Network Analysis & Systems

Koshy George

Dept. of Elect. & Comm. Engineering,
PES University;
PES Centre for Intelligent Systems

UE18EC201: Network Analysis & Systems

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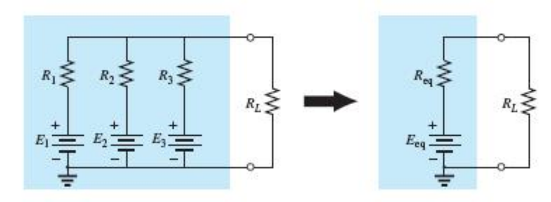
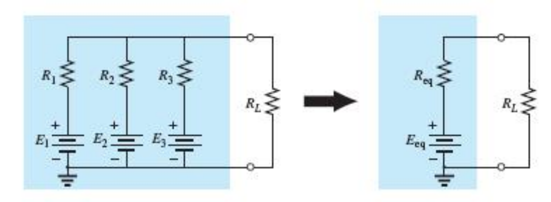
Disclaimer (2)

Millman's Theorem (1)

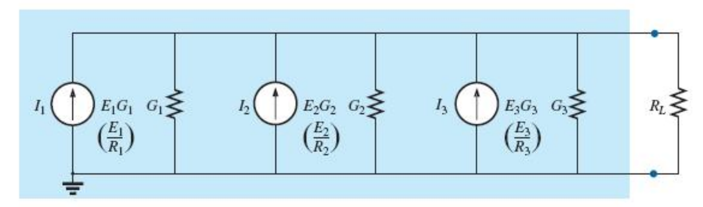


- Millman's theorem allows us to reduce any number of parallel voltage sources to one!
- The steps involved are:
  1. Convert all voltage sources to current sources.
  2. Combine all these current sources.
  3. Convert the resulting source to a voltage source.

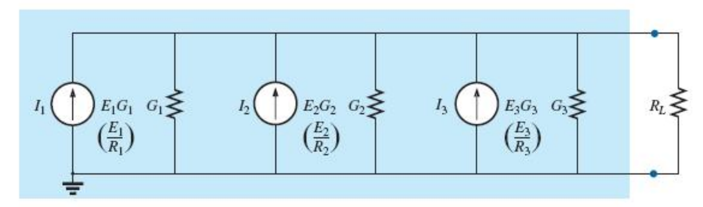
Millman's Theorem (2)



Step 1:



Millman's Theorem (3)

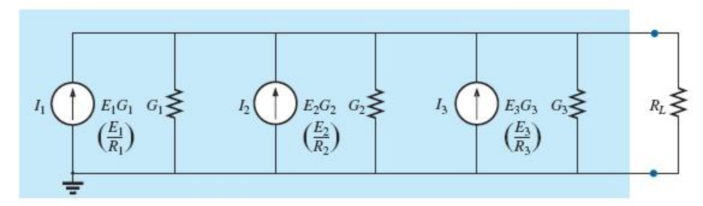


Step 2:

$$I_T = I_1 + I_2 + I_3$$

$$G_T = G_1 + G_2 + G_3$$

Millman's Theorem (3)

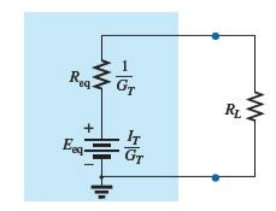


Step 2:

$$I_T = I_1 + I_2 + I_3$$

$$G_T = G_1 + G_2 + G_3$$

Step 3:



$$E_{eq} = \frac{I_T}{G_T} = \frac{I_1 + I_2 + I_3}{G_1 + G_2 + G_3}$$

Millman's Theorem (4)

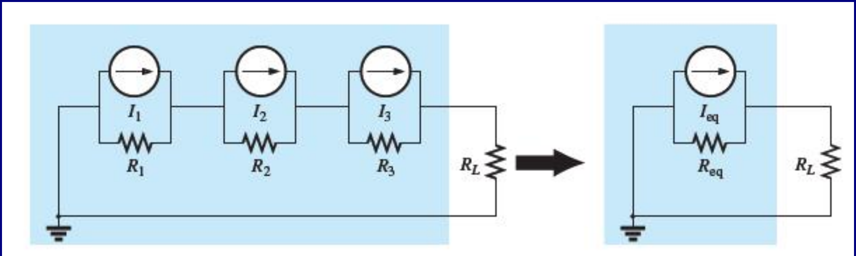
More generally,

$$Z_{eq} = \frac{1}{\frac{1}{Z_1} + \frac{1}{Z_2} + \cdots + \frac{1}{Z_n}}$$

and

$$\mathbf{V}_{eq} = \frac{\frac{\mathbf{V}_1}{Z_1} + \frac{\mathbf{V}_2}{Z_2} + \cdots + \frac{\mathbf{V}_n}{Z_n}}{\frac{1}{Z_{eq}}}$$

