Ch.8 Homework problems

JFET

[7] $V_{GS(off)} = -8^V$, $I_{DSS} = 10mA$, $V_{GS}=0$ & $V_{DS} > V_p \rightarrow I_D = ??$

$V_p = -V_{GS(off)} = 8^V$

$\because$ at $V_{GS}=0$ and $V_{DS} > V_p \rightarrow I_D = I_{DSS}$

$\therefore$ $\boxed{I_D = 10\ mA}$

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[9] $V_{GS(off)} = -4V$, $V_{DD} \uparrow$ untill I_D is steady state $\rightarrow V_{DS} = ??$

as $V_{DD} \uparrow$, $V_{DS} \uparrow$ and $I_D \uparrow$

when $V_{DS} = V_p = -V_{GS(off)} = 4^V \rightsquigarrow I_D$ is saturated as I_{DSS}

$\therefore$ $\boxed{V_{DS} = 4^V}$

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[12] $g_{m0} = 3200\mu S$, $V_{GS(off)} = -8^V$; $g_m = ??$ at $V_{GS} = -4V$

$$\because \quad g_m = g_{m0}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)$$

$$= 3200\mu\left[1 - \frac{-4}{-8}\right]$$

$$= 3200\mu * 0.5 = \boxed{1600\ \mu S}$$

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[13] $V_{GS(off)} = -7V$, $g_{m0} = 2000\mu S$; g_m & $g_{fs} = ??$ at $V_{GS} = -2^V$

$$g_m = g_{m0}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right) = 2000\left(1 - \frac{-2}{-7}\right)$$

$\therefore$ $g_m = 1428.6\ \mu S$

$\boxed{g_{fs} = g_m = 1428.6\ \mu S}$

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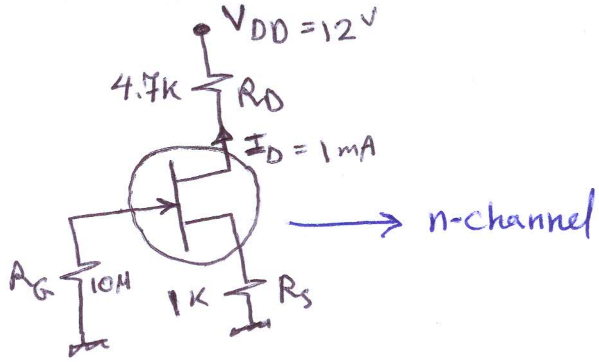
a) $V_G = 0$

$V_S = I_D R_S = 1mA * 1k\Omega$

$= 1V$



∴ $V_{GS} = V_G - V_S = 0 - 1$

∴ $\boxed{V_{GS} = -1\,V}$

∵ $V_D = V_{DD} - I_D R_D = 12 - 1mA * 4.7K = 7.3\,V$

∴ $V_{DS} = V_D - V_S = 7.3 - 1$ ∴ $\boxed{V_{DS} = 6.3\,V}$

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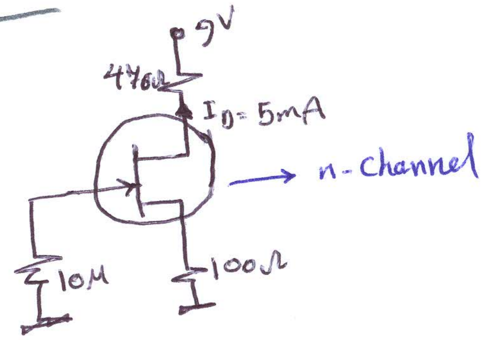
b) $V_{GS} = V_G - V_S$

