Desk Copy

ECE 300
Spring Semester, 2006
HW Set #5:

Due: February 16, 2006 Name wlg
wlg : Version 2 Print (last, first)

Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. **Do neat work. Underline your answers. Show how you got your equations. Be sure to show how you got your answers.** Each problem counts 10 points.

Work the following problem from the text.

4.34 $R_{TH} = 28\ \Omega$, $V_{TH} = 92$ V

4.36 $R_{TH} = 8\ \Omega$, $V_{TH} = 40$ V, (could also be $V_{TH} = 10$ V depending on where you "look" in) i = 500 mA

4.38 $R_{TH} = 58\ \Omega$, $V_{TH} = 19.2$ V, $V_0 = 12.8$ V

4.41 (a) Draw your Thevenin equivalent circuit with actual values on the circuit.
(b) Draw your Norton equivalent circuit with actual values on the circuit.
For the Norton circuit, actually find $I_{\text{short circuit}}$.
$R_{TH} = 4\ \Omega$, $V_{TH} = -8$ V, $I_N = -2$ A

4.47 $R_{TH} = 0.476\ \Omega$, $V_{TH} = 1.19$ V, $I_N = 2.5$ A

4.52 $R_{TH} = 2\ k\Omega$, $V_{TH} = -80$V: Also run Pspice on this problem. Run to determine (and verify) $V_{TH} = V_{OS}$ and again to determine $I_N = I_{SS} = -40$ mA. Include a print outs of each case.

4.53 $R_{TH} = 3\ \Omega$, $I_N = 1$ A: Actually find the short circuit current for I_N. Do not use

$$I_N = V_{TH}/R_{TH}$$

4.54 $R_{TH} = -16.67\ \Omega$, $V_{TH} = 2$ V : V Also run Pspice on this problem. Run to determine (and verify) $V_{TH} = V_{OS}$ and again to determine $I_N = I_{SS} = 16.67$ A. Include a print outs of each case.

4.57 $R_{TH} = 10\ \Omega$, $V_{TH} = 166.7$ V, $I_N = 16.67$ A (Actually find the short circuit current for I_N)

4.64 $V_{TH} = 0$, $R_{TH} = -1\ \Omega$

4.71 R = 8 kΩ, P = 1.15 W

4.34 Find the Thevenin equivalent at terminals *a*-*b* of the circuit in Fig. 4.102.

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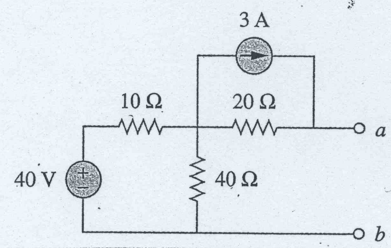
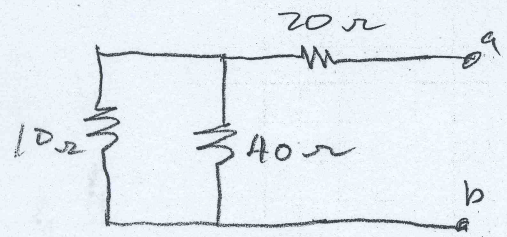


With sources turned off we have



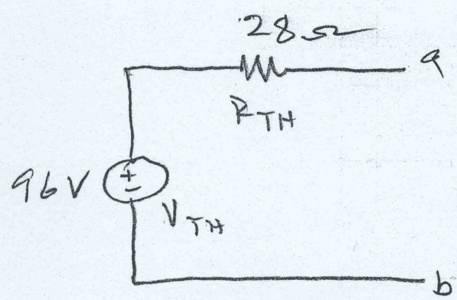
$R_{ab} = R_{TH}$

$$R_{TH} = 20 + \frac{10 \times 40}{10 + 40} = 28\,\Omega$$

$$V_{ab} = \frac{40 \times 40}{40 + 10} + 3 \times 20$$

voltage Divisor

$$V_{ab} = V_{TH} = 32 + 60 = 96\ V$$



Thevenin Circuit

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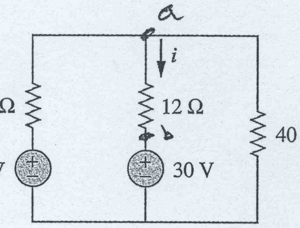
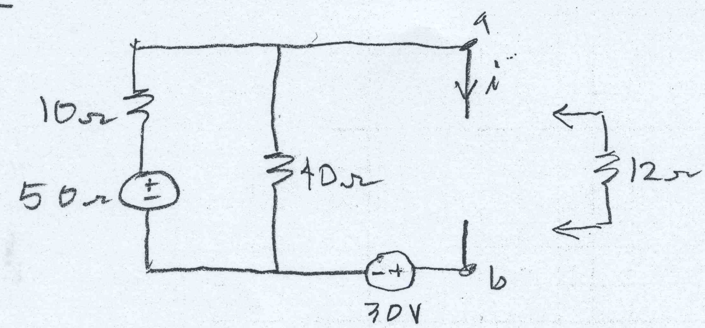
4.36 Solve for the current i in the circuit of Fig. 4.103 using Thevenin's theorem. (*Hint:* Find the Thevenin equivalent seen by the 12-Ω resistor.)

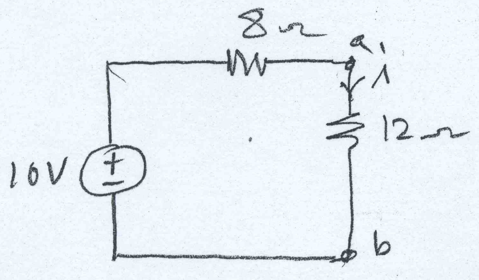


REDRAWN



$$R_{TH} = \frac{40 \times 10}{40 + 10} = 8\,\Omega$$

$$V_{TH} = \frac{50 \times 40}{40 + 10} - 30 = 10\,V$$



$$i = \frac{10}{20} = 0.5\,A$$

$$i = 500\,mA$$

4.38

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4.38 Apply Thevenin's theorem to find V_o in the circu
Fig. 4.105.

