1 장

1. 전기량$(q) = \int_0^2 6000t + 9000t^2 dt$

「 $\int t^n dt \rightarrow \frac{1}{n+1} t^{n+1}$ 」

$$\int_0^2 (6000t + 9000t^2) dt$$

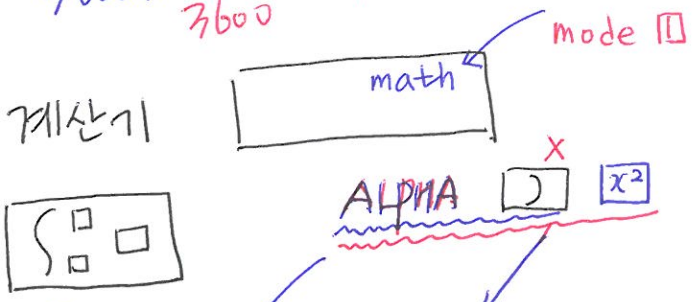
$$= \left[\frac{6000}{2} t^2 + \frac{9000}{3} t^3 \right]_0^2$$

$$= \left[3000 \times 2^2 + 3000 \times 2^3 \right]$$

$= 36000$ [A·S]

$= 36000 \times \frac{1}{3600}$ [Ah] $= 10$ [Ah]

「 계산기



$$\int_{0}^{2} (6000X + 9000X^2) dx$$

$= 36000$ [A.S]

$= 36000 \times \frac{1}{3600} = 10$ [Ah]

2. 1 [Kg·m/s]

* 1kg = 9.8N

1 [Kg·m/s] → 9.8N

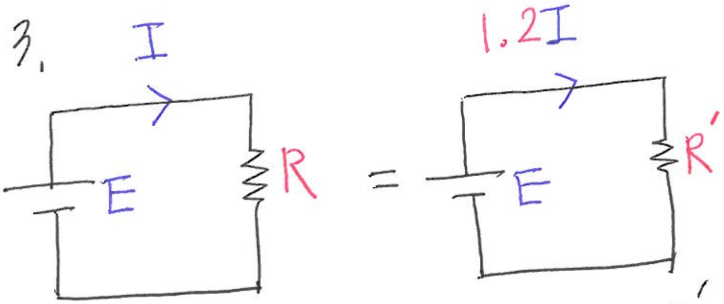
*

$= 1$ [9.8 N·m/s]

$= 9.8$ [Nm/s] → = J

$= 9.8$ [J/S] $= 9.8$ [W]

3.

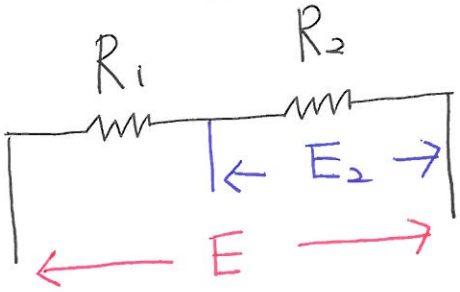


$E = IR$ ＝ $E = 1.2I \cdot R'$

$\cancel{I}R = 1.2\cancel{I} \cdot R'$

$\therefore R' = \frac{1}{1.2} R = 0.83R$

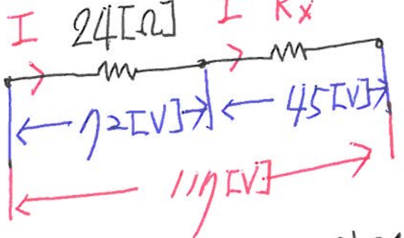
4



$$E_2 = \frac{R_2}{R_1 + R_2} \cdot E$$

「 직렬 분배전압 자기것 」

5



직렬에서는 전류가 일정하므로

$I = \frac{72}{24} = \frac{45}{R_x}$ 이용

$$I = \frac{72}{24} = 3 = \frac{45}{R_x}$$

$$R_x = \frac{45}{3} = 15[\Omega]$$

또는

$$72 = \frac{24}{24 + R_x} \times 117$$

계산기 미지수 구하는 방법

ALPHA $\boxed{\text{CALC}}$

$$72 = \frac{24}{24 + X} \times 117$$

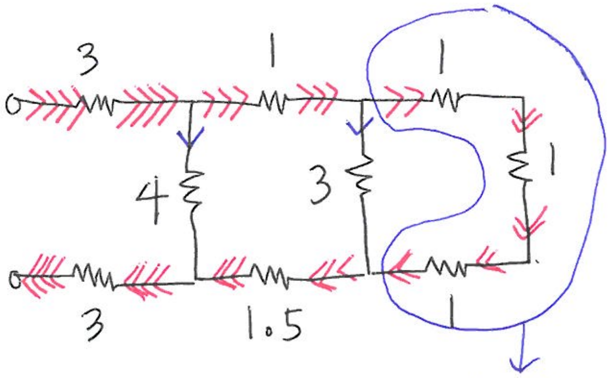
Shift SOLVE

solve for x
전에 계산한 값

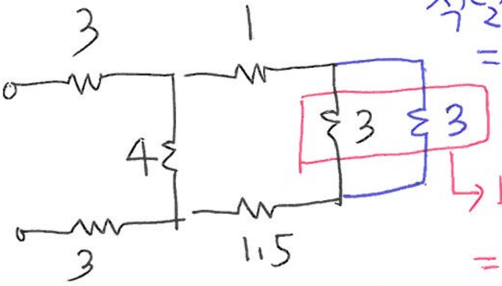
$\boxed{=}$

x = 15 ← 답
L-R = 0

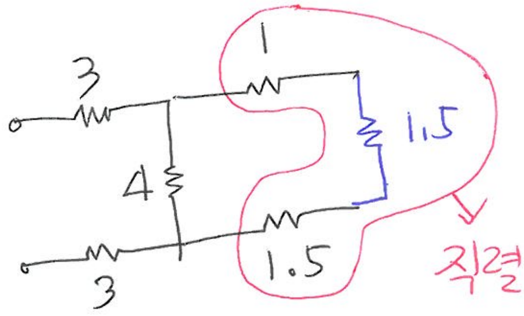
6.



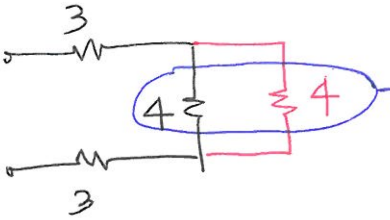
직렬 합성 = 3



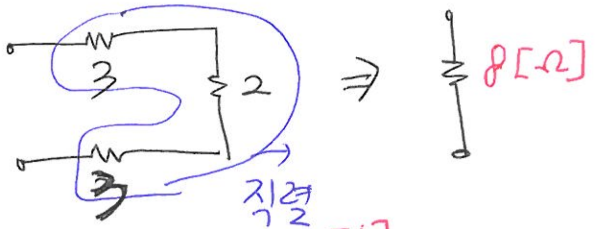
병렬합성 $= \frac{3}{2} = 1.5$



직렬 = 4

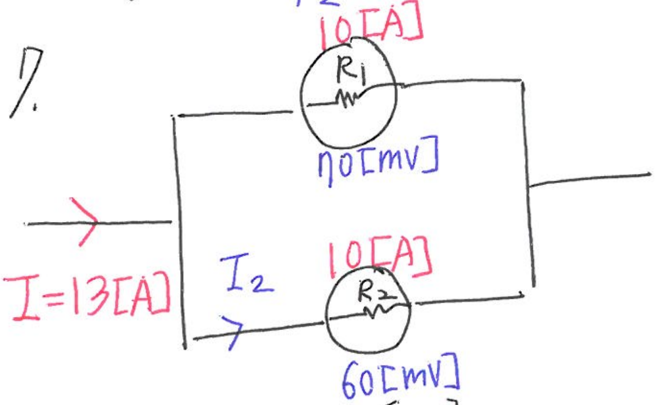


병렬 $= \frac{4}{2} = 2$



직렬

7.



$$\cdot R_1 = \frac{V}{I} = \frac{70[mV]}{10[A]} = 7[m\Omega]$$

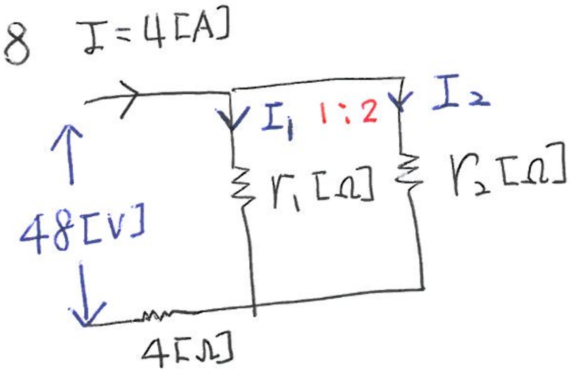
$$\cdot R_2 = \frac{V}{I} = \frac{60[mV]}{10[A]} = 6[m\Omega]$$

$$\cdot I_2 = \frac{R_1}{R_1 + R_2} \cdot I$$

$$= \frac{7}{7+6} \times 13$$

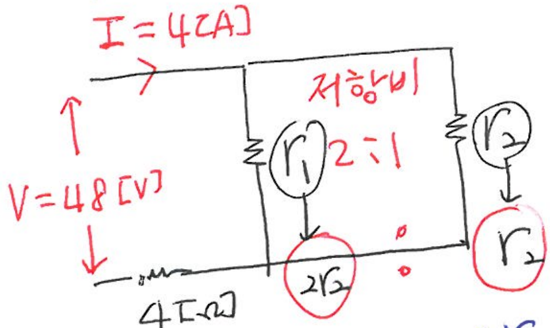
$$= 7[A]$$

8 $I = 4[A]$



∘ 병렬에서 전류비가 1:2이면

저항비는 2:1 ($I = \frac{V}{R}$ 기억)



$$합성저항(R) = 4 + \frac{2r_2 \times r_2}{2r_2 + r_2}$$

$$= 4 + \frac{2r_2^{\cancel{2}}}{3\cancel{r_2}}$$

$$= 4 + \frac{2}{3}r_2$$

$$R = \frac{V}{I} = 4 + \frac{2}{3}r_2$$

$$12 = \frac{48}{4} = 4 + \frac{2}{3}r_2$$

$$12 - 4 = \frac{2}{3}r_2$$

$$\frac{3}{2} \times 8 = \frac{3}{2} \times \frac{2}{3}r_2$$

$$\therefore r_2 = 12\,[\Omega]$$

$$r_1 = 2r_2 = 2 \times 12 = 24[\Omega]$$

9. 검류계전류 $= I_G = \frac{1}{n}I$

↳ = 전체 전류의 $\frac{1}{n}$

$$I_G = \frac{1}{n}I = \underbrace{\frac{r_1}{R+r_1} \cdot I}_{병렬의\ 분배전류}$$

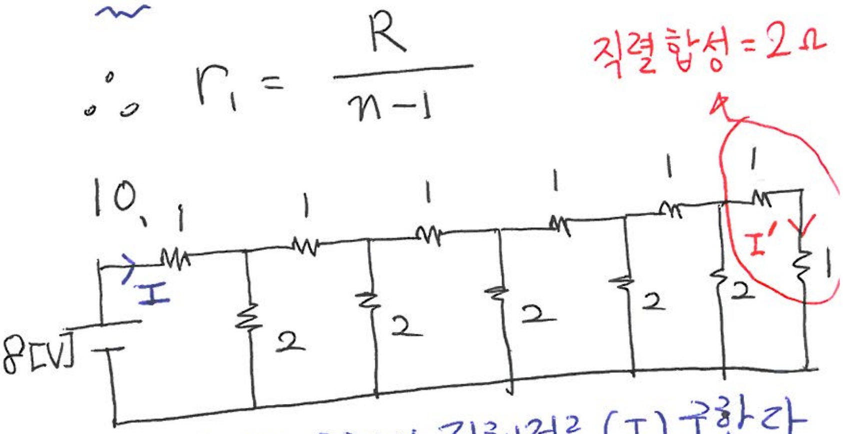
$$\frac{1}{n}\cancel{I} = \frac{r_1}{R+r_1} \cdot \cancel{I}$$

$$R + r_1 = n r_1$$

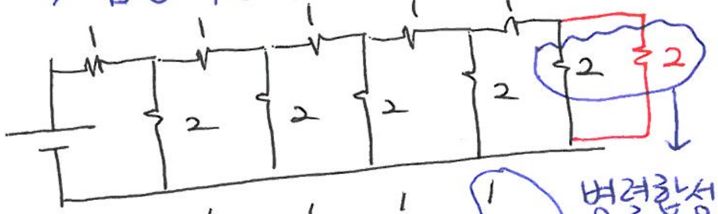
$$R = n r_1 - r_1 = (n-1) r_1$$

$$\therefore r_1 = \frac{R}{n-1}$$

10.

