SELF-BIAS

JFET DC BIASING

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TOPIC OUTLINE

Self-Bias

- Gate-to-Source Loop
- Drain-to-Source Loop
- Transconductance Curve

SELF-BIAS

GENERAL RELATIONSHIPS

Gate Current

$$i_G \cong 0$$

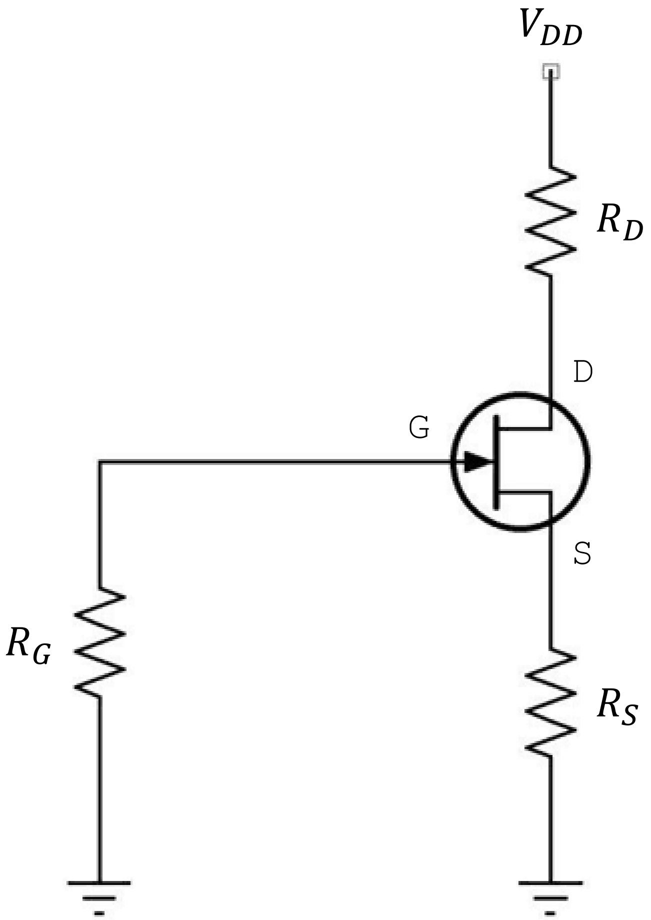
Drain Current

