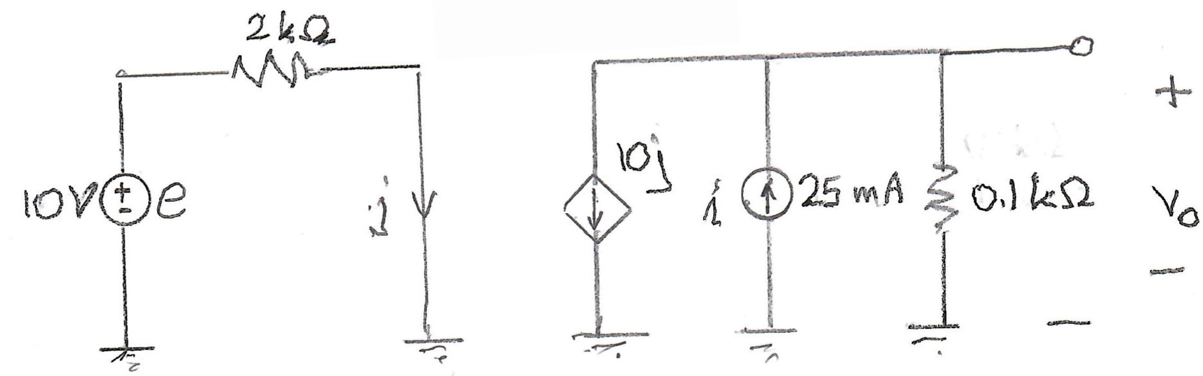
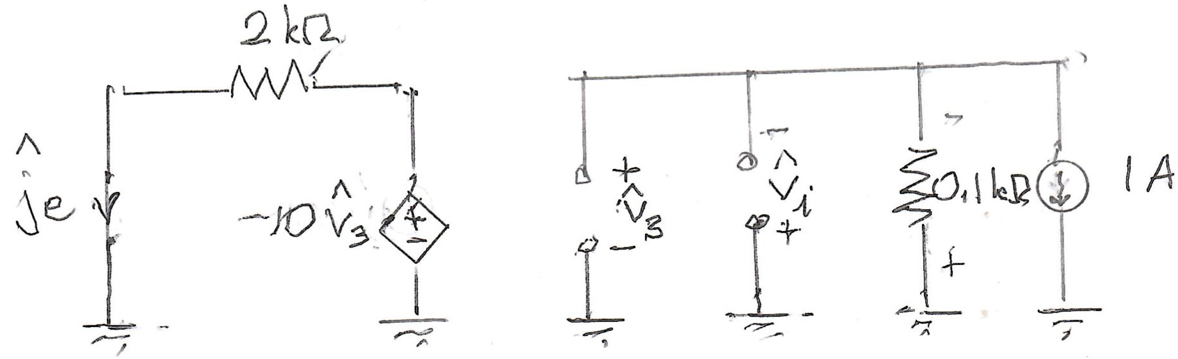
580 HW 3

1.

N:



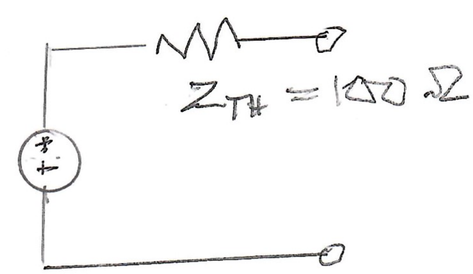


$V_o = -\hat{j}_e \cdot e + \hat{V}_i \cdot i = -5 + 2.5 = -2.5\text{ V} = V_{TH}$

