Homework #1 (7장)

7.1.1 전류가 $i(t) = 10\cos(314t - 60°)$ A일 때, 전류의 주기와 헤르츠 단위의 주파수를 계산하라.

풀이 :

$\omega = 314 = 2\pi f$

$\rightarrow 2\pi f = 314$

$\Leftrightarrow f = \frac{314}{2\pi}$ [Hz]

$\rightarrow T = \frac{1}{f} = \frac{2\pi}{314}$

$\therefore T = \frac{2\pi}{314},\ f = \frac{314}{2\pi}$ [Hz] //

7.1.3 다음의 전압과 전류가 주어질 때,

$$i(t) = 5\sin(314t + 30°)\ \mathrm{V}$$
$$v(t) = 10\cos(314t - 20°)\ \mathrm{V}$$

$i(t)$와 $v(t)$ 간의 위상 관계를 구하라.

풀이 :

$i(t) = 5\sin(314t + 30°)$

$= 5\cos(314t + 30° - 90°)$

$= 5\cos(314t - 60°)$

$\rightarrow \theta_1 = -60°$

$v(t)$'s $\theta_2 = -20°$

$\rightarrow \theta_1 - \theta_2 = -60° - (-20°)$

$= -40°$

$\therefore$ $i(t)$는 $v(t)$보다 40° 늦음.

$=$ $i(t)$는 $v(t)$보다 40° lagging. //

7.4.2 그림 P7.4.2에서 아래의 전압이 인가되었을 때 커패시터에 흐르는 전류를 계산하라.

(a) $v_1(t) = 20\cos(314t - 60°)\ \mathrm{V} = 20\angle -60°$ ⋮ $\omega : 314$

(b) $v_2(t) = 24\sin(314t + 30°)\ \mathrm{V} = 24\angle 30°$ ⋮ $\omega : 314$

해답은 주파수 및 시간 영역에서 모두 표현하라.

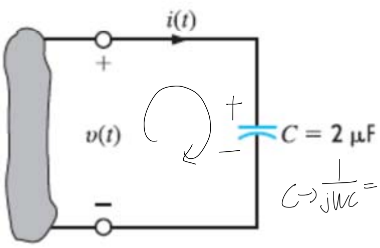


그림 P7.4.2

$C \rightarrow \frac{1}{j\omega C} = \frac{1}{j \cdot 314 \cdot 2 \cdot 10^{-6}}$

$= \frac{10^6}{628j}$

풀이 :

(a)

$20\angle -60° = \frac{10^6}{628j} \cdot i$

$\rightarrow i = \frac{20\angle -60°}{10^6} \cdot 628j$

$= \frac{10 - 10\sqrt{3}j}{10^6} \cdot 628j$

$= \frac{1 - \sqrt{3}j}{10^5} \cdot 628j$

$= (j + \sqrt{3}) \cdot \frac{628}{10^5}$

$= (j + \sqrt{3})\, 6.28m$ [A] (cos 기준)

$\rightarrow 2 \times 6.28 = 12.56$

$\therefore$ 주파수영역: $(j + \sqrt{3})\, 6.28m$ [A], (cos 기준)

시간 영역: $12.56(\cos(314t + 60°))$ [A] (cos 기준) //

(b) $24\angle 30° = \frac{10^6}{628j} \cdot i$

$\rightarrow i = \frac{24\angle 30°}{10^6} \cdot 628j$

$= \frac{12\sqrt{3} + 12j}{10^6} \cdot 628j$

$= 628 \cdot 12(\sqrt{3}j - 1) \cdot \mu$

$= 7536(\sqrt{3}j - 1)\mu$ [A] (sin 기준)

$\rightarrow 2 \times 7536 = 15072$

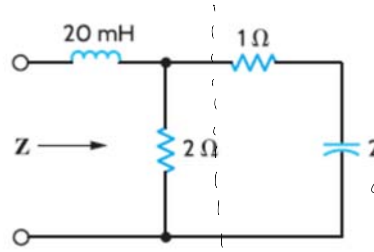
$\therefore$ 주파수영역: $7536(\sqrt{3}j - 1)\mu$ [A] (sin 기준)

시간 영역: $15072\sin(314t - 30°)$ [A] (sin 기준) //

$f = 50 \rightarrow \omega = 2\pi f \,\big|_{f=50} = 100\pi$

7.5.3 그림 P7.5.3 회로망에서 주파수가 50 Hz일 때, 주파수 영역 임피던스 **Z**를 구하라.