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

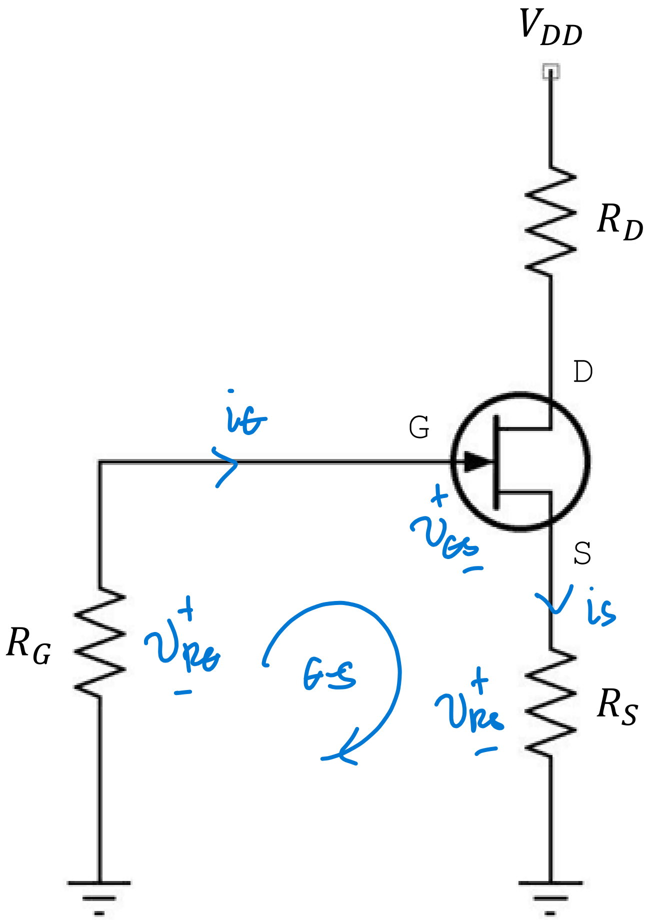
Source Current

$$i_D = i_S$$

SELF-BIAS CONFIGURATION



GATE-TO-SOURCE



KVL @ G-S

$$-v_{RG} + v_{GS} + v_{RS} = 0$$

$$v_{GS} = v_{RG} - v_{RS}$$

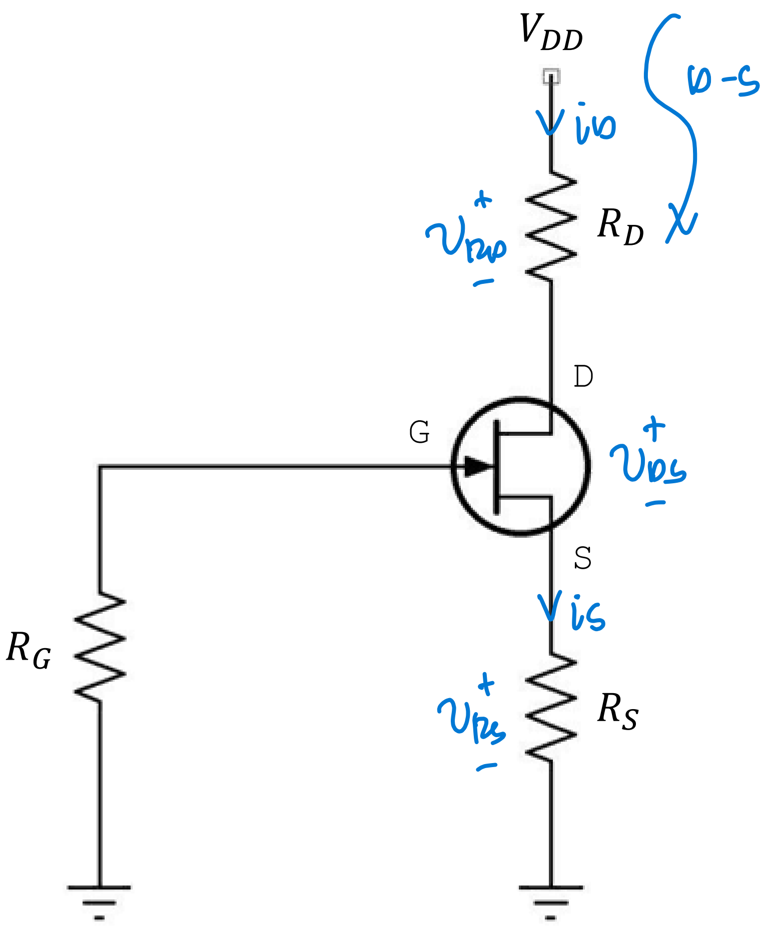
$$v_{GS} = \cancel{i_G}^{\,0} R_G - \cancel{i_S}^{\,i_D} R_S$$

