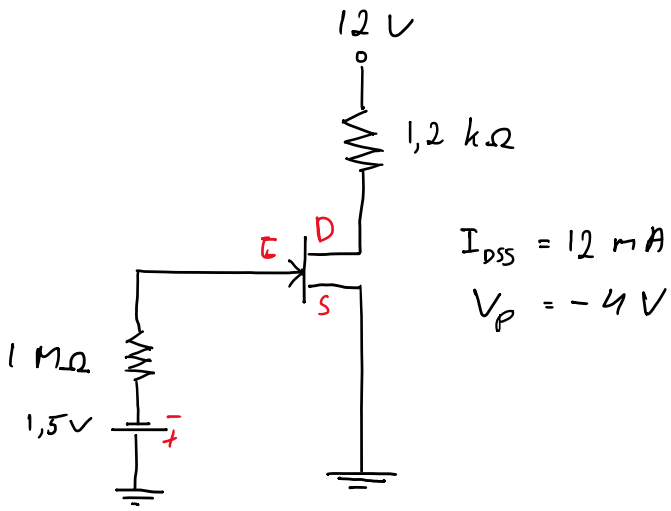
M. Hasyim Abdillah P. 1101101095 TT-43-11

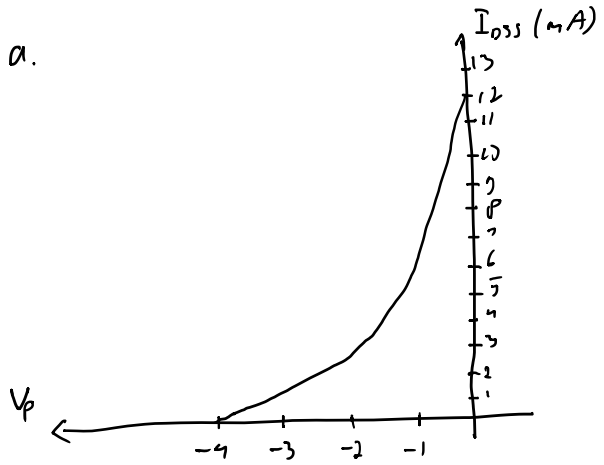
1. Fixed-Bias



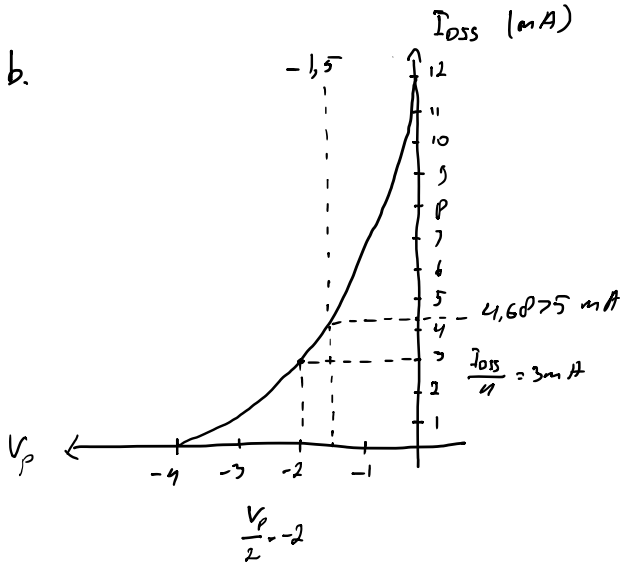

$I_{DSS} = 12\ mA$

$V_p = -4\ V$

a.




b.




