台灣科技大學一百一十學年度上學期平時考（二）

科目名稱：電路學(一)　開課系所：電子系 ET2103301　地點：國際大樓 IB501

考試時間：111 年 11 月 24 日　下午 13:20 至 15:10 (不可使用工程計算機)

1. (20%) Please calculate the maximum power that can be transferred to R_L in Fig. 1.

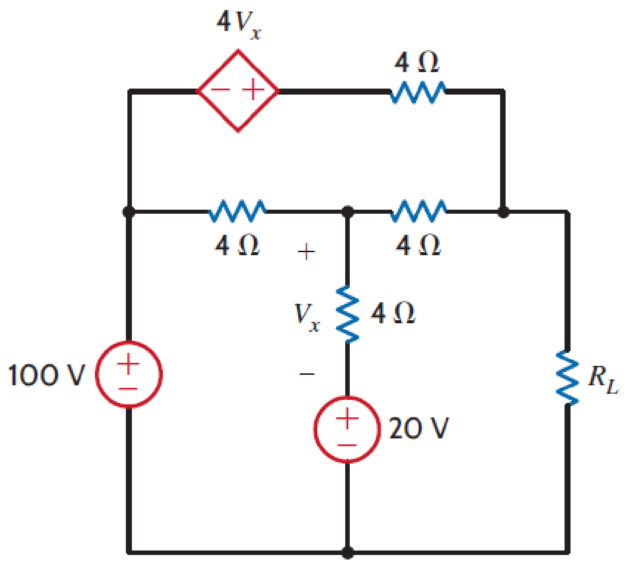


Fig. 1.

2. (15%) Please find the voltage transfer equation (inputs v_1, v_2; output v_3) for the circuit in Fig. 2.

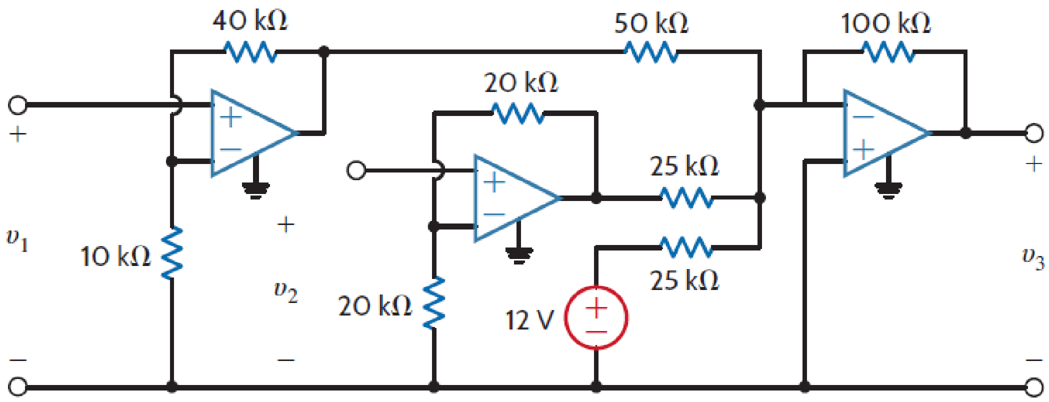


Fig. 2.

3. (15%) The current in a 5-mH inductor is given by the waveform in Fig. 3. Please calculate the waveform for the voltage across the inductor.

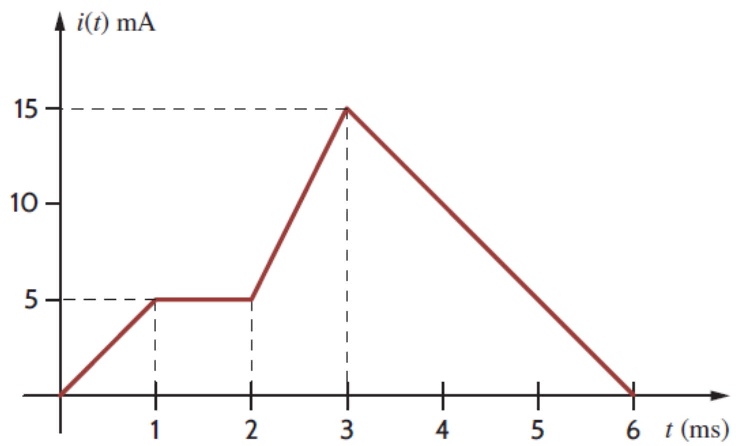


Fig. 3.

