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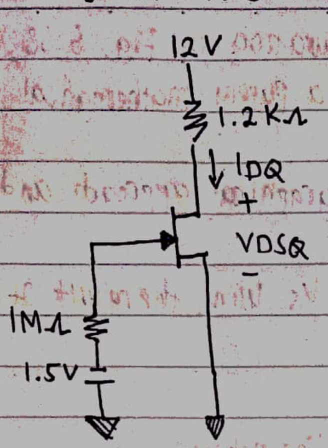
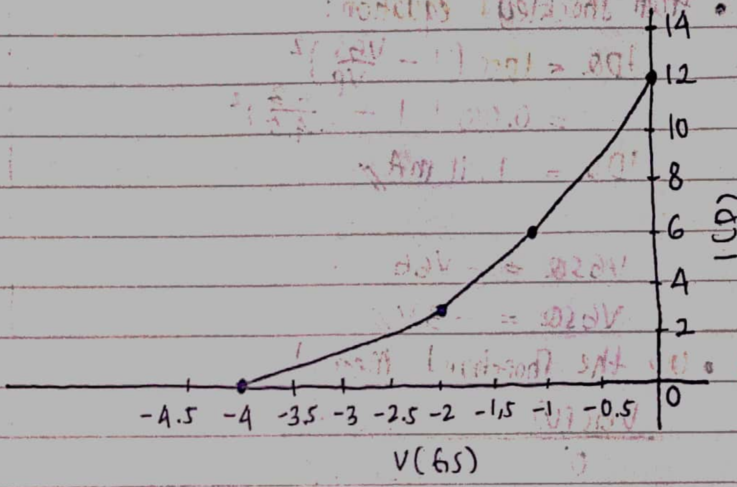


$I_{DSS} = 12\ mA$
$V_P = -4V$

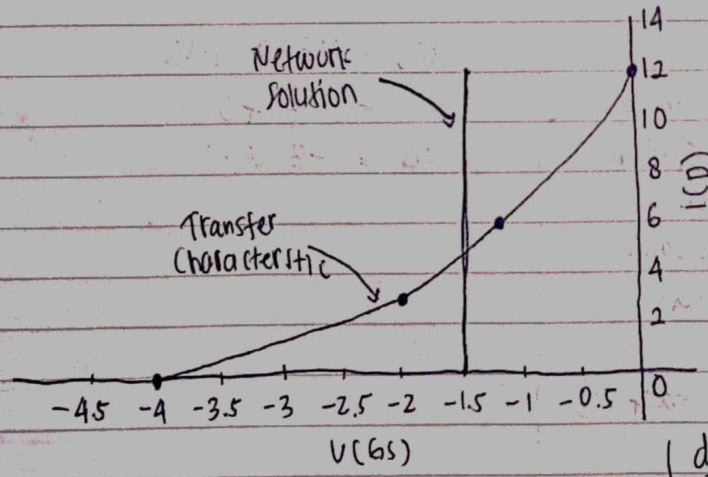
for the fixed-bias configuration of Fig. 6.67
a.) sketch the transfer characteristics of the device
b.) superimpose the network equation on the same graph.
c.) Determine I_{DQ} and V_{DSQ}
d.) Using Shockly's equation, solve for I_{DQ} and then find V_{DSQ}, compare with the solution of part c.

a.) • Use the shorthand method

V_{GS} (V)	I_D (mA)
0	$I_{DSS} = 12$
$0.3 V_P = -1.2$	$\frac{I_{DSS}}{2} = 6$
$0.5 V_P = -2$	$\frac{I_{DSS}}{4} = 3$
$V_P = -4$	0



b.) • for the given network, $V_{GS} = 1,5$ V, therefore



c.) from the intersection on figure 2

$I_{DQ} = 4{,}7\ mA$ //

for the given network, V_{DSQ} is given by

$V_{DSQ} = V_{DD} - I_{DQ} \cdot R_D$

$= 12 - 4.7 \times 1.2$

$V_{DSQ} = 6.36\ V$ //

d.) Recall Shockley's equation

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

$= 0{,}012 \left(1 - \frac{-1.5}{-4}\right)^2$

$I_{DQ} = 4.6875\ mA$ // → almost same as part c

Since V_{DSQ} is given by,

$V_{DSQ} = V_{DD} - I_{DQ} \cdot R_D$

$= 12 - 4.6875 \times 1.2$

$V_{DSQ} = 6.375\ V$ //

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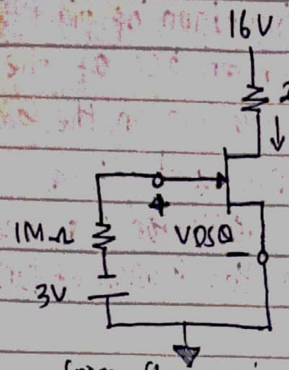


