CHAPTER

1.6

THE RLC CIRCUITS

1. The natural response of an *RLC* circuit is described by the differential equation

$$\frac{d^2v}{dt^2} + 2\frac{dv}{dt} + v = 0, \quad v(0) = 10, \quad \frac{dv(0)}{dt} = 0.$$

The $v(t)$ is

(A) $10(1+t)e^{-t}$ V (B) $10(1-t)e^{-t}$ V

(C) $10e^{-t}$ V (D) $10te^{-t}$ V

2. The differential equation for the circuit shown in fig. P1.6.2. is

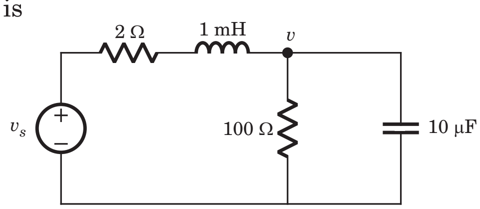

Fig. P1.6.2

(A) $v''(t) + 3000v'(t) + 1.02 \times 10^8 v(t) = 10^8 v_s(t)$

(B) $v''(t) + 1000v'(t) + 1.02 \times 10^8 v(t) = 10^8 v_s(t)$

(C) $\frac{v''(t)}{10^8} + \frac{2v'(t)}{10^5} + 1.02v(t) = v_s(t)$

(D) $\frac{v''(t)}{10^8} + \frac{2v'(t)}{10^5} + 1.98v(t) = v_s(t)$

3. The differential equation for the circuit shown in fig. P1.6.3 is

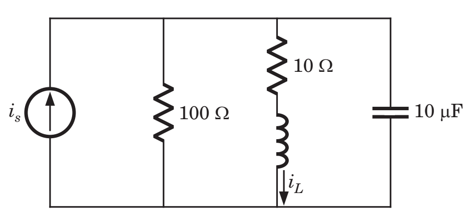

Fig. P.1.6.3

(A) $i''_L(t) + 1100i''_L(t) + 11 \times 10^8 i_L(t) = 10^8 i_s(t)$

(B) $i''_L(t) + 1100i''_L(t) + 11 \times 10^8 i_L(t) = 10^8 i_s(t)$

(C) $\frac{i''_L(t)}{10^8} + \frac{1.1i''_L(t)}{10^4} + 1.1i_L(t) = i_s(t)$

(D) $\frac{i''_L(t)}{10^8} + \frac{11i'_L(t)}{10^4} + 11i_L(t) = i_s(t)$

4. In the circuit of fig. P.1.6.4 $v_s = 0$ for $t > 0$. The initial condition are $v(0) = 6$ V and $dv(0)/dt = -3000$ V/s. The $v(t)$ for $t > 0$ is

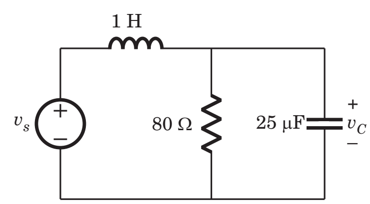

Fig. P1.6.4

(A) $-2e^{-100t} + 8e^{-400t}$ V (B) $6e^{-100t} + 8e^{-400t}$ V

(C) $6e^{-100t} - 8e^{-400t}$ V (D) None of the above

5. The circuit shown in fig. P1.6.5 has been open for a long time before closing at $t = 0$. The initial condition is $v(0) = 2$ V. The $v(t)$ for $t >$ is

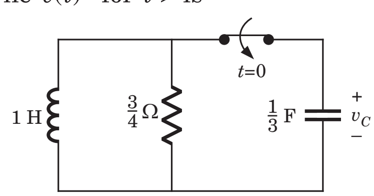

Fig. P.1.6.5

(A) $5e^{-t} - 7e^{-3t}$ V (B) $7e^{-t} - 5e^{-3t}$ V

(C) $-e^{-t} + 3e^{-3t}$ V (D) $3e^{-t} - e^{-3t}$ V

Statement for Q.6–7:

