

Output Characteristics

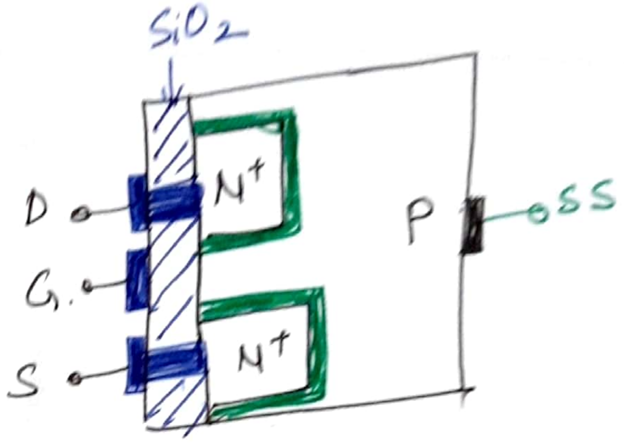
$$\boxed{I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2}$$

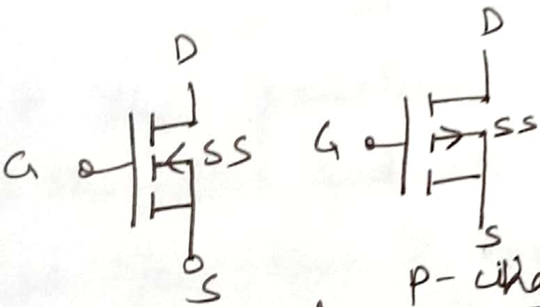
Enhancement Type MOSFET.
(E-MOSFET).

(N-channel)

1) Construction.

*(No channel present during construction in E-MOSFET)





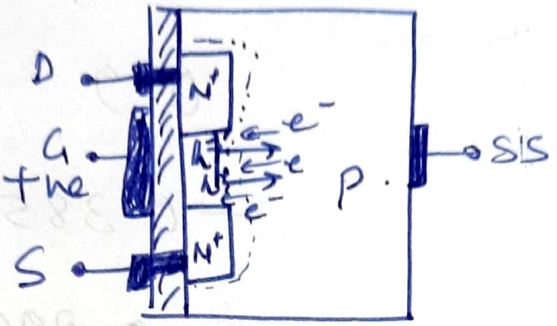
N-channel. p-channel

Working of N-channel E-MOSFET.

1) when $V_{DS} = +ve$, $V_{GS} = 0V$.
→ No current flows, due to depletion layer ~~between~~ at the P-N junction.

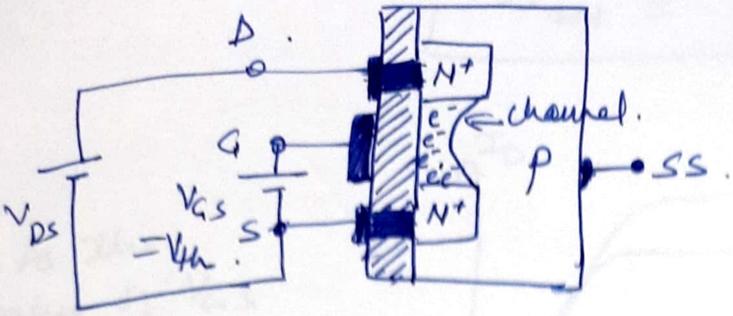
2) when $V_{DS} = +ve$, $V_{GS} = -ve$.
→ No curren flows, As it support the formation of depletion layer.

3) when $V_{GS} = +ve$

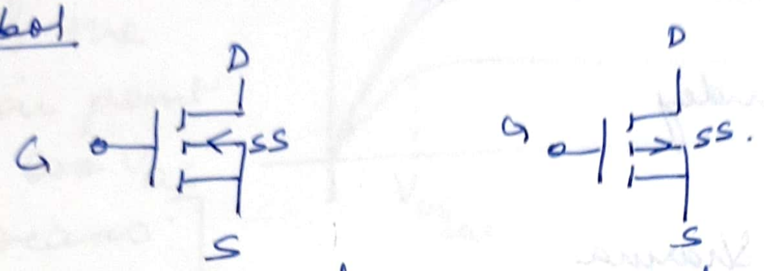


* The positive voltage on gate will repel the holes and attract the electrons of the p type S/c. due to ~~the~~ the SiO_2 layer the electrons do not reaches the gate and gets accumulated near the surface of SiO_2 layer. As we keep on increasing +ve voltage on Gate, a stage will come at which a thin layer formed at the surface which will have larger no of electrons as compared to holes and hence we will say that the p-type S/c has been changed into N-type. This layer is called inversion layer and acts as a channel b/w the drain and Source.

* The Value of V_{GS} at which inversion layer creates as a channel b/w Drain and Source is called Threshold voltage (V_{th}).