c. $I_{D_Q} = 4,6875\ mA$

$V_{DS_Q} = V_{DD} - I_D R_D = 12 - 4,6875\ mA \cdot 1,2\ k\Omega$

$= 12 - 5,625$

$= 6,375\ V$

d. $I_{D_Q} = I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2$

$= 12\left(1 - \frac{-1,5}{-4}\right)^2$

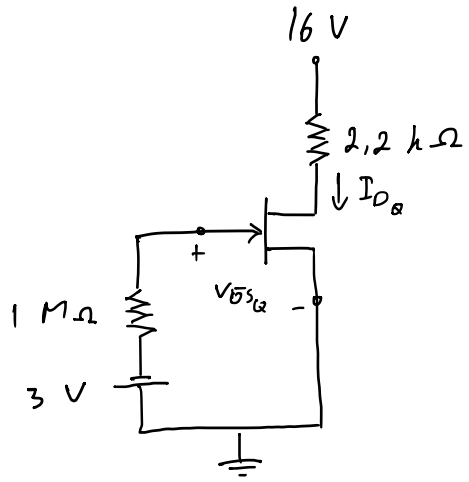
$= 4,6875\ mA$

$V_{DS_Q} = V_{DD} - I_{D_Q} R_D$

$= 12 - 4,6875\ mA \cdot 1,2\ k\Omega$

$= 6,375\ V$

2.



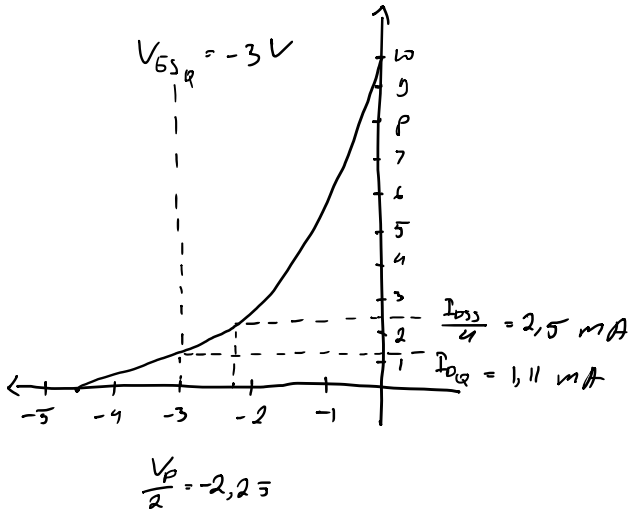

$I_{DSS} = 10\ mA$

$V_P = -4,5\ V$

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

$V_{GS_Q} = -V_{GG} = -3\ V$

b.




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

$= 16 - 2,44$

$= 13,56\ V$

$V_{DS} = V_D - V_S$ ($V_S = I_D R_S$)

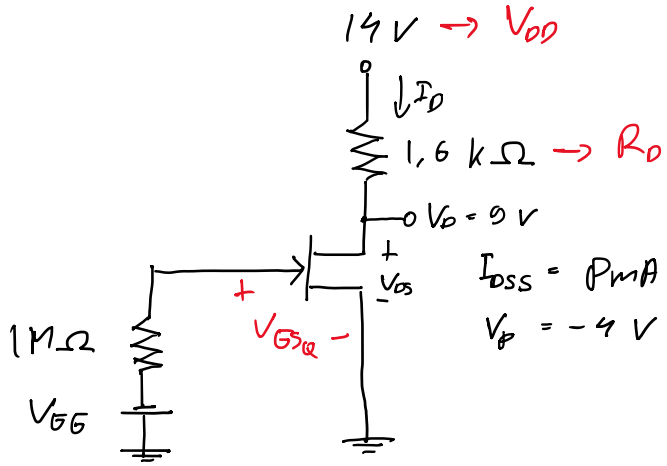
$V_{DD} - I_D R_D$

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

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

$V_S = 0\ V$

3.