$$\boxed{v_{GS} = -i_D R_S}$$

Shockley's Equation

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

DRAIN-TO-SOURCE



KVL @ D-S

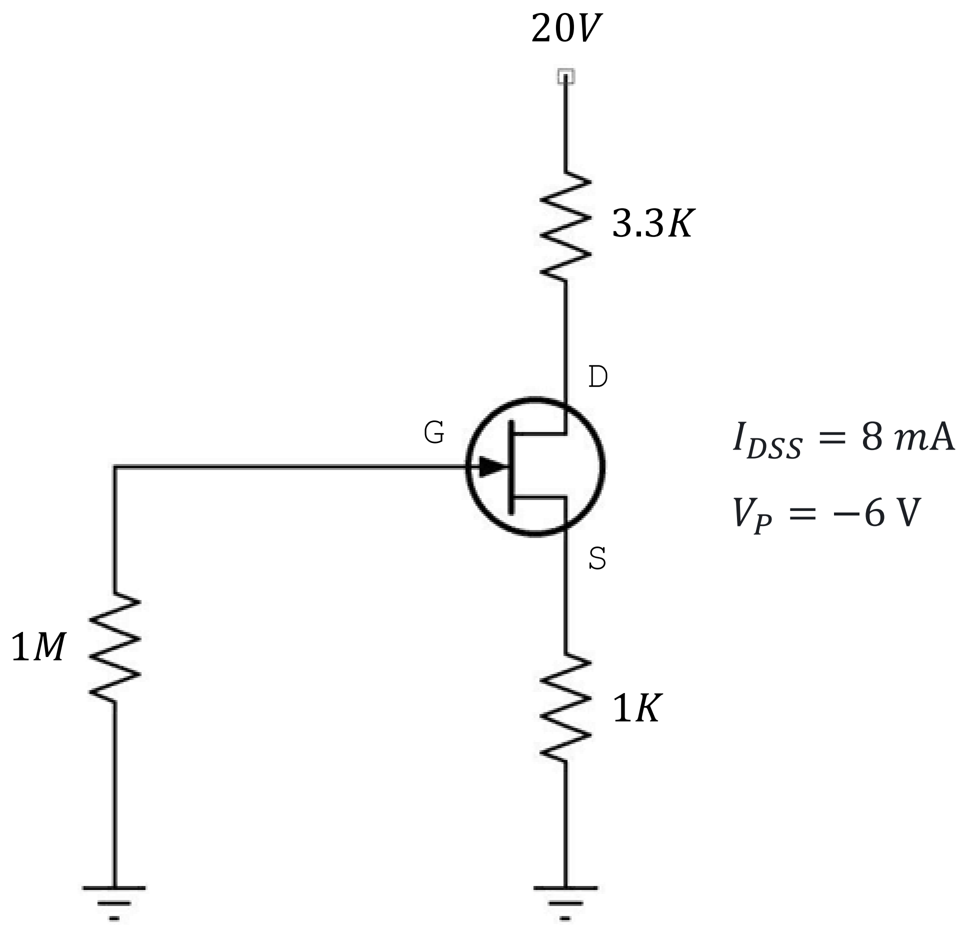
$$-v_{DD} + v_{RD} + \underline{v_{DS}} + v_{RS} = 0$$

$$v_{DS} = v_{DD} - v_{RD} - v_{RS}$$

$$v_{DS} = v_{DD} - i_D R_D - \cancelto{i_D}{i_S} R_S$$

$$\boxed{v_{DS} = V_{DD} - i_D (R_D + R_S)}$$

EXERCISE

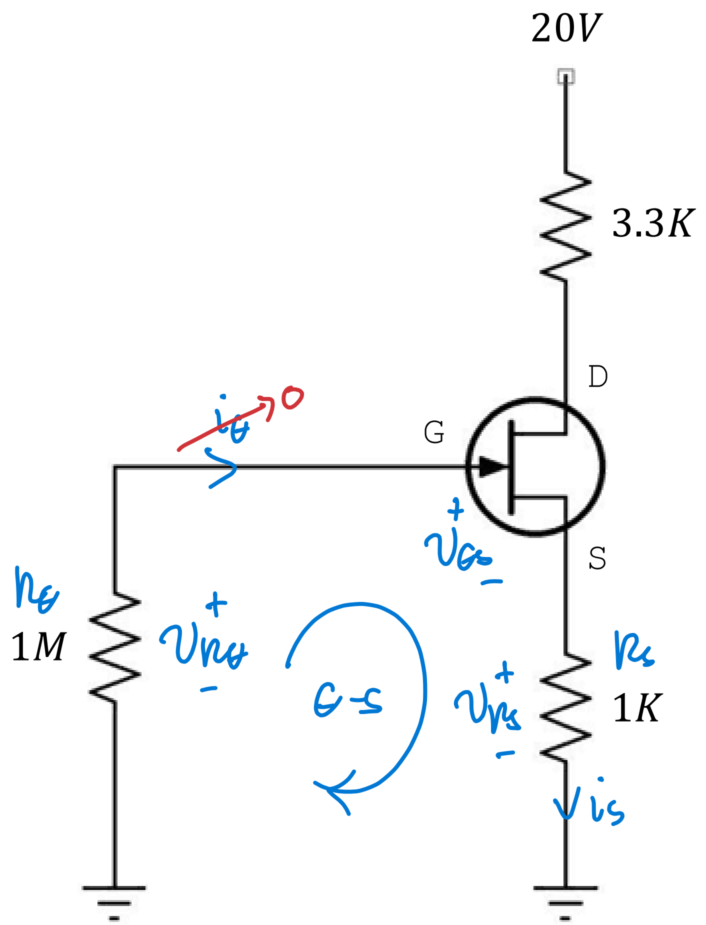


For the given network, determine the following :

- Gate-source voltage (v_{GSQ})
- Drain current (i_{DQ})
- Drain-source voltage (v_{DS})
- Source voltage (v_S)

and sketch the transconductance curve.

