Solution Training Second Partial Integrator Exam

TE1002 Circuits 1

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Problem 1

For the circuit of Fig. 4.73, determine the mesh current i_1 and the power dissipated by the 1 Ω resistor.

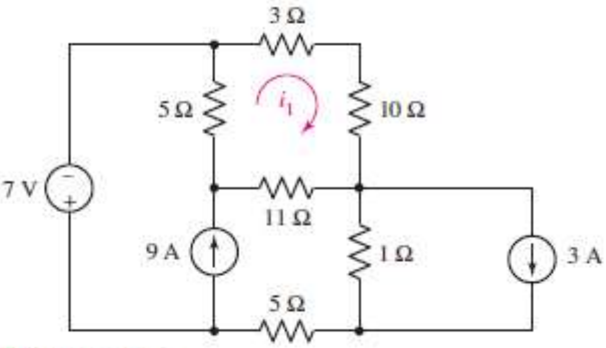


FIGURE 4.73

Solution Problem 1

Define (left to right) three clockwise mesh currents i_2, i_3 and i_4. Then, we may create a supermesh from meshes 2 and 3. By inspection, $i_4 = 3$ A.

Our mesh/supermesh equations are:

$$7 + 5i_2 - 5i_1 + 11i_3 - 11i_1 + (1)i_3 - (1)i_4 + 5i_3 = 0$$

$$-5i_2 + (3 + 5 + 10 + 11)i_1 - 11i_3 = 0$$

$$i_3 - i_2 = 9$$

Solving, $\boxed{i_1 = -874.3 \text{ mA}}$

$i_2 = -7.772$ A

$i_3 = 1.228$ A

$i_4 = 3$ A

Thus, the 1 Ω resistor dissipates $P_{1\Omega} = (1)(i_4 - i_3)^2 = \boxed{3.141 \text{ W}}$

Problem 2

(a) Employ superposition to determine the individual contribution from each independent source to the current i_x as labeled in the circuit shown in Fig. 5.57. (b) Compute the power absorbed by each 1 Ω resistor.

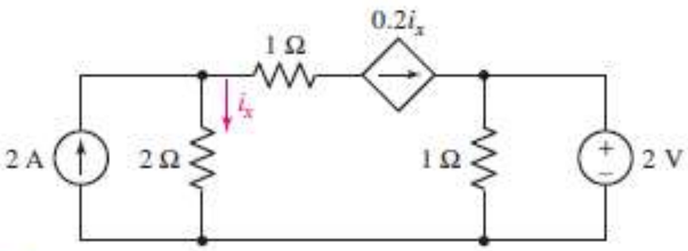


FIGURE 5.57

Solution Problem 2

(a) Begin by short-circuiting the voltage source.

KCL yields $2 = i_x' + 0.2 i_x'$ or $i_x' = \frac{2}{1.2} = \boxed{1.667\ \text{A}}$

Now, open-circuit the independent current source instead.

$i_x'' = -0.2 i_x''$ therefore $\boxed{i_x'' = 0}$

Hence, $i_x = i_x' + i_x'' = 1.667\ \text{A}$

(b) $P_{1\Omega(\text{left})} = (1)(0.2 i_x)^2 = \boxed{111\ \text{mW}}$

$P_{1\Omega(\text{right})} = \frac{(2)^2}{1} = \boxed{4\ \text{W}}$

Problem 3

(*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.

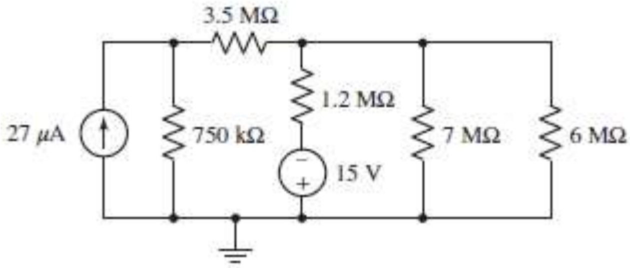


FIGURE 5.62

Solution Problem 3

(a) Perform the following steps in order:

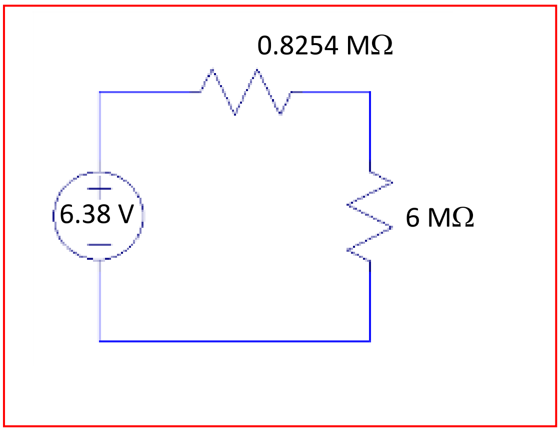
Combine the 27 μA and 750 kΩ to obtain 20.25 V in series with 750 kΩ in series with 3.5 MΩ.

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 4

Determine the Thévenin equivalent of the network shown in Fig. 5.74 as seen looking into the two open terminals.

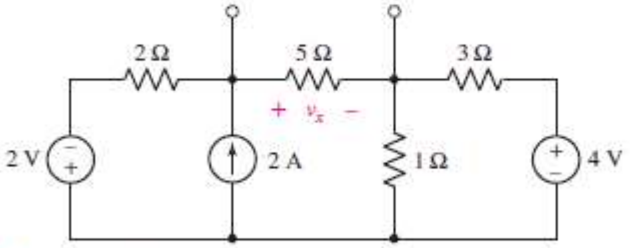


FIGURE 5.74

Solution Problem 4

Define three clockwise mesh currents i_1, i_2, i_3 starting on the left.

Then

$$2 + 2i_1 + 6i_2 - i_3 = 0 \quad [1]$$

$$-i_2 + 4i_3 + 4 = 0 \quad [2]$$

$$i_2 - i_1 = 2 \quad [3]$$

Solving,

i_2 = 129 mA. Hence, $v_{oc} = v_x = 5i_2$ = $\boxed{645.2 \text{ mV}}$

Next, short the voltage sources and open circuit the current source. Then,

$R_{th} = 5 \,||\, (2 + 3||1)$ = $\boxed{1.774\ \Omega}$

Problem 5

Determine the Thévenin and Norton equivalents of the circuit shown in Fig. 5.83, as seen by an unspecified element connected between terminals *a* and *b*.

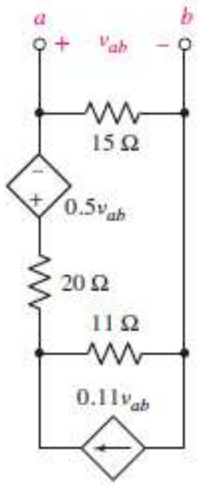


FIGURE 5.83

Solution Problem 5

Rotate the diagram 90º clockwise. Connect a 1 A source between *a* and *b* such that the head of the arrow points to terminal *a*. Define a clockwise mesh current i_2 flowing into the '+' reference of the dependent voltage source. Then,

$$11(i_2 - 0.11v_{ab}) + 20i_2 + 0.5v_{ab} + 15(i_2 + 1) = 0$$

$$where$$

$$v_{ab} = 15(i_2 + 1)$$

Solving, v_{ab} = 13.15 V.

Hence, $R_{Th} = v_{ab}/1$ = $\boxed{13.15\ \Omega.}$

Since there is no independent source in the network, this represents both the Thévenin and Norton equivalent.

Problem 6

(*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.

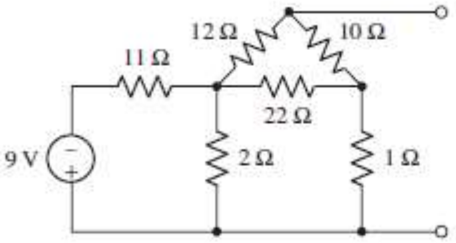


FIGURE 5.102

Solution Problem 6

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