4. (20%) The switch in the circuit in Fig. 4 is moved at t = 0. Please find $i_R(t)$ for t > 0 using the step-by-step technique.

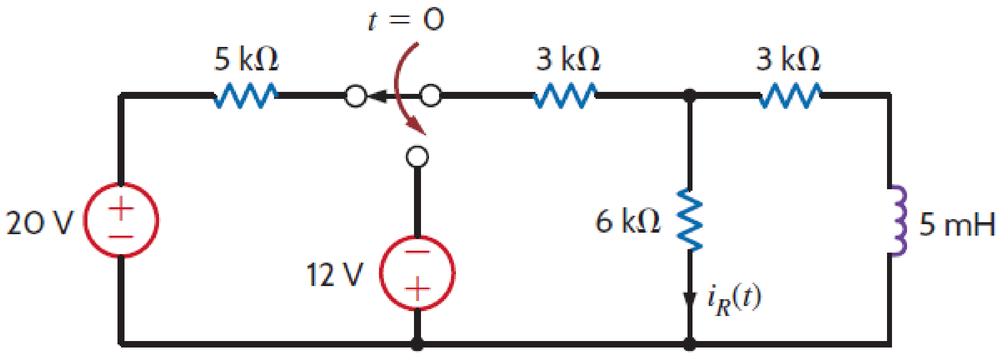


Fig. 4.

5. (20%) Please find $i_o(t)$ for t > 0 in Fig. 5.

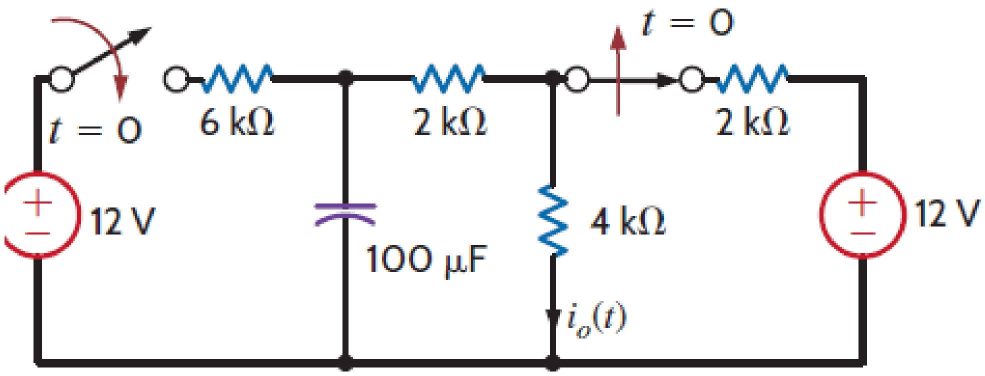


Fig. 5.

6. (20%) The switch in Fig. 6 has been closed for a long time and is opened at t = 0. Please find $i(t)$ for t > 0.in Fig. 6.

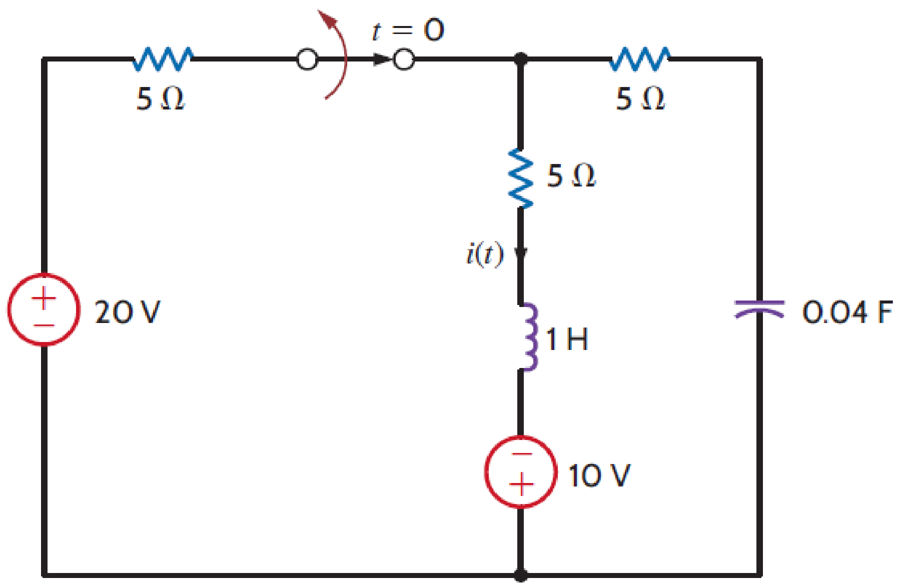
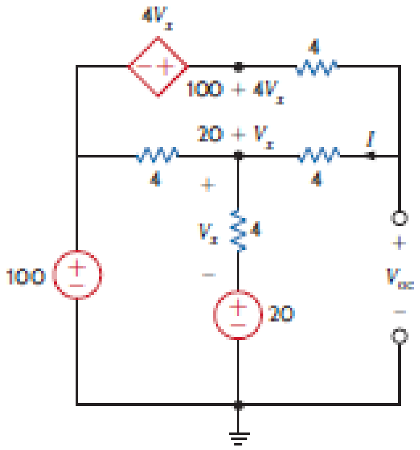