for the fixed-bias configuration of Fig. 6.68, Det:

a.) I_{DQ} and V_{GSQ} using a purely mathematical approach

b.) Repeat part (a) using a graphical approach and compare result.

c.) find V_{DS}, V_D, V_G, and V_S using the result of part (a)

$I_{DSS} = 10\,mA$

$V_P = -4.5V$

→ • from Shockley's equation:

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

$= 0.010\left(1 - \frac{-3}{-4.5}\right)^2$

$I_{DQ} = 1.11\,mA$ //

$V_{GSQ} = -V_{GG}$

$V_{GSQ} = -3V$ //

b.) • use the shorthand method

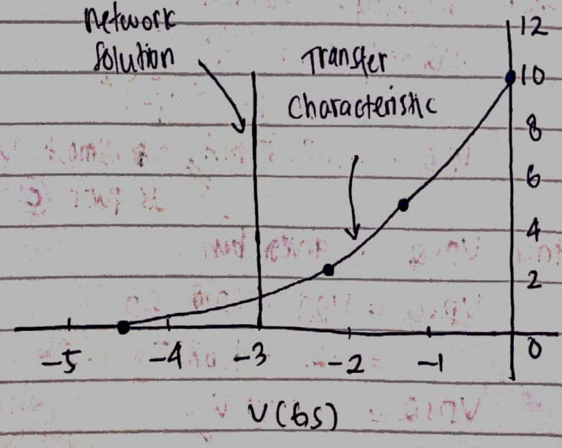
V_{GS} (V)	I_D (mA)
0	$I_{DSS} = 10$
$0.3V_P = -1.35$	$\frac{I_{DSS}}{2} = 5$
$0.5V_P = -2.25$	$\frac{I_{DSS}}{4} = 2.5$
$V_P = -4.5$	0

Sketch the transfer characteristics curve using the evaluated data with the network solution superimposed, from the sketched curve,

$I_{DQ} = 1{,}15\,mA$ → almost the same as part (a)

$V_{GSQ} = -V_{GG}$

$V_{GSQ} = -3V$ → the same as part (a)



c.) • from the network,

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

$= 16 - (1.11 \times 10^{-3})(2200)$

$V_{DS} = 13.56\,V$ //

Since the source is connected to the ground, thus $V_S = 0\,V$ //

$V_D = V_{DS} + V_S$

$= 13.56 + 0$

$V_D = 13.56\,V$ //

$V_G = V_{GSQ} + V_S$

$= -3 + 0$

$V_G = -3\,V$ //

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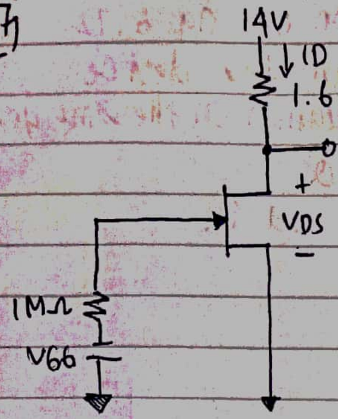

$I_{DSS} = 8\,mA$

$V_P = -4V$

Given the measured value of V_D in fig. 6.69,

a.) I_D

b.) V_{DS}

c.) V_{GG}

a.) $I_D = \dfrac{V_{DD} - V_D}{R_D} = \dfrac{14 - 9}{1600} = 3.125\,mA$ //

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

Since $V_S = 0\,V$ as it is connected to the ground,

$V_{DS} = 6 - 0$

$V_{DS} = 6V$ //

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

$3.125 \times 10^{-3} = 0{,}008\left(1 - \dfrac{V_{GS}}{-4}\right)^2$

$V_{GS} = -1{,}5\,V$

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

$V_{GG} = 1.5V$ //

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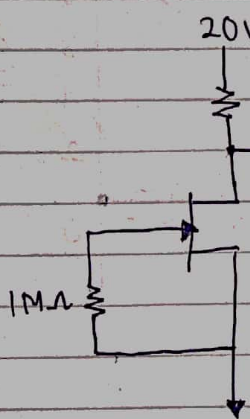


$I_{DSS} = 5\,mA$

$V_P = -5V$

Determine V_D for the fixed-bias configuration of fig. 6.70.