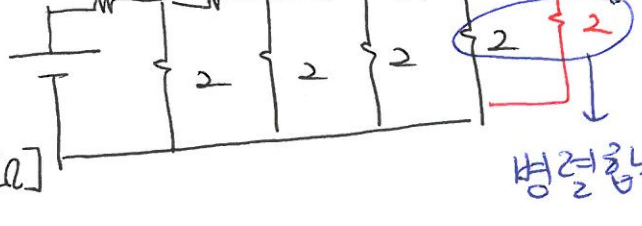


→ 합성저항 구해서 전체전류 (I) 구한다

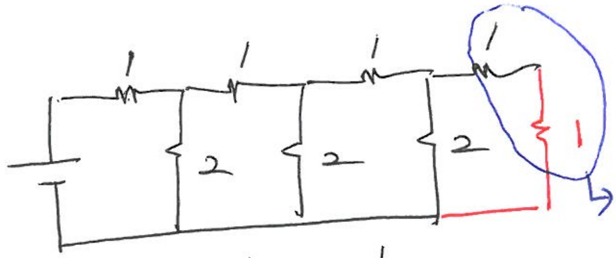


병렬합성=1Ω

↳ 직렬합성 =2[Ω]

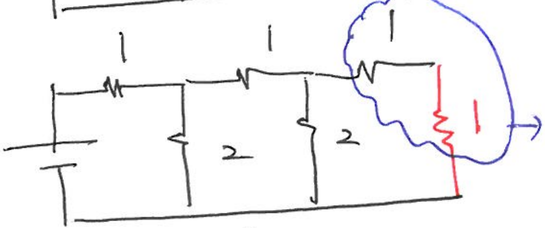


병렬합성=1[Ω]

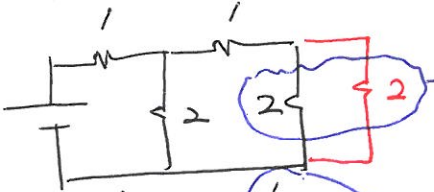


→ 직렬 = 2[Ω]

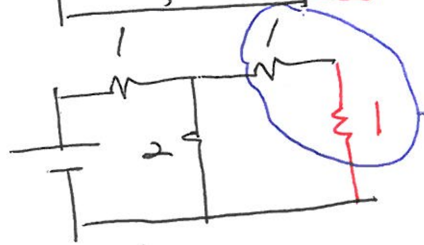
→ 병렬 = 1[Ω]



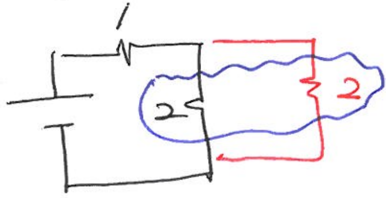
→ 직렬 = 2[Ω]



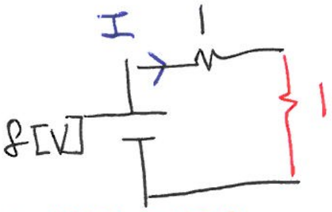
→ 병렬 = 1[Ω]



→ 직렬 = 2[Ω]

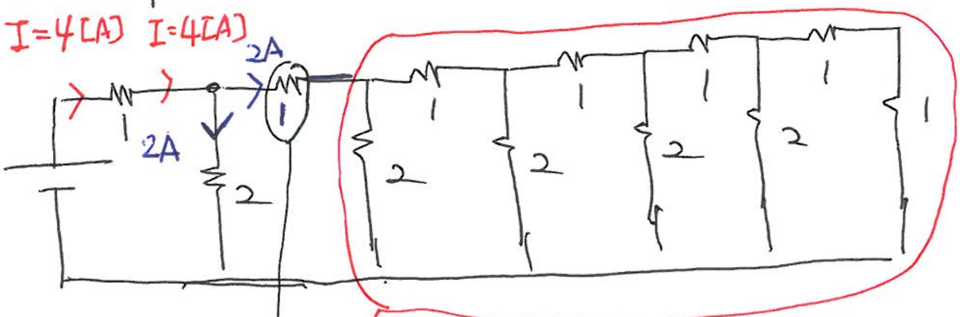


→ 병렬 = 1[Ω]



∴ 전체전류 (I)

$$I = \frac{8}{1+1} = 4[A]$$

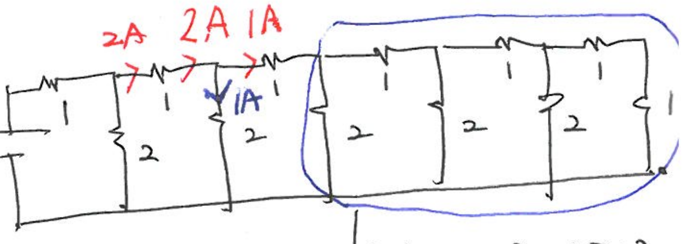


합성저항은 1[Ω] 이고

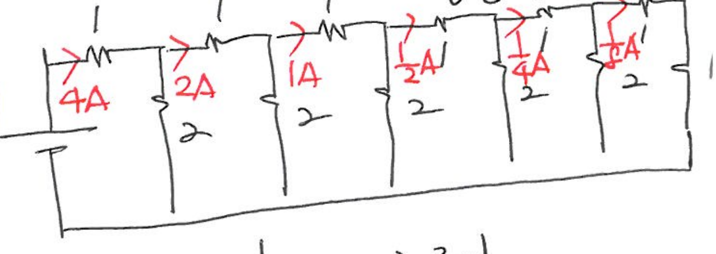
1Ω 과 직렬이므로

전체합성저항은 2[Ω] 이므로

전류는 반절씩 나눠진다

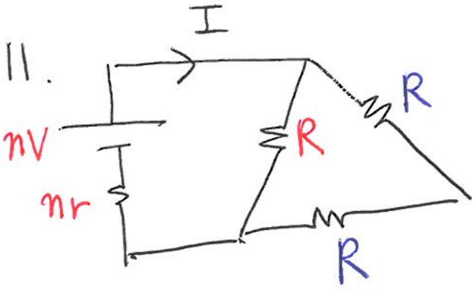


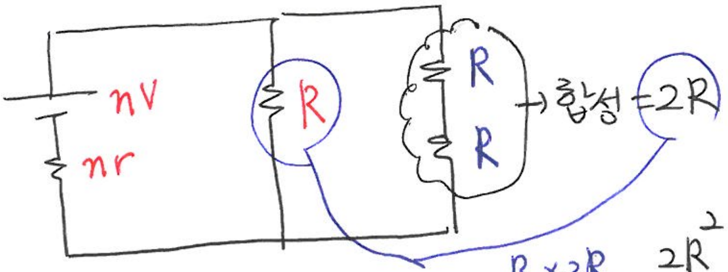
합성저항 1[Ω]



마지막은 $\frac{1}{8}$[A] 흐른다

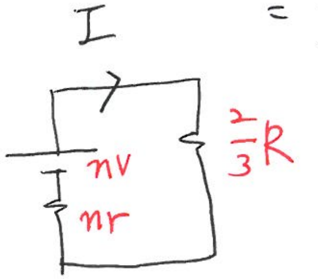
11.





$$합성 = \frac{R \times 2R}{R+2R} = \frac{2R^2}{3R}$$

$$= \frac{2}{3}R$$



$$nV = I(nr + \frac{2}{3}R)$$

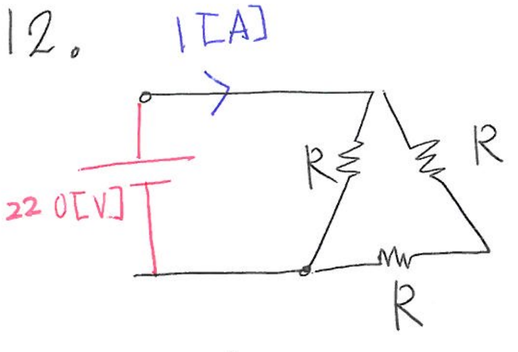
$$nr + \frac{2}{3}R = \frac{nV}{I}$$

$$\frac{2}{3}R = \frac{nV}{I} - nr$$

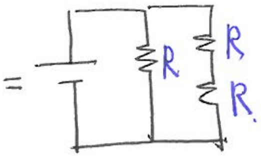
$$\frac{3}{2} \times \frac{2}{3}R = \frac{3}{2}n(\frac{V}{I} - r)$$

$$R = \frac{3}{2}n(\frac{V}{I} - r)$$

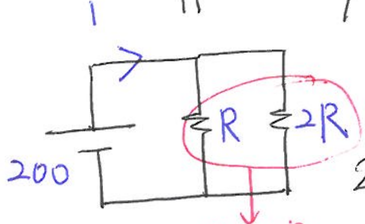
12.



=



||



$= \frac{R\times 2R}{R+2R}$

$= \frac{2R^2}{3R}$

$= \frac{2}{3}R$

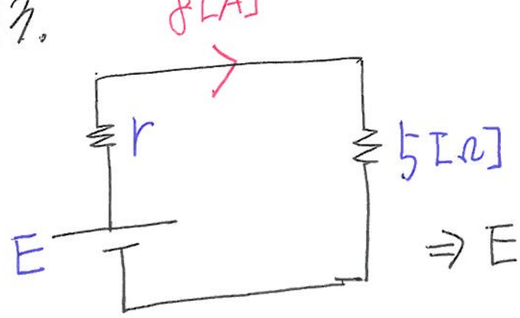
합성저항 $= \frac{V}{I} = \frac{2}{3}R$

$\frac{3}{2}\times \frac{220}{1} = \frac{3}{2}\times\frac{2}{3}R$

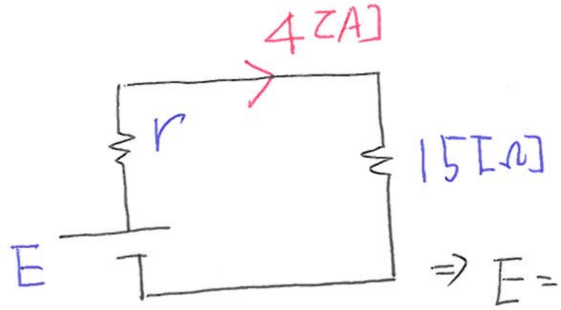
$\therefore R = \frac{3}{2}\times 220$

$= 330\ [\Omega]$

13.



$\Rightarrow E = 8\times(r+5)$



$\Rightarrow E = 4\times(r+15)$

$E = 8\times(r+5) = 4\times(r+15)$

$8r+40 = 4r+60$

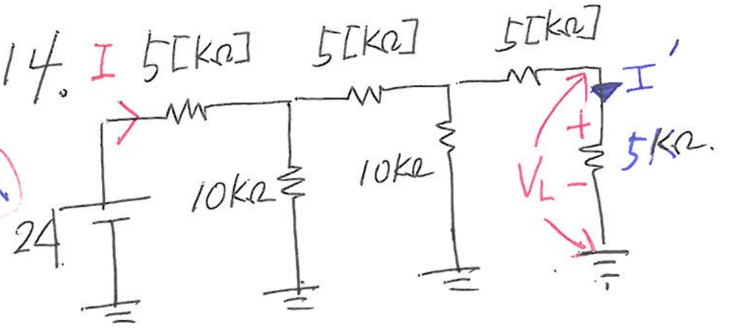
$8r-4r = 60-40$

$4r = 20 \Rightarrow r = 5\,[\Omega]$

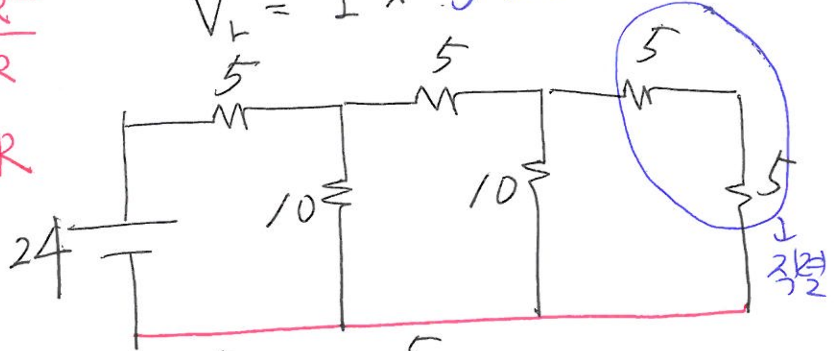
$E = 8\times(r+\overset{5}{5})$

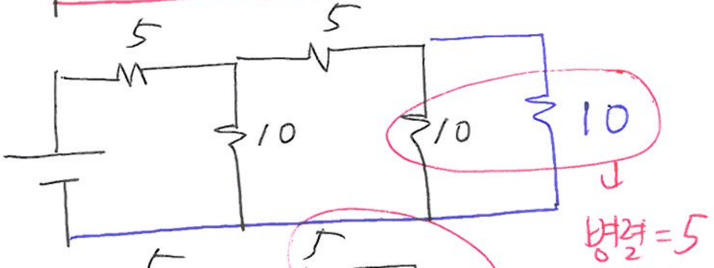
$= 8\times 10 = 80\ [V]$

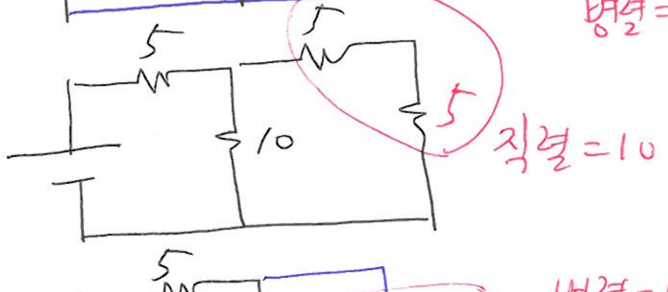
14.

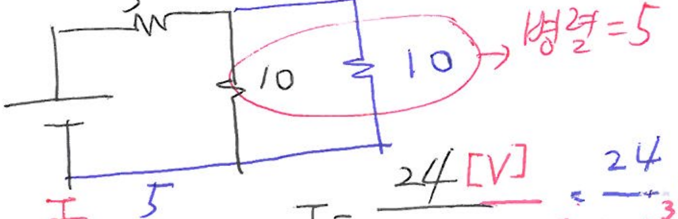


$V_L = I' \times 5\times10^3\,[\Omega]$



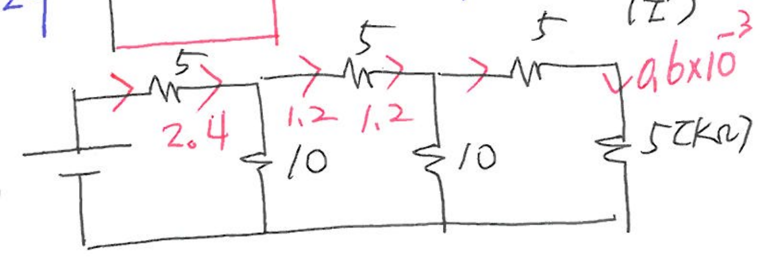






$I = \frac{24\,[V]}{(5+5)\,[k\Omega]} = \frac{24}{10\times10^3}\,[A]$

$= 2.4\times10^{-3}\,[A]$

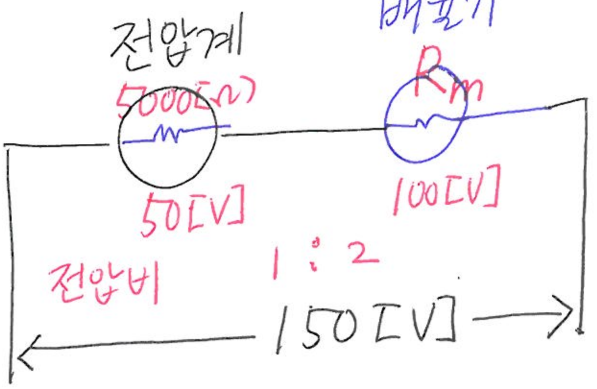


$V_L = I' \times 5 [k\Omega]$

$= 0.6 \times 10^{-3} \times 5 \times 10^{3} [\Omega]$

$= 3 [V]$

15.