Millman's Theorem — Dual (5)



$$R_{eq} = R_1 + R_2 + R_3$$

$$I_{eq} = \frac{I_1 R_1 + I_2 R_2 + I_3 R_3}{R_{eq}}$$

Millman's Theorem — Dual (6)

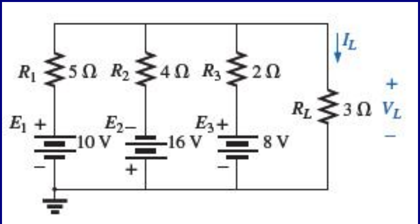
More generally,

$$Z_{eq} = Z_1 + Z_2 + \cdots Z_n$$

and

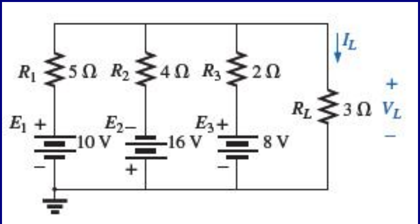
$$\mathbf{I}_{eq} = \frac{\mathbf{I}_1 Z_1 + \mathbf{I}_2 Z_2 + \cdots + \mathbf{I}_n Z_n}{Z_{eq}}$$

Examples (1)



$$\frac{1}{R_{eq}} =$$

Examples (1)

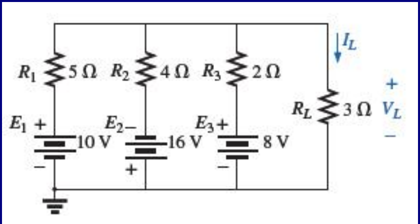


$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = 0.95\ \mathrm{S}$$

Therefore,

$$E_{eq} =$$

Examples (1)



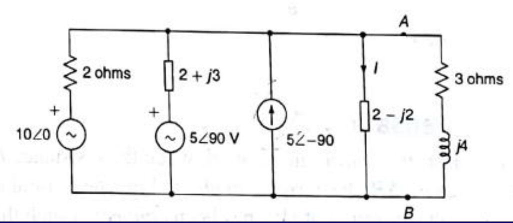
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = 0.95 \text{ S}$$

Therefore,

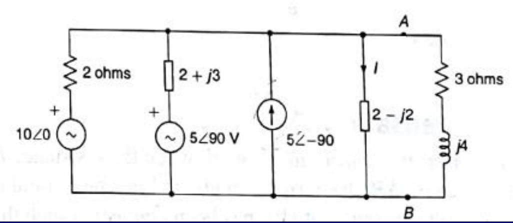
$$E_{eq} = \left(\frac{E_1}{R_1} - \frac{E_2}{R_2} + \frac{E_3}{R_3}\right) R_{eq} = \frac{2}{0.95} = 2.11 \text{ V}$$

Therefore, a voltage of 2.11 V in series with a 1.05 Ω.

Examples (2)



Examples (2)

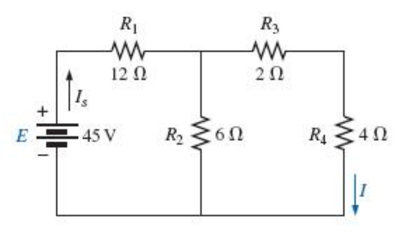


- Equivalent admittance:

$$\frac{1}{Z_{eq}} = \frac{1}{2} + \frac{1}{2+j3} + \frac{1}{2-j2} = 0.9038 + j0.0192$$

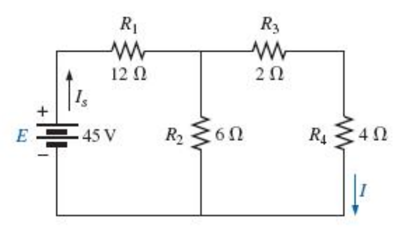
- Equivalent source:
$V = \left(\frac{10\underline{/0^\circ}}{2} + \frac{5\underline{/90^\circ}}{2+j3} + 5\underline{/-90^\circ} \right) /(0.9038 + j0.0192)$
$= 6.7059 - j4.8235.$