Circuit is shown in fig. P.1.6. Initial conditions are $i_1(0) = i_2(0) = 11$ A

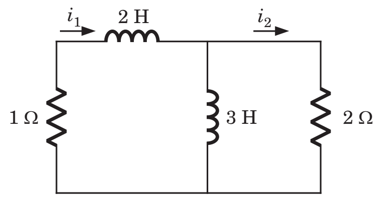

Fig. P1.6.6–7

6. $i_1(1\,\text{s}) = ?$

(A) 0.78 A (B) 1.46 A

(C) 2.56 A (D) 3.62 A

7. $i_2(1\,\text{s}) = ?$

(A) 0.78 A (B) 1.46 A

(C) 2.56 A (D) 3.62 A

8. $v_C(t) = \ ?$ for $t > 0$

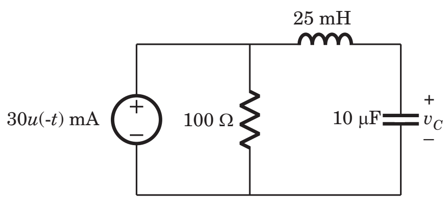

Fig. P1.6.8

(A) $4e^{-1000t} - e^{-2000t}$ V (B) $(3 + 6000t)e^{-2000t}$ V

(C) $2e^{-1000t} + e^{-2000t}$ V (D) $(3 - 6000t)e^{-2000t}$ V

9. The circuit shown in fig. P1.6.9 is in steady state with switch open. At $t = 0$ the switch is closed. The output voltage $v_C(t)$ for $t > 0$ is

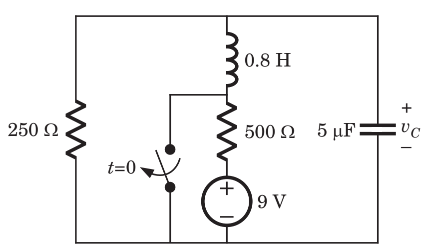

Fig. P1.6.9

(A) $-9e^{-400t} + 12e^{-300t}$

(B) $e^{-400t}[3\cos 300t + 4\sin 300t]$

(C) $e^{-300t}[3\cos 400t + 4\sin 300t]$

(D) $e^{-300t}[3\cos 400t + 2.25\sin 300t]$

10. The switch of the circuit shown in fig. P1.6.10 is opened at $t = 0$ after long time. The $v(t)$, for $t > 0$ is

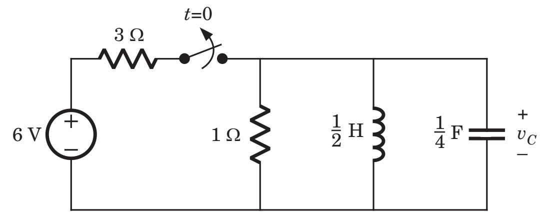

Fig. P1.6.10

(A) $4e^{-2t}\sin 2t$ V (B) $-4e^{-2t}\sin 2t$ V

(C) $4e^{-2t}\cos 2t$ V (D) $-4e^{-2t}\cos 2t$ V

11. In the circuit of fig. P1.6.23 the switch is opened at $t = 0$ after long time. The current $i_L(t)$ for $t > 0$ is

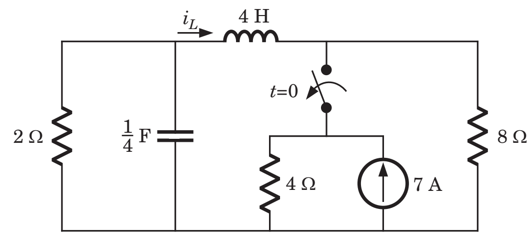

Fig. P1.6.11

(A) $e^{-2t}(2\cos t + 4\sin t)$ A (B) $e^{-2t}(3\sin t - 4\cos t)$ A

(C) $e^{-2t}(-4\sin t + 2\cos t)$ A (D) $e^{-2t}(2\sin t - 4\cos t)$ A

Statement for Q.12–14:

In the circuit shown in fig. P1.6.12–14 all initial condition are zero.

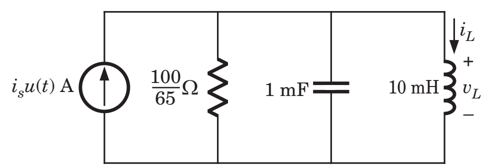

Fig. P1.5.12-14

12. If $i_s(t) = 1$ A, then the inductor current $i_L(t)$ is

(A) 1 A (B) t A

(C) $t + 1$ A (D) 0 A

13. If $i_s(t) = 0.5t$ A, then $i_L(t)$ is

(A) $0.5t + 3.25 \times 10^{-3}$ A (B) $2t - 3250$ A

(C) $0.5t - 0.25 \times 10^{-3}$ A (D) $2t + 3250$ A

14. If $i_s(t) = 2e^{-250t}$ A then $i_L(t)$ is

(A) $\frac{4000}{3} te^{-250t}$ A (B) $\frac{4000}{3} e^{-250t}$ A

(C) $\frac{200}{7} e^{-250t}$ A (D) $\frac{200}{7} te^{-250t}$ A

15. The forced response for the capacitor voltage $v_f(t)$ is

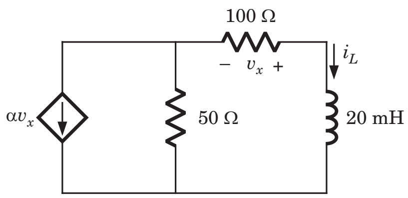

Fig. P1.6.15

(A) $0.2t + 1.17 \times 10^{-3}$ V (B) $0.2t - 1.17 \times 10^{-3}$ V

(C) $1.17 \times 10^{-3}t - 0.2$ V (D) $1.17 \times 10^{-3}\, t + 0.2$ V

16. For a *RLC* series circuit $R = 20\,\Omega$, $L = 0.6$ H, the value of C will be
[CD =critically damped, OD =over damped, UD =under damped].

