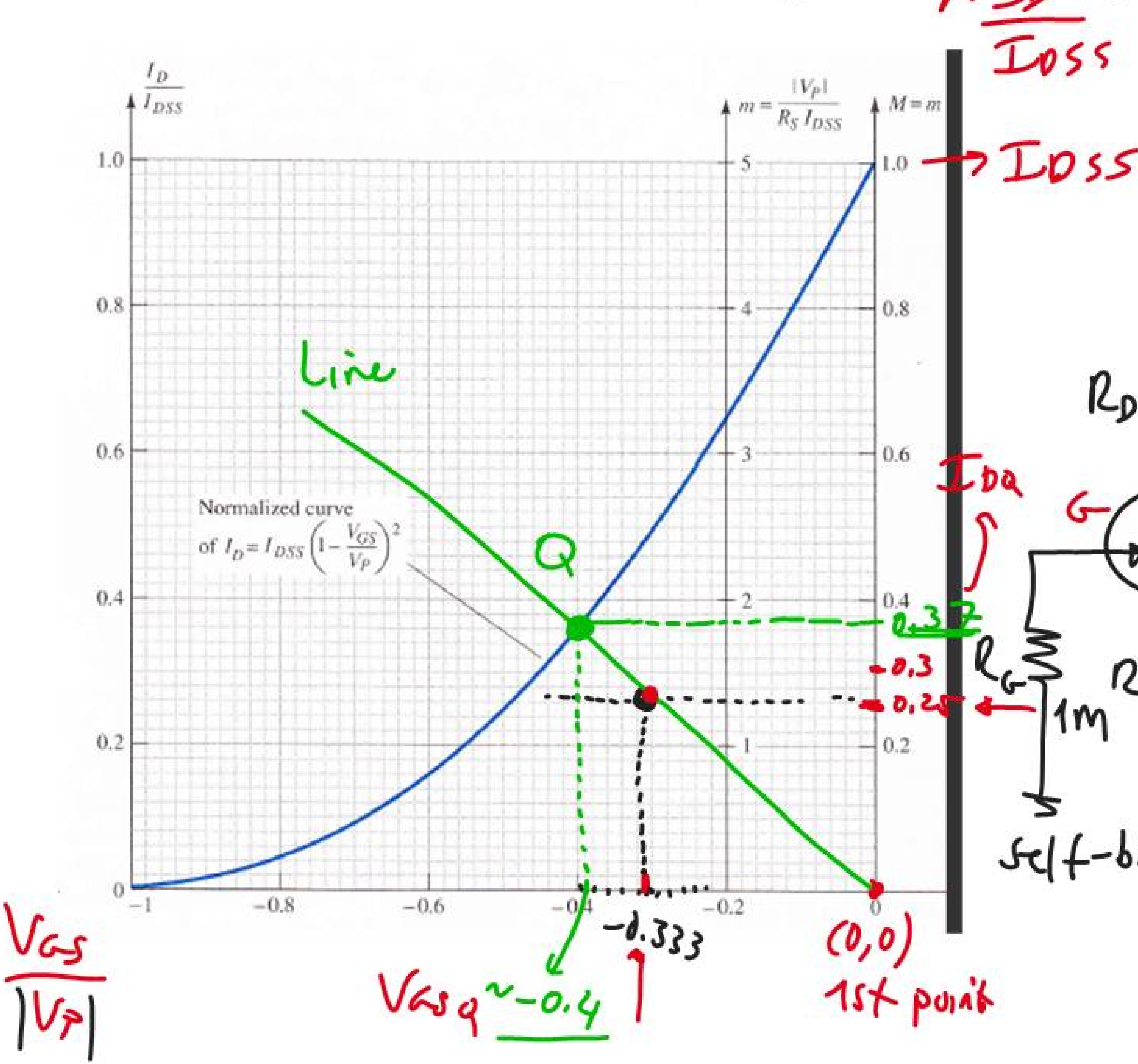
26.04.2011

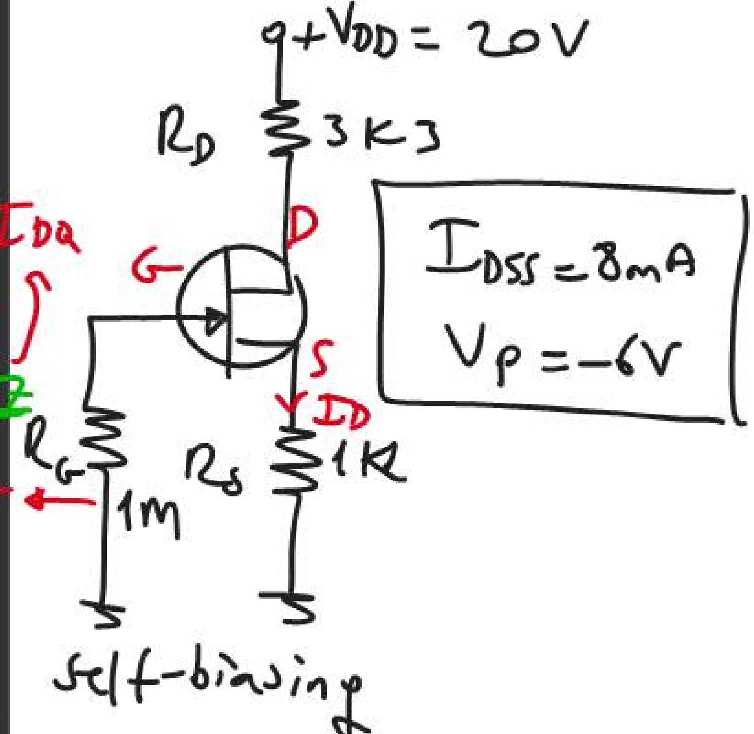
<Z>

Assistant

Osman Öz

ex Determine Q point (V_{GSQ}, I_{DQ}, V_{DSQ})





① Graphical Solution

$V_{GS} = V_G - V_S$

$V_G = 0V$

$V_{GS} = -V_S$

$V_{GS} = -I_D \cdot R_S$

$$\boxed{V_{GS} = -10^3 \cdot I_D}$$

a line equation between I_D and V_{GS}.