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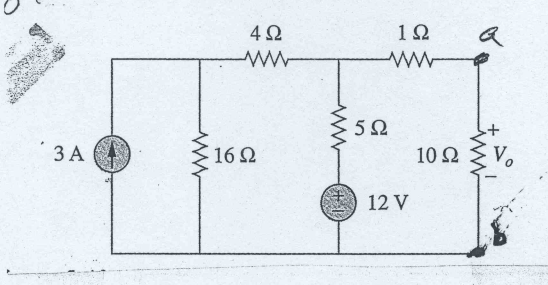
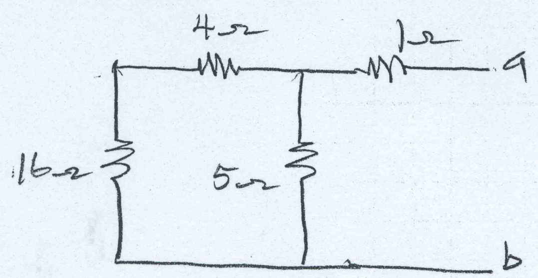
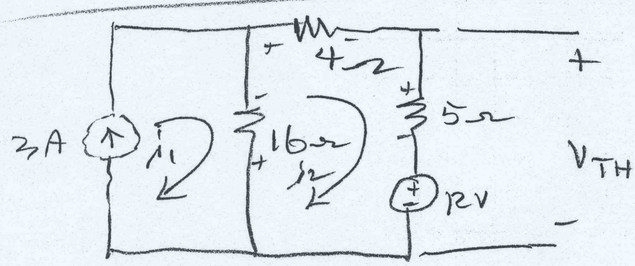


Remove the load and turn off the sources



$$\boxed{R_{TH} = \frac{20 \times 5}{20+5} + 1 = 5\Omega}$$



No current in the 1Ω resistor so no voltage drop there.

$$25 i_2 + 12 - 16 i_1 = 0$$

but $i_1 = 3A$

$$25 i_2 = 16 \times 3 - 12 = 36$$

$$i_2 = \frac{36}{25}$$

$$\boxed{V_{TH} = 12 + \frac{36}{25} \times 5 = 19.2V}$$

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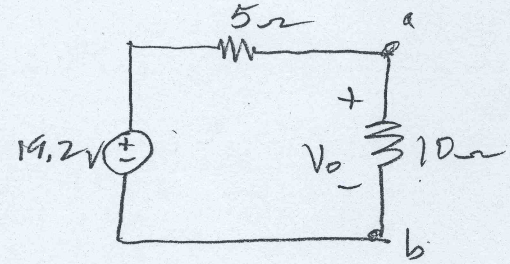
4.38 continued



Voltage divisions

$$V_o = \frac{(19.2)\cdot 10}{10+5} = 12.8$$

$$\boxed{V_o = 12.8\ V}$$

4.41 Find the Thevenin and Norton equivalents at terminals *a-b* of the circuit shown in Fig. 4.108.

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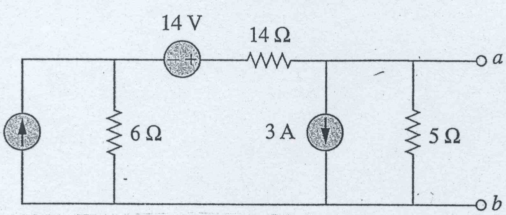
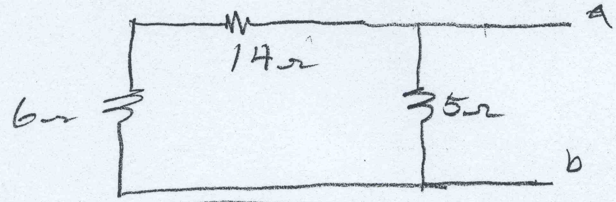


To find R_{TH}



$$\boxed{R_{TH} = \frac{5 \times 20}{5+20} = 4\,\Omega}$$

To find V_{TH}

using nodal and source transformation

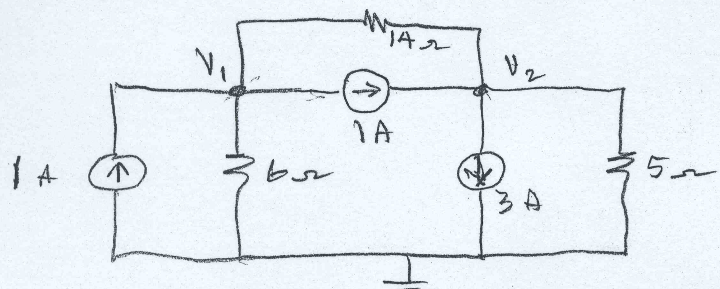


Figure 1

$$\begin{array}{cc} G_{11} & G_{12} \\ \end{array}$$
$$\begin{bmatrix} .2381 & -0.0714 \\ -0.0714 & .2714 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 0 \\ -2 \end{bmatrix}$$
$$\begin{array}{cc} G_{21} & G_{22} \\ \end{array}$$

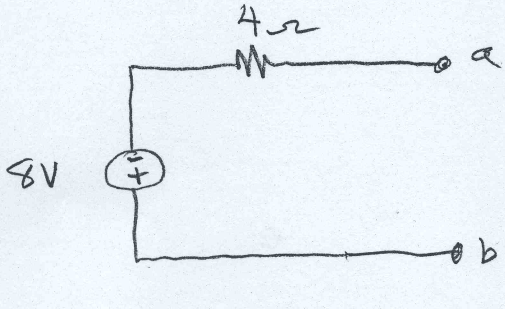
$G_{11} = \frac{1}{6} + \frac{1}{14}$

$G_{11} = .2381$

$G_{22} = \frac{1}{5} + \frac{1}{14}$

$G_{22} = .2714$

$V_1 = -2.4\text{ V}$ $\quad V_2 = \boxed{V_{TH} = -8\text{V}}$



Thevenin ckt

4.41 why

We know that $I_N = -\frac{8}{4} = -2A$ up

We find (verify) this by find the I_{SS} of the following ckt.

