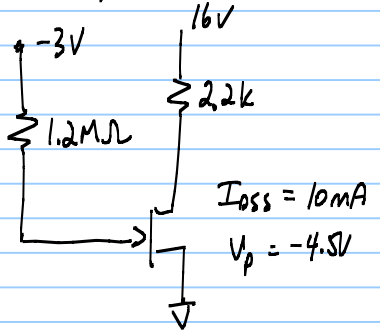
Chapter 7 # 2a, 35-37 (use universal curve to find I_{DQ} & V_{GSQ}. Then find V_{DSQ})

26, 27, 28

Note Title 8/11/2018

2a) For the fixed-bias configuration below find I_{DQ} and V_{GSQ} using a purely mathematical approach.



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

$$= 10mA\left(1 - \frac{-3}{-4.5}\right)^2 = 1.11mA$$

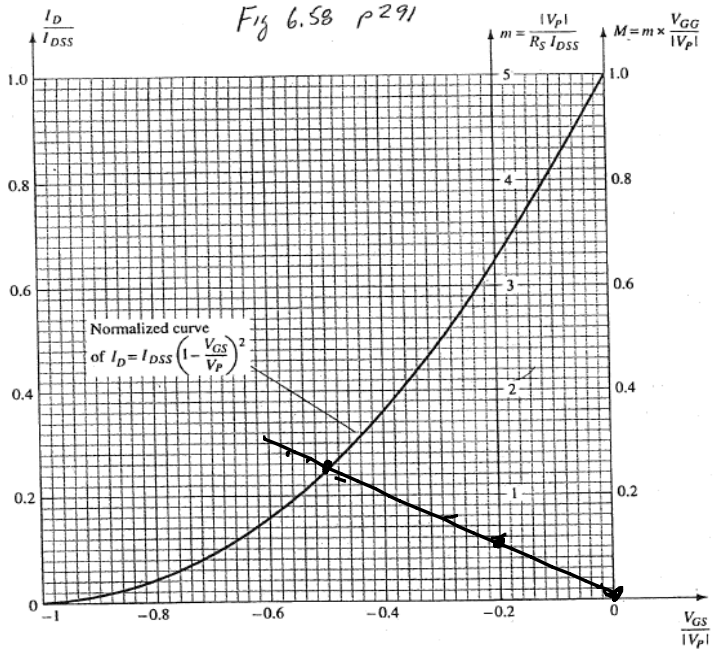
$$V_{DSQ} = 16 - I_{DQ}(2.2k) = +13.6V$$

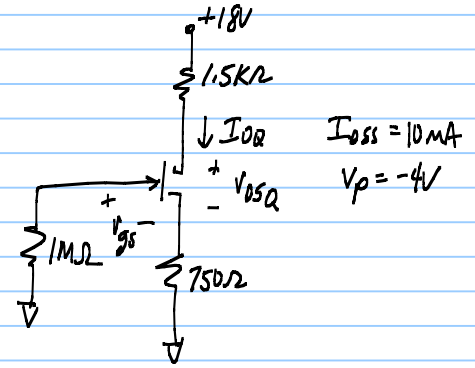
verify in sat: $|V_{DS}| > |V_p| - |V_{GS}|$

$13.6 > 4.5 - 3 = 1.5V$ ✓

35 → #6 w/ universal curve. Find I_{DQ} & V_{GSQ}. Then find V_{DSQ}.

Fig 6.58 p291





$$m = \frac{4}{750 - 10m} = 0.533$$

$$M = 0.533\,\frac{0}{4} = 0$$

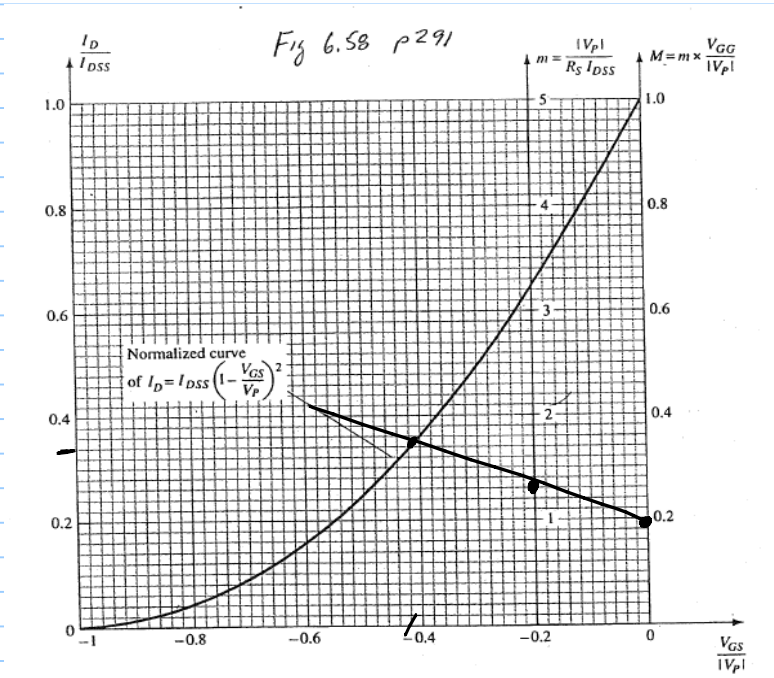
$$\frac{I_D}{I_{DSS}} = 0.26 \qquad I_{DQ} = 2.6mA$$