1st point is → $(0, 0)$ (V_{GS}, I_D)

$V_{GS} = 0 \quad I_D = 0 \rightarrow$ ORIGIN

$V_{GS} = -2V \rightarrow I_D = -\frac{-2}{10^3} = +2mA$

To find on the characteristics:

$$\frac{V_{GS}}{V_P} = \frac{-2V}{(+6)} = -\frac{1}{3} = -0.333$$

$$\frac{I_D}{I_{DSS}} = \frac{2 \times 10^{-3}}{8 \times 10^{-3}} = \frac{1}{4} = 0.25$$

2nd point is = $(-0.333, 0.25)$

After finding Q in the graphics (characteristics) ←

$\frac{I_{DQ}}{I_{DSS}} \cong 0.37 \rightarrow I_{DQ} = 0.37 \times 8mA$

$\frac{V_{GSQ}}{|V_P|} \cong -0.4 \rightarrow V_{GSQ} = -0.4 \times 6V$

$$\boxed{\begin{array}{l} I_{DQ} \cong 2.96mA \\ V_{GSQ} = -2.4V \end{array}}$$

$V_{DD} - I_D R_D - I_D \cdot R_S - V_{DS} = 0$ Output KVL

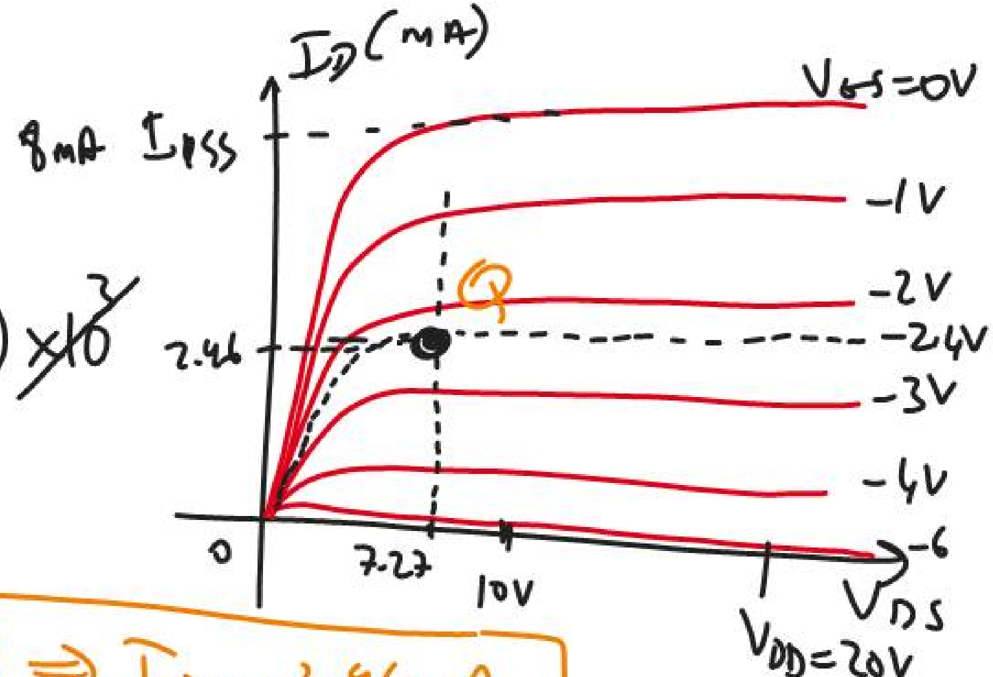
$V_{DD} - I_D(R_D + R_S) - V_{DS} = 0$

$V_{DS} = V_{DD} - I_D(R_D + R_S)$

$V_{DS} = 20V - 2.96 \times 10^{-3} (3.3 + 1) \times 10^{3}$

$V_{DS_Q} \cong 20 - 2.96 \times 4.3$

$\boxed{V_{DSQ} \cong 7.27V}$



Q ⇒ $I_{DQ} = 2.96$ mA
$V_{GSQ} = -2.4V$
$V_{DSQ} = +7.27V$

2) Analytical method:

$V_{GS} = -I_D \cdot R_S$

$$V_{GS} = -10^3 I_D$$ 1st Eqn.