$V_{GS} = 0$

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

$= 0{,}005\left(1 - \dfrac{0}{-5}\right)^2$

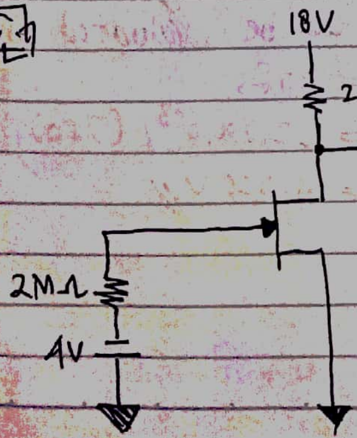
$= 5\,mA$ //

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

$= 20 - (0{,}005)(2200)$

$V_D = 9V$ //

5.



$I_{DSS} = 8\,mA$

$V_P = 4V$

Determine V_D for the fixed-bias configuration of fig. 6.71.

$V_{GS} = -4V$

Since $V_{GS} \leq V_P$, $I_D = 0\,mA$

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

$= 18 - (0) \cdot (2000)$

$V_D = 18\,V$ //

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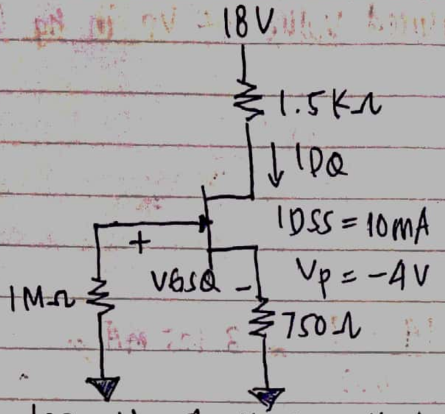
6.1 For the self-bias configuration of fig. 6.72

a.) Sketch the transfer curve for the device

b.) Superimpose the network equation on the same graph

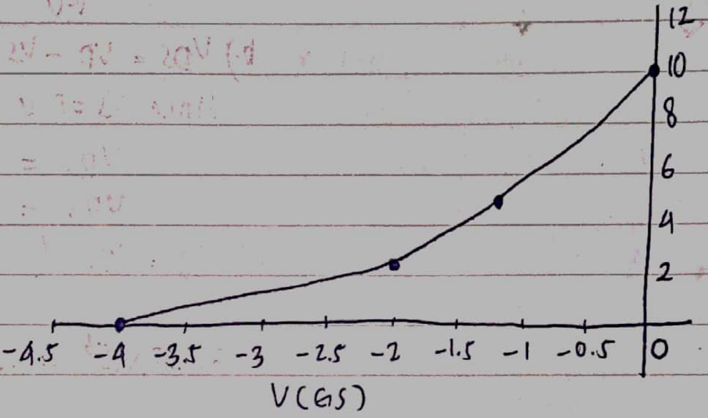
c.) Determine I_{DQ} and V_{GSQ}

d.) Calculate V_{DS}, V_D, V_G, and V_S



a.) Use the shorthand method

V_{GS} (V)	I_D (mA)
0	$I_{DSS} = 10$
$0.3V_P = -1.2$	$\frac{I_{DSS}}{2} = 5$
$0.5V_P = -2$	$\frac{I_{DSS}}{4} = 2.5$
$V_P = -4$	0



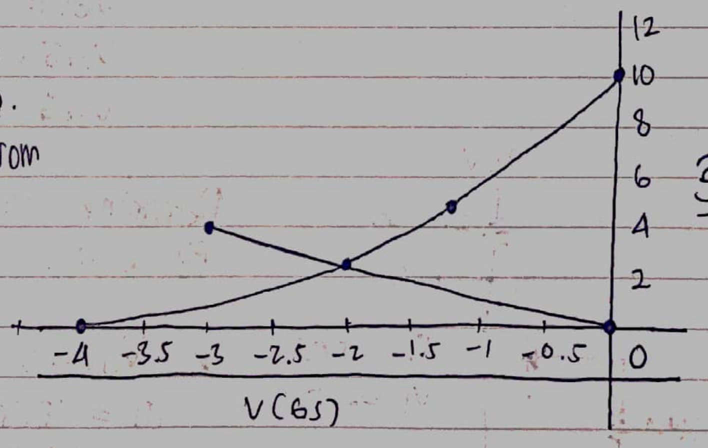
b.) For the given network, the network equation line can be defined by two points, first of which is the origin. The seconds point can be evaluated from the network equation,

