Exercises

1.1 Given the circuit in Fig.E1.1 with $E = 60$ V, $J = 1$ A, $R_1 = R_2 = R_3 = 10\ \Omega$, $R_4 = 30\ \Omega$. Find I_0, I_1, I_2, I_3, I_4.

1.2 Given the circuit in Fig.E1.2 with $E = 20$ V, $J = 2$ A, $R_0 = 5\ \Omega$, $R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 30\ \Omega$, $R_4 = 10\ \Omega$. Find I_0, I_1, I_2, I_3, I_4.

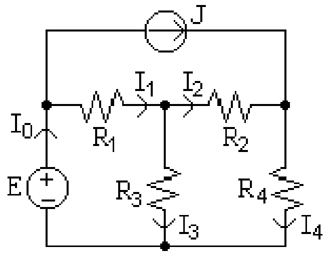


Fig.E1.1

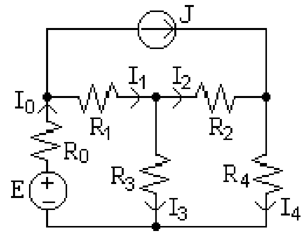


Fig.E1.2

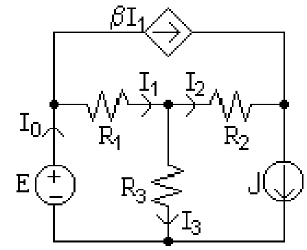


Fig.E1.3

1.3 Given the circuit in Fig.E1.3 with $E = 50$ V, $J = 1$ A, $\beta = 2$, $R_1 = R_2 = R_3 = 10\ \Omega$. Find I_0, I_1, I_2, I_3.

1.4 Given the circuit in Fig.E1.4 with $E = 20$ V, $J = 2$ A, $\beta = 2$, $R_0 = 5\ \Omega$, $R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 30\ \Omega$. Find I_0, I_1, I_2, I_3.

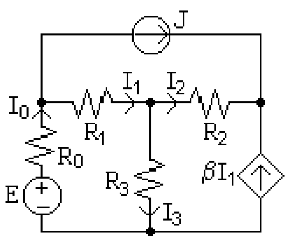


Fig.E1.4

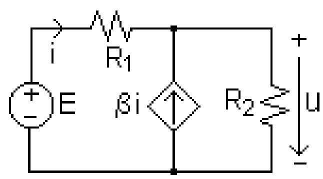


Fig.E1.5

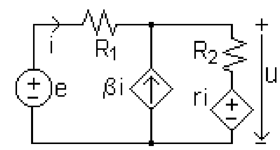


Fig.E1.6

1.5 Given the circuit in Fig.E1.5 with $E = 20$ V, $R_1 = 1$ kΩ, $R_2 = 10\ \Omega$, $\beta = 99$. Find u and i.

1.6 Given the circuit in Fig.E1.6 with $e = 20\sin(10t)$ V, $R_1 = 100\ \Omega$, $R_2 = 25\ \Omega$, $\beta = 3$, $r = 10\ \Omega$. Find u and i.

1.7 Given the circuit in Fig E1.7 with $R = 0.1\ \Omega$, $L = 0.1$ H. Find u if $i = 10^3 t$ A

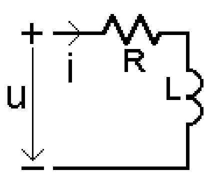


Fig.E1.7

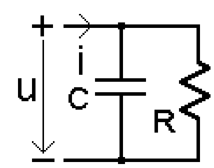


Fig.E1.8

1.8 Given the circuit in Fig E1.8 with $R = 10$ kΩ, $C = 100\ \mu$F. Find i if $u = 10^5 t$ V

2.1 Given the circuit in Fig.E2.1 with $e(t) = 50\sin(100t)$ V, $R = 10\ \Omega$, $L = 1$ H, $C = 1000\ \mu$F, $\beta = 19$. Find u(t) and i(t).
Solution: $i(t) = 0.5\sin(100t)$ A; $u(t) = 50\sqrt{2}\sin(100t - 45^o)$ V

