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ECE 300
Spring Semester, 2006
Test #2

wlg Exam B

Name wlg
Print (last, first)

Work the exam on the space provided below the problem. Work on one side of your paper only. Problems 1 through 4 are 20% each. Problem 5 is 10%. Take home problem is 10%.

(1) Determine the value of V_S in the opamp circuit of Figure 1 so that $V_O = -2$ V.

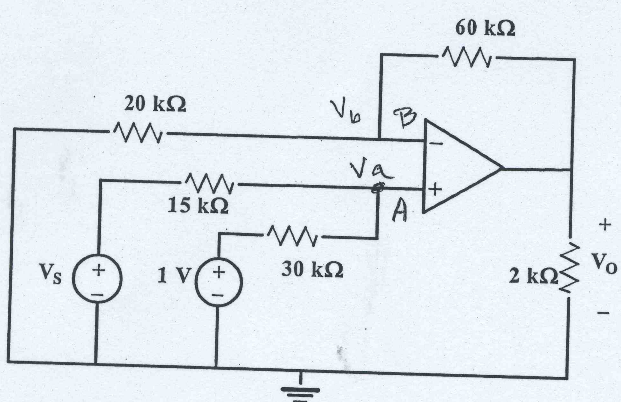


Figure 1: Circuit for problem 1.

At A

$$\frac{V_a - V_s}{15K} + \frac{V_a - 1}{30K} = 0$$

$$2V_a - 2V_s + V_a - 1 = 0$$

$$3V_a = 2V_s + 1$$

$$V_a = \left[\frac{2V_s + 1}{3}\right] \qquad (1)$$

At B

$V_b = V_a$; write a node equation

$$\frac{\left[\frac{2V_s+1}{3}\right]}{20K} + \frac{\left[\frac{2V_s+1}{3} - V_o\right]}{60K} = 0$$

(1) continued

$$\frac{2V_s+1}{} + \frac{2V_s+1}{3} - V_o = 0$$

$$6V_s + 3 + 2V_s + 1 - 3V_o = 0$$

$$8V_s = 3V_o - 4$$

$$V_s = \left.\frac{3V_o - 4}{8}\right|_{V_o=-2} = \frac{-10}{8}$$

$$\boxed{V_s = \frac{-10}{8}\,V = -1.25\,V}$$

(2) You are given the circuit shown in Figure 2.

(a) Find the Thevenin equivalent circuit, with respect to terminals a-b.

(b) Draw the Thevenin equivalent circuit: include V_{TH} and R_{TH}.

(c) What resistor placed between terminals a-b will give maximum power Transfer to this resistor? Determine the value of this power.

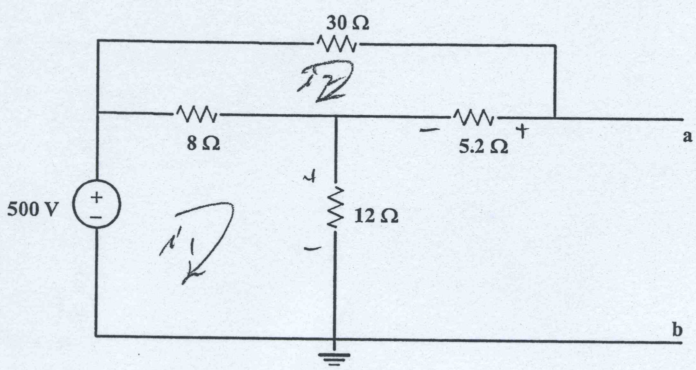
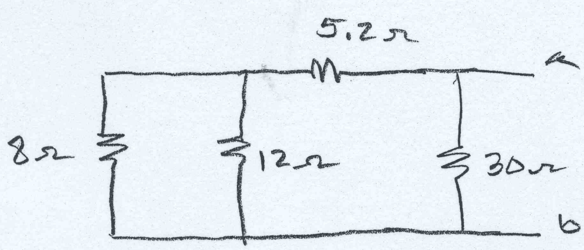


Figure 2: Circuit for problem 2.

(a) First find R_{TH}.



$$8 \| 12 = \frac{8 \times 12}{20} = 4.8\,\Omega$$

$$R_{TH} = 30 \| 10 = \frac{30 \times 10}{40} = 7.5\,\Omega$$

$$\boxed{R_{TH} = 7.5\,\Omega}$$

Using mesh

$$\begin{bmatrix} 20 & -8 \\ -8 & 43.2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 500 \\ 0 \end{bmatrix}$$

$i_1 = 27\,A$ $\quad i_2 = 5\,A$

(2) cont.