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

for $I_D = 4\,mA$,

$$V_{GS} = -(0.004)(750)$$

$$= -3V$$



c.) From the intersection on figure 2,

$$I_{DQ} = 2,7\,mA$$

$$V_{GSQ} = -1,9\,V$$

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

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

$= (18 - (2.7\times10^{-3})(1500)) - ((2.7\times10^{-3})(750))$

$V_{DS} = 11,925\,V$

$V_D = V_{DD} - I_D R_D$

$= 18 - (2,7\times10^{-3})(1500)$

$V_D = 13,95\,V$

• Since $I_G = 0$, thus

$V_G = 0\,V$

while V_S can be evaluated as,

$V_S = I_D R_S$

$= (2,7\times10^{-3})(750)$

$V_S = 2,025\,V$

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7.1) Determine IDQ for the network of fig. 6.72 using a purely mathematical approach. That is, establish a quadratic equation for ID and choose the solution compatible with the network characteristics. Compare to the solution obtained in problem 6.

- Recall Shockley's equation,

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

Since $V_{GS} = -I_D R_S$, therefore,

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

$$= 0{,}010\left(1 + \frac{750 I_D}{-4}\right)^2$$

Solve the equation for I_D,

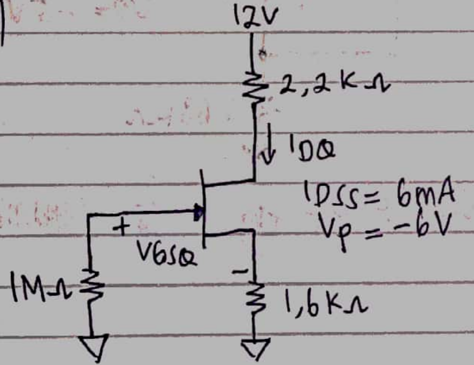
$I_D = 2{,}609$ mA, OR $I_D = 10{,}9$ mA

$I_{DQ} = 2{,}609$ mA, very close to 2,7 mA calculated in Problem 6.

8.1) For the network of Fig. 6.73. determine

a.) V_{GSQ} and I_{DQ}

b.) V_{DS}, V_D, V_G, and V_S



a.) $V_{GS} = V_G - V_S$

$V_{GS} = 0 - (1{,}6 I_D + 3)$

$V_{GS} = -1{,}6 I_D - 3$

$$I_D = -\frac{V_{GS} + 3}{1{,}6} \quad \ldots (1)$$

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

$$-\frac{V_{GS}+3}{1{,}6} = 6\left(1 - \frac{V_{GS}}{-6}\right)^2$$

$$-\frac{5}{8}V_{GS} - \frac{15}{8} = 6 + 2V_{GS} + \frac{V_{GS}^2}{6}$$

$$\frac{V_{GS}^2}{6} + \frac{21}{8}V_{GS} + \frac{63}{8} = 0$$

Solving this quadratic equation,

$V_{GS} = -4{,}03$ V, OR $V_{GS} = -11{,}72$ V (rejected < V_P)

$V_{GSQ} = -4{,}03$ V

Substituting the value of V_{GSQ} in Eq. (1) gives.