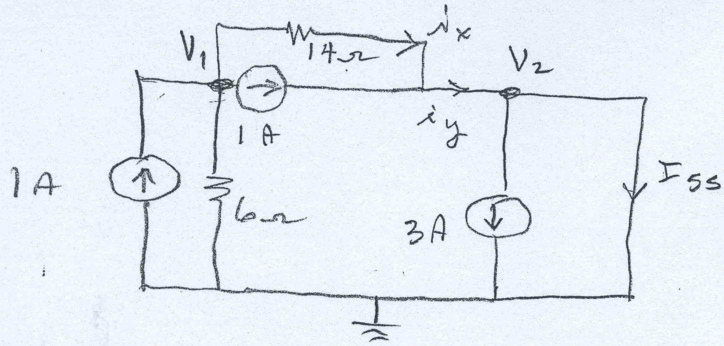
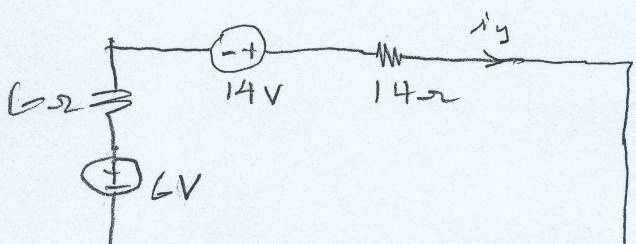


Figure 2

The short circuit shorts out the 5Ω resistor so we leave it off the circuit.

We can proceed with nodal analysis, find V_1 & V_2. From V_1 & V_2 we find i_x. Then $i_y = i_x + 1$. Next $I_{SS} = I_y - 3$.

Another way is convert the current sources shunted by resistors to voltage sources in series with resistor.



Note that the 3A source just goes away. $3 \times 0 = 0$

$i_y = \frac{20}{20} = 1A.$

Back to figure 2. $I_{SS} = i_y - 3 = -2A$

This is what we found from $\frac{V_{TH}}{R_{TH}}$, QED

4.47

4.47 Obtain the Thevenin and Norton equivalent circuits of the circuit in Fig. 4.114 with respect to terminals *a* and *b*.

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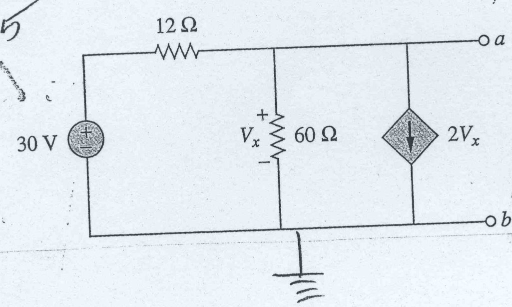
#5



To find V_{TH}:

Use Nodal Analysis

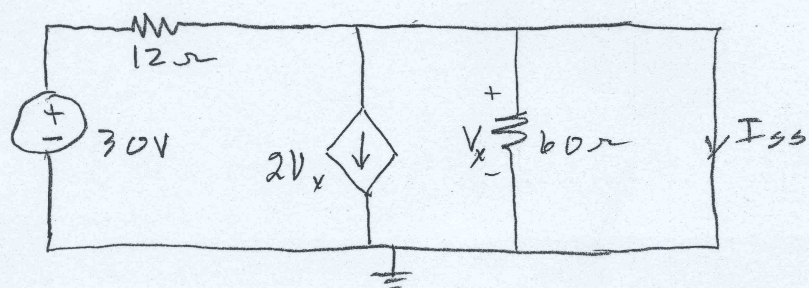
$$\frac{V_x - 30}{12} + \frac{V_x}{60} + 2V_x = 0$$

$$5V_x - 150 + V_x + 120V_x = 0$$

$$126V_x = 150$$

$$V_x = T_{TH} = 1.19\,V$$

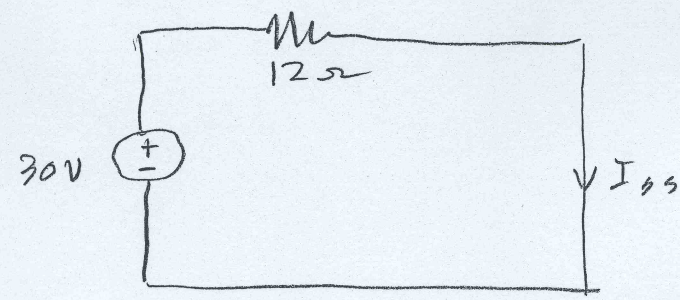
Now Find I_N



When we place the short across the load we short out the 60Ω resistor. This makes V_x go to zero. With V_x going to zero, the $2V_x$ current source goes to zero (Disabled)