$= -V_S = -I_D R_S$

$= -5mA * 100 = -5*10^{-3}*100$

∴ $\boxed{V_{GS} = -0.5\,V}$



$V_{DS} = V_D - V_S$

$= V_{DD} - I_D(R_D + R_S) = 9 - 5mA(470 + 100) = 9 - 2.85$

∴ $\boxed{V_{DS} = 6.15\,V}$

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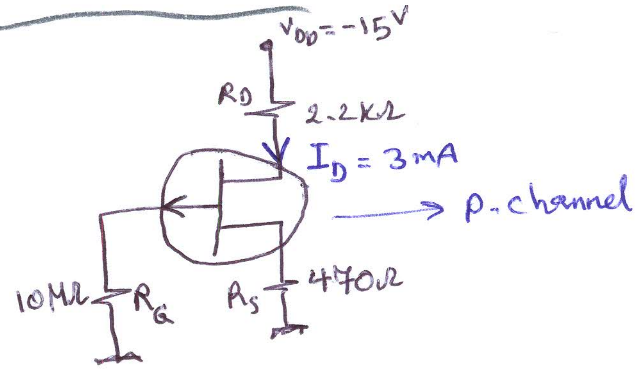
c) $V_G = 0$

$V_S = -I_D R_S$

$= -3*10^{-3}*470$

$= -1.41\,V$



∵ $V_{GS} = V_G - V_S$ ∴ $\boxed{V_{GS} = 1.41\,V}$

$V_D = V_{DD} + I_D R_D$

$= -15 + 3mA * 2.2K = -8.4\,V$

∵ $V_{DS} = V_D - V_S$

$= -8.4 + 1.41$

∴ $\boxed{V_{DS} = -6.99\,V}$

21 from the graph:

at $I_D = 9.5\,mA \rightarrow V_{GS} \simeq -2^V$

$$\therefore \quad R_S = \left| \frac{V_{GS}}{I_D} \right| = \left| \frac{-2}{9.5\,mA} \right| \simeq \underline{210.53\ \Omega}$$

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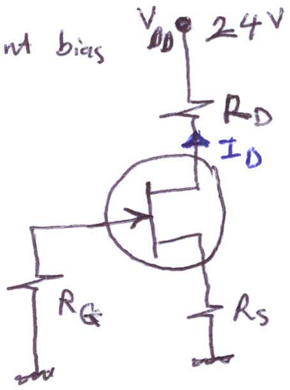
22 $I_{DSS} = 14\ mA$, $V_{GS(off)} = -10^V$, set up a midpoint bias



for midpoint bias:

$$I_D = \frac{1}{2} I_{DSS} \quad \therefore \boxed{I_D = 7\,mA}$$

$$V_{GS} = \frac{V_{GS(off)}}{3.4} \quad \therefore \boxed{V_{GS} = -2.94\,V}$$

$$V_D = \frac{V_{DD}}{2} = \frac{24}{2} \quad \therefore V_D = 12\ V$$

$$\because \quad V_G = 0 \quad \therefore V_S = -V_{GS} = 2.94^V$$

$$\therefore \quad V_{DS} = V_D - V_S = 12 - 2.94 \quad \therefore \boxed{V_{DS} = 9.06\ V}$$

$$R_S = \left| \frac{V_{GS}}{I_D} \right| = \left| \frac{-2.94}{7\ mA} \right| \quad \therefore \boxed{R_S = 420\,\Omega}$$

$$\because \quad V_D = V_{DD} - I_D R_D \quad \therefore R_D = \frac{V_{DD} - V_D}{I_D} = \frac{24 - 12}{7\ mA}$$

$$\therefore \boxed{R_D \simeq 1.71\ K\Omega}$$

and R_G any large resistance Let $\boxed{R_G = 10\ M\Omega}$

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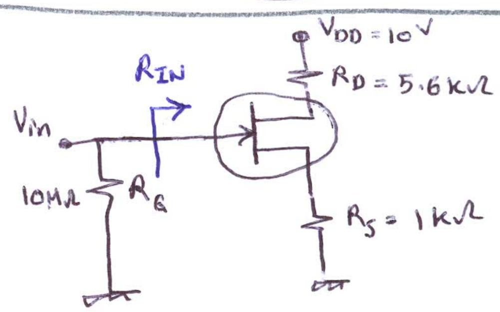
23 $I_{GSS} = 20\ nA$ at $V_{GS} = -10^V$



$$R_{IN(tot)} = R_G // R_{IN}$$

$$\because \quad R_{IN} = \left| \frac{V_{GS}}{I_{GSS}} \right| = \left| \frac{-10}{20\ nA} \right| = 0.5\ G\Omega$$

or $\quad R_{in} = 500\ M\Omega$

$$\therefore \quad R_{IN(tot)} = 10M // 500\Omega = \frac{10 * 500}{10 + 500} \quad \therefore \boxed{R_{IN(tot)} \simeq 9.8\ M\Omega}$$