$$I_{DQ} = -\frac{V_{GSQ} + 3}{1{,}6}$$

$$I_{DQ} = -\frac{-4{,}03 + 3}{1{,}6} = 643{,}75\ \mu A$$

Thus, $V_{GSQ} \approx -4$ V

$I_{DQ} \approx 0{,}644$ mA

b.) $V_D = 12 - 2{,}2 I_{DQ}$

$= 12 - 2{,}2 \times 0{,}644 = 10{,}583$ V

$V_S = 1{,}6 I_D + 3$

$= 1{,}6 \times 0{,}644 + 3 = 4{,}03$ V

Therefore,

$V_{DS} = V_D - V_S$

$= 10{,}583 - 4{,}03$

$= 6{,}553$ V

$V_G = 0$

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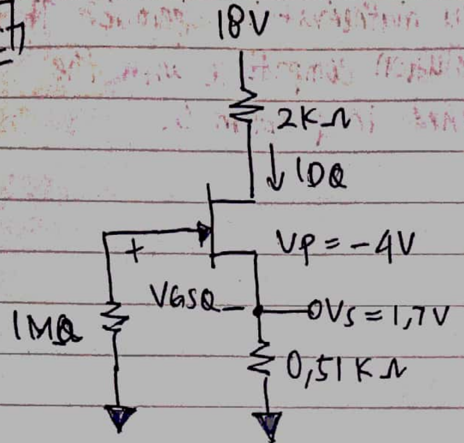


Given the measurement $V_S = 1{,}7V$, for the network of fig. 6.74, determine.
a.) I_{DQ}
b.) V_{GSQ}
c.) I_{DSS}
d.) V_D
e.) V_{DS}

a.) $V_S = I_{DQ} . R_S$
$1{,}7 = I_{DQ}(510)$
$I_{DQ} = 3{,}33 \text{ mA}$

b.) $V_{GSQ} = V_G - V_S$
while $V_G = 0$ V, therefore,
$V_{GSQ} = -V_S$
$V_{GSQ} = -1{,}7V$ //

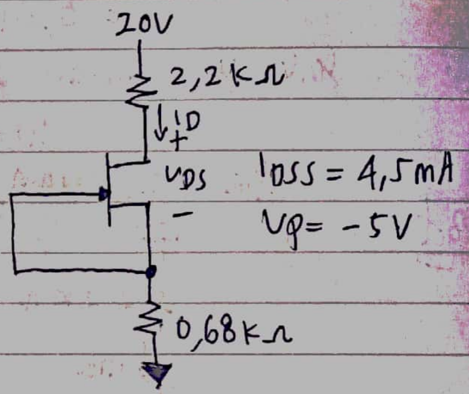
c.) $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$

$3{,}33 \times 10^{-3} = I_{DSS}\left(1 - \frac{-1{,}7}{-4}\right)^2$
$I_{DSS} = 10{,}07 \text{ mA}$ //

d.) $V_D = V_{DD} - I_D R_D$
$= 18 - (3{,}33 \times 10^{-3} \times 2000)$
$V_D = 11{,}34 V$ //

e.) $V_{DS} = V_D - V_S$
$= 11{,}34 - 1{,}7$
$V_{DS} = 9{,}64 V$ //

10.



$I_{DSS} = 4{,}5mA$
$V_P = -5V$

for the network of fig. 6.75, determine
a.) I_D
b.) V_{DS}
c.) V_D
d.) V_S

a.) The gate terminal of the device is directly connected to the source terminal, thus $V_{GS} = 0$
$I_D = I_{DSS} = 4{,}5 \text{ mA}$ //

b.) Applying KVL to the loop that passes through the drain and source terminals gives

$20 = 2{,}2 I_D + V_{DS} + 0{,}68 I_D - 4$
$20 = 2{,}2 \times 4{,}5 + V_{DS} + 0{,}68 \times 4{,}5 - 4$
$V_{DS} = 11{,}04 V$ //

OR

$V_{DS} = V_D - V_S$
$= 10{,}1 - (-0{,}94)$
$= 11{,}04 V$ //

c.) $V_D = 20 - 2{,}2 I_D$
$= 20 - 2{,}2 \times 4{,}5$
$V_D = 10{,}1 V$ //

d.) $V_S = 0{,}68 I_D - 4$
$= 0{,}68 \times 4{,}5 - 4$
$V_S = -0{,}94 V$ //

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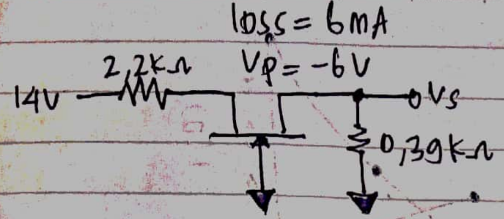
11.1

find V_S for the network of Fig. 6.76.