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

$9V = 14 - I_D \cdot 1{,}6\,k\Omega$

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

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

$= 9V - 0$

$= 9V$

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

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

ES $3{,}125 = 8\left(1 - \frac{fV_{GG}}{f4}\right)^2$

$\frac{3{,}125}{8} = \sqrt{\frac{25}{64}} = \sqrt{\left(1 - \frac{V_{GG}}{4}\right)^2}$

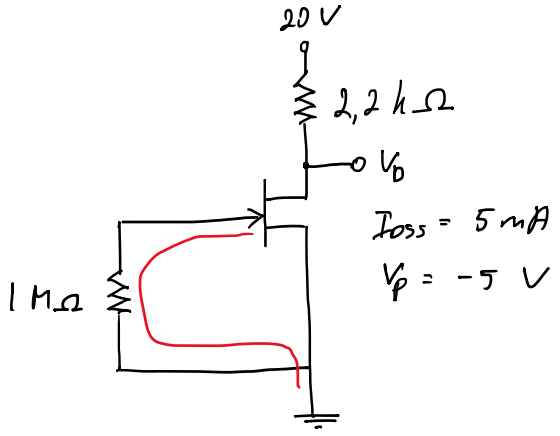
$\frac{5}{8} \times 4 = 1 - \frac{V_{GG}}{4} \times 4$

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

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

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

4.




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

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

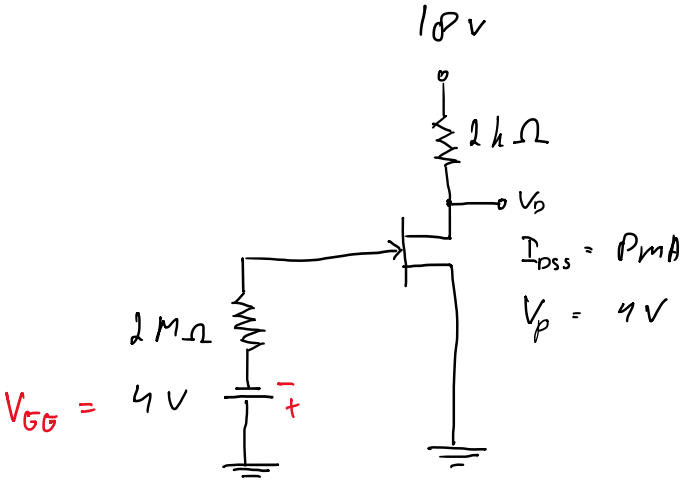
$$I_D = 5\,mA$$

$$V_D = V_{DD} - I_D R_D = 20 - 5\,mA \cdot 2{,}2\,k\Omega$$

$$= 20 - 11$$

$$= 9\,V$$

5.




$V_{GS} = -V_{GG}$

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

$$I_D = 8\,mA\left(1 - \frac{-4}{4}\right)^2$$

$$I_D = 8\,mA \cdot 4$$

$$I_D = 32\,mA$$

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

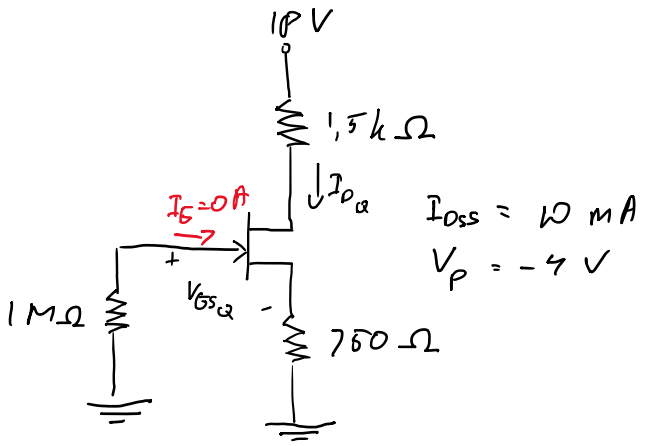
$$= 10 - 32\,mA \cdot 2\,k\Omega$$

$$= -46\,V$$

$$I_D = 8\,mA\left(1 - \frac{-4}{-4}\right)^2$$

$I_D = 0 \rightarrow V_D = V_{DD} - I_D R_D = V_{DD} = 10\,V$

6.

