

IT CookBook, 처음 만나는 회로이론

[연습문제 답안 이용 안내]

- 본 연습문제 답안의 저작권은 방성완과 한빛아카데미(주)에 있습니다.
- 이 자료를 무단으로 전제하거나 배포할 경우 저작권법 136조에 의거하여 최고 5년 이하의 징역 또는 5천만원 이하의 벌금에 처할 수 있고 이를 병과(併科)할 수도 있습니다.

Chapter 01 연습문제 답안

1.1 $10^6 \times q_e = 10^6 \times -1.602 \times 10^{-19} = -1.602 \times 10^{-13} [\text{C}]$

1.2 $G = \frac{i}{v} = \frac{2 \times 10^{-3}}{20} = 10^{-4} [\text{S}]$
 $R = \frac{1}{G} = \frac{1}{10^{-4}} = 10 [\text{k}\Omega]$

1.3 $P = \frac{v^2}{R} = \frac{(10)^2}{10 \times 10^3} = 10 [\text{mW}]$

1.4 전압원 V_A : $P = -V_A I = -(-10 \text{ V})(5 \text{ A}) = 50 [\text{W}]$, 소모하는 전력
전압원 V_B : $P = V_B I = (20 \text{ V})(5 \text{ A}) = 100 [\text{W}]$, 소모하는 전력
전압원 V_C : $P = V_C I = -(30 \text{ V})(5 \text{ A}) = 150 [\text{W}]$, 공급하는 전력

1.5 접점 6개, 분기 8개

1.6 $i = 1 [\text{A}]$

1.7 $v_1 = 6i = -12 [\text{V}]$, $v_2 = -4i = 8 [\text{V}]$

1.8 $v_1 = 20 [\text{V}]$, $v_2 = 40 [\text{V}]$

1.9 $10 [\Omega]$

1.10 $8 [\text{S}]$

Chapter 02 연습문제 답안

$$2.1 \quad v_3 = V_s \times \frac{8}{R_{eq}} = 3 \times \frac{8}{24} = 1 \text{ [V]}$$

$$2.2 \quad i_1 = 20 \times \frac{4}{6+4} = 8 \text{ [mA]}, \quad i_2 = 12 \times \frac{5}{20+5} = 2.4 \text{ [mA]}, \quad i_3 = 12 \times \frac{20}{20+5} = 9.6 \text{ [mA]}$$

$$2.3 \quad v_1 = \frac{12}{5} \text{ [V]}, \quad v_2 = -\frac{4}{5} \text{ [V]}$$

$$2.4 \quad i_1 = I_1 = 9 \text{ [A]}$$

$$2.5 \quad I_1 = I_1' + I_1'' = 1 + 4 = 5 \text{ [A]}, \quad I_2 = I_2' + I_2'' = 1 - 2 = -1 \text{ [A]}$$

$$2.6 \quad 12 \text{ [V]}$$

$$2.7 \quad i = \frac{6}{6+4} \times (-2) = -1.2 \text{ [A]}$$

$$2.8 \quad v = V_{th} = \frac{6}{3+6} \times (-9) = -6 \text{ [V]}$$

$$2.9 \quad R_N = (20 + 30) \parallel (40 + 10) = \frac{50 \times 50}{50 + 50} = 25 \text{ } [\Omega], \quad I_N = \frac{V_N}{R_N} = \frac{50}{25} = 2 \text{ [A]}$$

$$2.10 \quad P_{\max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{4^2}{4 \times 3} = \frac{4}{3} \text{ [W]}$$