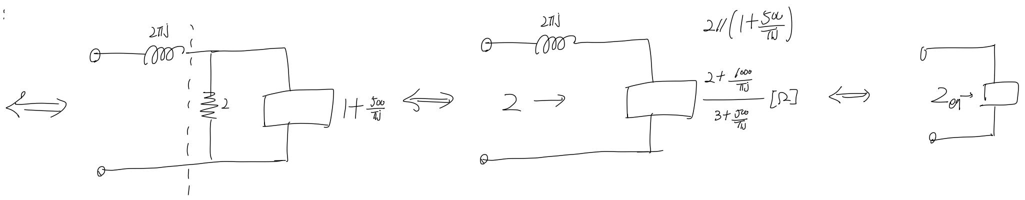
$L \rightarrow j\omega L : j \cdot 100\pi \cdot 20 \cdot 10^{-3} = 2\pi j \, [\Omega]$



$C \rightarrow \frac{1}{j\omega C} = \frac{1}{j \cdot 100\pi \cdot 20 \cdot 10^{-6}} = \frac{1}{2\pi j \cdot 10^{-3}} = \frac{10^3}{2\pi j} = \frac{500}{\pi j} \, [\Omega]$

그림 P7.5.3

풀이 :



$$2 /\!/ \left(1+\frac{500}{\pi j}\right) = \frac{2\cdot\left(1+\frac{500}{\pi j}\right)}{2+\left(1+\frac{500}{\pi j}\right)} = \frac{2+\frac{1000}{\pi j}}{3+\frac{500}{\pi j}} \, [\Omega]$$

$$Z_{eq} = 2\pi j + \frac{2+\frac{1000}{\pi j}}{3+\frac{500}{\pi j}} \, [\Omega]$$

$$= 2\pi j + \frac{2\pi j + 1000}{3\pi j + 500} \, [\Omega]$$

$$= \frac{2\pi j(3\pi j + 500)}{3\pi j + 500} + \frac{2\pi j + 1000}{3\pi j + 500} \, [\Omega]$$

$$= \frac{-6\pi^2 + 1002\pi j + 1000}{3\pi j + 500} \, [\Omega]$$

$$\therefore Z_{eq} = \frac{-6\pi^2 + 1002\pi j + 1000}{3\pi j + 500} \, [\Omega]$$

7.5.5 그림 P7.5.5 회로망에서 주파수 영역 임피던스 **Z**를 구하라.

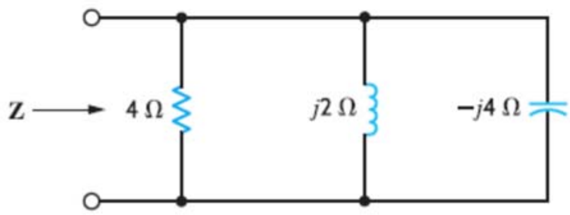


그림 P7.5.5

풀이 :

$R \rightarrow R : 4\,\Omega$

$L \rightarrow j\omega L : 2j\,\Omega$

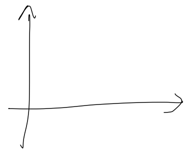
$C \rightarrow \frac{1}{j\omega C} : -4j\,\Omega$

$$\rightarrow Z_{eq} = 4 /\!/ 2j /\!/ -4j = \frac{1}{\frac{1}{4} + \frac{1}{2j} + \frac{1}{-4j}}$$

$$\rightarrow \frac{1}{4} + -\frac{j}{2} + \frac{j}{4}$$

$$= \frac{1}{\frac{1-2j+j}{4}} = \frac{4}{1-j} \times 1+j = \frac{4(1+j)}{1+1} = 2+2j$$

$$\therefore Z_{eq} : 2+2j \, [\Omega]$$



7.6.2 그림 P7.6.2에서 $i_s(t)$가 1 cos (2500t − 45°) A일 때 주파수 영역 회로를 그리고 $v_o(t)$를 계산하라. 또한, 페이저도를 이용하여 $i_C(t) + i_R(t) = i_S(t)$임을 보여라.