EXERCISE



$I_{DSS} = 8\ mA$

$V_P = -6$ V

Solution

KVL @ G-S

$$-\cancel{V_{RG}}^{\,\to 0} + V_{GS} + \cancel{V_{RS}}^{\,\to i_D R_S} = 0$$

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

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

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

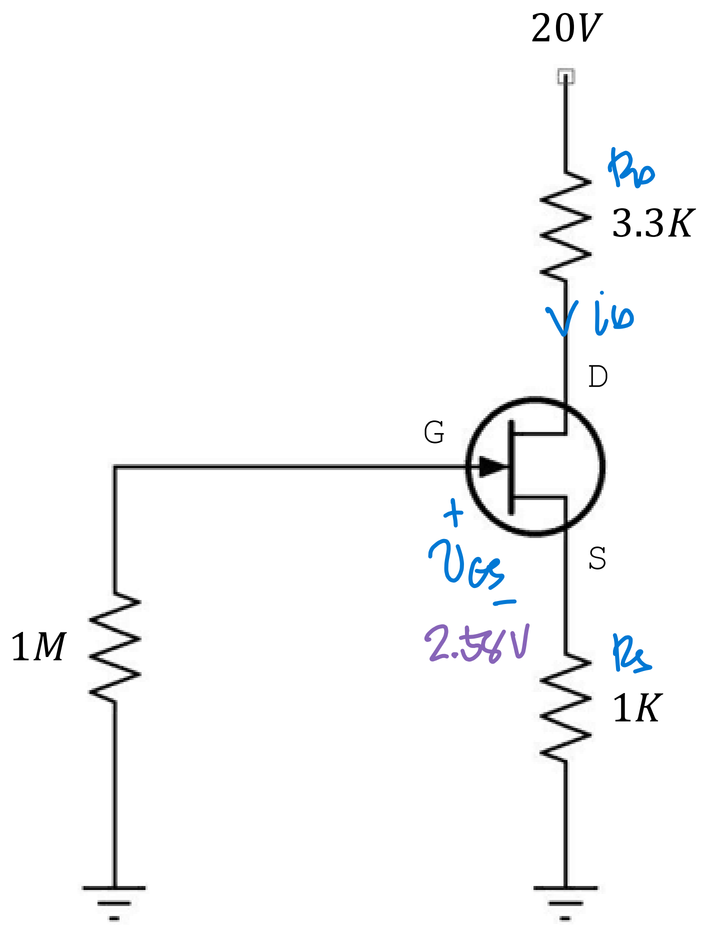
$$V_{GS} = -I_{DSS}R_S + 2I_{DSS}R_S\frac{V_{GS}}{V_P} - I_{DSS}R_S\frac{V_{GS}^2}{V_P^2}$$

$$V_{GS} = -(8m\cdot 1K) + 2(8m\cdot 1K)\frac{V_{GS}}{-6} - (8m\cdot 1K)\frac{V_{GS}^2}{(-6)^2}$$