Chapter 03 연습문제 답안

$$3.1 \quad i_C(t) = C \frac{dv_C(t)}{dt} = 60 \times 10^{-3} \frac{220 - 120}{6} = 1 \text{ [A]}$$

$$3.2 \quad v_1 = 10i_1 = 10 \text{ [V]}, \quad v_2 = 40 - 25i_1 = 15 \text{ [V]}$$

$$3.3 \quad C = 10 \text{ [\mu F]}$$

$$3.4 \quad C_{eq} = 4F + 6F = 10 \text{ [F]}$$

$$3.5 \quad C_{eq} = \frac{2 \times 2}{2 + 2} = 1 \text{ [F]}$$

$$3.6 \quad v_1 = \frac{C_{eq}}{C_{eq} + C_1} \times 90 = \frac{4}{4 + 4} \times 90 = 45 \text{ [V]}, \quad v_2 = v_{eq} = 45 \text{ [V]}$$

$$v_3 = \frac{3}{6 + 3} \times 45 = 15 \text{ [V]}, \quad v_4 = v_2 - v_3 = 45 - 15 = 30 \text{ [V]}$$

$$3.7 \quad v_L(t) = L \frac{di_L(t)}{dt} = 6 \times 10^{-3} \times \frac{(100 - 50) \times 10^{-3}}{2 \times 10^{-3}} = 150 \text{ [mV]}$$

$$3.8 \quad i_L = \frac{2}{8 + 2} \times 10 = 2 \text{ [A]}, \quad W_L = \frac{1}{2} Li_L^2 = \frac{1}{2} \times 5 \times 10^{-3} \times 2^2 = 10 \text{ [mJ]}$$

$$3.9 \quad L_{eq} = \frac{50 \times 50}{50 + 50} = 25 \text{ [mH]}$$

$$3.10 \quad L_{eq} = \frac{20 \times 5}{20 + 5} = 4 \text{ [H]}$$

Chapter 04 연습문제 답안

4.1 $i_1 = 1, i_2 = -1, i_3 = -3$

4.2
$$\mathbf{A} = \begin{bmatrix} 2 & 4 & -1 & -3 \\ 1 & -3 & 7 & -2 \\ -3 & -2 & 6 & 1 \\ -1 & 1 & 4 & -3 \end{bmatrix}, \quad \mathbf{x} = \begin{bmatrix} i_1 \\ i_2 \\ i_3 \\ i_4 \end{bmatrix}, \quad \mathbf{c} = \begin{bmatrix} -2 \\ 4 \\ 1 \\ 7 \end{bmatrix}$$

4.3
$$\mathbf{A}^{-1} = \frac{1}{3} \begin{bmatrix} 5 & 2 & -1 \\ -2 & 1 & 1 \\ -2 & -2 & 1 \end{bmatrix} = \begin{bmatrix} 1.6667 & 0.6667 & -0.3333 \\ -0.6667 & 0.3333 & 0.3333 \\ -0.6667 & -0.6667 & 0.3333 \end{bmatrix}$$

4.4 $v_1 = \frac{|D_1|}{|D|} = \frac{0}{10} = 0, \quad v_2 = \frac{|D_2|}{|D|} = \frac{0}{10} = 0, \quad v_3 = \frac{|D_3|}{|D|} = \frac{10}{10} = 1$

4.5 $v_C(t) = 7 - 5e^{-0.2t}$

4.6 $v_C(t) = (1 + 2t)e^{-3t}$

4.7
$$\frac{(6 - j2) + (j4 - 6)}{1 - j} = \frac{j2}{1 - j} \cdot \frac{1 + j}{1 + j} = \frac{-2 + j2}{2} = -1 + j, \quad |z| = \sqrt{(-1)^2 + 1^2} = \sqrt{2}$$