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$ Shockley's Eqn.

$$I_D = 8\times10^{-3}\left(1 - \frac{V_{GS}}{-6}\right)^2$$

$$I_D = 8\times10^{-3}\left(1 + \frac{V_{GS}}{6}\right)^2$$ 2nd equation

Two unknowns $\Rightarrow I_D, V_{GS}$

$$I_D = +8\times10^{-3}\left(1 - \frac{10^3 I_D}{6}\right)^2$$

$$= 8\times10^{-3}\left(\frac{6 - 10^3 I_D}{6}\right)^2$$

$$I_D = \frac{8\times10^{-3}}{36}\left(6 - I_D\cdot10^3\right)^2$$

$$36 I_D = 8\times10^{-3}\left(36 - 12\times10^3 I_D + 10^6 I_D^2\right)$$

$$8\times10^{-3}\times10^6 I_D^2 - 12\times10^3\times8\times10^{-3} I_D - 36 I_D + 8\times10^{-3}\times36 = 0$$

$$8\times10^3 I_D^2 - 132 I_D + 8\times36\times10^{-3} = 0$$

$$ax^2 + bx + c = 0$$

$$I_{D1,2} = \frac{+132 \pm \sqrt{132^2 - 4\times64\times36}}{2\times8\times10^3}$$