Fig. 6.

1.

Solution:

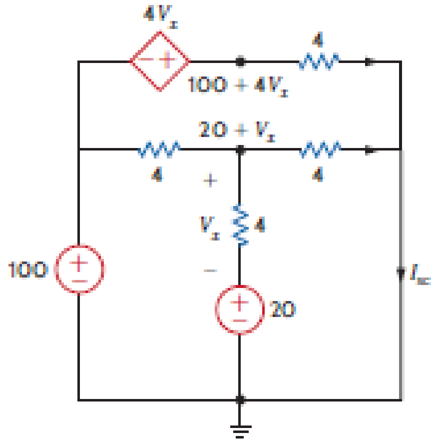


$$\frac{20+V_x-100}{4}+\frac{V_x}{4}+\frac{20+V_x-(100+4V_x)}{4+4}=0$$

$$\Rightarrow V_x = 240\text{ V}$$

$$I=\frac{100+4V_x-(20+V_x)}{4+4}=100\text{ A}$$

$$V_{oc}=4I+V_x+20=660\text{ V}$$



$$\frac{20+V_x-100}{4}+\frac{V_x}{4}+\frac{20+V_x}{4}=0$$

$$\Rightarrow 3V_x = 60 \Rightarrow V_x = 20\text{ V}$$

$$I_{sc}=\frac{100+4V_x}{4}+\frac{20+V_x}{4}=55\text{ A}$$

$$R_{Th}=\frac{V_{oc}}{I_{sc}}=12\Omega=R_L$$

$$P_{R_L}=\frac{V_{oc}^2}{4R_{Th}}=9075\text{ W}$$

2.

ABP 4.3.33 Find the voltage transfer equation (inputs v_1, v_2; output v_3) for the circuit in Fig. ABP4.3.33.

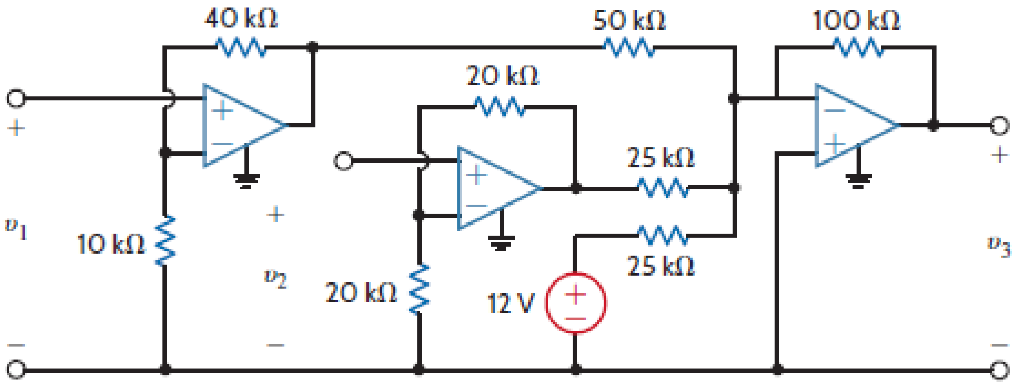


FIGURE ABP4.3.33

Solution:

Left op-amp (noninverting):

$$\frac{V_{01}}{v_1} = 1 + \frac{40\text{ k}\Omega}{10\text{ k}\Omega} = 5 \rightarrow V_{01} = 5 \cdot v_1$$