4.8 (a) $2\angle 120^\circ$

(b) $z_1 = 2\angle 120^\circ = 2 \left[\cos \frac{2\pi}{3} + j \sin \frac{2\pi}{3} \right]$

$$z = (2)^6 \left[\cos \left(6 \times \frac{2\pi}{3} \right) + j \sin \left(6 \times \frac{2\pi}{3} \right) \right] = 64$$

$$4.9 \quad F(s) = -\frac{3e^{-s}}{s} - \frac{3e^{-s}}{s^2} + \frac{3}{s^3} - \frac{3e^{-2s}}{s} + \frac{3e^{-s}}{s} = \frac{3}{s^2}(1 - e^{-s} - se^{-2s})$$

$$4.10 \quad f(t) = 2e^{-3t} - 2e^{-t} + 4te^{-t}$$

Chapter 05 연습문제 답안

$$5.1 \quad i(t) = -C \frac{dv_C(t)}{dt} = -\frac{1}{2} \left(-\frac{1}{5} \right) 12e^{-t/5} = 1.2e^{-0.2t} \text{ [A]}$$

$$5.2 \quad i(t) = i(0^-)e^{-t/\tau} = 1.54e^{-2t} \text{ [A]}$$

$$5.3 \quad i(t) = \frac{20}{20+5} \times -i_L(t) = -8e^{-2t} \text{ [A]}$$

$$5.4 \quad v_C(t) = 3e^{-t} - 3e^{-3t} \text{ [V]}$$

$$5.5 \quad i(t) = \left(2\cos 3t + \frac{8}{3}\sin 3t \right) e^{-4t} \text{ [A]}$$

$$5.6 \quad i_L(t) = 20e^{-10t} - 5e^{-40t} \text{ [A]}$$

$$5.7 \quad v_C(t) = (8\cos t + 4\sin t)e^{-t/2} \text{ [V]}, \quad i_C(t) = -2\sin te^{-t/2} \text{ [A]}$$

$$5.8 \quad v_{C_2}(t) = \left(\frac{RI_0C_2}{C_1 + C_2} + V_0 \right) e^{s_1t} - \left(\frac{RI_0C_1}{C_1 + C_2} \right) e^{s_2t} \text{ [V]}$$

$$5.9 \quad L = \frac{1}{C} = \frac{1}{100 \times 10^{-3}} = 10 \text{ [H]}$$

$$5.10 \quad i_L(t) = -30\sin\left(\frac{10}{3}t\right) \text{ [A]}$$

Chapter 06 연습문제 답안

6.1 (a) $-3\sin 2t = 3\cos(2t + 90^\circ)$

(b) $3\sin(2t - 40^\circ) = 3\cos(2t - 40^\circ - 90^\circ) = 3\cos(2t - 130^\circ)$

(c) $-3\sin(2t + 40^\circ) = 3\cos(2t + 40^\circ + 90^\circ) = 3\cos(2t + 130^\circ)$

6.2 진폭 $A = 2$, 위상은 $\phi = -30^\circ$ (혹은 $-\pi/6$ 라디안), 각주파수는 $\omega = 2\pi$, 고유주파수는 $f = \frac{\omega}{2\pi} = \frac{2\pi}{2\pi} = 1$ [Hz], 주기는 $T = \frac{1}{f} = \frac{1}{1} = 1$ [s]이다.

6.3 $V_{\text{rms}} = \sqrt{12} = 2\sqrt{3}$ [V]

6.4 $f(t) = a_0 + \sum_{n=1}^{\infty} (a_n \cos n\omega_0 t + b_n \sin n\omega_0 t) = 12 - \sum_{n=\text{홀수}}^{\infty} \frac{16}{n\pi} \sin nt$

6.5 $\mathbf{I}(j\omega) = 10\angle 150^\circ$, $\mathbf{V}(j\omega) = 40\angle 150^\circ$

6.6 (a) $i(t) = -2.93 \times \sqrt{2} \cos(20t + 45^\circ) = -4.14 \cos(20t + 45^\circ)$

(b) (a)의 결과와 동일하게 된다.