Examples (3)



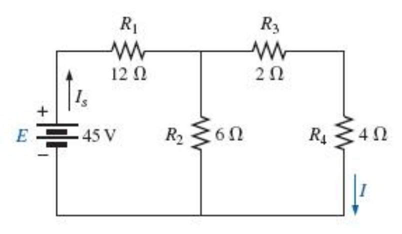
- $R_{eq} =$

Examples (3)



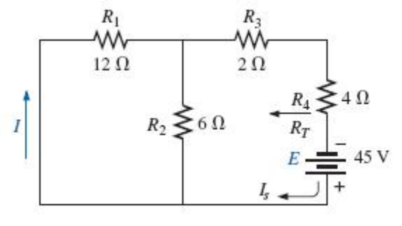
- $R_{eq} = 15\Omega$.
- $I =$

Examples (3)



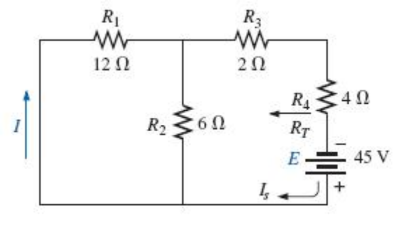
- $R_{eq} = 15\Omega$.
- $I = 1.5$ A.

Examples (4)



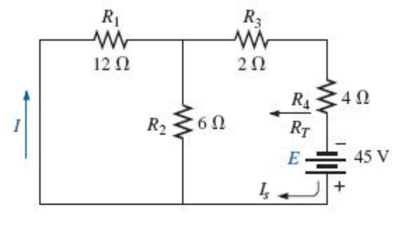
- $R_{eq} =$

Examples (4)



- $R_{eq} = 10\Omega$.
- $I =$

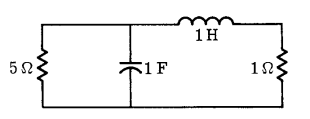
Examples (4)



- $R_{eq} = 10\Omega$.
- $I = 1.5$ A.

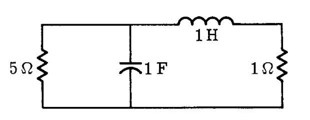
Examples (5)

Reciprocity Theorem:

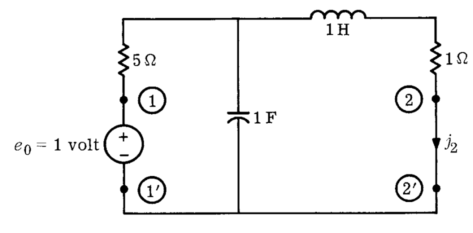


Examples (5)

Reciprocity Theorem:

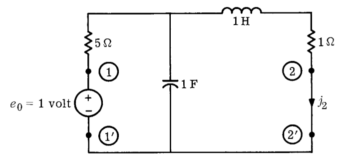


Reciprocity under DC conditions:



Examples (6)

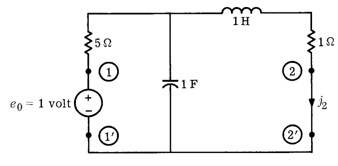
Reciprocity under DC conditions:



Current $j_2 =$

Examples (6)

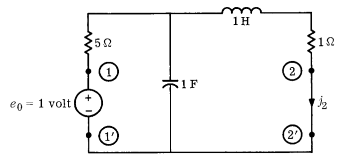
Reciprocity under DC conditions:



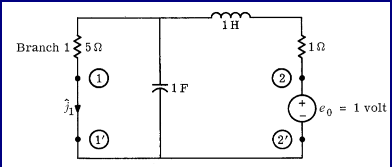
Current $j_2 = 1/6$ A.

Examples (6)

Reciprocity under DC conditions:



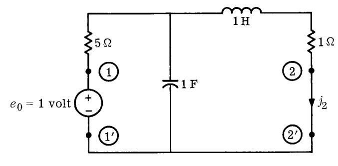
Current $j_2 = 1/6$ A.