Symbol

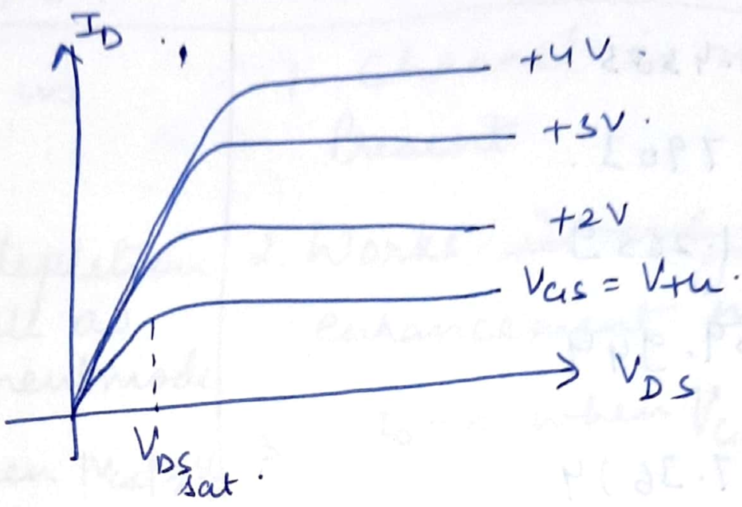


Now we apply the voltage V_{DS} b'etween the Drain and source with V_{GS} voltage greater than V_{th}. Since the channel has been formed b/w drain and source, then the current I_D starts flowing from drain to source. As we increases V_{DS} the current I_D also increases and at the same time the effective voltage in the channel ($V_{GD} = V_{GS} - V_{DS}$) Decreases due to which the channel also starts to diminish (More at the drain and less at the source). Thus as the V_{DS} reaches ($V_{GS} - V_T$) the channel at drain gets pinched off. and the current I_D becomes Constant.

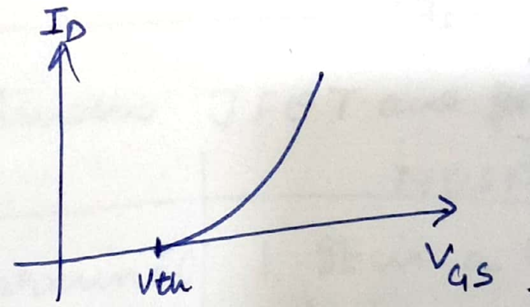
Thus we have.

$$\boxed{V_{DS_{sat}} = V_{GS} - V_{th}}$$

[* As the value of V_{GS} increases the saturation point for the ~~Ore~~ V_{DS} also increases]



Output Characteristics of N-channel E-MOSFET



Transfer characteristics

Current Equation for E-MOSFET

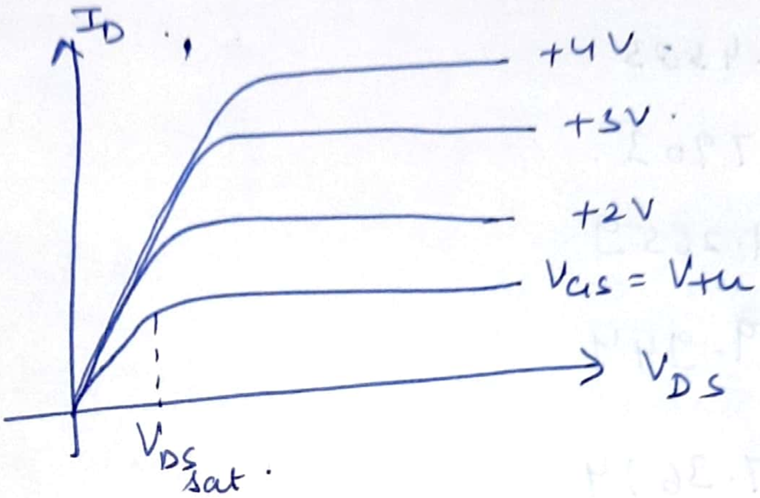
$$\boxed{I_D = k\,(V_{GS} - V_{th})^2}$$

where k is a constant.

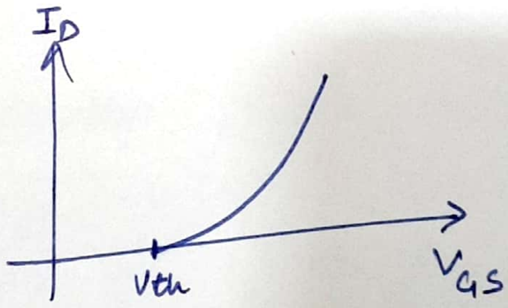
Thus we have.

$$\boxed{V_{DS_{sat}} = V_{GS} - V_{th}}$$

[* As the value of V_{GS} increases the saturation point for the ~~Ora~~ V_{DS} also increases.]



Output Characteristics of N-channel E-MOSFET.



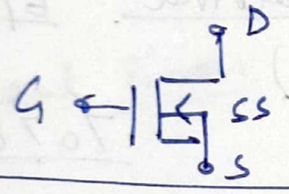
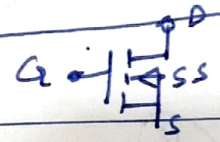
Transfer characteristics.

Current Equation for E-MOSFET.

$$\boxed{I_D = k\,(V_{GS} - V_{th})^2}$$

where k is a constant.

Comparison b/w D-MOSFET and E-MOSFET

D-MOSFET	E-MOSFET
1. channel is Present	1. Channel is not Present
2. Works in depletion mode as well as in Enhancement mode	2. Works in only the enhancement mode.
3. $I_D = 0$ when $\lvert V_{GS} \rvert \geq V_P$	3. $I_D = 0$ when $V_{GS} \leq V_{TH}$
4. $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$	4. ~~$I_D = I_{DSS}/(1-$~~ $\boxed{4.\ I_D = k(V_{gs} - V_{TH})^2}$
	

Comparison between JFET and MOSFET.

JFET	MOSFET
1. It is a 3-terminal device	1. It is a 4-terminal device.
2. do not have insulation layer (SiO_2)	2. Have insulating layer between the Gate and the channel.
3. I/p resistance are very much smaller than MOSFET	3. Input resistance is very high.
4. O/p resistance is lower than MOSFET	4. O/p resistance is higher than JFET.