6.7 $Z_{eq}(j\omega) = 3 + 1 - j3 = 4 - j3$ [Ω]

6.8 $Z_{eq} = \frac{1}{Y_{eq}} = \frac{25(4 - j3)}{(4 + j3)(4 - j3)} = 4 - j3$ [Ω]

6.9 $i(t) = 0.5 \cos(10t + 45^\circ)$ [A]

6.10 $i_1(t) = 0.2 \cos(10t + 18.43^\circ)$ [A]

Chapter 07 연습문제 답안

$$7.1 \quad p(t) = 100[\cos(30^\circ) + \cos(100t + 60^\circ)] = 50\sqrt{3} + \cos(100t + 60^\circ) \text{ [W]}$$

$$7.2 \quad P_{avg} = \frac{1}{2}(20)(10)\cos(45^\circ - 15^\circ) = 50\sqrt{3} \text{ [W]}$$

$$7.3 \quad P_{avg} = \frac{1}{2}|\mathbf{I}_s|^2 \times 5 = \frac{1}{2}(1.2649)^2 \times 5 = 5.2 \text{ [W]}$$

$$7.4 \quad P_{avg, \max} = \frac{|\mathbf{V}_{Th}|^2}{8R_{Th}} = \frac{(3\sqrt{10})^2}{8(10.3)} = 1.09 \text{ [W]}$$

$$7.5 \quad (a) \quad V_{rms} = 5 \text{ [V]}$$

$$(b) \quad I_{rms} = \sqrt{(5)^2 + \frac{(3)^2}{2}} = 5.43 \text{ [A]}$$

$$(c) \quad V_{rms} = \sqrt{\frac{(7)^2 + (3)^2}{2}} = 5.39 \text{ [V]}$$

$$7.6 \quad V_{rms} = \sqrt{4} = 2 \text{ [V]}$$

$$7.7 \quad pf = \cos(-45^\circ) = 0.707$$

$$7.8 \quad \text{복소 전력 : } \mathbf{S} = \frac{1}{2}\mathbf{VI}^* = \frac{1}{2}(100\angle 75^\circ)(5\angle -40^\circ) = 250\angle 35^\circ$$

$$\text{피상 전력 : } P_{app} = |\mathbf{S}| = 250 \text{ [VA]}$$

$$\text{평균 전력 : } 204.79 \text{ [W]}$$

$$\text{무효 전력 : } 143.39 \text{ [VAR]}$$

$$7.9 \quad C = \frac{2Q_c}{\omega \mathbf{V}_s^2} = \frac{(2)(400)}{(2\pi)(60)(100)^2} = 212.3 \text{ } [\mu\text{F}]$$

$$7.10 \quad \mathbf{I}_a = \frac{\mathbf{V}_{an}}{\mathbf{Z}_Y} = \frac{300\angle 0^\circ}{10\angle -36.87^\circ} = 30\angle 36.87^\circ \text{ [A]}$$

$$\mathbf{I}_b = \mathbf{I}_a \angle -120^\circ = 30\angle (36.87^\circ - 120^\circ) = 30\angle -83.13^\circ \text{ [A]}$$

$$\mathbf{I}_c = \mathbf{I}_b \angle -120^\circ = 30\angle (-83.13^\circ - 120^\circ) = 30\angle 156.87^\circ \text{ [A]}$$

$$\mathbf{V}_{ab} = \sqrt{(450)^2 + (150\sqrt{3})^2} \angle \tan^{-1}\left(\frac{\sqrt{3}}{3}\right) = 474\angle 30^\circ \text{ [V]}$$

$$\mathbf{V}_{bc} = 474\angle (30^\circ - 120^\circ) = 474\angle -90^\circ \text{ [V]}$$

$$\mathbf{V}_{ca} = 474\angle (-90^\circ - 120^\circ) = 474\angle +150^\circ \text{ [V]}$$

