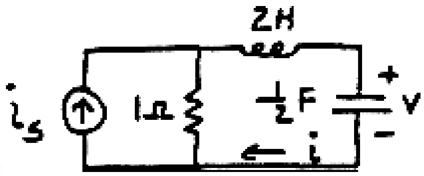
Chapter 9 - Complete Response of Circuits with Two Energy Storage Elements

Exercises

Ex. 9.3-1



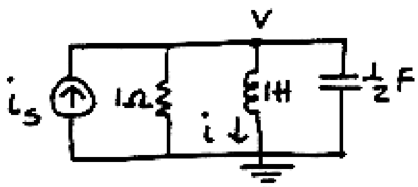
KVL a: $2\,{}^{di}\!/_{dt} + v + 1(i - i_s) = 0$

$\Rightarrow v = -2\,{}^{di}\!/_{dt} - i + i_s$

$$i = {}^{1}\!/_{2}\,{}^{dv}\!/_{dt} = {}^{1}\!/_{2}\,{}^{d}\!/_{dt}\left(-2\,{}^{di}\!/_{dt} - i + i_s\right) = {}^{1}\!/_{2}\,{}^{di_s}\!/_{dt} - {}^{1}\!/_{2}\,{}^{di}\!/_{dt} - \frac{d^2i}{dt^2}$$

$$\therefore \underline{\frac{d^2i}{dt^2} + \frac{1}{2}\frac{di}{dt} + i = \frac{1}{2}\frac{di_s}{dt}}$$

Ex. 9.3-2



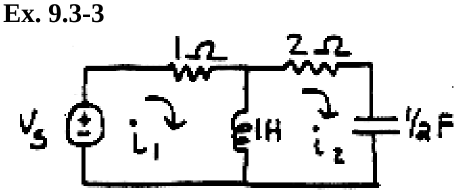
KCL at v : using $s = {}^{d}\!/_{dt}$

$\underline{\frac{v}{1} + i + {}^{1}\!/_{2}sv = i_s}$ (1)

also $\underline{v = si}$ (2) Solving for i in (1) & plugging into (2)

yields $s^2v + 2sv + 2v = 2si_s$ or $\underline{\frac{d^2v}{dt} + 2\frac{dv}{dt} + 2v = 2\frac{di_s}{dt}}$

Ex. 9.3-3



KVL ai_1 : $\underline{i_1 + s(i_1 - i_2) = v_s}$ (1)

where $s = {}^{d}\!/_{dt}$

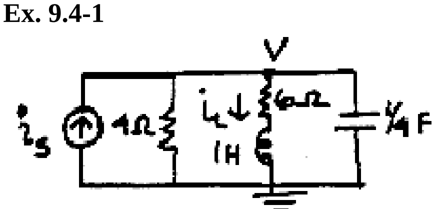
KVL ai_2 : $2i_2 + 2\left({}^{1}\!/_{s}\right)i + s(i_2 - i_1) = 0$

$\Rightarrow \underline{i_1 = 2\left({}^{1}\!/_{s}\right)i_2 + \left({}^{1}\!/_{s^2}\right)i_2 + i_2}$ (2)

Plugging (2) into (1) yields

$3s^2i_2 + 4si_2 + 2i_2 = s^2v_s$ or $\underline{3\frac{d^2i_2}{dt^2} + 4\frac{di_2}{dt} + 2i_2 = \frac{d^2v_s}{dt^2}}$

Ex. 9.4-1



KVL at v : $\frac{v}{4} + i_L + {}^{1}\!/_{4}\,{}^{dv}\!/_{dt} = i_s$ (1)

KVL right mesh a: $v = 6i_L + {}^{di_L}\!/_{dt}$ (2)

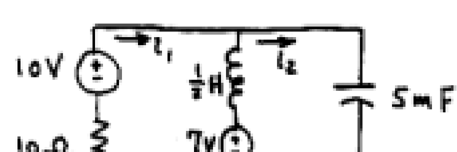
Plugging (2) into (1) yields $\frac{d^2i_L}{dt^2} + 7\frac{di_L}{dt} + 10i_L = 4i_s$

