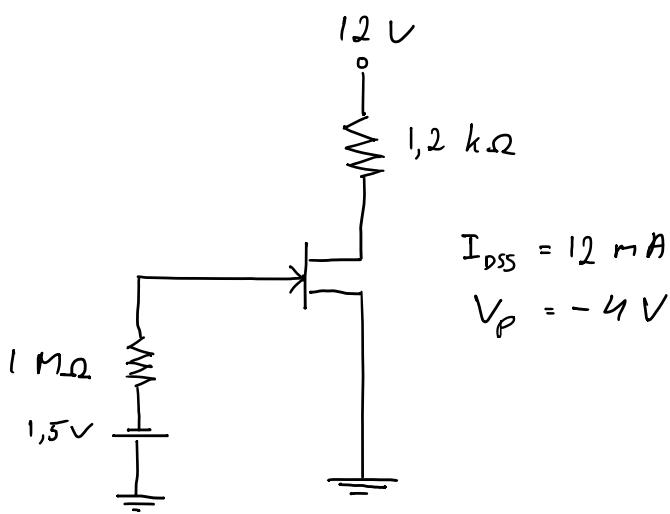


M. Hasyim Abdullah P.

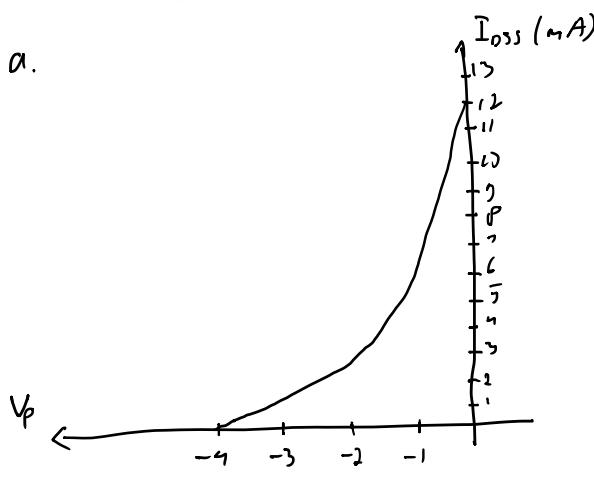
1101101095

TT-93-11

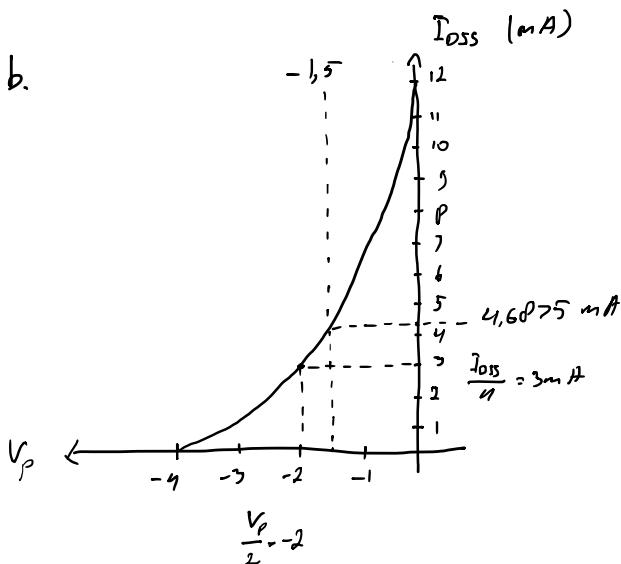
1.



a.



b.



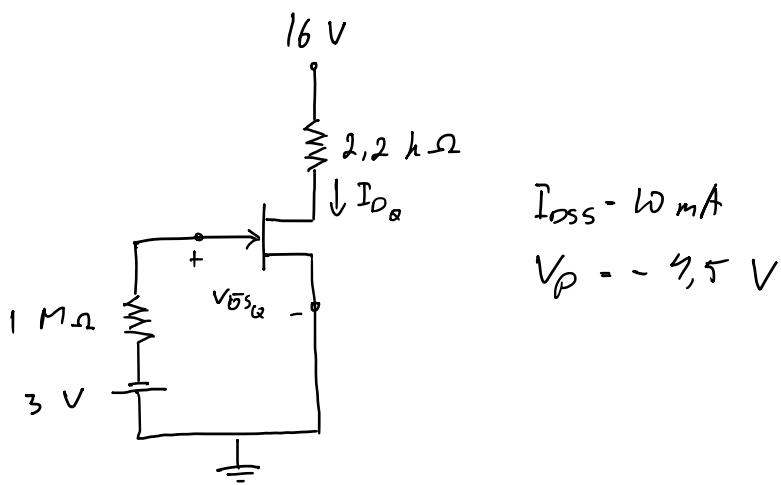
C. $I_{DQ} = 4,6075 \text{ mA}$

$$\begin{aligned}V_{DSQ} &= V_{DD} - I_D R_D = 12 - 4,6075 \text{ mA} \cdot 1,2 \text{ k}\Omega \\&= 12 - 5,625 \\&= 6,375 \text{ V}\end{aligned}$$

d. $I_{DQ} = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2$
 $= 12 \left(1 - \frac{-1,5}{-4}\right)^2$
 $= 4,6075 \text{ mA}$