Chapter 08 연습문제 답안

$$8.1 \quad \frac{\mathbf{V}_o(j\omega)}{\mathbf{V}_s(j\omega)} = \sqrt{(1.5)^2 + (-0.5)^2} \tan^{-1}\left(\frac{-0.5}{1.5}\right) = 1.581 \angle -18.43^\circ$$

$$8.2 \quad \frac{\mathbf{V}_o(j\omega)}{\mathbf{V}_s(j\omega)} = \frac{(2.2 - j0.4)(13 + j)}{(13 - j)(13 + j)} = \frac{29 - j3}{170}$$

$$8.3 \quad \mathbf{H}_I(j\omega) = \frac{\mathbf{I}_o(j\omega)}{\mathbf{I}_s(j\omega)} = \frac{(1 + j)(4.5 - j5)}{(4.5 + j5)(4.5 - j5)} = \frac{9.5 - j0.5}{45.25}$$

$$8.4 \quad Q = \frac{\omega_r}{\text{BW}} = \frac{5000}{125} = 40$$

$$8.5 \quad \omega_r = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = \sqrt{\frac{1}{(50 \times 10^{-3})(4 \times 10^{-6})} - \frac{(20)^2}{(50 \times 10^{-3})^2}} = 2200 \text{ [rad/s]}$$
$$Q = \omega_r RC = (2200)(20)(4 \times 10^{-6}) = 0.18$$

$$8.6 \quad \omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(20 \times 10^{-3})(50 \times 10^{-6})}} = 1000 \text{ [rad/s]}$$

$$\text{BW} = \frac{1}{RC} = \frac{1}{(10 \times 10^3)(50 \times 10^{-6})} = 2 \text{ [rad/s]}$$

$$Q = \frac{\omega_r}{\text{BW}} = \frac{1000}{2} = 500$$

$$8.7 \quad |\mathbf{H}(j2)| = \frac{2}{4(\sqrt{1^2 + 2^2})^2} = 0.1$$

$$8.8 \quad \omega_0 = \frac{1}{(1)(1)} = 1 \text{ [rad/s]}$$

$$8.9 \quad H_{dB} = 20 \log_{10} 2 + 20 \log_{10} \left| 1 + \frac{j\omega}{20} \right| - 20 \log_{10} \left| 1 + \frac{j\omega}{2} \right| - 20 \log_{10} \left| 1 + \frac{j\omega}{5} \right|$$

$$\phi = \tan^{-1} \left(\frac{\omega}{20} \right) - \tan^{-1} \left(\frac{\omega}{2} \right) - \tan^{-1} \left(\frac{\omega}{5} \right)$$

$$8.10 \quad \mathbf{H}(j\omega) = \frac{10 \left[\frac{1}{10} (10 + j\omega) \right]}{\left[\frac{1}{100} (100 + j\omega) \right] \left[\frac{1}{1000} (1000 + j\omega) \right]} = \frac{10^5 (10 + j\omega)}{(100 + j\omega)(1000 + j\omega)}$$

Chapter 09 연습문제 답안

$$9.1 \quad H(s) = \mathcal{L}\left[\frac{1}{2}(3e^{at} + e^{-at})\right] = \frac{1}{2}\left[\frac{3}{s-a} + \frac{1}{s+a}\right] = \frac{2s+a}{s^2-a^2}$$

$$9.2 \quad \mathcal{L}[\cos(t-1)u(t-1)] = \frac{se^{-s}}{s^2+1^2}$$

$$9.3 \quad F(s) = \frac{F_1(s)}{1-e^{-2s}} = \frac{-\pi(1+e^{-s})}{(s^2+\pi^2)(1-e^{-2s})}$$

$$9.4 \quad f(t) = f_a(t) + f_b(t) + f_c(t) = 4u(t) - 2u(t-1) + 2u(t-3) - 4u(t-4)$$

$$9.5 \quad \mathbf{Z}_{in}(s) = \frac{1}{s} \parallel \frac{2s^2+5s+2}{3+2s} = \frac{\frac{1}{s}(2s^2+5s+2)}{\frac{1}{s}+3+2s} = \frac{2s^2+5s+2}{2s^2+3s+1} = \frac{(2s+1)(s+2)}{(2s+1)(s+1)} = \frac{s+2}{s+1}$$