$\therefore$ characteristic equation $\Rightarrow \underline{s^2 + 7s + 10 = 0}$

& natural frequencies $\Rightarrow$ $s = -2, \underline{-5}$

Ex. 9.4-2

Assume zero initial conditions



$$\text{loop 1}: \; 10i_1 + \frac{1}{2}\frac{di_1}{dt} - \frac{1}{2}\frac{di_2}{dt} = 10-7$$

$$\text{loop 2}: \; -\frac{1}{2}\frac{di_1}{dt} + \frac{1}{2}\frac{di_2}{dt} + 200\int i_2 dt = 7$$

$$\text{determinant}: \begin{bmatrix} \left(10 + \frac{1}{2}s\right) & -\frac{1}{2}s \\ -\frac{1}{2}s & \left(\frac{1}{2}s + \frac{200}{s}\right) \end{bmatrix}$$

$$s^2 + 20s + 400 = 0, \quad \therefore \; s = -10 \pm j\,17.3$$

Ex. 9.5-1

Let $i_s = 0$, have parallel RLC circuit

$$\alpha = \frac{1}{2RC} = \frac{1}{2(6)(1/42)} = 7/2$$

$$\omega_o^2 = \frac{1}{LC} = \frac{1}{(7)(1/42)} = 6$$

$$\therefore s = -\alpha \pm \sqrt{\alpha^2 - \omega_o^2} = -7/2 \pm \sqrt{(7/2)^2 - 6} = -1, -6$$

$$\therefore v_n(+) = A_1 e^{-t} + A_2 e^{-6t}$$

Need $v_n(0)$ and $\left.\frac{dv_n}{dt}\right|_{t=0}$ to evaluate A_1 & A_2

$t = 0^+$

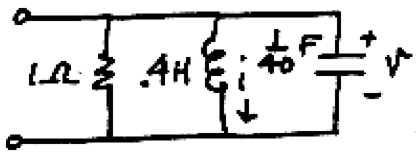
$i_R = 0 \quad \therefore i_c = -10$ A

$$\Rightarrow \left.\frac{dv}{dt}\right|_{t=0} = \frac{i_c(0)}{C} = \frac{-10}{1/42} = -420\frac{V}{s}$$

So
$$\left.\begin{aligned} v_n(0) &= 0 = A_1 + A_2 \\ \left.\frac{dv_n}{dt}\right|_{t=0} &= -420 = -A_1 - 6A_2 \end{aligned}\right\} A_1 = -84, \; A_2 = 84$$

$$\therefore v_n(t) = -84e^{-t} + 84e^{-6t} \text{ V}$$

Ex. 9.5-2



$$s^2 + \frac{1}{RC}s + \frac{1}{LC} = 0 \quad \Rightarrow \quad s^2 + 40s + 100 = 0$$

$$s = -2.7\ ,\ -37.3$$

$v(0) = 0\ ,\ i(0) = 1A$

$$v_n = A_1 e^{-2.7t} + A_2 e^{-37.3t}\ ,\ v(0) = 0 = A_1 + A_2 \qquad (1)$$

$$\text{KCL at } t = 0^+ \text{ yields : } \frac{v(0^+)}{1} + i(0^+) + \frac{1}{40}\frac{dv(0^+)}{dt} = 0$$

$$\therefore \frac{dv(0^+)}{dt} = -40v(0^+) - 40i(0^+) = -40(1) = -2.7A_1 - 37.3A_2 \qquad (2)$$

