MOSFET NOTES

MOSFET is an active device which can control flow of current through it.

Full form METAL Oxide Semiconductor ~~FET~~ Field Effect transistor.

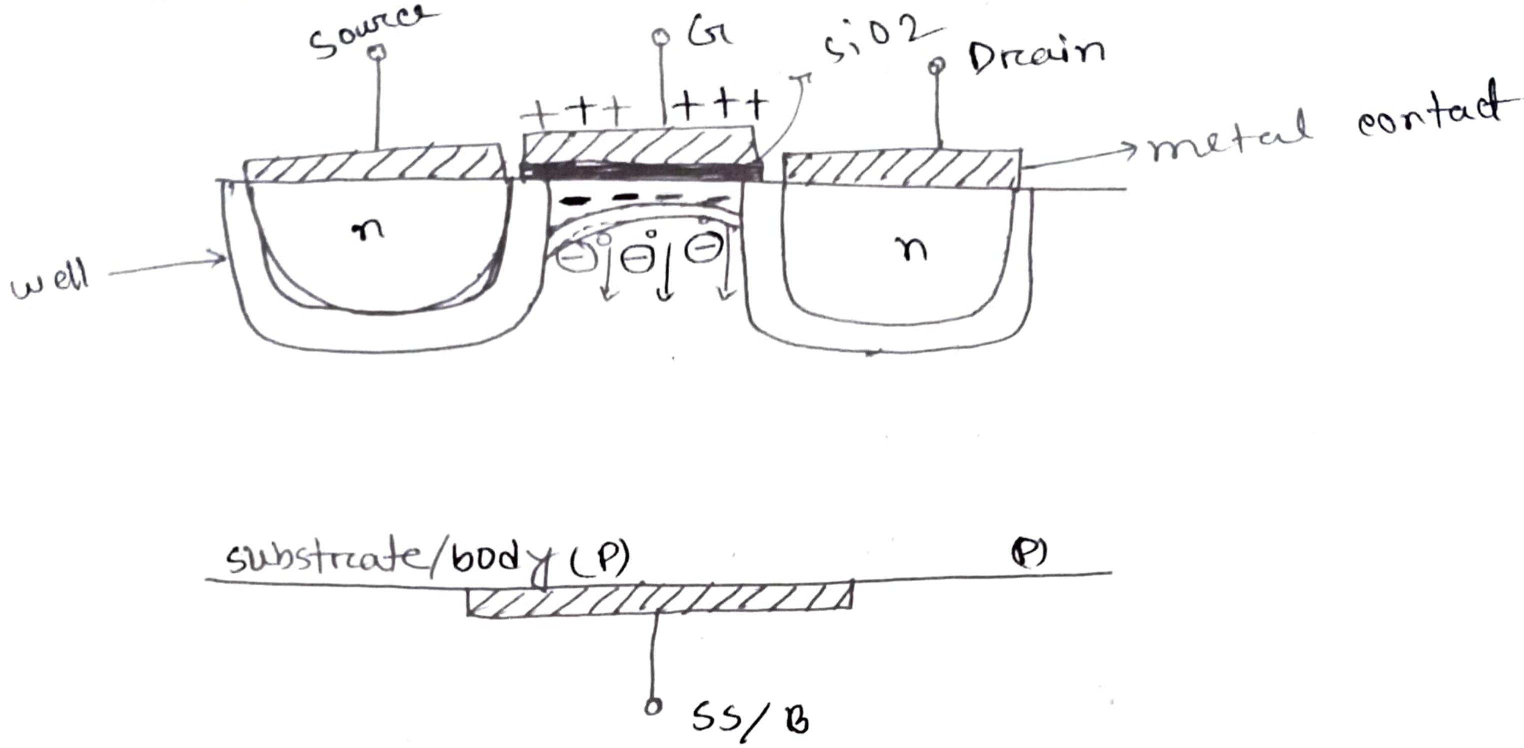
It is of two types → Depletion type MOSFET → n chann, p channel

→ Enhancement type MOSFET → n channel, P channel

Diff between D &

MOSFET NOTES

* Constructions ~~of~~ & working of Enhancement type MOSFET E-MOS.