Middle op-amp (noninverting):

$$\frac{V_{02}}{v_2} = 1 + \frac{20\text{ k}\Omega}{20\text{ k}\Omega} = 2 \rightarrow V_{02} = 2 \cdot v_2$$

Right op-amp (inverting summer):

$$v_3 = -\left(\frac{R_F}{R_1} \cdot V_{01} + \frac{R_F}{R_2} \cdot V_{02} + \frac{R_F}{R_3} \cdot 12\text{ V}\right)$$

$$= -\left(\frac{100\text{ k}\Omega}{50\text{ k}\Omega} \cdot (5v_1) + \frac{100\text{ k}\Omega}{25\text{ k}\Omega} \cdot (2v_2) + \frac{100\text{ k}\Omega}{25\text{ k}\Omega} \cdot 12\text{ V}\right)$$

$$\rightarrow v_3 = -(10v_1 + 8v_2 + 48\text{ V})$$

3.

ABP 5.2.10 The current in a 5-mH inductor is given by the waveform in Fig. ABP5.2.10. Calculate the waveform for the voltage across the inductor.

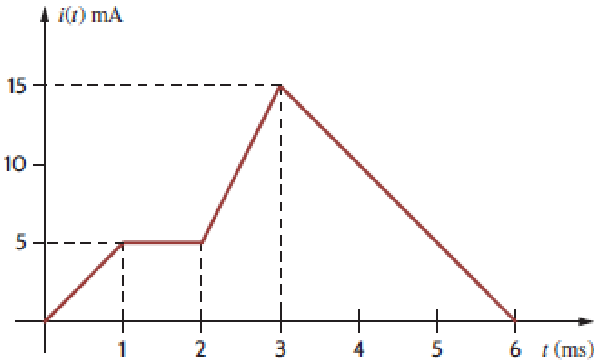


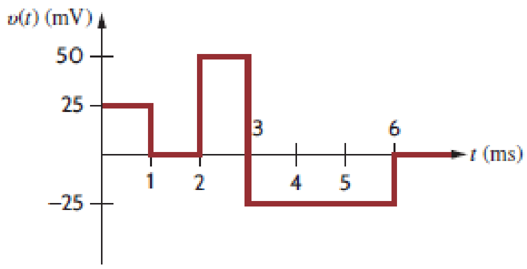
FIGURE ABP5.2.10

Solution:

$$i(t)=\begin{cases}\dfrac{5\times10^{-3}}{1\times10^{-3}}t=5t, & 0\le t\le 1\text{ ms}\\ 5\times10^{-3}, & 1\text{ ms}\le t\le 2\text{ ms}\\ \dfrac{10\times10^{-3}}{1\times10^{-3}}t-15\times10^{-3}=10t-15\times10^{-3}, & 2\text{ ms}\le t\le 3\text{ ms}\\ \dfrac{-15\times10^{-3}}{3\times10^{-3}}t+30\times10^{-3}=-5t+30\times10^{-3}, & 3\text{ ms}\le t\le 6\text{ ms}\\ 0, & t\ge 6\text{ ms}\end{cases}$$

$$v(t)=L\cdot\frac{di(t)}{dt}=(5\times10^{-3})\cdot\begin{cases}5, & 0\le t\le 1\text{ ms}\\ 0, & 1\text{ ms}\le t\le 2\text{ ms}\\ 10, & 2\text{ ms}\le t\le 3\text{ ms}\\ -5, & 3\text{ ms}\le t\le 6\text{ ms}\\ 0, & t\ge 6\text{ ms}\end{cases}$$

$$v(t)=\begin{cases}25\text{ mV}, & 0\le t\le 1\text{ ms}\\ 0\text{ V}, & 1\text{ ms}\le t\le 2\text{ ms}\\ 50\text{ mV}, & 2\text{ ms}\le t\le 3\text{ ms}\\ -25\text{ mV}, & 3\text{ ms}\le t\le 6\text{ ms}\\ 0\text{ V}, & t\ge 6\text{ ms}\end{cases}$$



4.

ABP 6.2.22 The switch in the circuit in Fig. ABP6.2.22 is moved at $t = 0$. Find $i_R(t)$ for $t > 0$ using the step-by-step technique.