from (1) and (2) $\Rightarrow A_1 = -1.16\ ,\ A_2 = 1.16$

So $v(t) = v_n(t) = -1.16e^{-2.7t} + 1.16e^{-37.3t}$

Ex. 9.6-1

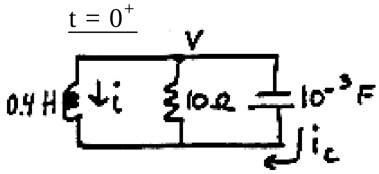
For parallel RLC

$$\alpha = \frac{1}{2RC} = \frac{1}{2(10)(10^{-3})} = 50,\ \omega_o^2 = \frac{1}{LC} = \frac{1}{(0.4)(10^{-3})} = 2500$$

$$\therefore s = -50 \pm \sqrt{(50)^2 - 2500} = -50,\ -50$$

$$\therefore v_n(t) = A_1 e^{-50t} + A_2 t e^{-50t}$$

$\underline{t = 0^+}$



with $i(0^+) = 0$ & $v(0^+) = 8V \Rightarrow i_c = \dfrac{-v(0^+)}{10\Omega} = -.8V$

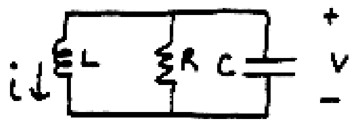
$$\therefore \left.\frac{dV}{dt}\right|_{t=0^+} = \frac{i_c(0^+)}{c} = -800 \text{ V/s}$$

So $v_n(0) = 8 = A_1 \Rightarrow v_n(t) = 8e^{-50t} + A_2 t e^{-50t}$

$$\frac{dv(0)}{dt} = -800 = -400 + A_2 \Rightarrow A_2 = -400$$

$$\therefore \underline{v_n(t) = 8e^{-50t} - 400t\, e^{-50t} \text{ V}}$$

Ex. 9.7-1



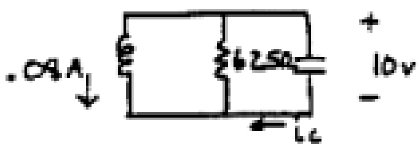
$$\alpha = \frac{1}{2RC} = \frac{1}{2(62.5)(10^{-6})} = 8000$$

$$\omega_o^2 = \frac{1}{LC} = \frac{1}{(.01)(10^{-6})} = 10^8$$

$$\therefore s = -\alpha \pm \sqrt{\alpha^2 - \omega_o^2} = -8000 \pm \sqrt{(8000)^2 - 10^8} = -8000 \pm j\,6000$$

$$\therefore v_n(t) = e^{-8000t}[A_1 \cos 6000\,t + A_2 \sin 6000t\,]$$

$\underline{t=0^+}$



$$\text{KCL at top : } .08 + \frac{10}{62.5} + i_c = 0$$

$$\Rightarrow i_c(0^+) = -.24 \text{ A}$$

$$\therefore \frac{dv(0^+)}{dt} = \frac{i_c(0^+)}{C} = -\,2.4\times10^{+5} \text{ V/s}$$

So $v_n(0) = 10 = A_1$

$$\frac{dv_n(0)}{dt} = -2.4\times10^5 = 6000A_2 - 8000(10) \Rightarrow A_2 = -26.7$$

$$\therefore \underline{v_n(t) = e^{-8000t}\,[10 \cos 6000\,t - 26.7 \sin 6000t\,] \text{ V}}$$

Ex. 9.8-1

(a) $v'' + 5v' + 6v = 8$

Try $v_f = B$ & plug into above $\Rightarrow 6B = 8 \;\; \therefore \underline{v_f = 8/6 \text{ V}}$

(b) $v'' + 5v' + 6v = 3e^{-4t}$

Try $v_f = Be^{-4t}$ & plug into above

$\Rightarrow (-4)^2 B + 5(-4)B + 6B = 3 \Rightarrow B = 3/2$

$$\therefore \underline{v_f = 3/2e^{-4t}}$$

(c) $v'' + 5v' + 6v = 2e^{-2t}$

Try $v_f = Bte^{-2t}$ (since -2 is a natural frequency)

