Problems

Section 7.1

7.1 In the circuit in Fig. P7.1, the voltage and current expressions are

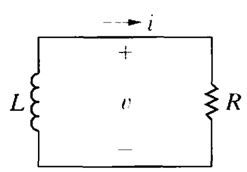
$$v = 160e^{-10t}\,\text{V}, \quad t \geq 0^+;$$

$$i = 6.4e^{-10t}\,\text{A}, \quad t \geq 0.$$

Find

a) R.
b) τ (in milliseconds).
c) L.
d) the initial energy stored in the inductor.
e) the time (in milliseconds) it takes to dissipate 60% of the initial stored energy.

Figure P7.1



7.2 a) Use component values from Appendix H to create a first-order RL circuit (see Fig. 7.4) with a time constant of 1 ms. Use a single inductor and a network of resistors, if necessary. Draw your circuit.

b) Suppose the inductor you chose in part (a) has an initial current of 10 mA. Write an expression for the current through the inductor for $t \geq 0$.

c) Using your result from part (b), calculate the time at which half of the initial energy stored in the inductor has been dissipated by the resistor.

7.3 The switch in the circuit in Fig. P7.3 has been open for a long time. At $t = 0$ the switch is closed.
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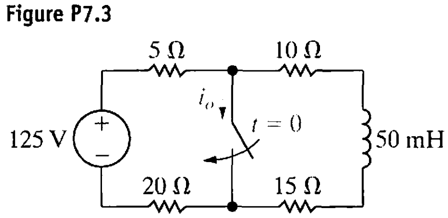
a) Determine $i_o(0^+)$ and $i_o(\infty)$.
b) Determine $i_o(t)$ for $t \geq 0^+$.
c) How many milliseconds after the switch has been closed will the current in the switch equal 3 A?

Figure P7.3



7.4 The switch in the circuit in Fig. P7.4 has been closed for a long time before opening at $t = 0$.
PSPICE
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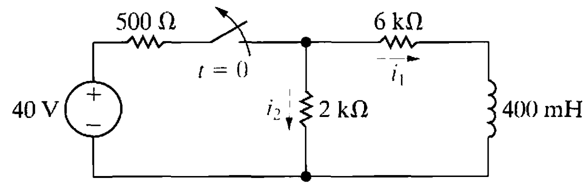
a) Find $i_1(0^-)$ and $i_2(0^-)$.
b) Find $i_1(0^+)$ and $i_2(0^+)$.
c) Find $i_1(t)$ for $t \geq 0$.
d) Find $i_2(t)$ for $t \geq 0^+$.
e) Explain why $i_2(0^-) \neq i_2(0^+)$.

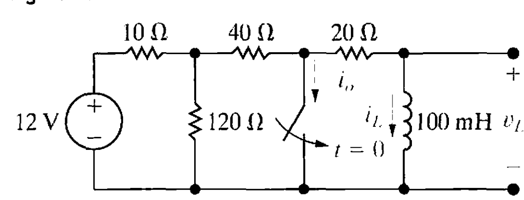
Figure P7.4



7.5 The switch shown in Fig. P7.5 has been open a long time before closing at $t = 0$.

a) Find $i_o(0^-)$.
b) Find $i_L(0^-)$.
c) Find $i_o(0^+)$.
d) Find $i_L(0^+)$.
e) Find $i_o(\infty)$.
f) Find $i_L(\infty)$.
g) Write the expression for $i_L(t)$ for $t \geq 0$.
h) Find $v_L(0^-)$.
i) Find $v_L(0^+)$.
j) Find $v_L(\infty)$.
k) Write the expression for $v_L(t)$ for $t \geq 0^+$.
l) Write the expression for $i_o(t)$ for $t \geq 0^+$.

Figure P7.5



7.6 The switch in the circuit in Fig. P7.6 has been closed a long time. At $t = 0$ it is opened. Find $i_o(t)$ for $t \geq 0$.
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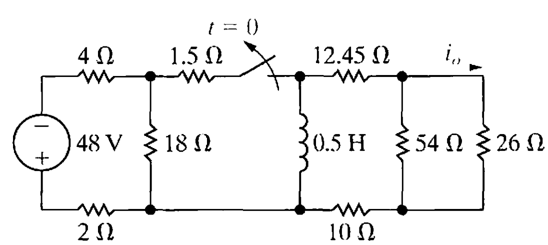
MULTISIM

Figure P7.6



7.7 In the circuit shown in Fig. P7.7, the switch makes contact with position b just before breaking contact with position a. As already mentioned, this is known as a make-before-break switch and is designed so that the switch does not interrupt the current in an inductive circuit. The interval of time between "making" and "breaking" is assumed to be negligible. The switch has been in the a position for a long time. At $t = 0$ the switch is thrown from position a to position b.

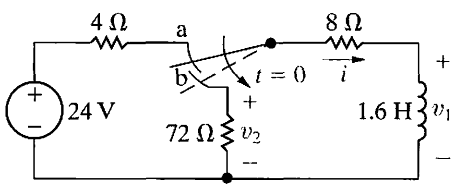
a) Determine the initial current in the inductor.

b) Determine the time constant of the circuit for $t > 0$.

c) Find i, v_1, and v_2 for $t \geq 0$.

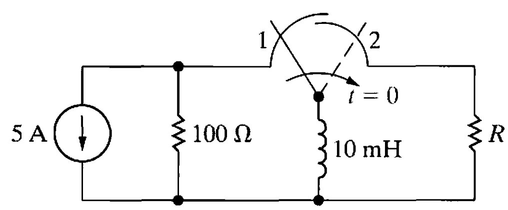
d) What percentage of the initial energy stored in the inductor is dissipated in the 72 Ω resistor 15 ms after the switch is thrown from position a to position b?

Figure P7.7



7.8 The switch in the circuit seen in Fig. P7.8 has been in position 1 for a long time. At $t = 0$, the switch moves instantaneously to position 2. Find the value of R so that 10% of the initial energy stored in the 10 mH inductor is dissipated in R in 10 μs.

Figure P7.8



7.9 In the circuit in Fig. P7.8, let I_g represent the dc current source, σ represent the fraction of initial energy stored in the inductor that is dissipated in t_o seconds, and L represent the inductance.

a) Show that

$$R = \frac{L \ln [1/(1 - \sigma)]}{2t_o}.$$

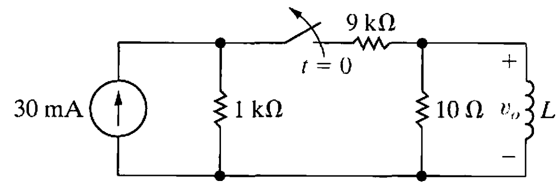
b) Test the expression derived in (a) by using it to find the value of R in Problem 7.8.

7.10 In the circuit in Fig. P7.10, the switch has been closed for a long time before opening at $t = 0$.

a) Find the value of L so that $v_o(t)$ equals $0.5\, v_o(0^+)$ when $t = 1$ ms.

b) Find the percentage of the stored energy that has been dissipated in the 10 Ω resistor when $t = 1$ ms.

Figure P7.10



7.11 In the circuit shown in Fig. P7.11, the switch has been in position a for a long time. At $t = 0$, it moves instantaneously from a to b.
PSPICE
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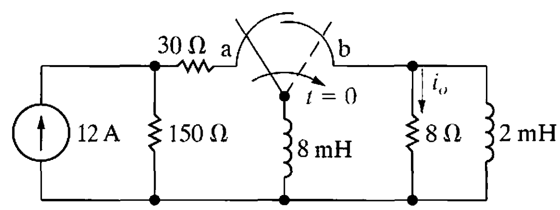
a) Find $i_o(t)$ for $t \geq 0$.

b) What is the total energy delivered to the 8 Ω resistor?