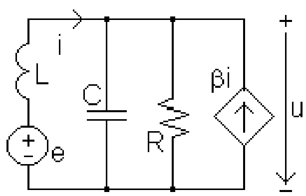


Fig.E2.1

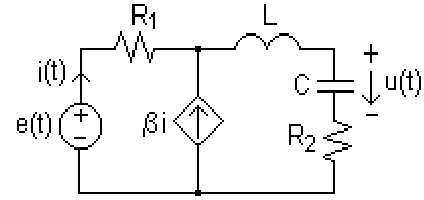


Fig.E2.2

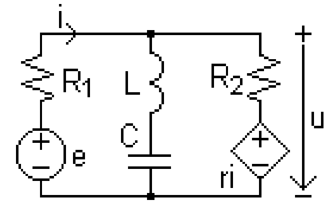


Fig.E2.3

2.2 Given the circuit in Fig.E2.2 with e(t) = 20sin(1000t) V, R_1 = 1 kΩ, R_2 = 10 Ω, L = 30 mH, C = 100 μF, β = 99. Find u(t) and i(t).

Solution: $i(t) = \dfrac{1}{100\sqrt{2}}\sin(1000t - 45^{\circ})$ A; $u(t) = 5\sqrt{2}\sin(1000t - 135^{\circ})$ V

2.3 Given the circuit in Fig.E2.3 with e(t) = 60sin(1000t) V, $R_1 = R_2 = r$ = 30 Ω, L = 30 mH, C = 50 μF. Find u(t) and i(t).

Solution: $i(t) = \dfrac{2\sqrt{5}}{3}\sin(1000t - 27^{\circ})$ A; $u(t) = 20\sqrt{2}\sin(1000t + 45^{\circ})$ V

2.4 The circuit in Fig.E2.4 is in sinusoidal steady-state with $U = U_L$ = 100V, $I_C = I_R$ = 1A (RMS values). Sketch the phasors of the voltages and currents. Find R, L, C and the input impedance of the one-port network if f = 50 Hz.

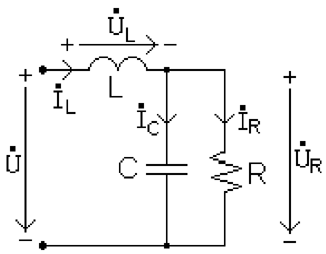


Fig.E2.4

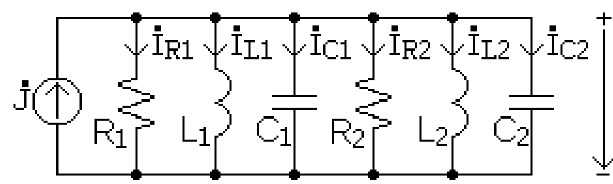


Fig.E2.5

2.5 The circuit in Fig.E2,5 is in sinusoidal steady-state with $I_{R1} = I_{L1}$ = 1A, $I_{C1} = I_{C2} = I_{R2}$ = 2A, I_{L2} = 3A, U = 50V (RMS values). Sketch the phasors of the voltages and currents. Find J and the complex power of the current source. Show that the sum of the complex powers for the six passive elements is equal to the complex power of the source.

Solution: $\dot{J} = 3\angle 0^{\circ}$ A

2.6 Find the resonant frequencies of the one-port networks in Fig.E2.6.

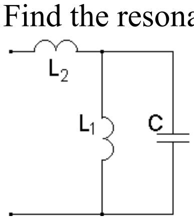


Fig.E2.6A

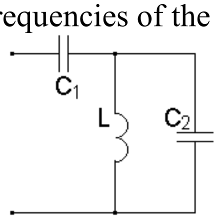


Fig.E2.6B

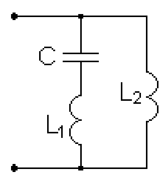


Fig.E2.6C

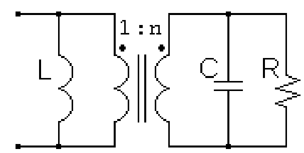


Fig.E2.6D

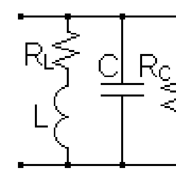


Fig.E2.6E

Solution:

Fig.E2.6A: $\omega_1 = \dfrac{1}{\sqrt{L_1C}}$, $\omega_2 = \sqrt{\dfrac{1}{L_1C} + \dfrac{1}{L_2C}}$; Fig.E2.6B: $\omega_1 = \dfrac{1}{\sqrt{LC_2}}$, $\omega_2 = \sqrt{\dfrac{1}{L(C_1 + C_2)}}$

Fig.E2.6C: $\omega_1 = \dfrac{1}{\sqrt{L_1C}}$, $\omega_2 = \sqrt{\dfrac{1}{(L_1 + L_2)C}}$; Fig.E2.6D: $\omega = \dfrac{1}{n\sqrt{LC}}$; Fig.E2.6E: $\omega = \sqrt{\dfrac{1}{LC} - \left(\dfrac{R_L}{L}\right)^2}$

2.7 The circuit in Fig.E2.7 is in sinusoidal steady-state with U = 220 V (RMS), f = 50 Hz. The load Z_L is inductive with active power P_L = 10 kW and $\cos(\varphi_L)$ = 0.707. Find the capacitance C such that the one-port network is inductive with $\cos(\varphi)$ = 0.95. Find I, I_L, I_C.

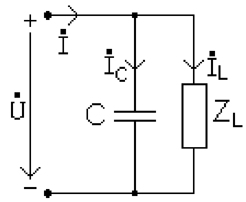


Fig.E2.7

2.8 Given the circuit in Fig.E2.8 with $\dot{E}$ = 20 V (RMS), ω = 500 rad/s, L_1 = 200 mH; C_1 = 10 μF, C_2 = 10 μF; R_2 = 200 Ω, the two-port network has $Z = \begin{bmatrix} 200 & 0 \\ 50 & 200j \end{bmatrix}$ Ω. Find $\dot{I}_1$, $\dot{I}_2$, $\dot{U}_1$, $\dot{U}_2$.

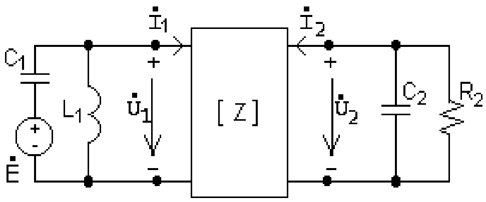


Fig.E2.8

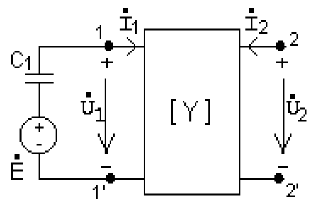


Fig.E2.9

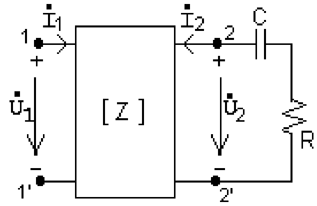


Fig.E2.10

2.9 Given the circuit in Fig.E2.9 with $\dot{E}$ = 100 V (RMS), ω = 500 rad/s, C_1 = 20 μF, the two-port has $Y = \begin{bmatrix} 0{,}002(1-2j) & 0 \\ 0{,}2 & 0{,}01(1+j) \end{bmatrix}$ S. Find the Thevenin equivalent circuit and the maximum active power of the one-port network.

2.10 Given the circuit in Fig.E2.10 with ω = 1000 rad/s, R = 100 Ω, C = 20 μF, the two-port has $Z = \begin{bmatrix} 100 & 0 \\ 50 & 100(1+j3) \end{bmatrix}$ Ω. Find $K_U = \dot{U}_2/\dot{U}_1$ and $K_I = \dot{I}_2/\dot{I}_1$.

2.11 Find the transfer function $H(j\omega) = \dfrac{V_o}{V_i}$ of the filters in Fig.E2.11 where R = 10 kΩ, C = 1 μF. Sketch the magnitude and the phase of H(jω) versus ω. Find the cut-off frequency ω_C.

