MECH 368 – ELECTRONICS FOR MECHANICAL ENGINEERS

ASSIGNMENT #1
(3.42, 3.43, 3.46, 3.67, 3.68, 3.69) - F

Problem 3.42

Solution:

Known quantities:

The values of the voltage sources and of the resistors in the circuit of Figure P3.42:

$$V_{S1} = V_{S2} = 12 \text{ V}$$
$$R_1 = R_2 = R_3 = 1 \text{ k}\Omega$$

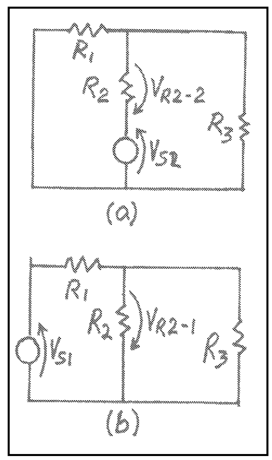
Find:

The voltage across R_2.

Analysis:

Specify the polarity of the voltage across R_2. Suppress the voltage source V_{S1} by replacing it with a short circuit. Redraw the circuit.

$$R_{eq} = R_1 \| R_3 = \frac{1}{2} \text{k}\Omega = 0.5 \text{ k}\Omega$$
$$V_{R2-2} = V_{S2} \frac{R_2}{R_2 + R_{eq}} = \frac{(12)(1000)}{1000 + 500} = 8 \text{ V}$$



Suppress the voltage source V_{S2} by replacing it with a short circuit. Redraw the circuit.

$$R_{eq} = R_2 \| R_3 = \frac{1}{2} \text{k}\Omega = 0.5 \text{ k}\Omega$$
$$V_{R2-1} = -V_{S1} \frac{R_{eq}}{R_1 + R_{eq}} = \frac{(12 \text{ V})(0.5 \text{ k}\Omega)}{1 \text{ k}\Omega + 0.5 \text{ k}\Omega} = -4 \text{ V}$$
$$V_{R2} = V_{R2-1} + V_{R2-2} = -4 \text{ V} + 8 \text{ V} = 4 \text{ V}$$

Note: Superposition must be used when the sources in a circuit are AC sources with different frequencies, or where some sources are DC and others are AC.

Problem 3.43

Solution:

Known quantities:

The values of the voltage sources and of the resistors in the circuit of Figure P3.43:

$$V_{S1} = V_{S2} = 450 \text{ V}$$

$$R_1 = 7\,\Omega \qquad R_2 = 5\,\Omega \qquad R_3 = 10\,\Omega \qquad R_4 = R_5 = 1\,\Omega$$

Find:

The component of the current through R_3 that is due to V_{S2}, using superposition.

Analysis:

Suppress V_{S1} by replacing it with a short circuit. Redraw the circuit.

R_1 and R_4 are in parallel:

$$R_{14} = \frac{R_1 R_4}{R_1 + R_4} = \frac{(7)(1)}{7+1} = 0.875\,\Omega$$

R_{14} is in series with R_3:

$$R_{143} = R_{14} + R_3 = 0.875 + 10 = 10.875\,\Omega$$

$$R_{eq} = R_5 + \left(R_2 \| R_{143}\right) = R_5 + \frac{R_2 R_{143}}{R_2 + R_{143}} = 1 + \frac{(5)(10.875)}{5 + 10.875} = 4.425\,\Omega$$

***OL*:** $$I_S = \frac{V_{S2}}{R_{eq}} = \frac{450}{4.425} = 101.695 \text{ A}$$

***CD*:** $$I_{R3-2} = \frac{I_S R_2}{R_2 + R_{143}} = \frac{(101.695)(5)}{5 + 10.875} = 32.03 \text{ A}$$

Problem 3.46

Solution:

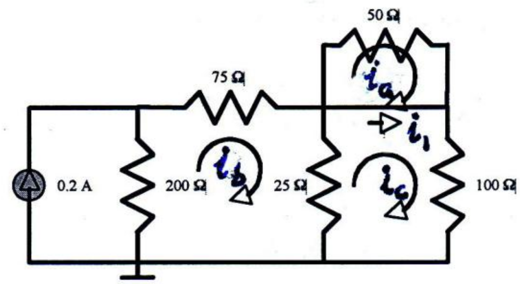
Known quantities:

The values of the resistors, of the voltage source and of the current source in the circuit

Find:

The current through the voltage source using superposition.

Analysis:



(1) Suppress voltage source *V*. Redraw the circuit.