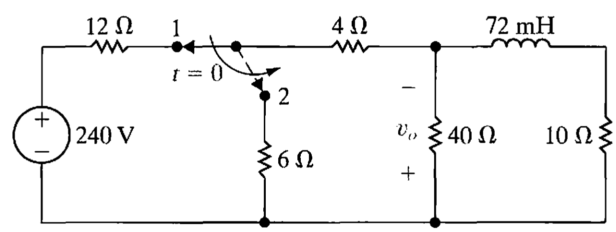
c) How many time constants does it take to deliver 95% of the energy found in (b)?

Figure P7.11



7.12 The switch in the circuit in Fig. P7.12 has been in position 1 for a long time. At $t = 0$, the switch moves instantaneously to position 2. Find $v_o(t)$ for $t \geq 0^+$.
PSPICE
MULTISIM

Figure P7.12



7.13 For the circuit of Fig. P7.12, what percentage of the initial energy stored in the inductor is eventually dissipated in the 40 Ω resistor?

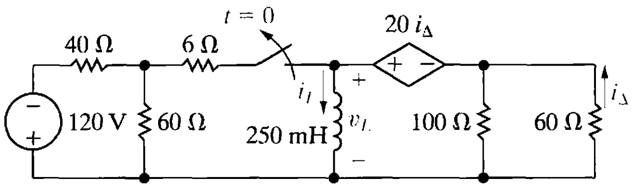
7.14 The switch in Fig. P7.14 has been closed for a long time before opening at $t = 0$. Find

a) $i_L(t)$, $t \geq 0$.

b) $v_L(t)$, $t \geq 0^+$.

c) $i_\Delta(t)$, $t \geq 0^+$.

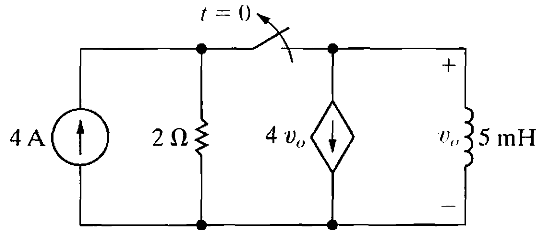
Figure P7.14



7.15 What percentage of the initial energy stored in the inductor in the circuit in Fig. P7.14 is dissipated by the 60 Ω resistor?

7.16 PSPICE MULTISIM The switch in the circuit in Fig. P7.16 has been closed for a long time before opening at $t = 0$. Find $v_o(t)$ for $t \geq 0^+$.

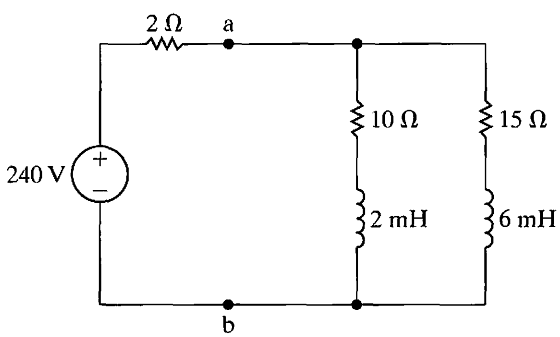
Figure P7.16



7.17 PSPICE MULTISIM The 240 V, 2 Ω source in the circuit in Fig. P7.17 is inadvertently short-circuited at its terminals a,b. At the time the fault occurs, the circuit has been in operation for a long time.

a) What is the initial value of the current i_{ab} in the short-circuit connection between terminals a,b?
b) What is the final value of the current i_{ab}?
c) How many microseconds after the short circuit has occurred is the current in the short equal to 114 A?

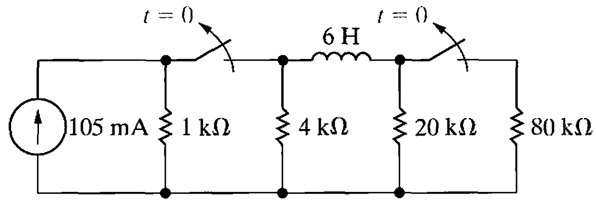
Figure P7.17



7.18 The two switches in the circuit seen in Fig. P7.18 are synchronized. The switches have been closed for a long time before opening at $t = 0$.

a) How many microseconds after the switches are open is the energy dissipated in the 4 kΩ resistor 10% of the initial energy stored in the 6 H inductor?
b) At the time calculated in (a), what percentage of the total energy stored in the inductor has been dissipated?

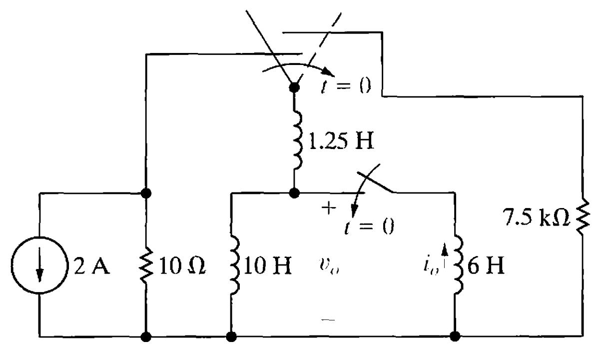
Figure P7.18



7.19 PSPICE MULTISIM The two switches shown in the circuit in Fig. P7.19 operate simultaneously. Prior to $t = 0$ each switch has been in its indicated position for a long time. At $t = 0$ the two switches move instantaneously to their new positions. Find

a) $v_o(t), t \geq 0^+$.
b) $i_o(t), t \geq 0$.

Figure P7.19



7.20 For the circuit seen in Fig. P7.19, find

a) the total energy dissipated in the 7.5 kΩ resistor.
b) the energy trapped in the ideal inductors.

Section 7.2

7.21 In the circuit in Fig. P7.21 the voltage and current expressions are

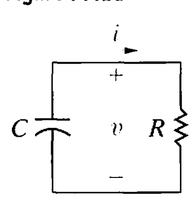
$$v = 72e^{-500t}\text{ V}, \quad t \geq 0;$$

$$i = 9e^{-500t}\text{ mA}, \quad t \geq 0^+.$$

Find

a) R.
b) C.
c) τ (in milliseconds).
d) the initial energy stored in the capacitor.
e) how many microseconds it takes to dissipate 68% of the initial energy stored in the capacitor.

Figure P7.21



7.22 a) Use component values from Appendix H to create a first-order *RC* circuit (see Fig. 7.11) with a time constant of 50 ms. Use a single capacitor and a network of resistors, if necessary. Draw your circuit.

b) Suppose the capacitor you chose in part (a) has an initial voltage drop of 50 V. Write an expression for the voltage drop across the capacitor for $t \geq 0$.

c) Using you result from part (b), calculate the time at which the voltage drop across the capacitor has reached 10 V.

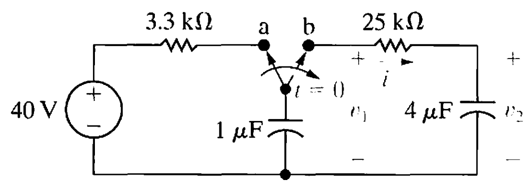
7.23 The switch in the circuit in Fig. P7.23 has been in position a for a long time and $v_2 = 0$ V. At $t = 0$, the switch is thrown to position b. Calculate

a) i, v_1, and v_2 for $t \geq 0^+$.

b) the energy stored in the capacitor at $t = 0$.

c) the energy trapped in the circuit and the total energy dissipated in the 25 kΩ resistor if the switch remains in position b indefinitely.

