VOLTAGE-DIVIDER

JFET DC BIASING

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TOPIC OUTLINE

Voltage-Divider Bias

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

VOLTAGE-DIVIDER BIAS

GENERAL RELATIONSHIPS

Gate Current

$$i_G \cong 0$$

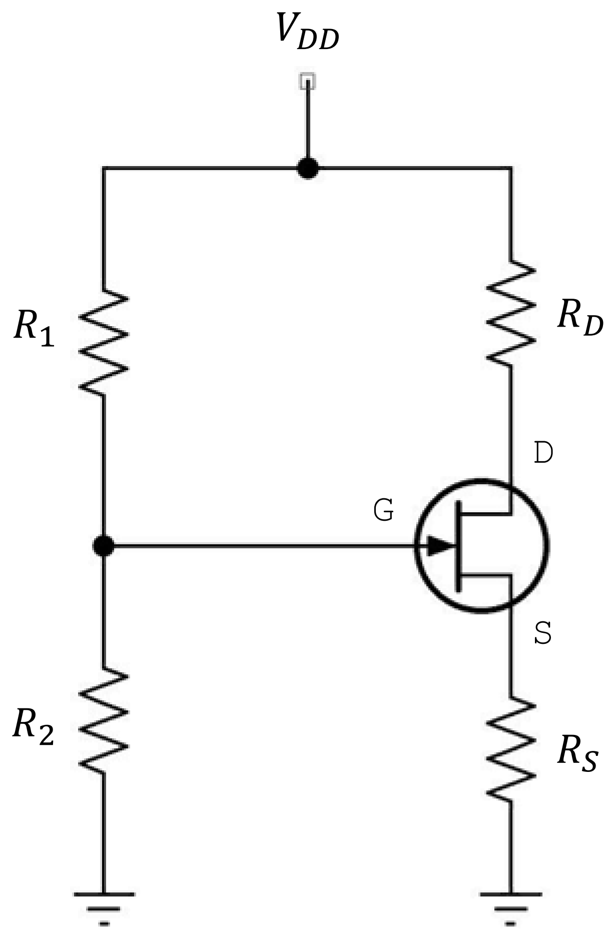
Drain Current

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

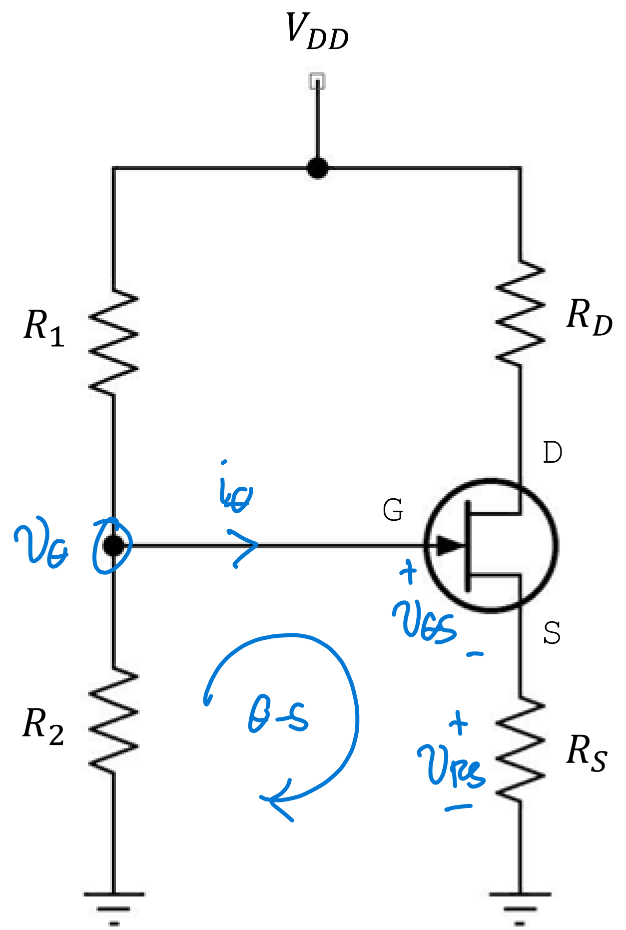
Source Current

$$i_D = i_S$$