For mesh (a): $i_a = 0$

For mesh (b): $i_b(200+75+25)+i_c(-25)-40=0$

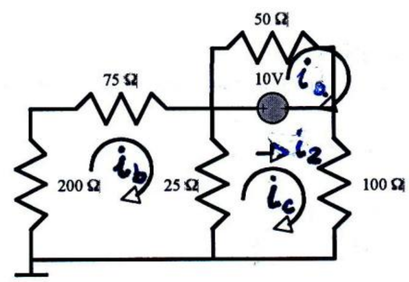
For mesh (c): $i_b(-25)+i_c(25+100)=0$

Solving,

$i_b = 136$ mA and $i_c = 27$ mA.

Therefore, $i_1 = i_c = 27$ mA.

(2) Suppress current source *I*. Redraw the circuit.



For mesh (a): $i_a(50)-10=0$

For mesh (b): $i_b(200+75+25)+i_c(-25)=0$

For mesh (c): $i_b(-25)+i_c(25+100)=-10$

Solving,

$i_a = 200$ mA, $i_b = -6.8$ mA and $i_c = -81$ mA.

Therefore,

$i_2 = i_c - i_a = -281$ mA.

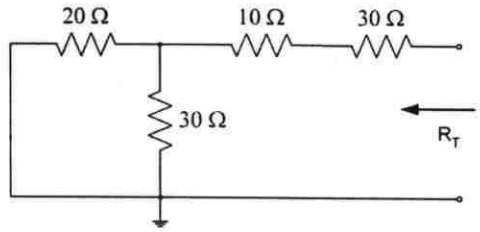
Using the principle of superposition, $i = i_1 + i_2 = -254$ mA

Problem 3.67

Solution:

Known quantities:
The schematic of the circuit (see Figure P3.26).

Find:
The Thévenin equivalent resistance seen by resistor R_5, the Thévenin (open-circuit) voltage and the Norton (short-circuit) current when R_5 is the load.

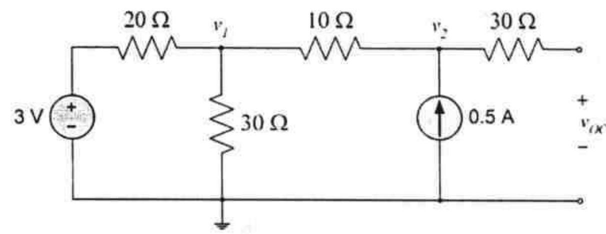


Analysis:

(1) Remove the load, leaving the load terminals open circuited, and the voltage sources. Redraw the circuit.

$$R_T = 30\,\Omega + 10\,\Omega + (20\,\Omega \,||\, 30\,\Omega) = 52\,\Omega$$

(2) Remove the load, leaving the load terminals open circuited. Redraw the circuit.



For node #1:

$$\frac{v_1 - 3}{20} + \frac{v_1}{30} + \frac{v_1 - v_2}{10} = 0$$

For node #2:

$$\frac{v_2 - v_1}{10} = 0.5$$

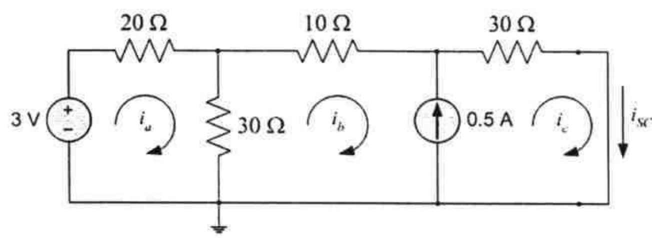
Solving the system,

$$v_1 = 7.8\text{ V} \text{ and } v_2 = 12.8\text{ V} .$$

Therefore,

$$v_{OC} = v_2 = 12.8\text{ V}.$$

(3) Replace the load with a short circuit. Redraw the circuit.



For mesh (a):

$$i_a(20+30) - i_b(30) = 3$$

For meshes (b) and (c):

$$-i_a(30) + i_b(30+10) + i_c(30) = 0$$

For the current source:

$$i_c - i_b = 0.5$$

Solving the system,

$$i_a = -92\text{ mA},\ i_b = -254\text{ mA} \text{ and } i_c = 246\text{ mA}.$$

Therefore,

$$i_{SC} = i_c = 246\text{ mA}.$$

Problem 3.68

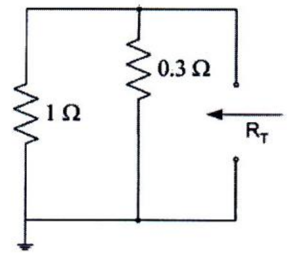
Solution:

Known quantities:

The schematic of the circuit (see Figure P3.41).

Find:

The Thévenin equivalent resistance seen by resistor R, the Thévenin (open-circuit) voltage and the Norton (short-circuit) current when R is the load.