$$9.6 \quad \mathbf{V}_1(s) = \frac{6(s+3)}{(s+2)^2}$$

$$9.7 \quad \mathbf{I}_1 = \frac{|D_1|}{|D|} = \frac{4(s+2)}{2s^2+5s+1}, \quad \mathbf{I}_2 = \frac{|D_2|}{|D|} = \frac{4}{2s^2+5s+1}$$

$$9.8 \quad v_o(t) = 2e^{-2t} - 10e^{-6t}$$

$$9.9 \quad \mathbf{H}(s) = \frac{\mathbf{V}_o(s)}{\mathbf{V}_s(s)} = \frac{10s(s+1)}{2s^2+12s+5} \cdot \frac{s}{2(s+1)} = \frac{5s^2}{2s^2+12s+5}$$

$$9.10 \quad \mathbf{H}(s) = \frac{\mathbf{V}_o(s)}{\mathbf{I}_s(s)} = \frac{2s^3}{2s^3+3s^2+s+1}$$

Chapter 10 연습문제 답안

$$10.1 \quad F(\omega) = \frac{j}{2} \left[\frac{2\omega(e^{-j2\omega})}{\omega^2 - \pi^2} + \frac{2\omega(e^{-j\omega})}{\omega^2 - \pi^2} \right] = \frac{j\omega}{\omega^2 - \pi^2} [e^{-j2\omega} + e^{-j\omega}]$$

$$10.2 \quad F(\omega) = \frac{-2[\cos(2\omega) - \cos(\omega)]}{j\omega}$$

$$10.3 \quad F(\omega) = 2e^{-j4\omega} \left[\frac{-\omega - 2\pi + \omega - 2\pi}{\omega^2 - 4\pi^2} \right] + 2 \left[\frac{\omega + 2\pi - \omega + 2\pi}{\omega^2 - 4\pi^2} \right] = \frac{-8\pi}{\omega^2 - 4\pi^2} [e^{-j4\omega} - 1]$$

$$10.4 \quad F(\omega) = \frac{2}{\omega^2} [\cos 3\omega - 2\cos 2\omega + \cos \omega]$$

$$10.5 \quad \mathbf{I}_o(\omega) = \frac{\mathbf{V}_s(\omega)}{1 + j2\omega} = \frac{1}{1 + j2\omega} \left(\frac{1}{j\omega} + \frac{1}{\omega^2} - \frac{e^{-j\omega}}{\omega^2} \right)$$

$$10.6 \quad i_o(t) = 2e^{-t/2}u(t) \text{ [A]}$$

$$10.7 \quad v_o(t) = 2e^{-t}u(t) - 2e^{-2t}u(t) \text{ [V]}$$

$$10.8 \quad i_o(t) = -\frac{2}{5}e^{-t/2}u(t) + \frac{12}{5}e^{-3t}u(t) \text{ [A]}$$

$$10.9 \quad i_o(t) = e^{-t/6}u(t) \text{ [A]}$$

$$10.10 \quad \mathbf{H}_v(\omega) = \frac{\mathbf{V}_o(\omega)}{\mathbf{V}_s(\omega)} = \frac{j4\omega}{1 + j\omega}$$

Chapter 11 연습문제 답안

11.1 $v_o = -4 \text{ [V]}$

11.2 $v_o = 4 \text{ [V]}$

11.3 $\frac{v_o}{v_s} = -4$

11.4 $\frac{v_o}{v_s} = -\frac{10}{5} = -2, \quad R_2 = 20 \text{ [k}\Omega\text{]}$

11.5 $v_p = 2 \text{ [V]}$

11.6 $i_0 = \frac{24}{4 \times 10^3} = 6 \text{ [mA]}$

11.7 $v_o = 10 \text{ [V]}$

11.8 $v_o = 3 \times v_n = 3 \times 2 = 6 \text{ [V]}$

11.9 $\frac{i_0}{i_s} = 3$

11.10 $\frac{v_o}{v_s} = -3$