4.47
continued

The circuit becomes



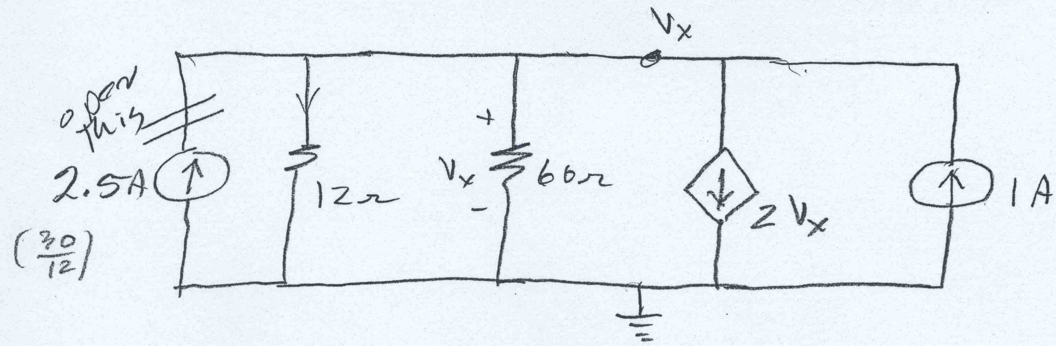
$$I_{ss} = \frac{30}{12} = \frac{15}{6} = \frac{5}{2} = 2.5\ A$$

$$R_{TH} = \frac{V_{oc}}{I_{ss}} = \frac{V_{TH}}{I_N} = \frac{1.19}{2.5}$$

$$\boxed{R_{TH} = 0.476\ \Omega}$$

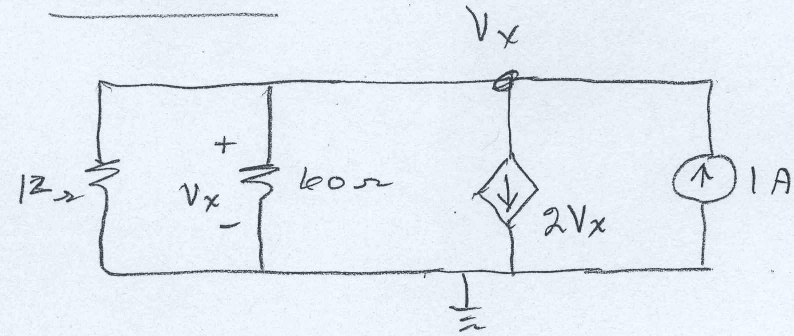
Easier than the other method of finding R_{TH}.

We illustrate the other method below:



$$R_{TH} = \frac{V_x}{1}$$ [Remember to turn-off all independent sources]