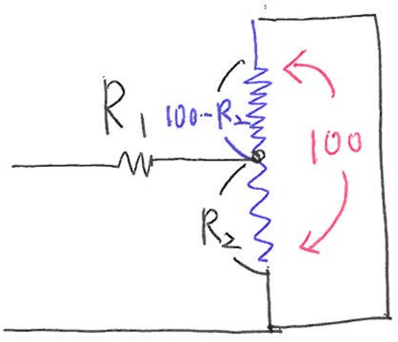


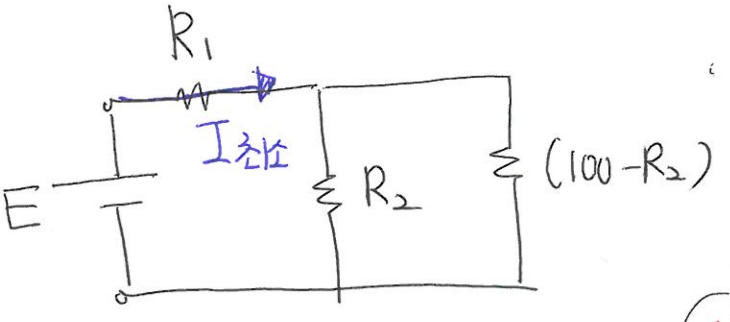
전압비 1 : 2 이면

저항비 1 : 2

5000 : 10,000 → 배율기 내부저항

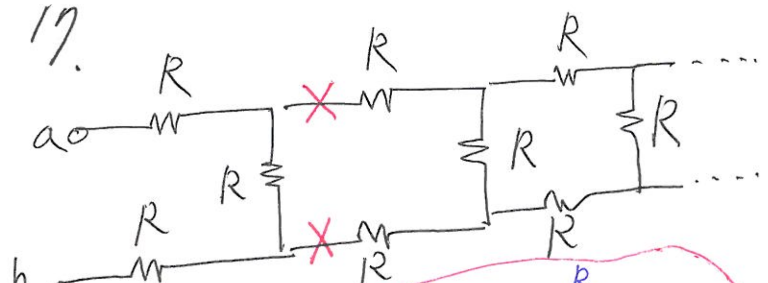
16.

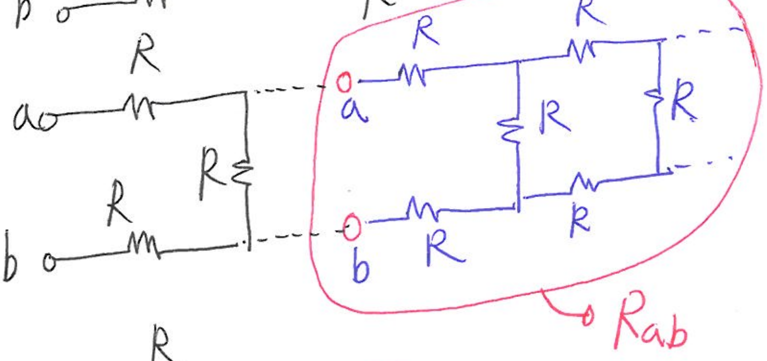


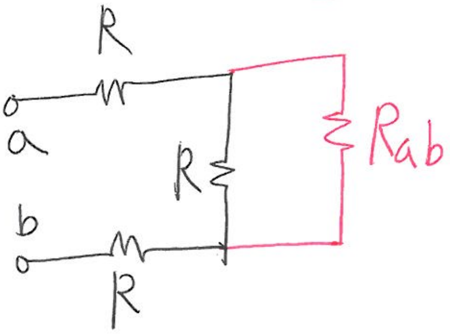


R₁에 흐르는 전류가 최소되려면
R₂가 100[Ω]의 $\frac{1}{2}$ 값인
50[Ω]일 때 최대저항이되어
R₁에 흐르는 전류가 최소가 된다

17.







$$R_{ab} = R + R + \frac{R \times R_{ab}}{R + R_{ab}}$$

$$R_{ab} = 2R + \frac{R \cdot R_{ab}}{R + R_{ab}}$$

$$R_{ab}(R + R_{ab}) = 2R \cdot (R + R_{ab}) + R \cdot R_{a}$$

$$\cancel{R R_{ab}} + R_{ab}^{2} = 2R^{2} + 2R R_{ab} + \cancel{R R_{ab}}$$

$$\boxed{1} R_{ab}^{2} \boxed{-2R} R_{ab} \boxed{-2R^{2}} = 0$$

근의 방정식

$$= \frac{-b \pm \sqrt{b^2-4ac}}{2 \times a}$$

$$= \frac{-(-2R) \pm \sqrt{(-2R)^2 - 4 \cdot 1 \cdot (-2R^2)}}{2 \times 1}$$

$$= \frac{2R \pm \sqrt{4R^2 + 8R^2}}{2}$$

단) $R=1$

$$= \frac{2 \times 1 \pm \sqrt{4 \cdot 1^2 + 8 \cdot 1^2}}{2}$$

$$= \frac{2 \pm \sqrt{4+8}}{2}$$

$$= \frac{2 \pm \sqrt{12}}{2}$$

$$= \frac{2 \pm 2 \cdot \sqrt{3}}{2}$$

$= 1 \pm \sqrt{3}$ 에서 저항은

(+) 값 이므로

$= 1 + \sqrt{3}$

계산기

$1 R_{ab}^2 - 2R R_{ab} - 2R^2 = 0$

에서 $R=1$

$\overset{a}{1} R_{ab}^2 \overset{b}{-2} R_{ab} \overset{c}{-2} = 0$

mode $\boxed{5}$

⋮

$3 : ax^2 + bx + c = 0$

3번선택

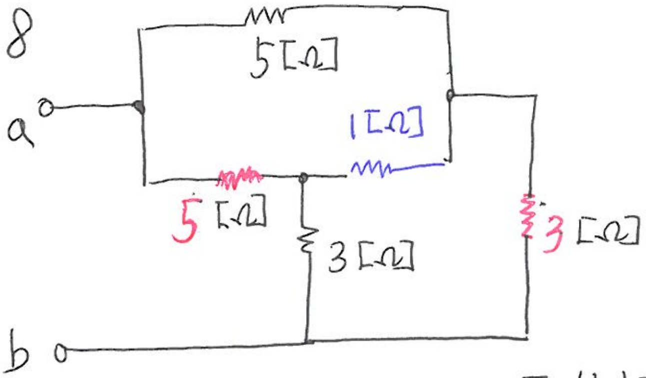
$$\begin{array}{cccc} & a & b & c \\ \lbrack & 1 & -2 & -2 \rbrack \end{array}$$

넘어갈때 $\boxed{=}$ 누름

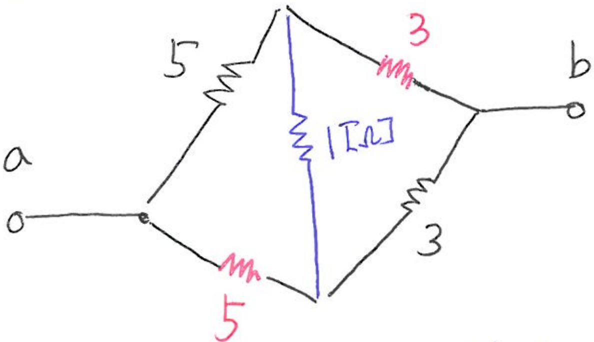
$X_1 = 2.732$, $X_2 = -0.\cancel{73}2$

$= 1+\sqrt{3}$

18

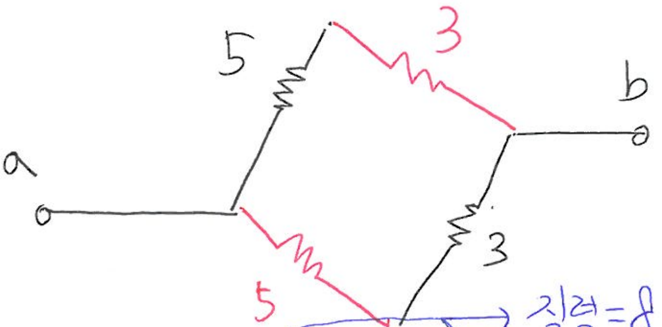


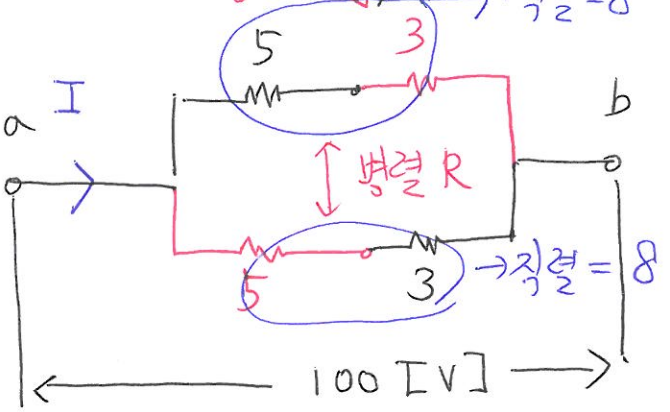
R이 5개 나오면 휘스톤 브리지 회로이고 만약 평형이면 1[Ω]을 개방하고 해석하면된다



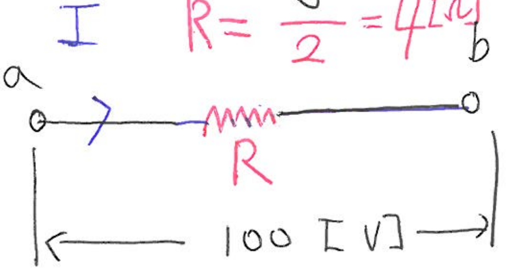
$5 \times 3 = 5 \times 3$ 같다

평형조건



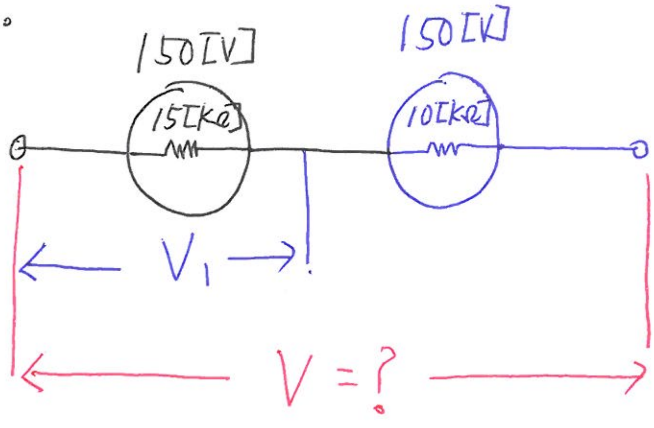


$$R=\frac{8}{2}=4[\Omega]$$



$$I=\frac{V}{R}=\frac{100}{4}=25[A]$$

19.



저항이 큰 전압계에 150[V]가 걸린다는 것을 이용하여

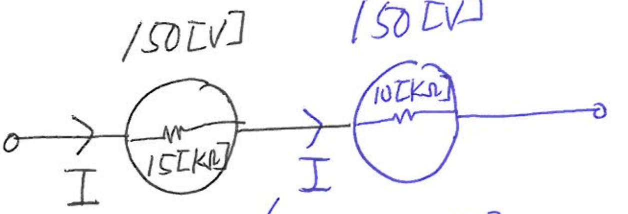
$$V_1=\frac{15}{15+10}\times V=150$$

$$15V=150(15+10)$$

$$15V=3750$$

$$V=\frac{3750}{15}=250[V]$$

또는

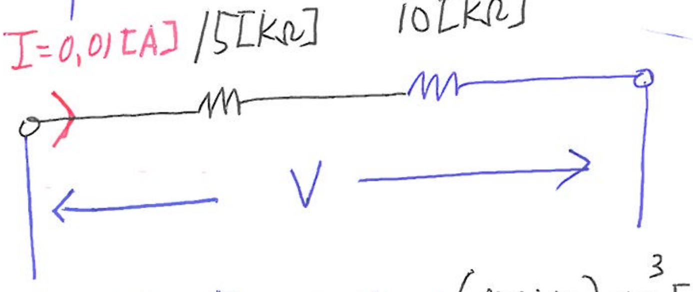


$$I=\frac{150[V]}{10\times10^3[\Omega]}=0,015[A]$$

$$I=\frac{150[V]}{15\times10^3[\Omega]}=0,01[A]$$

직렬은 전류가 같아야 한다.

전류가 같으려면 0,01 [A]가 흘러야 한다 (둘중에 작은전류)



$$V=I\times R=0,01\times(15+10)\times10^3[\Omega]$$

$$=250[V]$$

2장

1. 실효값(I)

$$I = \sqrt{\frac{1}{T}\cdot\int_0^T i^2\,dt}$$

$$I^2 = \frac{1}{T}\int_0^T i^2\,dt$$

$$I = \sqrt{i^2 \text{의 한주기 평균값}}$$

2. 정현파 평균값$(I_{av}) = \frac{2\cdot V_m}{\pi}$

$$I_{av} = \frac{2}{\pi}\cdot V_m = 0.636\,V_m$$

3. 실효값 314 ⇒ $\frac{V_m}{\sqrt{2}} = 314$

$$V_m = 314 \times \sqrt{2}$$

$$\text{평균값} = \frac{2\cdot V_m}{\pi} = \frac{2\times 314\times\sqrt{2}}{\pi}$$

$$= 282.6\ [V]$$

4 평균값 X 어떤수 = 실효값

↓

$$\frac{2I_m}{\pi} \times \square = \frac{I_m}{\sqrt{2}}$$

$$\square = \frac{\pi}{2\cdot\sqrt{2}}$$

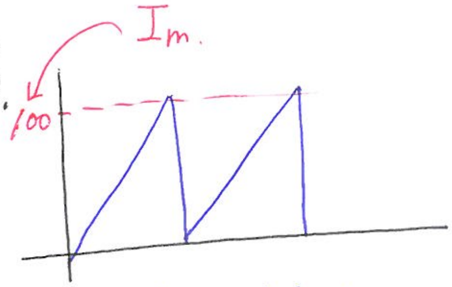
5 문제그림은 정현반파 = 반파정류

반파 정류 실효값 $= \frac{I_m}{\sqrt{2}} \times \frac{1}{\sqrt{2}}$

$\div\sqrt{2}$

$$= \frac{I_m}{2}$$

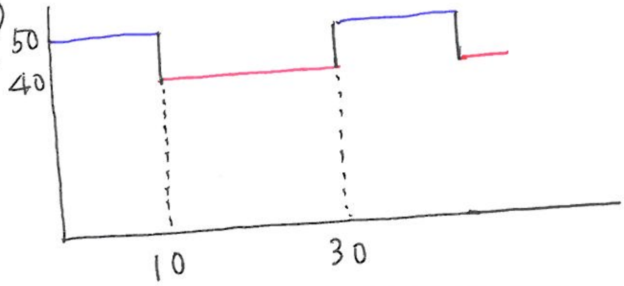
6.