VOLTAGE-DIVIDER BIAS CONFIGURATION



GATE-TO-SOURCE



KVL @ G-S

$$-v_G + \underline{v_{GS}} + v_{RS} = 0$$

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

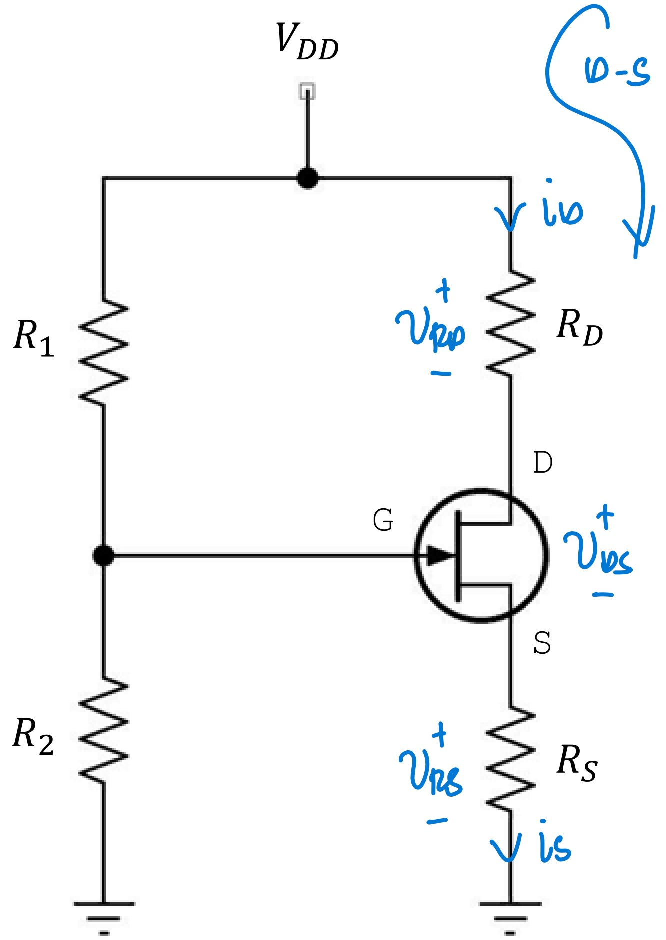
$$v_{GS} = v_G - \cancel{i_G} R_S \quad i_D$$

$$\boxed{v_{GS} = v_G - i_D R_D}$$

by VDT

$$v_G = V_{DD} \frac{R_2}{R_1 + R_2}$$

DRAIN-TO-SOURCE



KVL @ D-S

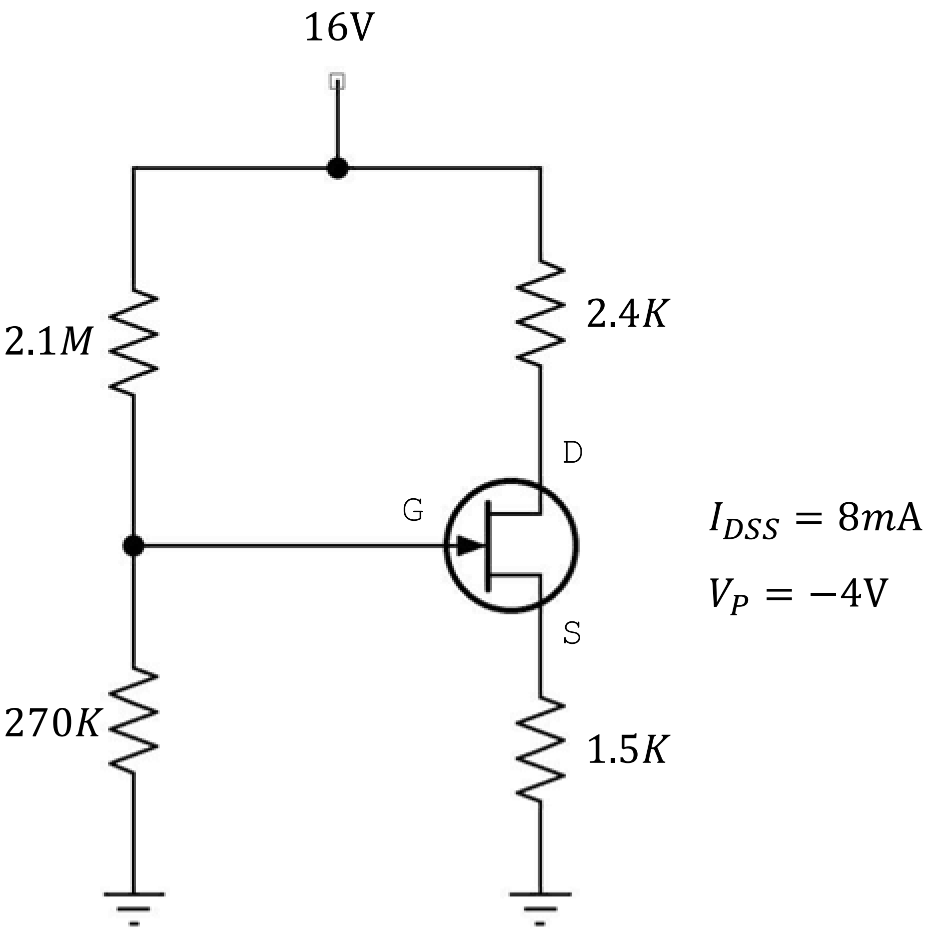
$$-v_{DD} + v_{RD} + \underline{v_{DS}} + v_{RS} = 0$$