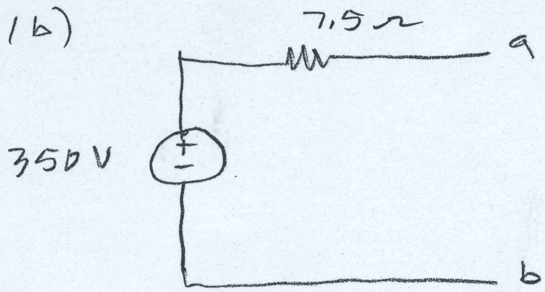
$$V_{ab} = 12 i_1 + 5.2 i_2$$

$$= 12 \times 27 + 5.2 \times 5$$

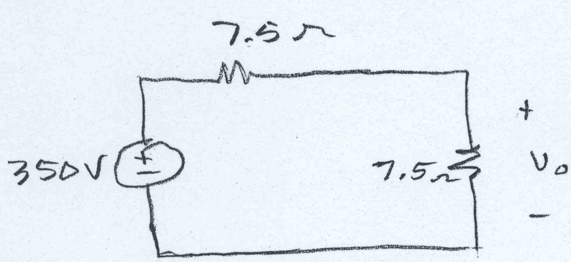
$$= 350\,V$$

$$V_{ab} = V_{TH} = 350\,V$$

(b)



(c) FOR max pwr xfer.



$$P_o = \frac{V_o^2}{7.5}$$

$$V_o = \frac{350}{2} = 175\,V$$

$$P_o = \frac{175^2}{7.5} = 4083\,W$$

$$\boxed{P_o = 4083\,W}$$

(3) You are given the circuit of Figure 3.

(a) Find the Norton equivalent circuit with respect to terminals a-b. You are required to find I_{NORTON} by actually finding the short circuit current.

(b) Draw your Norton equivalent circuit showing the I_{NORTON}, R_{TH} and terminals a-b.

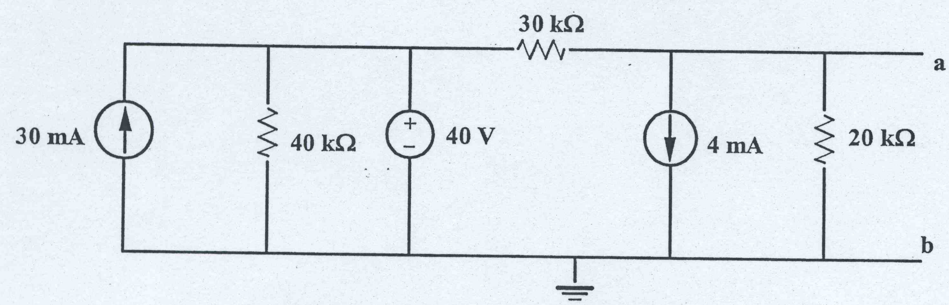
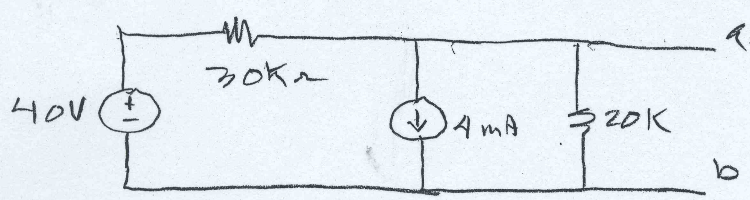


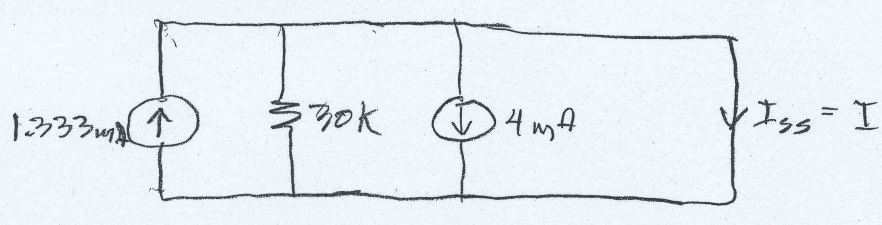
Figure 3: Circuit for problem 3.

(a) The circuit can be redrawn as follows



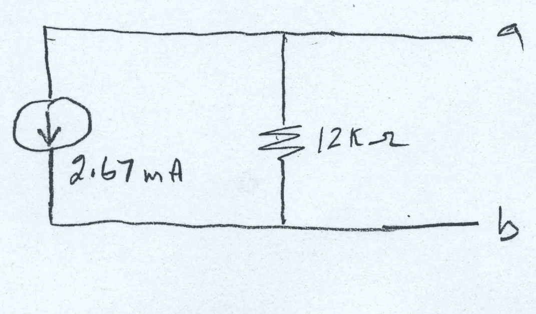
$\therefore \quad R_{TH} = \dfrac{30K \times 20K}{50K} = 12K$

shorting a-b, shorts out the 20kΩ resistor.
The circuit becomes (with a source transformation)



$I_N = -4 + 1.333 = -2.67mA$

(b)



Norton Equivalent Circuit

(4) You are given the circuit of Figure 4.