$\hat{V}_i = -100 = -\hat{V}_3$, $\hat{j}_e = +0.5$

$\hat{V}_o = \hat{V}_3 = -100\text{ V} = Z_{TH}$

$-2.5\text{V} = V_{TH}$



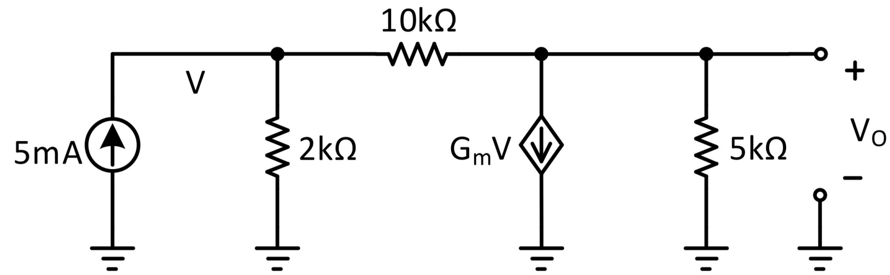
Check: in N

$j = 5\text{ mA}$, $V_o = 100\,(0.025 - 0.05) = -2.5\text{V}$

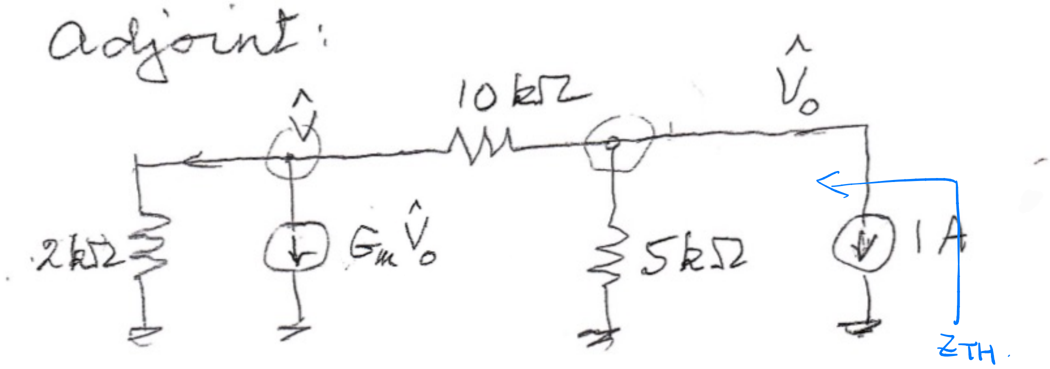
Short circuit current $= -0.025$ A

$Z_{TH} = 100\ \Omega$

2.



adjoint:



$$0.5\hat{V} + 3\hat{V}_o + 0.1(\hat{V} - \hat{V}_o) = 0 \quad ①$$

$$2.9\hat{V}_o = -0.6\hat{V},$$

$$0.1(\hat{V} - \hat{V}_o) = 10^3 + 0.2\hat{V}_o \quad ②$$

$$0.1\hat{V} = 10^3 + 0.3\hat{V}_o$$

$$0.1 \cdot \frac{2.9}{-0.6}\hat{V}_o = 10^3 + 0.3\hat{V}_o$$

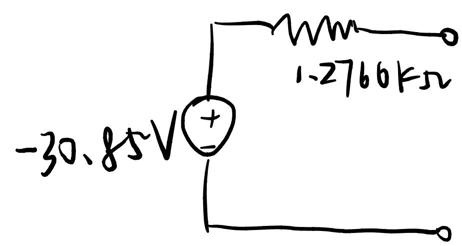
$$-\left(\frac{2.9}{6} + 0.3\right)\hat{V}_o = 10^3$$

$$-\frac{4.7}{6}\hat{V}_o = 10^3, \quad \hat{V}_o = -\frac{6000}{4.7} \cong -1276.6\,V$$

$$\hat{V} = -\frac{2.9}{0.6}\hat{V}_o = \frac{29000}{4.7}\,V$$

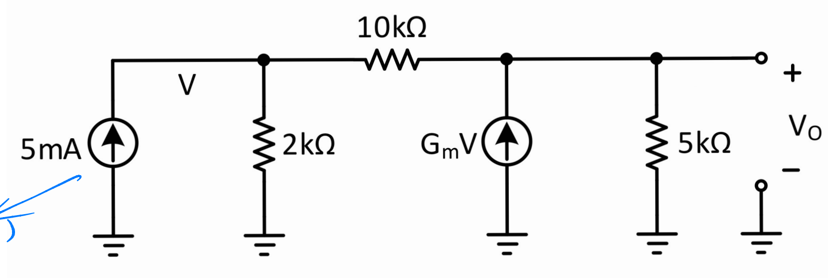
$$V_o = -i \cdot \hat{V} = -5mA \cdot \frac{29000}{4.7}\,V/A \cong -30.85\,V = V_{TH}$$