	CD	OD	UD
(A)	$C = 6$ mF	$C > 6$ mF	$C < 6$ mF
(B)	$C = 6$ mF	$C < 6$ mF	$C > 6$ mF
(C)	$C > 6$ mF	$C = 6$ mF	$C < 6$ mF
(D)	$C < 6$ mF	$C = 6$ mF	$C > 6$ mF

17. The circuit shown in fig. P1.6.17 is critically damped. The value of R is

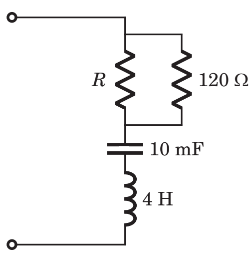

Fig. P1.6.17

(A) 40 Ω (B) 60 Ω

(C) 120 Ω (D) 180 Ω

18. The step response of an *RLC* series circuit is given by

$$\frac{d^2 i(t)}{dt} + \frac{2di(t)}{dt} + 5i(t) = 10,\ i(0^+) = 2,\ \frac{di(0^+)}{dt} = 4.$$

The $i(t)$ is

(A) $1 + e^{-t}\cos 4t$ A (B) $4 - 2e^{-t}\cos 4t$ A

(C) $2 + e^{-t}\sin 4t$ A (D) $10 + e^{-t}\sin 4t$ A

19. In the circuit shown in fig. P 1.5.19 $v(t)$ for $t > 0$ is

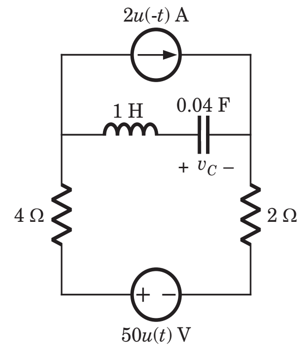

Fig. P1.6.19

(A) $50 - (46.5 \sin 3t + 62 \cos 3t)e^{-4t}$ V

(B) $50 + (46.5 \sin 3t + 62 \cos 3t)e^{-4t}$ V

(C) $50 + (62 \cos 4t + 46.5 \sin 4t)e^{-3t}$ V

(D) $50 - (62 \cos 4t + 46.5 \sin 4t)\, e^{-3t}$ V

20. In the circuit of fig. P1.6.20 the switch is closed at $t = 0$ after long time. The current $i(t)$ for $t > 0$ is

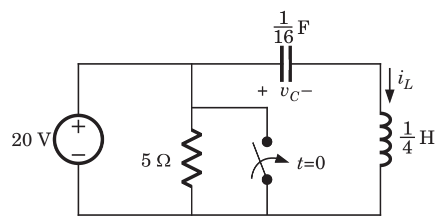

Fig. P1.6.20

(A) $-10 \sin 8t$ A (B) $10 \sin 8t$ A

(C) $-10 \cos 8t$ A (D) $10 \cos 8t$ A

21. In the circuit of fig. P1.6.21 switch is moved from 8 V to 12 V at $t = 0$. The voltage $v(t)$ for $t > 0$ is

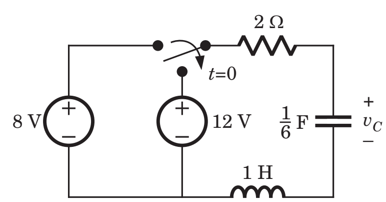

Fig. P1.6.21

(A) $12 - (4 \cos 2t + 2 \sin 2t)e^{-t}$ V

(B) $12 - (4 \cos 2t + 8 \sin 2t)e^{-t}$ V

(C) $12 + (4 \cos 2t + 8 \sin 2t)e^{-t}$ V

(D) $12 + (4 \cos 2t + 2 \sin 2t)e^{-t}$ V

22. In the circuit of fig. P1.5.22 the voltage $v(t)$ is

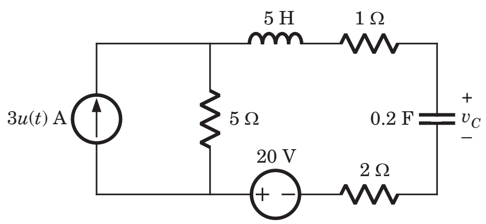

Fig. P1.6.22

(A) $40-(20\cos 0.6t+15\sin 0.6t)e^{-0.8t}$ V

(B) $35+(15\cos 0.6t+20\sin 0.6t)e^{-0.8t}$ V

(C) $35-(15\cos 0.6t+20\sin 0.6t)\,e^{-0.8t}$ V

(D) $35-15\cos 0.6t\,e^{-0.8t}$ V

23. In the circuit of fig. P1.6.23 the switch is opened at $t=0$ after long time. The current $i(t)$ for $t>0$ is

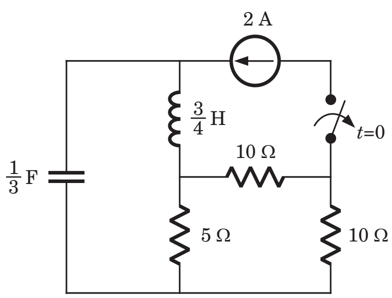

Fig. P1.6.23

(A) $e^{-2.306t}+e^{-0.869t}$ A

(B) $-e^{-2.306t}+2e^{-0.869t}$ A

(C) $e^{-4.431t}+e^{-0.903t}$ A

(D) $2e^{-4.431t}-e^{-0.903t}$ A

24. In the circuit of fig. P1.6.24 switch is moved from position a to b at $t=0$. The $i_L(t)$ for $t>0$ is

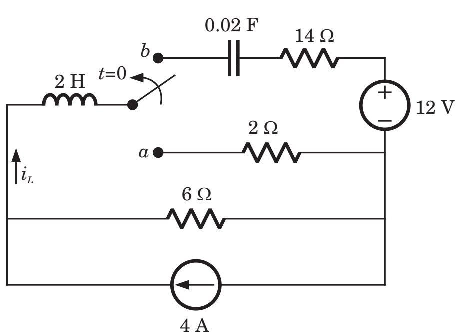

Fig. P1.6.24

(A) $(4-6t)e^{4t}$ A (B) $(3-6t)e^{-4t}$ A

(C) $(3-9t)e^{-5t}$ A (D) $(3-8t)e^{-5t}$ A

25. In the circuit shown in fig. P1.6.25 a steady state has been established before switch closed. The $i(t)$ for $t>0$ is