Figure P7.23



7.24 PSPICE MULTISIM The switch in the circuit in Fig. P7.24 is closed at $t = 0$ after being open for a long time.

a) Find $i_1(0^-)$ and $i_2(0^-)$.

b) Find $i_1(0^+)$ and $i_2(0^+)$.

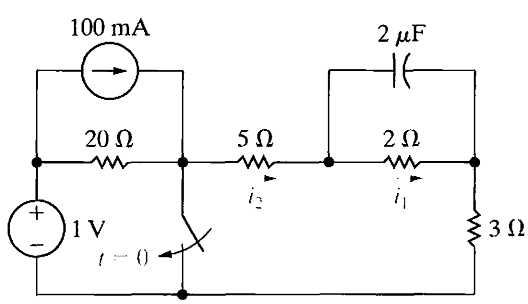
c) Explain why $i_1(0^-) = i_1(0^+)$.

d) Explain why $i_2(0^-) \neq i_2(0^+)$.

e) Find $i_1(t)$ for $t \geq 0$.

f) Find $i_2(t)$ for $t \geq 0^+$.

Figure P7.24

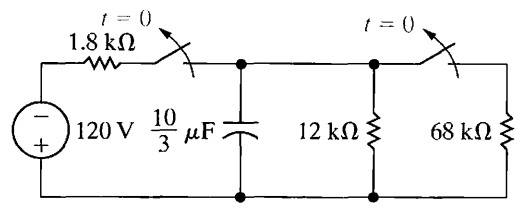


7.25 In the circuit shown in Fig. P7.25, both switches operate together; that is, they either open or close at the same time. The switches are closed a long time before opening at $t = 0$.

a) How many microjoules of energy have been dissipated in the 12 kΩ resistor 12 ms after the switches open?

b) How long does it take to dissipate 75% of the initially stored energy?

Figure P7.25



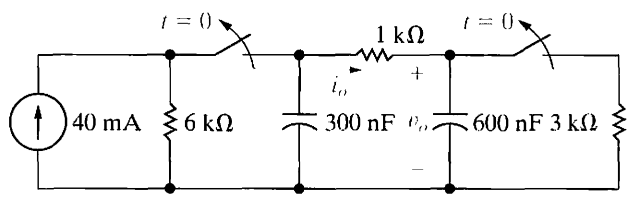
7.26 PSPICE MULTISIM Both switches in the circuit in Fig. P7.26 have been closed for a long time. At $t = 0$, both switches open simultaneously.

a) Find $i_o(t)$ for $t \geq 0^+$.

b) Find $v_o(t)$ for $t \geq 0$.

c) Calculate the energy (in microjoules) trapped in the circuit.

Figure P7.26

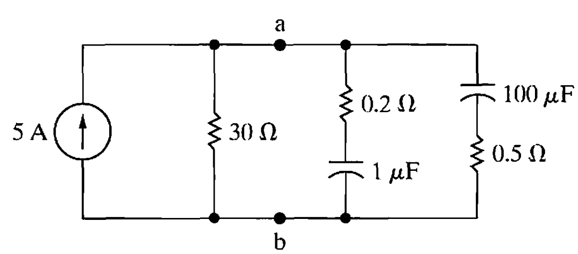


7.27 PSPICE MULTISIM After the circuit in Fig. P7.27 has been in operation for a long time, a screwdriver is inadvertently connected across the terminals a,b. Assume the resistance of the screwdriver is negligible.

a) Find the current in the screwdriver at $t = 0^+$ and $t = \infty$.

b) Derive the expression for the current in the screwdriver for $t \geq 0^+$.

Figure P7.27

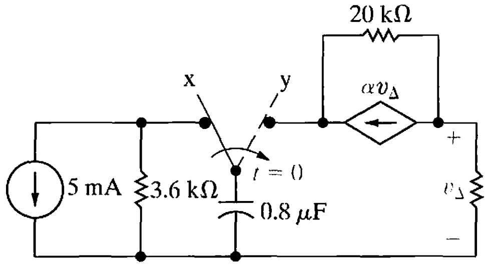


7.28 The switch in the circuit seen in Fig. P7.28 has been in position x for a long time. At $t = 0$, the switch moves instantaneously to position y.

a) Find α so that the time constant for $t > 0$ is 40 ms.

b) For the α found in (a), find v_Δ.

Figure P7.28



7.29 a) In Problem 7.28, how many microjoules of energy are generated by the dependent current source during the time the capacitor discharges to 0 V?

b) Show that for $t \geq 0$ the total energy stored and generated in the capacitive circuit equals the total energy dissipated.

7.30 The switch in the circuit in Fig. P7.30 has been in position 1 for a long time before moving to position 2 at $t = 0$. Find $i_o(t)$ for $t \geq 0^+$.
PSPICE
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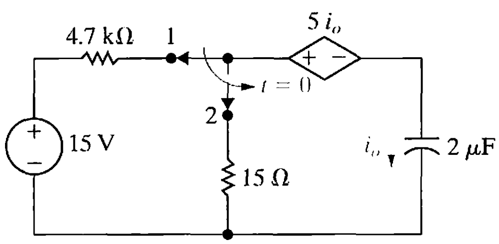
Figure P7.30



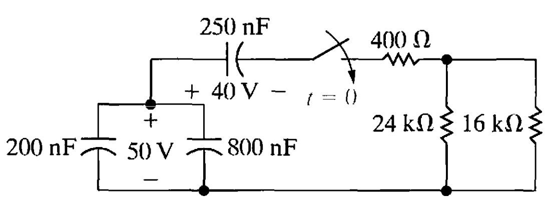
7.31 At the time the switch is closed in the circuit in Fig. P7.31, the voltage across the paralleled capacitors is 50 V and the voltage on the 250 nF capacitor is 40 V.
PSPICE
MULTISIM

a) What percentage of the initial energy stored in the three capacitors is dissipated in the 24 kΩ resistor?

b) Repeat (a) for the 400 Ω and 16 kΩ resistors.

c) What percentage of the initial energy is trapped in the capacitors?

Figure P7.31



7.32 At the time the switch is closed in the circuit shown in Fig. P7.32, the capacitors are charged as shown.

a) Find $v_o(t)$ for $t \geq 0^+$.

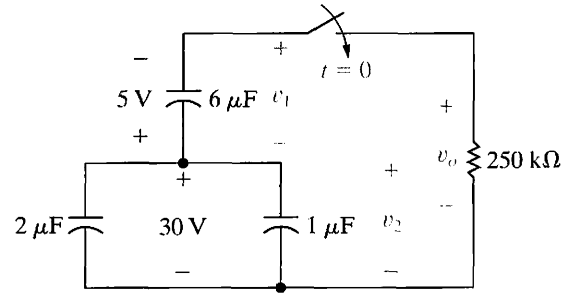
b) What percentage of the total energy initially stored in the three capacitors is dissipated in the 250 kΩ resistor?

c) Find $v_1(t)$ for $t \geq 0$.

d) Find $v_2(t)$ for $t \geq 0$.

e) Find the energy (in millijoules) trapped in the ideal capacitors.

Figure P7.32



Section 7.3

7.33 The current and voltage at the terminals of the inductor in the circuit in Fig. 7.16 are

$$i(t) = (4 + 4e^{-40t})\text{ A}, \quad t \geq 0;$$

$$v(t) = -80e^{-40t}\text{ V}, \quad t \geq 0^+.$$

a) Specify the numerical values of V_s, R, I_o, and L.

b) How many milliseconds after the switch has been closed does the energy stored in the inductor reach 9 J?