$$\cancel{V_{GS}}^{\,\to 0} = -8 - 2.67V_{GS} - 0.22V_{GS}^2$$

$$\underline{-V_{GS}} \qquad\qquad \underline{-V_{GS}}$$

EXERCISE



$I_{DSS} = 8\ mA$

$V_P = -6$ V

Solution

$0 = -8 - 3.67\, V_{GS} - 0.22\, V_{GS}^2$

$V_{GS} = -14.10V$

$\boxed{V_{GSQ} = -2.58\,V}$

ans

Shockley's Equation

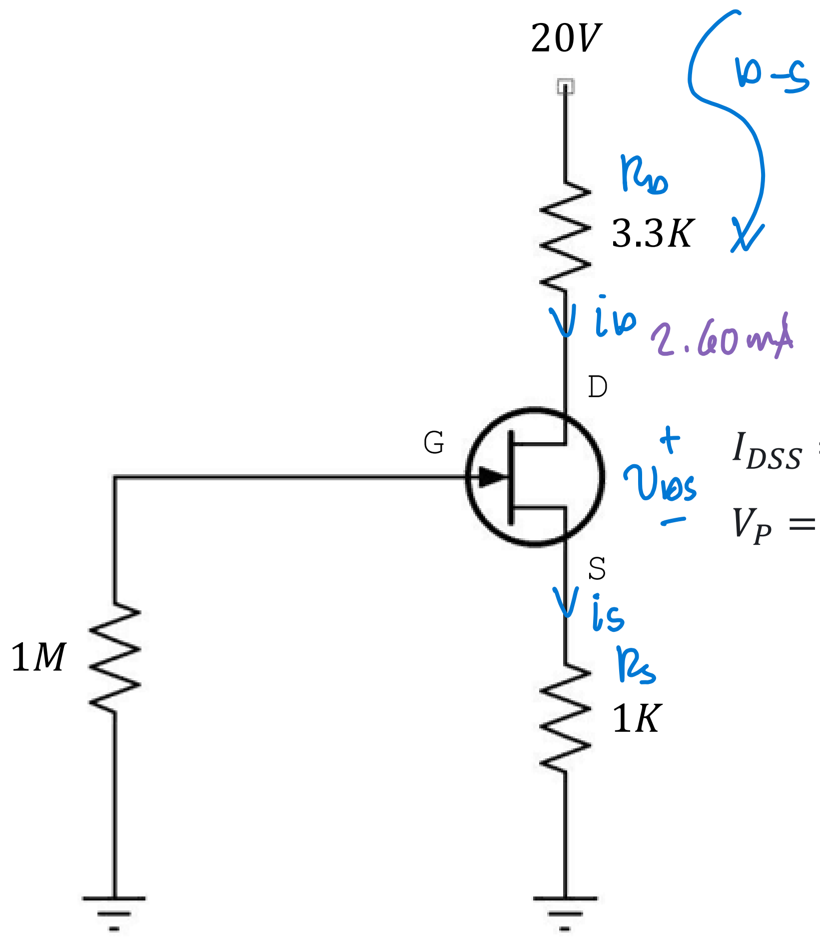
$i_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$