풀이 :

$\cos(2500t - 45^\circ) = i_S(t)$

$= 1\angle -45^\circ$; $w = 2500$

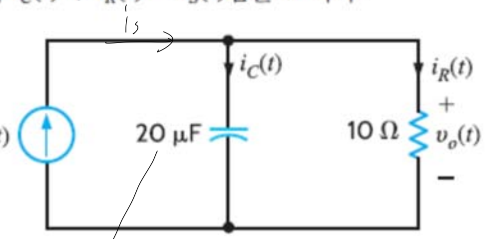
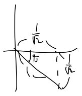


그림 P7.6.2

$= \frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}}j$

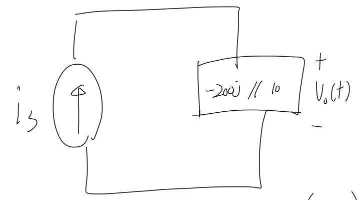


$C \rightarrow \frac{1}{j\omega C} = \frac{1}{j \cdot 2500 \cdot 20 \cdot 10^{-6}}$

$= \frac{1}{50j \cdot 10^{-3}} = \frac{10^3}{50j} = \frac{20}{j} = -20j\ [\Omega]$

$R \rightarrow R : 10\,\Omega$

$=$



$\rightarrow Z_{eq} : -20j \,//\, 10 = \frac{(-20j)\,10}{-20j + 10} = \frac{-20j}{1-2j}(1+2j)$

$= \frac{-20j + 40}{5}$

$= -4j + 8$

KVL $\rightarrow V_o(t) = i_S \cdot (8 - 4j)$

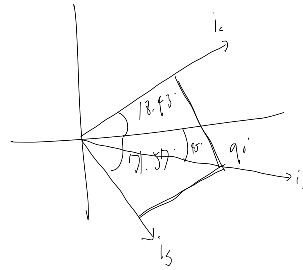
$= \frac{1}{\sqrt{2}}(1-j)(8-4j)$

$= \frac{1}{\sqrt{2}}(8 - 4j - 8j - 4) = \frac{1}{\sqrt{2}}(4 - 12j) = 4\sqrt{5}\angle -71.57^\circ\ [V]$

$\rightarrow i_c(t) = \frac{V_o(t)}{-20j} = \frac{4\sqrt{5}\angle -71.57^\circ}{20\angle -90^\circ} = \frac{\sqrt{5}}{5}\angle 18.43^\circ\ [A]$

$\rightarrow i_R(t) = \frac{V_o(t)}{10} = \frac{4\sqrt{5}\angle -71.57^\circ}{10\angle 0^\circ} = \frac{2\sqrt{5}}{5}\angle -71.57^\circ\ [A]$

$\therefore V_o = 4\sqrt{5}\angle -71.57^\circ\ [V]$,



7.7.4 그림 7.7.4에서 주파수 영역 전압 $\mathbf{V}_o$를 구하라.

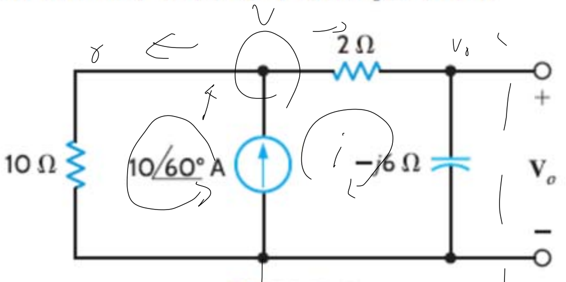
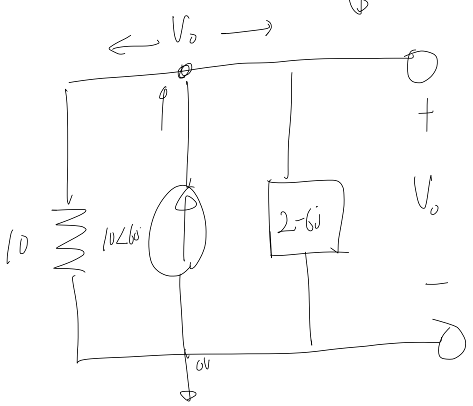
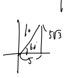