~~For~~ p-

In case of p ~~type~~ channel E-MOS, substrate is of n type and source and drain are p type

The gate terminal is not directly connected with the body, it is over a very thin layer of SiO_2

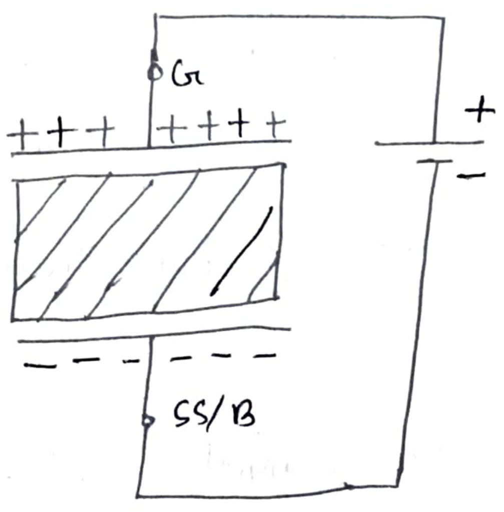
There is no channel initially between Drain & source.

Now lets see how the channel is formed

We know, substrate is of p-type material, where majority charge carrier is holes and minority charge carrier ~~are~~ is electron. Charge neutrality is maintained, i.e mobile charge carrier = immobile ions.

Now we will make the gate terminal more positive with respect ~~of~~ to SS.

Suppose, the gate and ~~so~~ substrate terminals are the two parallel plate of a capacitor and the SiO_2 acts as die-electric material like the following –