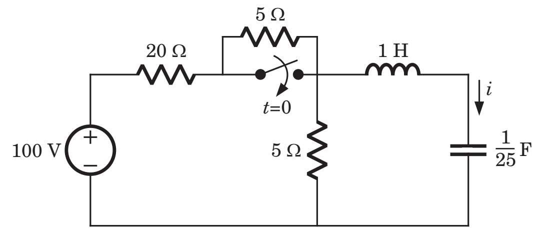

Fig. P1.6.25

(A) $0.73e^{-2t}\sin 4.58t$ A

(B) $0.89e^{-2t}\sin 6.38t$ A

(C) $0.73e^{-4t}\sin 4.58t$ A

(D) $0.89e^{-4t}\sin 6.38t$ A

26. The switch is closed after long time in the circuit of fig. P1.6.26. The $v(t)$ for $t>0$ is

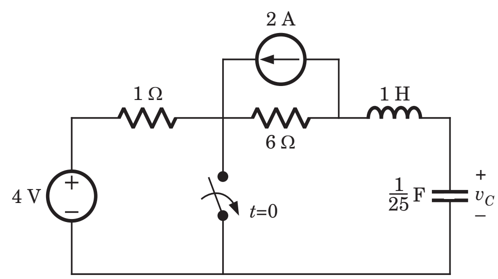

Fig. P1.6.26

(A) $-8+6e^{-3t}\sin 4t$ V

(B) $-12+4e^{-3t}\cos 4t$ V

(C) $-12+(4\cos 4t+3\sin 4t)e^{-3t}$ V

(D) $-12+(4\cos 4t+6\sin 4t)e^{-3t}$ V

27. $i(t)=?$

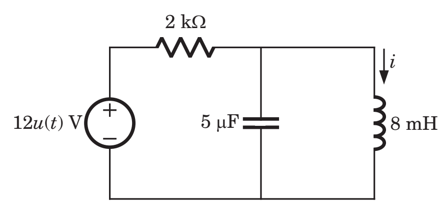

Fig. P1.6.27

(A) $6-(6\cos 500t+6\sin 5000t)e^{-50t}$ mA

(B) $8-(8\cos 500t+0.06\sin 5000t)e^{-50t}$ mA

(C) $6-(6\cos 5000t+0.06\sin 5000t)e^{-50t}$ mA

(D) $6e^{-50t}\sin 5000t$ mA

28. In the circuit of fig. P1.6.28 $i(0) = 1$ A and $v(0) = 0$. The current $i(t)$ for $t > 0$ is

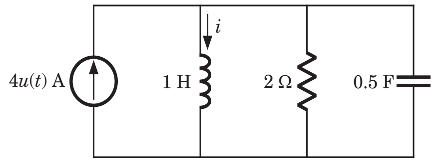

Fig. P1.6.28

(A) $4 + 6.38\, e^{-0.5t}\, A$ (B) $4 - 6.38\, e^{-0.5t}\, A$

(C) $4 + (3\cos 1.32t + 1.13\sin 1.32t)e^{-0.5t}$ A

(D) $4 - (3\cos 1.32t + 1.13\sin 1.32t)e^{-0.5t}$ A

29. In the circuit of fig. P1.6.29 a steady state has been established before switch closed. The $v_o(t)$ for $t > 0$ is

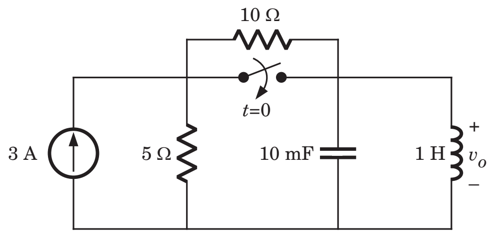

Fig. P1.6.29

(A) $100te^{-10t}$ V (B) $200te^{-10t}$ V

(C) $400te^{-50t}$ V (D) $800te^{-50t}$ V

30. In the circuit of fig. P1.6.30 a steady state has been established before switch closed. The $i(t)$ for $t > 0$ is

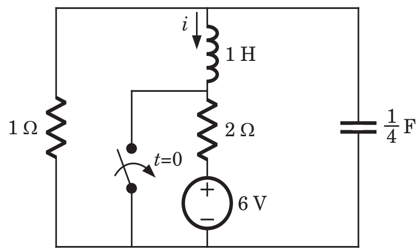