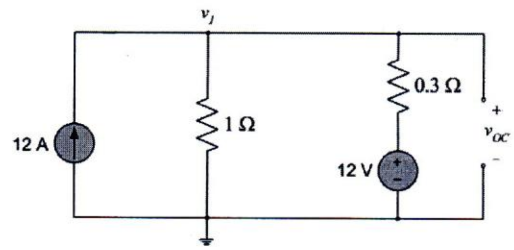


Analysis:

(1) Remove the load, leaving the load terminals open circuited, and the voltage sources. Redraw the circuit.

$R_T = 1\ \Omega \,\|\, 0.3\ \Omega = 0.23\ \Omega$

(2) Remove the load, leaving the load terminals open circuited. Redraw the circuit.

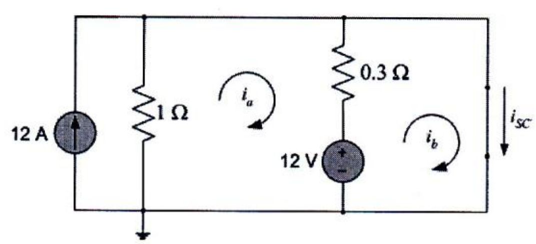


For node #1: $\dfrac{v_1}{1} + \dfrac{v_1 - 12}{0.3} = 12$

Solving,
$v_1 = 12\ \text{V}$.

Therefore,
$v_{OC} = v_1 = 12\ \text{V}$.

(3) Replace the load with a short circuit. Redraw the circuit.



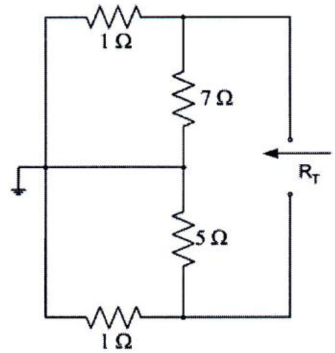
For mesh (a): $i_a(1+0.3) - i_b(0.3) - 12(1) + 12 = 0$

For mesh (b): $-i_a(0.3) + i_b(0.3) = 12$

Solving the system,
$i_a = 12\ \text{A}$ and $i_b = 52\ \text{A}$.

Therefore,
$i_{SC} = i_b = 52\ \text{A}$.

Problem 3.69



Solution:

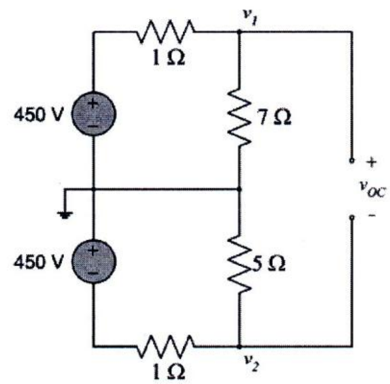
Known quantities:
The schematic of the circuit (see Figure P3.43).

Find:
The Thévenin equivalent resistance seen by resistor R_3, the Thévenin (open-circuit) voltage and the Norton (short-circuit) current when R_3 is the load.

Analysis:
(1) Remove the load, leaving the load terminals open circuited, and the voltage sources. Redraw the circuit.

$R_T = 1\ \Omega \,\|\, 7\ \Omega + 1\ \Omega \,\|\, 5\ \Omega = 1.71\ \Omega$

(2) Remove the load, leaving the load terminals open circuited. Redraw the circuit.

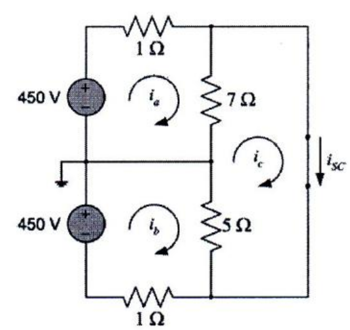


For node #1: $\frac{v_1 - 450}{1} + \frac{v_1}{7} = 0$

For node #2: $\frac{v_2 + 450}{1} + \frac{v_2}{5} = 0$

Solving the system,
$v_1 = 393.75$ V and $v_2 = -375$ V.
Therefore,
$v_{OC} = v_1 - v_2 = 768.75$ V.

(3) Replace the load with a short circuit. Redraw the circuit.



For mesh (a):
$i_a(1+7) - i_c(7) = 450$

For mesh (b):
$i_b(5+1) - i_c(5) = 450$

For mesh (c):
$-i_a(7) - i_b(5) + i_c(7+5) = 0$

Solving the system,
$i_a = 450$ A, $i_b = 450$ A and $i_c = 450$ A.
Therefore,
$i_{SC} = i_c = 450$ A.