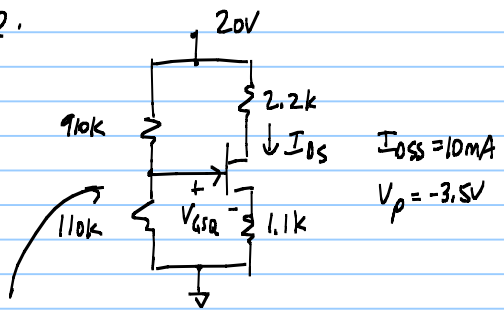
$$\frac{V_{GS}}{|V_p|} = -0.5 \qquad V_{GSQ} = -2V$$

$$V_{DSQ} = 18 - 2.6mA(1.5k + 0.75k) = 12.15V$$

check $|V_{DS}| > |V_p| - |V_{GS}|$ $\quad 12.5 > 4 - 2$ ✓ SAT

36 → #12 w/ universal curve. Find I_{DQ} & V_{GSQ}. Then find V_{DSQ}.





$$V_{GG} = \frac{20(110k)}{910k + 110k} = 2.15V$$

$$m = \frac{3.5V}{(1.1k)(10mA)} = 0.318$$

$$M = 0.318 \quad \frac{(2.15)}{3.5} = 0.195$$

$$I_{DQ} = (0.34)(10mA) = 3.4mA$$

$$V_{GSQ} = (-0.42)(3.5) = -1.47V$$

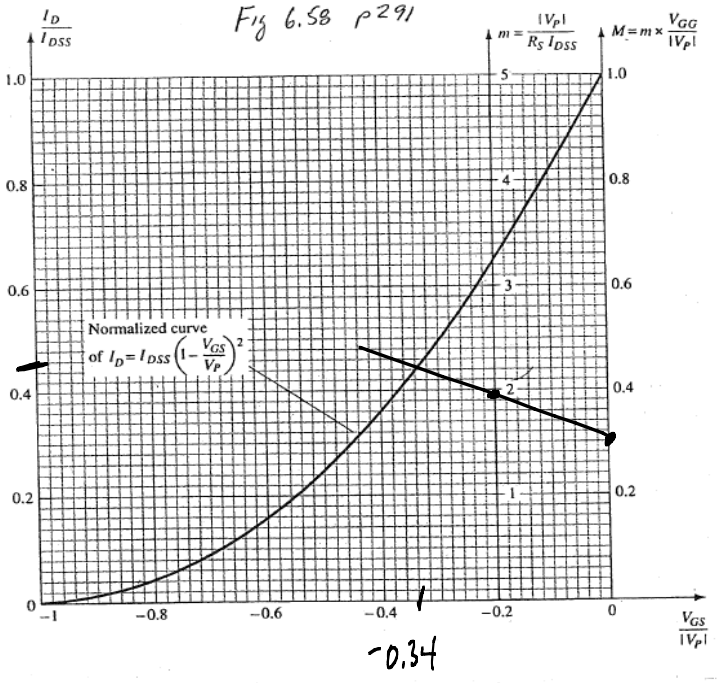
$$V_{DSQ} = 20 - 3.4mA(2.2k + 1.1k) = 8.78V$$

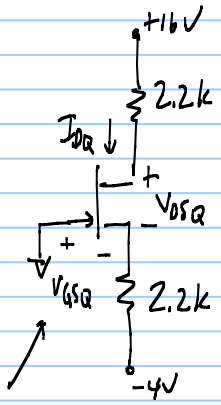
Check sat. $|V_{DSQ}| > |V_P| - |V_{GSQ}|$

$8.78 > 3.5 - 1.47$ ✓

37 → #16 w/ universal curve. Find I_{DQ} & V_{GSQ}. Then find V_{DSQ}.

Fig 6.58 p291





$I_{DSS} = 6mA$

$V_p = -6V$

error in book. then labeled as V_{DSQ}.

$V_{GG} = V_{GS}$ when $I_D = 0$

$V_{GG} = 4V$

$m = \frac{6}{(2.2k)6mA} = 0.45$

$M = 0.45\ \frac{4}{6} = 0.3$

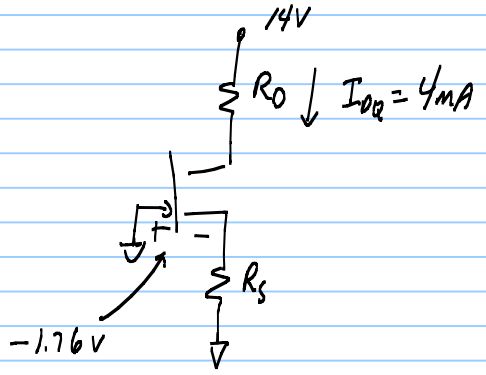
$I_{DQ} = (6mA)(0.46) = 2.76mA$

$V_{GSQ} = (6V)(-0.34) = 2.04V$

$V_{DSQ} = 16 + 4 - 2.76mA(2.2k + 2.2k)$

$V_{DSQ} = 7.86V \quad (> 6 - 2.04 \ \checkmark)$

#26 Design a self-biased network using a JFET transistor with $I_{DSS} = 8mA$ and $V_p = -6V$ to have a Q point at $I_{DQ} = 4mA$ using a supply of 14V. Assume that $R_D = 3R_S$. and use standard values.