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

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

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

EXERCISE

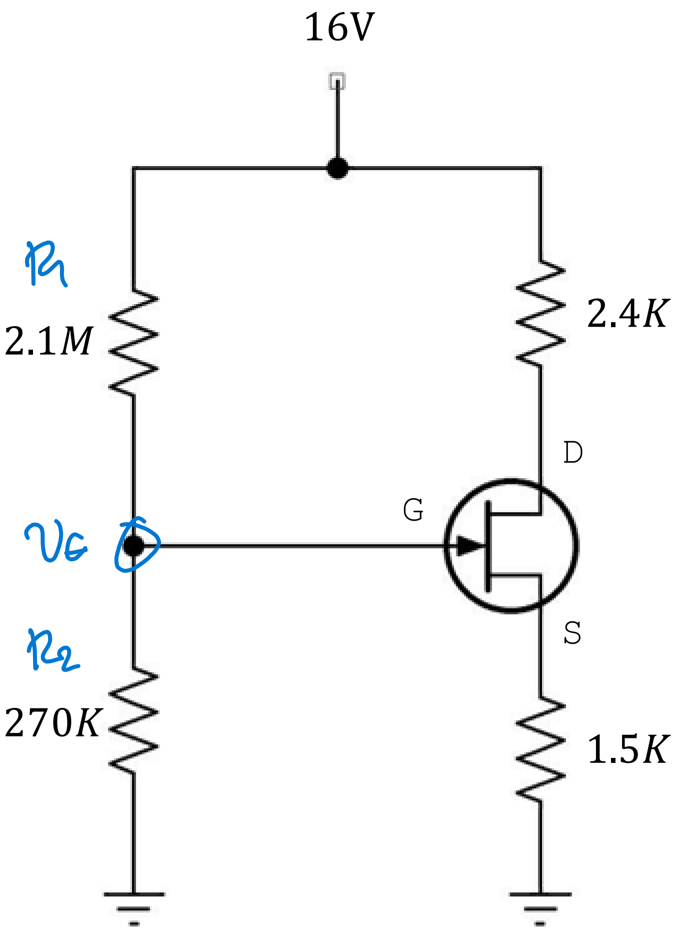


For the given network, determine the following :

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

and sketch the transconductance curve.