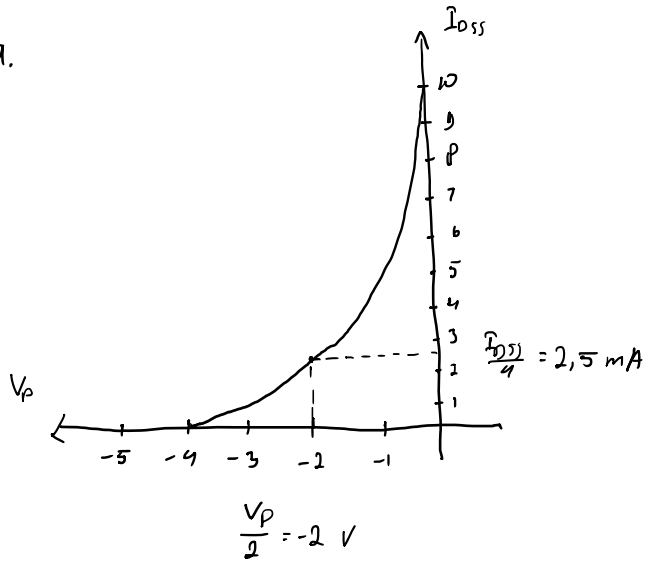



$I_{DSS} = 10$ mA

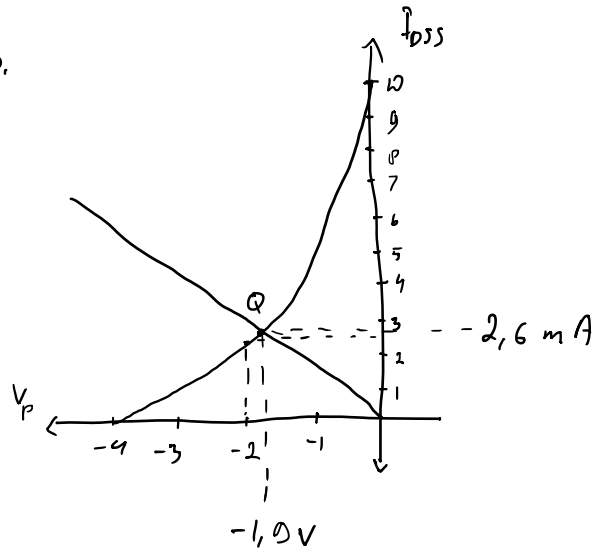
$V_P = -4$ V

Self-Bias

a.




b.




c. $I_{D_Q} = 2,6$ mA

$V_{GS_Q} = -1,9$ V

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

$V_{GS} = -I_D R_S$

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

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

$AI_D^2 + BI_D + C = 0$

$I_{D_{1,2}} \rightarrow I_D \leq I_{DSS}$ &

$V_{GS} \geq V_P$

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

$= 18 - 2,6\text{ mA}(1,5\text{ k}\Omega + 750\,\Omega)$

$= 18 - 5,85$

$= 12,15$ V

$V_{DS} = V_D - V_S$

$12,15 = 14,1 - V_S$

$V_S = 1,95$ V

$V_D = V_{DD} - I_D R_D$

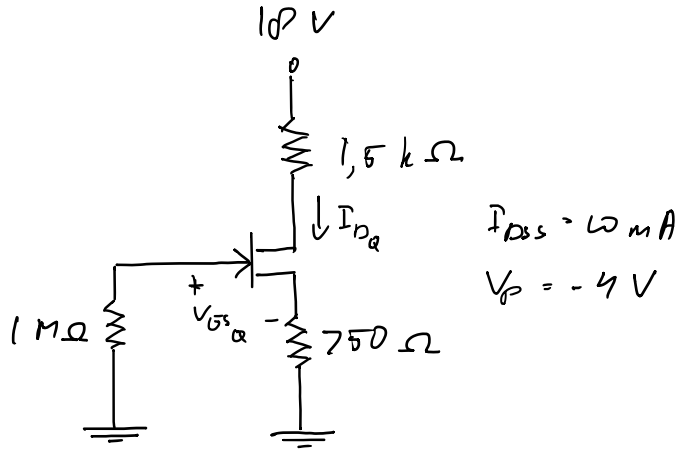
$= 18 - 2,6\text{ mA} \cdot 1,5\text{ k}\Omega$

$= 18 - 3,9$

$= 14,1$ V

$V_G = 0$ V

7.