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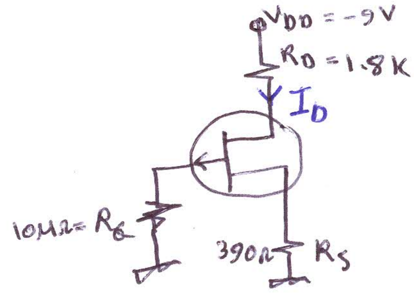


$\because V_G = 0, \quad V_S = -I_D R_S$

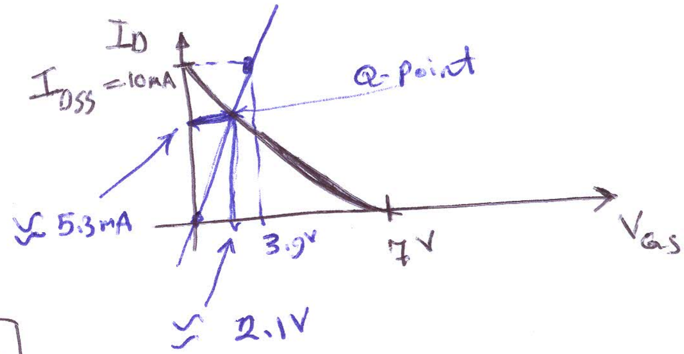
$\therefore V_{GS} = +I_D R_S$

at $I_D = 0$

$\therefore V_{GS} = 0 * (390) = 0$

at $I_D = I_{DSS} = 10mA$

$V_{GS} = 10mA(390\Omega) = 3.9^V$



$\therefore$ the Q-point is: (from graph)

$V_{GS} \simeq 2.1^V$ and $I_D \simeq 5.3\ mA$

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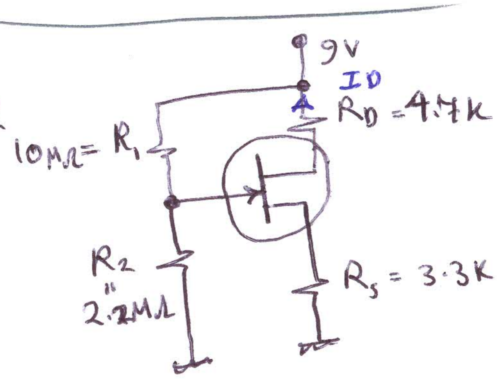
$V_D = 5^V$, determine the Q-point ??
↳ I_D & V_{GS} ??



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

$\therefore I_D = \frac{V_{DD} - V_D}{R_D} = \frac{9-5}{4.7K}$

$\therefore I_D \simeq 0.851\ mA$

$V_G = V_{DD}\left(\frac{R_2}{R_1+R_2}\right) = 9\left(\frac{2.2}{12.2}\right) \quad \therefore V_G \simeq 1.623\ V$

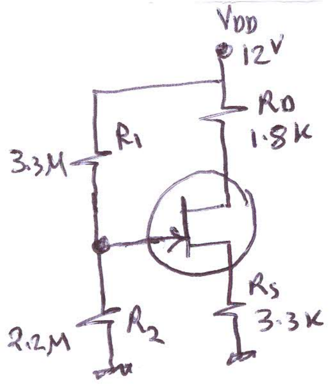
$V_S = I_D R_S = (0.851\ mA) * (3.3\ k\Omega) \quad \therefore V_S \simeq 2.81\ V$

