Electric Circuits - Homework 01

Automation Class 1802

(Due date: 2020/10/5)

This assignment covers Ch1 and Ch2 of the textbook. The full credit is 100 points. For each question, detailed derivation processes and accurate numbers are required to get full credit.

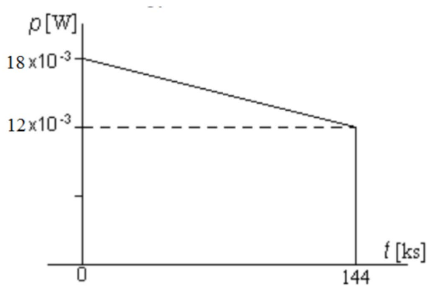
1. (15 points) Problem 1.13 of the textbook (p41), while the current is changed from 9 mA to 12 mA.

Ans:

W

$$p = ui; \qquad w = \int_0^t p dx$$

Since the energy is the area under the power vs. time plot, let us plot p vs. t.



Note that in constructing the plot above, we used the fact that 40 hr = 144,000 s = 144 ks

$$p(0) = (1.5)(12 \times 10^{-3}) = 18 \times 10^{-3} W$$

$$p(144ks) = (1)(12 \times 10^{-3}) = 12 \times 10^{-3} W$$

$$w = (12 \times 10^{-3})(144 \times 10^3) + \frac{1}{2}(18 \times 10^{-3} - 12 \times 10^{-3})(144 \times 10^3) = 2160J$$

2. (15 points) Problem 2.7 of the textbook (p71), while the left and middle independent voltage sources are changed from 50 V and 80 V to 100 V and 200 V, respectively.

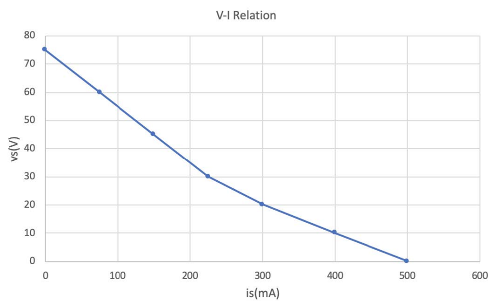
Ans:

The interconnection is valid. In the middle branch, the value of the current i_Δ must be -25 A, since the 25 A current source supplies current in this branch in the direction opposite the direction of the current i_Δ. Therefore, the voltage supplied by the dependent voltage source in the left hand branch is $6(-25) = -150$ V. This gives a voltage drop from the top terminal to the bottom terminal in the left hand branch of $100 - (-150) = 250$ V. And the voltage drop between these same terminals in the right hand branch is 250 V, due to the voltage source in that right branch. Therefore, the interconnection is valid.

3. (20 points) Problem 2.17 of the textbook (p73), while the resistor in (c) is changed from 400 Ω to 100 Ω.

Ans:

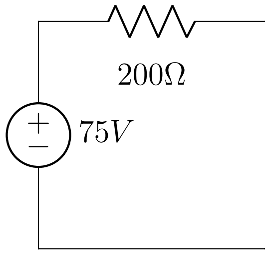
a). Begin by constructing a plot of voltage versus current:



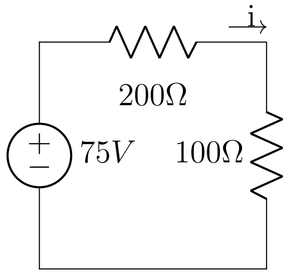
b). Since the plot is linear for $0 \leq i_s \leq 225$ mA amd since R $= \Delta v/\Delta i$, we can calculate R from the plotted values as follows:

$$R = \frac{\Delta v}{\Delta i} = \frac{75 - 30}{0.225 - 0} = \frac{45}{0.225} = 200\Omega$$

We can determine the value of the ideal voltage source by considering the value of v_s when $i_s = 0$. When there is no current, there is no voltage drop across the resistor, so all of the voltage drop at the output is due to the voltage source. Thus the value of the voltage source must be 75 V. The model, valid for $0 \leq i_s \leq 225$ mA, is shown below:



c). The circuit is shown below:



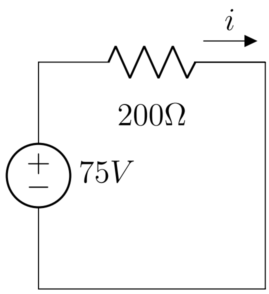
Write a KVL equation in the clockwise direction, starting below the voltage source. Use Ohm's law to express the voltage drop across the resistors in terms of the current i:

$$-75 + 200i + 100i = 0, \qquad so \qquad 300i = 75V$$

Thus,

$$i = \frac{75}{300} = 250mA$$

d). The circuit is shown below:



Write a KVL equation in the clockwise direction, starting below the voltage source. Use Ohm's law to express the voltage drop across the resistors in terms of the current i:

$$-75 + 200i = 0, \qquad so \qquad 200i = 75V$$

Thus,

$$i = \frac{75}{200} = 375mA$$

e). The short circuit current can be found in the table of values (or from the plot) as the value of the current is when the voltage $v_s = 0$. Thus, $i_{sc} = 500mA$ (from table)

f). The plot of voltage versus current constructed in part (a) is not linear (it is piecewise linear, but not linear for all values of i_s). Since the proposed circuit model is a linear model, it cannot be used to predict the nonlinear behavior exhibited by the plotted data.