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

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

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

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

$$I_D = \frac{1}{100}\left(1 - \frac{375\,I_D}{2}\right)^2$$

$$I_D = \frac{1}{100}\left(\frac{2 - 375\,I_D}{2}\right)^2$$

$$I_D = \frac{(2 - 375\,I_D)^2}{100 \cdot 2^2}$$

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

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

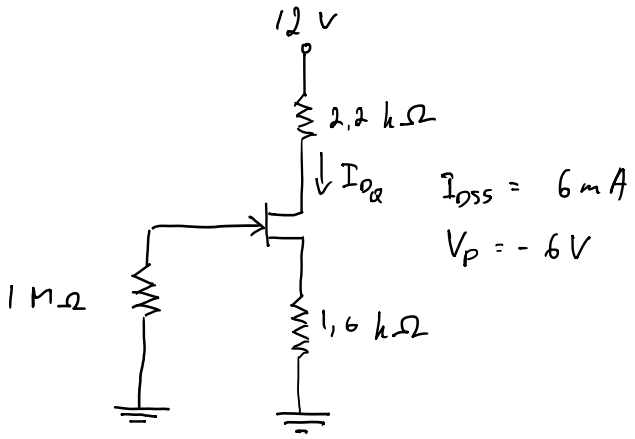
$$375^2\,I_D^2 - 1900\,I_D + 4 = 0$$

$$I_{D_{1,2}} = \frac{1900 \pm \sqrt{1900^2 - 4 \cdot 375^2 \cdot 4}}{2 \cdot 375^2}$$

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

$I_{D_2} = 10{,}9\,mA$ ✗

P.




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

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

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

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

$I_D = 0,006A\left(1 - \frac{800 I_D}{3}\right)^2$

$I_D = \frac{6}{1000}\left(\frac{3 - 800 I_D}{3}\right)^2$

$I_D = \frac{6(3 - 800 I_D)^2}{1000 \cdot 3^2}$

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

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

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

$I_{D_1} = 1,73\ mA$

$I_{D_2} = 8,11\ mA$

$I_{DQ} = I_{D_1} = 1,73\ mA$

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

$= -1,73mA \cdot 1,6k\Omega$

$= -2,768\ V$

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

$= 12 - 1,73mA(2,2k\Omega + 1,6k\Omega)$

$= 12 - 6,574$

$= 5,426\ V$

$V_D = V_{DD} - I_D R_D$

$= 12 - 1,73mA \cdot 2,2k\Omega$

$= 8,194\ V$

$V_G = 0\ V$

$V_S = V_G - V_{GS}$

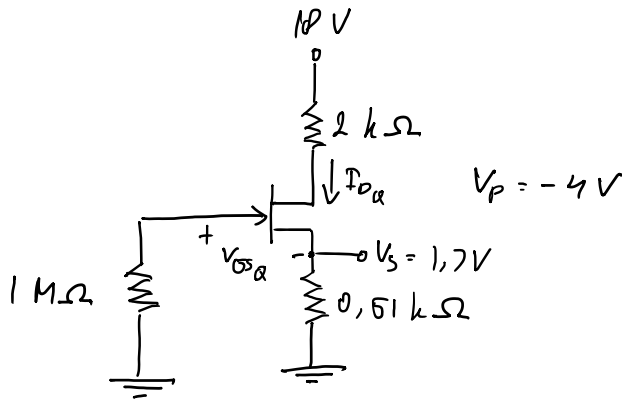
$= 0 - (-2,768)$

$= 2,768\ V$

$V_{GS} = V_G - V_S$

$V_S = V_G - V_{GS}$

9.