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

$$4mA = 8mA\left(1 - \frac{V_{GS}}{6}\right)^2$$

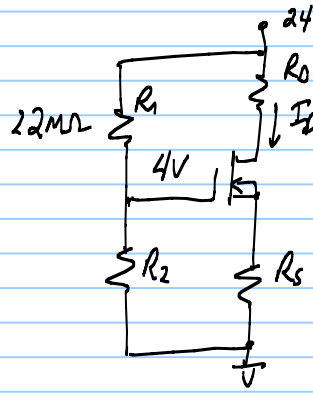
$$\sqrt{0.5} = 1 - \frac{V_{GS}}{6}$$

$$\frac{V_{GS}}{6} = 1 - 0.707 \qquad V_{GSQ} = -1.76V$$

So voltage across R_S is also 1.76 $\qquad R_S = \frac{1.76}{4mA} = 440\Omega$

use $R_S = 470\Omega$ Closest $\qquad R_D = 3R_S = 1410 \qquad$ use $R_D = 1.2k$ went down because R_S went up. Balance it out.

#27 Design a voltage divider bias network using a depletion type MOSFET with $I_{DSS} = 10mA$ and $V_p = -4V$ to have a Q-point at $I_{DQ} = 2.5mA$ using a supply of 24V. In addition, set $V_G = 4V$ and $R_D = 2.5R_S$ with $R_i = 22M\Omega$. Use standard values.



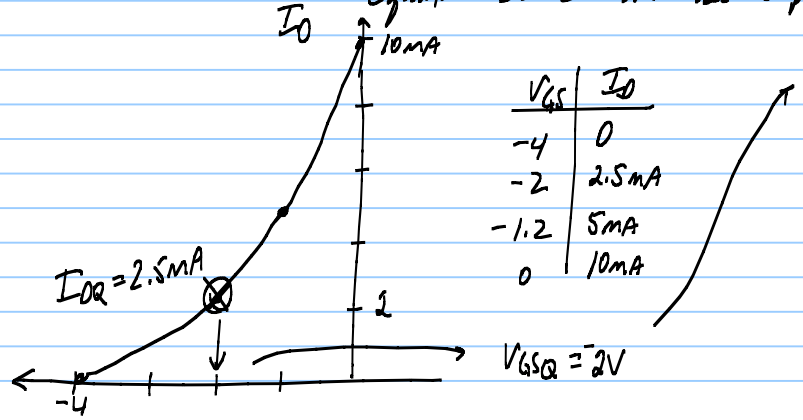
$I_{DSS} = 10mA$
$V_p = -4V$

current in $R_1 = \frac{24-4}{22M} = 0.91\mu A$

$R_2 = \frac{4V}{0.91\mu A} = 4.4M\Omega$

↑ same current as R_1 since $I_G = 0$

Can use plot or equation to convert I_{DQ} to V_{GSQ}. Last problem used equation so I will use a plot on this one

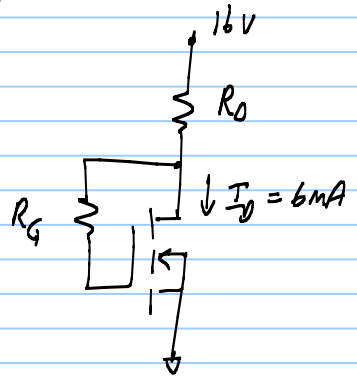


V_{GS}	I_D
−4	0
−2	2.5mA
−1.2	5mA
0	10mA

$$R_S = \frac{2V}{2.5mA} = 2.4k \quad \text{pick } 2.2k$$

$$R_D = 2.5R_S = 6k \quad \text{pick } 5.6k$$

#28 Design the network below using an Enhancement type MOSFET with $V_{GS(TH)} = 4V$ and $K = 0.5 \times 10^{-3} A/V^2$ to have a Q point of $I_{DQ} = 6mA$. Use a supply of 16V and standard values.



Draw drain curve to solve OR use equation.

Equation easier.

$$I_D = K(V_{GS} - V_{GS(TH)})^2$$

$$4mA = 0.5 mA/V^2 (V_{GS} - 4)^2$$

$$\sqrt{8} = V_{GS} - 4 \qquad V_{GSQ} = 6.83V = V_{DSQ}$$

$$R_D = \frac{16 - 6.83}{6mA} = 1.53k \Rightarrow \text{use } \boxed{1.8k = R_D}$$

R_G can be any MΩ resistor.