EXERCISE



$I_{DSS} = 8mA$

$V_P = -4V$

Solution

by VDT

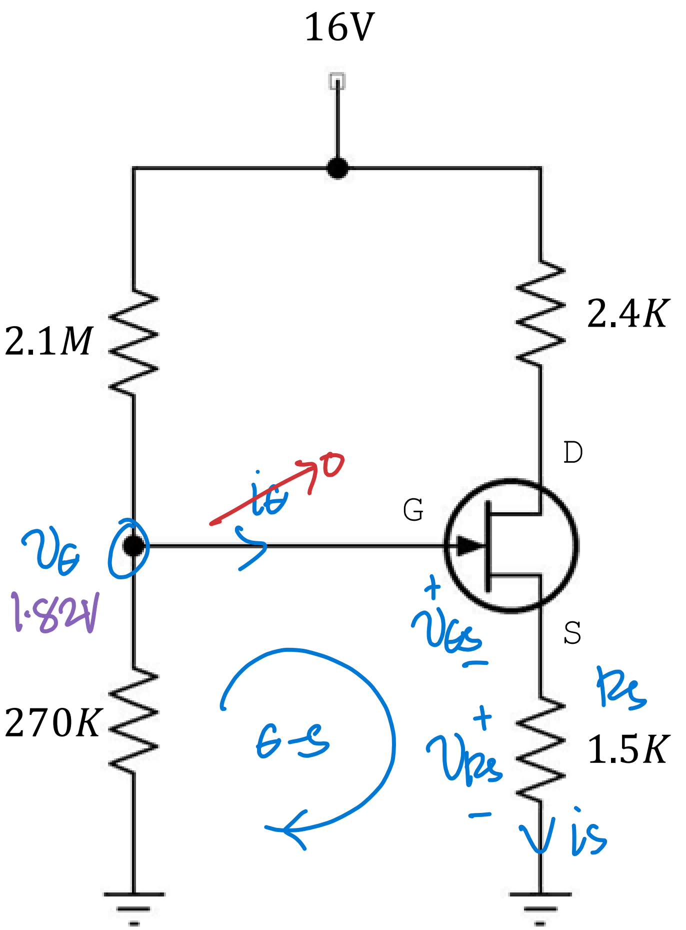
$$V_G = V_{DD} \frac{R_2}{R_1 + R_2}$$

$$V_G = 16 \frac{270K}{2.1M + 270K}$$

$$\boxed{V_G = 1.82V}$$

ans

EXERCISE



$I_{DSS} = 8mA$

$V_P = -4V$

Solution

KVL @ GS

$-V_G + V_{GS} + V_{RS} = 0$

$V_{GS} = V_G - \cancel{V_{RS}} \rightarrow i_S R_S$

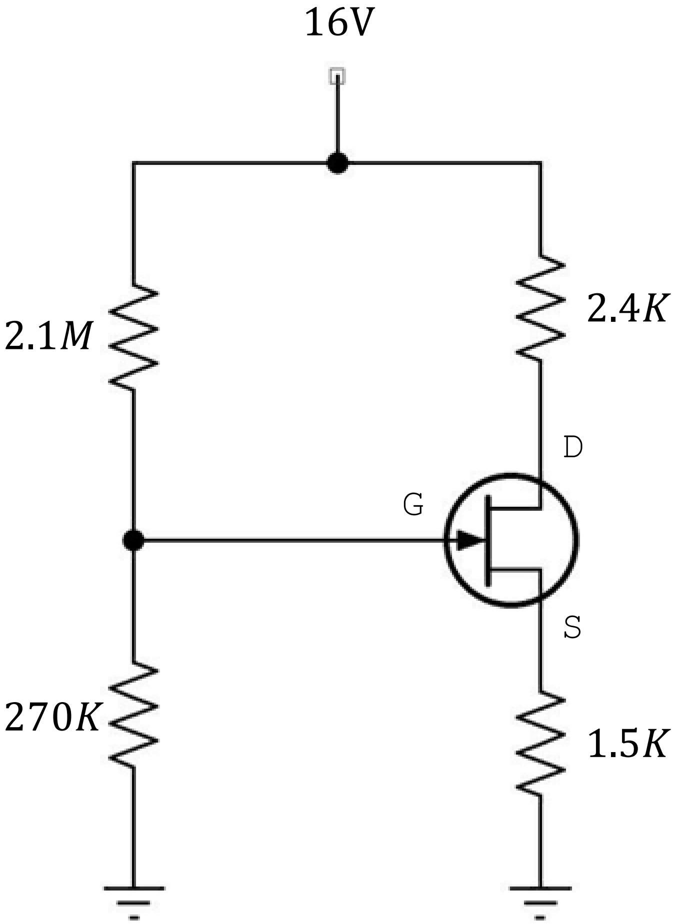
$V_{GS} = V_G - i_D R_S$

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

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

$V_{GS} = 1.82 - (8m)(1.5K)\left[1 - \frac{2V_{GS}}{-4} + \frac{V_{GS}^2}{(-4)^2}\right]$

EXERCISE



$I_{DSS} = 8mA$

$V_P = -4V$

Solution

$$V_{GS} = 1.82 - \underline{12}\left(1 + \frac{V_{GS}}{2} + \frac{V_{GS}^2}{16}\right)$$

$$\cancel{V_{GS} - V_{GS}}^{\,0} = \underline{1.82 - 12} - 6V_{GS} - 0.75V_{GS}^2 - V_{GS}$$