$i_D = 8m\left(1 - \frac{-2.58}{-6}\right)^2$

$\boxed{i_{DQ} = 2.60\ mA}$

ans

EXERCISE



$I_{DSS} = 8\ mA$

$V_P = -6$ V

Solution

KVL @ D-S

$$-V_{DD} + V_{RD} + V_{DS} + V_{RS} = 0$$

$$V_{DS} = V_{DD} - V_{RD} - V_{RS} = 0$$

$$V_{DS} = V_{DD} - i_D R_D - \cancel{i_S}^{\,i_D} R_S$$

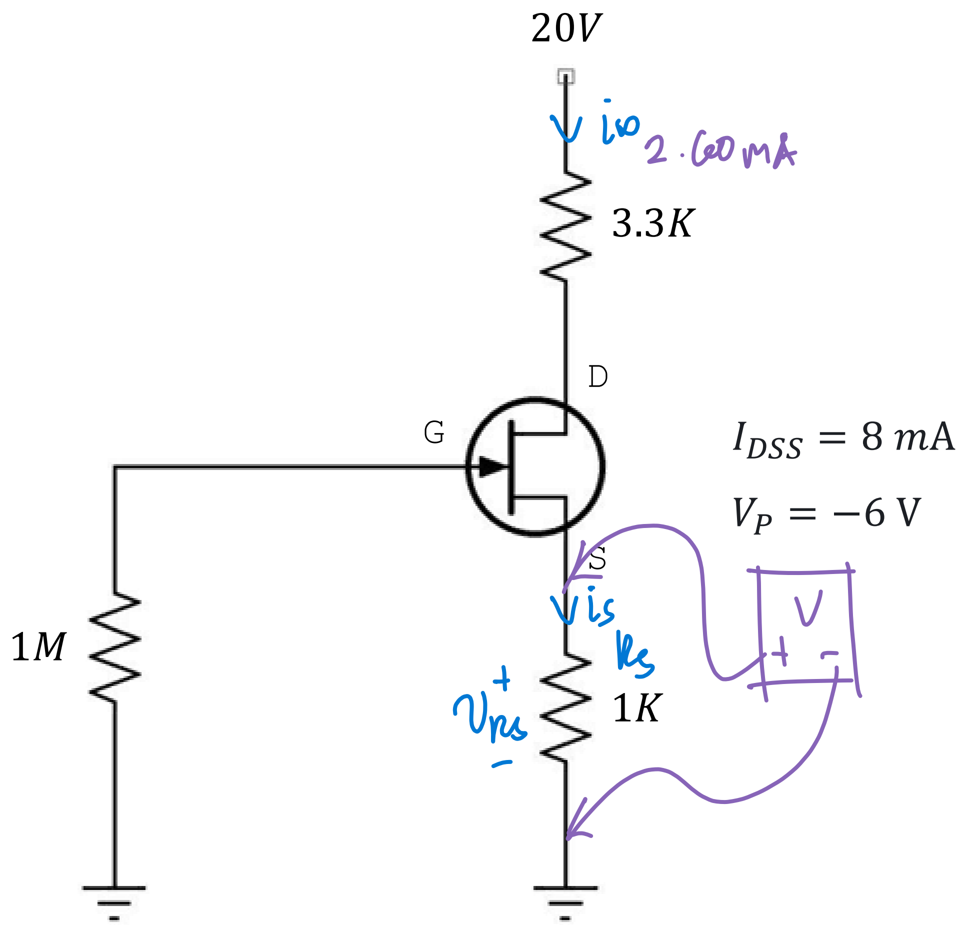
$$V_{DS} = V_{DD} - i_D (R_D + R_S)$$

$$V_{DS} = 20 - 2.60m(3.3k + 1k)$$

$$\boxed{V_{DS} = 8.82V}$$

ans

EXERCISE



Solution

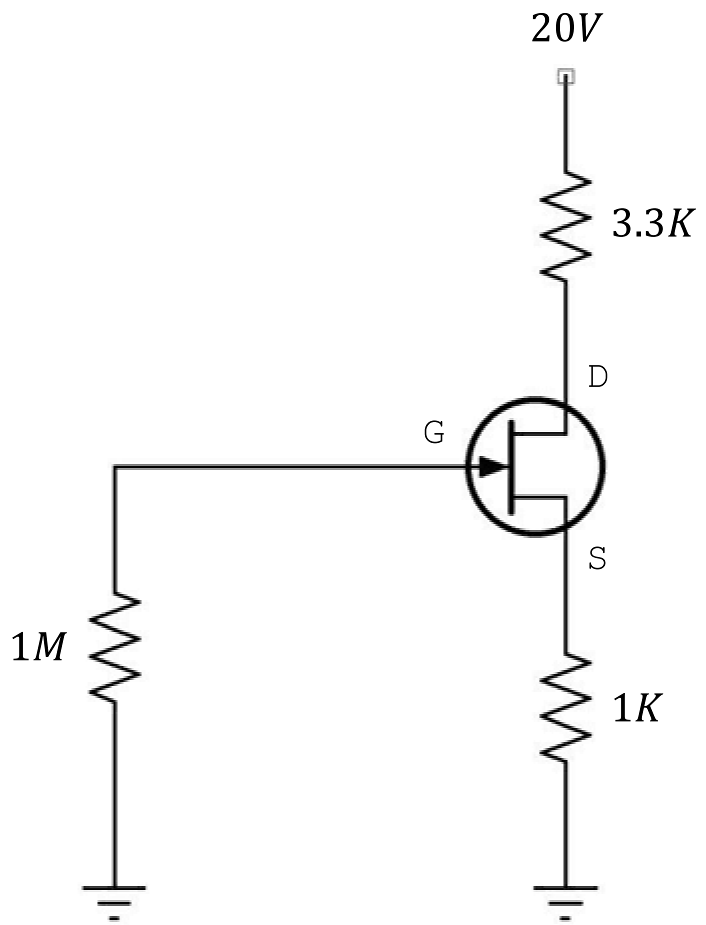