톱니파 실효값 $= \frac{I_m}{\sqrt{3}}$

$$= \frac{100}{\sqrt{3}} = 57.7$$

7.



$$\text{실효값 } I = \sqrt{\frac{1}{T}\int_0^T i^2\,dt}$$

T = 주기 = 30

$$i^2 = \int_0^{10} 50^2\,dt + \int_{10}^{30} 40^2\,dt$$

$$I = \sqrt{\frac{1}{30}\cdot\left[\int_0^{10} 50^2\,dt + \int_{10}^{30} 40^2\,dt\right]}$$

$$* \int a\,dt \rightarrow at$$

$$I = \sqrt{\frac{1}{30}\left[2500t\Big|_0^{10} + 1600t\Big|_{10}^{30}\right.}$$

$$I = \sqrt{\frac{1}{30}\cdot\left[2500\times10 + (1600\times30) - (1600\times10)\right]}$$

$= 10\sqrt{19} = 43.58$ [A]

또는

$$I = \sqrt{\frac{1}{T}\int_0^T i^2\,dt}$$

$$= ③\sqrt{\underset{②}{\frac{1}{30}}\left[\underbrace{\int_0^{10}50^2\,dt+\int_{10}^{30}40^2\,dt}_{①}\right]}$$

계산기 모드

① $\int_0^{10}50^2\,dx+\int_{10}^{30}40^2\,dx$

$= 57000$

② $57000\times\frac{1}{30}=1900$

③ $\sqrt{1900}=10\sqrt{19}=43,58$

8. 파형률 $= \frac{\text{2등 실효값}}{\text{3등 평균값}}$

9. 실효값 표현 (I)

$$I=\sqrt{\frac{1}{T}\int_0^T i^2\,dt}$$

$$I=\frac{\text{최대값}}{\sqrt2}$$

$$I=\frac{\pi}{2\sqrt2}\times\text{평균값}$$

$$=\frac{\cancel{\pi}}{\cancel{2}\sqrt2}\times\frac{\cancel{2}\times\text{최대값}}{\cancel{\pi}}$$

$$=\frac{\text{최대값}}{\sqrt2}$$

10. 파형률 = 1.11 (1)

↳ 정현파

<참고>

정현반파 = 1.57

삼각파 = 1.15

11. 정현파 파고율 $= \dfrac{\text{최대값}}{\text{실효값}}$

$$= \frac{I_m}{\frac{I_m}{\sqrt{2}}}$$

$$= \frac{I_m \cdot \sqrt{2}}{I_m}$$

$$= \sqrt{2} = 1.414$$

12. 파고율 = 2

↳ 반파 정류 파고율 $= \dfrac{\text{최대값}}{\text{실효값}}$

$$= \frac{I_m}{\frac{I_m}{2}}$$

$$= \frac{I_m \cdot 2}{I_m}$$

$$= 2$$

13. 구형파는 파고율, 파형률 모두 1 이다

14. 구형파의 파형률 + 파고율

$$= 1 + 1 = 2$$

15. 구형 반파 파고율 $= \dfrac{\text{최대값}}{\text{실효값}}$

$$= \frac{I_m}{\frac{I_m}{\sqrt{2}}} = \frac{I_m \cdot \sqrt{2}}{I_m}$$

$$= \sqrt{2}$$

16. 열선형계기 ⇒ 실효값

가동코일형 ⇒ 평균값

구형 반파 가동코일형 (평균값)

$$= \frac{I_m}{2} = \frac{10\sqrt{2}}{2} = 5\sqrt{2}$$

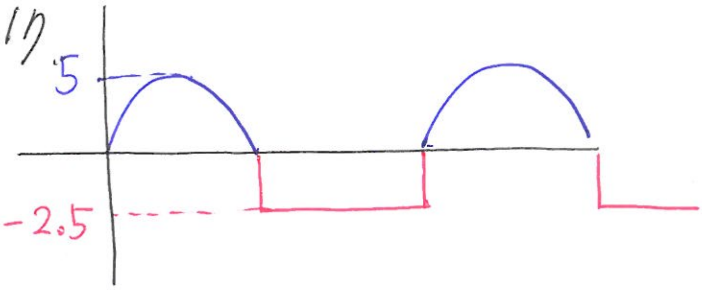
$$= 7.07$$

단) 구형 반파 열선형계기 (실효값) = 10

$$\frac{I_m}{\sqrt{2}} = 10$$

$$\therefore \boxed{I_m = 10\sqrt{2}}$$

17.



평균값 = 각 부분 평균값 합

= 정현반파 평균값 + 구형반파 평균값

$$= \frac{5}{\pi} + (-1.25) = 0.341$$

「 정형반파 평균값 $= \dfrac{I_m}{\pi} = \dfrac{5}{\pi}$

구형반파 평균값 $= \dfrac{I_m}{2} = \dfrac{-2.5}{2}$

$= -1.25$ 」

18 최대값 (V_m) = 100 [V]

$V(t) = V_m \sin(\omega t + \theta)$

$V(t) = 100 \sin(\omega t + \theta)$

t = 0 에서 50 [V] → V(0) = 50

$V(0) = 100 \cdot \sin(\omega \times 0 + \theta)$

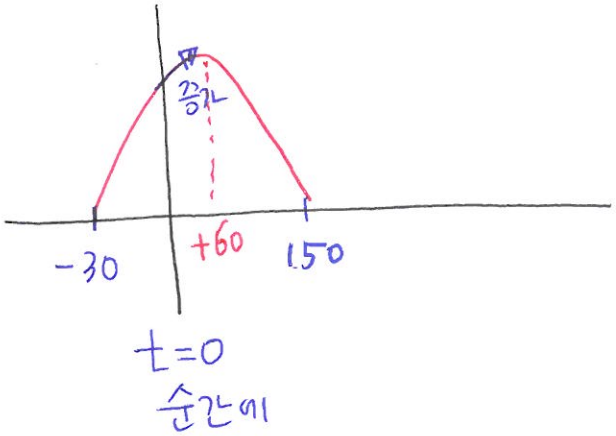
$= 100 \sin\theta = 50$

$\therefore \sin\theta = \frac{50}{100} = \frac{1}{2} = 0,5$

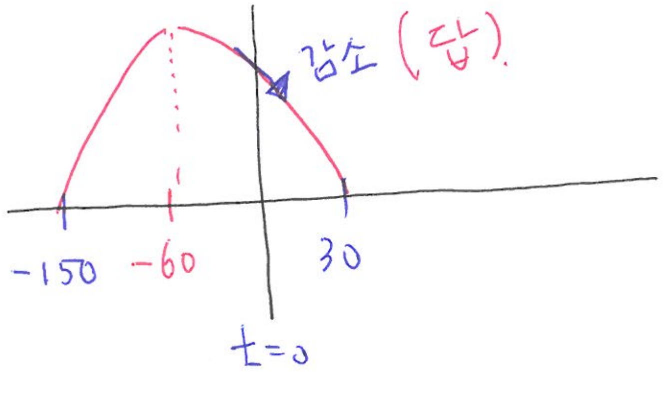
sin θ 가 0.5 나오는것은 30°, 150°

즉 θ = 30

$V(t) = 100 \sin(\omega t + 30)$



$V(t) = 100 \sin(\omega t + 150)$



19.

초기위상

$i_1 = 20\sqrt{2} \sin(\omega t + 60)$

↳ $A\angle\theta = \frac{20\sqrt{2}}{\sqrt{2}}\angle 60$

실효값. 초기위상

$= 20\angle 60$

$i_2 = 10\sqrt{2} \cdot \sin(\omega t - 30)$

↳ $A\angle\theta = 10\angle -30$

합성 $20\angle 60 + 10\angle -30$

계산기 CMPLX

↳ mode $\boxed{2}$

$20\angle 60 + 10\angle -30$

↳ Shift $\boxed{(-)}$

↳ [$\boxed{-}$ (−)]

= 복소수 $\boxed{S\Leftrightarrow D}$ = 18,66 + j 12.32

= Shift $\boxed{2}$ $\boxed{3}$ $\boxed{=}$

= $\boxed{10\sqrt{5}}\angle 33,43$

↳ $\boxed{S\Leftrightarrow D}$ $\underbrace{22,36}_{크기}\angle 33,43$

20. $I_1 = 10\angle \tan^{-1}\frac{4}{3}$

$I_2 = 10\angle \tan^{-1}\frac{3}{4}$

$I = I_1 + I_2$

$\boxed{\text{CMPLX}}$

$\tan^{-1}$

shift $\boxed{\tan}$

$10\angle \tan^{-1}\left(\frac{4}{3}\right) + 10\angle \tan^{-1}\left(\frac{3}{4}\right)$

$= 14 + 14i = 14 + j14$

21. $Z = 15 + j4$, $I = 10(2+j1)$

$V = Z \cdot I$

일단 10 빼고

$\boxed{\text{CMPLX}}$

$(15 + 4i) \times \boxed{10}(2 + 1i)$

$= 26 + 23i = 26 + j23$

$= \boxed{10}(26 + j23)$

$= 10(26 + j23)$

22. $E = 100 + j20$, $I = 4 + j3$

$Z = \frac{E}{I} = \frac{100 + 20i}{4 + 3i}$

$= 18,4 - 8,8i$

$= 18,4 - j8,8$

23 $A_1 = 20\left(\cos\frac{\pi}{3} + j\sin\frac{\pi}{3}\right)$

↳ $20\angle 60$

$A_2 = 5\left(\cos\frac{\pi}{6} + j\sin\frac{\pi}{6}\right)$

↳ $5\angle 30$

<참고>

$Z = a + jb <$ $|Z| = \sqrt{a^2+b^2}$, $\theta = \tan^{-1}\frac{b}{a}$

$\cos\theta = \frac{a}{Z}$, $\sin\theta = \frac{b}{Z}$

↳ $a = Z\cos\theta$ ↳ $b = Z\sin\theta$

$a + jb = Z\cos\theta + jZ\sin\theta$

$= Z(\cos\theta + j\sin\theta)$

$= Z \cdot e^{j\theta}$

$= Z\angle\theta$

응 (차)

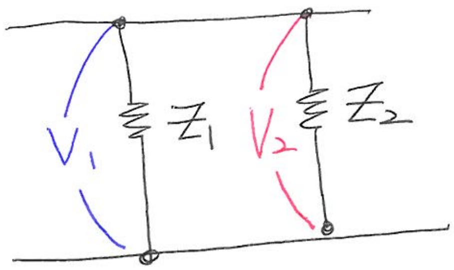
$$\frac{20\angle 60}{5\angle 30} = 4\angle 30$$

$4\angle 30$

$= 4\cdot(\cos 30 + j\sin 30)$

$= 4\cdot\left(\cos\frac{\pi}{6} + j\sin\frac{\pi}{6}\right)$

24.



$V_1 = \sqrt{3} + jY$, $V_2 = V\angle 30$

병렬회로 이므로 전압이 같다

$V_1 = V_2$

$\sqrt{3} + jY = V\angle 30$

〃 $= V\cdot(\cos 30 + j\sin 30)$

〃 $= V\cdot\left(\frac{\sqrt{3}}{2} + j\frac{1}{2}\right)$

$\boxed{\sqrt{3}} + j\boxed{Y} = \boxed{\frac{\sqrt{3}}{2}V} + j\boxed{\frac{1}{2}V}$

$\sqrt{3} = \frac{\sqrt{3}}{2}\cdot V$ $V=2$

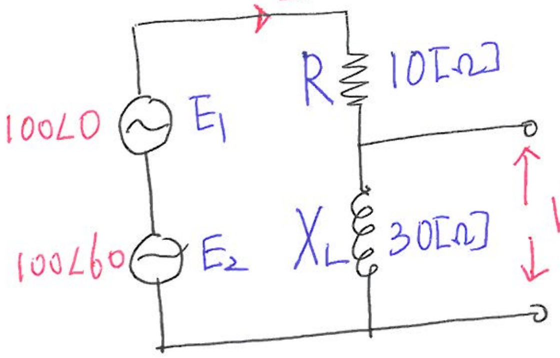
$Y = \frac{1}{2}\cdot \overset{2}{V} = 1$

<추가>

그림과 같은 회로에서 E_1, E_2가 각각 100[V]이면서 60°의 위상차가 있다

↳ $E_1 = 100\angle 0$, $E_2 = 100\angle 60$

유도리액턴스의 단자전압[V]은



① 164
② 174
③ 200
④ 150

$V_L = I\cdot X_L$ 단) $I = \frac{E_1+E_2}{Z}$

$= \left(\frac{E_1+E_2}{Z}\right)\cdot X_L$ 단) $Z = R + jX$

$= \left(\frac{E_1+E_2}{R+jX_L}\right)\cdot X_L$

$= \frac{E_1+E_2}{\sqrt{R^2+X_L^2}} \times X_L$

$= \frac{100\angle 0 + 100\angle 60}{\sqrt{10^2+30^2}} \times 30$

= 복소수 → shift $\boxed{2}$ $\boxed{3}$ $\boxed{=}$

$= 30\sqrt{30}\angle 30 = \underset{\text{답}}{164.3}\angle 30$

제3장

1. $V(t) = V_m \cdot \underset{\downarrow \sin\omega t}{\cos\omega t}$

$V(t) = V_m \cdot \sin(\omega t + 90)$

$i(t) = I_m \cdot \sin\omega t$

↳ 비교 ⇒ 전압이 전류보다 90° 빠르다

= 전류가 전압보다 90° 느리다

↳ 인덕턴스 소자 성질

2. 전압을 가하니 90° 위상 뒤진전류

↳ 전류가 전압보다 90° 느리다

(지상전류, 유도성 회로)

3. 0,1[H] 인 코일 ⇒ $L = 0,1[H]$

리액턴스 377[Ω] ⇒ $X_L = 377$

$X_L = 377$

↓

$\omega L = 2\pi f L = 377$

$\therefore f = \frac{377}{2\pi L} = \frac{377}{2\pi \times 0,1} = 600.014$

4. L 만의 회로 전류 i

$e_L = L\frac{di}{dt}$ 에서 양변에 $\int$

$\int e\, dt = L \overset{=1}{\boxed{\int dt \cdot \frac{d}{dt}}} \cdot i$

$L i = \int e\, dt$

$i = \frac{1}{L}\int e\, dt$

5 ② 일정한 전류가 흐를때 ⇒ $\frac{di}{dt} = 0$

전압은 ⇒ $V_L = L \cdot \boxed{\frac{di}{dt}}$ → 위조건에서 0

$= 0[V]$

6. $L = 2[H]$

$i(t) = 20 \cdot \varepsilon^{-2t} = 20 \cdot e^{-2t}$ 와같다

L의 단자전압 $= V_L = L \cdot \frac{di}{dt}$

$= L \cdot \frac{d}{dt} i = 2 \times \frac{d}{dt}[20 \cdot e^{-2t}]$

$= 2 \times 20 \times \frac{d}{dt} \cdot e^{-2t}$

$= 2 \times 20 \times -2 \cdot e^{-2t}$

$= -80 \cdot e^{-2t} = -80 \cdot \varepsilon^{-2t}$

지수함수 미분

$\frac{d}{dt} e^{-st} = -s \cdot e^{-st}$

↑ t 옆에 있는 -s를 밖으로 밀도 나머지는 곱

7 어떤 코일 ⇒ L

전류가 0,01 [s] 사이에 50[A]에서 10[A]