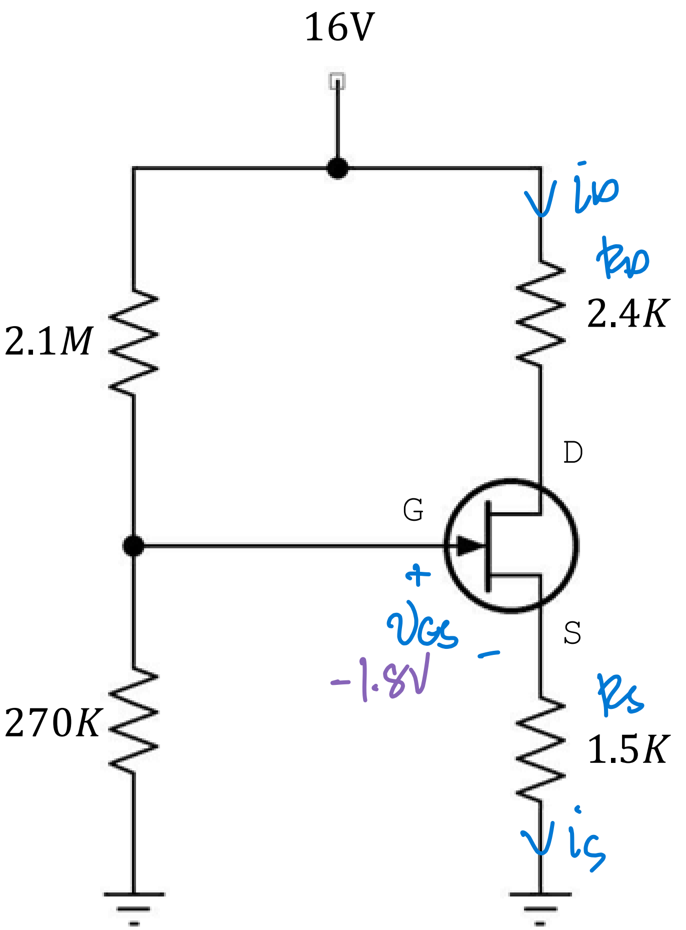
$$0 = -10.18 - 7V_{GS} - 0.75V_{GS}^2$$

$$V_{GS} = -7.53V$$

$$\boxed{V_{GSQ} = -1.8V}$$

ans

EXERCISE



$I_{DSS} = 8mA$

$V_P = -4V$

Solution

Shockley's Equation

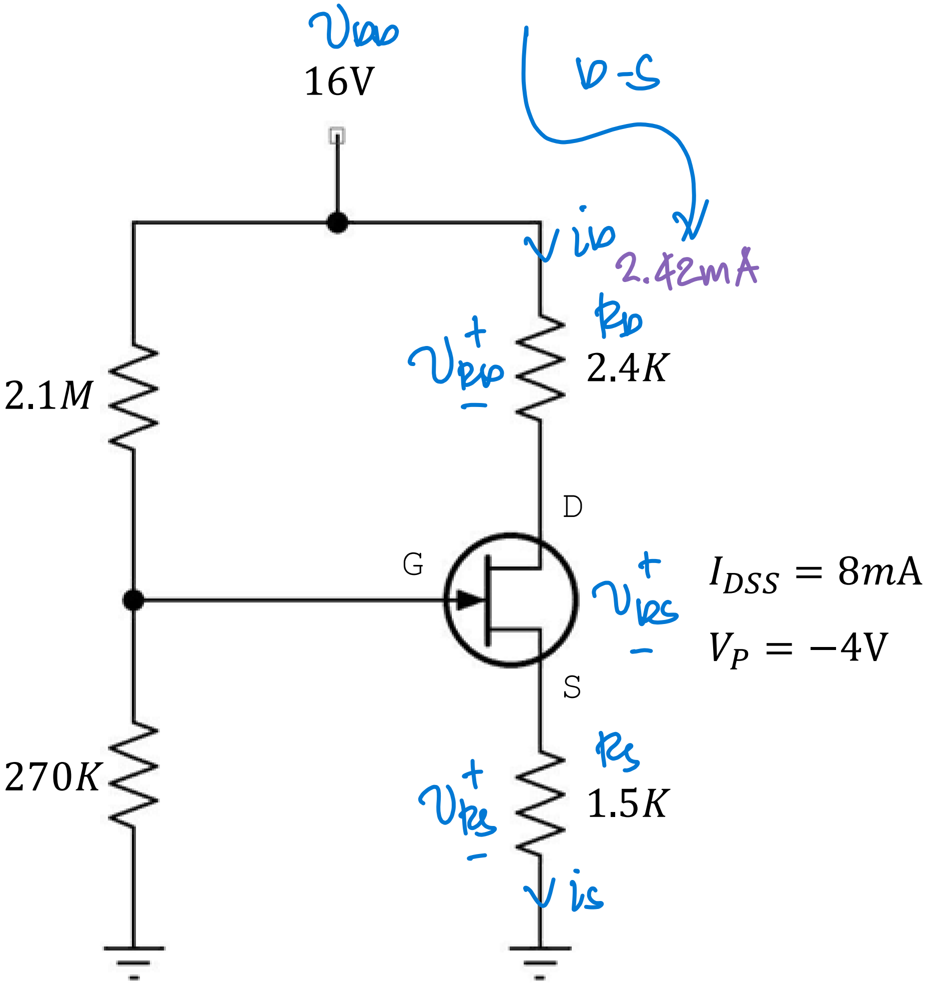
$$i_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

