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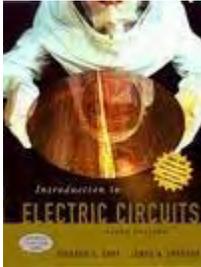
Introduction to

ELECTRIC CIRCUITS

SIXTH EDITION

with *Electric
Circuit Study
Applets*

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Solution Manual

to accompany

Introduction to Electric Circuits, 6e

By R. C. Dorf and J. A. Svoboda

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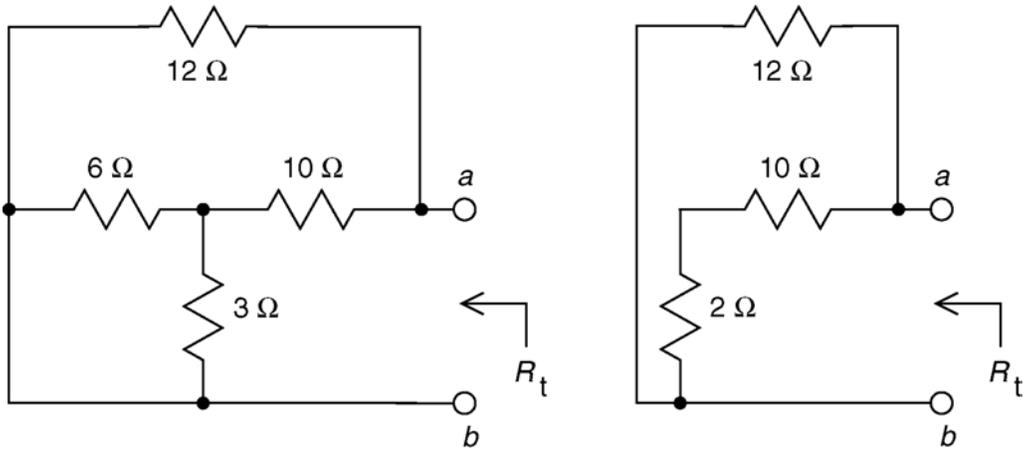
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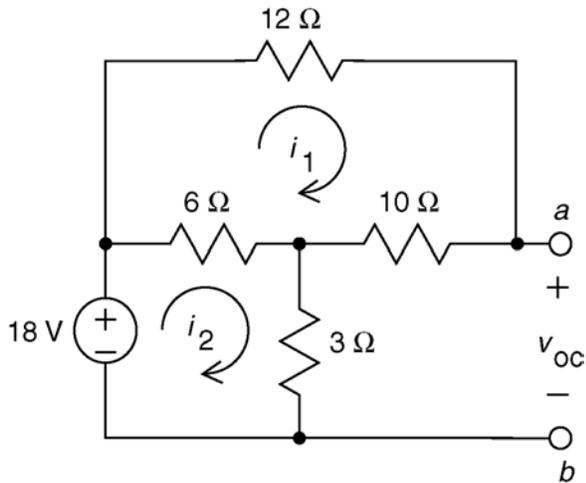
P5.5-4

Find R_t :



$$R_t = \frac{12(10+2)}{12+(10+2)} = 6 \Omega$$

Write mesh equations to find v_{oc} :



Mesh equations:

$$12 i_1 + 10 i_1 - 6(i_2 - i_1) = 0$$

$$6(i_2 - i_1) + 3 i_2 - 18 = 0$$

$$28 i_1 = 6 i_2$$

$$9 i_2 - 6 i_1 = 18$$

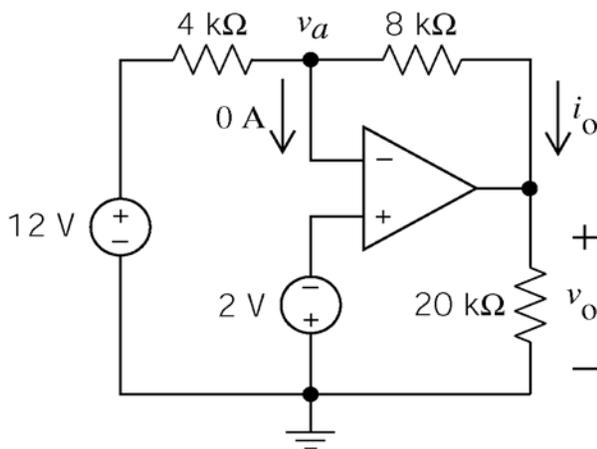
$$36 i_1 = 18 \Rightarrow i_1 = \frac{1}{2} \text{ A}$$

$$i_2 = \frac{14}{3} \left(\frac{1}{2} \right) = \frac{7}{3} \text{ A}$$

Finally,
$$v_{oc} = 3 i_2 + 10 i_1 = 3 \left(\frac{7}{3} \right) + 10 \left(\frac{1}{2} \right) = 12 \text{ V}$$