그림 P7.7.4

풀이 :



$10\angle 60^\circ = \frac{V_o - 0}{10} + \frac{V_o - 0}{2 - 6j}$



$= \frac{V_o}{10} + \frac{V_o(1+3j)}{20}$

$5 + 5\sqrt{3}j = \frac{V_o(3+3j)}{20}$

$V_o = \frac{20}{3(1+j)} \cdot 5(1+\sqrt{3}j)$

$= \frac{100}{3}(1+\sqrt{3}j)(1-j)\cdot\frac{1}{2}$

$= \frac{50}{3}(1 - j + \sqrt{3}j + \sqrt{3})$

$= \frac{50}{3}[1+\sqrt{3} + j(-1+\sqrt{3})]$

$\therefore \frac{50}{3}[1+\sqrt{3} + j(-1+\sqrt{3})]\ [V]$

7.7.8 그림 7.7.8 회로에서 주파수 영역 전류 **I**를 구하라.

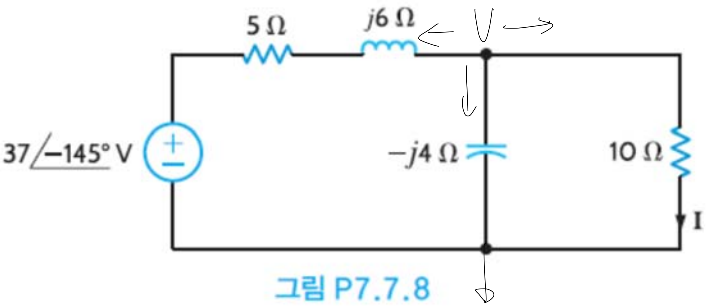
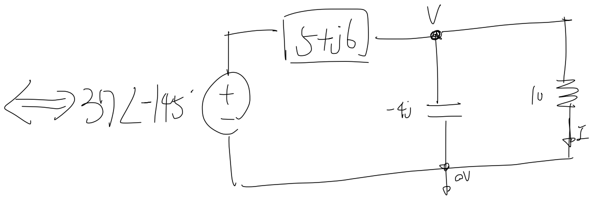


그림 P7.7.8

풀이:



$$\longrightarrow \frac{V-(37\angle -145^\circ)}{5+6j} + \frac{V-0}{-4j} + \frac{V-0}{10} = 0$$

$$\longrightarrow V = 20\angle 125^\circ \ (= -11.472 + j16.383V)$$

$$\longrightarrow I = \frac{V}{10} = \frac{-11.472+j16.383}{10}$$

$$= -1.1472 + j1.6383 \ [A]$$

$\therefore I = -1.1472 + j1.6383$ [A]

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7.8.3 그림 7.8.3 회로에서 노드 해석을 이용하여 전압 $\mathbf{V}_o$를 구하라.

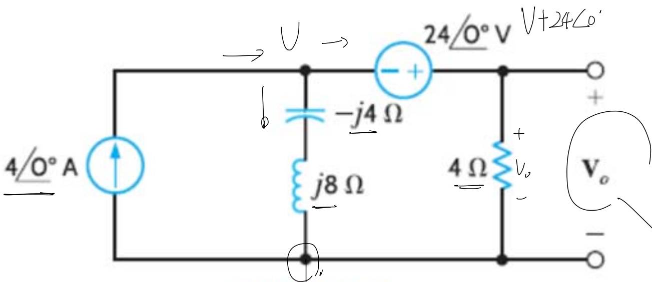
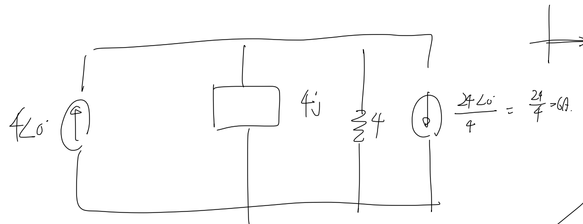