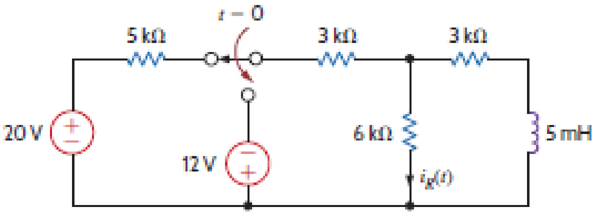
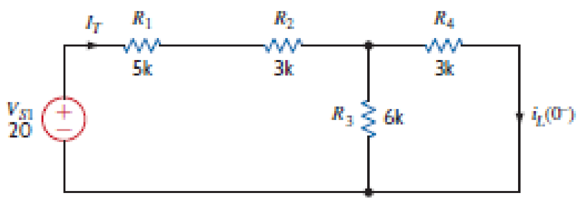


FIGURE ABP6.2.22

Solution:

$$i_R(t) = K_1 + K_2 e^{-t/\tau}$$

$t = 0^-$



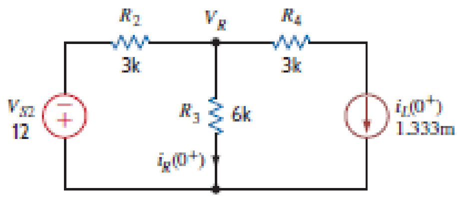
$$I_T = \frac{V_{S1}}{R_1 + R_2 + (R_3 \parallel R_4)}$$

$$I_T = 2 \text{ mA}$$

$$i_L(0^-) = \frac{I_T \cdot R_3}{R_3 + R_4}$$

$$I_L(0^-) = 1.333 \text{ mA} = i_L(0^+)$$

$t = 0^+$



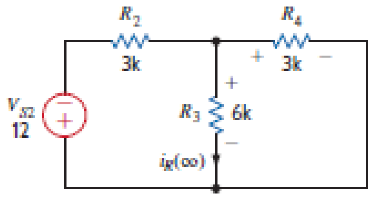
KCL:

$$\frac{V_R + V_{S2}}{R_2} + \frac{V_R}{R_3} + i_L(0^+) = 0$$

$$V_R = -10.667 \text{ V}$$

$$i_R(0^+) = \frac{V_R}{R_3} = -1.778 \text{ mA}$$

$t = \infty$

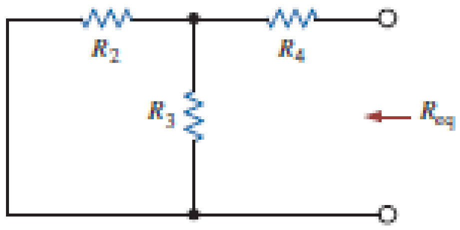


$R' = R_3 \parallel R_4 = 2\text{k}$

$$V_R = -\frac{V_{S2} \cdot R'}{R_2 + R'} = -4.8 \text{ V}$$

$$i_R(\infty) = \frac{V_R}{R_3}$$

$$i_R(\infty) = -0.8 \text{ mA}$$



$$R_{eq} = (R_2 \parallel R_3) + R_4 = 5 \text{ k}\Omega$$

$$\tau = \frac{L}{R_{eq}} = 1 \text{ µs}$$

$$i_R(0^+) = -1.778 \text{ mA} = K_1 + K_2$$

$$i_R(\infty) = -0.8 \text{ mA} = K_1$$

$$K_2 = -0.978 \text{ mA}$$

$$i_R(t) = -\left[0.8 + 0.978 e^{-t/1\times10^{-6}}\right] \text{ mA}, \quad t > 0$$

5.

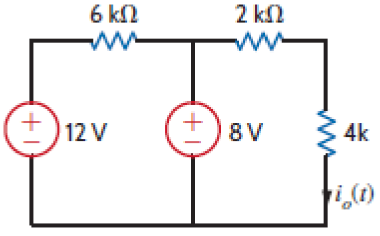
Solution:

@ $t = 0^-$

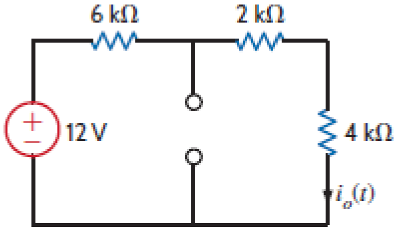
$$v_C = \frac{4 \cdot 12}{4+2} = 8 \text{ V}$$