$\Rightarrow \frac{di}{dt} = \frac{50-10}{0,01} \Rightarrow$ $di = 50-10 = 40$, $dt = 0.01$

20[V] 기전력 $= V_L$

$V_L = L\frac{di}{dt} \Rightarrow L = \frac{V_L \cdot dt}{di}$

$L = \frac{20 \times 0.01}{40} = 5 \times 10^{-3}$ [H]

↓ $\times 10^3$

= 5 [mH]

8. 인덕턴스 ⇒ $L = 0.1[H]$ ⇒ $X_L = \omega L [\Omega]$

실효값 ⇒ $V = 100[V] \xrightarrow[\text{최대값}]{} V_m = 100\sqrt{2}$

위상각 0인 전압 가했을때 전류 순시값

↳ L 회로에서는 전류가 전압보다 $90°(=\frac{\pi}{2})$ 느리다

* 전류순시값$(i(t)) = I_m \cdot \sin(\omega t - 90)$

$$i(t) = \frac{V_m}{X_L} \cdot \sin(\omega t - 90)$$

$$= \frac{V_m}{\omega L} \cdot \sin\left(2\pi \times 60 t - \frac{\pi}{2}\right)$$

$$= \frac{100\sqrt{2}}{2\pi \times 60 \times 0.1} \times \sin\left(377 t - \frac{\pi}{2}\right)$$

$$= 3.75 \cdot \sin\left(377 t - \frac{\pi}{2}\right)$$

9. 4[H] 인덕터 ⇒ $L = 4[H]$

$X_L = \omega L = 100 \times 4 = 400$

$V = 8\angle -50° \Rightarrow V_m = 8 \cdot \sqrt{2} \angle -50°$

전류 순시값 ⇒ 각은 전압보다 90°느리다 $= -90°$

$$\hookrightarrow i = \frac{V_m}{X_L} \cdot \sin(\omega t \underbrace{-50}_{\text{전압위상각}} - 90)$$

$$i = \frac{V_m}{\omega L} \cdot \sin(100 t - 140)$$

$$i = \frac{8\sqrt{2}}{100 \times 4} \cdot \sin(100 t - 140)$$

$$= 0.02 \cdot \sin(100 t - 140)$$

10. 코일에 축적되는 평균에너지 $= W_L$

$$W_L = \frac{1}{2} \cdot \overset{[H]}{L} I^2 [J]$$

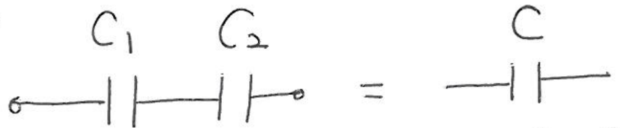
단) $I = \frac{V}{X_L}$ ↙ 실효값 $= \frac{V}{\omega L} = \frac{V}{2\pi f \cdot L[H}$

$$= \frac{50}{2\pi \times 60 \times 20 \times 10^{-3}}$$

$$W_L = \frac{1}{2} \times 20 \times 10^{-3} \times \left(\frac{50}{2\pi \times 60 \times 20 \times 10^{-3}}\right)^2$$

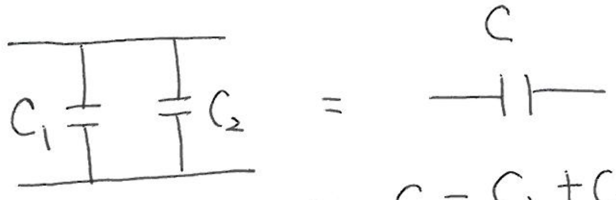
$$= 0.439 [J]$$

11.



$$C = \frac{C_1 \cdot C_2}{C_1 + C_2}$$

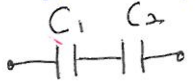
콘덴서 직렬은 저항의 병렬꼴과 같다



$$C = C_1 + C_2$$

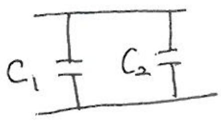
콘덴서 병렬은 저항의 직렬과같다

① 콘덴서 직렬연결시 합성정전용량 3.75



$$\Rightarrow C = \frac{C_1 \cdot C_2}{C_1 + C_2} = 3.75$$

② 콘덴서 병렬연결시 합성정전용량 16



$$\Rightarrow C = C_1 + C_2 = 16$$

③ $C_1 + C_2 = 16$, $\frac{C_1 \cdot C_2}{C_1 + C_2} = 3.75$

$C_1 + C_2 = 16$

$C_1 \cdot C_2 = 60$

보기에서 + =16

X =60은 6과10

$\frac{C_1 \cdot C_2}{16} = 3.75$

$C_1 \cdot C_2 = 3.75 \times 16$

$C_1 \cdot C_2 = 60$

12 용량리액턴스 $= X_C = \frac{1}{\omega C}$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f \cdot C}$

$= \frac{1}{2\pi \times 60 \times 1 \times 10^{-6}} = 2652.5[\Omega]$

13. $i(t) = I \cdot e^{st}$

전류가 C에 흐를때 → $\boxed{i = C\frac{dV}{dt}}$

임피던스 $= Z = \frac{V(t)}{i(t)} = \frac{\frac{1}{C}\boxed{\int i\,dt}}{I \cdot e^{st}}$

$Z = \frac{\frac{1}{C} \cdot \boxed{\frac{1}{s} I e^{st}}}{I \cdot e^{st}} = \frac{1}{CS}[\Omega]$

→ $\int i\,dt = \overset{=1}{\boxed{\int dt \cdot \frac{d}{dt}}} \cdot CV$

- $CV = \int i\,dt \Rightarrow V(t) = \frac{1}{C}\boxed{\int i\,dt}$
- $\boxed{\int i(t)dt} = \int I \cdot e^{st} dt = I \int e^{st} dt$

$= I \cdot \frac{1}{s} \cdot e^{st}$

14. $C = 3[\mu F]$, $X_C = 50[\Omega]$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi \cdot f \cdot C} = 50$

$\therefore f = \frac{1}{2\pi \times 50 \times C} = \frac{1}{2\pi \times 50 \times 3 \times 10^{-6}}$

$= 1061.03[HZ]$

$= 1.061 \times 10^{3}[HZ]$

15. C만의회로, 100 = 실효값 = V

60[mA] 전류 흐를때 C값.

$I = \frac{V}{X_C} = \frac{V}{\frac{1}{\omega C}} = \omega C V$

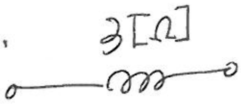
$C = \frac{I[A]}{\omega V} = \frac{60 \times 10^{-3}[A]}{2\pi \times 60 \times 100}$

$C = 1.59 \times 10^{-6}[F]$

$\downarrow \times 10^{6}$

$C = 1.59\ [\mu F]$

16.

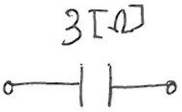


$X_L = \omega L = 2\pi f L = 3[\Omega]$

$L = \frac{3}{2\pi f} = \frac{3}{2\pi \times 60} = 7.9 \times 10^{-3}[H]$

$\downarrow \times 10^{3}$

$= 7.9\ [mH]$



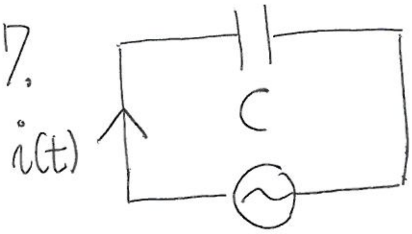
$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = 3[\Omega]$

$C = \frac{1}{2\pi \times 60 \times 3} = 8.84 \times 10^{-4}[F]$

$\downarrow \times 10^{6}$

$= 884\ [\mu F]$

17.



$e(t) = E_m \cdot \sin\omega t$.

$$i(t) = C \cdot \frac{d}{dt} \cdot e(t)$$

$$= C \cdot \frac{d}{dt} \cdot E_m \cdot \sin\omega t$$

$$= C E_m \frac{d}{dt} \sin\omega t$$

$$= C E_m \cdot \omega \cos\omega t$$

$$= \omega C E_m \cdot \underbrace{\overset{0°}{\cos\omega t}}_{\downarrow \sin} \text{ (기존각 +90)}$$

$$= \omega C E_m \cdot \sin(\omega t + 90)$$

18. 17번 결과식을 이용하는 문제.

위상각 0° 전압 $\xrightarrow{전류}$ 90° 빠르다

최대값 = $\sqrt{2}$ × 실효값

$$i(t) = \omega C E_m \cdot \sin(\omega t + 90)$$

$$= 2\pi \cdot 1000 \cdot 0.1 \times 10^{-6} \times \sqrt{2} \cdot 1414 \sin(\omega t + 90)$$

$$= 1.256 \cdot \sin(\omega t + 90)$$

19. 콘덴서 (c)에 흐르는 전류 (i_c)

$$i_c = C \frac{dV}{dt}\left[\frac{V}{S}\right] = 100 \times 10^{-6} \times 30 \left[\frac{V}{ms}\right]$$

$$= 100 \times 10^{-6} \times \frac{30}{10^{-3}} \left[\frac{V}{s}\right]$$

$$= 3 [A]$$

20 C 의 축적에너지 (W_c)

$$W_c = \frac{1}{2} \cdot C V^2 [J]$$

21.

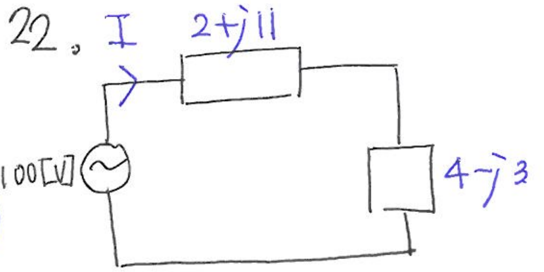
$$V = L \cdot \frac{di}{dt} \Rightarrow$$ L 에서는 시간에 따라 전류가 변한다

코일 ↙ L

$$i = C \frac{dV}{dt} \Rightarrow$$ C 에서는 시간에 따라 전압이 변한다

콘덴서 ↙ C

22.



$$I = \frac{100}{2+j11+(4-j3)} \Rightarrow \text{계산기}$$

$$I = \frac{100}{(2+11i)+(4-3i)}$$

$$I = 6-8i = \boxed{6-j8}$$

$$|I| = \sqrt{6^2+8^2} = 10 [A]$$

$$\boxed{6-8i}$$

Shift $\boxed{2}$ $\boxed{3}$ $\boxed{=}$ $\underset{\text{답}}{10}\angle -53.1$

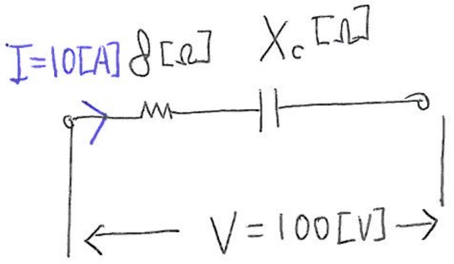
23. R-C 직렬 ····· 전류(I)

$$I = \frac{V}{Z} = \frac{V}{R-jX_c} = \frac{V}{\sqrt{R^2+X_c^2}}$$

$$= \frac{V}{\sqrt{R^2+\left(\frac{1}{wC}\right)^2}} = \frac{100}{\sqrt{100^2+\left(\frac{1}{2\pi\cdot 60\cdot 30\times10^{-6}}\right)^2}}$$

$= 0{,}749[A]$

24.



$$I = \frac{V}{Z} = \frac{V}{R-jX_c} = \frac{V}{\sqrt{R^2+X_c^2}}$$

$$I = \frac{V}{\sqrt{R^2+X_c^2}} = \frac{100}{\sqrt{8^2+X_c^2}} = 10$$

$$\frac{100}{10} = \sqrt{8^2+X_c^2} = 10$$ (양변제곱)

$$8^2+X_c^2 = 10^2 = 100$$

$$X_c^2 = 100-8^2 = 100-64 = 36$$

$$\sqrt{X_c^2} = \sqrt{36} \Rightarrow X_c = 6[\Omega]$$

25. R-L 직렬 ···· $\cos\theta = \frac{R}{\sqrt{R^2+X_L^2}}$

$$\cos\theta = \frac{50}{\sqrt{50^2+(2\pi\times 50\times 200\times10^{-3})^2}}$$

$= 0{,}622 \times 100[\%] = 62{,}2[\%]$

26. R-C 직렬 ···· $\cos\theta = \frac{R}{\sqrt{R^2+X_c^2}}$

$$\cos\theta = \frac{100}{\sqrt{100^2+\left(\frac{1}{2\pi\times 50\times 10\times10^{-6}}\right)^2}}$$

$= 0{,}29$

27. R-C직렬 ··· $\cos\theta = \frac{R}{\sqrt{R^2+X_c^2}}$

$$\cos\theta = \frac{9}{\sqrt{9^2+2^2}} = 0{,}976$$

28.