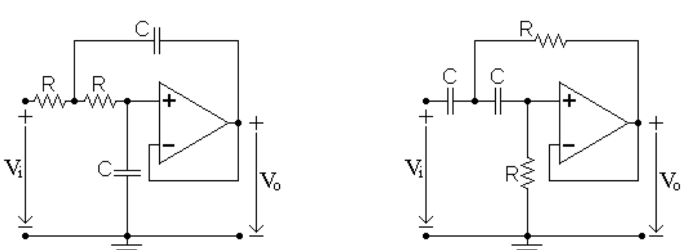


Fig.E2.11

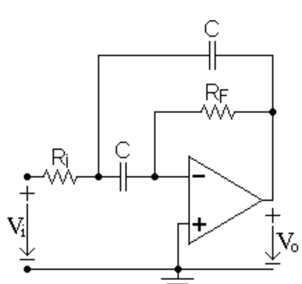


Fig.E2.12

2.12 Find the transfer function $H(j\omega) = \dfrac{V_o}{V_i}$ of the filter in Fig.E2.12 where R_F = 10 kΩ, R_i = 10 kΩ, C = 1 μF. Sketch the magnitude and the phase of H(jω) versus ω. Find the cut-off frequencies ω_C.

2.13 The RL load in Fig.E2.13 is compensated by adding the shunt capacitance C so that the power factor of the combined (compensated) circuit is exactly unity. How is C related to R, L, and ω in that case?

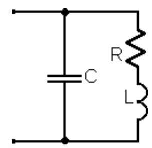


Fig.E2.13

3.1 Given the circuit in Fig.E3.1 with R = 100 Ω, L = 100 mH, C = 10 μF.

a) Find the voltage transfer function $K_u(j\omega) = \dfrac{\dot{U}}{\dot{E}}$

b) Find u(t) if e(t) = 100 + 100sin(500t) + 100sin(1000t) V.

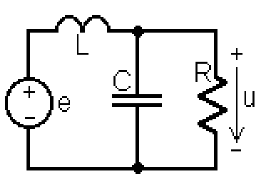


Fig.E3.1

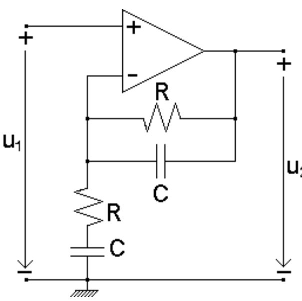


Fig.E3.2

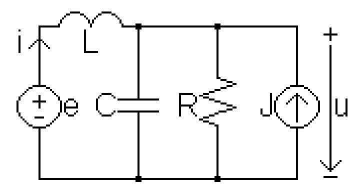


Fig.E3.3

3.2 Given the circuit in Fig.E3.2 with R = 10 kΩ, C = 1 μF.

a) Find the voltage transfer function $K_u(j\omega) = \dfrac{\dot{U}_2}{\dot{U}_1}$

b) Find $u_2(t)$ if $u_1(t)$ = 100 + 100sin(500t) + 100sin(1000t) V.

3.3 Given the circuit in Fig.E3.3 with e(t) = 100 + 100sin(1000t) V, J = 2 + 2cos(1000t) A, R = 100 Ω, L = 100 mH, C = 10 μF. Find u(t) and i(t).

3.4 The circuit in Fig.E3.4 has R = 1Ω, L = 1H, C = 1F. J is a periodic current source with period $T_o = 2\pi$ [s]. Expand J(t) into Fourier series. Find an expression of u(t) and i(t).

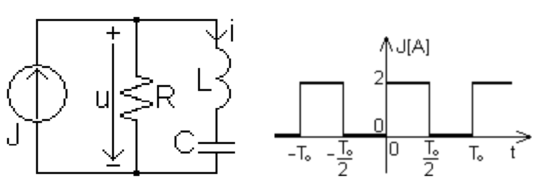


Fig.E3.4

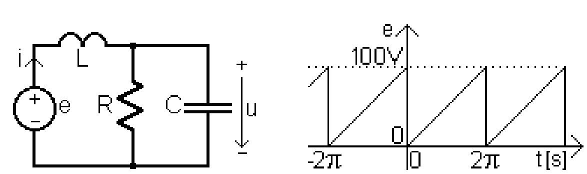
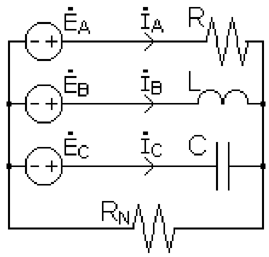