Fig. P1.6.30

(A) $2e^{-2t}\sin 2t$ A (B) $-e^{-2t}\sin 2t$ A

(C) $-2(1 - t)e^{-2t}$ A (D) $2(1 - t)e^{-2t}$ A

31. In the circuit of fig. P1.6.31 a steady state has been established. The $i(t)$ for $t > 0$ is

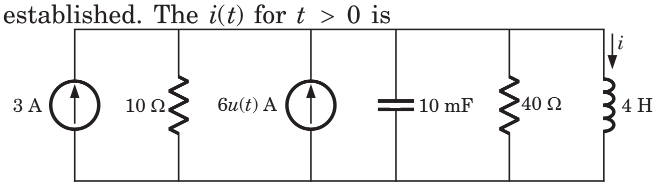

Fig. P1.6.31

(A) $9 + 2e^{-10t} - 8e^{-2.5t}$ A (B) $9 - 8e^{10t} + 2e^{-2.5t}$ A

(C) $9 + (2\cos 10t + \sin 10t)e^{-2.5t}$ A

(D) $9 + (\cos 10t + 2\sin 10t)e^{-2.5t}$ A

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SOLUTIONS

1. (A) $s^2 + 2s + 1 = 0 \quad \Rightarrow \quad s = -1, -1,$

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

$v(0) = 10$ V, $\quad \dfrac{dv(0)}{dt} = 0 = -1A_1 + A_2$

$A_1 = A_2 = 10$

2. (A) $i_L = \dfrac{v}{100} + 10 \times 10^{-6}\dfrac{dv}{dt}$

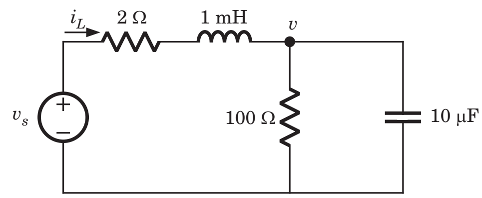

Fig. S1.6.2

$$v_s = 2i_L + 10^{-3}\frac{di_L}{dt} + v$$

$$= 2\left(\frac{v}{100} + 10^{-6} \times 10^{-t}\frac{dv}{dt}\right) + 10^{-3}\left(\frac{1}{100}\frac{dv}{dt} + 10 \times 10^{-6}\frac{d^2v}{dt^2}\right) + v$$

$$10^8 v_s(t) = v''(t) + 3000v'(t) + 1.02v(t)$$

3. (C) $i_s = \dfrac{v_C}{100} + i_L + 10\mu\dfrac{dv_C}{dt}$

$$v_C = 10i_L + 10^{-3}\frac{di_L}{dt}$$

$$i_s = 0.1i_L + 10^{-5}\frac{di_L}{dt} + i_L + 10^{-5}\frac{d}{dt}(10i_L + 10^{-3}\frac{di_L}{dt})$$

$$= 0.1i_L + 10^{-5}\frac{di_L}{dt} + i_L + 10^{-4}\frac{di_L}{dt} + 10^{-8}\frac{d^2i_L}{dt^2}$$

$$\Rightarrow \frac{i_L''(t)}{10^8} + \frac{1.1}{10^4}i_L'(t) + 1.1i_L(t) = i_s(t)$$