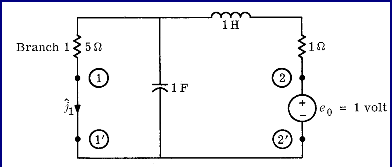
Current $\hat{j}_1 =$

Examples (6)

Reciprocity under DC conditions:



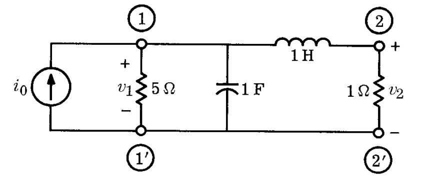
Current $j_2 = 1/6$ A.



Current $\hat{j}_1 = 1/6$ A.

Examples (7)

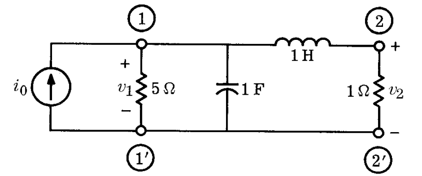
Reciprocity under sinusoidal steady-state conditions:



$$i_0(t) = 2\cos(2t + \pi/6)$$

Examples (7)

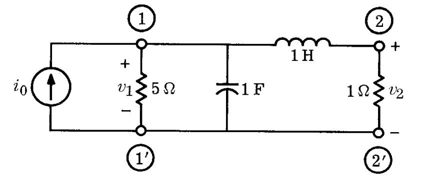
Reciprocity under sinusoidal steady-state conditions:



$i_0(t) = 2\cos(2t + \pi/6)$
$v_2(t) =$

Examples (7)

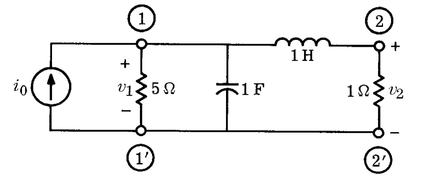
Reciprocity under sinusoidal steady-state conditions:



$i_0(t) = 2\cos(2t + \pi/6)$
$v_2(t) = 0.542e^{j250} =$
$0.542\cos(2t + 250^\circ)$ V.

Examples (7)

Reciprocity under sinusoidal steady-state conditions:



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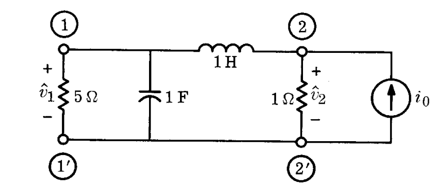
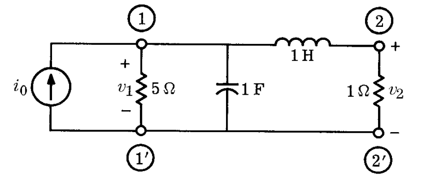


$\hat{v}_1 =$

Examples (7)

Reciprocity under sinusoidal steady-state conditions:



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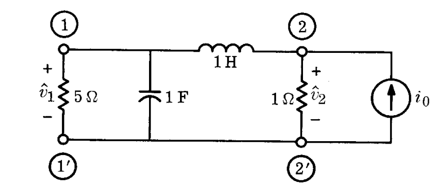
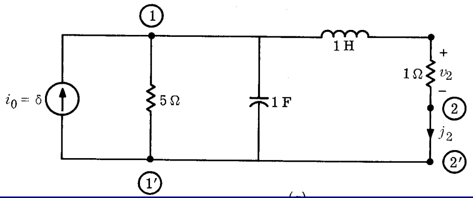


$\hat{v}_1 = 0.542e^{j250} =$
$0.542\cos(2t + 250^\circ)$ V.

Examples (7)

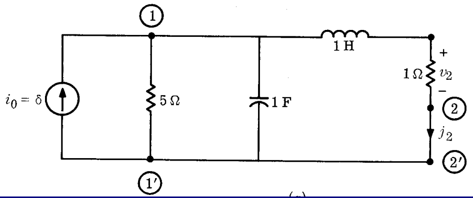
Reciprocity under transient conditions:



$j_2 =$

Examples (7)

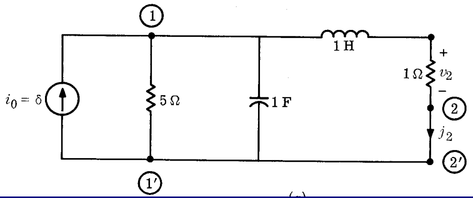
Reciprocity under transient conditions:



$j_2 =$
$1.09e^{-0.6t} \sin 0.916t1(t)$ A.