a. $V_S = I_D R_S$

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

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

$I_{DQ} = 3,33$ mA

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

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

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

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

$I_{DSS} = 10$ mA

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

$V_D = 18 - 3,33\,mA \cdot 2\,k\Omega$

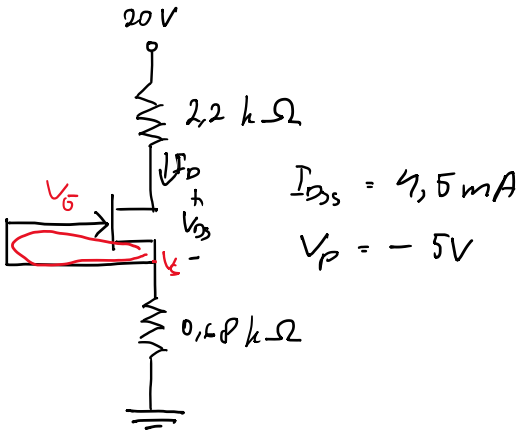
$V_D = 11,34$ V

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

$= 11,34 - 1,7$

$= 9,64$ V

10.




$I_{DSS} = 4,5\ mA$

$V_P = -5V$

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

$V_{GS} = 0$

a. $V_{GS} = -I_D R_S = 0\ V$

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

$I_D = I_{DSS}\left(1 - \frac{0}{V_P}\right)^2$

$I_D = 4,5\ mA\left(1 - \frac{0}{-5\ V}\right)^2$

$I_D = 4,5\ mA$

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

$V_{DS} = 20 - 4,5\ mA\ (2,2\ k\Omega + 0,68\ k\Omega)$

$V_{DS} = 20 - 12,96$

$V_{DS} = 7,04\ V$

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

$= 20 - 4,5\ mA \cdot 2,2\ k$

$= 20 - 9,9$

$= 10,1\ V$

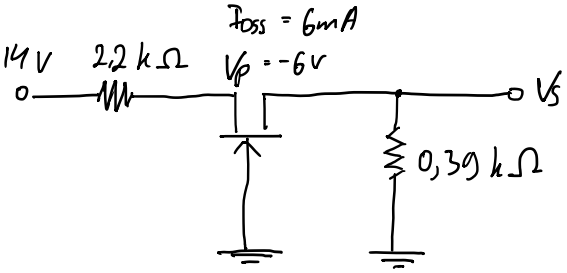
d. $V_{DS} = V_D - V_S$

$V_S = V_D - V_{DS}$

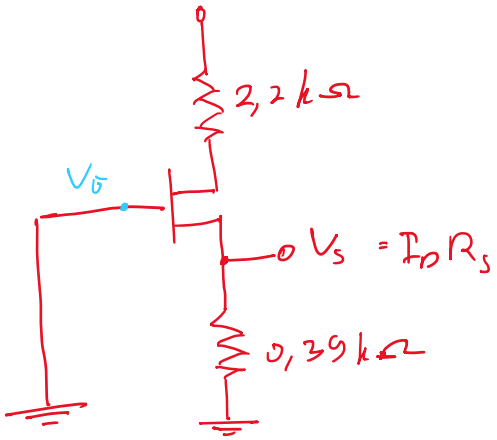
$V_S = 10,1 - 7,04$

$V_S = 3,06\ V$

11.