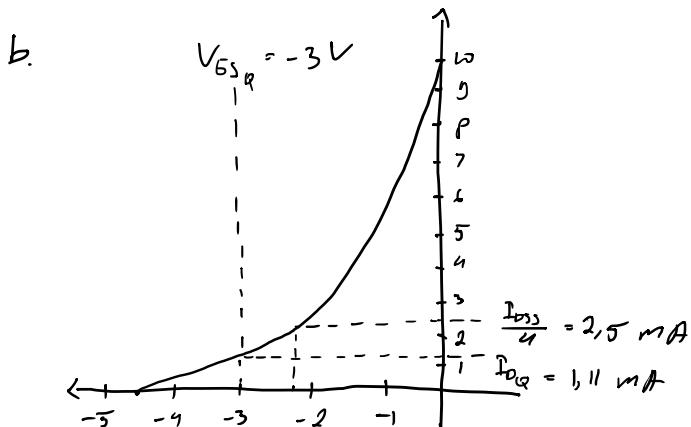
$$\begin{aligned}V_{DSQ} &= V_{DD} - I_{DQ} R_D \\&= 12 - 4,6075 \text{ mA} \cdot 1,2 \text{ k}\Omega \\&= 6,375 \text{ V}\end{aligned}$$

2.



$$a. \quad I_{DQ} = I_{DSS} \left(1 - \frac{V_{GS}}{V_P} \right)^2 = 10 \left(1 - \frac{-3}{-4,5} \right)^2 = 1,11 \text{ mA}$$

$$V_{G_{S_Q}} = -V_{GG} = -3 \text{ V}$$



$$c. \quad V_{DS} = V_{DD} - I_D R_D = 16 - 1,11 \text{ mA} \cdot 2,2 \text{ kΩ}$$

$$= 16 - 2,44$$

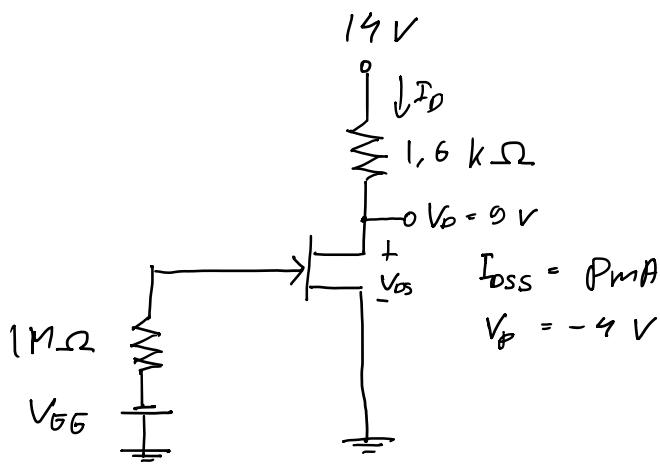
$$= 13,56 \text{ V}$$

$$V_D = V_{DS} = 13,56 \text{ V}$$

$$V_G = V_{GS} = -3 \text{ V}$$

$$V_S = 0 \text{ V}$$

3.



$$a. \quad V_D = V_{DD} - I_D R_D$$

$$0V = 14 - I_D \cdot 1,6 \text{ k}\Omega$$

$$I_D = \frac{5V}{1,6 \text{ k}\Omega} = 3,125 \text{ mA}$$

$$b. \quad V_{DS} = V_D - V_S$$

$$= 0V - 0$$

$$= 0V$$

$$c. \quad V_{GS} = -V_{GG}$$

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

$$3,125 = P \left(1 - \frac{-V_{GG}}{-4} \right)^2$$

$$\frac{25}{64} = \left(1 - \frac{V_{GG}}{4} \right)^2$$

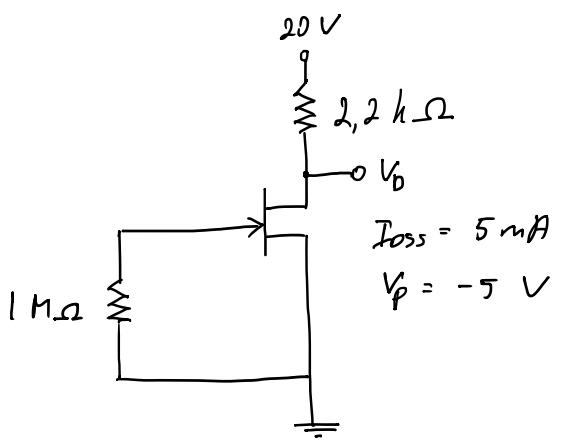
$$\frac{5}{16} = 1 - \frac{V_{GG}}{4}$$

$$2,5 = 4 - V_{GG}$$

$$V_{GG} = 1,5V$$

$$V_{GG} = 1,76V$$

4.



