P325 Practice 9.1

(a) $\left.\begin{array}{l} \alpha = \frac{1}{2RC} \\ R = 100\,\Omega \\ \alpha = 1000\,s^{-1} \end{array}\right\} \Rightarrow \quad C = 5\,\mu F$

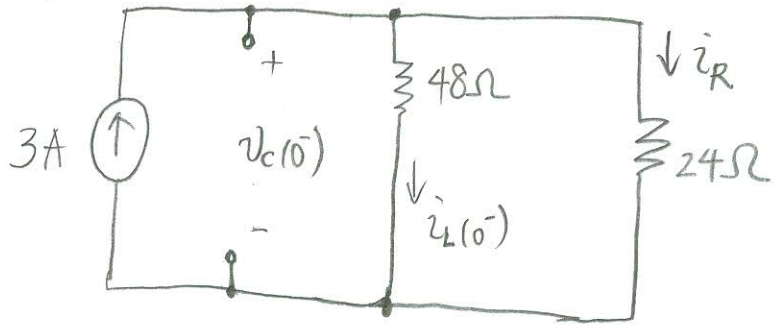
(b) $\left.\begin{array}{l} \omega_0 = \frac{1}{\sqrt{LC}} \\ C = 5\,\mu F \\ \omega_0 = 800\ rad/s \end{array}\right\} \Rightarrow \quad L = 312.5\,mH$

(c) $s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2} = -400\,s^{-1}$

(d) $s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2} = -1600\,s^{-1}$

P329 Practice 9.2

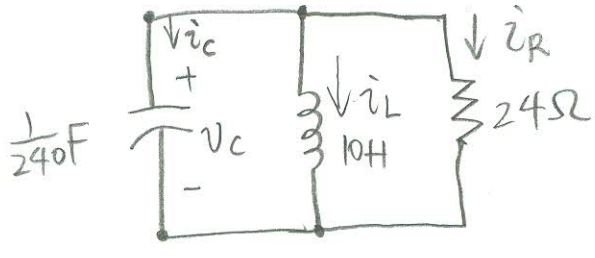
$t = 0^-$,



(a) $i_L(0^-) = \frac{24}{48+24} \cdot 3 = 1\,(A)$

(b) $v_c(0^-) = i_L(0^-) \cdot 48 = 48\,(V)$

$t \geq 0^+$,



parallel RLC

$v_c(0^+) = v_c(0^-) = 48V$,

(c) $i_R(0^+) = \frac{v_c(0^+)}{24} = 2A$

(d)

$$\alpha = \frac{1}{2RC} = \frac{1}{2 \cdot 24 \cdot \frac{1}{240}} = 5\ (s^{-1})$$

$$\omega_0 = 1/\sqrt{LC} = \frac{1}{\sqrt{10 \times \frac{1}{240}}} = 2\sqrt{6}\ (rad/s)$$

$$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2} = -5 + \sqrt{25-24} = -4\ (s^{-1})$$

$$s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2} = -5 - \sqrt{25-24} = -6\ (s^{-1})$$

$$v_c(t) = A_1 e^{-4t} + A_2 e^{-6t} \Rightarrow v_c(0) = A_1 + A_2 = 48 \quad ①$$

$$\frac{dv_c}{dt} = -4A_1 e^{-4t} - 6A_2 e^{-6t}$$

$$i_c = C(dv_c/dt), \quad i_L(0^+) = i_L(0^-) = 1A$$

$$\boxed{i_c(0^+) = -i_L(0^+) - i_R(0^+) = -1 - 2 = -3\ (A)}$$

$$\Rightarrow i_c(0) = -\frac{1}{240}(4A_1 + 6A_2) = -3$$

$$\Rightarrow 2A_1 + 3A_2 = 360 \quad ②$$

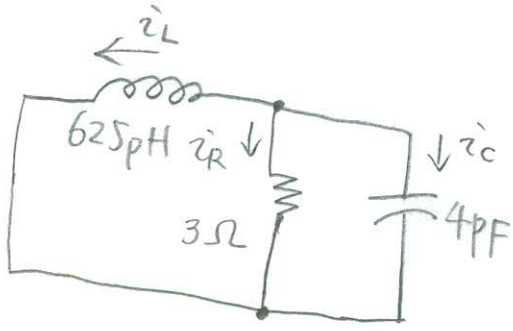
Solving ① ② $\Rightarrow$ $A_1 = -216$, $A_2 = 264$