4.47 continued



$$\frac{V_x}{12} + \frac{V_x}{60} + 2V_x - 1 = 0$$

$$5V_x + V_x + 120V_x - 60 = 0$$

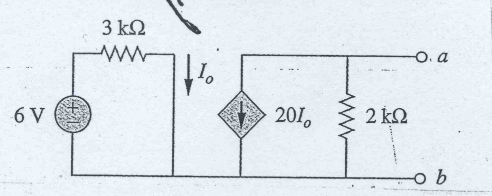
$$126V_x = 60$$

$$V_x = 0.476\text{ V}$$

$$R_{TH} = \frac{V_{TH}}{1}$$

$$R_{TH} = 0.476\ \Omega \qquad \text{QED}$$

4.52 For the transistor model in Fig. 4.118, obtain the Thevenin equivalent at terminals *a-b*.



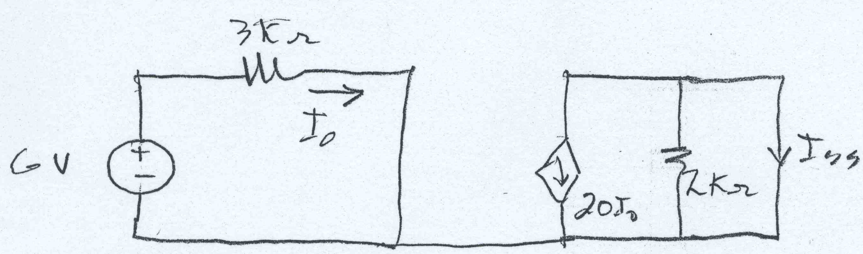
$$V_{TH} = V_{OS} = -20I_o \times 2K$$

$$I_o = \frac{6}{3K} = 2K^{-1}\ A$$

$$\therefore\ V_{OS} = V_{ab} = V_{TH} = -20 \times 2K \times 2K^{-1}$$

$$\boxed{V_{TH} = -80\ V}$$ Verify from PSpice

To find R_{TH}, find I_{SS}. The circuit to find I_{SS} is shown below

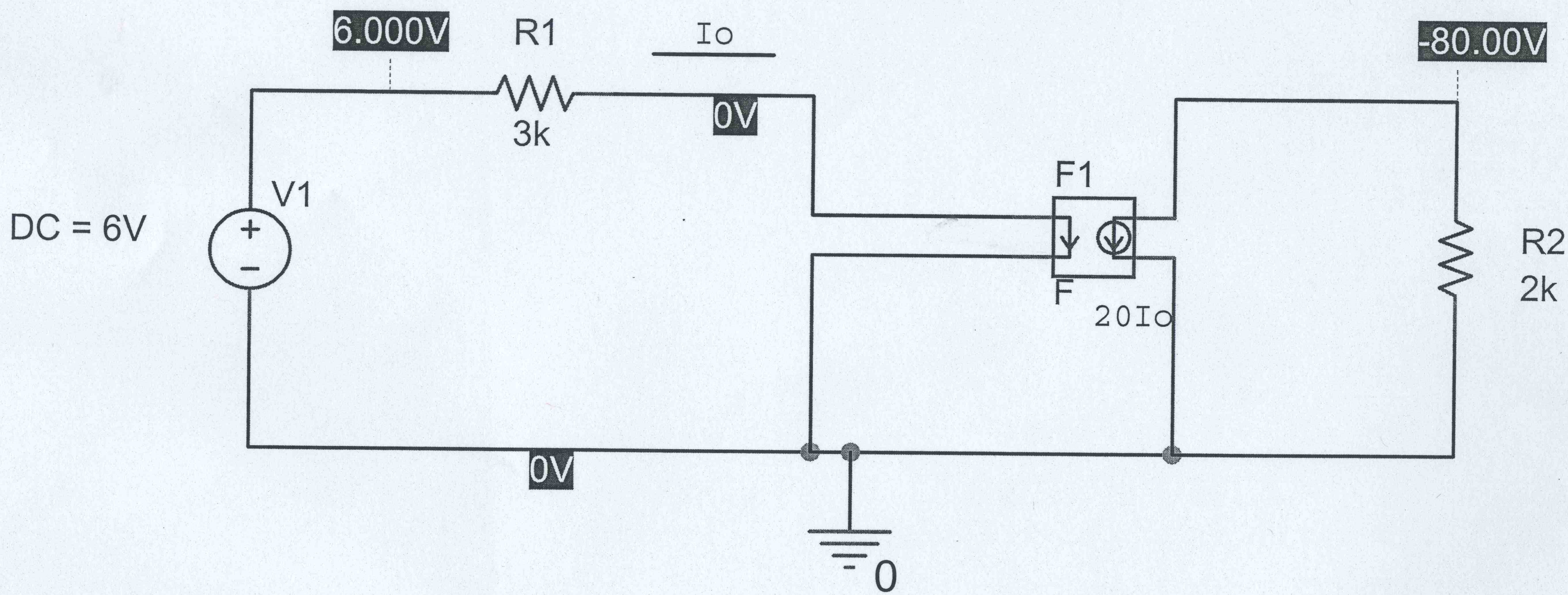


$$I_o = \frac{6}{3K} = 2K^{-1}$$

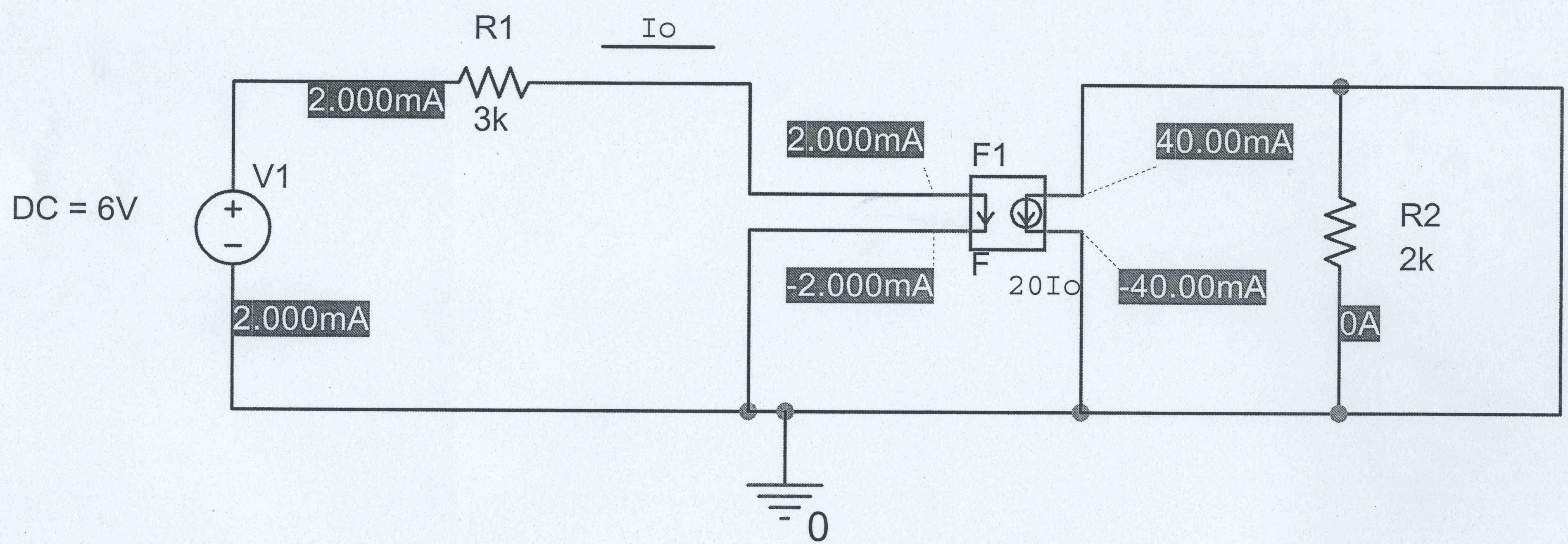
$$I_{SS} = -20I_o = -20 \times 2K^{-1} = -40K^{-1}$$

$$\boxed{R_{TH} = \frac{V_{OS}}{I_{SS}} = \frac{-80}{-40K^{-1}} = 2K\Omega}$$

$$\boxed{I_{SS} = -40\ mA}$$ verify from PSpice



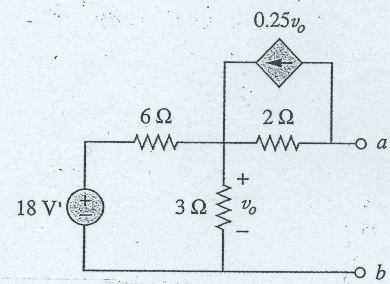
Circuit for Thevenin Voltage: Problem 4.52