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

$$I_D = 5 \text{ mA} \left(1 - \frac{0}{-5}\right)^2$$

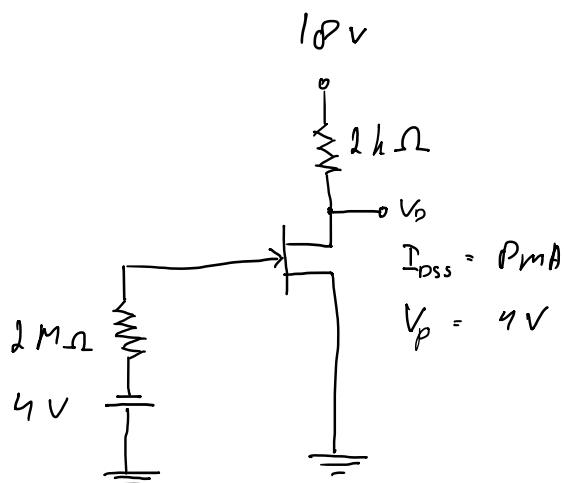
$$I_D = 5 \text{ mA}$$

$$V_D = V_{DD} - I_D R_D = 20 - 5 \text{ mA} \cdot 2.2 \text{ k}\Omega$$

$$= 20 - 11$$

$$= 9 \text{ V}$$

5.



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

$$I_D = 32 \text{ mA} \left(1 - \frac{-4}{4}\right)^2$$

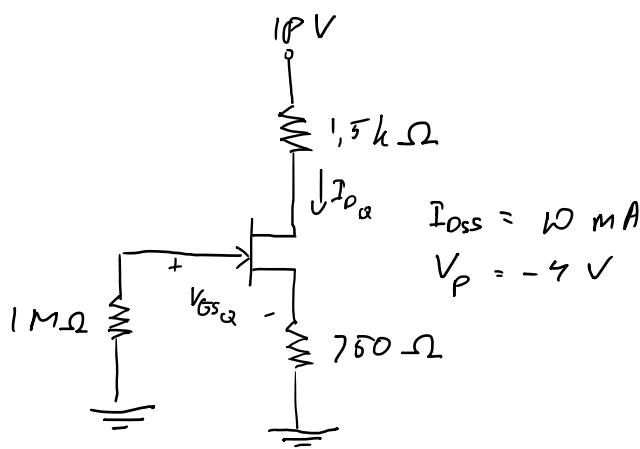
$$I_D = 32 \text{ mA} \cdot 4$$

$$V_D = V_{DD} - I_D R_D$$

$$= 10 - 32 \text{ mA} \cdot 2 \text{ k}\Omega$$

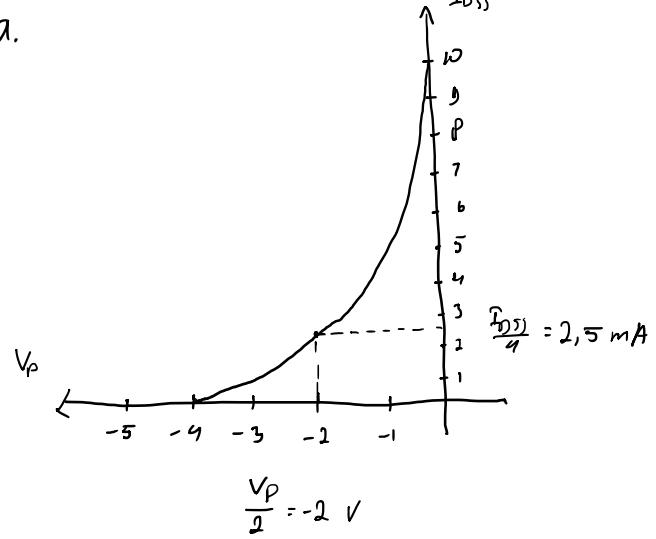
$$= -46 \text{ V}$$

6.