$v_{RS} = \cancel{i_S} R_S$ $\to i_D$

$v_{RS} = 2.60m(1k)$

$\boxed{v_S = 2.6V}$

Ans

EXERCISE



$I_{DSS} = 8\ mA$

$V_P = -6$ V

Solution

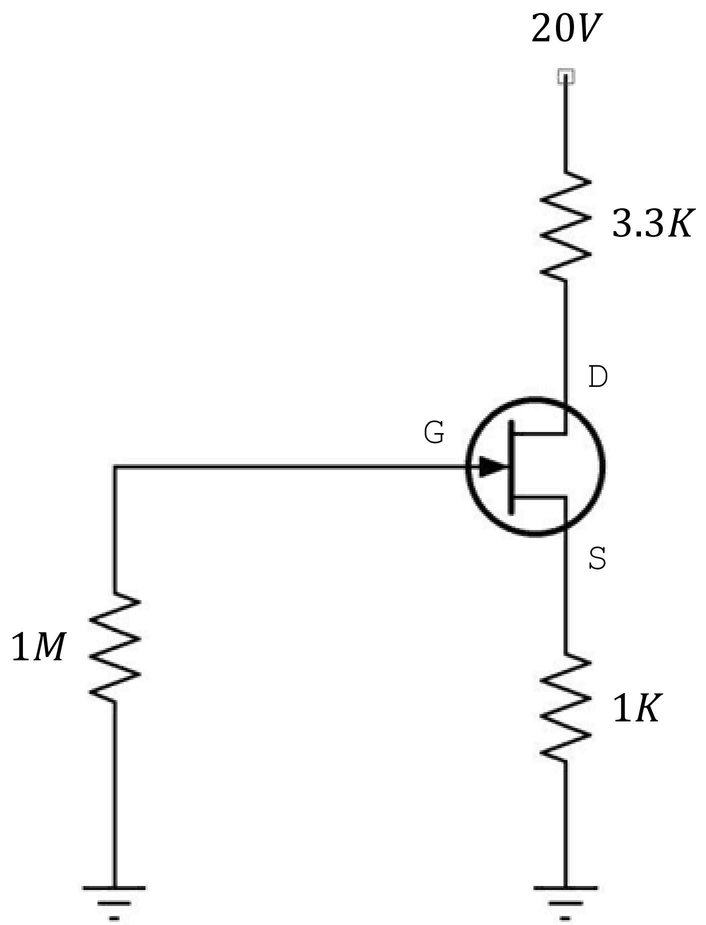
Transconductance Curve

$i_D = \frac{1}{4} I_{DSS} \Big|_{v_{GS} = \frac{1}{2} V_P}$

$i_D = \frac{1}{4}(8mA) \Big|_{v_{GS} = \frac{1}{2}(-6V)}$

$i_D = 2mA \Big|_{v_{GS} = -3V}$

EXERCISE



$I_{DSS} = 8\ mA$

$V_P = -6$ V

Solution

Transconductance Curve

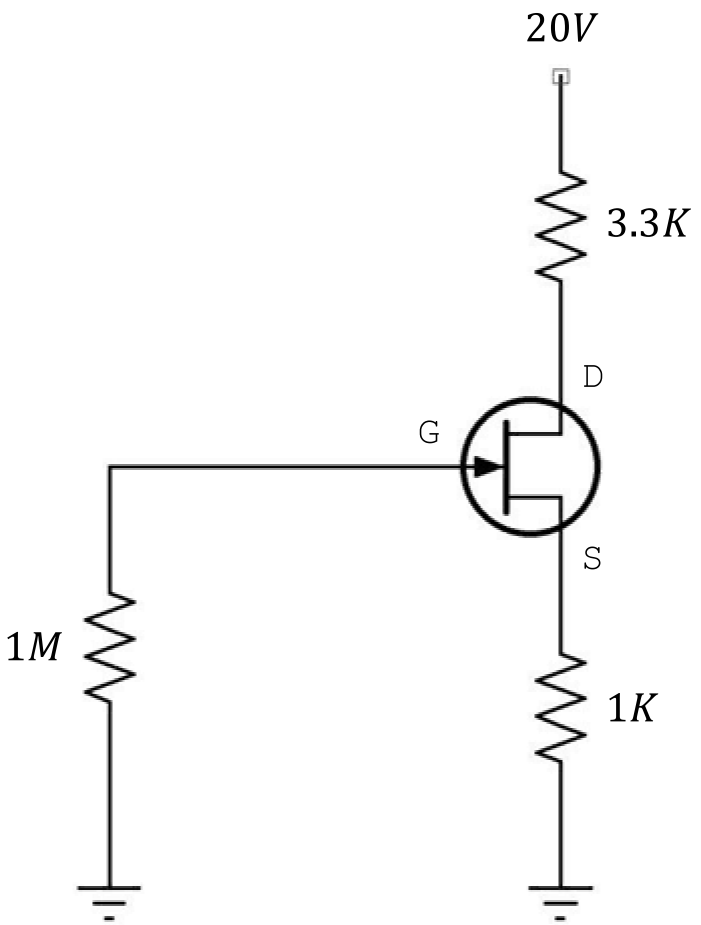
$V_{GS} = 0.3V_P \mid i_D = \frac{1}{2} I_{DSS}$