$$Z_{TH} = \frac{\hat{V}_o}{-1A} = 1.2766\,k\Omega$$

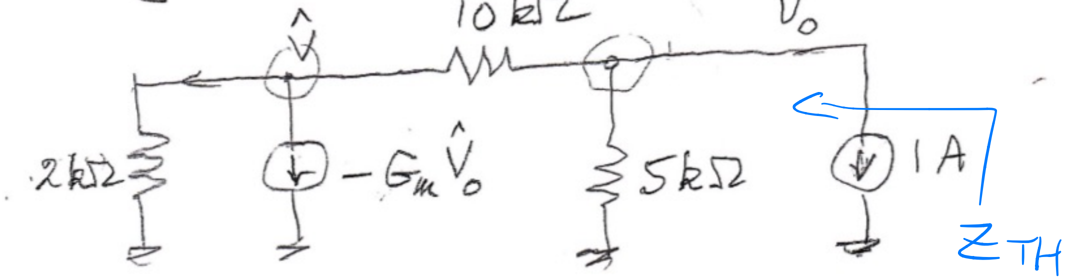


2.

(OR, if you are using this network)



adjoint:



$$-\frac{\hat{V}}{2} + 3\hat{V}_o + 0.1(\hat{V}_o - \hat{V}) = 0$$

$$3.1\hat{V}_o = 0.6\hat{V}$$

$$0.1(\hat{V} - \hat{V}_o) = 10^3 + 0.2\hat{V}_o$$

$$0.1\hat{V} = 10^3 + 0.3\hat{V}_o$$

$$0.1\,\frac{3.1}{0.6}\,\hat{V}_o = 10^3 + 0.3\hat{V}_o$$

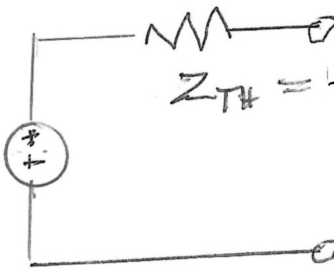
$$\left(\frac{3.1}{6} - 0.3\right)\hat{V}_o = 10^3$$

$$\frac{1.3}{6}\hat{V}_o = 10^3, \quad \hat{V}_o = \frac{6000}{1.3} \cong 4615.4\text{ V}$$

$$\hat{V} = \frac{31}{6}\hat{V}_o = \frac{310000}{13}\text{ V}$$

$$V_o = -i\cdot\hat{V} = -5mA \cdot \frac{310000}{13}\text{ V/A} \cong -119.23V = V_{TH}$$

$$Z_{TH} = \frac{\hat{V}_o}{-1A} = -4.6154\text{ k}\Omega$$

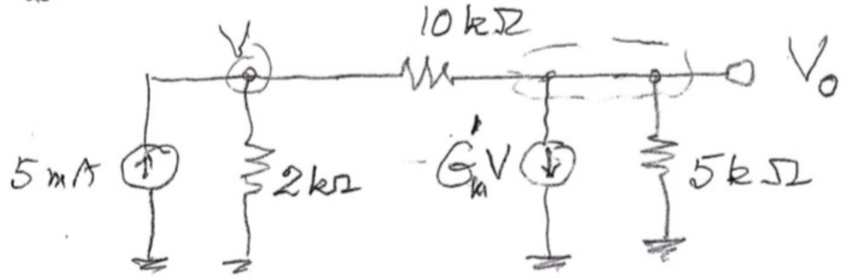


$Z_{TH} = -4.6154$ kΩ

$-119.23V = V_{TH}$

Z'

Another approach for obtainning V_o : solving the original circuit directly



$$G_m = 3\ mS, \quad G_m' = -G_m$$

$$\frac{\partial V_o}{\partial G_m} = ? \qquad (5.325 \times 10^4\ V/S)$$

$$5 + 0.1(V_o - V) = 0.5V$$

$$0.1(V - V_o) + G_m V = 0.2 V_o$$

$$V_o = 10[0.6V - 5] = 6V - 50$$

$$V_o = \frac{1}{0.3}[0.1V + G_m V] = (1 + 10G_m)V/3$$

$$6V - 50 = \frac{31}{3}V$$

$$V = \frac{50}{-13/3} = -\frac{150}{13} \simeq -11.538\ V$$

$$V_o = -\frac{900}{13} - 50 \cong -119.23\ V$$

Extra derivation on sensitivity of V_o to dG_m.

$$\frac{\partial V_o}{\partial G_m'} = V\hat{V}_o = -\frac{150}{13} \times \frac{6 \times 10^4}{13} = -\frac{9 \times 10^6}{169} \simeq -53.25 \times 10^3\ \frac{V}{S}$$

$$\frac{\partial V_o}{\partial G_m} = +53.25\ V/mS$$