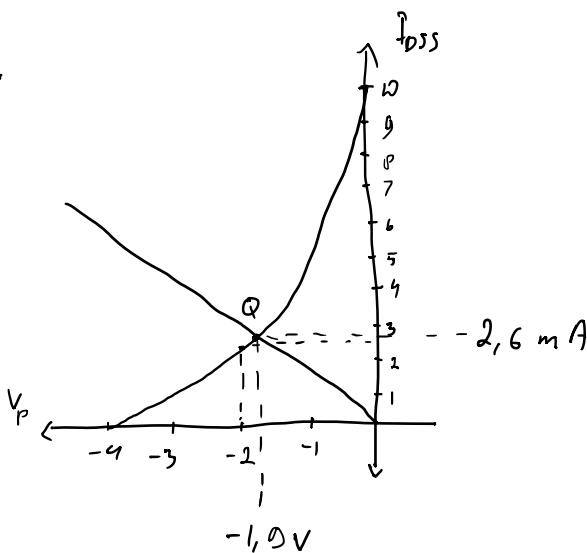
$$I_{DSS} = 10 \text{ mA}$$

$$V_P = -4 \text{ V}$$



$$\frac{V_P}{2} = -2 \text{ V}$$

b.



$$c. I_{DQ} = 2.6 \text{ mA}$$

$$V_{GSQ} = -1.0 \text{ V}$$

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

$$= 10 - 2.6 \text{ mA} (1.5 \text{ k}\Omega + 750 \text{ }\Omega)$$

$$= 10 - 5.05$$

$$= 12.15 \text{ V}$$

$$V_{DS} = V_D - V_S$$

$$12.15 = 14.1 - V_S$$

$$V_S = 1.95 \text{ V}$$

$$V_D = V_{DD} - I_D R_D$$

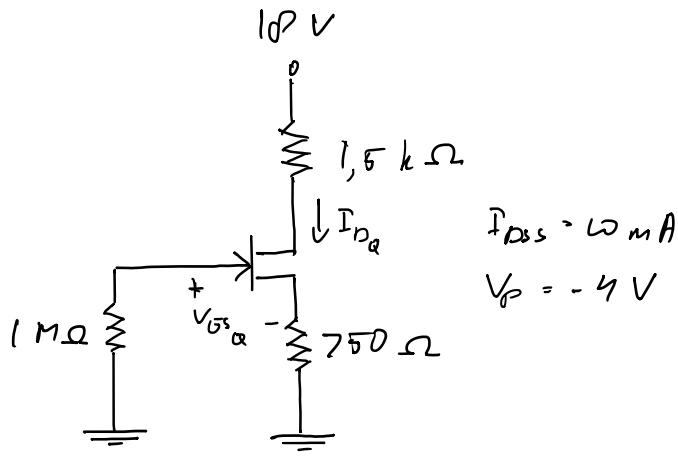
$$= 10 - 2.6 \text{ mA} \cdot 1.5 \text{ k}\Omega$$

$$= 10 - 3.9$$

$$= 14.1 \text{ V}$$

$$V_G = 0 \text{ V}$$

7.



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

$$I_D = 10mA \left(1 - \frac{V_{GS}}{-4V}\right)^2 \leftarrow V_{GS} = -I_D R_S$$

$$I_D = 0,01A \left(1 - \frac{-I_D R_S}{-4V}\right)^2$$

$$I_D = 0,01 \left(1 - \frac{I_D \cdot 750}{4}\right)^2$$

$$I_D = \frac{1}{150} \left(1 - \frac{375 I_D}{2}\right)^2$$

$$I_D = \frac{1}{150} \left(\frac{2 - 375 I_D}{2}\right)^2$$

$$I_D = \frac{(2 - 375 I_D)^2}{150 \cdot 2^2}$$

$$I_D = \frac{4 - 1500 I_D + 375^2 I_D^2}{400}$$

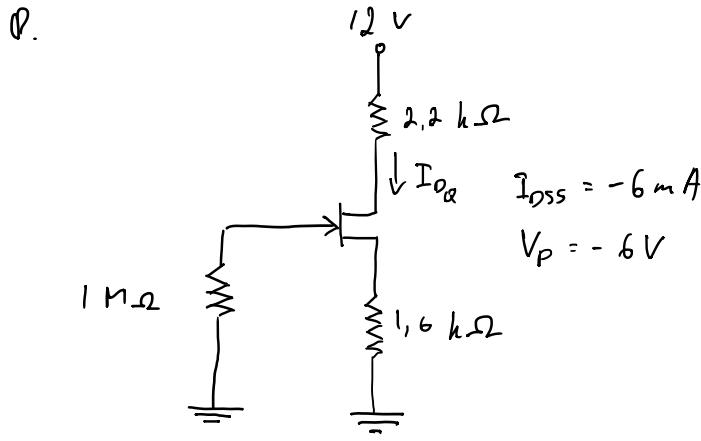
$$400 I_D = 4 - 1500 I_D + 375^2 I_D^2$$

$$375^2 I_D^2 - 1500 I_D + 4 = 0$$

$$I_{D,1,2} = \frac{1500 \pm \sqrt{1500^2 - 4 \cdot 375^2 \cdot 4}}{2 \cdot 375^2}$$

$$I_{D_1} = 2,61 \text{ mA} \longrightarrow I_{D_Q} = I_{D_1} = 2,61 \text{ mA} \quad (\cancel{I_{D_Q} \leq I_{DSS} \text{ dan } V_{GS} \geq V_P})$$