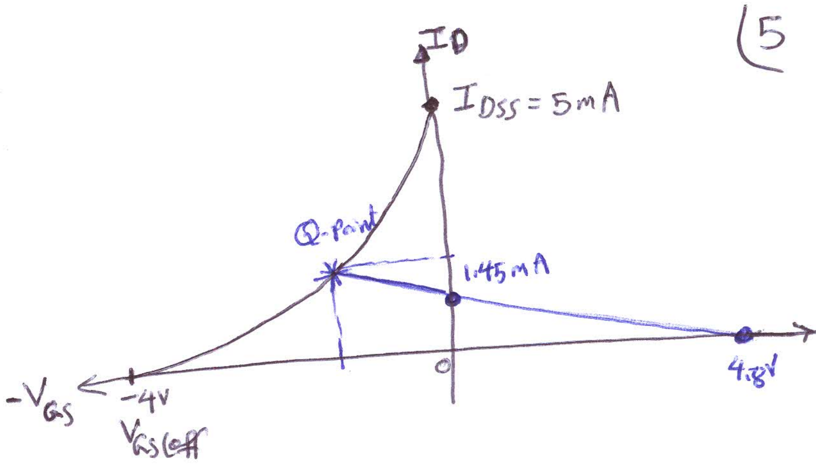
$\therefore V_{GS} = V_G - V_S = 1.623 - 2.81 \quad \therefore V_{GS} = -1.187\ V$

$\therefore$ the Q-point is: $V_{GS} = -1.187\ V$ and $I_D = 0.851\ mA$

[27]

Find Q-Point ??





$$V_G = \left(\frac{R_2}{R_1+R_2}\right) V_{DD} = \frac{2.2}{3.3+2.2}(12) = 4.8^V$$

$$V_S = I_D R_S$$

at $I_D = 0$: $V_S = 0$, $V_G = 4.8$ $\therefore V_{GS} = 4.8^V$

at $V_{GS} = 0$: $\therefore 0 = 4.8 - I_D R_S$ $\therefore I_D = \frac{4.8}{R_S} \simeq 1.45\ mA$

$\therefore$ the Q-point is : (from graph)

$V_{GS} \simeq -1.4\ V$ & $I_D \simeq 2\ mA$

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[29] $V_{DS_1} = 0.4 \rightarrow I_{D_1} = 0.15\ mA$, $V_{DS_2} = 0.6\ V \rightarrow I_{D_2} = 0.45\ mA$;

range of R_{DS} values ??

$$\because R_{DS} = \frac{V_{DS}}{I_D}$$

$$\therefore R_{DS_1} = \frac{0.4}{0.15\ mA} \simeq 2.67\ K\Omega$$

$$R_{DS_2} = \frac{0.6}{0.45\ mA} \simeq 1.33\ K\Omega$$

$\therefore$ the range of R_{DS} values : $1.33 < R < 2.67$ $(K\Omega)$

and

$$\Delta R_{DS} = R_{DS_2} - R_{DS_1} = -1.34\ K\Omega$$

i.e. decreases by 1.34 KΩ

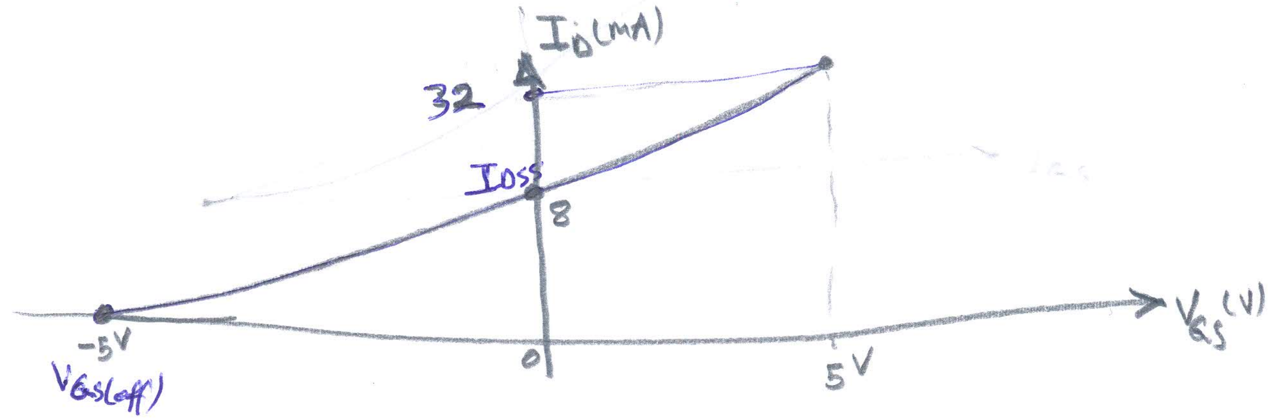
38 $V_{GS(off)} = -5^V$, $I_{DSS} = 8mA$