$$i_D = 8m\left(1 - \frac{-1.8}{-4}\right)^2$$

$$\boxed{i_{DQ} = 2.42mA}$$

ans

EXERCISE



Solution

KVL @ D-S

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

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

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

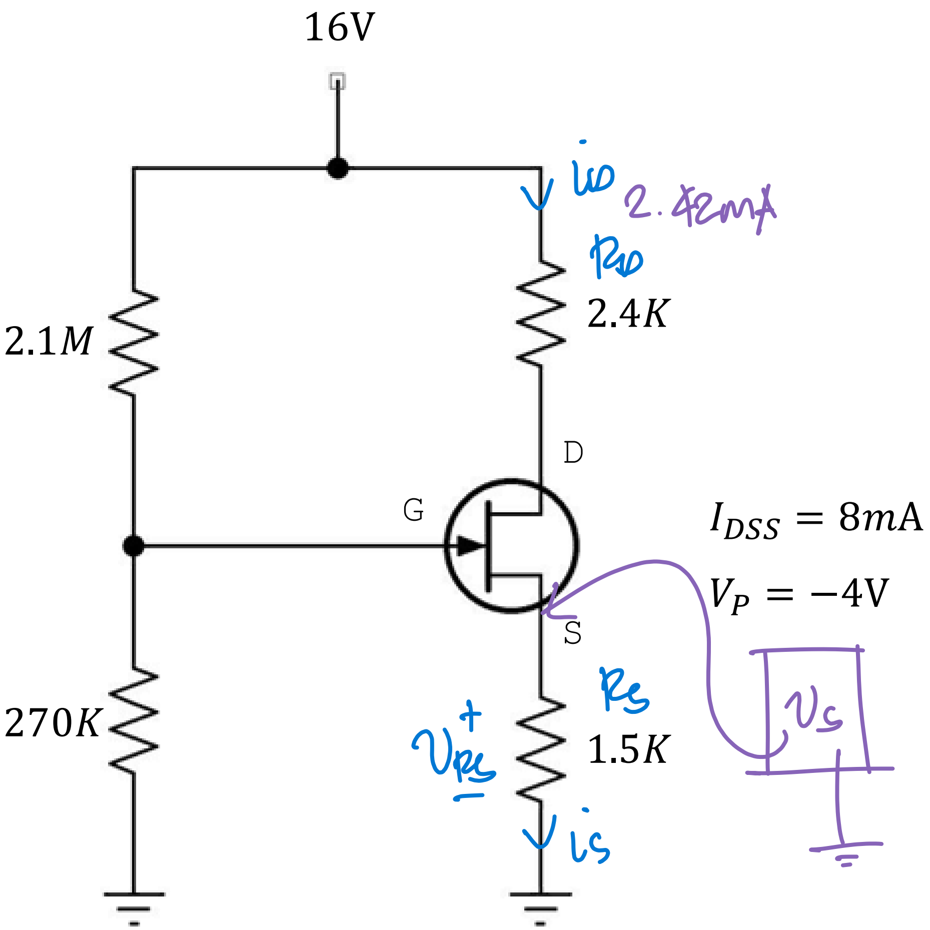
$$V_{DS} = V_{DD} - i_D (R_D + R_S)$$

$$V_{DS} = 16 - 2.42m(2.4K + 1.5K)$$

$$\boxed{V_{DS} = 6.56V}$$