$$I_{D_2} = 10,9 \text{ mA}$$



$$a. \quad V_{DS} = -I_D R_S$$

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

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

$$I_D = 6 \text{ mA} \left(1 - \frac{-I_D \cdot 1.6 \text{ k}\Omega}{-6 \text{ V}} \right)^2$$

$$I_D = 0.006 \text{ A} \left(1 - \frac{800 I_D}{3} \right)^2$$

$$I_D = \frac{6}{800} \left(\frac{3 - 800 I_D}{3} \right)^2$$

$$I_D = \frac{6 (3 - 800 I_D)^2}{600 \cdot 3^2}$$

$$I_D = \frac{9 - 4800 I_D + 800^2 I_D^2}{1500}$$

$$800^2 I_D^2 - 6300 I_D + 9 = 0$$

$$I_D = \frac{6300 \pm \sqrt{6300^2 - 4 \cdot 800^2 \cdot 9}}{2 \cdot 800^2}$$

$$I_{D_1} = 1.73 \text{ mA}$$

$$I_{D_2} = 0.11 \text{ mA}$$

$$I_{D_Q} = I_D = 1.73 \text{ mA}$$

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

$$= -1.73 \text{ mA} \cdot 1.6 \text{ k}\Omega$$

$$= -2.76 \text{ V}$$

$$b. \quad V_D = V_D - I_D (R_D + R_S)$$

$$= 12 - 1.73 \text{ mA} (2.2 \text{ k}\Omega + 1.6 \text{ k}\Omega)$$

$$= 12 - 6.574$$

$$= 5.426 \text{ V}$$

$$V_D = V_D - I_D R_D$$

$$= 12 - 1.73 \text{ mA} \cdot 2.2 \text{ k}\Omega$$

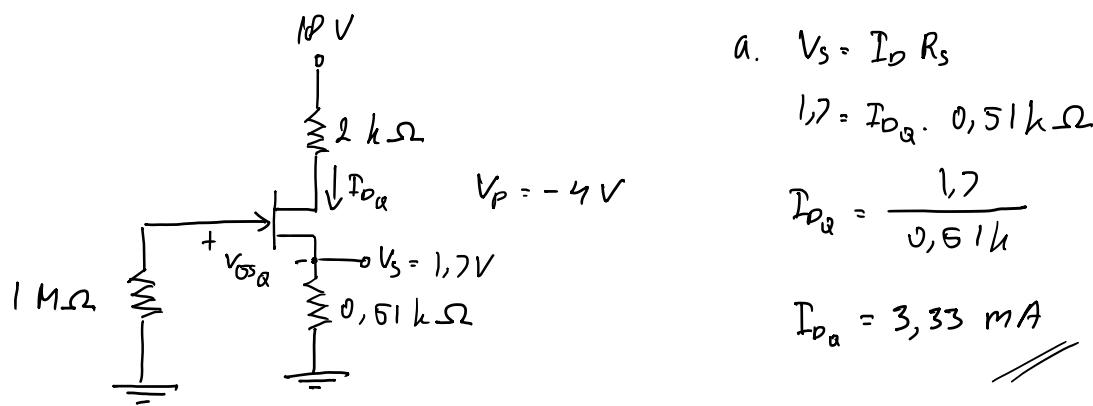
$$= 8.194 \text{ V}$$

$$V_G = 0 \text{ V}$$

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

$$= 0 - (-2.76 \text{ V})$$

$$= 2.76 \text{ V}$$



$$a. \quad V_S = I_D R_S$$

$$1,7 = I_{DQ} \cdot 0,51 k\Omega$$

$$I_{DQ} = \frac{1,7}{0,51 k\Omega}$$

$$I_{DQ} = 3,33 \text{ mA}$$

//

$$b. \quad V_{GSQ} = -I_D R_S = -V_S = -1,7 \text{ V}$$

$$\hookrightarrow \quad I_{DQ} = I_{DSS} \left(1 - \frac{V_{GSQ}}{V_P} \right)^2$$