Common Gate 14V




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

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

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

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

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

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

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

$$12675 I_D^2 - 890 I_D + 3 = 0$$

$$I_{D_{1,2}} = \frac{890 \pm \sqrt{890^2 - 4.12675.3}}{2.12675}$$

$$I_{D_1} = 66,67\ mA$$

$$I_{D_2} = 3,55\ mA$$

$$I_{D_Q} = I_{D_2} = 3,55\ mA$$

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

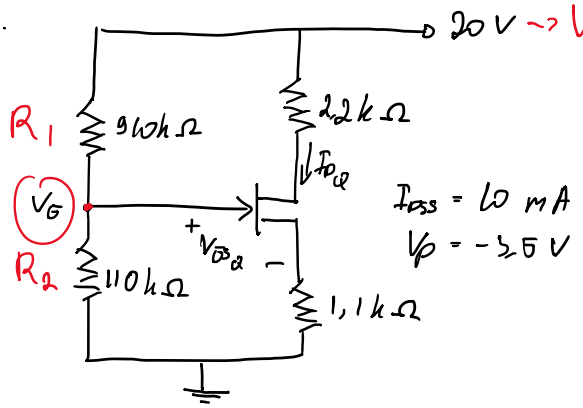
$$V_G - V_S = -3,55\ mA \cdot 0,39\ k\Omega$$

$$0 - V_S = -1,3845\ V$$

$$V_S = 1,3845\ V$$

12.

Voltage Divider - Bias




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

$V_G = \frac{110k}{960k + 110k} \cdot 20V$

$V_G = \frac{110k}{1020k} \cdot 20V$

$V_G = 2,16\ V$

b. $V_{GS} = V_G - I_D R_S$ ($I_D R_S = V_S$)

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

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

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

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

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

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

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

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

$I_{D_1} = 7,98\ mA$

$I_{D_2} = 3,31\ mA \rightarrow I_{D_Q} = 3,31\ mA$

$V_{GS_Q} = 2,16 - I_{D_Q} \cdot 1,1k\Omega$

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

$V_{GS_Q} = -1,48\ V$

$V_{GS_1} = 2,16 - 7,98mA \cdot 1,1k\Omega$

$V_{GS_1} = -6,61$

$V_{GS_2} = 2,16 - 3,31mA \cdot 1,1k\Omega$

$V_{GS_2} = -1,48\ V$ ✓

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

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

$V_D = 12,718\ V$

$V_S = I_D R_S$

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

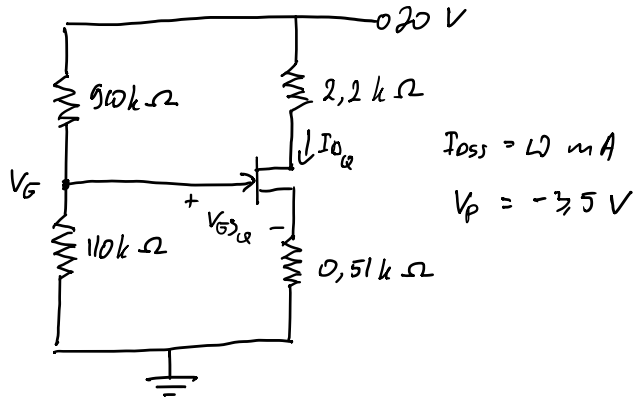
$V_S = 3,641\ V$

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

$V_{DS_Q} = 12,718 - 3,641$

$V_{DS_Q} = 9,077\ V$

13.