$$I_{D1,2} = +8.25\times10^{-3} \pm 5.7\times10^{-3}$$

I_D can not be greater than $I_{DSS} \Rightarrow 8\ mA$

$I_D = (8.25 - 5.7) \times 10^{-3} = \underline{2.55\ mA}$

$\boxed{I_{DQ} = 2.55\ mA}$ $\rightarrow$ $V_{GS} = -I_D \times 10^3$

$V_{GS} = -2.55 \times 10^{-3} \times 10^3$

$\boxed{V_{GS} = -2.55V}$

$V_{DS} = V_{DD} - I_D(R_D + R_S)$

$V_{DS} = 20 - 2.55 \times 10^{-3} \times 4.3 \times 10^3$

$\boxed{V_{DS} = 9.035V}$

<u>Analytical Solution</u>

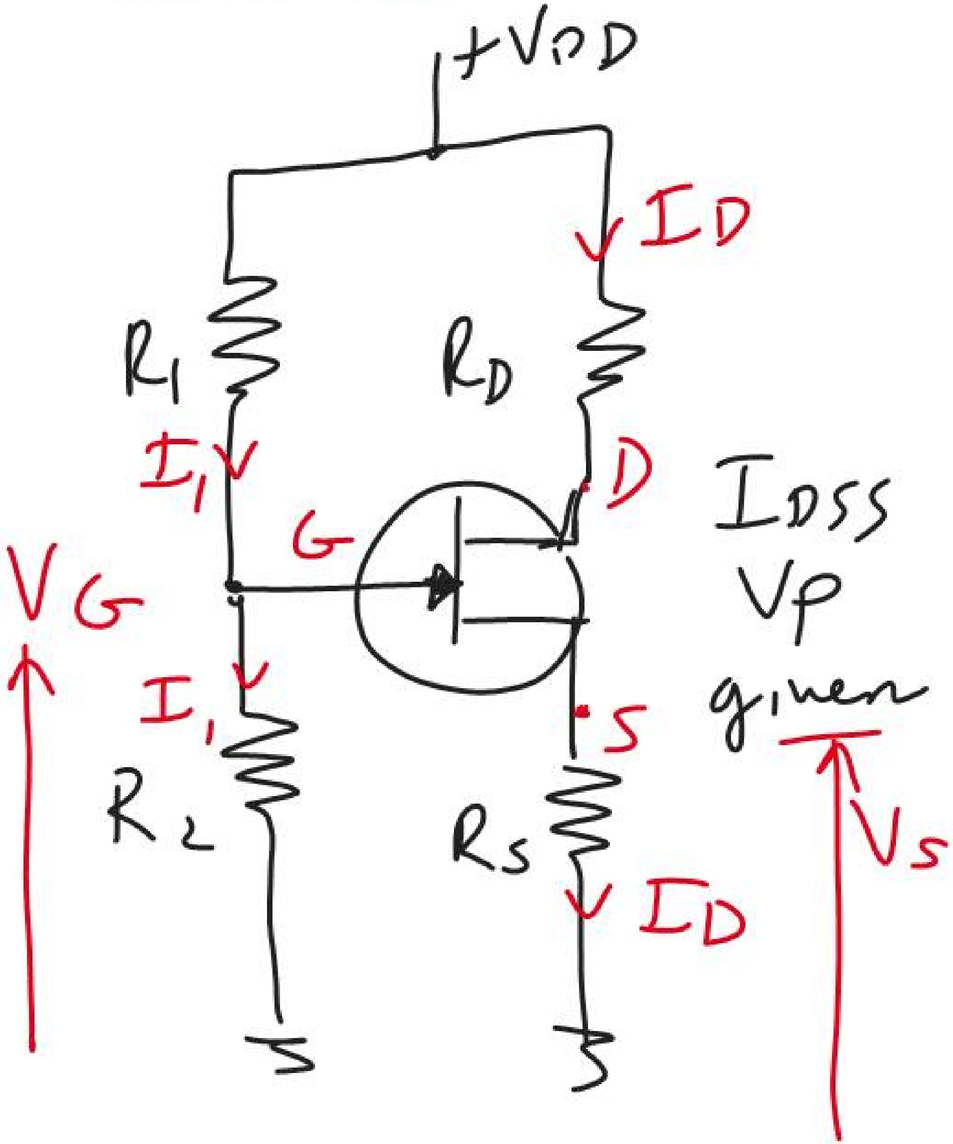
$Q \Rightarrow$

$I_{DQ} = 2.55\ mA$

$V_{GS_Q} = -2.55V$

$V_{DS_Q} = 9.035V$

a VOLTAGE DIVIDER BIASING

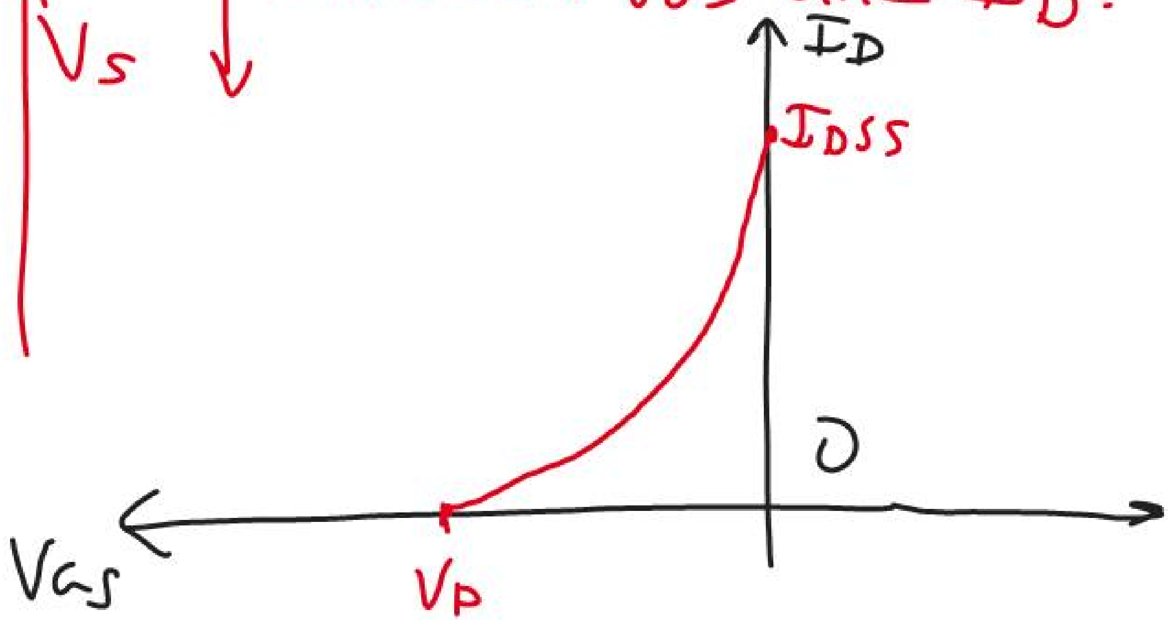


$$V_G = \frac{V_{DD}}{R_1 + R_2} \cdot R_2$$

$$V_{GS} = V_G - V_S$$

$$\boxed{V_{GS} = V_G - I_D \cdot R_S}$$

a line equation between V_{GS} and I_D.