$$3,33 \text{ mA} = I_{DSS} \left(1 - \frac{-1,7}{-4} \right)^2$$

$$I_{DSS} = \frac{3,33}{\left(1 - \frac{1,7}{4} \right)^2}$$

$$I_{DSS} = 10 \text{ mA}$$

$$d. \quad V_D = V_{DD} - I_D R_D$$

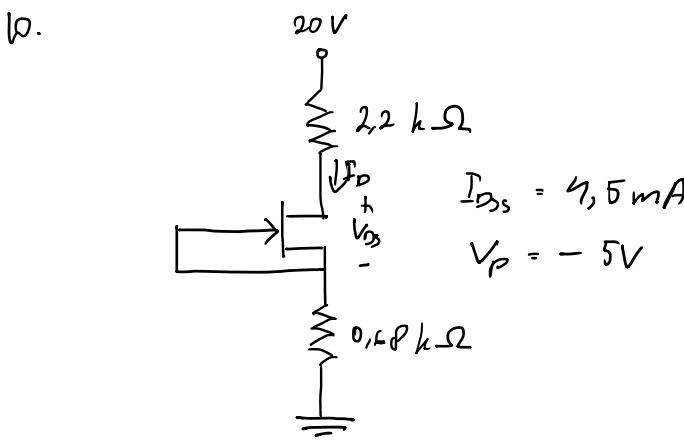
$$V_D = 10 - 3,33 \text{ mA} \cdot 2 \text{ k}\Omega$$

$$V_D = 11,34 \text{ V}$$

$$e. \quad V_{DS} = V_D - V_S$$

$$= 11,34 - 1,7$$

$$= 9,64 \text{ V}$$



a. $V_{DS} = -I_D R_S = 0 \checkmark$

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

$$I_D = I_{DSs} \left(1 - \frac{0}{-5V}\right)^2$$

$$I_D = 4.5 \text{ mA} \left(1 - \frac{0}{-5V}\right)^2$$

$$\cancel{I_D = 4.5 \text{ mA}}$$

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

$$V_{DS} = 20 - 4.5 \text{ mA} (2.2 \text{ k}\Omega + 0.68 \text{ k}\Omega)$$

$$V_{DS} = 20 - 12.06$$

$$\cancel{V_{DS} = 7.04 \text{ V}}$$

c. $V_D = V_{DD} - I_D R_D$

$$= 20 - 4.5 \text{ mA} \cdot 2.2 \text{ k}\Omega$$

$$= 20 - 9.9$$

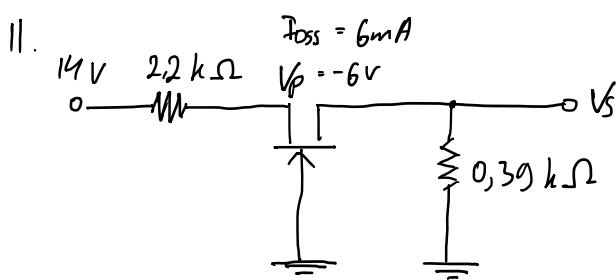
$$= 10.1 \checkmark$$

d. $V_{DS} = V_D - V_S$

$$V_S = V_D - V_{DS}$$

$$V_S = 10.1 - 7.04$$

$$V_S = 3.06 \text{ V}$$



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

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

$$I_D = 6 \text{ mA} \left(1 - \frac{-I_D R_S}{-6 \text{ V}} \right)^2$$

$$I_D = \frac{6}{1000} \text{ A} \left(1 - \frac{I_D \cdot 390}{6} \right)^2$$

$$\frac{I_D}{3} = \frac{3}{500} \left(1 - 65 I_D \right)^2$$

$$\frac{500}{3} I_D = 1 - 130 I_D + 65^2 I_D^2$$

$$500 I_D = 3 - 390 I_D + 3.65^2 I_D^2$$

$$12675 I_D^2 - 820 I_D + 3 = 0$$

$$I_{D_{1,2}} = \frac{820 \pm \sqrt{820^2 - 4 \cdot 12675 \cdot 3}}{2 \cdot 12675}$$

$$I_{D_1} = 66.67 \text{ mA}$$

$$I_{D_2} = 3.55 \text{ mA}$$

$$I_{D_Q} = I_{D_2} = 3.55 \text{ mA}$$

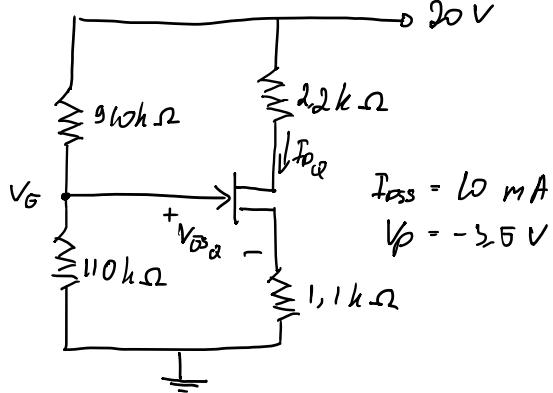
$$V_{GS} = -I_D R_S$$

$$V_G - V_S = -3.55 \text{ mA} \cdot 0.39 \text{ k}\Omega$$

$$0 - V_S = -1.3045 \text{ V}$$

$$V_S = 1.3045 \text{ V}$$

12.