a) as $V_{GS(off)}$ is $-ve$ $\therefore$ it is a <u>n-channel</u> MOSFET

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

$V_{GS}(V)$	-5	-4	-3	-2	-1	0	1	2	3	4	5
I_D (mA)	0	0.32	1.28	2.88	5.12	8	11.52	15.68	20.48	25.92	32

($V_{GS(off)}$ → -5; I_{DSS} → 8)



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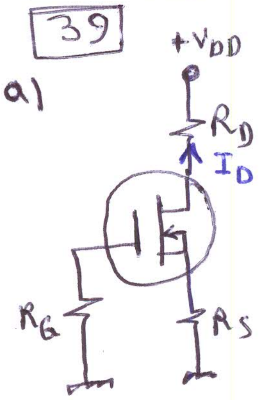
a)



$V_G = 0$ as $I_G = 0$

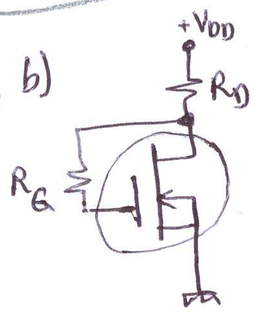
$V_S = I_D R_S$

$\therefore V_{GS} = -I_D R_S$ "-ve"

$\because$ DMOSFET is n-channel

$\therefore$ depletion

b)



$V_{GS} = V_{DS}$ as $I_G = 0$

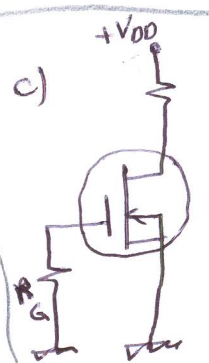
$\because V_{DS} = V_{DD} - I_D R_D > 0$

$\therefore V_{GS}$ is +ve

and DMOSFET is n-channel

$\therefore$ Enhancement mode

c)



$V_G = 0$ as $I_G = 0$

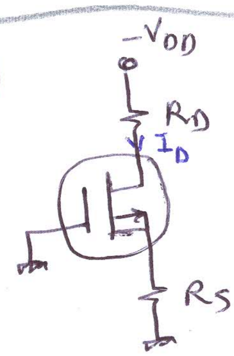
$V_S = 0$

$\therefore V_{GS} = 0$

$\therefore$ neither depletion nor enhancement mode

it is zero biased

d)



$V_G = 0$

$V_S = -I_D R_S$

$\therefore V_{GS} = I_D R_S > 0$

$\therefore V_{GS}$ is +ve and DMOSFET is P-channel

$\therefore$ depletion mode

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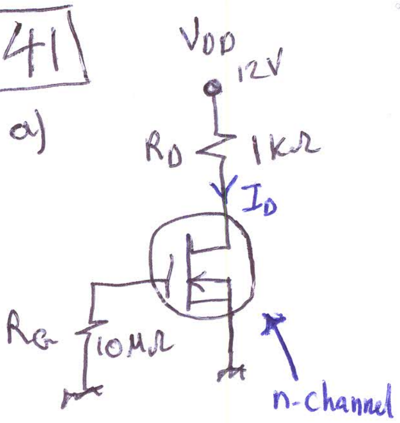
a)