7.34 a) Use component values from Appendix H to create a first-order RL circuit (see Fig. 7.16) with a time constant of 8 μs. Use a single inductor and a network of resistors, if necessary. Draw your circuit.

b) Suppose the inductor you chose in part (a) has no initial stored energy. At $t = 0$, a switch connects a voltage source with a value of 25 V in series with the inductor and equivalent resistance. Write an expression for the current through the inductor for $t \geq 0$.

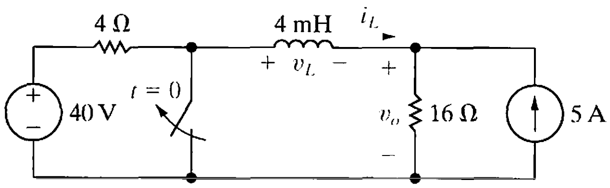
c) Using your result from part (b), calculate the time at which the current through the inductor reaches 75% of its final value.

7.35 The switch in the circuit shown in Fig. P7.35 has been closed for a long time before opening at $t = 0$.
PSPICE
MULTISIM

a) Find the numerical expressions for $i_L(t)$ and $v_o(t)$ for $t \geq 0$.

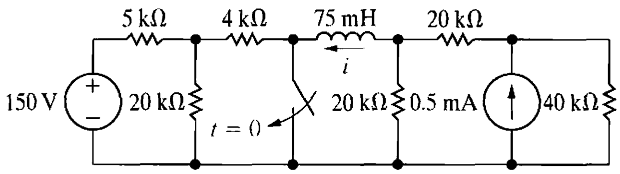
b) Find the numerical values of $v_L(0^+)$ and $v_o(0^+)$.

Figure P7.35



7.36 After the switch in the circuit of Fig. P7.36 has been open for a long time, it is closed at $t = 0$. Calculate (a) the initial value of i; (b) the final value of i; (c) the time constant for $t \geq 0$; and (d) the numerical expression for $i(t)$ when $t \geq 0$.

Figure P7.36



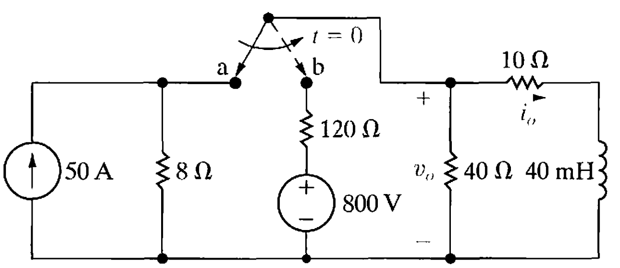
7.37 The switch in the circuit shown in Fig. P7.37 has been in position a for a long time. At $t = 0$, the switch moves instantaneously to position b.

PSPICE MULTISIM

a) Find the numerical expression for $i_o(t)$ when $t \geq 0$.

b) Find the numerical expression for $v_o(t)$ for $t \geq 0^+$.

Figure P7.37



7.38 a) Derive Eq. 7.47 by first converting the Thévenin equivalent in Fig. 7.16 to a Norton equivalent and then summing the currents away from the upper node, using the inductor voltage v as the variable of interest.

b) Use the separation of variables technique to find the solution to Eq. 7.47. Verify that your solution agrees with the solution given in Eq. 7.42.

7.39 The switch in the circuit shown in Fig. P7.39 has been closed for a long time. The switch opens at $t = 0$. For $t \geq 0^+$:

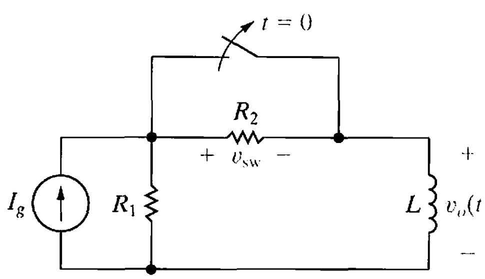
a) Find $v_o(t)$ as a function of I_g, R_1, R_2, and L.

b) Explain what happens to $v_o(t)$ as R_2 gets larger and larger.

c) Find v_{SW} as a function of I_g, R_1, R_2, and L.

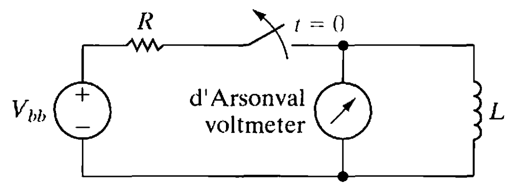
d) Explain what happens to v_{SW} as R_2 gets larger and larger.

Figure P7.39



7.40 The switch in the circuit in Fig. P7.40 has been closed for a long time. A student abruptly opens the switch and reports to her instructor that when the switch opened, an electric arc with noticeable persistence was established across the switch, and at the same time the voltmeter placed across the coil was damaged. On the basis of your analysis of the circuit in Problem 7.39, can you explain to the student why this happened?

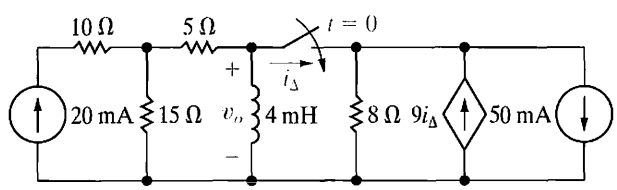
Figure P7.40



7.41 The switch in the circuit in Fig. P7.41 has been open a long time before closing at $t = 0$. Find $v_o(t)$ for $t \geq 0^+$.

PSPICE MULTISIM

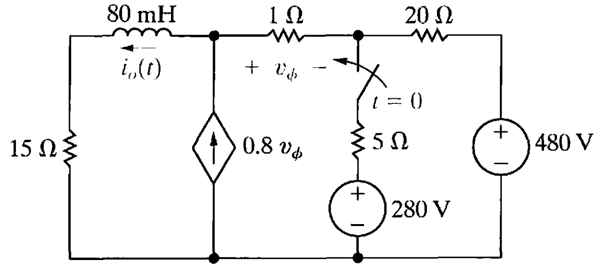
Figure P7.41



7.42 The switch in the circuit in Fig. P7.42 has been open a long time before closing at $t = 0$. Find $i_o(t)$ for $t \geq 0$.

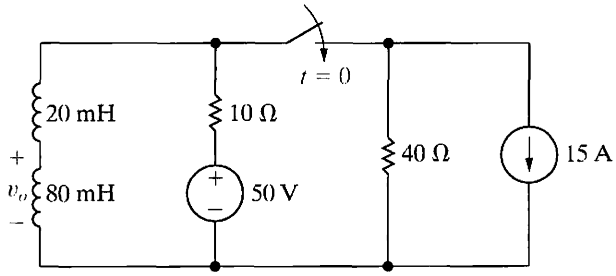
PSPICE MULTISIM

Figure P7.42



7.43 The switch in the circuit in Fig. P7.43 has been open a long time before closing at $t = 0$. Find $v_o(t)$ for $t \geq 0^+$.
PSPICE MULTISIM

Figure P7.43

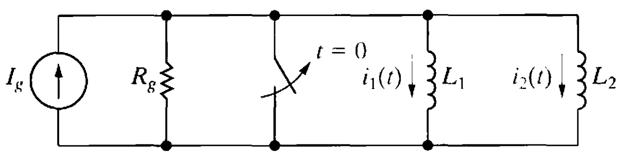


7.44 There is no energy stored in the inductors L_1 and L_2 at the time the switch is opened in the circuit shown in Fig. P7.44.

a) Derive the expressions for the currents $i_1(t)$ and $i_2(t)$ for $t \geq 0$.

b) Use the expressions derived in (a) to find $i_1(\infty)$ and $i_2(\infty)$.