$$a. \quad V_G = \frac{R_2}{R_s + R_2} V_{DD}$$

$$V_G = \frac{110k}{9k + 110k} \cdot 20V$$

$$V_G = \frac{110k}{100k + 110k} \cdot 20V$$

$$V_G = 2,16V$$

$$b. \quad V_{GS} = V_G - I_D R_S$$

$$V_{GS} = 2,16 - I_D \cdot 1,1k\Omega$$

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

$$I_D = 10mA \left(1 - \frac{2,16 - 1100I_D}{-3,5} \right)^2$$

$$I_D = \frac{1}{100} A \left(\frac{3,5}{-3,5} + \frac{2,16 - 1100I_D}{3,5} \right)^2$$

$$I_D = \frac{(5,66 - 1100I_D)^2}{100 \cdot 3,5^2}$$

$$1225I_D^2 = 32,04 - 12452I_D + 1100^2 I_D^2$$

$$1100^2 I_D^2 - 13677I_D + 32,04 = 0$$

$$I_{D,1,2} = \frac{13677 \pm \sqrt{13677^2 - 4 \cdot 1100^2 \cdot 32,04}}{2 \cdot 1100^2}$$

$$I_{D,1} = 7,07mA$$

$$I_{D,2} = 3,31mA \rightarrow I_{D,Q} = 3,31mA$$

$$V_{GSQ} = 2,16 - I_{DQ} \cdot 1,1k\Omega$$

$$V_{GSQ} = 2,16 - 3,31mA \cdot 1,1k\Omega$$

$$V_{GSQ} = -1,48V$$

$$c. \quad V_D = V_{DD} - I_D R_D$$

$$V_D = 20 - 3,31mA \cdot 2,2k\Omega$$

$$V_D = 12,71V$$

$$V_S = I_D R_S$$

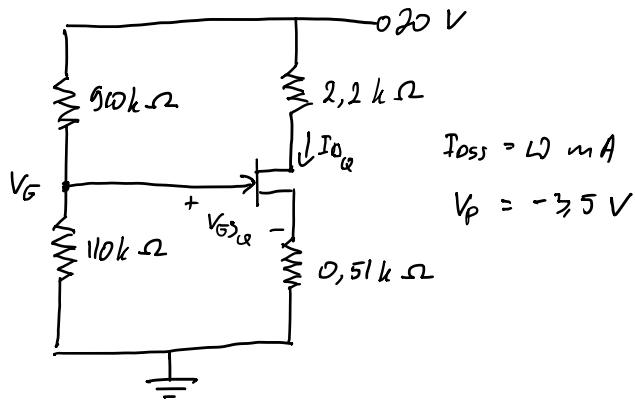
$$V_S = 3,31mA \cdot 1,1k\Omega$$

$$V_S = 3,641V$$

$$d. \quad V_{DSQ} = V_D - V_S$$

$$V_{DSQ} = 12,71V - 3,641$$

$$V_{DSQ} = 9,077V$$



$$I_{DS} = 10 \text{ mA}$$

$$V_P = -3.5 \text{ V}$$

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

$$V_G = \frac{110k}{90k + 110k} 20 \text{ V}$$

$$V_G = 2.16 \text{ V}$$

$$V_{GSQ} > V_G - I_D R_S$$

$$V_{GS} = 2.16 - I_D \cdot 0.51k \Omega$$

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

$$I_D = 10 \text{ mA} \left(1 - \frac{2.16 - 5.05 I_D}{-3.5}\right)^2$$

$$25500^2 I_D^2 - 17495500 I_D + 1000000 = 0$$

$$I_{D1} = 21.06 \text{ mA}$$

$$I_{D2} = 5.05 \text{ mA}$$

$$I_{DQ} = 5.05 \text{ mA}$$

$$V_{GSQ} = 2.16 - I_D \cdot 0.51k \Omega$$

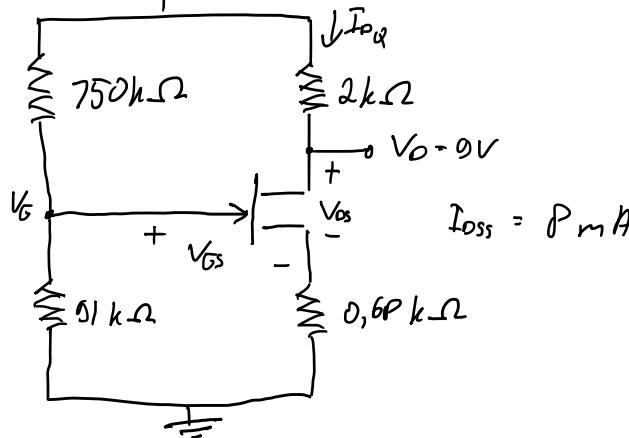
$$V_{GSQ} = 2.16 - 5.05 \text{ mA} \cdot 0.51k \Omega$$

$$V_{GSQ} = -0.8235 \text{ V}$$

b. Nilai minimum dari R_S adalah 0Ω

\therefore semakin kecil nilai R_S maka semakin besar nilai I_{DQ} dan V_{GSQ}

14.