$\because V_{GS} = 0$ as $I_G = 0$

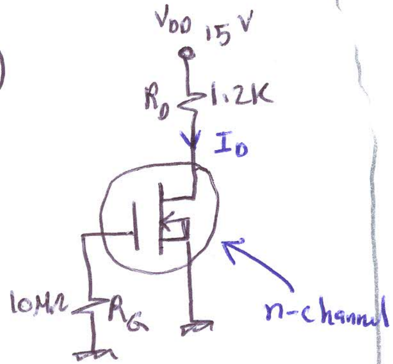
$\therefore I_D = I_{DSS} = 8\,mA$

$\because V_{DS} = V_{DD} - I_D R_S$

$= 12 - (8\,mA)(1\,k\Omega)$

$\therefore \boxed{V_{DS} = 4\,V}$

b)



$V_{GS} = 0$

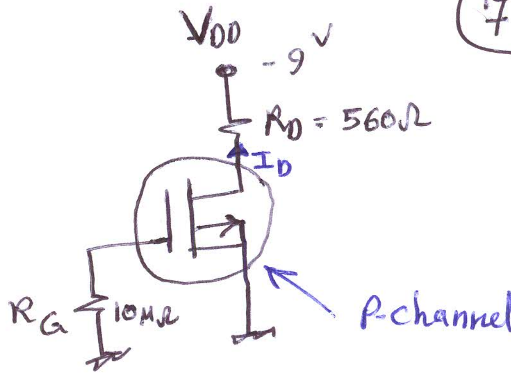
$\therefore I_D = I_{DSS} = 8\,mA$

$\therefore V_{DS} = 15 - (8m * 1.2k)$

$= 15 - 9.6$

$\therefore \boxed{V_{DS} = 5.4\,V}$

c)



$V_{GS} = 0$, $I_D = I_{DS} = 8\,mA$

$\because V_{DS} = V_{DD} + I_D R_S$

$= -9 + (8\,mA)(560\,\Omega)$

$= -9 + (8 * 10^{-3} * 560)$

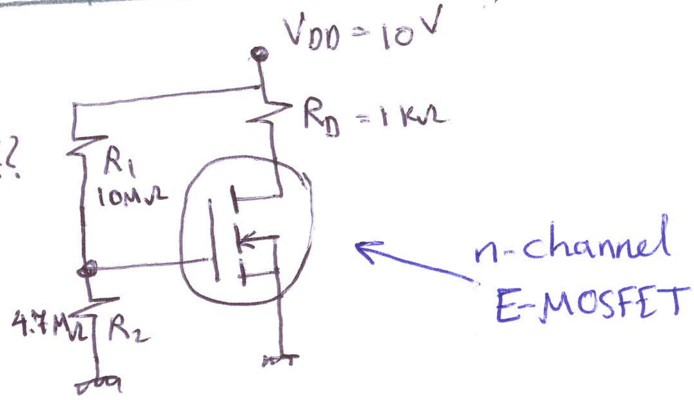
$= -9 + 4.48$

$\therefore \boxed{V_{DS} = -4.52\,V}$

42

a) $I_{D(on)} = 3\,mA$ at $V_{GS} = 4\,V$

$V_{GS(th)} = 2\,V$, $V_{GS}, V_{DS} = ???$



$$V_{GS} = V_{DD}\left(\frac{R_2}{R_1 + R_2}\right)$$

$$= 10\left[\frac{4.7M}{14.7M}\right]$$

$$\therefore \boxed{V_{GS} \simeq 3.197\,V}$$

$$\because I_D = K\left(V_{GS} - V_{GS(th)}\right)^2$$

$$\therefore K = \frac{I_{D(on)}}{\left(V_{GS} - V_{GS(th)}\right)^2} = \frac{3\,mA}{(4-2)^2} = 0.75\,mA/V^2$$

$\therefore$ at $V_{GS} = 3.197$:

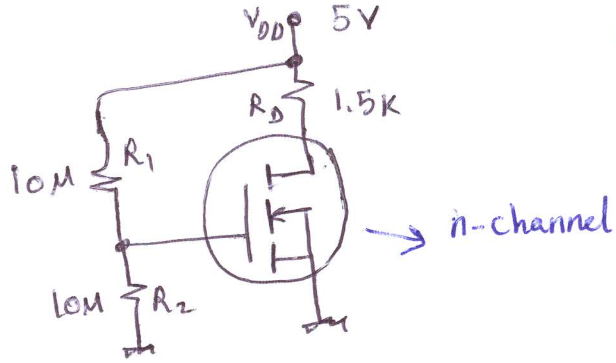
$$I_D = 0.75\,(3.197 - 2)^2 = 1.075\,mA$$

$$\because V_{DS} = V_{DD} - I_D R_D = 10 - (1.075\,mA)(1\,k\Omega)$$

$$\therefore \boxed{V_{DS} = 8.925\,V}$$

42 b) $I_{D(on)} = 2\,mA$ at $V_{GS} = 3V$

$V_{GS(th)} = 1.5V$



$$\therefore V_{GS} = \left(\frac{R_2}{R_1+R_2}\right) V_{DD}$$

$$= \left(\frac{10M}{10M+10M}\right) 5 = \frac{1}{2} * 5$$

$$\therefore \boxed{V_{GS} = 2.5\,V}$$

$$K = \frac{I_{D(on)}}{(V_{GS} - V_{GS(th)})^2} = \frac{2m}{(3-1.5)^2} \simeq 0.89\ mA/V^2$$

$$\therefore I_D = 0.89\,(2.5-1.5)^2 = 0.89\ mA$$

$$\therefore V_{DS} = V_{DD} - I_D R_D = 5 - 0.89m * 1.5K$$

$$\therefore \boxed{V_{DS} = 3.665\ V}$$

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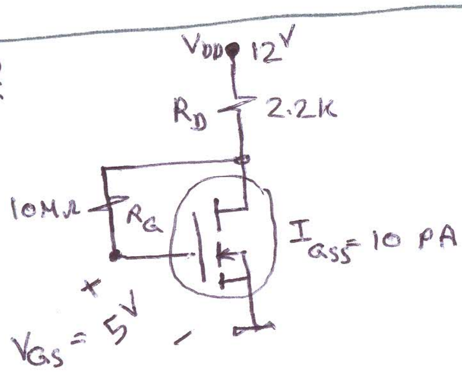
43 I_D, V_{DS} ??

a)



$$\because V_{GS} = V_{DS} - I_{GSS} R_G$$

$$\therefore V_{DS} = 5 + (10*10^{-12})(10*10^{6}) = 5 + 10^{-4}$$

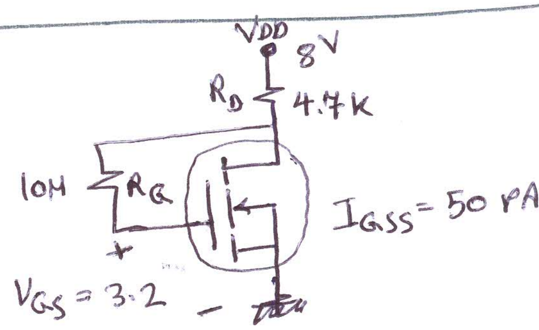
$$\therefore \boxed{V_{DS} = 5.0001\ V}$$

$$\because V_{DS} = V_{DD} - I_D R_D$$

$$\therefore I_D = \frac{V_{DD} - V_{DS}}{R_D} = \frac{12 - 5.0001}{2.2K}$$

$$\therefore \boxed{I_D \simeq 3.182\ mA}$$

b)



$$V_{DS} = V_{GS} + I_{GSS} * R_G$$

$$= 3.2 + (50*10^{-12})(10*10^{6})$$

$$= 3.2 + 5*10^{-4}$$

$$\therefore \boxed{V_{DS} = 3.2005\ V}$$

$$I_D = \frac{V_{DD} - V_{DS}}{R_D} = \frac{8 - 3.2005}{4.7K}$$

$$\therefore \boxed{I_D \simeq 1.02\ mA}$$