Solution Second Partial Integrator Exam

TE1002 Circuits 1

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Problem 1 (15 points)

Employ superposition principles to obtain a value for the current I_x as labeled in Fig. 5.56.

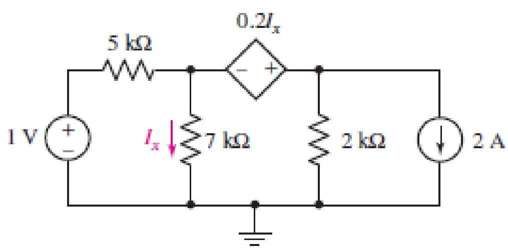


FIGURE 5.56

Solution Problem 1

We select the bottom node as the reference, then identify v_1 with the lefthand terminal of the dependent source and v_2 with the righthand terminal.

Via superposition, we first consider the contribution of the 1 V source:

$$\frac{v_1'-1}{5000}+\frac{v_1'}{7000}+\frac{v_2'}{2000}=0 \quad \text{and}$$

$$\left(1+\frac{0.2}{7000}\right)v_1'-v_2'=0$$

Solving, v_1' = 0.237 V

Next, we consider the contribution of the 2 A source:

$$\frac{v_1''}{5000}+\frac{v_1''}{7000}+\frac{v_2''}{2000}=-2 \quad \text{and}$$

$$\left(1+\frac{0.2}{7000}\right)v_1''-v_2''=0$$

Solving, v_1" = –2373 V. Adding our two components, v_1 = –2372.763 V.

Thus, $i_x = v_1/7000 = \boxed{-338.9661\ \text{mA}}$

Problem 2 (15 points)

(*a*) Using repeated source transformations, reduce the circuit of Fig. 5.62 to a voltage source in series with a resistor, both of which are in series with the 6 MΩ resistor. (*b*) Calculate the power dissipated by the 6 MΩ resistor using your simplified circuit.

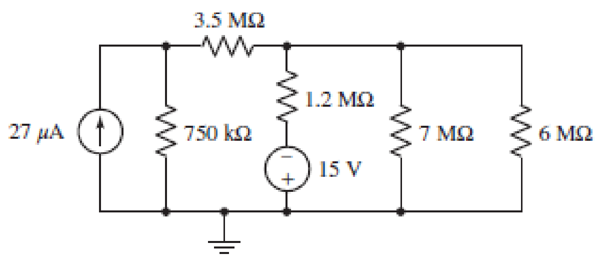


FIGURE 5.62

Solution Problem 2

(a) Perform the following steps in order:

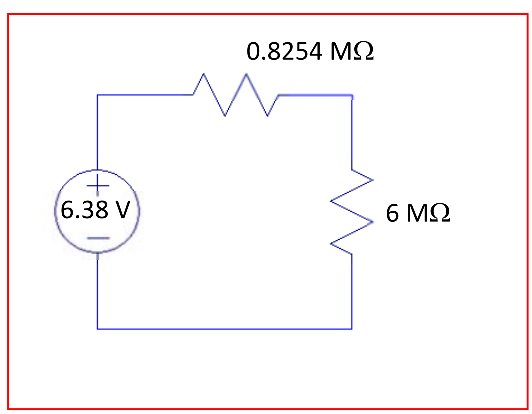
Combine the 27 μA and 750 kΩ to obtain 20.25 V in series with 750 kΩ in series with 3.5 MΩ.

Convert this series combination to a 4.25 MΩ resistor in parallel with a 4.765 μA source, arrow up.

Convert the 15 V/ 1.2 MΩ series combination into a 12.5 μA source (arrow down) in parallel with 1.2 MΩ. This appears in parallel with the current source from above as well as the 7 MΩ and 6 MΩ.

Combine: 4.25 MΩ || 1.2 MΩ || 7 MΩ = 0.8254 MΩ. This, along with the -12.5 μA + 4.765 μA yield a -7.735 μA source (arrow up) in parallel with 825.4 kΩ in parallel with 6 MΩ.

Convert the current source and 825.4 kΩ resistor into a 6.38 V source ('+' reference up) in series with 825.4 kΩ and 6 MΩ.



(b) $P_{6M\Omega} = \left[\dfrac{6.38}{6\times10^6 + 825.4\times10^3}\right]^2 \left(6\times10^6\right) = \boxed{5.24\ \mu\text{W}}$

Problem 3 (20 points)

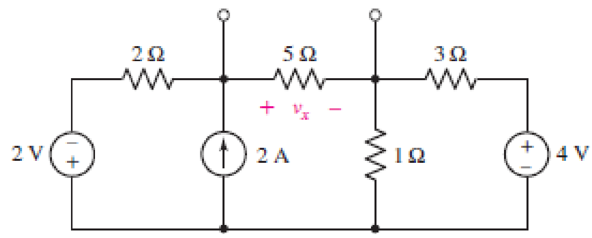


FIGURE 5.74

(*a*) Determine the Norton equivalent of the circuit depicted in Fig. 5.74 as seen looking into the two open terminals. (*b*) Compute power dissipated in a 5 Ω resistor connected in parallel with the existing 5 Ω resistor. (*c*) Compute the current flowing through a short circuit connecting the two terminals.