① 저항은 Z의 실수값

$V = 100\sin 120\pi t$

↳ $A\angle\theta = \frac{100}{\sqrt{2}}\angle 0$

$i = 2\sin(120\pi t - 45)$

↳ $A\angle\theta = \frac{2}{\sqrt{2}}\angle -45$

② $$Z = \frac{V}{I} = \frac{\frac{100}{\sqrt{2}}\angle 0}{\frac{2}{\sqrt{2}}\angle -45}$$

$$= \underbrace{35{,}35}_{R} + j\underbrace{35{,}35}_{X}$$

$R = 35{,}35 = \frac{50}{\sqrt{2}}$

29. R-L-C 직렬 ····· 최대값 전류 (I_m)

$e = \overset{V_m}{100} \sin(\omega t + 30)$

$I_m = \frac{V_m}{Z} = \frac{V_m}{R + jX_L - jX_c}$

$= \frac{100}{30 + j70 - j30} = \frac{100}{30 + j40}$

$= \frac{100}{\sqrt{30^2 + 40^2}} = \frac{100}{50} = 2[A]$

30 R-L-C 직렬회로에서
최대전류는 공진 일때이다
(주파수 0 에서 ∞까지 변화)

$I_m = \frac{V}{Z} = \frac{V}{R + jX_L - jX_c}$

$I_m = \frac{V}{R + j(X_L - X_c)}$ 단) $X_L = X_c$ 공진

$I_m = \frac{V}{R} = \frac{100}{10 \times 10^3} = 10 \times 10^{-3}$ [A]

$= 10$ [mA]

31. R-L-C 직렬에서 C의 단자전압

$V_c = I \cdot X_c$ 단) $I = \frac{V}{Z}$

$V_c = I \cdot X_c$ 단) $I = \frac{V}{Z} = \frac{V}{R + j(X_L - X_c)}$

$= \frac{\frac{141.4}{\sqrt{2}}}{200 + j(600 - 800)} \times 800$

$= \frac{\frac{141.4}{\sqrt{2}}}{200 - j200} \times 800$ = 복소수 나오면
크기로 변환 = 282.8[V

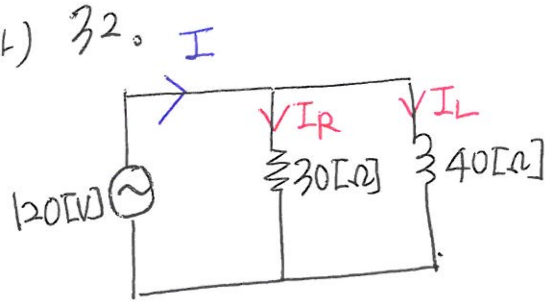
◎ $V = \underset{V_m}{\boxed{141.4}} \sin \underset{\omega}{377} t$

$\rightarrow V = \frac{V_m}{\sqrt{2}}$

$X_L = \omega L = 377 \times 1.59 \fallingdotseq 600$ [Ω

$X_c = \frac{1}{\omega C} = \frac{1}{377 \times 3.315 \times 10^{-6}} = 800$ [Ω]

32.



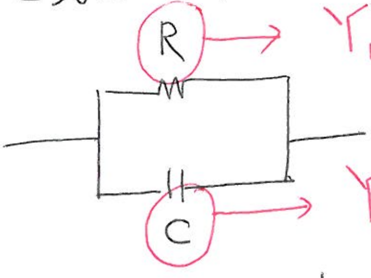
$I = I_R - jI_L$

$I = \frac{V}{R} - j\frac{V}{X_L} = \frac{120}{30} - j\frac{120}{40}$

$I = \overset{I_R}{4} - j\overset{I_L}{3} \Rightarrow |I| = \sqrt{4^2 + 3^2} = 5[A]$

$\cos\theta = \frac{I_R}{I} = \frac{4}{5} = 0.8$

33. $e_s(t) = 3 \cdot e^{-5t}$



$\rightarrow Y_1 = \frac{1}{R}$

$\rightarrow Y_2 = j\omega C$

$$Z = \frac{1}{Y} = \frac{1}{\frac{1}{R} + j\omega C} = \frac{1}{1 + j\omega CR}$$

$Z = \frac{1}{1 + j\omega CR}$ 보기에 답 없음

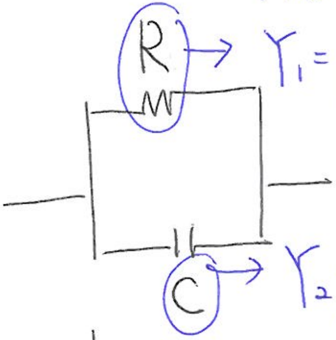
$Z = \frac{1}{1 - 5CR}$

$$e_s(t) = 3 \cdot e^{\textcircled{-5}t} \overset{j\omega = -5}{=} 3 \cdot e^{\textcircled{j\omega}t}$$

지수함수꼴 $= A \cdot e^{j\theta}$ 에서 $\theta = \omega t$

$= A e^{\textcircled{j\omega}t}$ t 옆에 있는 값이 jω값

34.



$\rightarrow Y_1 = \frac{1}{R}$

$\rightarrow Y_2 = j\omega C$

$Y = Y_1 + Y_2$

$$Y = \frac{1}{R} + j\omega C$$

$$= \frac{1}{R}(1 + j\omega CR)$$

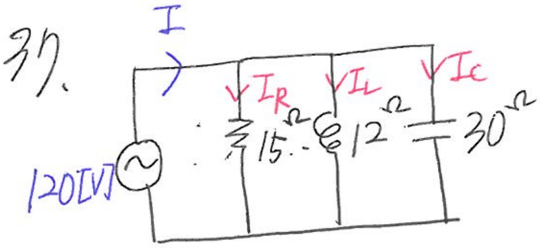
35 R − X 병렬 $\cos\theta = \frac{X}{\sqrt{R^2 + X_c^2}}$

$$\cos\theta = \frac{X_c}{\sqrt{R^2 + X_c^2}} = \frac{\frac{1}{\omega C}}{\sqrt{R^2 + (\frac{1}{\omega C})^2}}$$

$$\frac{\frac{1}{\omega C}}{\sqrt{R^2 + (\frac{1}{\omega C})^2}} \times \frac{\omega C}{\sqrt{(\omega C)^2}} = \frac{1}{\sqrt{1 + (\omega CR)^2}}$$

36. 32번 문제와 동일

37.



$$I = I_R - jI_L + jI_C$$

$$I = \frac{V}{R} - j\frac{V}{X_L} + j\frac{V}{X_C}$$

$$I = \frac{120}{15} - j\frac{120}{12} + j\frac{120}{30}$$

$$= 8 - j10 + j4$$

$$= \boxed{8} - j6 \Rightarrow |I| = \sqrt{8^2 + 6^2} = 10[A]$$

$I_R \rightarrow$

$$\cos\theta = \frac{I_R}{|I|} = \frac{8}{10} = 0.8 \xrightarrow{\times 100[\%]} = 80[\%]$$

38. 동상 나오면 공진

$$X_L = X_C \Rightarrow \omega L = \frac{1}{\omega C}$$

$$\boxed{\omega^2 LC = 1}$$

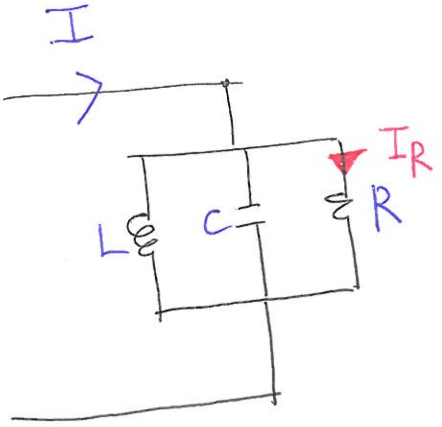
39. 직렬공진 [Z 최소, I 최대

40. 직렬공진시 C값

$\omega^2LC = 1$ 에서 $C = \frac{1}{\omega^2 L}$

$$C = \frac{1}{(2\pi \times 1000)^2 \times 20\times10^{-3}} = 1.26\times10^{-6}\,[F] = 1.26\,[\mu F]$$

41.



$I = I_R$ 되는 조건은 공진일때

즉 공진주파수 구하라?

$$\omega^2LC = 1$$

$$\omega^2 = \frac{1}{LC} \Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

$$2\pi f = \omega = \frac{1}{\sqrt{LC}}$$

$$\therefore f = \frac{1}{2\pi\sqrt{LC}}$$

42. 병렬공진 [Y = 최소, I = 최소

43. 직렬공진 시 선택도 Q

$$Q = \frac{\sqrt{\frac{L}{C}}}{R} = \frac{1}{R}\cdot\sqrt{\frac{L}{C}}$$

44. 직렬공진 첨예도=선택도 Q

$$Q = \frac{\sqrt{\frac{L}{C}}}{R} = \frac{\sqrt{\frac{10\times10^{-3}}{1\times10^{-6}}}}{10} = 10$$

45. 병렬공진시 선택도 Q

$$Q = R\cdot\sqrt{\frac{C}{L}} \Rightarrow Q \propto R$$

R이 커지면 Q 커진다

46. 공진시 어드미턴스(어드미턴스허수부=0)

$$Y = \frac{1}{R+j\omega L} + j\omega C \quad \begin{pmatrix}(a+b)\times(a-b)\\ = a^2-b^2\end{pmatrix}$$

$$= \frac{1}{(R+j\omega L)} \times \frac{(R-j\omega L)}{(R-j\omega L)} + j\omega C$$

$$= \frac{R-j\omega L}{R^2 - \underbrace{(j\omega L)^2}_{j^2\omega^2L^2 = -\omega^2L^2}} + j\omega C = \frac{R-j\omega L}{R^2+\omega^2L^2} + j\omega C$$

$$Y = \frac{R}{R^2+\omega^2L^2} + j\Big(\omega C - \frac{\omega L}{R^2+\omega^2L^2}\Big)$$

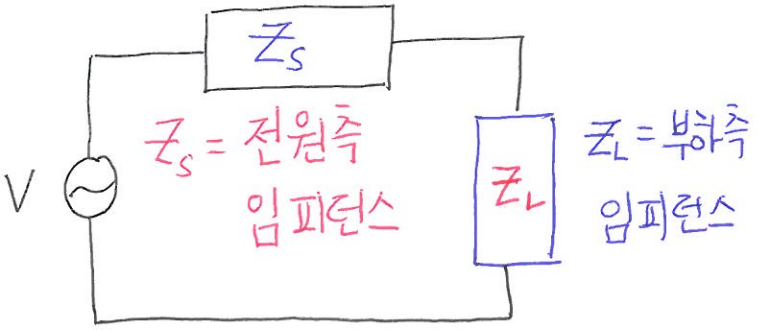
$$\hookrightarrow \cancel{\omega}C = \frac{\cancel{\omega}L}{R^2+\omega^2L^2}$$

$$R^2+\omega^2L^2 = \frac{L}{C}$$

$$Y_0 = \frac{R}{R^2+\omega^2L^2} = \frac{R}{\frac{L}{C}} = \frac{RC}{L}$$

4장

3. 최대 전력



1) 최대 전력 조건

① 최상의 방법

공액복소수

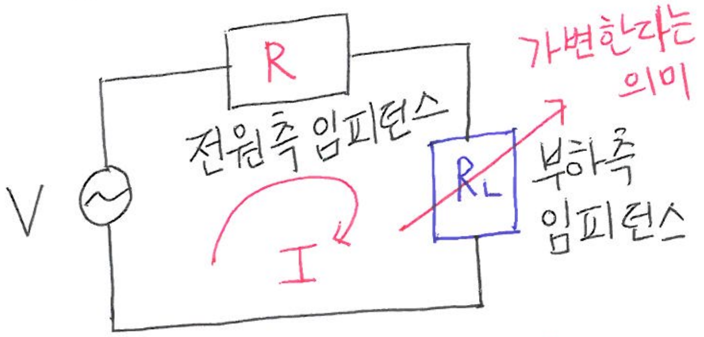
$Z_L = Z_s^*$ ⇒ 복소수일때

② 차선책

$|Z_L| = |Z_s|$ ⇒ 실수 또는 허수일때

2) 적용 예

① R 과 R_L 일때



㉠ 부하전력(P_L) = $I^2 \cdot R_L$ [W]

↳ 직렬이므로 (I^2R) 이용

$P_L = I^2 R_L$ 단) $I = \frac{V}{R+R_L}$

$P_L = \left(\frac{V}{R+R_L}\right)^2 \times R_L$

$$P_L = \frac{V^2}{(R+R_L)^2} \times R_L$$

㉡ 최대 전력 조건

전원측 실수, 부하측 실수이므로 차선책 적용

$|Z_L| = |Z_s|$

$|R_L| = |R|$

∴ $R = R_L$

㉢ 최대전력(P_m)

↳ 부하전력(P_L) 결과에 최대전력 조건 ($R=R_L$) 적용

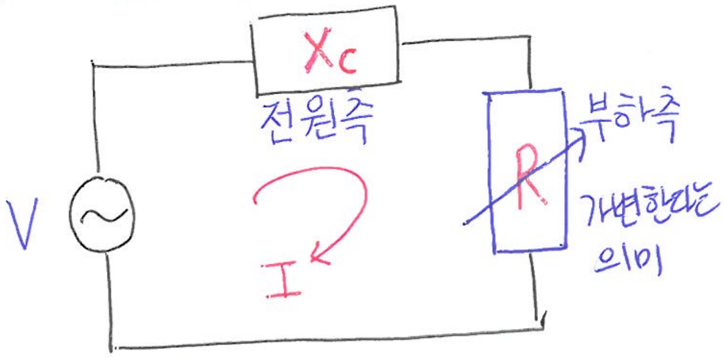
$P_m = \frac{V^2}{(R+R_L)^2} \times R_L$ 단) $R=R_L$

$P_m = \frac{V^2}{(R+R)^2} \times R$

$= \frac{V^2}{(2R)^2} \times R = \frac{V^2}{4R^{\cancel{2}}} \times \cancel{R}$

$P_m = \frac{V^2}{4R}$ 또는 $\frac{V^2}{4R_L}$ [W]

② R 과 X_c 일때



㉠ 부하전력 (P_L) = $I^2 \cdot R$ [W]

$P_L = I^2 \cdot R$ 단) $I = \frac{V}{R - jX_c}$

$P_L = \left(\frac{V}{\sqrt{R^2+X_c^2}}\right)^2 \cdot R$ $I = \frac{V}{\sqrt{R^2+X_c^2}}$

$P_L = \frac{V^2}{R^2+X_c^2} \times R$ [W]

㉡ 최대 전력 조건 } 전원, 허수 부하, 실수 차선책

$|Z_L| = |Z_s|$

$|R| = |X_c|$

$\therefore R = X_c$

㉢ 최대전력 (P_m) } 부하전력 식에 $R=X_c$ 적용

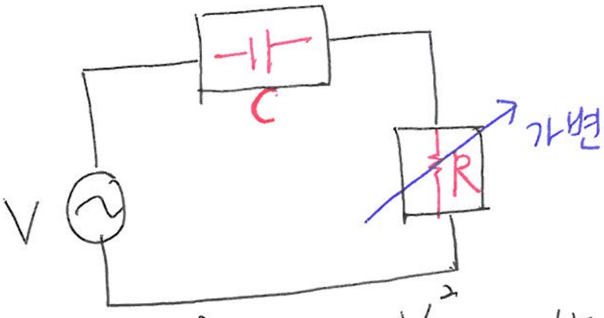
$P_m = \frac{V^2}{R^2+X_c^2} \times R$ 단) $R=X_c$

$P_m = \frac{V^2}{R^2+R^2} \times R$

$P_m = \frac{V^2}{2R^{\cancel{2}}} \times \cancel{R}$

$P_m = \frac{V^2}{2R}$ 또는 $\frac{V^2}{2\cdot X_c}$

만약 최대전력 물어 보면.