Examples (7)

Reciprocity under transient conditions:



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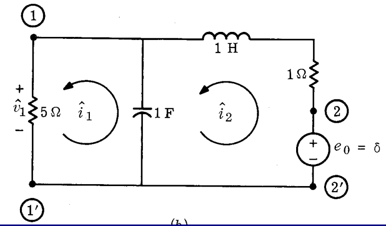
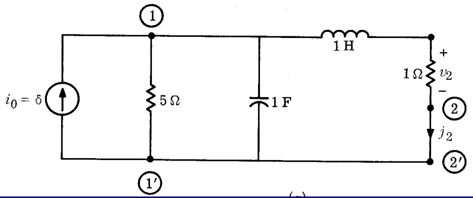


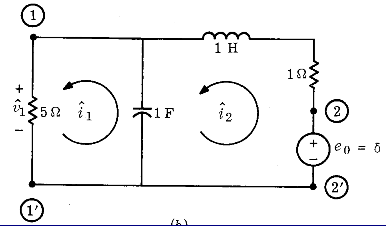
$\hat{j}_1 =$

Examples (7)

Reciprocity under transient conditions:



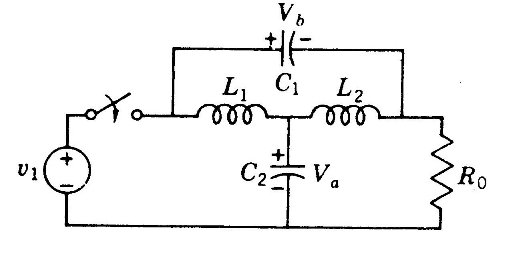
$j_2 = 1.09e^{-0.6t} \sin 0.916t1(t)$ A.



$\hat{j}_1 = 1.09e^{-0.6t} \sin 0.916t1(t)$ A.

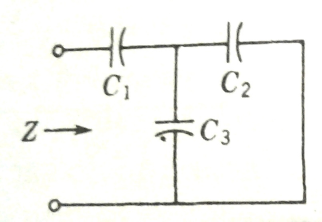
Examples (8)

Prob. 9-6, Van Valkenburg:



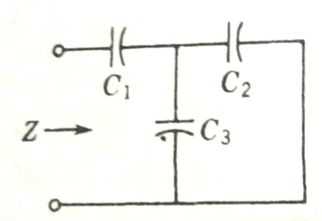
Examples (9)

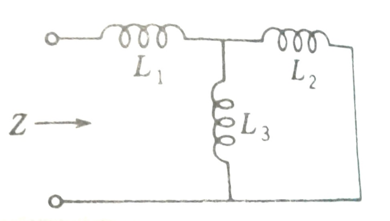
Prob. 9-7, Van Valkenburg:



Examples (9)

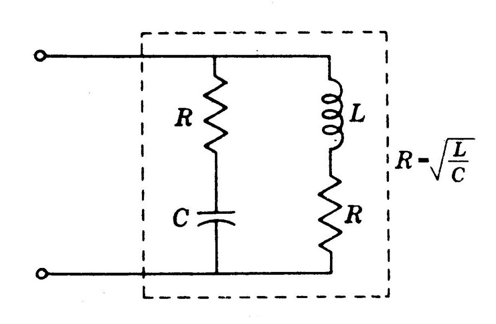
Prob. 9-7, Van Valkenburg:





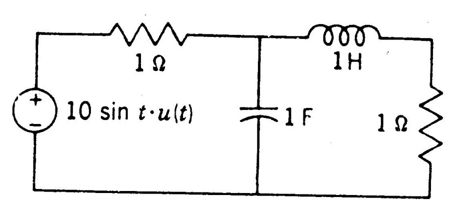
Examples (10)

Prob. 9-12, Van Valkenburg:



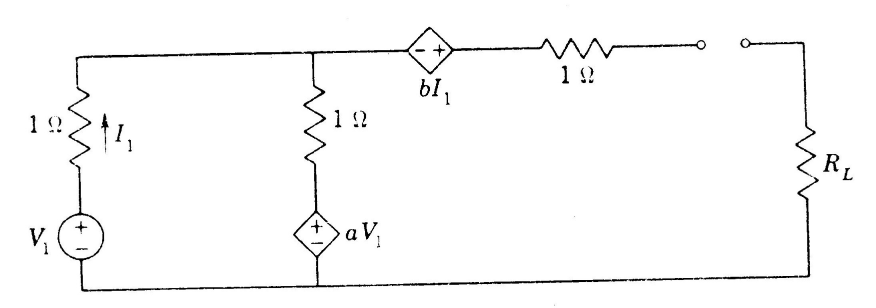
Examples (11)