Fig.E3.5

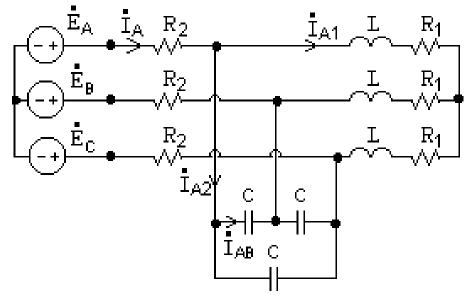
3.5 The circuit in Fig.E3.5 has R = 1Ω, L = 1H, C = 1F. e is a periodic voltage source with period $T_o = 2\pi$ [s]. Expand e(t) into Fourier series. Find an expression of u(t) and i(t).

3.6 Given the three-phase circuit in Fig.3.6 with $R = \omega L = 1/(\omega C) = 100\ \Omega$. The three-phase source is balanced with line voltage $U_L = 380$ V (RMS). Find the voltage U_N between the two neutral points as function of R_N. Find R_N such that $U_N = U_d/10$. With this value of R_N, sketch the phasor diagram of the circuit.

3.7 Given the three-phase circuit in Fig.3.7 with $R_1 = \omega L = 100\ \Omega$, $1/\omega C = 600\ \Omega$, $R_2 = 20\ \Omega$. The three-phase source is balanced (+) sequence with phase voltage $V_P = 220$ V (RMS). Find I_A, I_{A1}, I_{A2} and I_{AB}.



Fig,3,6



Fig,3,7

4.1 Given the circuit in Fig.E4.1 with $e = 100\cos(1000t)$ V, $R = 100\ \Omega$, $L = 100$ mH, $C = 10\ \mu$F. The switch is open for very long time and is closed at $t = 0$. Find $u(t)$ and $i(t)$.

4.2 Given the circuit in Fig.E4.2 with $R = 100\Omega$, $L = 100$ mH, $C = 10\ \mu$F. For $t < 0$, K is open, the capacitor is uncharged and $i(t) = 0$ A. At $t = 0$, K is closed. Find $u(t)$, $i(t)$, $i_1(t)$ and $i_2(t)$ in two cases:
a) $e = 100$ V (DC)   b) $e = 100\cos(1000t)$ V   c) $e = 100 + 100\cos(1000t)$ V

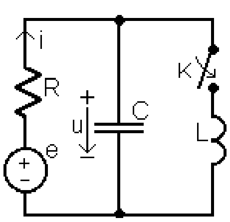


Fig.E4.1

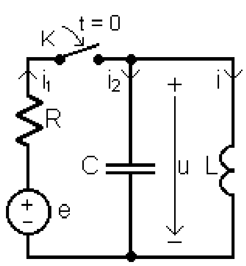


Fig.E4.2

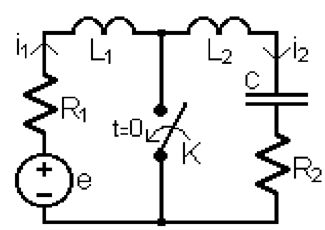


Fig.E4.3

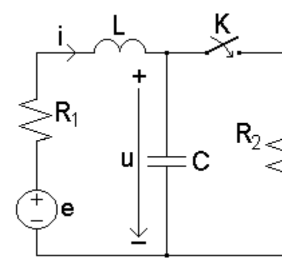


Fig.E4.4

4.3 Given the circuit in Fig.E4.3 with $e(t) = 100\sin(1000t)$ V, $R_1 = R_2 = 100\ \Omega$, $L_1 = 200$ mH, $L_2 = 100$ mH, $C = 10\ \mu$F. The switch K is open for very long time and is closed at $t = 0$. Find $i_1(t)$ and $i_2(t)$.