$V_{GS} = 0.3(-6V) \mid i_D = \frac{1}{2}(8mA)$

$V_{GS} = -1.8V \mid i_D = 4mA$

EXERCISE

Solution



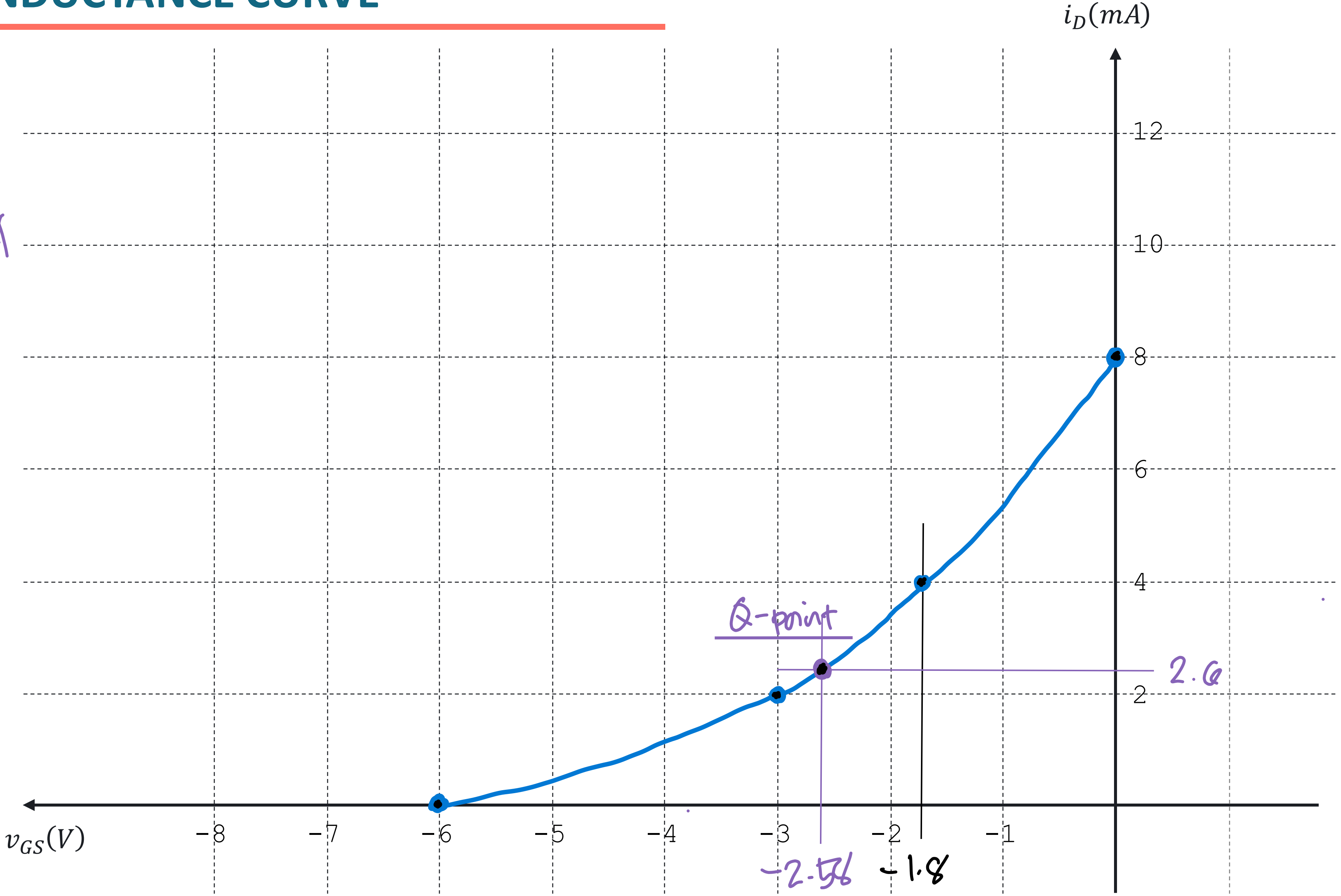
$I_{DSS} = 8\ mA$

$V_P = -6\ \text{V}$

TRANSCONDUCTANCE CURVE

$i_{DQ} = 2.6mA$

$V_{GS} = -2.58V$



LABORATORY