4. (A) $\dfrac{v}{80} + 25\mu\dfrac{dv}{dt} + \int(v - v_s)dt = 0$

$$\Rightarrow \frac{d^2v}{dt^2} + 500\frac{dv}{dt} + 40000 = 0$$

$s^2 + 500s + 40000 = 0$

$\Rightarrow \quad s = -100, -400,$

$v(t) = Ae^{-100t} + Be^{-400t}$

$A + B = 6,\ -100A - 400B = -3000 \quad \Rightarrow \quad B = 8,\ A = -2$

5. (C) The characteristic equation is $s^2 + \dfrac{s}{RC} + \dfrac{1}{LC} = 0$

After putting the values, $s^2 + 4s + 3 = 0$

$v(t) = Ae^{-t} + Be^{-3t},$

$v(0^+) = 2\text{ V} \quad \Rightarrow \quad A + B = 2$

$i_L(0^+) = 0 \Rightarrow \quad i_R(0) = \dfrac{2}{3/4} = \dfrac{8}{3},$

$-C\dfrac{dv(0^+)}{dt} = \dfrac{8}{3} \quad \Rightarrow \quad \dfrac{dv(0^+)}{dt} = -8,$

$-A - 3B = -8, \quad B = 3, \quad A = -1$

6. (D) $i_1 + 5\dfrac{di_1}{dt} - 3\dfrac{di_2}{dt} = 0,$

$2i_2 + \dfrac{3di_2}{dt} - 3\dfrac{di_1}{dt} = 0$

$(1 + 5s)i_1 - 3si_2 = 0, \ -3si_1 + (2 + 3s)i_2 = 0$

$(1 + 5s)i_1 - \dfrac{(3s)(3s)i_1}{2 + 3s} = 0$

$\Rightarrow \quad 6s^2 + 13s + 2 = 0$

$\Rightarrow \quad s = -\dfrac{1}{6}, -2$

$i_1 = A\,e^{-\frac{1}{6}t} + Be^{-2t}\ , \quad i(0) = A + B = 11$

In differential equation putting $t = 0$ and solving

$\dfrac{di_1(0^+)}{dt} = -\dfrac{33}{2}, \quad \dfrac{di_2(0^+)}{dt} = -\dfrac{143}{6}$

$-\dfrac{A}{6} - 2B = -\dfrac{33}{2}, \Rightarrow \quad A = 3, B = 8,$

$i_1 = 3e^{-\frac{t}{6}} + 8e^{-2t},$

$i_1(1\text{ s}) = 3e^{-\frac{1}{6}} + 8e^{-2} = 3.62\text{ A}$

7. (A) $i_2 = Ce^{-\frac{t}{6}} + De^{-2t}$

$i_2(0) = 11 = C + D, \ \dfrac{di_2(0)}{dt} = \dfrac{-143}{6} = -\dfrac{C}{6} - 2D$

$C = -1$ and $D = 12$

$i_2 = -e^{-\frac{t}{6}} + 12e^{-2t}\text{ A}, \quad i_2\,(1\text{ s}) = e^{-\frac{1}{6}} + 12e^{-2} = 0.78\text{ A}$

8. (B) $v_C(0^+) = 30\text{m} \times 100 = 3\text{ V}$

$C\dfrac{dv_C(0^-)}{dt} = i_L(0^-) = 0 = i_L(0^+) = C\dfrac{dv_C(0^+)}{dt}$

$s^2 + \dfrac{100}{25 \times 10^{-3}}s + \dfrac{1}{25 \times 10^{-3} \times 10 \times 10^{-6}}$

$\Rightarrow \quad s = -2000, \ -2000$

$v_C(t) = (A_1 + A_2t)e^{-2000t}$

$\dfrac{dv_C(t)}{dt} = A_2e^{-2000t} + (A_1 + A_2t)e^{-2000t}(-2000)$

$v_C(0^+) = A_1 = 3, \ \dfrac{dv_C(0)}{dt} = A_2 - 2000 \times 3 = 0$

$\Rightarrow \quad A_2 = 6000$

9. (B) $v_C(0^+) = 3\text{ V}, \quad i_L(0^+) = -12\text{ mA}$

$\dfrac{v_C}{250} + i_L + 5 \times 10^{-6}\dfrac{dv_C}{dt} = 0$

$\dfrac{3}{250} - 12\text{m} + 5 \times 10^{-6}\dfrac{dv_C(0^+)}{dt} = 0 \quad \Rightarrow \quad \dfrac{dv_C(0^+)}{dt} = 0$