Figure P7.44



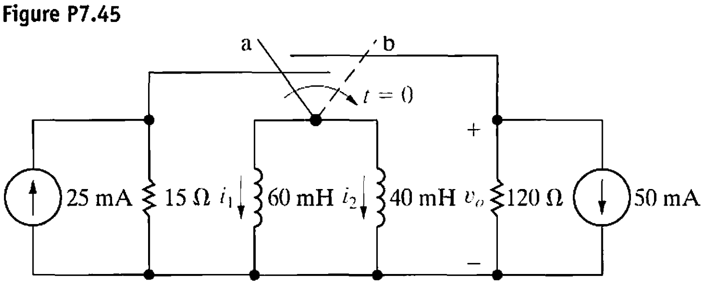
7.45 The make-before-break switch in the circuit of Fig. P7.45 has been in position a for a long time. At $t = 0$, the switch moves instantaneously to position b. Find
PSPICE MULTISIM

a) $v_o(t)$, $t \geq 0^+$.

b) $i_1(t)$, $t \geq 0$.

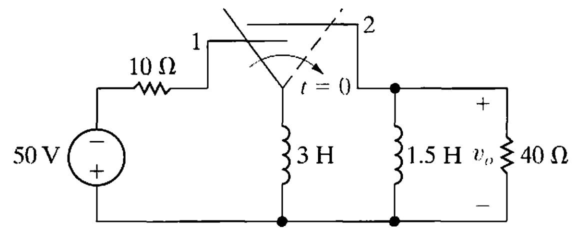
c) $i_2(t)$, $t \geq 0$.

Figure P7.45



7.46 The switch in the circuit in Fig. P7.46 has been in position 1 for a long time. At $t = 0$ it moves instantaneously to position 2. How many milliseconds after the switch operates does v_o equal 100 V?
PSPICE MULTISIM

Figure P7.46



7.47 For the circuit in Fig. P7.46, find (in joules):

a) the total energy dissipated in the 40 Ω resistor;

b) the energy trapped in the inductors;

c) the initial energy stored in the inductors.

7.48 The current and voltage at the terminals of the capacitor in the circuit in Fig. 7.21 are

$$i(t) = 3e^{-2500t}\ \text{mA}, \qquad t \geq 0^+;$$

$$v(t) = (40 - 24e^{-2500t})\ \text{V}, \qquad t \geq 0.$$

a) Specify the numerical values of I_s, V_o, R, C, and τ.

b) How many microseconds after the switch has been closed does the energy stored in the capacitor reach 81% of its final value?

7.49 a) Use component values from Appendix H to create a first-order *RC* circuit (see Fig. 7.21) with a time constant of 250 ms. Use a single capacitor and a network of resistors, if necessary. Draw your circuit.

b) Suppose the capacitor you chose in part (a) has an initial voltage drop of 100 V. At $t = 0$, a switch connects a current source with a value of 1 mA in parallel with the capacitor and equivalent resistance. Write an expression for the voltage drop across the capacitor for $t \geq 0$.

c) Using your result from part (b), calculate the time at which the voltage drop across the capicitor reaches 50 V.

7.50 The switch in the circuit shown in Fig. P7.50 has been closed a long time before opening at $t = 0$.
PSPICE MULTISIM

a) What is the initial value of $i_o(t)$?

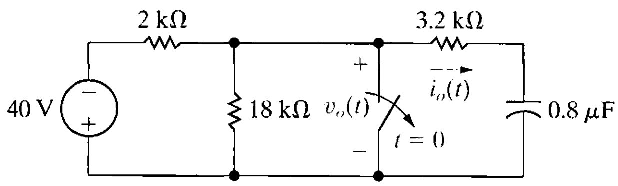
b) What is the final value of $i_o(t)$?

c) What is the time constant of the circuit for $t \geq 0$?

d) What is the numerical expression for $i_o(t)$ when $t \geq 0^+$?

e) What is the numerical expression for $v_o(t)$ when $t \geq 0^+$?

Figure P7.50

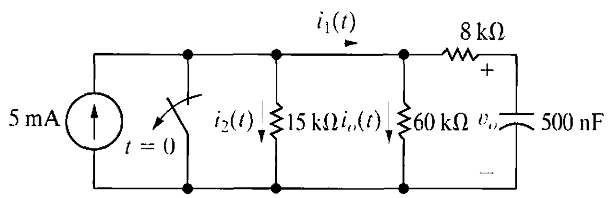


7.51 The switch in the circuit shown in Fig. P7.51 has been closed a long time before opening at $t = 0$. For $t \geq 0^+$, find

PSPICE MULTISIM

a) $v_o(t)$.
b) $i_o(t)$.
c) $i_1(t)$.
d) $i_2(t)$.
e) $i_1(0^+)$.

Figure P7.51

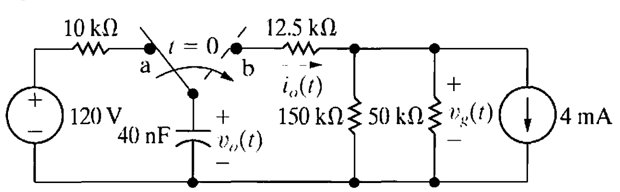


7.52 The switch in the circuit seen in Fig. P7.52 has been in position a for a long time. At $t = 0$, the switch moves instantaneously to position b. For $t \geq 0^+$, find

PSPICE MULTISIM

a) $v_o(t)$.
b) $i_o(t)$.
c) $v_g(t)$.
d) $v_g(0^+)$.

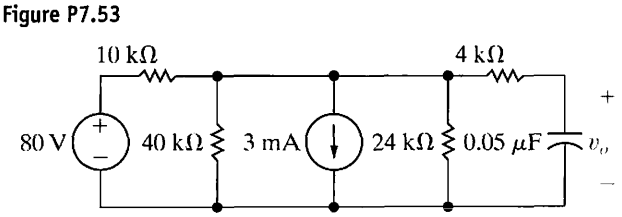
Figure P7.52



7.53 The circuit in Fig. P7.53 has been in operation for a long time. At $t = 0$, the voltage source reverses polarity and the current source drops from 3 mA to 2 mA. Find $v_o(t)$ for $t \geq 0$.

PSPICE MULTISIM

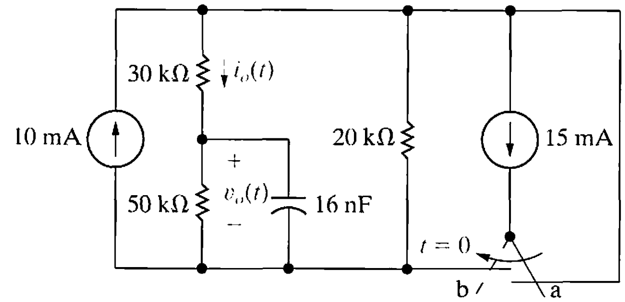
Figure P7.53



7.54 The switch in the circuit seen in Fig. P7.54 has been in position a for a long time. At $t = 0$, the switch moves instantaneously to position b. Find $v_o(t)$ and $i_o(t)$ for $t \geq 0^+$.

