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# [연습문제 답안 이용 안내]

# Chapter 01 연습문제 답안

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

**1.2** $G = \dfrac{i}{v} = \dfrac{2 \times 10^{-3}}{20} = 10^{-4}\,[\mathrm{S}]$

$R = \dfrac{1}{G} = \dfrac{1}{10^{-4}} = 10\,[\mathrm{k\Omega}]$

**1.3** $P = \dfrac{v^2}{R} = \dfrac{(10)^2}{10 \times 10^3} = 10\,[\mathrm{mW}]$

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

**1.5** 접점 6개, 분기 8개

**1.6** $i = 1\,[\mathrm{A}]$

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

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

**1.9** $10[\Omega]$

**1.10** $8[\mathrm{S}]$

# Chapter 02 연습문제 답안

2.1 $v_3 = V_S \times \frac{8}{R_{eq}} = 3 \times \frac{8}{24} = 1\,[\mathrm{V}]$

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

2.3 $v_1 = 4\,[\mathrm{V}],\ v_2 = 4\ [\mathrm{V}]$

2.4 $i_1 = I_1 = 9\,[\mathrm{A}]$

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

2.6 $12\,[\mathrm{V}]$

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

2.8 $v = V_{Th} = \frac{6}{3+6} \times (-9) = -6\,[\mathrm{V}]$

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

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

# Chapter 03 연습문제 답안

3.1 $i_C(t) = C\dfrac{dv_C(t)}{dt} = 60\times10^{-3}\dfrac{220-120}{6} = 1\,[\mathrm{A}]$

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

3.3 $C = 10\,[\mu\mathrm{F}]$

3.4 $C_{eq} = 4F + 6F = 10\,[\mathrm{F}]$

3.5 $C_{eq} = \dfrac{2\times2}{2+2} = 1\,[\mathrm{F}]$

3.6 $v_1 = \dfrac{C_{eq}}{C_{eq}+C_1}\times90 = \dfrac{4}{4+4}\times90 = 45\,[\mathrm{V}],\quad v_2 = v_{eq} = 45\,[\mathrm{V}]$

$v_3 = \dfrac{3}{6+3}\times45 = 15\,[\mathrm{V}],\quad v_4 = v_2 - v_3 = 45-15 = 30\,[\mathrm{V}]$

3.7 $v_L(t) = L\dfrac{di_L(t)}{dt} = 6\times10^{-3}\times\dfrac{(100-50)\times10^{-3}}{2\times10^{-3}} = 150\,[\mathrm{mV}]$

3.8 $i_L = \dfrac{2}{8+2}\times10 = 2\,[\mathrm{A}],\quad W_L = \dfrac{1}{2}Li_L^2 = \dfrac{1}{2}\times5\times10^{-3}\times2^2 = 10\,[\mathrm{mJ}]$

3.9 $L_{eq} = \dfrac{50\times50}{50+50} = 25\,[\mathrm{mH}]$

3.10 $L_{eq} = \dfrac{20\times5}{20+5} = 4\,[\mathrm{H}]$

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

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

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

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

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

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

# Chapter 05 연습문제 답안

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

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

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

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

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

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

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

5.8 $v_{C_2}(t) = \left(\dfrac{RI_0C_2}{C_1+C_2} + V_0\right)e^{s_1 t} - \left(\dfrac{RI_0C_1}{C_1+C_2}\right)e^{s_2 t}$ [V]

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

5.10 $i_L(t) = -30\sin\left(\dfrac{10}{3}t\right)$ [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 $f=\dfrac{\omega}{2\pi}=\dfrac{2\pi}{2\pi}=1\,[\mathrm{Hz}]$, 주기는 $T=\dfrac{1}{f}=\dfrac{1}{1}=1\,[\mathrm{s}]$이다.

**6.3** $V_{\mathrm{rms}}=\sqrt{12}=2\sqrt{3}\,[\mathrm{V}]$

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

**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** $Z_{eq}(j\omega)=3+1-j3=4-j3\,[\Omega]$

**6.8** $Z_{eq}=\dfrac{1}{Y_{eq}}=\dfrac{25(4-j3)}{(4+j3)(4-j3)}=4-j3\,[\Omega]$

**6.9** $i(t)=0.5\cos(10t+45^\circ)\,[\mathrm{A}]$

**6.10** $i_1(t)=0.2\cos(10t+18.43^\circ)\,[\mathrm{A}]$

# Chapter 07 연습문제 답안

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

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

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

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

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

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

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

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

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

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

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

평균 전력 : 204.79 [W]

무효 전력 : 143.39 [VAR]

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

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

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

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

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

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

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

# Chapter 08 연습문제 답안

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

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

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

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

8.5 $$\omega_r = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = \sqrt{\frac{1}{(50\times10^{-3})(4\times10^{-6})} - \frac{(20)^2}{(50\times10^{-3})^2}} = 2200\ [\text{rad/s}]$$

$$Q = \omega_r RC = (2200)(20)(4\times10^{-6}) = 0.18$$

8.6 $$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(20\times10^{-3})(50\times10^{-6})}} = 1000\ [\text{rad/s}]$$

$$\text{BW} = \frac{1}{RC} = \frac{1}{(10\times10^{3})(50\times10^{-6})} = 2\ [\text{rad/s}]$$

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

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

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

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

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

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

# Chapter 09 연습문제 답안

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

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

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

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

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

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

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

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

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

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

# Chapter 10 연습문제 답안

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

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

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

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

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

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

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

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

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

10.10 $$\mathbf{H}_V(\omega)=\frac{\mathbf{V}_o(\omega)}{\mathbf{V}_S(\omega)}=\frac{j4\omega}{1+j\omega}$$

# Chapter 11 연습문제 답안

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

11.2 $v_o = 4\,[\mathrm{V}]$

11.3 $\dfrac{v_o}{v_S} = -4$

11.4 $\dfrac{v_o}{v_S} = -\dfrac{10}{5} = -2$, $R_2 = 20\,[\mathrm{k\Omega}]$

11.5 $v_p = 2\,[\mathrm{V}]$

11.6 $i_0 = \dfrac{24}{4\times 10^3} = 6\,[\mathrm{mA}]$

11.7 $v_0 = 10\ \ [\mathrm{V}]$

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

11.9 $\dfrac{i_0}{i_S} = 3$

11.10 $\dfrac{v_0}{v_S} = -3$