(checked using LNAP 8/15/02)

P6.4-3



The voltages at the input nodes of an ideal op amp are equal so $v_a = -2 \text{ V}$.

Apply KCL at node a :

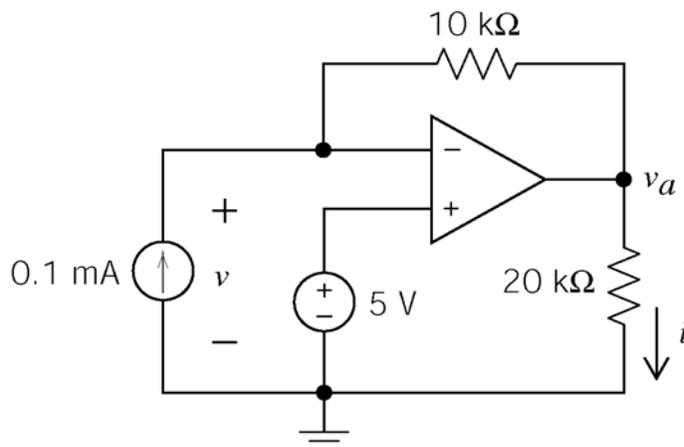
$$\frac{v_o - (-2)}{8000} + \frac{12 - (-2)}{4000} = 0 \Rightarrow v_o = -30 \text{ V}$$

Apply Ohm's law to the 8 kΩ resistor

$$i_o = \frac{-2 - v_o}{8000} = 3.5 \text{ mA}$$

(checked using LNAP 8/16/02)

P6.4-4



The voltages at the input nodes of an ideal op amp are equal so $v = 5 \text{ V}$.

Apply KCL at the inverting input node of the op amp:

$$-\left(\frac{v_a - 5}{10000}\right) - 0.1 \times 10^{-3} - 0 = 0 \Rightarrow v_a = 4 \text{ V}$$

Apply Ohm's law to the 20 kΩ resistor

$$i = \frac{v_a}{20000} = \frac{1}{5} \text{ mA}$$

(checked using LNAP 8/16/02)

P6.4-5

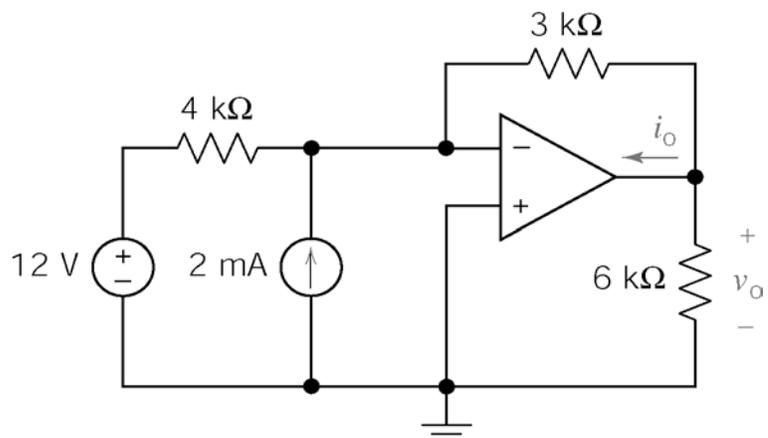
The voltages at the input nodes of an ideal op amp are equal so $v_a = 0 \text{ V}$. Apply KCL at node a :

$$-\left(\frac{v_o - 0}{3000}\right) - \left(\frac{12 - 0}{4000}\right) - 2 \cdot 10^{-3} = 0$$

$$\Rightarrow v_o = -15 \text{ V}$$

Apply KCL at the output node of the op amp:

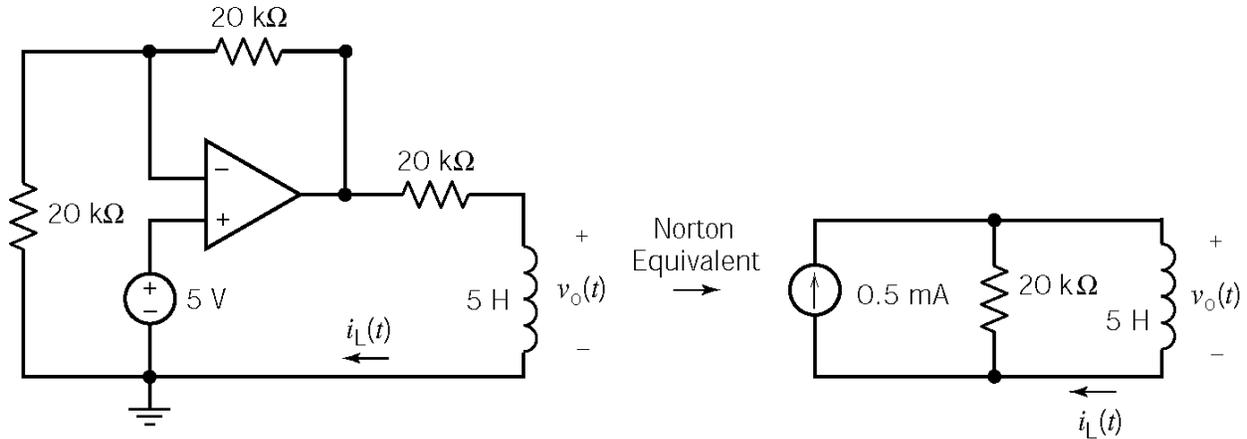
$$i_o + \frac{v_o}{6000} + \frac{v_o}{3000} = 0 \Rightarrow i_o = 7.5 \text{ mA}$$



(checked using LNAP 8/16/02)

P8.3-6

Before the switch opens, $v_o(t) = 5 \text{ V} \Rightarrow v_o(0) = 5 \text{ V}$. After the switch opens the part of the circuit connected to the capacitor can be replaced by it's Norton equivalent circuit to get:



Therefore $\tau = \frac{5}{20 \times 10^3} = 0.25 \text{ ms}$.

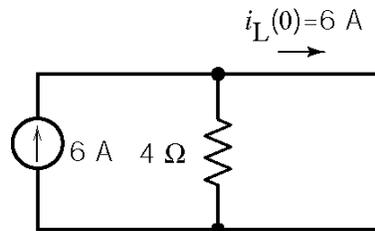
Next, $i_L(t) = i_{sc} + (i_L(0) - i_{sc}) e^{-\frac{t}{\tau}} = 0.5 - 0.25 e^{-4000t} \text{ mA}$ for $t > 0$

Finally, $v_o(t) = 5 \frac{d}{dt} i_L(t) = 5 e^{-4000t} \text{ V}$ for $t > 0$

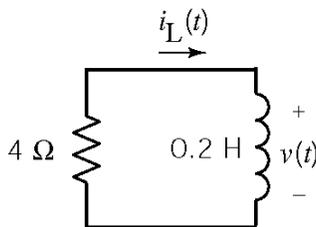
P8.3-7

At $t = 0^-$ (steady-state)

Since the input to this circuit is constant, the inductor will act like a short circuit when the circuit is at steady-state:



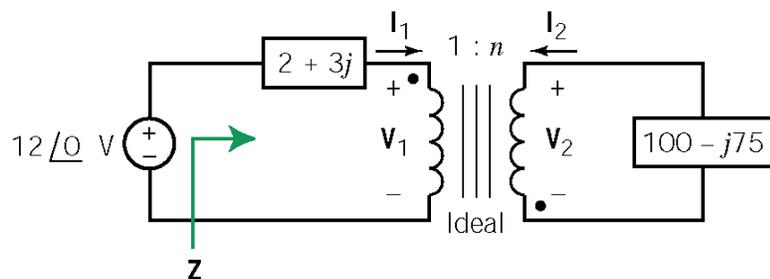
for $t > 0$



$i_L(t) = i_L(0) e^{-(R/L)t} = 6 e^{-20t} \text{ A}$

Section 11-10: The Ideal Transformer

P11.10-1



$$\mathbf{Z} = (2 + j3) + \frac{(100 - j75)}{5^2} = 6 \Omega$$

$$\mathbf{I}_1 = \frac{12 \angle 0^\circ}{\mathbf{Z}} = \frac{12 \angle 0^\circ}{6} = 2 \text{ A}$$