ans

EXERCISE



Solution

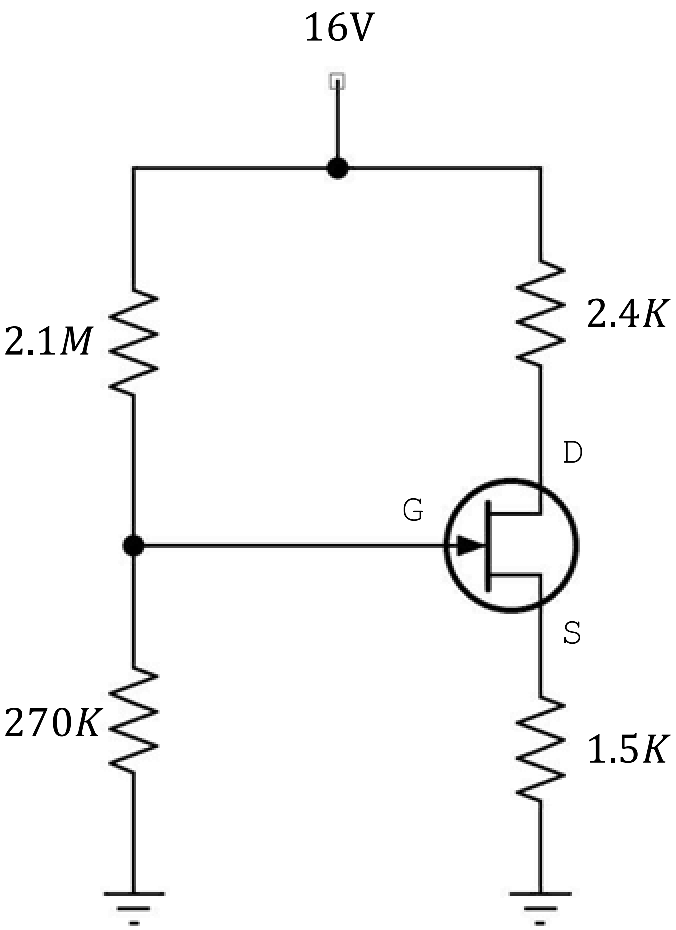
$v_{Rs} = \cancel{i_s}^{\,i_D} R_s$

$\cancel{v_{Rs}}^{\,v_s} = 2.42m(1.5k)$

$\boxed{v_s = 3.63V}$

ans

EXERCISE



$I_{DSS} = 8mA$

$V_P = -4V$

Solution

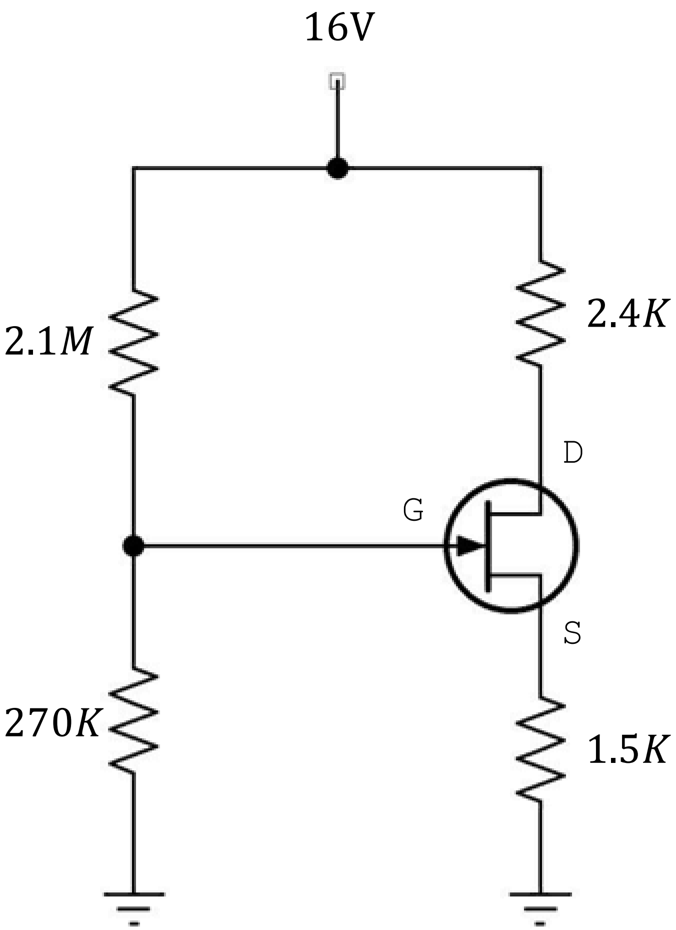
Transconductance Curve

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

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