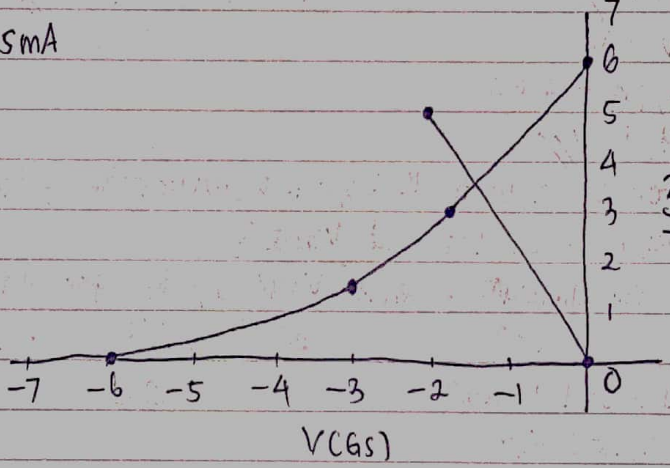


V_{GS} (V)	I_D (mA)
0	$I_{DSS} = 6$
$0,3V_P = -1,8$	$\frac{I_{DSS}}{2} = 3$
$0,5V_P = -3$	$\frac{I_{DSS}}{4} = 1,5$
$V_P = -6$	0

$V_{GS} = -I_D R_S$; for $I_D = 5mA$

$V_{GS} = -(0,005)(390)$

$V_{GS} = -1,95V$



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

$V_{GSQ} = -1,4V$

$V_S = V_G - V_{GS}$

$= 0 - (-1,4)$

$V_S = 1,4V$ //

12.1

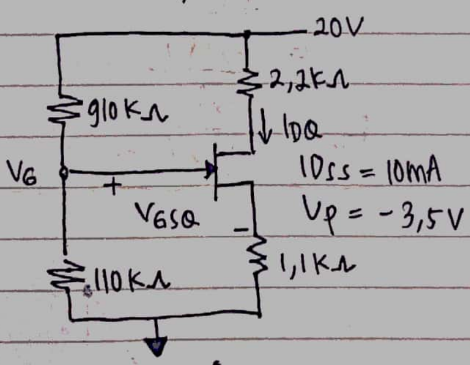
for the network of Fig. 6.11, Determine:

a.) V_G

b.) I_{DQ} and V_{GSQ}

c.) V_D and V_S

d.) V_{DSQ}



• from Voltage division at gate,

a.) $$V_G = \frac{110 \times 10^3}{110 \times 10^3 + 910 \times 10^3}(20)$$

$V_G = 2,157 \ V$ //

b.)

V_{GS} (V)	I_D (mA)
0	$I_{DSS} = 10$
$0,3V_P = -1,05$	$\frac{I_{DSS}}{2} = 5$
$0,5V_P = -1,75$	$\frac{I_{DSS}}{4} = 2,5$
$V_P = -3,5$	0

from the network equation,

$V_{GS} = V_G - I_D R_S$

$= 2,157 - 1100 \ I_D$ ... ①

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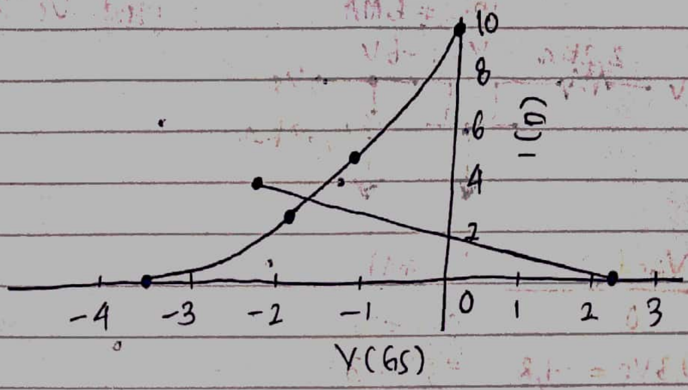
- for $I_D = 0\,mA$
  $\rightsquigarrow V_{GS} = 2{,}157 - 1100\,(0)$
  $= 2{,}157\ V$ //
- for $I_D = 4\,mA$
  $\rightsquigarrow V_{GS} = 2{,}157 - (1100)(0{,}004)$
  $= -2{,}243\ V$ //



$I_{DQ} = 3{,}3\ mA$ // $V_{GSQ} = -1{,}5\ V$ //

c.) $V_D = V_{DD} - I_D R_D$
$= 20 - (0{,}0033)(2200)$
$V_D = 12{,}74\ V$ //

$V_S = I_D R_S$
$= (0{,}0033)(1100)$
$V_S = 3{,}63\ V$ //

d.) $V_{DS} = V_D - V_S$
$= 12{,}74 - 3{,}63$
$V_{DSQ} = 9{,}11\ V$ //

13. a.) repeat problem 12 with $R_S = 0{,}51\,k\Omega$ (about 50% of the value of 12). what is the effect of a smaller R_S on I_{DQ} and V_{GSQ}?
b.) what is the minimum possible value of R_S for the network of fig. 6.77?