그림 P7.8.3

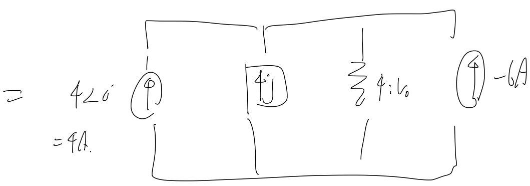
$\therefore V_o = -4(1+j)$ [V]

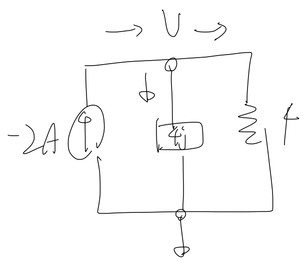
풀이:



병렬이니 같네요

$\frac{V}{4j}$ $\frac{Vj}{4}$





$$\therefore -2 = \frac{V-0}{4j} + \frac{V-0}{4}$$

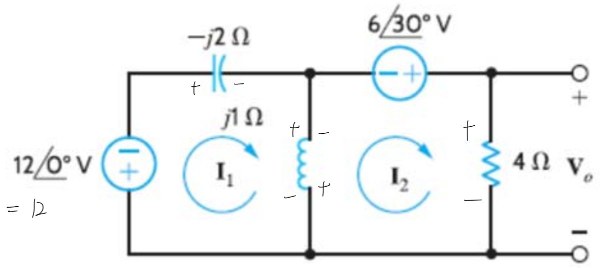
$$\Leftrightarrow -2 = -\frac{Vj}{4} + \frac{V}{4}$$

$$-8 = V(1-j)$$

$$V = \frac{-8}{1-j}\cdot\frac{1+j}{1+j} = \frac{-8(1+j)}{2} = -4(1+j)$$

7.8.7 그림 7.8.7 회로에서 망로 해석을 이용하여 전압 $\mathbf{V}_o$를 구하라.

$= 3\sqrt{3}+3j$



$= 12$

그림 P7.8.7

풀이 :

KVL at Mesh1 ····· $12 = -2jI_1 + j(I_1 - I_2)$

$12 = -jI_1 - jI_2$

KVL at Mesh2 ····· $3\sqrt{3}+3j = j(I_2 - I_1) + 4I_2$

$3\sqrt{3}+3j = -jI_1 + (4+j)I_2$

$\rightarrow \quad 12 = -jI_1 - jI_2$

$- \quad 3\sqrt{3}+3j = -jI_1 + (4+j)I_2$

$12 - 3\sqrt{3} - 3j = (-4-2j)I_2$

$\rightarrow I_2 = \frac{(12-3\sqrt{3}-3j)}{(-4-2j)}$

$= \frac{(3\sqrt{3}-12+3j)}{4+2j}$

$\rightarrow V_o = 4 \cdot I_2 = 4 \cdot \frac{(3\sqrt{3}-12+3j)}{4+2j}$

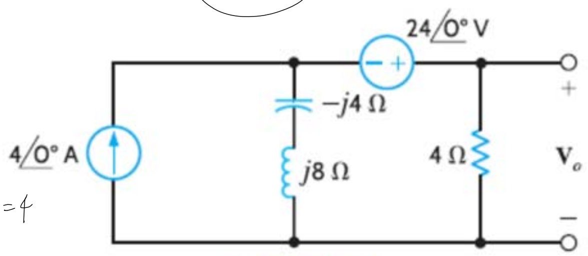
$= \frac{2(3\sqrt{3}-12+3j)}{2+j} \quad (2-j)$

$= \frac{2}{4+1}\left(6\sqrt{3} - 3\sqrt{3}j - 24 + 12j + 6j + 3\right)$

$= \frac{2}{5}\left[6\sqrt{3} - 21 + (-3\sqrt{3}+18)j\right] \quad (V)$

$\therefore V_o = \frac{2}{5}\left[6\sqrt{3} - 21 + (-3\sqrt{3}+18)j\right] \quad (V)$ //

7.8.9 문제 7.8.3을 중첩의 원리를 이용하여 구하라.