$\Rightarrow (4t-4)B + 5B(1-2t) + 6Bt = 2 \Rightarrow B = 2$

$$\therefore \underline{v_f = 2te^{-2t}}$$

Ex. 9.8-2

$i'' + 9i' + 20i = 36 + 12t$

Try $i_f = A + Bt$ & plug into above

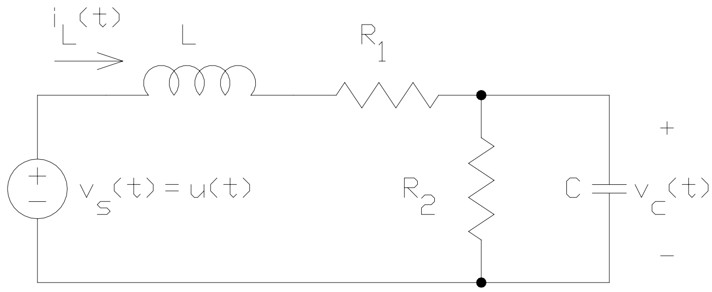
$0 + 9B + 20(A+Bt) = 36 + 12t$

$\Rightarrow 20Bt = 12t\,, \;\; \Rightarrow B = .6$

$\Rightarrow 9B + 20A = 36\,, \;\; \Rightarrow A = 1.53$

$\therefore \underline{i_f = 1.53 + 0.6t} \text{ A}$

Ex 9.9-1



When the circuit reaches steady state after t = 0, the capacitor acts like an open circuit and the inductor acts like a short circuit. Under these conditions

$$v_C(\infty) = \frac{R_2}{R_1 + R_2} 1$$

Next, represent the circuit by a 2nd order differential equation:

KCL at the top node of R_2 gives: $$\frac{v_C(t)}{R_2} + C \frac{d}{dt} v_C(t) = i_L(t)$$

KVL around the outside loop gives: $$v_s(t) = L \frac{d}{dt} i_L(t) + R_1 i_L(t) + v_C(t)$$

Use the substitution method to get

$$\begin{aligned} v_s(t) &= L \frac{d}{dt}\left(\frac{v_C(t)}{R_2} + C \frac{d}{dt} v_C(t)\right) + R_1\left(\frac{v_C(t)}{R_2} + C \frac{d}{dt} v_C(t)\right) + v_C(t) \\ &= LC \frac{d^2}{dt^2} v_C(t) + \left(\frac{L}{R_2} + R_1 C\right)\frac{d}{dt} v_C(t) + \left(1 + \frac{R_1}{R_2}\right) v_C(t) \end{aligned}$$

(a) C = 1 F, L = 0.25 H, $R_1 = R_2$ = 1.309 Ω

Use the steady state response as the forced response:

$$v_f = v_C(\infty) = \frac{R_2}{R_1 + R_2} 1 = \frac{1}{2}$$

The characteristic equation is

$$s^2 + \left(\frac{1}{R_2 C} + \frac{R_1}{L}\right) s + \left(\frac{1 + \frac{R_1}{R_2}}{LC}\right) = s^2 + 6s + 8 = (s+2)(s+4)$$

so the natural response is

$$v_n = A_1 e^{-2t} + A_2 e^{-4t} \text{ V}$$

The complete response is

$$v_c(t) = \frac{1}{2} + A_1\, e^{-2t} + A_2\, e^{-4t} \text{ V}$$

$$i_L(t) = \frac{v_C(t)}{1.309} + \frac{d}{dt} v_C(t) = -1.236\, A_1\, e^{-2t} - 3.236\, A_2\, e^{-4t} + 0.3819$$