Prob. 9-15, Van Valkenburg:



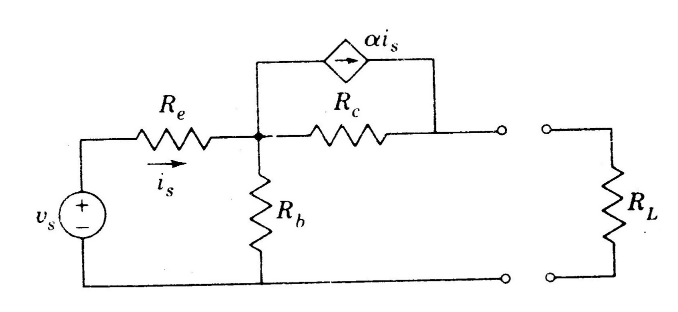
Examples (12)

Prob. 9-17, Van Valkenburg:



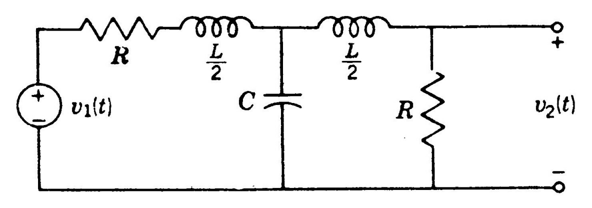
Examples (13)

Prob. 9-20, Van Valkenburg:

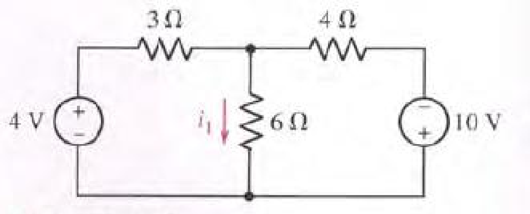


Examples (14)

Prob. 9-28, Van Valkenburg:

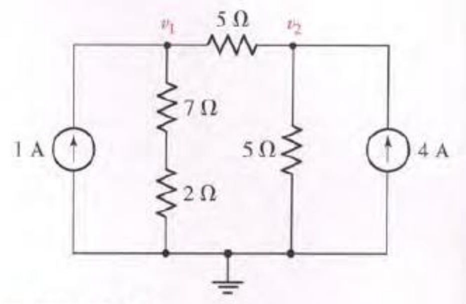


Examples (15)



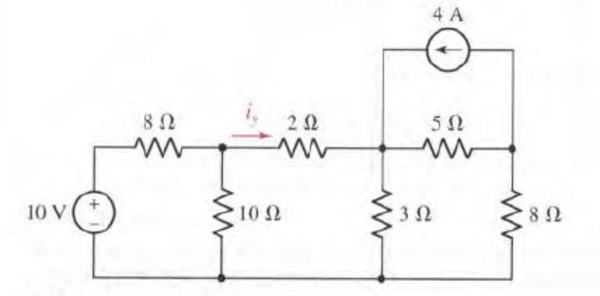
- Find the contribution of the 4 V source to the current labelled i_1.
- Find the contribution of the 10 V source to the current labelled i_1.
- Determine i_1.

Examples (16)



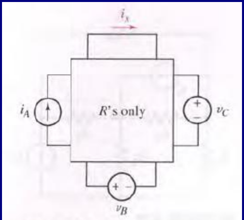
- Determine the contribution of the 1 A source to v_1.
- Calculate the total current flowing through the 7 Ω resistor.

Examples (17)



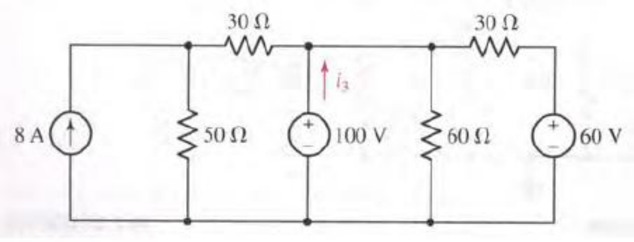
Use the principle of superposition to determine the current labelled i_y.