@ $t = 0^+$

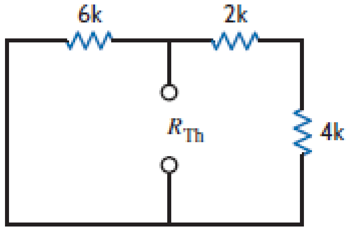
$$i_o = \frac{8}{6\text{k}} = \frac{4}{3} \text{ mA}$$



@ $t = \infty$



$$i_o = \frac{12}{12\text{k}} = 1 \text{ mA}$$



$$R_{\text{Th}} = (6 \,\|\, 6)\text{ k} = 3 \text{ k}\Omega$$

$$\tau = R_{\text{Th}} C = 3 \text{ k}\Omega \cdot 100\ \mu\text{F}$$

$$= \frac{3000}{100 \times 10^{-6}}$$

$$= \frac{3}{10} \text{ s}$$

$$i_o(t) = 1 + \left[\frac{4}{3} - 1\right] e^{-10t/3} \text{ mA}$$

$$= 1 + \frac{1}{3} e^{-10t/3} \text{ mA}$$

6.

ABP 6.3.1 The switch in the circuit in Fig. ABP6.3.1 has been closed for a long time and is opened at $t = 0$. Find $i(t)$ for $t > 0$.

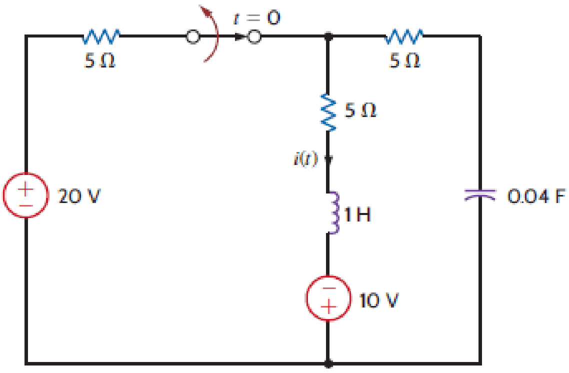
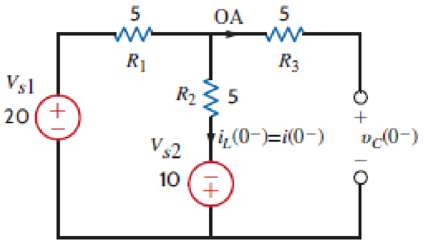


FIGURE ABP6.3.1

Solution:



$t = 0^-$

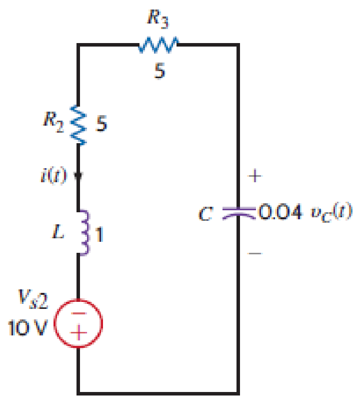
$$i(0^-) = \frac{V_{S2} + V_{S1}}{R_1 + R_2}$$

$$i(0^-) = 3\ \mathrm{A}$$

$$v_C(0^-) = V_{S1} - R_1 \cdot i(0^-)$$

$$v_C(0^-) = 5\ \mathrm{V} = v_C(0^+)$$

$t > 0$



$$v_C(t) = -\frac{1}{C}\int i(t)dt$$

$$V_{S2} = \frac{1}{C}\int i(t)dt + (R_2 + R_3)i(t) + L\frac{di(t)}{dt}$$

$$0 = \frac{d^2 i(t)}{dt} + \frac{(R_2 + R_3)}{L} \cdot \frac{di(t)}{dt} + \frac{1}{LC} \cdot i(t)$$

$$S^2 + 10\ s + 25 = 0$$

$$(s + 5)(s + 5) = 0,\ s_1 = s_2 = 5$$

$$i(t) = Ae^{-5t} + Bte^{-5t}$$

$$i(0^+) = i(0^-) = 3\ \mathrm{A} = \mathrm{A}$$

$$-v_C(0^+) = V_{S2} - (R_2 + R_3)i(0^+) - L\left.\frac{di(t)}{dt}\right|_{t=0}$$

$$-(5) = (10) - (10)(3) - (1)[-5\,\mathrm{A} + \mathrm{B}],\ A = 3$$

$$B = 0$$

$$i(t) = 3e^{-5t}\ \mathrm{A}, \quad t > 0$$