At t = 0+

$$0 = v_c(0+) = A_1 + A_2 + 0.5$$

$$0 = i_L(0+) = -1.236\, A_1 - 3.236\, A_2 + 0.3819$$

Solving these equations gives A_1 = -1 and A_2 = 0.5, so

$$v_c(t) = \frac{1}{2} - e^{-2t} + \frac{1}{2} e^{-4t} \text{ V}$$

(b) C = 1 F, L = 1 H, R_1 = 3 Ω, R_2 = 1 Ω

Use the steady state response as the forced response:

$$v_f = v_C(\infty) = \frac{R_2}{R_1 + R_2} 1 = \frac{1}{4}$$

The characteristic equation is

$$s^2 + \left(\frac{1}{R_2\, C} + \frac{R_1}{L} \right) s + \left(\frac{1 + \frac{R_1}{R_2}}{LC} \right) = s^2 + 4s + 4 = (s+2)^2$$

so the natural response is

$$v_f = (A_1 + A_2\, t)\, e^{-2t} \text{ V}$$

The complete response is

$$v_c(t) = \frac{1}{4} + (A_1 + A_2\, t)\, e^{-2t} \text{ V}$$

$$i_L(t) = v_C(t) + \frac{d}{dt} v_C(t) = \frac{1}{4} + \left((A_2 - A_1) - A_2\, t \right) e^{-2t}$$

At t = 0+

$$0 = v_c(0+) = A_1 + \frac{1}{4}$$

$$0 = i_L(0+) = \frac{1}{4} + A_2 - A_1$$

Solving these equations gives A_1 = -0.25 and A_2 = -0.5, so

$$v_c(t) = \frac{1}{4} - \left(\frac{1}{4} + \frac{1}{2} t \right) e^{-2t} \text{ V}$$

(c) C = 0.125 F, L = 0.5 H, R_1 = 1 Ω, R_2 = 4 Ω

Use the steady state response as the forced response:

$$v_f = v_C(\infty) = \frac{R_2}{R_1+R_2}1 = \frac{4}{5}$$

The characteristic equation is

$$s^2 + \left(\frac{1}{R_2 C} + \frac{R_1}{L}\right)s + \left(\frac{1+\frac{R_1}{R_2}}{LC}\right) = s^2 + 4s + 20 = (s+2-j4)(s+2+j4)$$

so the natural response is

$$v_f = e^{-2t}\left(A_1 \cos 4t + A_2 \sin 4t\right) \text{ V}$$

The complete response is

$$v_c(t) = 0.8 + e^{-2t}\left(A_1 \cos 4t + A_2 \sin 4t\right) \text{ V}$$

$$i_L(t) = \frac{v_C(t)}{4} + \frac{1}{8}\frac{d}{dt}v_C(t) = 0.2 + \frac{A_2}{2}e^{-2t}\cos 4t - \frac{A_1}{2}e^{-2t}\sin 4t$$

At t = 0+

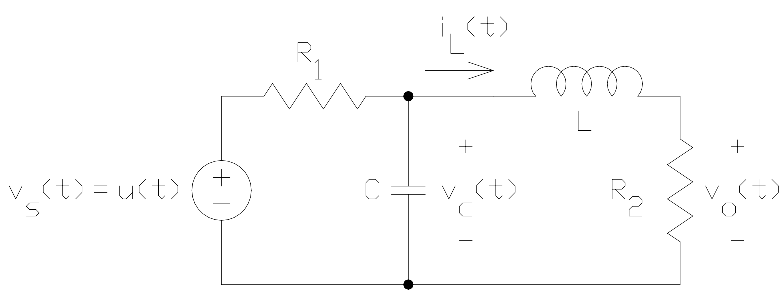
$$0 = v_c(0+) = 0.8 + A_1$$

$$0 = i_L(0+) = 0.2 + \frac{A_2}{2}$$

Solving these equations gives A_1 = -0.8 and A_2 = -0.4, so

$$v_c(t) = 0.8 - e^{-2t}\left(0.8\cos 4t + 0.4\sin 4t\right) \text{ V}$$

Ex 9.9-2



When the circuit reaches steady state after t = 0, the capacitor acts like an open circuit and the inductor acts like a short circuit. Under these conditions

$$v_C(\infty) = \frac{R_2}{R_1+R_2}1, \quad i_L(\infty) = \frac{1}{R_1+R_2} \quad and \quad v_o(\infty) = \frac{R_2}{R_1+R_2}1$$