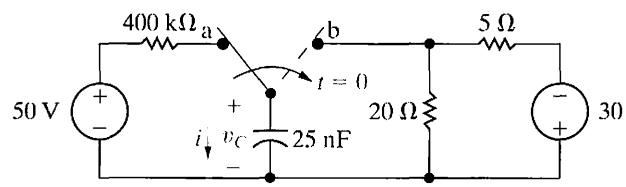
PSPICE MULTISIM

Figure P7.54



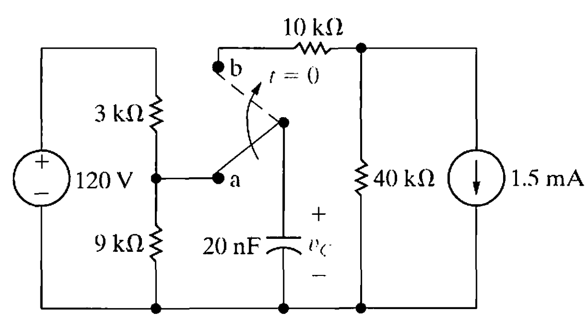
7.55 Assume that the switch in the circuit of Fig. P7.55 has been in position a for a long time and that at $t = 0$ it is moved to position b. Find (a) $v_C(0^+)$; (b) $v_C(\infty)$; (c) τ for $t > 0$; (d) $i(0^+)$; (e) v_C, $t \geq 0$; and (f) i, $t \geq 0^+$.

Figure P7.55



7.56 The switch in the circuit of Fig. P7.56 has been in position a for a long time. At $t = 0$ the switch is moved to position b. Calculate (a) the initial voltage on the capacitor; (b) the final voltage on the capacitor; (c) the time constant (in microseconds) for $t > 0$; and (d) the length of time (in microseconds) required for the capacitor voltage to reach zero after the switch is moved to position b.

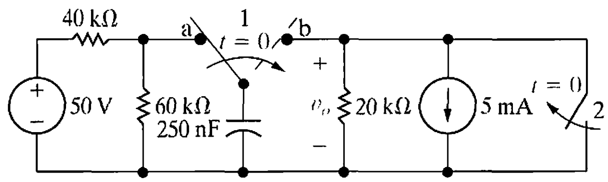
Figure P7.56



7.57 The switch in the circuit in Fig. P7.57 has been in position a for a long time. At $t = 0$, the switch moves instantaneously to position b. At the instant the switch makes contact with terminal b, switch 2 opens. Find $v_o(t)$ for $t \geq 0$.

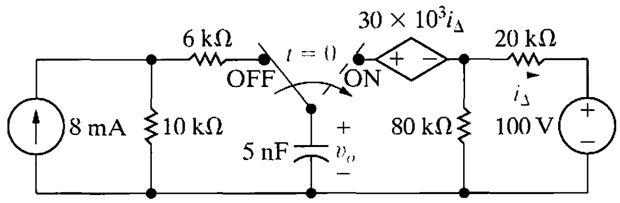
PSPICE MULTISIM

Figure P7.57



7.58 The switch in the circuit shown in Fig. P7.58 has
PSPICE MULTISIM
been in the OFF position for a long time. At $t = 0$, the switch moves instantaneously to the ON position. Find $v_o(t)$ for $t \geq 0$.

Figure P7.58



7.59 Assume that the switch in the circuit of Fig. P7.58
PSPICE MULTISIM
has been in the ON position for a long time before switching instantaneously to the OFF position at $t = 0$. Find $v_o(t)$ for $t \geq 0$.

7.60 The switch in the circuit shown in Fig. P7.60 opens at
PSPICE MULTISIM
$t = 0$ after being closed for a long time. How many milliseconds after the switch opens is the energy stored in the capacitor 36% of its final value?

7.61 a) Derive Eq. 7.52 by first converting the Norton equivalent circuit shown in Fig. 7.21 to a Thévenin equivalent and then summing the voltages around the closed loop, using the capacitor current i as the relevant variable.

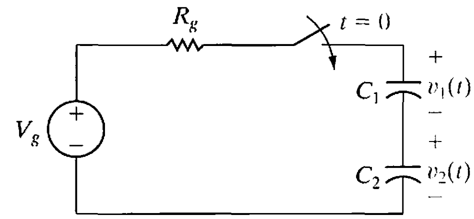
b) Use the separation of variables technique to find the solution to Eq. 7.52. Verify that your solution agrees with that of Eq. 7.53.

7.62 There is no energy stored in the capacitors C_1 and C_2 at the time the switch is closed in the circuit seen in Fig. P7.62.

a) Derive the expressions for $v_1(t)$ and $v_2(t)$ for $t \geq 0$.

b) Use the expressions derived in (a) to find $v_1(\infty)$ and $v_2(\infty)$.

Figure P7.62

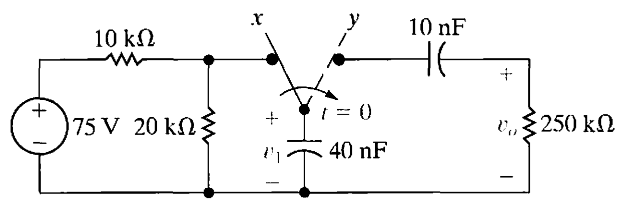


7.63 The switch in the circuit in Fig. P7.63 has been in position x for a long time. The initial charge on the 10 nF capacitor is zero. At $t = 0$, the switch moves instantaneously to position y.

a) Find $v_o(t)$ for $t \geq 0^+$.

b) Find $v_1(t)$ for $t \geq 0$.

Figure P7.63



7.64 The switch in the circuit of Fig. P7.64 has been in
PSPICE MULTISIM
position a for a long time. At $t = 0$, it moves instantaneously to position b. For $t \geq 0^+$, find

a) $v_o(t)$.

b) $i_o(t)$.

c) $v_1(t)$.

d) $v_2(t)$.

e) the energy trapped in the capacitors as $t \rightarrow \infty$.

Figure P7.64

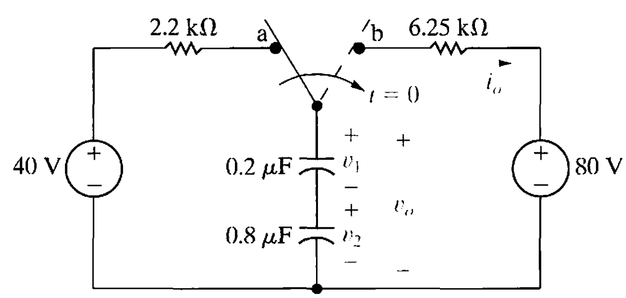
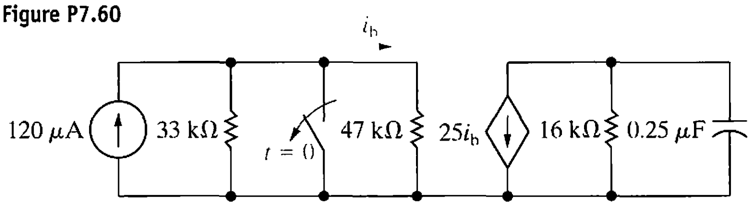


Figure P7.60



Section 7.4

7.65 Repeat (a) and (b) in Example 7.10 if the mutual inductance is reduced to zero.

7.66 PSPICE MULTISIM There is no energy stored in the circuit in Fig. P7.66 at the time the switch is closed.

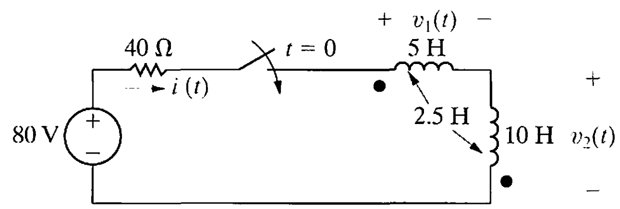
a) Find $i(t)$ for $t \geq 0$.

b) Find $v_1(t)$ for $t \geq 0^+$.

c) Find $v_2(t)$ for $t \geq 0$.

d) Do your answers make sense in terms of known circuit behavior?

Figure P7.66



7.67 PSPICE MULTISIM Repeat Problem 7.66 if the dot on the 10 H coil is at the top of the coil.

7.68 There is no energy stored in the circuit of Fig. P7.68 at the time the switch is closed.

a) Find $i_o(t)$ for $t \geq 0$.