$s^2 + \dfrac{s}{250 \times 5 \times 10^{-6}} + \dfrac{1}{0.8 \times 5 \times 10^{-6}} = 0$

$\Rightarrow \quad s^2 + 800s + 25 \times 10^4 = 0$

$\Rightarrow \quad s = -400 \pm j300$

$v_C(t) = e^{-400t}(A_1\cos 300t + A_2\sin 300t)$

$A_1 = 3, \ \dfrac{dv_C(0)}{dt} = -400A_1 + 300A_2\ , \quad A_2 = 4$

10. (B) $v(0^+) = 0, \quad i_L(0^+) = 2\text{ A}, \quad \dfrac{1}{4}\dfrac{dv_C(0^+)}{xdt} = -2$

$s^2 + 4s + 8 = 0 \quad \Rightarrow \quad s = -2 \pm j2$

$v_C(t) = e^{-2t}(A_1\cos 2t + A_2\sin 2t)$

$A_1 = 0, \ \dfrac{dv_C\,(0^+)}{dt} = -8 = -2\,(0 + 0) + (0 + 2A_2), \ A_2 = -4$

11. (D) $i_L(0^+) = -4, \quad v_C(0^+) = 8\text{ V}$

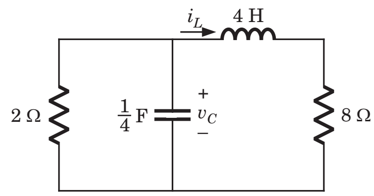

Fig. S1.6.11

$4\dfrac{di_L(0^+)}{dt} = 8 - (-4) \times 8 \quad \Rightarrow \quad \dfrac{di_L(0^+)}{dt} = 10$

$\dfrac{s}{4}v_C + \dfrac{1}{2}v_C + i_L = 0, \quad v_C = 4si_L + 8i_L$

$s^2i_L + 4si_L + 5 = 0, \quad s = -2 \pm j$

$i_L(t) = e^{-2t}(A_1\cos t + A_2\sin t)$

$A_1 = -4, \ \dfrac{di_L(0^+)}{dt} = 10 = -2\,(A_1 + 0) + A_2, \ A_2 = 2$

12. (A) $i_s = \dfrac{v}{100/65} + 10^{-3}\dfrac{dv}{dt} + i_L, \ v = 10 \times 10^{-3}\dfrac{di_L}{dt}$

$i_s = \dfrac{65}{100}(10 \times 10^{-3})\dfrac{di_L}{dt} + 10^{-3}(10 \times 10^{-3})\dfrac{d^2i_L}{dt} + i_L = 0$

$\dfrac{d^2i_L}{dt} + 650\dfrac{di_L}{dt} + 10^5i_L = 10^5i_s$

Trying $i_L(t) = B$

$0 + 0 + 10^5B = 10^5, \qquad B = 1, \qquad i_L = 1\text{ A}$

13. (A) Trying $i_L(t) = At + B,$

$0 + 650A + (At + B)10^5 = 10^5(0.5t), \ A = 0.5$

$$\frac{di(0^+)}{dt} = \frac{-16}{3} = -4.431\ A - 0.903B$$

$A = 1,\ B = 1$

24. (C) $v_C(0) = 0, \quad i_L(0) = \frac{4 \times 6}{6 + 2} = 3$

$$0.02 \frac{dv_C(0)}{dt} = i_L(0) = 3 \quad \Rightarrow \quad \frac{dv_C(0)}{dt} = 150$$

$$\alpha = \frac{6 + 14}{2 \times 2} = 5, \quad \omega_o = \frac{1}{\sqrt{2 \times 0.02}} = 5$$

$\alpha = \omega_o$ critically damped

$v(t) = 12 + (A + Bt)e^{-5t}$

$0 = 12 + A, \quad 150 = -5A + B \quad \Rightarrow \quad A = -12, \quad B = 90$

$v(t) = 12 + (90t - 12)e^{-5t}$

$i_L(t) = 0.02(-5)\ e^{-5t}(90t - 12) + 0.02(90)e^{-5t} = (3 - 9t)e^{-5t}$

25. (A) $v(0^+) = \frac{100 \times 5}{5 + 5 + 20} = \frac{50}{3}\ , \quad i_L(0^+) = 0$