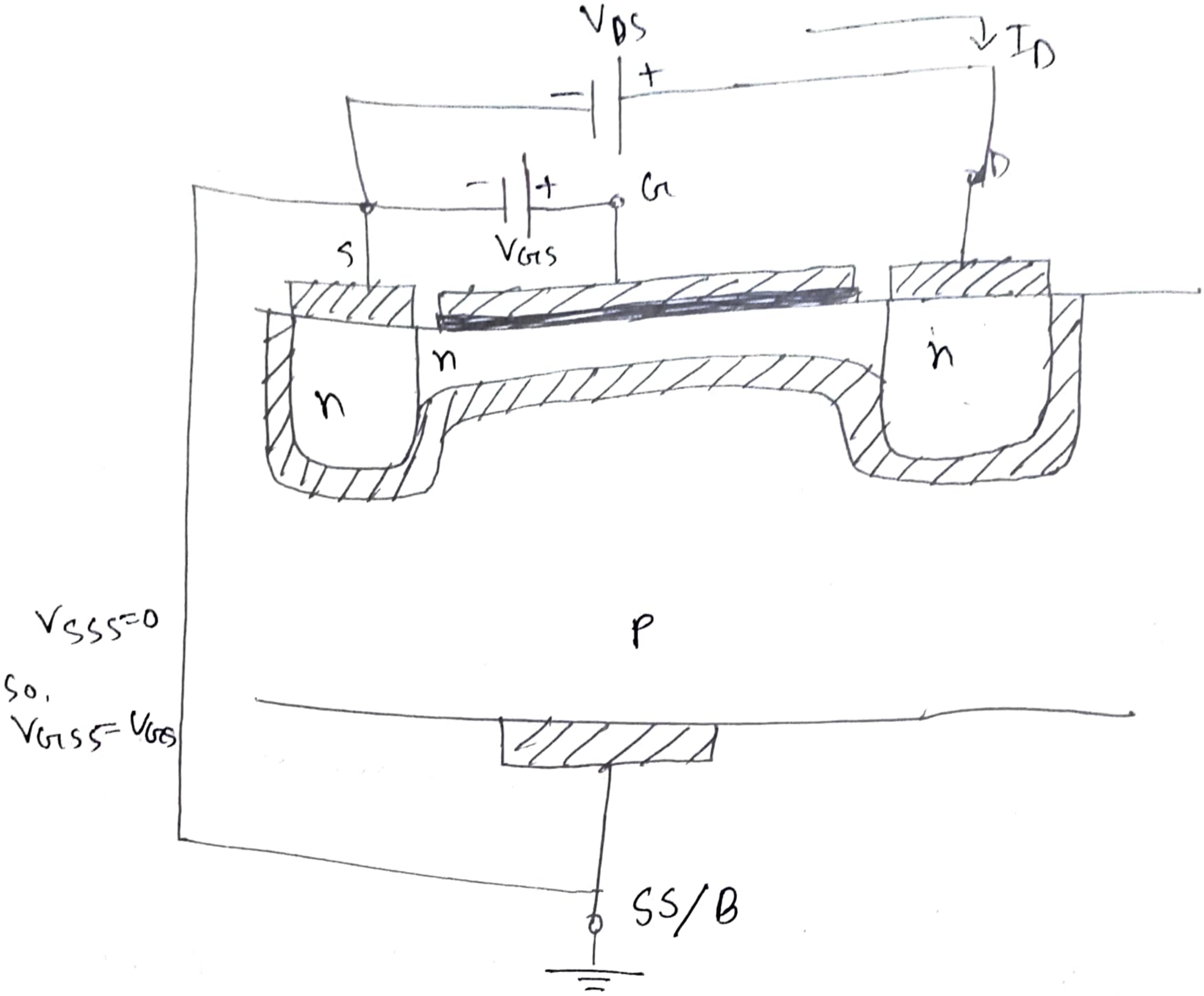


~~What~~ After applying voltage, positive charge will accumulate over Gate terminal, negative charges will accumulate to the substrate when we increase V_{GS} then the minority charge carrier of substreate gets accumulated near the contact. When we further increase V_{GS}, uncovering of negative ions will take place and the surface near the contact will become more negative. this is called inversion of p-type material to ntype material near contact of the body

Now channel will be formed between source and drain

* So, when $V_{GS} > 0$, inversion happened, p-type material changed into n-type and conductive channel have been formed between Drain & Source.

$V_{GS} \uparrow\uparrow \rightarrow$ channel depth will be increased.



~~of~~ most of the time S and SS/B terminal are shorted,

Now, if V_{GS} is greater ~~greater~~ than threshold voltage V_T, ~~&~~ then current I_D will flow through channel ~~to~~ from source to drain,

Effect of V_{DS} on depletion layer:

To find it we have find, V_{GD}

V

$$V_G - V_{GS} + V_{DS} = V_D$$
$$V_G - V_D = V_{GS} - V_{DS}$$

$\therefore V_{GD} = V_{GS} - V_{DS}$

Case 1: $V_{DS} = 0V$

$V_{GD} = V_{GS}$

that means if no bias is applied ~~to~~ between Drain & Source, then the

$V_{GD} = V_{GS}$ so, the depletion region will be same.

~~Yes~~ Let, $V_T = 1V$

$V_{GS} = 2V = V_{GD}$

So, channel width will be corresponding to

$V_{GS} - V_T = 2 - 1 = 1V$

$CH_1 \rightarrow 1V$

if $V_{GS} = 3V = V_{GD}$,

$\therefore CH_2 \rightarrow 2V$

So, $CH_2 > CH_1$

Case 2 : $V_{DS} > 0V$

~~V_{GD}~~ $\cdot$ $V_{GD} = V_{GS} - V_{DS}$

$V_{DS} \uparrow$

So, V_{GD} will be lower

$V_{GD} \neq V_{GS}$

this implies that Drain is becoming more positive, So, the depletion region will no longer be uniform.

the depletion region will be increased near drain terminal.

Case 2 : we will make,

$V_{DS} = V_{GS} - V_T$

$\therefore V_{GD} = V_{GS} - V_{DS}$

$= V_{GS} - V_{GS} + V_T$

$= V_T$

The channel will become extremely narrow near drain

This condition is known as pinch off.

V_{DS} is $V_{DS saturation}$

if we increase V_{DS} more, current I_D will remain constant.