Next, represent the circuit by a 2nd order differential equation:

KVL around the right-hand mesh gives: $$v_C(t) = L\frac{d}{dt}i_L(t) + R_2\, i_L(t)$$

KCL at the top node of the capacitor gives: $$\frac{v_s(t) - v_C(t)}{R_1} - C\frac{d}{dt}v_C(t) = i_L(t)$$

Use the substitution method to get

$$\begin{aligned} v_s(t) &= R_1 C\frac{d}{dt}\left(L\frac{d}{dt}i_L(t) + R_2\, i_L(t)\right) + \left(L\frac{d}{dt}i_L(t) + R_2\, i_L(t)\right) + R_1\, i_L(t) \\ &= R_1 LC\frac{d^2}{dt^2}i_L(t) + \left(L + R_1 R_2 C\right)\frac{d}{dt}i_L(t) + \left(R_1 + R_2\right)i_L(t) \end{aligned}$$

Using $v_o(t) = \frac{i_L(t)}{R_2}$ gives

$$v_o(t) = \frac{R_1}{R_2}LC\frac{d^2}{dt^2}i_L(t) + \left(\frac{L}{R_2} + R_1 C\right)\frac{d}{dt}i_L(t) + \left(\frac{R_1 + R_2}{R_2}\right)i_L(t)$$

(a) C = 1 F, L = 0.25 H, $R_1 = R_2$ = 1.309 Ω

Use the steady state response as the forced response:

$$v_f = v_o(\infty) = \frac{R_2}{R_1 + R_2}1 = \frac{1}{2}$$

The characteristic equation is

$$s^2 + \left(\frac{1}{R_1 C} + \frac{R_2}{L}\right)s + \left(\frac{1 + \frac{R_2}{R_1}}{LC}\right) = s^2 + 6s + 8 = (s+2)(s+4)$$

so the natural response is

$$v_n = A_1\, e^{-2t} + A_2\, e^{-4t}\ \text{V}$$

The complete response is

$$v_o(t) = \frac{1}{2} + A_1\, e^{-2t} + A_2\, e^{-4t}\ \text{V}$$

$$i_L(t) = \frac{v_o(t)}{1.309} = \frac{1}{2.618} + \frac{A_1}{1.309}\, e^{-2t} + \frac{A_2}{1.309}\, e^{-4t}\ \text{V}$$

$$v_C(t) = 1.309\, i_L(t) + \frac{1}{4}\frac{d}{dt}i_L(t) = \frac{1}{2} + 0.6167\, A_1\, e^{-2t} + 0.2361\, A_2\, e^{-4t}$$

At t = 0+

$$0 = i_L(0+) = \frac{1}{2.618} + \frac{A_1}{1.309} + \frac{A_2}{1.309}$$

$$0 = v_C(0+) = \frac{1}{2} + 0.6167\, A_1 + 0.2361\, A_2$$

Solving these equations gives A_1 = -1 and A_2 = 0.5, so

$$v_o(t) = \frac{1}{2} - e^{-2t} + \frac{1}{2} e^{-4t} \text{ V}$$

(b) C = 1 F, L = 1 H, R_1 = 1 Ω, R_2 = 3 Ω

Use the steady state response as the forced response:

$$v_f = v_o(\infty) = \frac{R_2}{R_1 + R_2} 1 = \frac{3}{4}$$

The characteristic equation is

$$s^2 + \left(\frac{1}{R_1 C} + \frac{R_2}{L} \right) s + \left(\frac{1 + \frac{R_2}{R_1}}{LC} \right) = s^2 + 4s + 4 = (s+2)^2$$

so the natural response is

$$v_f = (A_1 + A_2 t) e^{-2t} \text{ V}$$

The complete response is

$$v_o(t) = \frac{3}{4} + (A_1 + A_2 t) e^{-2t} \text{ V}$$

$$i_L(t) = \frac{v_o(t)}{3} = \frac{1}{4} + \left(\frac{A_1}{3} + \frac{A_2}{3} t \right) e^{-2t} \text{ V}$$

$$v_C(t) = 3 i_L(t) + \frac{d}{dt} i_L(t) = \frac{3}{4} + \left(\left(\frac{A_1}{3} + \frac{A_2}{3} \right) + \frac{A_2}{3} t \right) e^{-2t}$$