4.4 Given the circuit in Fig.E4.4 with $R_1 = R_2 = 100\ \Omega$, $L = 100$ mH, $C = 10\ \mu$F. The switch K is open for very long time and is closed at $t = 0$. Find $u(t)$ and $i(t)$ in two cases:
a) $e = 100$ V (DC)   b) $e = 100\cos(1000t)$ V   c) $e = 100 + 100\cos(1000t)$ V

4.5 Given the circuit in Fig.E4.5 with $R = 100\ \Omega$, $L = 100$ mH, $C = 10\ \mu$F. Find $u(t)$ and $i(t)$.

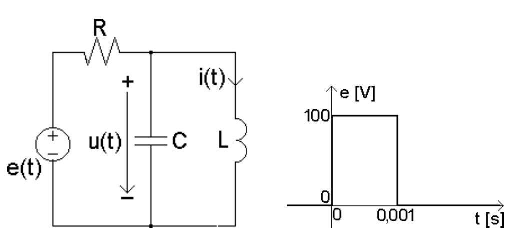


Fig.E4.5

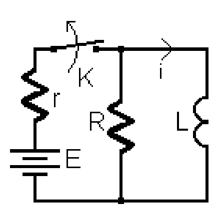


Fig.E4.6

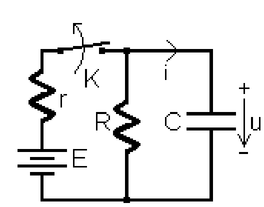


Fig.E4.7

4.6 Consider the circuit in Fig.E4.6 with E = 24 V, r = 100Ω, R = 1 kΩ, L = 100 mH. The switch K is closed for very long time and suddenly open at t = 0. Find the current i.

4.7 Consider the circuit in Fig.E4.7 with E = 24 V, r = 2 kΩ, R = 10 kΩ, C = 10 μF. The switch K is closed for very long time and suddenly open at t = 0. Find the voltage u.

5.1 Consider the circuit in Fig.E.1 with e(t) = 20sin(100πt) V, R = 1 kΩ, $V_{Z1} = V_{Z2}$ = 10V. Find and sketch the waveform of the voltage u(t).

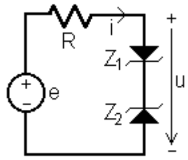


Fig.E5.1

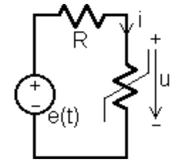


Fig.E5.2

5.2 Consider the circuit in Fig.E5.2 with e(t) = 40 + sin(100πt) V, R = 2 Ω, the Volt-Ampere characteristics of the nonlinear resistor is given by $u = i^3/50$. Linearize the circuit at the DC operating point and find i(t).

6.1 The lossless transmission line in Fig.E6.1 has length d = 20 m, L_0 = 2.5 μH/m and C_0 = 1 nF/m. The source is sinusoidal with amplitude E = 50 V, frequency f = 1 MHz. R_1 = 25 Ω. R_2 = 100 Ω. Find and sketch the distribution of the voltage and the current along the line.

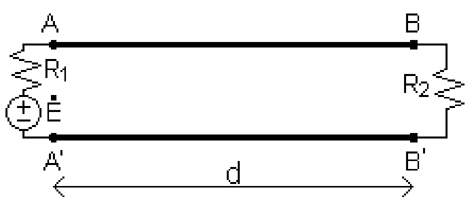


Fig.E6.1

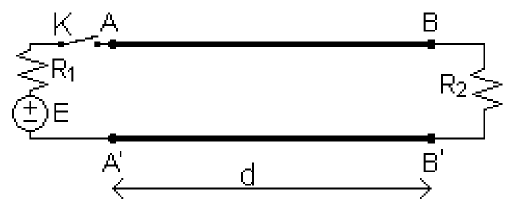


Fig.E6.2

6.2 The lossless transmission line in Fig.E6.2 has length d = 20 m, L_0 = 2.5 μH/m and C_0 = 1 nF/m. The DC voltage source has E = 50 V. R_1 = 50 Ω. R_2 = 100 Ω. The switch K is initially open and is closed at t = 0. Find and sketch the distribution of the voltage and the current along the line at times t_1 = 0.6 μs, t_2 = 1.6 μs and t_3 = 2.6 μs.