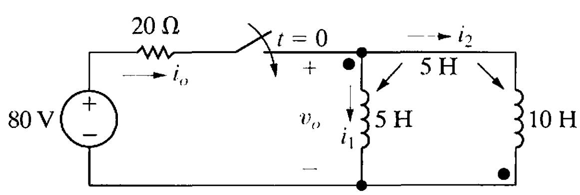
b) Find $v_o(t)$ for t $\geq 0^+$.

c) Find $i_1(t)$ for $t \geq 0$.

d) Find $i_2(t)$ for $t \geq 0$.

e) Do your answers make sense in terms of known circuit behavior?

Figure P7.68



7.69 PSPICE MULTISIM There is no energy stored in the circuit in Fig. P7.69 at the time the switch is closed.

a) Find $i_o(t)$ for $t \geq 0$.

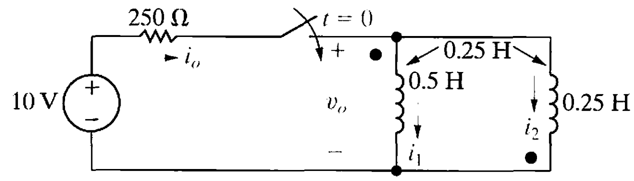
b) Find $v_o(t)$ for $t \geq 0^+$.

c) Find $i_1(t)$ for $t \geq 0$.

d) Find $i_2(t)$ for $t \geq 0$.

e) Do your answers make sense in terms of known circuit behavior?

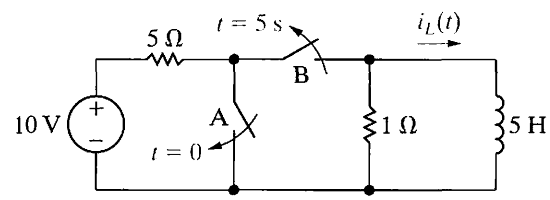
Figure P7.69



Section 7.5

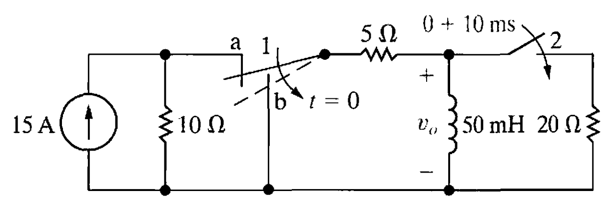
7.70 PSPICE MULTISIM In the circuit in Fig. P7.70, switch A has been open and switch B has been closed for a long time. At $t = 0$, switch A closes. Five seconds after switch A closes, switch B opens. Find $i_L(t)$ for $t \geq 0$.

Figure P7.70



7.71 PSPICE MULTISIM The action of the two switches in the circuit seen in Fig. P7.71 is as follows. For $t < 0$, switch 1 is in position a and switch 2 is open. This state has existed for a long time. At $t = 0$, switch 1 moves instantaneously from position a to position b, while switch 2 remains open. Ten milliseconds after switch 1 operates, switch 2 closes, remains closed for 10 ms and then opens. Find $v_o(t)$ 25 ms after switch 1 moves to position b.

Figure P7.71



7.72 For the circuit in Fig. P7.71, how many milliseconds after switch 1 moves to position b is the energy stored in the inductor 4% of its initial value?

7.73 PSPICE MULTISIM The switch in the circuit shown in Fig. P7.73 has been in position a for a long time. At $t = 0$, the switch is moved to position b, where it remains for 1 ms. The switch is then moved to position c, where it remains indefinitely. Find

a) $i(0^+)$.

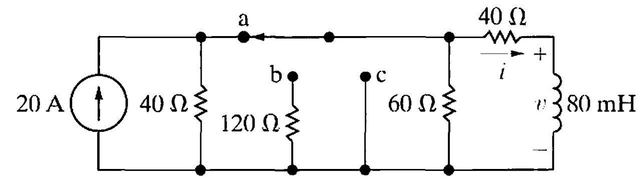
b) $i(200\ \mu s)$.

c) $i(6\text{ ms})$.

d) $v(1^-\text{ ms})$.

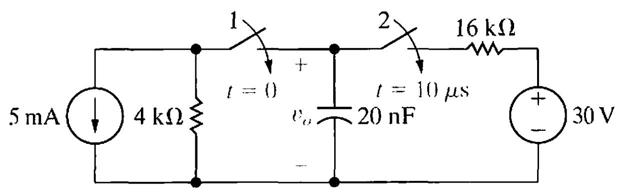
e) $v(1^+\text{ ms})$.

Figure P7.73



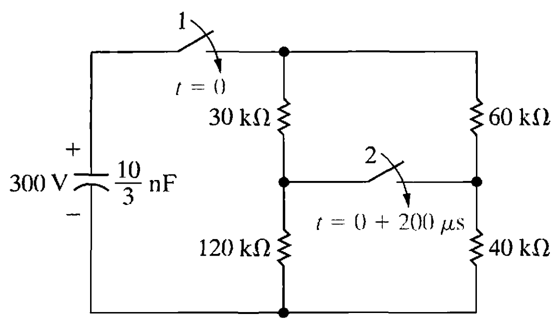
7.74 There is no energy stored in the capacitor in the circuit in Fig. P7.74 when switch 1 closes at $t = 0$. Ten microseconds later, switch 2 closes. Find $v_o(t)$ for $t \geq 0$.
PSPICE MULTISIM

Figure P7.74



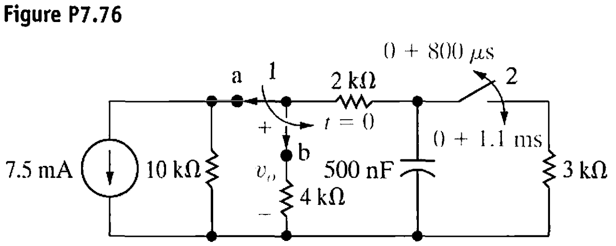
7.75 The capacitor in the circuit seen in Fig. P7.75 has been charged to 300 V. At $t = 0$, switch 1 closes, causing the capacitor to discharge into the resistive network. Switch 2 closes 200 μs after switch 1 closes. Find the magnitude and direction of the current in the second switch 300 μs after switch 1 closes.
PSPICE MULTISIM

Figure P7.75



7.76 In the circuit in Fig. P7.76, switch 1 has been in position a and switch 2 has been closed for a long time. At $t = 0$, switch 1 moves instantaneously to position b. Eight hundred microseconds later, switch 2 opens, remains open for 300 μs, and then recloses. Find v_o 1.5 ms after switch 1 makes contact with terminal b.