(e) $v_c(t) = -216e^{-4t} + 264e^{-6t}$ V, $t > 0$

$$v_c(0.2) = -216e^{-4\times0.2} + 264e^{-6\times0.2}$$

$$= -17.5398 \text{ (V)}$$

P331 Practice 9.3



Parallel RLC

$$\alpha = \frac{1}{2RC} = \frac{1}{2\times3\times4\times10^{-12}}\,(s^{-1}) = \frac{1}{24\times10^{-12}}\,(s^{-1})$$

$$\omega_0 = 1/\sqrt{LC} = \frac{1}{\sqrt{625\times10^{-12}\times4\times10^{-12}}} = \frac{10^{12}}{50} = \frac{10^{11}}{5}\,(rad/s)$$

$$s_1 = -\alpha + \sqrt{\alpha^2-\omega_0^2} = -5.1138\times10^{9}\,(s^{-1})$$

$$s_2 = -\alpha - \sqrt{\alpha^2-\omega_0^2} = -7.822\times10^{10}\,(s^{-1})$$

$$i_R(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}, \quad t>0$$

$$i_L(0^+) = i_L(0^-) = 6A$$

$$v_C(0^+) = v_C(0^-) = 0V$$

$$i_R(0^+) = \frac{v_C(0^+)}{3} = 0,$$

$$\Rightarrow i_R(0) = A_1 + A_2 = 0 \qquad (1)$$

$$i_C = C\frac{dv_C}{dt} = C\frac{dv_R}{dt} \quad (\text{notice } v_C = v_R),$$

$$= 4\times10^{-12} \times 3\left(A_1 s_1 e^{s_1 t} + A_2 s_2 e^{s_2 t}\right)$$

By KCL,

$$i_C(0^+) = -i_L(0^+) - i_R(0^+)$$

$$= -6 - 0 = -6$$

thus,

$$-4\times10^{-12}\times3\left(A_1 \times 5.1138\times10^{9} + A_2 \times 7.822\times10^{10}\right) = -6 \quad ②$$

solving ①②,

$$\Rightarrow A_1 = -6.8394 \text{ A}$$

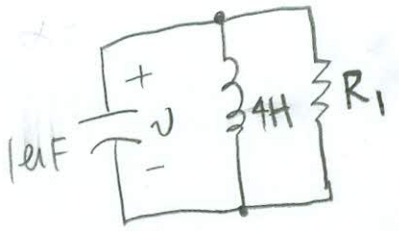
$$A_2 = 6.8394 \text{ A}$$

therefore

$$i_R(t) = 6.8394\left(e^{-7.822\times10^{10}t} - e^{-0.5\,1138\times10^{10}t}\right) \text{A}$$

Practice 9.5

a) for $t>0$, Parallel RLC,



$$\alpha = \frac{1}{2R_1C}$$

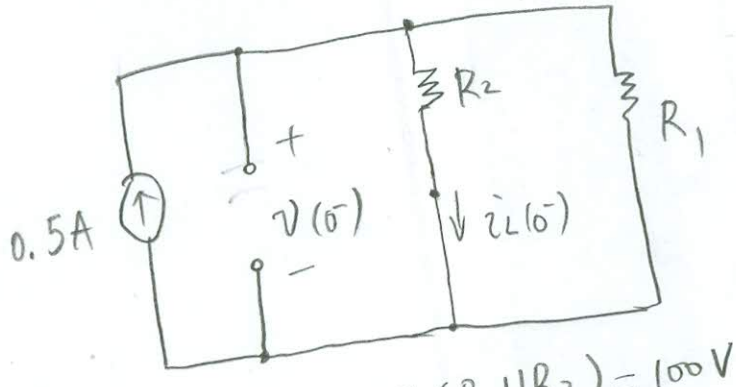
$$\omega_0 = \frac{1}{\sqrt{LC}}$$

Critical damping $\Rightarrow \alpha = \omega_0$,

$$\Rightarrow R_1 = \sqrt{\frac{L}{4C}} = \sqrt{\frac{4}{4\times10^{-6}}} = 10^3(\Omega)$$