$i_f = 0$ A

$$\frac{di_L(0^+)}{dt} = 20 - \frac{50}{3} = \frac{10}{3}$$

$$\alpha = \frac{4}{2 \times 1} = 2, \ \omega_o = \frac{1}{\sqrt{1 \times \frac{1}{25}}} = 5$$

$s = -2 \pm \sqrt{4 - 25} = -2 \pm j4.58$

$i(t) = (A\cos 4.58t + B\sin 4.58t)e^{-2t}$

26.(A) $i_L(0^+) = 0,\ v_L(0^+) = 4 - 12 = -8$

$$\frac{1}{25}\frac{dv_L(0^+)}{dt} = i_L(0^+) = 0$$

$$\alpha = \frac{6}{2} = 3,\ W_o = \frac{1}{\sqrt{1 \times 1/25}} = 5$$

$\beta = -3 \pm \sqrt{9 - 25} = -3 \pm j4$

$v_1(t) = -12 + (A\cos 4t + B\sin 4t)e^{-3t}$

$v_L(0) = -8 = 12 + A, \quad \Rightarrow A = 4$

$$\frac{dv_L(0)}{dt} = 0 = -3A + 4B, \quad \Rightarrow B = 3$$

27. (C) $\alpha = \frac{1}{2RC} = \frac{1}{2 \times 2k \times 54} = 50$

$$W_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8m \times 5\mu}} = 5000$$

$\alpha < W_o$, underdamped response.

$s = -50 \pm \sqrt{50^2 - 5000^2} = -50 \pm j5000$

$i(t) = 6 + (A\cos 5000t + B\sin 5000t)e^{-50t}$ mA

$i(0) = 6 = 6 + A, \quad \Rightarrow A = -6$

$$\frac{di(0)}{dt} = -50A + 5000B = 0, \quad B = -0.06$$

28.(D) $i(0^+) = 1$ A, $v(0^+) = \frac{Ldi(0^+)}{dt}$

$$\alpha = \frac{1}{2 \times 2 \times 0.5} = 0.5, \quad W_o = \frac{1}{\sqrt{1 - 0.5}} = \sqrt{2}$$

$s = -0.5 \pm \sqrt{0.5^2 - 2} = 0.5 \pm j1.323$

$i(t) = 4 + (A\cos 1.32t + B\sin 1.32t)e^{-0.5}t$

$1 = 4 + A, \quad \Rightarrow A = -3$

$$\frac{di(0)}{dt} = 0 = 0.5A + 1.32B, \quad B = -1.13$$

29. (B) $V_o(0^+) = 0\ , i_L(0^+) = 1$ A

$$\frac{di_L(0^+)}{dt} = v_1(0) = 0$$

$$\alpha = \frac{1}{2 \times 5 \times 0.01} = 10, \quad W_o = \frac{1}{\sqrt{1 \times 0.01}} = 10$$

$\alpha = W_o$, so critically damped response

$s = -10, -10$

$i(t) = 3(A + Bt)e^{-10t}, \quad i(0) = 1 = 3 + A$

$$\frac{di(0^+)}{dt} = -10A + B$$

$i_L(t) = 3 - (2 + 20t)e^{-10t}, \quad v_o = \frac{Ldi_L(t)}{dt} = 200te^{-10t}$

30. (C) $i(0^+) = \frac{-6}{1 + 2} = -2$ A, $\quad v_c(0^+) = 2 \times 1 = 2 = \frac{di(0^+)}{dt}$

$$\alpha = \frac{1}{2RC} = \frac{1}{2 \times 1 \times 0.25} = 2, \quad W_o = \frac{1}{\sqrt{LC}} = 2$$

$\alpha = W_o$, critically damped response

$s = -2, -2$

$i(t) = (A + Bt)e^{-2t}, \quad A = -2$

$$\frac{di(t)}{dt} = (-2 + Bt)e^{2t}(-2) + (0 + B)e^{-2t}$$

At $t = 0, \ \Rightarrow B = -2$

31. (A) $i(0^+) = 3$ A, $v_C(0^+) = 0$ V $= \frac{4di(0^+)}{dt}$

$i_s = 9$ A, $R = 10 || 40 = 8\,\Omega$

$$\alpha = \frac{1}{2RC} = \frac{1}{2 \times 8 \times 0.01} = 6.25$$

$$W_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{4 \times 0.01}} = 5$$

$\alpha > W_o$, so overdamped response

$s = -6.25 \pm \sqrt{6.25^2 - 25} = -10, -2.5$

$i(t) = 9 + Ae^{-10t} + Be^{-2.5t}$

$3 = 9 + A + B, \quad 0 = -10A - 2.5B$

On solving, $A = 2,\ B = -8$

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