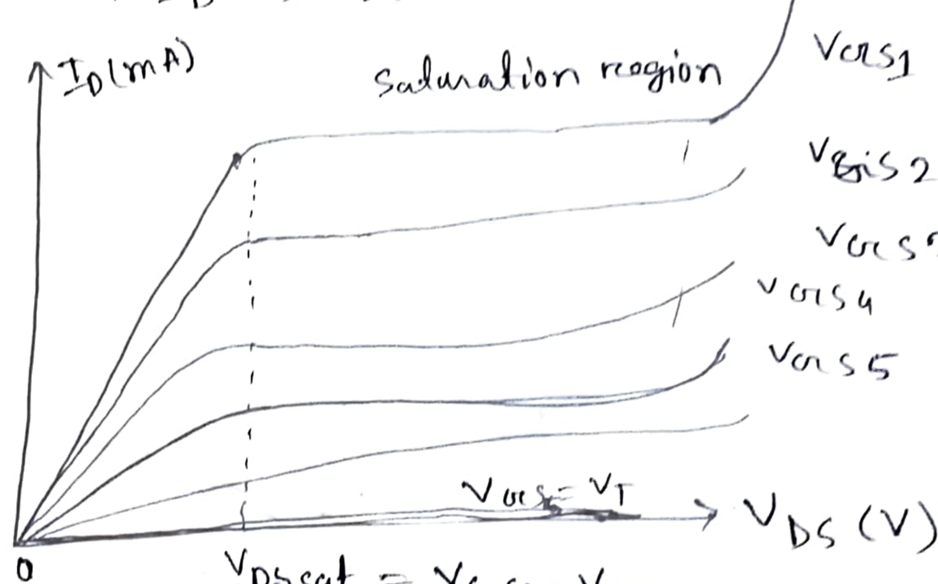
Output Curve & Transfer Curve

~~Out~~ Output current $= I_D$

Output voltage $= V_{DS}$

input voltage controlled variable V_{GS}

Output curve $\longrightarrow$ I_D vs V_{DS} for different V_{GS}



$V_{DS sat} = V_{GS1} - V_T$

V_T = threshold voltage and constant K is given

Case 1: $V_{GS} > V_T$, so, there will be channel between D & S

$V_{eff} = V_{GS1} - V_T$

V_{eff} affect the width of channel

$V_{DS} = 0V$, so, now current flows ~~through~~

from D to S

when $V_{DS} = V_{DS\,sat}$

I_D = constant (pinch off)