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

EXERCISE



$I_{DSS} = 8mA$

$V_P = -4V$

Solution

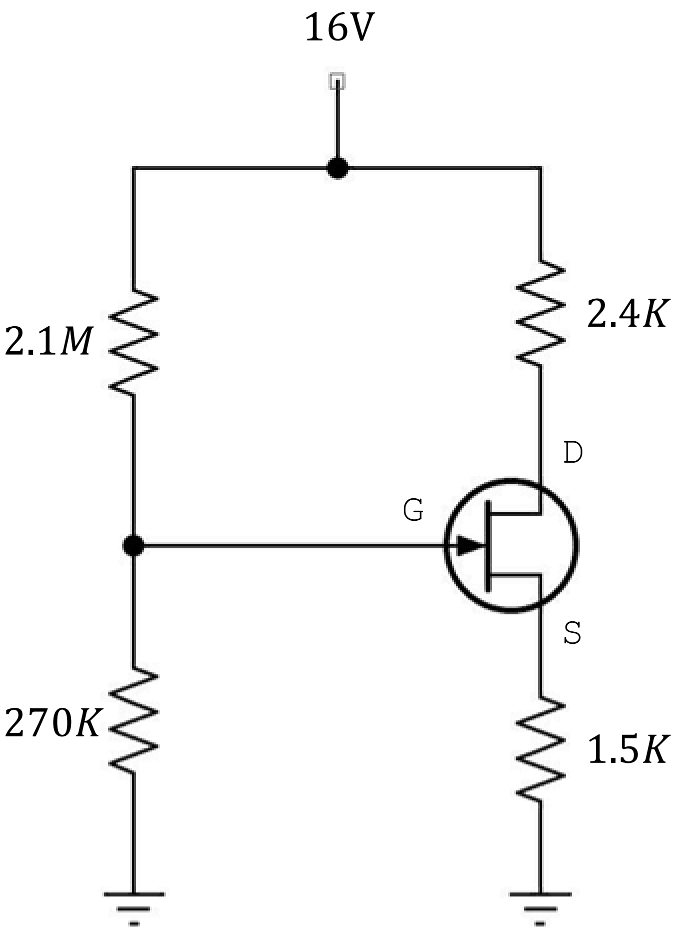
Transconductance Curve

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

$V_{GS} = 0.3(-4V) \;|\; i_D = \frac{1}{2}(8mA)$

$V_{GS} = -1.2V \;|\; i_D = 4mA$

EXERCISE

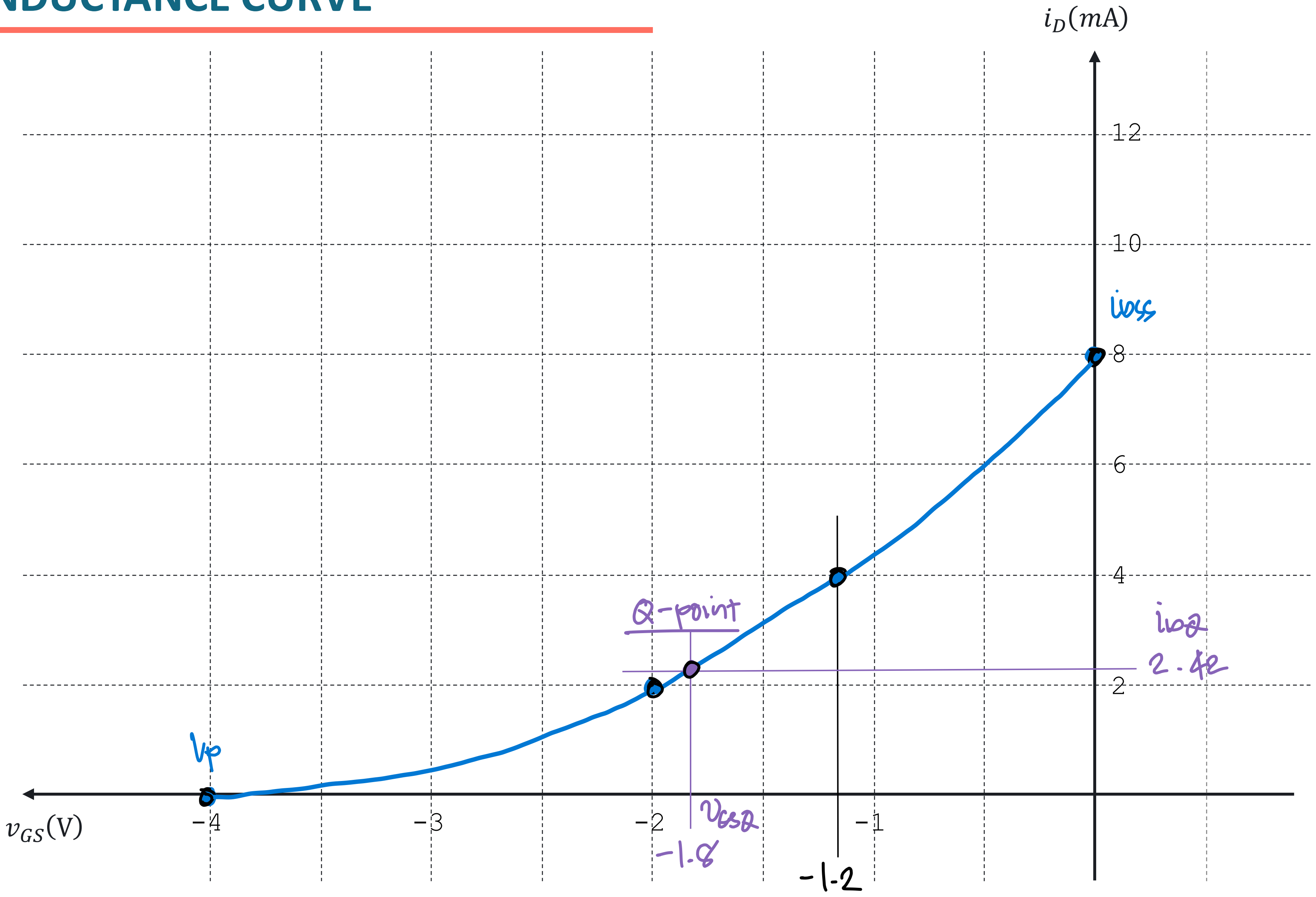


$I_{DSS} = 8mA$

$V_P = -4V$

Solution

TRANSCONDUCTANCE CURVE



LABORATORY