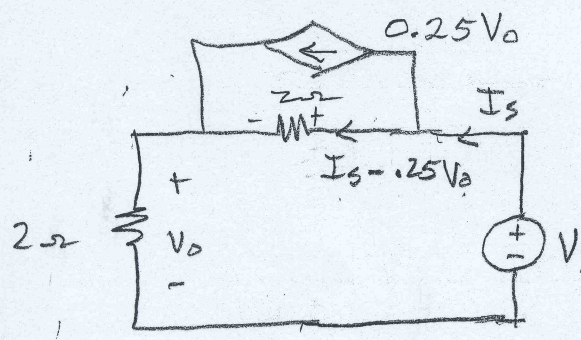
Circuit For Problem 4.52: Showing Currents

4.53

4.53 Find the Norton equivalent at terminals *a-b* of the circuit in Fig. 4.119.



To find R_{TH} use the following circuit.



$$-V_s + 2\,(I_s - 0.25V_o) + 2I_s = 0$$

$$V_o = 2I_s$$

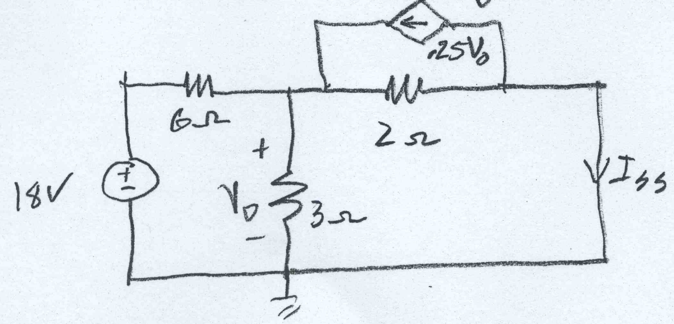
$$-V_s + 2\,(I_s - 0.25 \times 2I_s) + 2I_s = 0$$

$$-V_s + 2I_s - I_s + 2I_s = 0$$

$$V_s = 3I_s$$

$$\boxed{R_{TH} = \frac{V_s}{I_s} = 3\Omega}$$

Use the following ckt to find I_N



4.53 continued

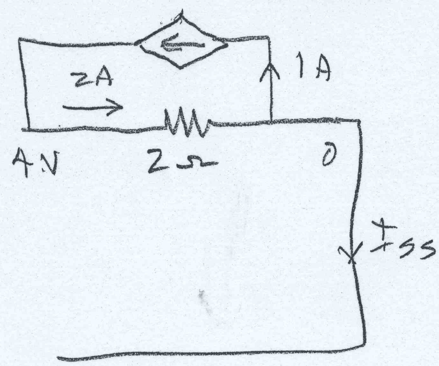
Write KCL at V_0 gives

$$\frac{V_0-18}{6}+\frac{V_0}{3}+\frac{V_0}{2}-0.25V_0=0$$

$$V_0-18+2V_0+3V_0-1.5V_0=0$$

$$4.5V_0=18$$

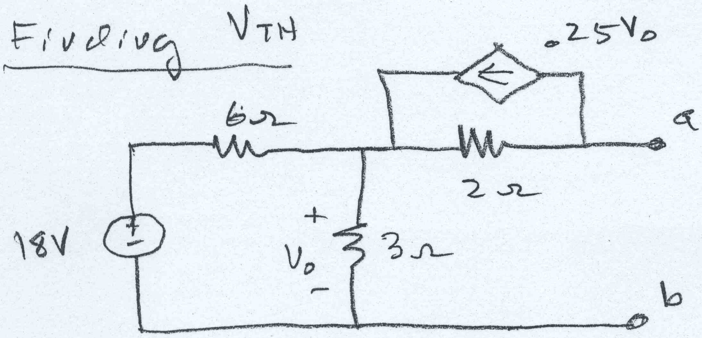
$V_0 = 4\text{ V}$ $\qquad .25V_0 = 1\text{A}$



$$I_{ss}+1=2$$

$$I_{ss}=I_N=1\text{A}$$

Finding V_{TH}

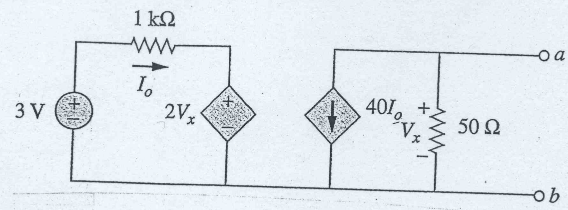


$$V_0=\frac{18\times 3}{3+6}=6\text{V}$$

$$V_{TH}=V_0-2\times .25V_0=6-3=3\text{ V}$$

$$\boxed{R_{TH}=\frac{V_{TH}}{I_N}=\frac{3}{1}=3\,\Omega}$$ Check

4.54 Find the Thevenin equivalent between terminals a-b of the circuit in Fig. 4.120.



FOR V_{TH}:

$$V_{TH} = V_x = -50 \times 40 I_o \qquad (1)$$

$$I_o = \frac{3 - 2V_x}{1K} \qquad (2)$$

Put (1) into (2)