(a) Give the value of the Thevenin voltage seen looking into terminals a-b.

(b) Determine the resistance R_{TH} seen looking into terminals a-b.

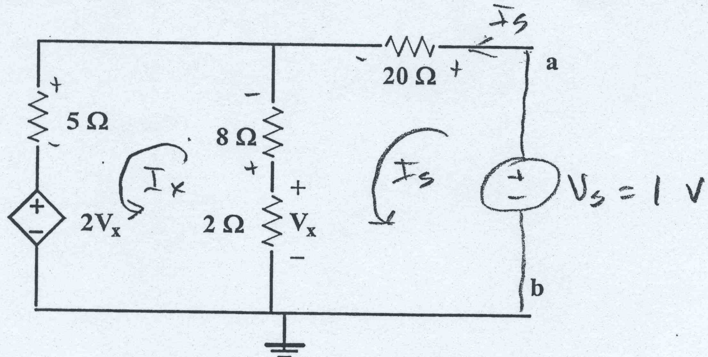


Figure 4: Circuit for problem 4.

(a) Since there are no independent sources, $V_{TH} = 0$. (It is a dead circuit).

(b) Apply a source, $V_s = 1V$, as shown in the diagram. Determine I_s. Then

$$R_{TH} = \frac{V_s}{I_s} = \frac{1}{I_s}$$

For mesh I_x

$$-V_x + 8(I_x - I_s) + 5I_x + 2V_x = 0$$

$$13I_x - 8I_s + V_x = 0 \qquad (1)$$

but $V_x = 2(I_s - I_x) = 2I_s - 2I_x \qquad (2)$

substitute (2) into (1)

$$13I_x - 8I_s + 2I_s - 2I_x = 0$$

$$\boxed{11I_x - 6I_s = 0} \qquad (3)$$

(4) continued

<u>For mesh I_5</u>

$$-1 + 30 I_5 - 10 I_x = 0$$

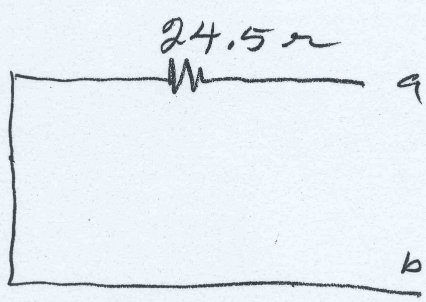
$$-10 I_x + 30 I_5 = 1 \qquad (4)$$

$$\begin{bmatrix} 11 & -6 \\ -10 & 30 \end{bmatrix} \begin{bmatrix} I_x \\ I_5 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$I_5 = 0.0407$ A

$$\boxed{R_{TH} = \frac{1}{.0407} \doteq 24.5\ \Omega}$$

(c)



Thevenin Circuit

B

(5) Find the voltage across each capacitor in the circuit show in in Figure 5.

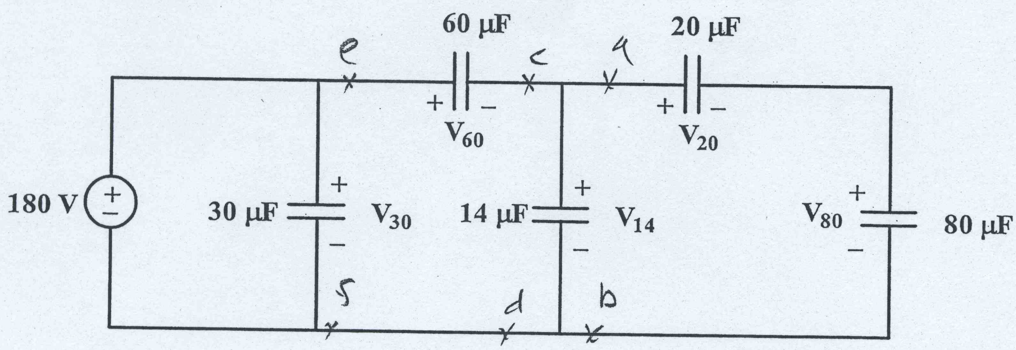


Figure 5: Circuit for problem 5.

$$C_{ab} = \left(\frac{20 \times 80}{20 + 80}\right)\mu F = 16\,\mu F$$

$$C_{cd} = 14\,\mu F + 16\,\mu F = 30\,\mu F$$

$$C_{ef} = \frac{60 \times 30}{60 + 30}\,\mu F = 20\,\mu F$$

$$\boxed{V_{30} = 180\,V}$$

$$\boxed{V_{60} = \left(\frac{180 \times 30}{30 + 60}\right) = 60\,V}$$

$$\boxed{V_{14} = 180 - V_{60} = 120\,V}$$

$$\boxed{V_{20} = \frac{V_{14} \times 80}{80 + 20} = 96\,V}$$

$$\boxed{V_{88} = V_{14} - 96 = 24\,V}$$