$$b. V_s = I_D R_s$$

$$V_s = 4,5 \text{ mA} \cdot 0,6P \text{ k}\Omega$$

$$V_s = 3,06 \text{ V}$$

$$V_{DS} = V_D - V_s$$

$$V_{DS} = 0 - 3,06$$

$$V_{GS} = 5,94 \text{ V}$$

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

$$V_G = \frac{91 \text{ k}}{750 \text{ k} + 91 \text{ k}} \cdot 18$$

$$V_G = \frac{91 \text{ k}}{841 \text{ k}} \cdot 18$$

$$V_G = 1,95 \text{ V}$$

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

$$= 1,95 - 3,06$$

$$= -1,11 \text{ V}$$

$$d. V_D = V_{DD} - I_D R_D$$

$$0 = 18 - I_D \cdot 2 \text{ k}\Omega$$

$$I_D = \frac{0}{2 \text{ k}\Omega}$$

$$I_D = 4,5 \text{ mA}$$

d.

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

$$4,5 \text{ mA} = P_{mA} \left(1 - \frac{-1,11 \text{ V}}{V_P} \right)^2$$

$$4,5 = P \left(1 + \frac{1,11}{100 V_P} \right)^2$$

$$4,5 = P \left(\frac{100 V_P + 1,11}{100 V_P} \right)^2$$

$$4,5 = P \frac{(100 V_P + 1,11)^2}{10000 V_P^2}$$

$$5625 V_P^2 = 10000 V_P^2 + 22200 V_P + 12321$$

$$4375 V_P^2 + 22200 V_P + 12321 = 0$$

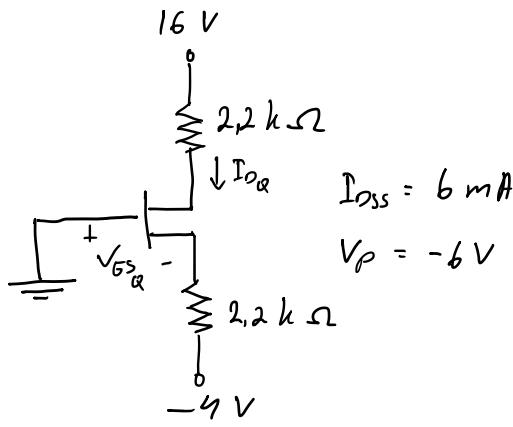
$$V_{P_{1,2}} = \frac{-22200 \pm \sqrt{22200^2 - 4 \cdot 4375 \cdot 12321}}{2 \cdot 4375}$$

$$V_{P_1} = -0,63 \text{ V}$$

$$V_{P_2} = -4,44 \text{ V}$$

$$(V_P \leq V_{GSQ})$$

$$\therefore V_P = V_{P_2} = -4,44 \text{ V}$$



$$a. V_{GS} = -V_{SS} - I_D R_S$$

$$V_{GS} = -(-4) - 6 \text{ mA} \cdot 2.2 \text{ k}\Omega$$

$$V_{GS} = 4 - 6 \cdot 2.2 \text{ k}\Omega$$

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

$$I_D = 6 \text{ mA} \left(1 - \frac{4 - 2.2 \text{ k}\Omega I_D}{-6} \right)^2$$

$$I_D = \frac{6}{1000} \left(1 + \frac{2 - 1100 I_D}{3} \right)^2$$

$$I_D = \frac{3}{500} \left(\frac{5 - 1100 I_D}{3} \right)^2$$

$$I_D = \frac{3(5 - 1100 I_D)}{500 \cdot 3^2}$$

$$1500 I_D = 25 - 1100 I_D + 1100^2 I_D^2$$

$$1100^2 I_D^2 - 12500 I_D + 25 = 0$$

$$I_{D_{1,2}} = \frac{12500 \pm \sqrt{12500^2 - 4 \cdot 1100^2 \cdot 25}}{2 \cdot 1100^2}$$

$$I_{D_1} = 7.62 \text{ mA}$$

$$I_{D_2} = 2.71 \text{ mA}$$

$$I_{D_Q} < I_{DSS} \Rightarrow I_{D_Q} = 2.71 \text{ mA}$$

$$V_{GS_Q} = 4 - 2.71 \text{ mA} \cdot 2.2 \text{ k}\Omega$$

$$= -1.062 \text{ V}$$

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

$$= 16 - (-4) - 2.71 \text{ mA} (2.2 \text{ k}\Omega + 2.2 \text{ k}\Omega)$$

$$= 20 - 11.924$$

$$= 8.076 \text{ V}$$

$$V_S = I_D R_S$$

$$= 2.71 \text{ mA} \cdot 2.2 \text{ k}\Omega$$

$$= 5.962 \text{ V}$$