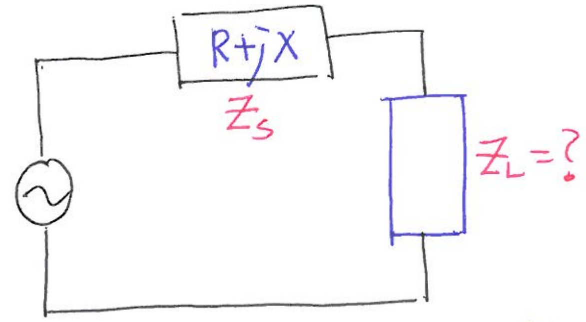
$P_m = \frac{V^2}{2R}$ 과 $\frac{V^2}{2X_c}$ 있는데.

R 값은 안주고 X_c 값 알수있으면

$P_m = \frac{V^2}{2\cdot X_c} = \frac{V^2}{2\cdot\frac{1}{wC}} = \frac{1}{2}\cdot wCV^2$ [W]

$\therefore P_m = \frac{1}{2} \times w \times C \times V^2$ [W]

③



* 전원측 임피던스 가 R+jX 일때 최대전력 조건 Z_L=?

< 복소수 이므로 최상의 방법 >

$Z_L = Z_s^* = (R+jX)^*$

$= R-jX$

4장

1. $e = \overset{V_m}{100} \cdot \sin(100\pi t + 30)$

↳ $A\angle\theta = \frac{100}{\sqrt{2}}\angle 30$ → 전압실효값

$i = \overset{I_m}{10} \cdot \cos(100\pi t - 60)$ → 기존각 +90

$= 10 \cdot \sin(100\pi t + 30)$

↳ $\frac{10}{\sqrt{2}}\angle 30$ → 전류실효값

소비전력

① 방법 1

$P = VI \cdot \cos\theta$ ← 위상차 = 큰각 - 작은각
파형이
같아야한다

$= \frac{100}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \cos(30-30)$

$= \frac{100}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \underbrace{\cos 0^\circ}_{=1} = 500[W]$

② 방법 2

$V = \frac{100}{\sqrt{2}}\angle 30, \quad I = \frac{10}{\sqrt{2}}\angle 30$

복소전력 $= V \cdot I^*$

$= \frac{100}{\sqrt{2}}\angle 30 \times \frac{10}{\sqrt{2}}\angle -30$

$= 500$ (실수 값만 존재하므로)

↳ 유효전력

③ 방법 3

$P = \frac{1}{2} \times V_m \times I_m \times \cos\theta$

$= \frac{1}{2} \times 100 \times 10 \times \cos(30-30)$

$P = \frac{1}{2} \times 100 \times 10 \times \cos 0^\circ$

$= 500 [W]$

2. $V = \overset{실효값}{100}\angle 60, \quad I = \overset{실효값}{20}\angle 30$

유효전력 = 소비전력 = P

① 방법 1

$P = VI\cos\theta$ → 위상차 = 큰각 - 작은각

$= 100 \times 20 \times \cos(60-30)$

$= 100 \times 20 \times \cos 30$

$= 1732 = 1000\sqrt{3}$

② 방법 2

복소전력 $= V \cdot I^*$

$= (100\angle 60) \times (20\angle -30)$

$= 1732 + 1000i$

$= \underbrace{1732}_{\text{유효전력}} \underbrace{+j\,1000}_{\text{(지상)무효전력}}$

복소전력 $= V \cdot I^*$

$= P \pm jP_r$ 에서

[$+jP_r$ = 지상무효전력

$-jP_r$ = 진상무효전력

3. $v = \overset{V_m}{\boxed{50}} \sin(\omega t + \theta)$

$i = \overset{I_m}{\boxed{4}} \sin(\omega t + \theta - 30)$

무효전력

① 방법 1

$P_r(Q) = \frac{1}{2} \times V_m \times I_m \times \sin \overset{\text{위상차}}{\theta}$

$= \frac{1}{2} \times 50 \times 4 \times \sin(\theta - (\theta - 30))$

$= \frac{1}{2} \times 50 \times 4 \times \overset{=\frac{1}{2}}{\boxed{\sin 30}}$

$= 50$ [Var]

② 방법 2

$P_r(Q) = VI \sin\theta$

$= \frac{50}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \sin(\theta - (\theta - 30))$

$= \frac{50}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \sin 30$

$= 50$ [Var]

4. $V = 100\angle 60$

$I = 10\sqrt{3} + j10$

무효전력 (P_r)

복소전력 $= V \cdot I^*$

$= (100\angle 60) \times (10\sqrt{3} - j10)$

$= (100\angle 60) \times (10\sqrt{3} - 10i)$

$= 1732 + 1000i$

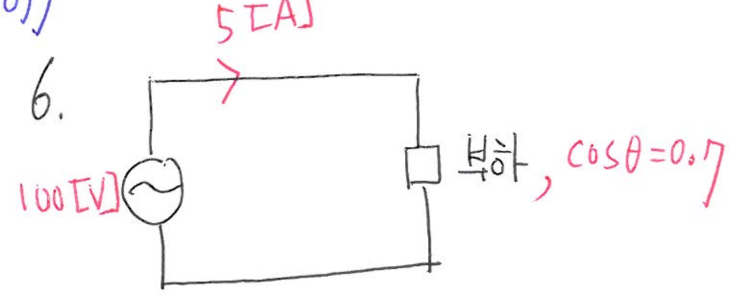
$= \underbrace{1732}_{P} \underbrace{\boxed{+}}_{\text{지상}} \underbrace{j1000}_{Q = P_r}$

5. $P = 300$ [W], $P_r = 400$ [Var]

피상전력 $= P_a = \sqrt{P^2 + P_r^2}$

$P_a = \sqrt{300^2 + 400^2} = 500$ [VA]

6.

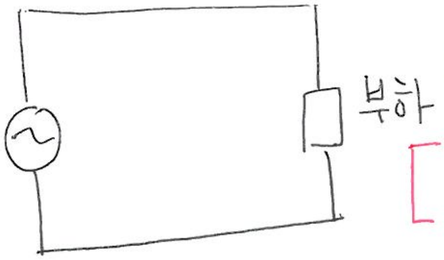


• 피상전력 $= P_a = V \cdot I$

$= 100 \times 5$

$= 500$ [VA]

7.



22 [kVA]

$\cos\theta = 0,8$

$\sin\theta = \sqrt{1-\cos^2\theta} = \sqrt{1-0,8^2} = 0,6$

무효전력 $= P_r = P_a \cdot \sin\theta = 22 \times 0,6 = 13,2$ [kVar]

$\ulcorner \sin\theta = \frac{P_r}{P_a} \Rightarrow P_r = P_a \cdot \sin\theta \lrcorner$

8. $P_a = \sqrt{P^2 + P_r^2}$

↓

$V \cdot I = \sqrt{P^2 + P_r^2}$

$I = \frac{\sqrt{P^2 + P_r^2}}{V} = \frac{\sqrt{300^2 + 400^2}}{100}$

$I = 5$ [A]

9. 역률 $= \cos\theta = \frac{P}{P_a} = \frac{P}{\sqrt{P^2 + P_r^2}}$

$\cos\theta = \frac{80}{\sqrt{80^2 + 60^2}} = \frac{80}{100}$

$\cos\theta = 0,8 \xrightarrow{\times 100[\%]} 80[\%]$

10. 소비 전력·량 $= P \cdot t$ [kWh]

$P[\text{kW}] \times t[\text{h}]$

소비전력량 $= P \cdot t = \overset{\text{kW}}{800} \times \overset{\text{h}}{2}$

$= 1600$ [kWh]

11. R − X 직렬 일때 소비전력(P)

$P = I^2 \cdot R$ 단) $I = \frac{V}{\sqrt{R^2 + X^2}}$

$P = \left(\frac{V}{\sqrt{R^2 + X^2}}\right)^2 \times R$

$P = \frac{V^2}{R^2 + X^2} \cdot R$ [W]

12. $\overset{(3\Omega)}{R} - \overset{(4\Omega)}{X}$ 직렬 일때

$V(t) = \boxed{100\sqrt{2}} \sin \omega t$

→ $V = 100$ [V] (실효값)

소비전력 (P)

$P = \frac{V^2}{R^2 + X^2} \times R$ [W] 이용

$= \frac{100^2}{3^2 + 4^2} \times 3$

$= 1200\,[\text{W}] \xrightarrow{\times 10^{-3}} 1,2\,[\text{kW}]$ 大

13. R − L 직렬 …… 무효전력(P_r)

$P_r = I^2 \cdot X_L$ 단) $I = \dfrac{V}{\sqrt{R^2+X_L^2}}$

$$P_r = \left(\frac{V}{\sqrt{R^2+X_L^2}}\right)^2 \times X_L$$

$$= \frac{V^2}{R^2+X_L^2} \times X_L \text{ [Var]}$$

$$= \frac{V^2}{R^2+(\omega L)^2} \times (\omega L)$$

$$= \frac{130^2 \times (2\pi \times 60 \times 13.3 \times 10^{-3})}{12^2+(2\pi \times 60 \times 13.3 \times 10^{-3})^2}$$

= 500.9 [Var]

↓ $\times 10^{-3}$

= 0.5 [KVar]

14. 리액턴스 X는 무효전력 안에 있다 ($P_a = V \cdot I$ [VA])

$P_r = I^2 \cdot X$ 단) $P_r = \sqrt{P_a^2 - P^2}$

$$\sqrt{P_a^2 - P^2} = I^2 \cdot X$$

$$X = \frac{\sqrt{P_a^2 - P^2}}{I^2} = \frac{\sqrt{(100 \times 20)^2 - 1200^2}}{20^2}$$

= 4 [Ω]

15. R의 전력손실은 ⇒ $I^2 \cdot R$

$= I^2 \cdot R$ 단) $I = \dfrac{V}{\sqrt{R^2+X_L^2}}$

$$= \frac{V^2}{R^2+X_L^2} \cdot R$$

L = 0 일때의 $\frac{1}{2}$ (L = 0 ⇒ $X_L = 0$)

$$= \frac{V^2}{R^2+0^2} \times R \times \frac{1}{2} = \frac{V^2}{2R}$$

* $\underbrace{\text{R의 전력손실은}}$ $\underbrace{\text{L=0 일때}}$ $\frac{1}{2}$

$$\frac{\cancel{V^2}}{R^2+X_L^2} \cdot R = \frac{\cancel{V^2}}{2R}$$

$$\frac{2R^2}{R^2+X_L^2} = 1$$ (분모분자 같아야함)

$2R^2 = R^2 + X_L^2$ ($X_L^2 = R^2$)

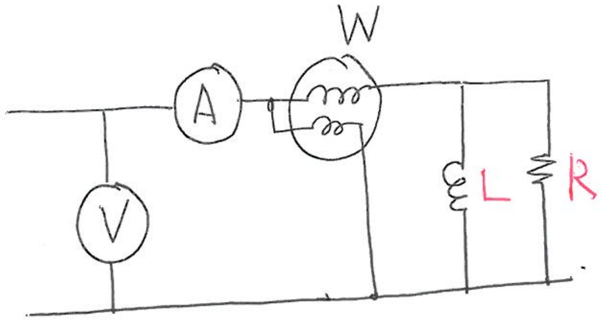
↳ $R^{\cancel{2}} = X_L^{\cancel{2}}$

$R = X_L = \omega L$

∴ $L = \dfrac{R}{\omega} = \dfrac{600}{2\pi \times 60}$ [H]

= 1.59 [H]

16.



인덕턴스 L은 저항과 병렬

이므로 무효전력(P_r) = $\frac{V^2}{X_L}$

$$P_r = \frac{V^2}{X_L} \Rightarrow X_L = \frac{V^2}{P_r}$$

$$\omega L = \frac{V^2}{P_r} \Rightarrow L = \frac{V^2}{\omega \cdot \sqrt{P_a^2 - P^2}}$$

$$L = \frac{240^2}{2\pi \times 60 \times \sqrt{(240 \times 5)^2 - 720^2}}$$

$$L = 0.159 = \frac{1}{2\pi}$$

$$L = \frac{\boxed{240^2} \rightarrow \cancel{57600}}{2\pi \times \underbrace{60 \times \sqrt{(240 \times 5)^2 - 720^2}}_{= \cancel{57600}}}$$

$$L = \frac{1}{2\pi}$$

17. R−C 병렬

$P = \frac{V^2}{R}$, $P_r = \frac{V^2}{X_c}$ 이용

① $P = \frac{V^2}{R} = 800$

$= \frac{100^2}{R} = 800 \Rightarrow R = \frac{100^2}{800}$

∴ $R = 12.5$ [Ω]

② $P_r = \frac{V^2}{X_c} = \frac{V^2}{\frac{1}{\omega C}} = \omega C V^2$

$600 = \omega C \times 100^2$

$$C = \frac{600}{\omega \times 100^2} = \frac{600}{2\pi \times 60 \times 100^2}$$

$C = 1.59 \times 10^{-4}$ [F]

$\downarrow \times 10^6$

$C = 159$ [μF]

18. 복소전력 = $V^* \cdot I$

결과 $\begin{cases} +jP_r = \text{진상무효전력} \\ -jP_r = \text{지상무효전력} \end{cases}$

복소전력 = $V \cdot I^*$

결과 $\begin{cases} +jP_r = \text{지상무효전력} \\ -jP_r = \text{진상무효전력} \end{cases}$

19. 복소전력 = $V \cdot I^*$

$= (100+30i) \times (16-3i)$

$= \underbrace{1690}_{P} \underbrace{\textcircled{+}}_{\text{지상}} j\,\underbrace{180}_{P_r}$

20. 3전류 계법

① $P = \frac{R}{2}(A_1^2 - A_2^2 - A_3^2)$ [W]

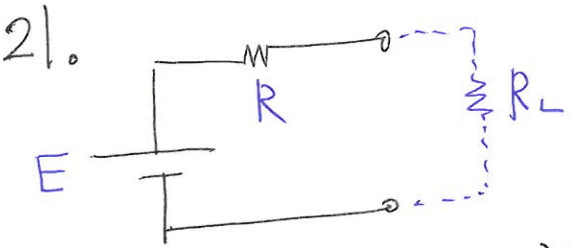
$= \frac{25}{2}\cdot(10^2 - 4^2 - 7^2)$

$= 437,5$ [W]

② $\cos\theta = \frac{A_1^2 - A_2^2 - A_3^2}{2\cdot A_2\cdot A_3} = \frac{10^2-4^2-7^2}{2\times4\times7}$

$= 0,625$

21.