$\rightsquigarrow$ a.) $V_G = \dfrac{110 \times 10^3}{110 \times 10^3 + 910 \times 10^3}\,(20)$

$V_G = 2{,}157\ V$ //

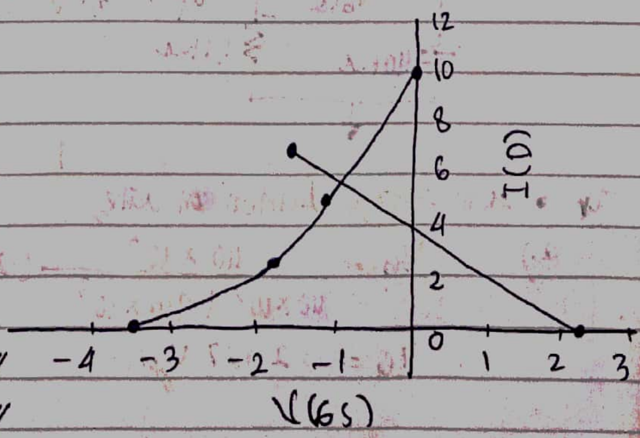
V_{GS} (V)	I_D (mA)
0	$I_{DSS} = 10$
$0{,}3V_P = -1{,}05$	$\frac{I_{DSS}}{2} = 5$
$0{,}5V_P = -1{,}75$	$\frac{I_{DSS}}{4} = 2{,}5$
$V_P = -3{,}5$	0

b.) $R_S = \dfrac{V_S}{I_{DSS}}$; since $V_{GS} = 0$ at $I_D = I_{DSS}$ from Shockley's equation, therefore,

$R_S = \dfrac{V_G}{I_{DSS}}$
$= \dfrac{2{,}157}{0{,}01}$
$R_S = 215{,}7\ \Omega$ //

$V_{GS} = V_G - I_D R_S$
$= 2{,}157 - 510\,I_D \ldots (1)$

- for $I_D = 0\,mA$ $\rightsquigarrow V_{GS} = 2{,}157 - (0)(510)$
  $= 2{,}157\ V$
- for $I_D = 7\,mA$ $\rightsquigarrow V_{GS} = 2{,}157 - (0{,}007)(510)$
  $= -1{,}413\ V$



$I_{DQ} = 5{,}8\ mA$ (increased to almost the double) //
$V_{GSQ} = -0{,}85\ V$ (Decreased to almost the half) //

$V_D = V_{DD} - I_D R_D$
$= 20 - (0{,}0058)(2200)$
$V_D = 7{,}24\ V$ //

$V_S = I_D R_S$
$= (0{,}0058)(510)$
$V_S = 2{,}958\ V$ //

$V_{DS} = V_D - V_S$
$= 7{,}24 - 2{,}958$
$V_{DSQ} = 4{,}282\ V$ //

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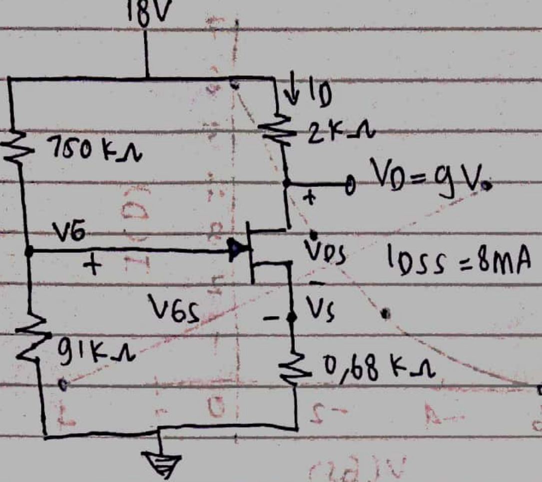
14.)