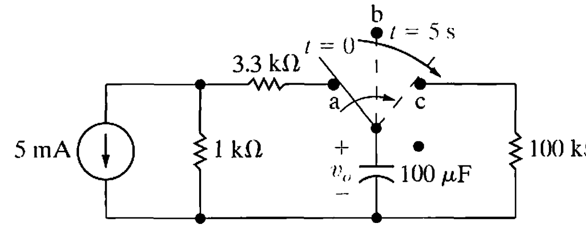
Figure P7.76



7.77 For the circuit in Fig. P7.76, what percentage of the initial energy stored in the 500 nF capacitor is dissipated in the 3 kΩ resistor?
PSPICE MULTISIM

7.78 The switch in the circuit in Fig. P7.78 has been in position a for a long time. At $t = 0$, it moves instantaneously to position b, where it remains for five seconds before moving instantaneously to position c. Find v_o for $t \geq 0$.
PSPICE MULTISIM

Figure P7.78



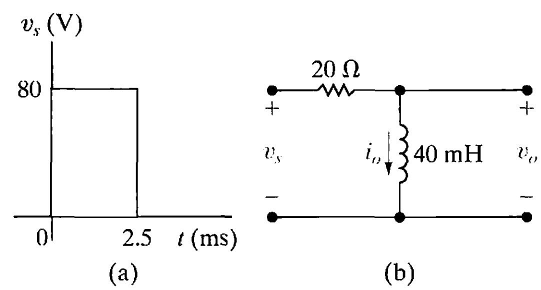
7.79 The voltage waveform shown in Fig. P7.79(a) is applied to the circuit of Fig. P7.79(b). The initial current in the inductor is zero.
PSPICE MULTISIM

a) Calculate $v_o(t)$.

b) Make a sketch of $v_o(t)$ versus t.

c) Find i_o at $t = 5$ ms.

Figure P7.79



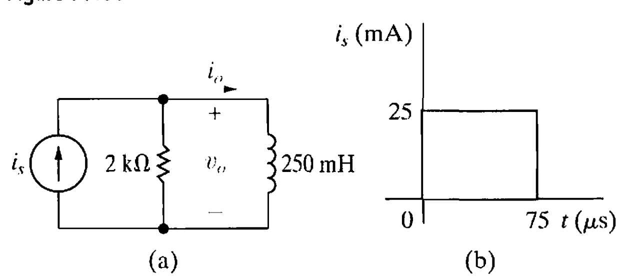
7.80 The current source in the circuit in Fig. P7.80(a) generates the current pulse shown in Fig. P7.80(b). There is no energy stored at $t = 0$.
PSPICE MULTISIM

a) Derive the numerical expressions for $v_o(t)$ for the time intervals $t < 0$, $0 \leq t \leq 75\ \mu$s, and $75\ \mu\text{s} \leq t < \infty$.

b) Calculate $v_o\ (75^-\ \mu\text{s})$ and $v_o\ (75^+\ \mu\text{s})$.

c) Calculate $i_o\ (75^-\ \mu\text{s})$ and $i_o\ (75^+\ \mu\text{s})$.

Figure P7.80

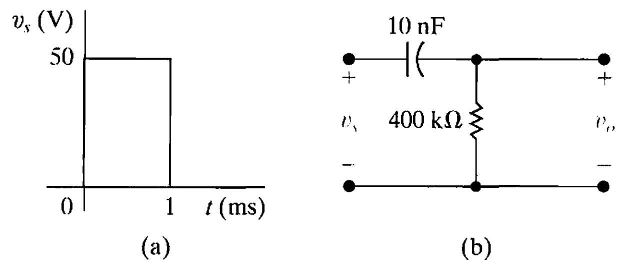


7.81 PSPICE MULTISIM The voltage waveform shown in Fig. P7.81(a) is applied to the circuit of Fig. P7.81(b). The initial voltage on the capacitor is zero.

a) Calculate $v_o(t)$.

b) Make a sketch of $v_o(t)$ versus t.

Figure P7.81



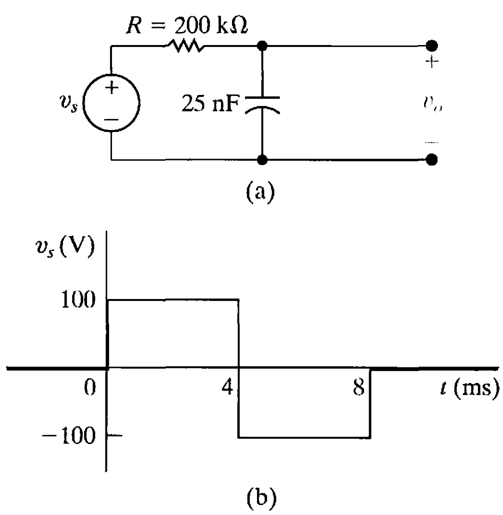
7.82 PSPICE MULTISIM The voltage signal source in the circuit in Fig. P7.82(a) is generating the signal shown in Fig. P7.82(b). There is no stored energy at $t = 0$.

a) Derive the expressions for $v_o(t)$ that apply in the intervals $t < 0$; $0 \leq t \leq 4$ ms; $4 \text{ ms} \leq t \leq 8$ ms; and $8 \text{ ms} \leq t < \infty$.

b) Sketch v_o and v_s on the same coordinate axes.

c) Repeat (a) and (b) with R reduced to 50 kΩ.

Figure P7.82



7.83 PSPICE MULTISIM The current source in the circuit in Fig. P7.83(a) generates the current pulse shown in Fig. P7.83(b). There is no energy stored at $t = 0$.

a) Derive the expressions for $i_o(t)$ and $v_o(t)$ for the time intervals $t < 0$; $0 < t < 2$ ms; and $2 \text{ ms} < t < \infty$.

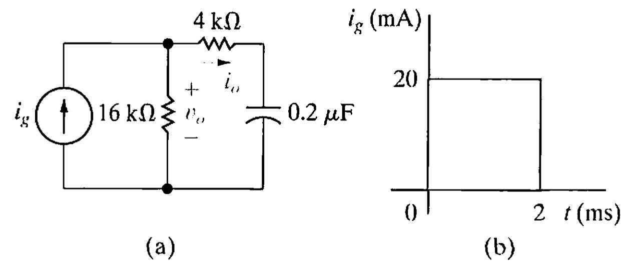
b) Calculate $i_o(0^-)$; $i_o(0^+)$; $i_o(0.002^-)$; and $i_o(0.002^+)$.

c) Calculate $v_o(0^-)$; $v_o(0^+)$; $v_o(0.002^-)$; and $v_o(0.002^+)$.

d) Sketch $i_o(t)$ versus t for the interval $-1 \text{ ms} < t < 4$ ms.

e) Sketch $v_o(t)$ versus t for the interval $-1 \text{ ms} < t < 4$ ms.

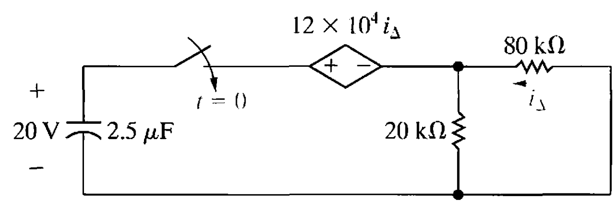
Figure P7.83



Section 7.6

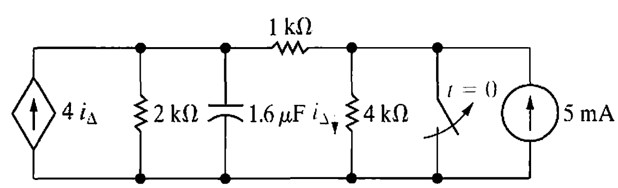
7.84 PSPICE MULTISIM The capacitor in the circuit shown in Fig. P7.84 is charged to 20 V at the time the switch is closed. If the capacitor ruptures when its terminal voltage equals or exceeds 20 kV, how long does it take to rupture the capacitor?

Figure P7.84



7.85 PSPICE MULTISIM The switch in the circuit in Fig. P7.85 has been closed for a long time. The maximum voltage rating of the 1.6 μF capacitor is 14.4 kV. How long after the switch is opened does the voltage across the capacitor reach the maximum voltage rating?

Figure P7.85



7.86 PSPICE MULTISIM The inductor current in the circuit in Fig. P7.86 is 25 mA at the instant the switch is opened. The inductor will malfunction whenever the magnitude of the inductor current equals or exceeds 5 A. How long after the switch is opened does the inductor malfunction?