$$V_x = -50 \times 40 \left[\frac{3 - 2V_x}{1K} \right]$$

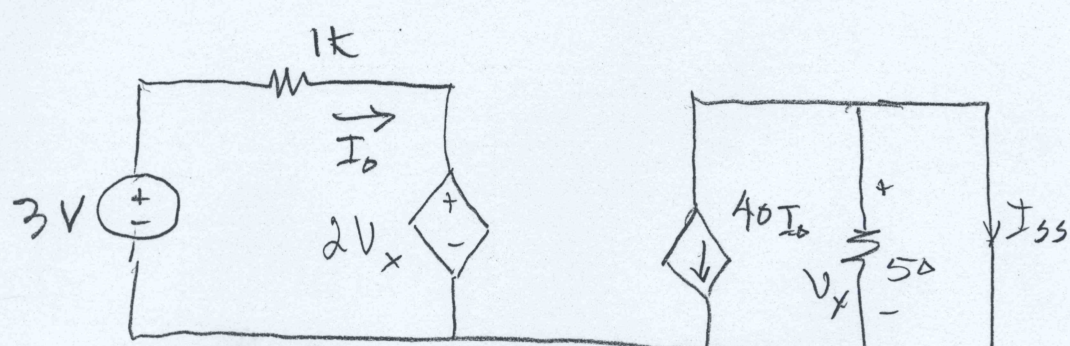
$$V_x = -6 + 4V_x$$

$$-3V_x = -6$$

$$\boxed{V_x = V_{TH} = 2}$$

Now find $I_{ss} = I_N$

Circuit to use:



4.54 Continued

The 50 Ω resistor is shorted.

This makes $V_x = 0$, makes the dependent voltage source $= 0$.

Therefore $I_0 = \frac{3}{1K} = 3\ mA$

$I_{ss} = -40 I_0 = -120\ mA = I_N$

$R_{TH} = \frac{V_{os}}{I_{ss}} = \frac{2}{-.120}$

$\boxed{R_{TH} = -16.67\ \Omega}$

4.54 (Continued)

The 50 Ω resistor is shorted.

This makes $V_x = 0$, makes the dependent voltage source $= 0$.

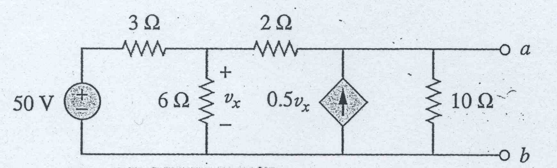
Therefore $I_o = \frac{3}{1K} = 3\ mA$

$I_{ss} = -40 I_o = -120\ mA = I_N$

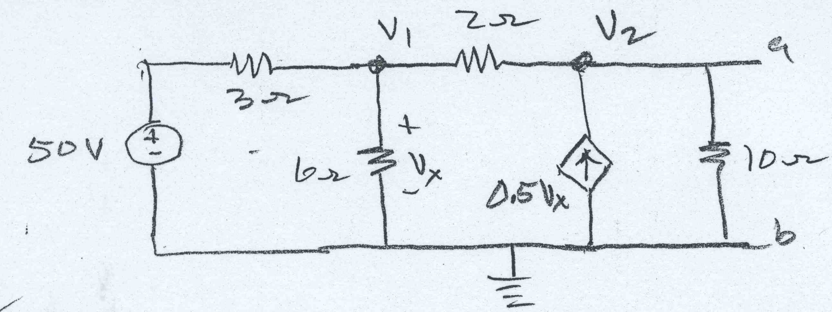
$R_{TH} = \frac{V_{os}}{I_{ss}} = \frac{2}{-.120}$

$$\boxed{R_{TH} = -16.67\ \Omega}$$

4.57 Obtain the Thevenin and Norton equivalent circuits at terminals *a*-*b* for the circuit in Fig. 4.123.



First find $V_{OS} = V_{TH}$.



$V_1 = V_x$

At V_1

$$\frac{V_1 - 50}{3} + \frac{V_1}{6} + \frac{V_1 - V_2}{2} = 0$$

$$2V_1 - 100 + V_1 + 3V_1 - 3V_2 = 0$$

$$\boxed{6V_1 - 3V_2 = 100}$$

At V_2

$$\frac{V_2 - V_1}{2} + \frac{V_2}{10} - 0.5V_1 = 0$$

$$5V_2 - 5V_1 + V_2 - 5V_1 = 0$$

$$\boxed{-10V_1 + 6V_2 = 0}$$

$$\begin{bmatrix} 6 & -3 \\ -10 & 6 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 100 \\ 0 \end{bmatrix}$$

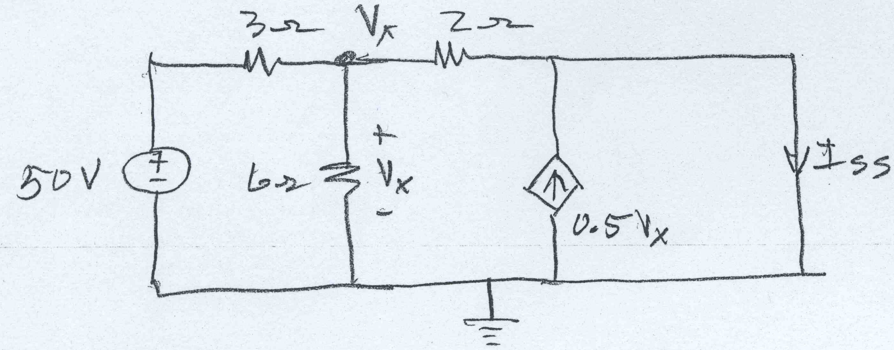
$V_1 = 100\text{ V}$

$V_2 = 166.7 = V_{TH}$

Now find the short circuit current.