for the network of Fig. 6.78, $V_D = 9V$.

a.) I_D
b.) V_S and V_{DS}
c.) V_G and V_{GS}
d.) V_P

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

$= \frac{18 - 9}{2000} = 4,5 mA$ //

b.) $V_S = I_D R_S$

$= (0,0045)(750)$

$= 3,375\ V$ //

$V_{DS} = V_D - V_S$

$= 9 - 3,375$

$= 5,625\ V$ //

c.) $V_G = \frac{91 \times 10^3}{91 \times 10^3 + 750 \times 10^3} (18)$

$V_G = 1,947\ V$ //

$V_{GS} = V_G - V_S$

$= 1,947 - 3,375$

$= -1,428\ V$ //

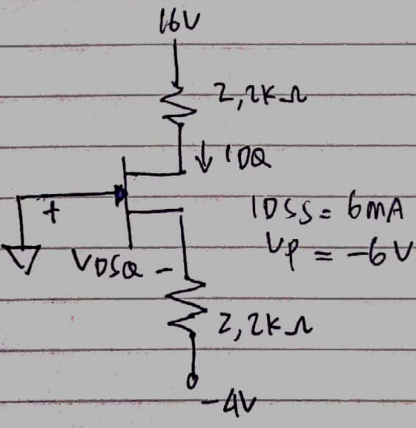
d.) $I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2$

$0,0045 = 0,008 \left(1 - \frac{-1,428}{V_P}\right)^2$

$V_P = \frac{-11 + \sqrt{73}}{3} V \vee V_P = \frac{-11 - \sqrt{73}}{3} V$

$= -0,818\ V$ // $\quad = -6,514 V$

15.)



for the network of Fig. 6.79, determine

a.) I_{DQ} and V_{GSQ}
b.) V_{DS} and V_S

V_{GS} (V)	I_D (mA)
0	$I_{DSS} = 6$
$0,3 V_P = -1,8$	$\frac{I_{DSS}}{2} = 3$
$0,5 V_P = -3$	$\frac{I_{DSS}}{4} = 1,5$
$V_P = -6$	0

$V_{GS} = V_G - (V_{SS} + I_D R_S)$

$= 0 - (-4 + 2200 I_D)$

$= 4 - 2200 I_D$ ... (1)

- for $I_D = 0 mA \Rightarrow V_{GS} = 4 - (0)(2200)$
  $= 4V$
- for $I_D = 4mA \Rightarrow V_{GS} = 4 - (0,004)(2200)$
  $= -4,8 V$

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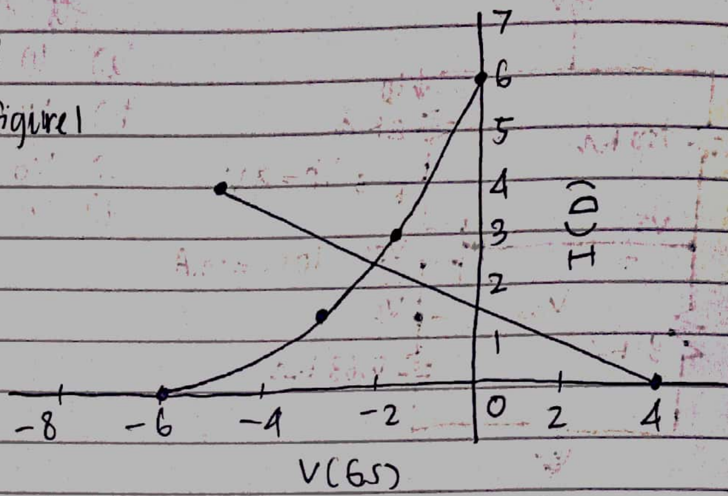
No.

Date :

- Sketch the transfer curve with the network equation superimposed on the same graph, from the intersection on figure 1



$I_{DQ} = 2{,}7\ mA$

$V_{GSQ} = -2V$

b.) $V_S = V_{SS} + I_D R_S$

$= -4 + (0{,}0027)(2200)$

$= 1{,}94\ V$

$V_{DS} = V_D - V_S$

$= (V_{DD} - I_D R_D) - V_S$

$= (16 - 0{,}0027 \times 2200) - 1{,}94$

$= 8{,}12\ V$