At t = 0+

$$0 = i_L(0+) = \frac{A_1}{3} + \frac{1}{4}$$

$$0 = v_C(0+) = \frac{3}{4} + \frac{A_1}{3} + \frac{A_2}{3}$$

Solving these equations gives A_1 = -0.75 and A_2 = -1.5, so

$$v_o(t) = \frac{3}{4} - \left(\frac{3}{4} + \frac{3}{2} t \right) e^{-2t} \text{ V}$$

(c) C = 0.125 F, L = 0.5 H, R_1 = 4 Ω, R_2 = 1 Ω

Use the steady state response as the forced response:

$$v_f = v_o(\infty) = \frac{R_2}{R_1 + R_2} 1 = \frac{1}{5}$$

The characteristic equation is

$$s^2+\left(\frac{1}{R_1 C}+\frac{R_2}{L}\right)s+\left(\frac{1+\frac{R_2}{R_1}}{LC}\right)=s^2+4s+20=(s+2-j4)(s+2+j4)$$

so the natural response is

$$v_f = e^{-2t}\left(A_1\cos 4t + A_2 \sin 4t\right)\text{ V}$$

The complete response is

$$v_o(t)=0.2+e^{-2t}\left(A_1\cos 4t + A_2 \sin 4t\right)\text{ V}$$

$$i_L(t)=\frac{v_o(t)}{1}=0.2+e^{-2t}\left(A_1\cos 4t + A_2 \sin 4t\right)\text{ V}$$

$$v_C(t)=i_L(t)+\frac{1}{2}\frac{d}{dt}i_L(t)=0.2+2A_2\,e^{-2t}\cos 4t-2A_1\,e^{-2t}\sin 4t$$

At t = 0+

$$0=i_L(0+)=0.2+A_1$$
$$0=v_C(0+)=0.2+2A_2$$

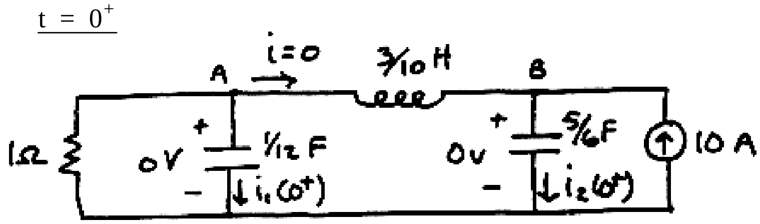
Solving these equations gives A_1 = -0.8 and A_2 = -0.4, so

$$v_c(t)=0.2-e^{-2t}\left(0.2\cos 4t+0.1\sin 4t\right)\text{ V}$$

Ex. 9.10-1

no initial stored energy $\Rightarrow$ $v_1(0^+) = v_2(0^+) = i(0^+) = 0$

<u>t = 0$^+$</u>



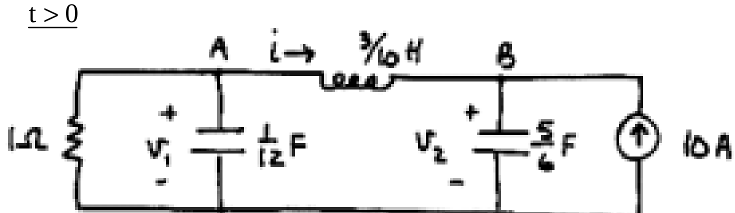
$$\text{KVL}\ :\ -0+\tfrac{3}{10}\,\frac{di(0^+)}{dt}+0=0\ \Rightarrow\ \frac{di(0^+)}{dt}=0$$