Examples (18)



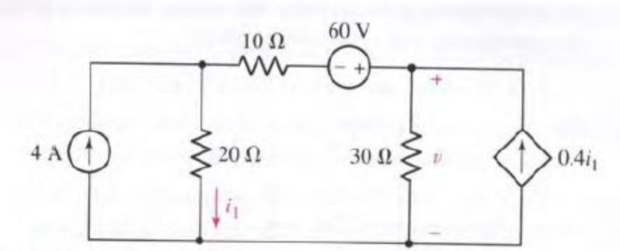
- With sources i_A and v_B on and $v_C = 0$, $i_x = 20$ A.
- With sources i_A and v_C on and $v_B = 0$, $i_x = -5$ A.
- With all three sources on, $i_x = 12$ A.
- Find i_x if the only source operating is (a) i_A, (b) v_B, (c) v_C.
- Find i_x if i_A and v_C are doubled in magnitude and v_B is reversed.

Examples (19)



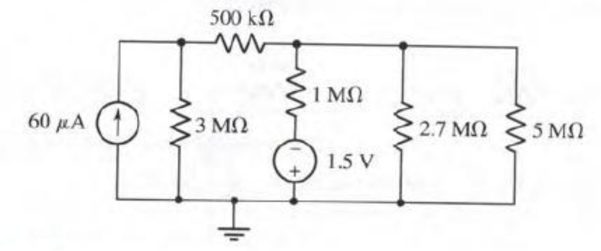
Use the principle of superposition to determine the current labelled i_3.

Examples (20)



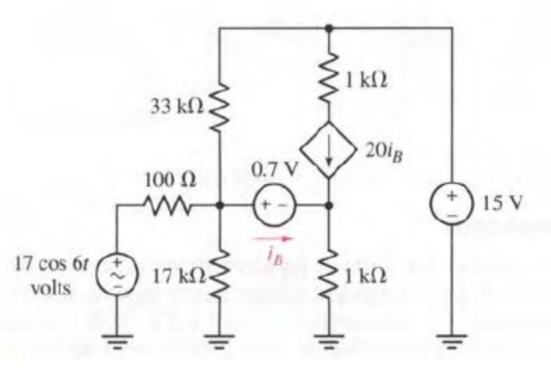
Use the principle of superposition to determine the voltage labelled v.

Examples (21)



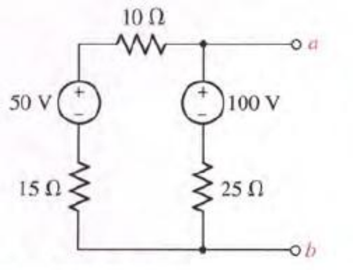
Use the principle of superposition to find the power dissipated by the 500 kΩ resistor.

Examples (22)



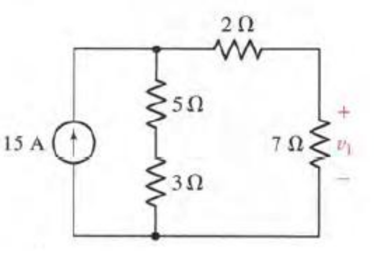
Use the principle of superposition to find i_B. (This circuit models a bipolar junction transistor amplifier.)

Examples (23)



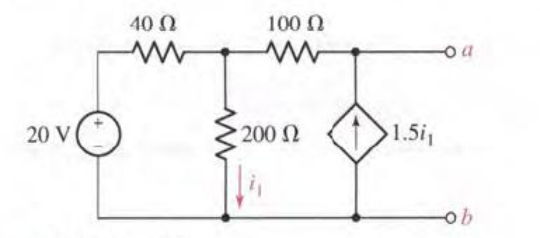
Find the Thévenin equivalent at terminals a and b. How much power would be delivered to a resistor connected to a and b if R_{ab} equals (a) 50 Ω, (b) 12.5 Ω.

Examples (24)



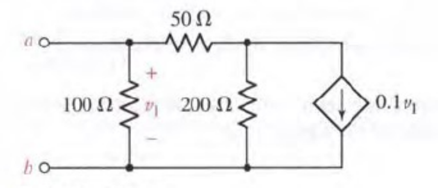
- Find the Thévenin equivalent of the network connected to the 7 Ω resistor.
- Find the corresponding Norton equivalent.
- Computer v_1 using both equivalent circuits.