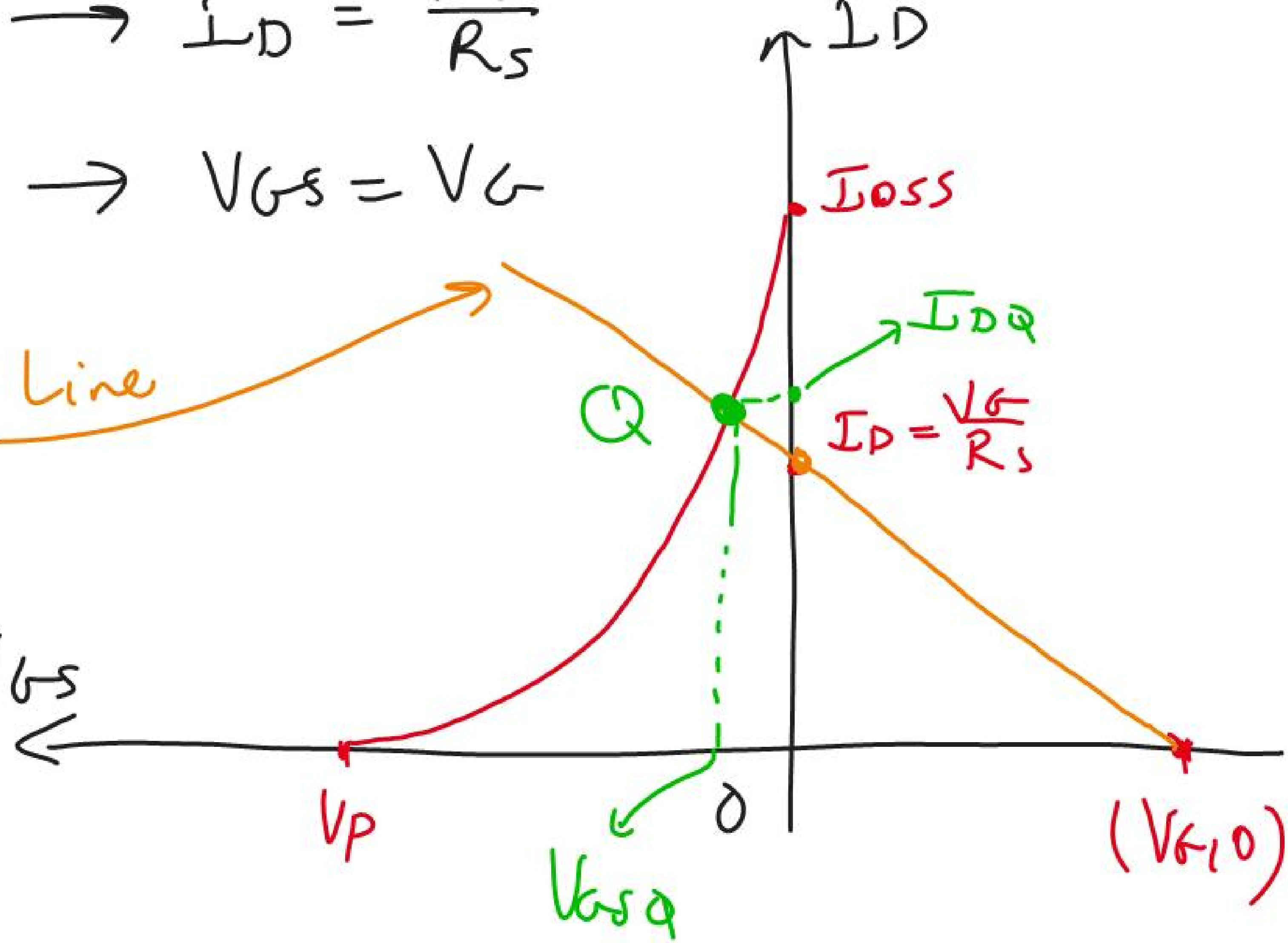


Draw the line

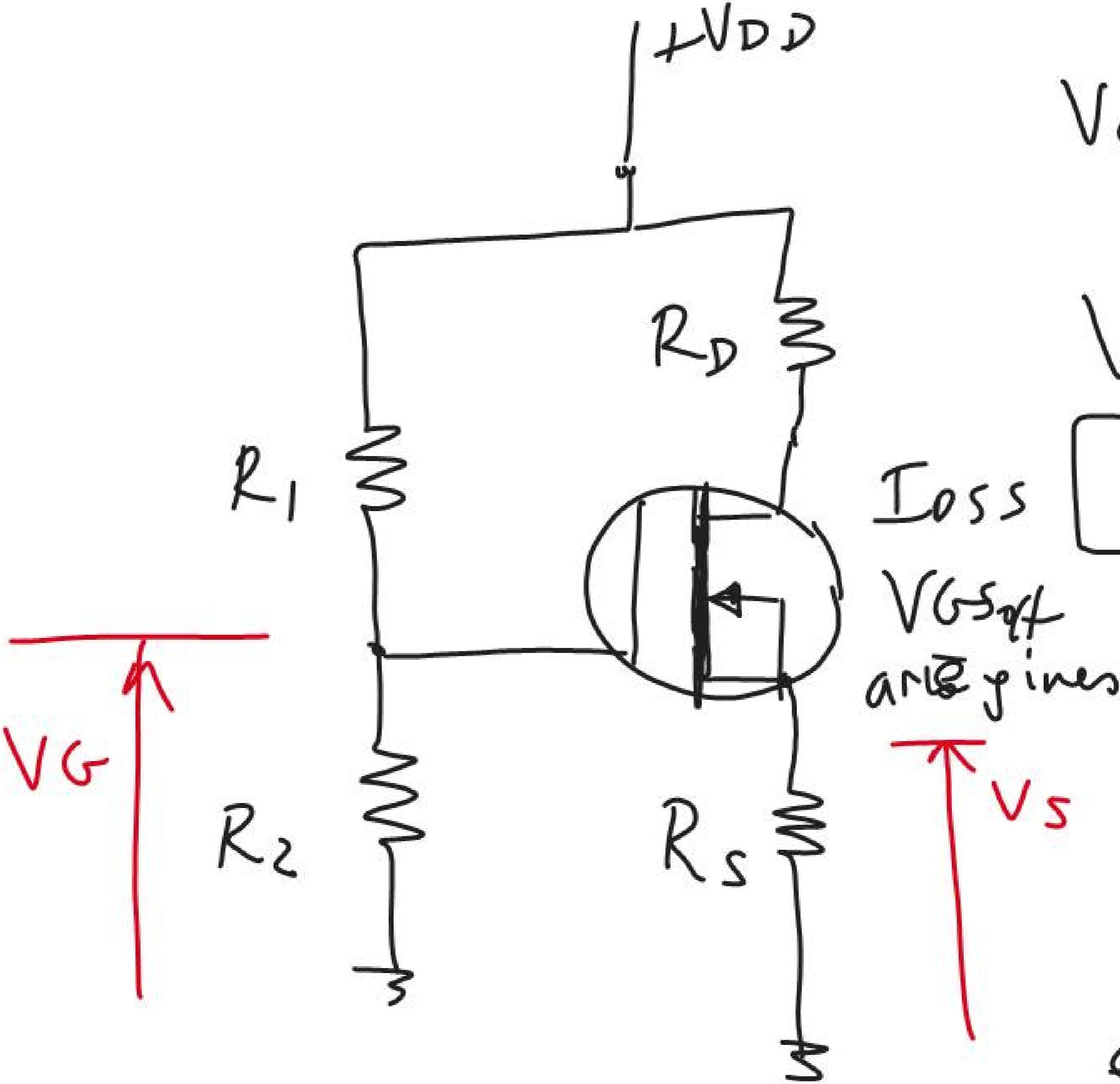
$$V_{GS} = V_G - I_D \cdot R_S$$

$$V_{GS} = 0 \rightarrow I_D = \frac{V_G}{R_S}$$

$$I_D = 0 \rightarrow V_{GS} = V_G$$