The short circuit current is equal to I_N

4.57 CONTINUED



$$\frac{V_x - 50}{3} + \frac{V_x}{6} + \frac{V_x}{2} = 0$$

$$2V_x - 100 + V_x + 3V_x = 0$$

$$6V_x = 100$$

$$V_x = \frac{50}{3}$$

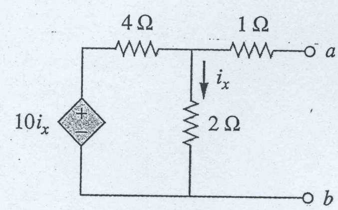
$$I_{ss} = \frac{V_x}{2} + 0.5V_x = V_x$$

$$I_{ss} = I_N = 16.67\text{ A}$$

$$R_{TH} = \frac{V_{TH}}{I_N} = \frac{166.7}{16.67}$$

$$\boxed{R_{TH} = 10\,\Omega}$$

4.64 Obtain the Thevenin equivalent seen at terminals a-b of the circuit in Fig. 4.130.

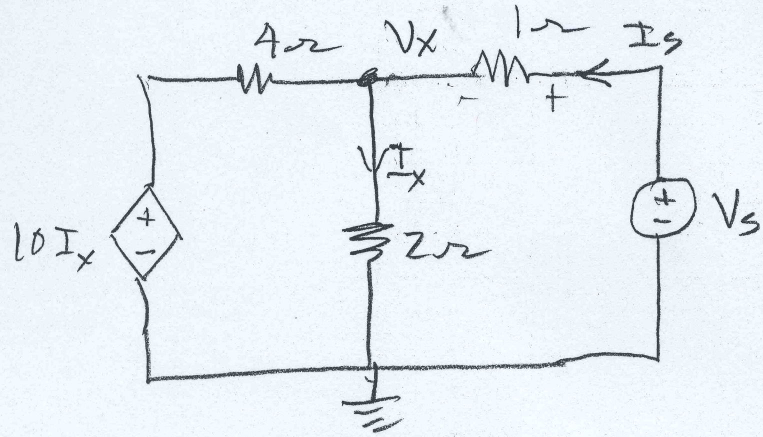


Since there are no independent sources, we have a dead circuit.

Therefore $V_{TH} = 0$, $I_N = 0$

Note: $R_{TH} = \dfrac{V_{TH}}{I_N} = \dfrac{0}{0}$ = indetermined

So we do the following



$-2+10-4-8$

$$\frac{V_x - 10I_x}{4} + \frac{V_x}{2} - I_s = 0$$

$$V_x = V_s - I_s \; ; \quad I_x = \frac{V_x}{2}$$

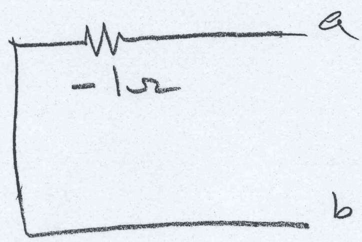
$$\frac{V_s - I_s}{4} - \frac{10(V_s - I_s)}{8} + \frac{V_s - I_s}{2} - I_s = 0$$

$$2V_s - 2I_s - 10V_s + 10I_s + 4V_s - 4I_s - 8I_s = 0$$

$$-4V_s - 4I_s = 0$$

4.64 continued

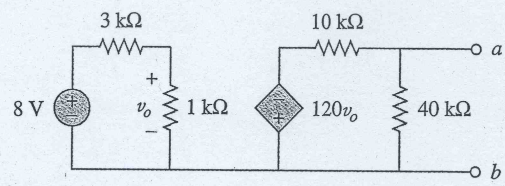
$$\frac{V_s}{I_s} = -\frac{4}{4} = -1\,\Omega$$



Thevenin & Norton Equivalent.

4.71

4.71 For the circuit in Fig. 4.137, what resistor connected across terminals *a-b* will absorb maximum power from the circuit? What is that power?



Find the Thevenin circuit

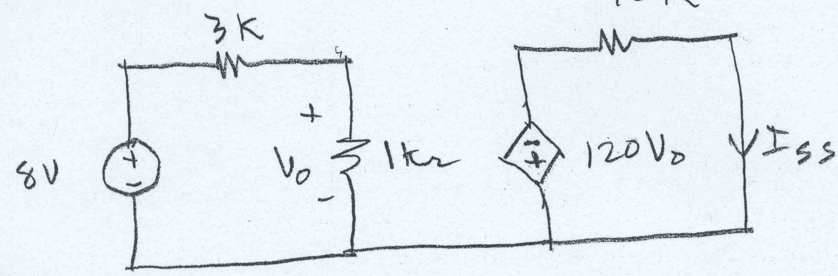
$$V_{OS} = V_{TH} = \frac{-120V_o \times 4\cancel{0}\cancel{K}}{5\cancel{0}\cancel{K}}$$

$$V_{TH} = -96V_o$$

$$V_o = \frac{8 \times 1K}{4K} = 2V$$

$$\boxed{V_{TH} = -192\ V}$$

Find $I_{SS} = I_N$

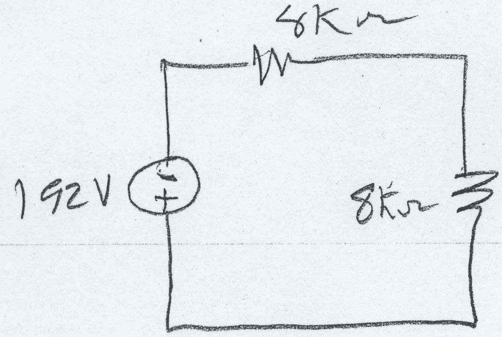


$$I_{SS} = -\frac{120V_o}{10K} \qquad V_o = 2V$$

$$I_{SS} = -\frac{240}{10K} = -24K^{-1}$$

$$R = \frac{V_{TH}}{I_N} = \frac{-192}{-.024} = 8k\Omega$$

4.71 continued



$$P_0 = \frac{V_0^2}{R} = \frac{(192/2)^2}{8K}$$

$$\boxed{P_0 = 1.152 \text{ W}}$$