Examples (25)



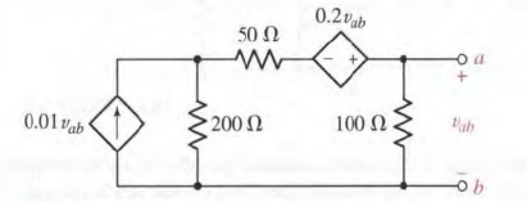
- Find the Thévenin equivalent of the network.
- What is the power delivered to a load of 100 Ω at *a* and *b*.

Examples (26)



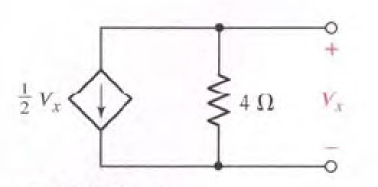
Find the Norton equivalent of the network.

Examples (27)



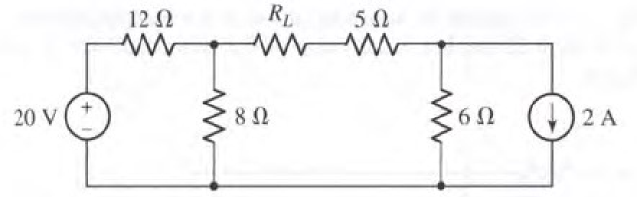
Find the Thévenin equivalent of the network.

Examples (28)



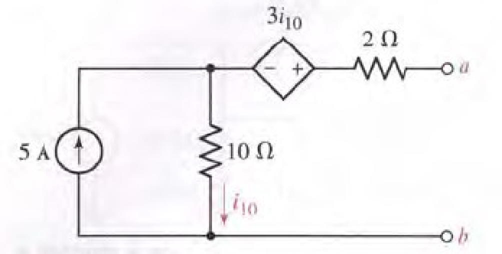
Find the Thévenin and Norton equivalents of the network.

Examples (29)



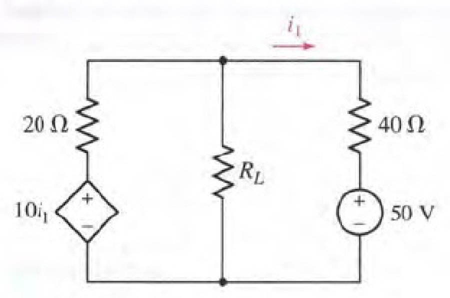
What is the maximum power that could be dissipated in R_L?

Examples (30)



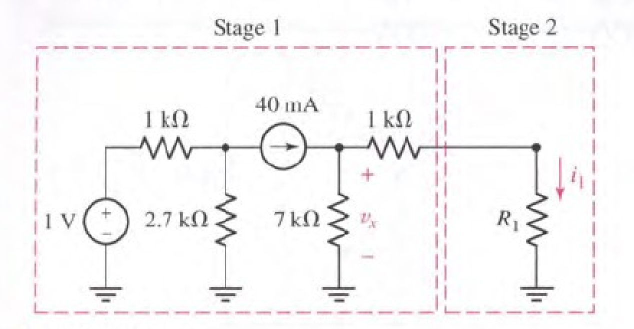
Find the Thévenin equivalent of the network. Determine the maximum power that can be drawn from it.

Examples (31)



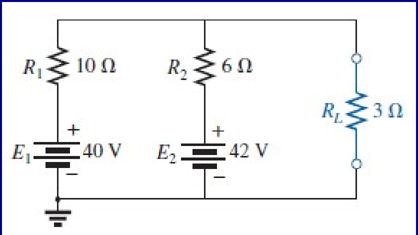
Determine that value of R_L to which a maximum power can be delivered. Calculate the voltage across the corresponding R_L. (The positive reference direction is at the top.)

Examples (32)



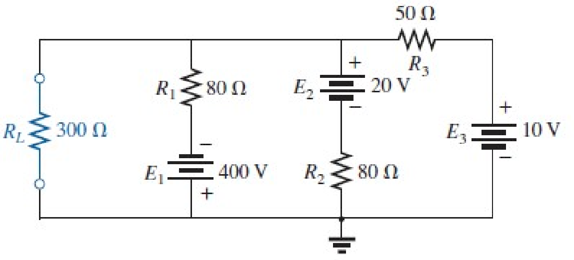
Select R_1 so that maximum power is transferred from Stage 1 to Stage 2.

Examples (33)



Using Millman's theorem find the current through and voltage across the resistor R_L.

Examples (34)



Using Millman's theorem find the current through and voltage across the resistor R_L.