D-MOSFET BIASING

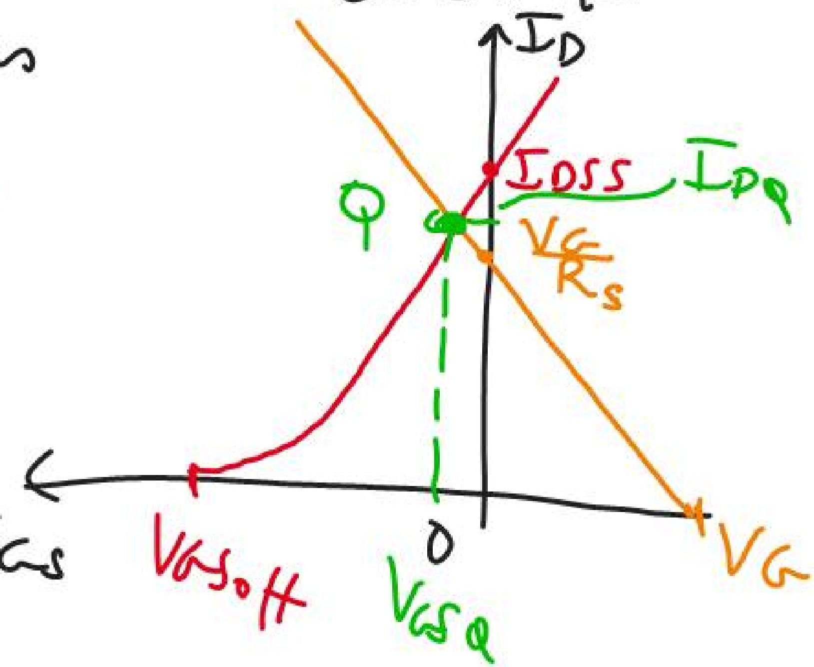


$$V_G = \frac{V_{DD}}{R_1 + R_2} \cdot R_2$$

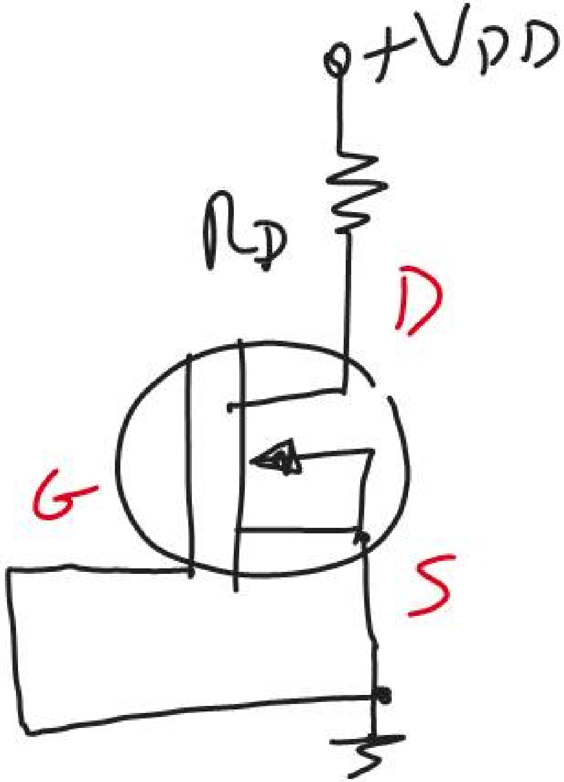
$$V_{GS} = V_G - V_S$$

$$\boxed{V_{GS} = V_G - I_D \cdot R_S}$$

Line eqn.