4. (10 points) Problem 2.20 of the textbook (p73), while the current ia is changed from 2 mA to 5 mA.

Ans:

a). Use KVL for the right loop to calculate the voltage drop across the right-hand branch v_0. This is also the voltage drop across the middle branch, so once v_0 is known, use Ohm's law to calculate i_0:

$$v_0 = 5000i_a + 4000i_a + 3000i_a = 12000(0.005) = 60V$$

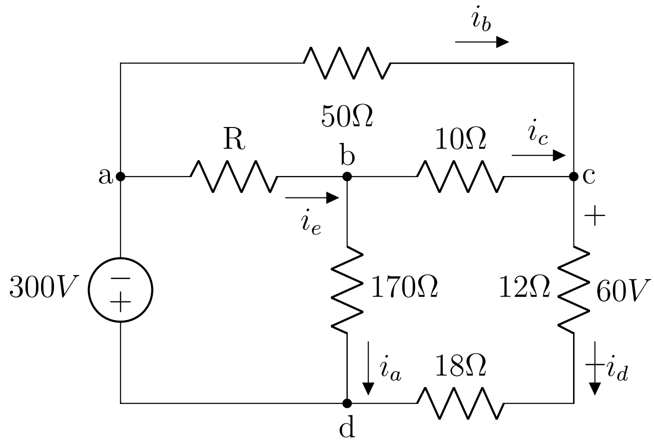
$$i_0 = \frac{60}{2000} = 30mA$$

b). $i_g = i_a + i_0 = 35mA$ c). The voltage drop across the source is v_0, seen by writing a KVL equation for the left loop.

Thus, $p_g = -v_0 i_g = -(60)(0.035) = 2.1W$

Thus the source delivers 2.1W.

5. (15 points) Problem 2.25 of the textbook (p74), while the voltage source is changed from 240 V to 300 V and the 45-Ω to 180-Ω resistances are changed to 50 Ω and 170 Ω, respectively.



$i_d = 60/12 = 5A;$ $v_{cd} = 60 + 18(5) = 150V$

$v_{ac} + v_{cd} = 300;$ $v_{ac} = 300 - 150 = 150V$

$i_b = v_{ac}/50 = 3A;$ $i_c = i_d - i_b = 2A$

$v_{bd} = 10i_c + v_{cd} = 170V;$ $i_a = v_{bd}/170 = 1A$

$i_e = i_a + i_c = 3A$

$v_{ab} + v_{bd} = 300;$ $v_{ab} = 300 - 170 = 130V$

$R = v_{ab}/i_e = 130/3 = 43.3\Omega$

6. (15 points) Problem 2.30 of the textbook (p75), while the left voltage source is changed from 100 V to 125 V.

a).

$$125 - 20i_\sigma + 18i_\Delta = 0$$

$$-18i_\Delta + 5i_\sigma + 40i_\sigma = 0; 18i_\Delta = 45i_\sigma$$

$$125 - 20i_\sigma + 45i_\Delta = 0$$

$$So, i_\sigma = 5A \qquad and \qquad i_\Delta = 12.5A$$

$$v_0 = 40i_\sigma = 200V$$

b). i_g = current out of the positive terminal of the 125 V source v_d = voltage drop across the 8_Δ source

$$\begin{aligned}
i_g &= i_\Delta + i_\sigma + 8i_\Delta = 9i_\Delta + i_\sigma = 117.5A \\
v_d &= 200 - 20 = 180V \\
\sum P_{gen} &= 125i_g + 20i_\sigma i_g = 125(117.5) + 20(5)(117.5) = 26437.5W \\
\sum P_{diss} &= 18(i_\Delta)^2 + 5i_\sigma(i_g - i_\Delta) + 40(i_\sigma)^2 + 8i_\Delta(v_d + 20) \\
&= (18)(12.5)^2 + 25(117.5 - 12.5) + (40)(25) + (8)(12.5)(200) \\
&= 26437.5W = \sum P_{gen}
\end{aligned}$$

7. (10 points) Problem 2.34 of the textbook (p76), while the resistance of the trunk is changed from 50 Ω to 150 Ω.

a). From the simplified circuit model, using Ohm's law and KVL :

$$400i + 150i + 200i - 250 = 0; i = 250/750 = 333mA$$

This current is nearly enough to stop the heart, according to Table 2.1, so a warning sign should be posted at the 250 V source.

b). The closest value from Appendix H to 400 is 390; The closest value from Appendix H to 150 is exactly 150. There are two possibilities for replacing the 200 resistor with a value from Appendix H – 180 and 220. We calculate the resulting current for each of these possibilities, and determine which current is closest to 333 mA:

$$390i + 150i + 180i - 250 = 0; i = 250/720 = 347mA$$

$$390i + 150i + 220i - 250 = 0; i = 250/760 = 329mA$$

Therefore, choose the 220 resistor to replace the 200 resistor in the model.