Case 2: $\uparrow V_{GS} \Rightarrow$ channel width $\uparrow\uparrow$

So, conductivity increases

So, Resistance decreases

$V_{GS2} < V_{GS1}$

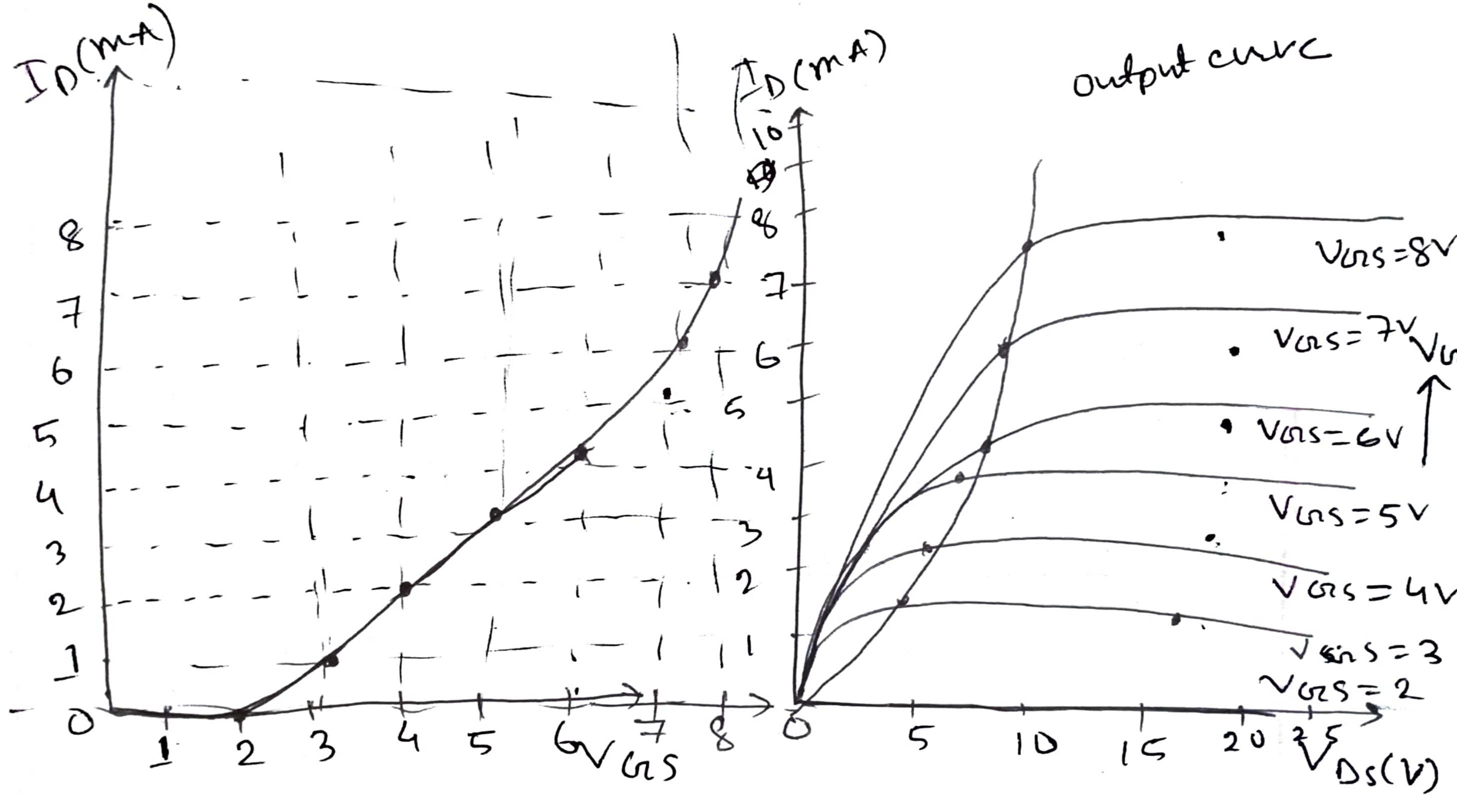
$P_2 < P_1$

$R_2 > R_1$

Slope 2 < slope 1

$$\boxed{I_D = K(V_{GS} - V_T)^2}$$

Transfer Characteristics of E-MOSFET



$V_T = 2V$ $K = 0.27 \times 10^{-13}\ A/V^2$

Math

1. ~~Ider~~ Firstly ~~ব~~ Emos or Dmos এটা নিশ্চিত করতে হবে।

For Emos, $I_D = K(V_{GS} - V_T)^2$

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

Example 7.9:

~~V_{GS} =~~

$V_{GS} = -I_D R_S$

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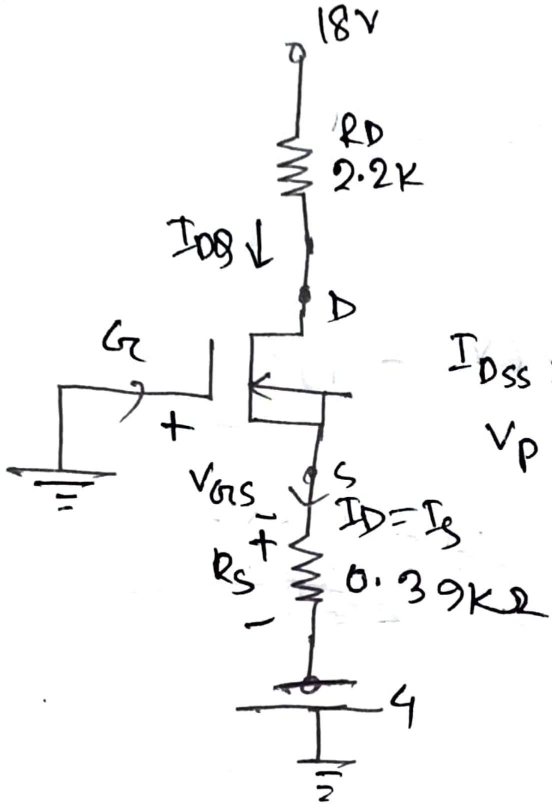
<u>Math</u>