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

$V_G = \frac{110k}{900k+110k} 20V$

$V_G = 2,16\ V$

$V_{GS_Q} = V_G - I_D R_S$

$V_{GS} = 2,16 - I_D . 0,51k\Omega$

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

$I_D = 10mA\left(1 - \frac{2,16 - 510 I_D}{-3,5}\right)^2$

$255000^2 I_D^2 - 17495500 I_D + 20029 = 0$

$I_{D_1} = 21,06\ mA$

$I_{D_2} = 5,25\ mA$

$I_{D_Q} = 5,25\ mA$

$V_{GS_Q} = 2,16 - I_D . 0,51k\Omega$

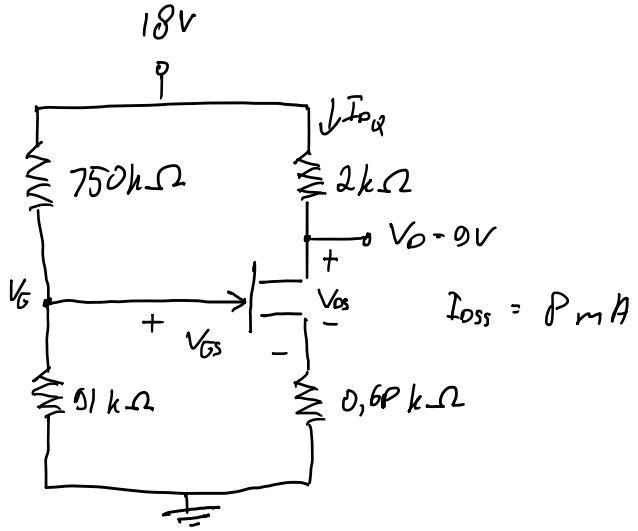
$V_{GS_Q} = 2,16 - 5,25mA . 0,51k\Omega$

$V_{GS_Q} = -0,8235\ V$

b. Nilai minimum dari Rs adalah 0 Ω

∴ Semakin kecil nilai $R_S$ maka semakin besar nilai $I_{D_Q}$ dan $V_{GS_Q}$

14.




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

$9 = 18 - I_D \cdot 2k\Omega$

$I_D = \frac{9}{2k\Omega}$

$I_D = 4,5\ mA$

b. $V_S = I_D R_S$

$V_S = 4,5\ mA \cdot 0,68k\Omega$

$V_S = 3,06\ V$

$V_{DS} = V_D - V_S$

$V_{DS} = 9 - 3,06$

$V_{DS} = 5,94\ V$

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

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

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

$V_G = 1,95\ V$

$V_{GS} = V_G - V_S$

$= 1,95 - 3,06$

$= -1,11\ V$

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

$4,5\ mA = 8\ mA\left(1 - \frac{-1,11\ V}{V_P}\right)^2$

$4,5 = 8\left(1 + \frac{111}{100V_P}\right)^2$

$4,5 = 8\left(\frac{100V_P + 111}{100V_P}\right)^2$

$4,5 = 8\ \frac{(100V_P + 111)^2}{10000V_P^2}$

$5625V_P^2 = 80000V_P^2 + 22200V_P + 12321$

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

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

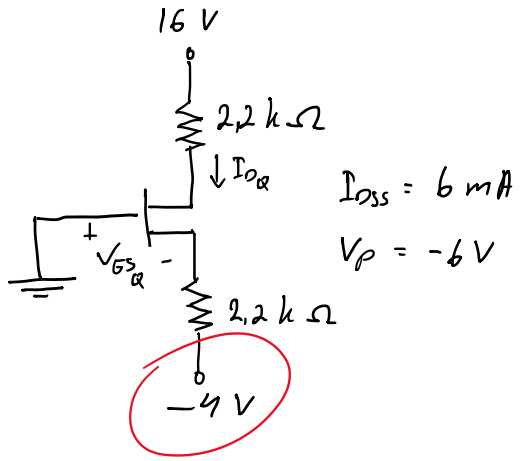
$V_{P_1} = -0,63\ V$

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

$(V_P \leq V_{GS_Q})$

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

15.




Common Gate

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

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

$V_{GS} = -(-4) - I_D \cdot 2,2k\Omega$

$V_{GS} = 4 - I_D \cdot 2,2k$

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

$I_D = 6mA\left(1 - \frac{4 - 2200 I_D}{-6}\right)^2$

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

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

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

$1500 I_D = 25 - 11000 I_D + 1100^2 I_D^2$

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

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

$I_{D_1} = 7,62\ mA$

$I_{D_2} = 2,71\ mA$

$I_{DQ} < I_{DSS} \Rightarrow I_{DQ} = 2,71\ mA$

$V_{GS_Q} = 4 - 2,71\ mA \cdot 2,2k\Omega$

$= -1,962\ V$

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

$= 16 - (-4) - 2,71\ mA(2,2k + 2,2k)$

$= 20 - 11,924$

$= 8,076\ V$

$V_S = I_D R_S$

$= 2,71\ mA \cdot 2,2k\Omega$

$= 5,962\ V$