ex

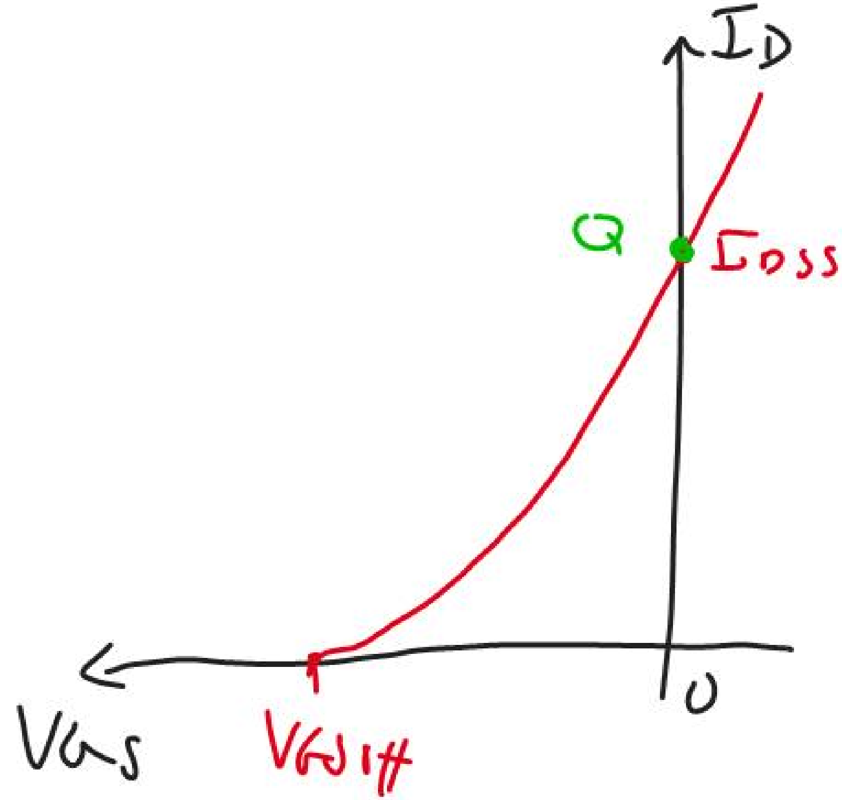


$$V_{GS} = V_G - V_S$$

$$\boxed{V_{GS} = 0V}$$

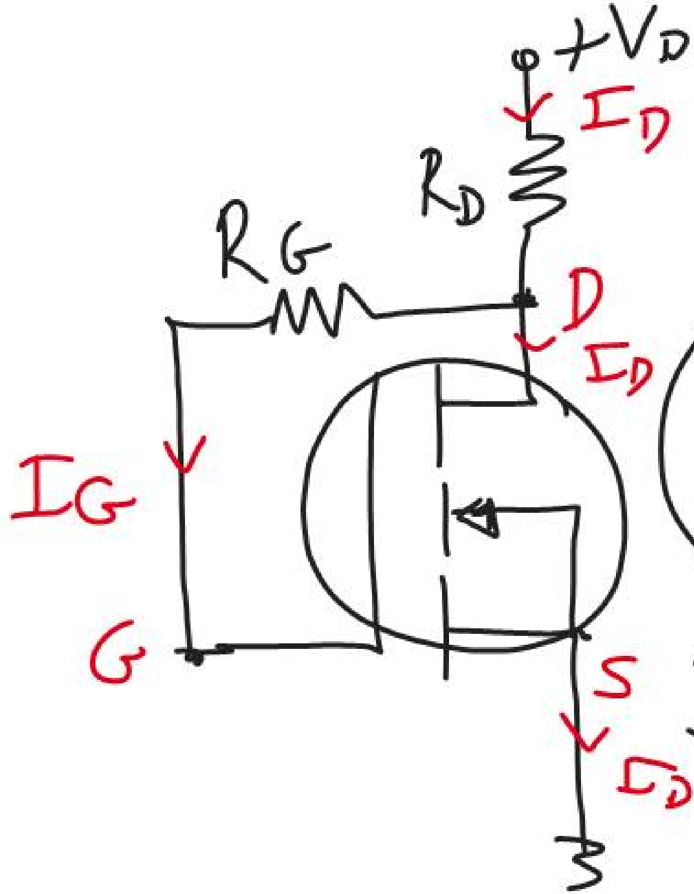
when $V_{GS} = 0V$

$$\boxed{I_D = I_{DSS}}$$



E-MOSFET BIASING

(1) Feedback Biasing



$I_G = 0$ (no gate current)

no voltage drop on R_G

$I_G \cdot R_G = 0$

$V_G = V_D$

$V_{GS} = V_{DS}$

given: K, $V_{GS_{off}} = V_T$

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

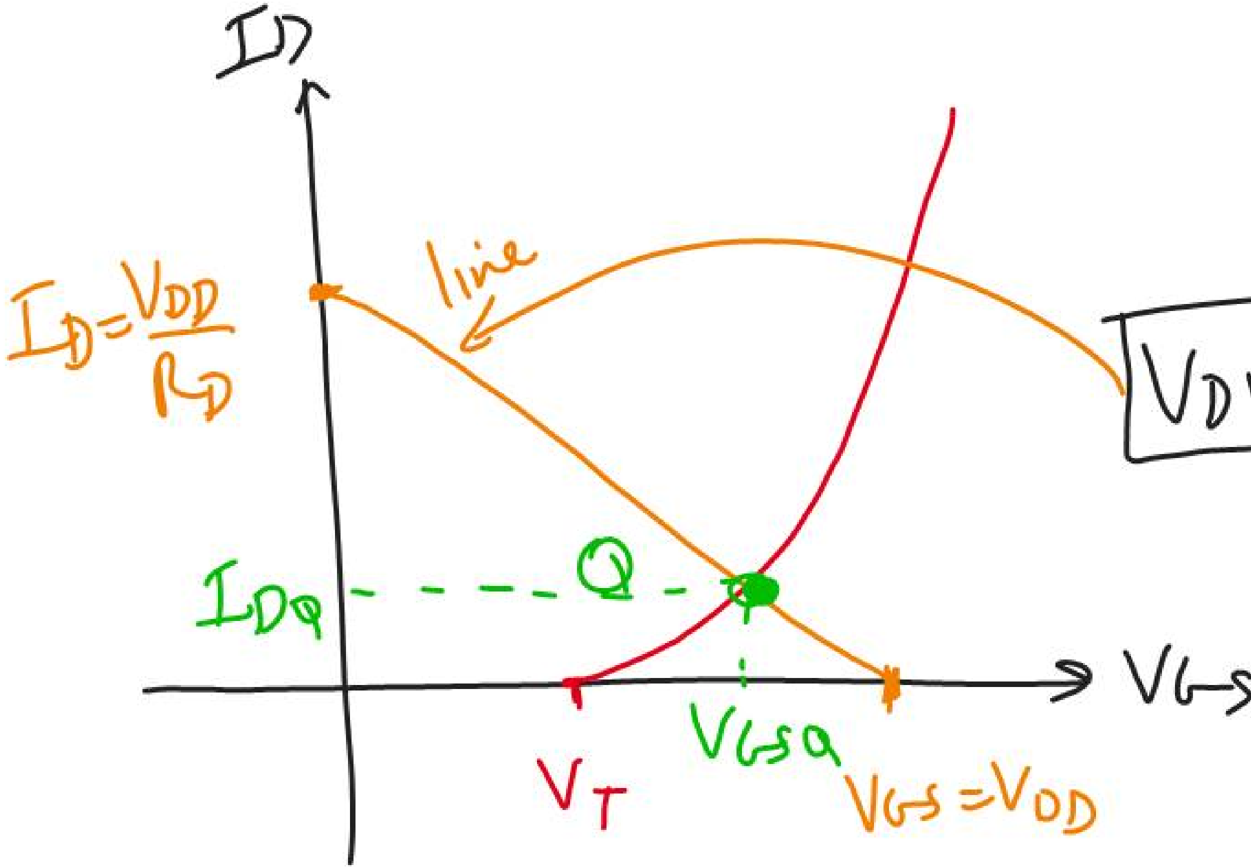
Output KVL:

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

$V_{DS} = V_{GS}$

$$V_{DD} - I_D R_D - V_{GS} = 0$$

A line equation between I_D and V_{GS}



$$V_{DD} - I_D R_D - V_{GS} = 0$$

$V_{GS} = 0 \quad I_D = \frac{V_{DD}}{R_D}$

$I_D = 0 \quad V_{GS} = V_{DD}$

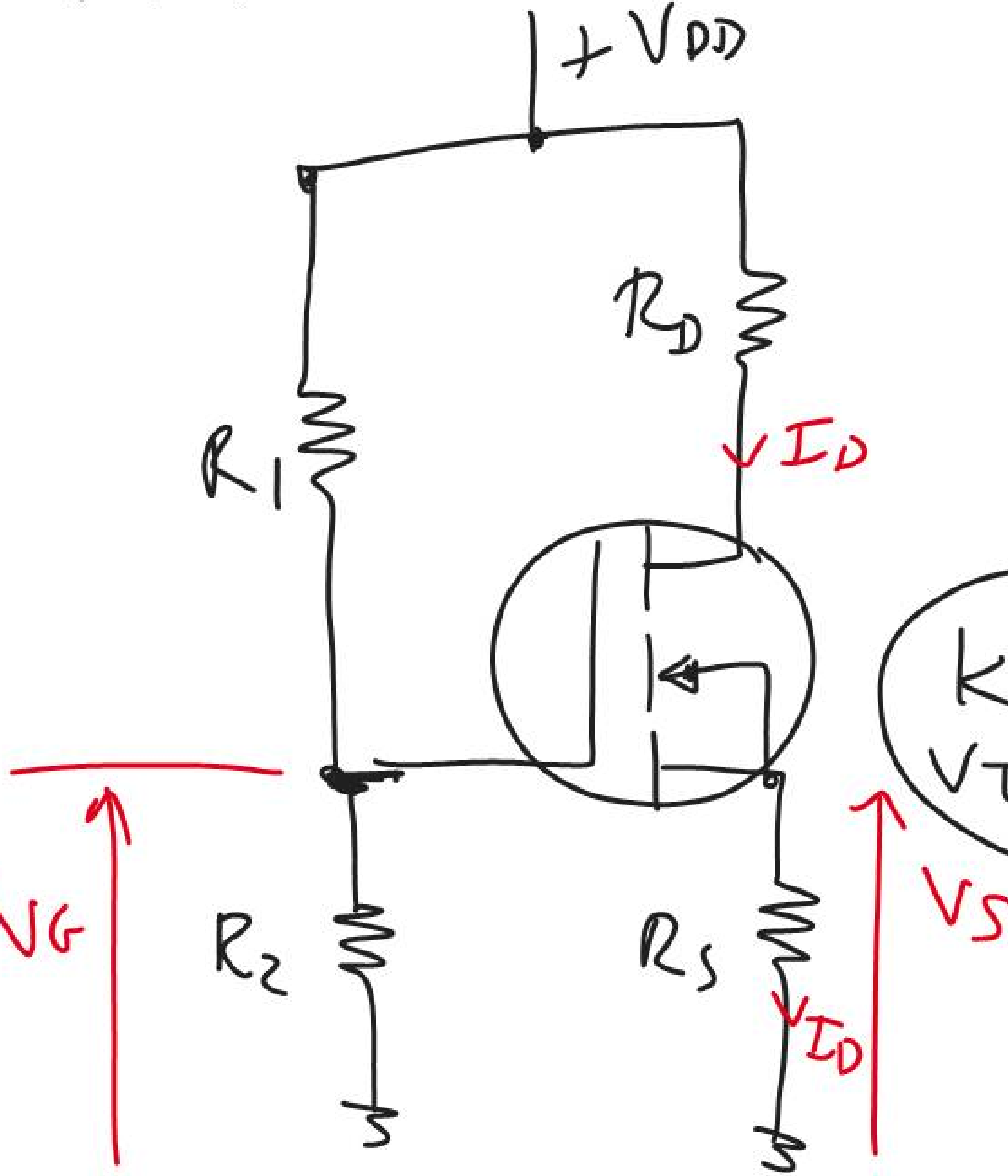
Or use analytical method:

$$I_D = \frac{V_{DD} - V_{GS}}{R_D} \Longrightarrow I_D = k(V_{GS} - V_T)^2$$

$$\frac{V_{DD} - V_{GS}}{R_D} = k(V_{GS} - V_T)^2$$

$ax^2 + bx + c = 0 \qquad x = V_{GS}$

Voltage Divider bias for E-MOSFET



$$V_G = \frac{V_{DD}}{R_1 + R_2} \cdot R_2$$

$$V_{GS} = V_G - V_S$$

$$\boxed{V_{GS} = V_G - I_D R_S}$$

Line

K, and V_T are given