*



$I_{DSS} = 8 mA$

$V_P = -8V$

We know,

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

Here,

$I_G \cong 0 A$

$V_G = 0V$

$I_D = I_S$

So,

$-V_{GS} - I_D R_S + 4 = 0$

$V_{GS} = 4 - I_D R_S \longrightarrow (ii)$

Putting the value of V_{GS}, from (ii) we get

$$I_D = I_{DSS}\left(1 - \frac{4 - I_D R_S}{V_P}\right)^2$$

$$\Rightarrow I_D = 8\left(1 - \frac{4 - I_D \times 0.39}{-8}\right)^2$$

$$\Rightarrow I_D = 8\left(1 + \frac{4}{8} - \frac{I_D \times 0.39}{8}\right)^2$$

$$\Rightarrow I_D = 8\left(1 + \frac{1}{2} - 0.04875 I_D\right)^2$$

$$\Rightarrow I_D = 8\left(1.5 - 0.04875 I_D\right)^2$$

$$\Rightarrow I_D = 8\left\{(1.5)^2 - 2 \times 1.5 \times 0.04875 I_D + 2.3765 \times 10^{-3} I_D^2\right\}$$

$$\Rightarrow I_D = 8\left[2.25 - 0.14625 I_D + 2.3765 \times 10^{-3} I_D^2\right]$$

$$\Rightarrow I_D = 18 - 1.17 I_D - 0.019012 I_D^2$$

$$\Rightarrow 0.01912 I_D^2 + 2.17 I_D - 18 = 0$$

Solving, $I_D = 7.7638 mA$

✓

So,

$V_{GS} = 4 - I_D \times R_S = \cancel{0} \; 0.972\,V$

Again, Apply KVL at output loop –

$18 - I_D R_D - V_{DS} - I_D R_S + 4 = 0$

$V_{DS} = 18 - I_D R_D - I_D R_S - 4$

$\therefore V_{DS} = -6.108$

$V_D - V_S = V_{DS}$

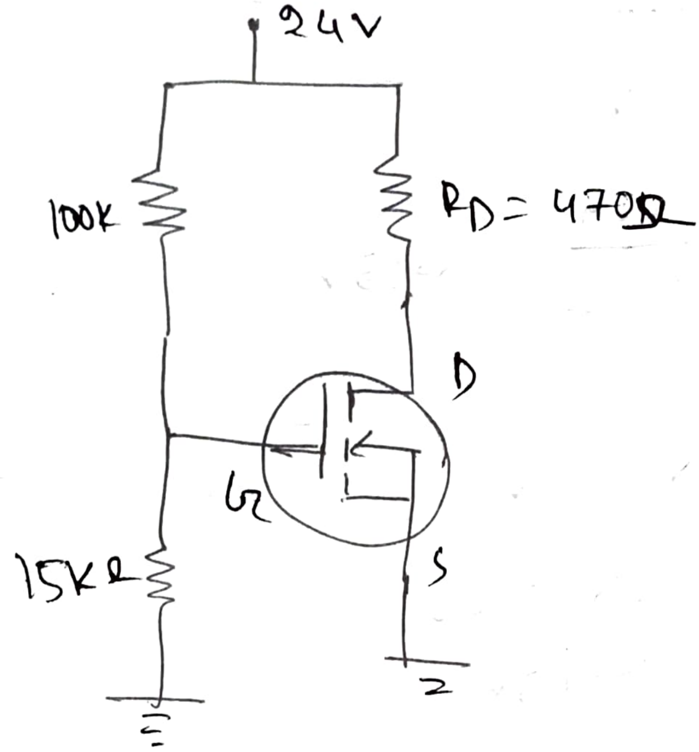
$V_S = V_D - V_{DS}$

$= 18 - I_D \times R_D - V_{DS}$

$= \cancel{18} = 0$

$= 7.02764\,V$

*



* V_{DS}
* V_{GS}

Here,

$I_D(ON) = 500mA$

$V_{GS}(on) = 10V$

$V_T = 1V$

$V_{DS} = ?$ $V_{GS} = ?$

W.K.now

$I_D(ON) = K(V_{GS(ON)} - V_T)^2$

$$K = \frac{I_D(ON)}{(V_{GS(ON)} - V_T)^2}$$

$$= \frac{500\,mA}{(10-1)^2} = 6.173\,mA/V^2$$

* here, $V_S = 0V$

$$V_G = \frac{15 \times 24}{15+100} = 3.13v$$

$V_{GS} = V_G - V_S$

$= \cancel{3}3.13 - 0$

$= 3.13v$

Again,

$I_D = K(V_{GS} - V_t)^2$

$= 6.173 \times 10^{-3} (3.13-1)^2 = 28 mA$

Applying KVL at output loop,

$24 - I_D R_D - V_{DS} = 0$

$\Rightarrow V_{DS} = 24 - I_D R_D$

$= 10.84V$ Ans