$$\text{KCL at A}:\ \frac{0\text{V}}{1\Omega}+i_1(0^+)+0=0\ \Rightarrow\ \frac{dv_1(0^+)}{dt}=0$$

$$\text{KCL at B}:\ -0+i_2(0^+)-10=0\ \Rightarrow\ i_2(0^+)=5/6\ \frac{dv_2(0^+)}{dt}=10\ \Rightarrow\ \frac{dv_2(0^+)}{dt}=12\text{ V/s}$$

Continued

<u>t > 0</u>



KCL at A : $\frac{v_1}{1} + \frac{1}{12}v_1' + i = 0$ (1)

KCL at B : $-i + (5/6)v'_2 = 10$ (2)

KCL $\downarrow$: $-v_1 + (3/10)i' + v_2 = 0$ (3)

Eliminating i from (1) & (3) yields

$$v_1 + \frac{1}{12}v'_1 + (5/6)v_2' - 10 = 0 \quad (4)$$

$$-v_1 + \frac{3}{10}\left(\frac{5}{6}v_2''\right) + v_2 = 0 \quad (5)$$

from (5) $v_1 = v_2 + \frac{1}{4}v_2''$ $\quad\therefore\ v_1' = v_2'' + (1/4)v_2''$

Now plugging into (4) yields

$$v_2' + \frac{1}{4}v_2'' + \frac{1}{12}\left(v_2' + \frac{1}{4}v_2'''\right) + \frac{5}{6}v_2' = 10$$

$$\underline{v_2''' + 12v_2'' + 44v_2' + 48v_2 = 480}$$

v_{2n}: $s^3 + 12s^2 + 44s + 48 = 0 \quad \Rightarrow s = -2, -4, -6$

$\therefore \quad v_{2n} = A_1e^{-2t} + A_2e^{-4t} + A_3e^{-6t}$

v_{2f}: try $v_{2f} = B$ and plug into Diff. Eq. $\Rightarrow B = 10$

$\therefore \quad v_2(t) = A_1e^{-2t} + A_2e^{-4t} + A_3e^{-6t} + 10$

Recall $v_2(0^+) = 0$, $\frac{dv_2(0^+)}{dt} = 12$ V/s

from (5) $\frac{d^2v_2(0^+)}{dt^2} = 4[v_1(0^+) - v_2(0^+)] = 0$

$$v_2(0^+) = 0 = A_1 + A_2 + A_3 + 10 \quad (6)$$

$$\frac{dv_2(0^+)}{dt} = 12 = -2A_1 - 4A_2 - 6A_3 \quad (7)$$

$$\frac{d^2v_2(0^+)}{dt^2} = 0 = 4A_1 + 16A_2 + 36A_3 \quad (8)$$

Solving (6) – (8) simultaneously yields

$A_1 = -15, \quad A_2 = 6, \quad A_3 = -1$

$\therefore \quad \underline{v_2(t) = -15e^{-2t} + 6e^{-4t} - e^{-6t} + 10 \text{ V}}$

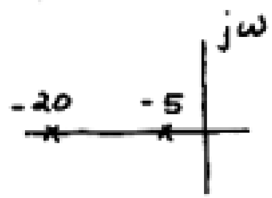
Ex. 9.11-1

$$s^2 + \frac{1}{RC}s + \frac{1}{LC} = 0 \quad L = 0.1, \ C = 0.1$$

so have $s^2 + \frac{10}{R}s + 100 = 0$

a) $R = 0.4\Omega \Rightarrow s^2 + 25s + 100 = 0$

$s = -5, \ -20$



b) $R = 1\Omega \Rightarrow s^2 + 10s + 100 = 0$

$s = -5 \pm j5\sqrt{3}$