Name: Solutions

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Time: 10 11 12 1

- There are 17 pages in this quiz, including this cover page.
- Please put your name in the space provided above, and circle the name of your recitation instructor together with the time of your recitation.
- Do your work for each question within the boundaries of that question, or on the back of the preceding page. When finished, clearly indicate your answer, perhaps by circling it.
- This is a closed-book quiz, but calculators and a single two-sided page of notes are allowed.
- Good luck!
Problem 1: Thevenin & Norton Equivalence – 10%

The objective of this problem is to determine the Thevenin and Norton equivalents observed at the output port of the network shown below. The network contains only independent sources and linear resistors.

(1A) Determine the Thevenin/Norton equivalent resistance $R_{TH}$ observed at the output port of the network. A numerical result with appropriate units is expected.

Using parallel and series resistor combinations, the circuit above reduces to

\[ \text{12V} \quad \text{1k}\Omega \quad 1\Omega \quad 2\text{mA} \]

Zerosing the sources, it is seen that $R_{TH} = 2\text{k}\Omega$.
(1B) Determine the Thevenin equivalent voltage $V_{\text{TH}}$ and the Norton equivalent current $I_N$ observed at the output port of the network. Numerical results with appropriate units are expected.

By superposition, the Thevenin equivalent voltage

$$12 \, V + 2 \, V = 14 \, V = V_{\text{TH}}.$$  

The Norton equivalent current is

$$\frac{V_{\text{TH}}}{R_{\text{TH}}} = I_N = 7 \, \text{mA}.$$
Problem 2: Power – 15%

Consider the network shown below. In this network, a Thevenin equivalent having an 80-V source and a resistance $R$ is connected to a load resistor also having resistance $R$ through two wires each modeled as having a 1-Ω resistance.

\[ R \quad \text{Thevenin}
\]
\[ \text{Equivalent} \quad 1 \, \Omega \quad \text{Wire} \quad \text{Load} \quad R \]

\[ 80 \, V \]

(2A) Determine the value of $R$ for which the greatest power is dissipated in the load. Also determine the corresponding load power. *Numerical results with appropriate units are expected.*

\[
\text{The dissipated power is} \quad \text{in the load} \quad R \cdot \text{Current}^2 = R \left( \frac{80 \, V}{2R+2\Omega} \right)^2
\]

\[
= R \left( \frac{40 \, V}{(R+1\omega)} \right)^2. \quad \text{This is maximized for}
\]

\[
(40 \, V)^2 (R+1\omega)^2 = 2 (R+1\omega) R (40 \, V)^2 \Rightarrow R = 1 \, \Omega.
\]

The dissipated power is 400 W. More generally, the dependence of dissipated power on $R$ is as follows.

\[ \text{Power} \]

\[ \begin{array}{c}
\text{400 W} \\
0 \\
1 \, \Omega \\
\end{array} \]

\[ \text{R} \]
In a separate instance it is observed that the power dissipated in the load is 300 W. It is also observed that the power dissipated in the load increases with decreasing $R$. Under these conditions, determine $R$. A numerical result with appropriate units is expected.

From the previous discussion, the upper solution for 300-W dissipation is derived as seen below.

![Graph showing power dissipation vs. resistance]

The requirement is \[ R \frac{(40 \text{ V})^2}{(R + 10 \text{ V})^2} = 300 \text{ W}. \]

The solution to this quadratic equation are $R = 3 \text{ V}$ and $R = \frac{1}{30} \text{ V}$. Choose $R = 3 \text{ V}$. 

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