Solution Problem 3

(a) Employ nodal analysis:

$$2 = \frac{v_1 + 2}{2} + \frac{v_1 - v_2}{5} \qquad [1]$$

$$0 = \frac{v_2 - v_1}{5} + v_2 + \frac{v_2 - 4}{3} \qquad [2]$$

Solving, $v_1 = 54/31$ V and $v_2 = 34/31$ V. Thus, $V_{TH} = v_X = v_1 - v_2 = 645.2$ mV

By inspection, $R_{TH} = 5 \parallel [2 + 1\|3] = 1.774\ \Omega$

Thus, $i_N = v_{TH}/R_{TH} = \boxed{363.7\text{ mA}}$ and $R_N = R_{TH} = \boxed{1.774\ \Omega}$

(b) $i_{load} = (0.3637)(1.774)/(5 + 1.774) = 95.25$ mA

$P_{load} = 5(i_{load})^2 = \boxed{45.36\text{ mW}}$

(c) $\boxed{363.7\text{ mA}}$

Problem 4 (20 points)

(a) Determine the two-component Thévenin equivalent of the network in Fig. 5.102. (b) Calculate the power dissipated by a 1 Ω resistor connected between the open terminals.

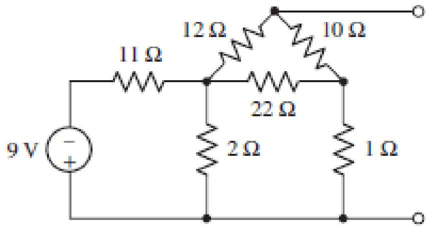


FIGURE 5.102

Solution Problem 4

(a) Shorting the 9 V source leaves the 11 Ω in parallel with 2 Ω.
Name this RA = 1.69 Ω.
Then, RB = 22 Ω, and RC = 1 Ω.

Converting this to a T network, with R = RA + RB + RC = 24.69 Ω.

$$R1 = \frac{RA \cdot RB}{R} = 1.51\ \Omega$$
$$R2 = \frac{RB \cdot RC}{R} = 0.891\ \Omega$$
$$R3 = \frac{RC \cdot RA}{R} = 0.0684\ \Omega$$

Then, R_{Th} = (12+R1) || (10+R2) + R3 = $\boxed{6.098\ \Omega.}$

Define three nodal voltages on the original circuit after naming the bottom node as the reference node: V1, V2, Voc. Then,

$$0 = \frac{V1-9}{11} + \frac{V1}{2} + \frac{V1-Voc}{12} + \frac{V1-V2}{22}$$
$$0 = \frac{V2}{1} + \frac{V2-V1}{22} + \frac{V2-Voc}{10}$$
$$0 = \frac{Voc-V2}{10} + \frac{Voc-V1}{12}$$

Solving, V_{oc} = $\boxed{-606.7\ \text{mV}}$

(b) $P_{1\Omega} = [0.6067/7.098]^2\ (1) = \boxed{7.306\ \text{mW}}$

Problem 5 (10 points)

Determine the Norton equivalent of the circuit drawn in Fig. 5.81 as seen by terminals *a* and *b*. (There should be no dependent sources in your answer.)

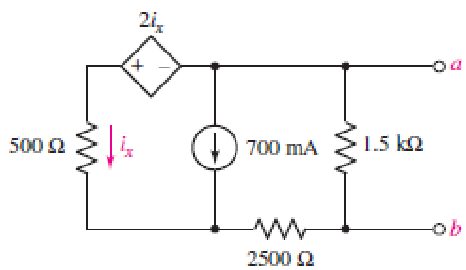


FIGURE 5.81

We short the terminals of the network and compute the short circuit current. To do this, define two clockwise mesh currents (the 1500 Ω resistor is shorted out).

$$500i_1 + 2i_x + 2500i_2 = 0 \qquad [1]$$
$$i_1 - i_2 = 0.7 \qquad [2]$$
$$i_1 = -i_x \qquad [3]$$

Or equivalently:

$$-500i_x + 2i_x + 2500i_2 = 0 \qquad [1]$$
$$-i_x - i_2 = 0.7 \qquad [2]$$

Solving, $i_2 = i_{sc} = i_N = \boxed{-116.3 \text{ mA}}$

Next, we zero out the independent source and connect a 1 A test source across the terminals *a* and *b* such that 1 A flows into *a*. Define v_{test} with the '+' reference at terminal *a*, and the cathode at terminal *b*. Then,

$$-2i_x + 500i_x + 2500i_x + 1500(i_x - 1) = 0$$
$$so$$
$$i_x = 0.333 \text{ A}$$

Solving, $v_{test} = 1500(1 - i_x) = 1000\text{V}$ so

$$R_{TH} = v_{test}/1\text{A} = \boxed{1000\ \Omega}$$