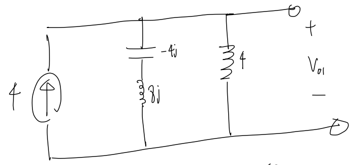


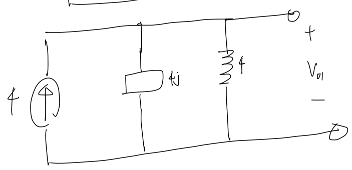
$= 4$

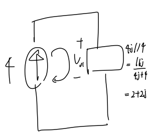
그림 P7.8.3

풀이 :

1) 전압원 제거 → 단락 (= 0V) (short)



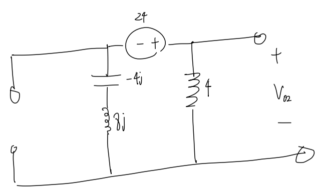


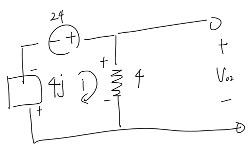


$4j // 4 = \frac{16j}{4j+4} = 2+2j$

$V_{o1} = 4(2+2j) = 8+8j\ [V]$

2) 전류원 제거 → 개방 (i = 0A) (open)





$V_{o2} = 4 \cdot i$

$24 = (4+4j)i$

$i = \frac{24}{4+4j} = \frac{6}{1+j} = \frac{6(1-j)}{2} = 3(1-j)$

$\rightarrow V_{o2} = 4i = 4 \cdot 3(1-j)$

$= 12 - 12j$

$V_o = V_{o1} + V_{o2}$

$= (8+8j) + (12-12j)$

$= 20 - 4j\ [V]$

$\therefore V_o = 20 - 4j\ [V]$ //

7.8.11 문제 7.8.3을 테브난의 정리를 이용하여 구하라.

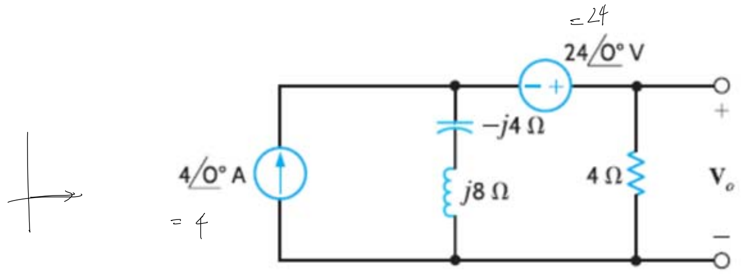
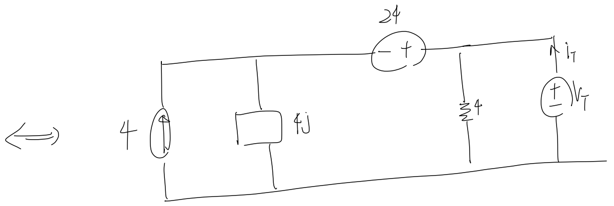
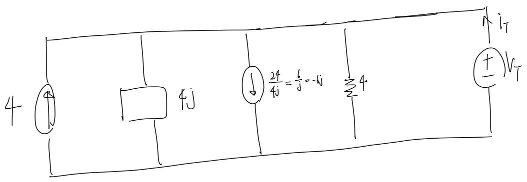
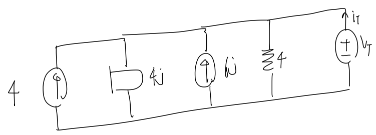


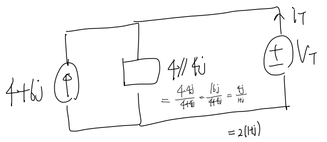
그림 P7.8.3

풀이 :

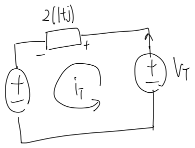








$2(4+6j)(1+j)$



$4+4j+6j-6$

$=-2+10j$

$$V_T = [2(1+j)]\,i_T + 2(4+6j)(1+j)$$

$$V_T = (2+2j)\,i_T + (-4+20j)$$

$\rightarrow R_{Th}: 2+2j$

$V_{Th}: -4+20j$

$\therefore V_o = -4+20j\ [V]$ //