$$= 1(k\Omega)$$

(b) at $t=0^-$,



$$v(0^-) = 0.5\,(R_1 \| R_2) = 100\,V, \quad \frac{R_1R_2}{R_1+R_2} = 200, \; R_1 = 1k\Omega$$

$$\Rightarrow R_2 = 250\,\Omega$$

(c)

$$\alpha = w_0 = \frac{1}{2 \times 1000 \times 10^{-6}} = 500 \ (s^{-1})$$

$$s_1 = s_2 = -\alpha = -500 \ (s^{-1})$$

$$v(t) = e^{-\alpha t}(A_1 t + A_2)$$

$$= e^{-500t}(A_1 t + A_2)$$

$$v(0) = 100 V,$$

$$\Rightarrow A_2 = 100$$

then $v(t) = e^{-500t}(A_1 t + 100)$

$$\frac{dv}{dt} = (A_1 t + 100)(-500)e^{-500t} + A_1 e^{-500t}$$

$$\frac{dv}{dt}\Big|_{t=0} = -50000 e^{-0} + A_1 = A_1 - 5 \times 10^4$$

$$\frac{dv}{dt}\Big|_{t=0} = \frac{i_C(0)}{C} = -\frac{i_{R_1}(0)}{C} - \frac{i_L(0)}{C} = -\frac{100}{10^3 \times 10^{-6}} - \frac{0.4}{10^{-6}} = -5 \times 10^5$$

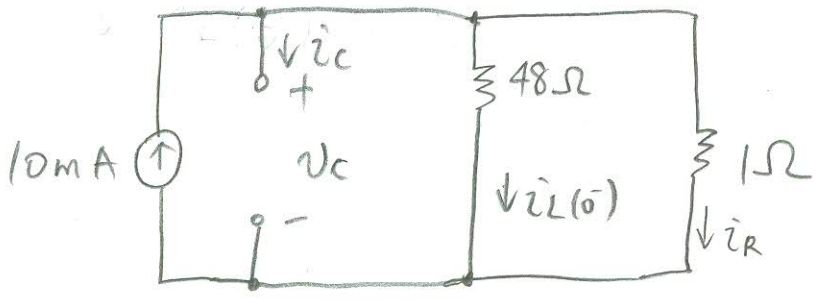
where $i_{R_1}(0) = \frac{v_C(0)}{R_1}$, $i_L(0) = i_L(0^-) = \frac{10^3}{10^3 + 250} 0.5 = 0.4 (A)$

$$\Rightarrow A_1 = -4.5 \times 10^5 (A)$$

$$\Rightarrow v(t) = e^{-500t}(-4.5 \times 10^5 t + 100), \quad v(1ms) = 350 e^{-0.5} = -212.285 (V)$$

P364 9.14

at $t=0^-$,



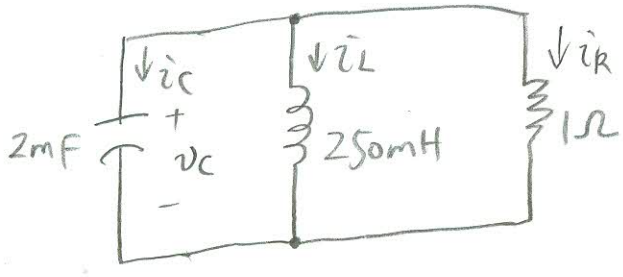
(a) $i_C(0^-) = 0$

(b) $i_L(0^-) = \frac{1}{48+1} \cdot 10mA = 0.2041\ mA$

(c) $i_R(0^-) = \frac{48}{48+1} \cdot 10mA = 9.7959\ mA$

(d) $v_C(0^-) = i_L(0^-) \cdot 48 = 9.7959\ mV$

after $t=0$,



parallel RLC,