$$\mathbf{V}_1 = \mathbf{I}_1 \left(\frac{100 - j75}{n^2} \right) = (2) \left(\frac{100 - j75}{25} \right) = 10 \angle -36.9^\circ \text{ V}$$

$$\mathbf{V}_2 = n\mathbf{V}_1 = 5 (10 \angle -36.9^\circ) = 50 \angle -36.9^\circ \text{ V}$$

$$\mathbf{I}_2 = \frac{\mathbf{I}_1}{n} = \frac{2}{5} \text{ A}$$

P11.10-2

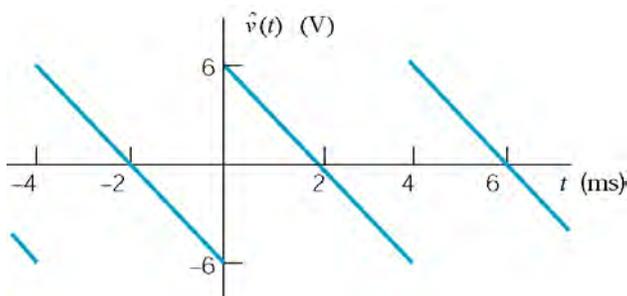
(a) $\mathbf{V}_0 = (5 \times 10^{-3})(10,000) = 50 \text{ V}$

$$n = \frac{N_2}{N_1} = \frac{\mathbf{V}_0}{\mathbf{V}_1} = \frac{50}{10} = 5$$

(b) $R_{ab} = \frac{1}{n^2} R_2 = \frac{1}{25} (10 \times 10^3) = 400 \Omega$

(c) $\mathbf{I}_s = \frac{10}{R_{ab}} = \frac{10}{400} = 0.025 \text{ A} = 25 \text{ mA}$

P15.8-6



Rather than find the Fourier Series of $v(t)$ directly, consider the signal $\hat{v}(t)$ shown above. These two signals are related by

$$v(t) = \hat{v}(t-1) - 6$$

since $v(t)$ is delayed by 1 ms and shifted down by 6 V.

The Fourier series of $\hat{v}(t)$ is obtained as follows:

$$T = 4 \text{ ms} \Rightarrow \omega_0 = \frac{2\pi \text{ radians}}{4 \text{ ms}} = \frac{\pi}{2} \text{ rad/ms}$$

$$\hat{a}_n = 0 \text{ because the average value of } \hat{v}(t) = 0$$

$$\hat{b}_n = \frac{1}{2} \int_0^4 (6-3t) \sin\left(n\frac{\pi}{2}t\right) dt \text{ because } \hat{v}(t) \text{ is an odd function.}$$

$$= 3 \int_0^4 \sin\left(n\frac{\pi}{2}t\right) dt - \frac{3}{2} \int_0^4 t \sin\left(n\frac{\pi}{2}t\right) dt$$

$$= 3 \frac{-\cos\left(n\frac{\pi}{2}t\right)}{n\frac{\pi}{2}} \Big|_0^4 - \frac{3}{2} \left[\left(\frac{1}{\frac{n^2\pi^2}{4}} \right) \sin\left(n\frac{\pi}{2}t\right) - \left(\frac{n\pi}{2}t\right) \cos\left(n\frac{\pi}{2}t\right) \right] \Big|_0^4$$

$$= \frac{6}{n\pi} (-1 + \cos(2n\pi)) - \frac{6}{n^2\pi^2} ((\sin(2n\pi) - 0) - (2n\pi - \cos(2\pi) - 0)) = \frac{12}{n\pi}$$

Finally,

$$\hat{v}(t) = \sum_{n=1}^{\infty} \frac{12}{n\pi} \sin n\frac{\pi}{2}t$$

The Fourier series of $v(t)$ is obtained from the Fourier series of $\hat{v}(t)$ as follows:

$$v(t) = -6 + \sum_{n=1}^{\infty} \frac{12}{n\pi} \sin n\frac{\pi}{2}(t-1) = -6 + \sum_{n=1}^{\infty} \frac{12}{n\pi} \sin\left(n\frac{\pi}{2}t - n\frac{\pi}{2}\right)$$

where t is in ms. Equivalently,