소비되는 전력을 최대로 했다

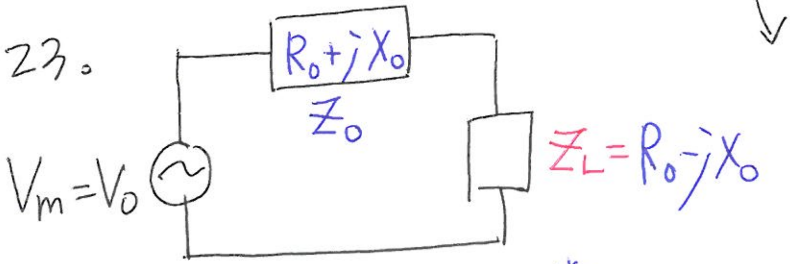
= 최대전력 (P_m)

∘ $P_m = \frac{V^2}{4R}$ 또는 $\frac{V^2}{4R_L}$

22 최대전력조건. ($R-r$)

$R = r$

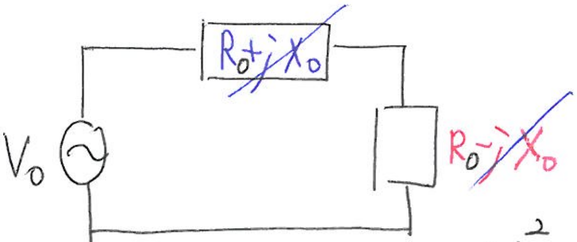
23.



최대전력 조건 $Z_L = Z_0^*$

$Z_L = (R_0+jX_0)^*$

$= R_0 - jX_0$



최대전력 (P_m) = $\frac{V^2}{4R_0}$ ← 실효값

$P_m = \frac{(\frac{V_0}{\sqrt{2}})^2}{4R_0} = \frac{V_0^2}{8R_0}$

24. 부하저항 R_L이 내부저항 R_0의 3배

↳ $R_L = 3R_0$

R_L에 소비되는 전력 P_L은 최대전력 (P_m)의 몇배

$\frac{V^2}{(R_0+R_L)^2}\times R_L = \frac{V^2}{4R_0}\times(?)$

단) $R_L = 3R_0$

$\frac{V^2}{(R_0+3R_0)^2}\times 3R_0 = \frac{V^2}{4R_0}\times(\ \ )$

$\frac{V^2}{(4R_0)^2}\times 3R_0 = \frac{V^2}{4R_0}\times(\ \ )$

$\frac{3V^2R_0}{16R_0^2} = \frac{3V^2}{16R_0} = \frac{V^2}{4R_0}\times(\frac{3}{4})$

몇배 = $\frac{3}{4}$ = 0,75

4 장

25. R에서 소비되는 전력을 최대로 하는 R값

$R = \frac{1}{\omega C}$ 일때 "최대전력공급"

26. 최대전력 공급 조건을 이용하여 $R = X_c$

$$P = I^2 R = \left(\frac{V}{\sqrt{R^2+X^2}}\right)^2 \times R$$

$$P = \frac{V^2}{\boxed{R}^2 + X_c^2} \times \boxed{R}\ [W]\ [R=X_c]$$

$$P = \frac{V^2}{X_c^2 + X_c^2} \times X_c$$

$$P = \frac{V^2}{2 \cdot X_c^{\cancel{2}}} \times \cancel{X_c}$$

$$P = \frac{V^2}{2X_c}$$

단) $X_c = \frac{1}{\omega C}$

$= \frac{1}{2\pi \times 60 \times 15 \times 10^{-6}}$

$= 176,83 [\Omega]$

$$P = \frac{200^2}{2 \times 176,83}$$

$P = 113,10 [W]$

27. 부하에는 리액턴스 성분이 없으므로 차선책을 적용한다

$$|Z| = |Z_L|$$

$$|R+jX| = |R_L|$$

$$\downarrow \qquad \downarrow$$

$$\sqrt{R^2+X^2} = R_L$$

5장

1. $V = L \cdot \frac{di}{dt}$

$$L = \frac{V \cdot dt}{di} = \frac{20 \times 0,5 \times 10^{-3}}{5}$$

$= 2 \times 10^{-3} [H]$

$\downarrow \times 10^3 \qquad \downarrow$

$= 2 \quad [mH]$

2. 2차 유도 기전력 (e_2)

$$e_2 = \underbrace{L_2 \cdot \frac{di_2}{dt}}_{} + M \frac{di_1}{dt}$$

↳ 문제조건에 2차값 없으므로 무시

$$e_2 = \underset{[H]}{M} \cdot \frac{di_1}{dt}$$

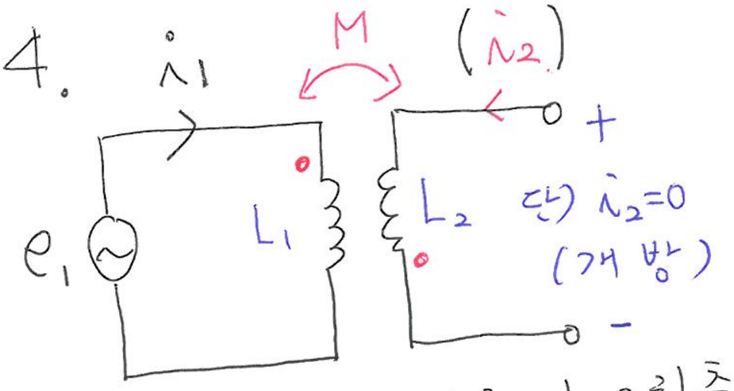
$= 100 \times 10^{-3} \times \frac{18-3}{0.3} = 5 [V]$

3. $e = M \cdot \frac{di}{dt}$ 에서

$$상호인덕턴스(M) = \frac{e \cdot dt}{di}$$

$$M = \frac{15 \times 1}{120} = \frac{1}{8} = 0{,}125[H]$$

4.



전류 방향 보면 1차측과 2차측 도트(•) 위치가 달라서 차동결합

$$e_2 = L_2 \cdot \cancel{\frac{di_2}{dt}} \bigcirc M \cdot \frac{di_1}{dt}$$

$= 0 \therefore i_2 = 0$

차동일때 ⊖

$$e_2 = -M \cdot \frac{di_1}{dt}$$

$$= -M \cdot \frac{d}{dt}(I_m \cdot \sin\omega t)$$

$$= -M \cdot I_m \cdot \underbrace{\frac{d}{dt}\sin\omega t}$$

$$= -\omega M I_m \cdot \cos\omega t$$

$$e_2 = -\omega M I_m \cdot \underline{\cos\omega t}$$

$$= \bigcirc\!\!\!\!- \; \omega M I_m \cdot \sin(\omega t + 90)$$

$$= \omega M I_m \cdot \sin(\omega t - 90)$$

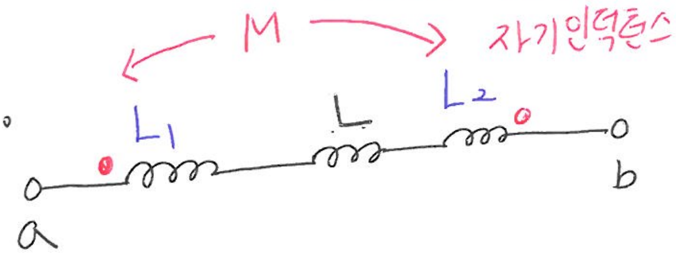
5. $K = \frac{M}{\sqrt{L_1 \cdot L_2}}$

결합계수

상호인덕턴스

1,(2)차 자기인덕턴스

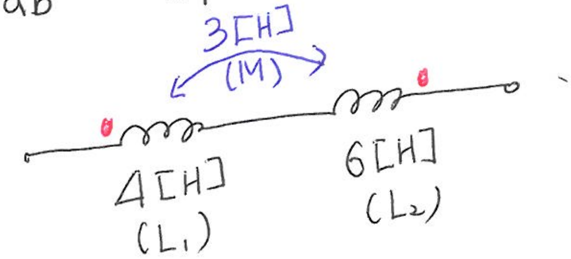
6.



합성인덕턴스 ⇒ 차동이므로

$$L_{ab} = L_1 + L_2 - 2M + L$$

7.



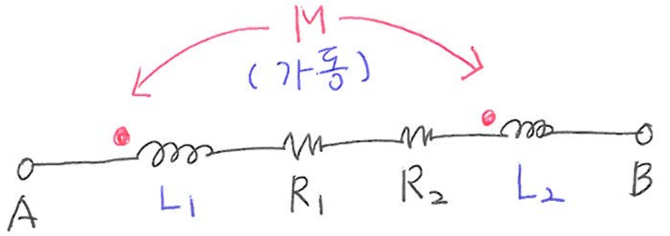
합성인덕턴스 ⇒ 차동이므로

$$L = L_1 + L_2 - 2 \cdot M$$

$$= 4 + 6 - (2 \times 3)$$

$$= 10 - 6 = 4[H]$$

8.

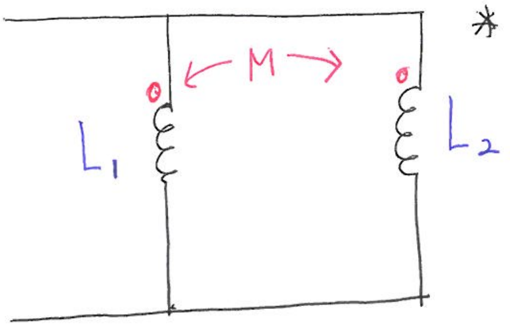


$$Z_{AB} = j\omega(L_1 + L_2 + 2M) + R_1 + R_2$$

$$Z_{AB} = j100 \times (6 + 7 + 2 \times 5) \times 10^{-3} + 4 + 9$$

$$= 13 + j2.3 \, [\Omega]$$

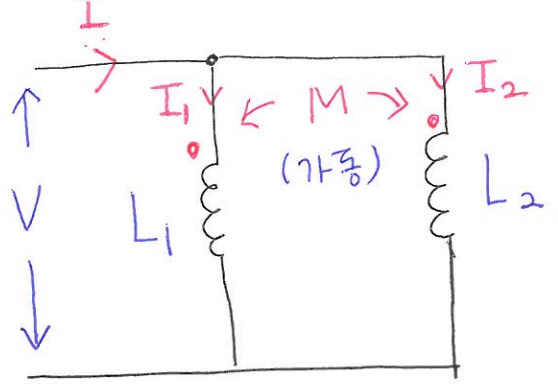
9.



*병렬 가동

Ⅱ 정석풀이

병렬 접속을 T 등가회로 바꾸면



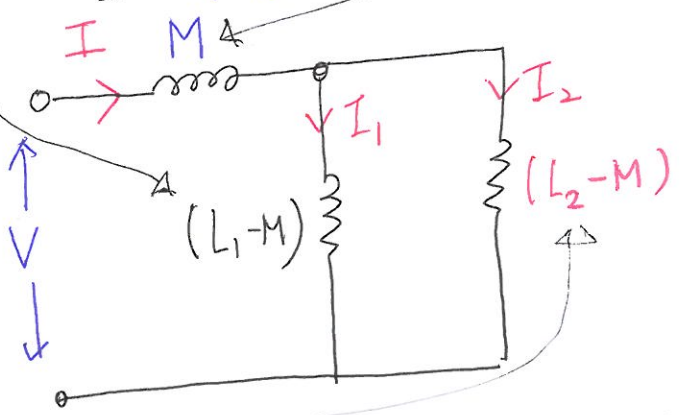
① $V = j\omega L_1 \times I_1 + j\omega M I_2$

① $V = j\omega L_1 \times I_1 + j\omega M I_2 + j\omega M I_1 - j\omega M I$

$V = j\omega L_1 I_1 - j\omega M I_1 + j\omega M I_2 + j\omega M I_1$

$V = j\omega(L_1 - M) I_1 + j\omega M \underbrace{(I_1 + I_2)}_{= I}$

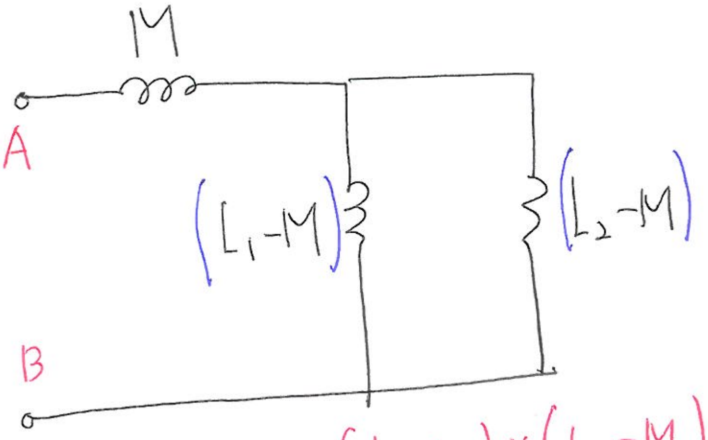
T형 등가회로



② $V = j\omega L_2 I_2 + j\omega M I_1 + j\omega M I_2 - j\omega M I_2$

$V = j\omega L_2 I_2 - j\omega M I_2 + j\omega M I_1 + j\omega M I_2$

$V = j\omega(L_2 - M) I_2 + j\omega M (I_1 + I_2)$



$$L_{AB} = M + \frac{(L_1-M)\times(L_2-M)}{(L_1-M)+(L_2-M)}$$

$$= M + \frac{L_1L_2 - ML_1 - ML_2 + M^2}{L_1+L_2-2M}$$

$$= \frac{M\cdot(L_1+L_2-2M) + L_1L_2 - ML_1 - ML_2 + M^2}{L_1+L_2-2M}$$

$$= \frac{\cancel{ML_1} + \cancel{ML_2} - 2M^2 + L_1L_2 - \cancel{ML_1} - \cancel{ML_2} + M^2}{L_1+L_2-2M}$$

$$= \frac{L_1L_2 - M^2}{L_1+L_2-2M}$$

10. 상호 인덕턴스가 없을때

합성인덕턴스는 저항의

합성 공식과 같다.

20 과 60 병렬.

$$L = \frac{20\times60}{20+60} = 15[mH]$$

11.

◎ 합성인덕턴스 최대값 = 가동결합

$L_{가동} = L_1 + L_2 + 2M$

◎ 합성인덕턴스 최소값 = 차동결합

$L_{차동} = L_1 + L_2 - 2M$

$M = K\cdot\sqrt{L_1\cdot L_2}$

$M = 0.9\sqrt{10\times10}$

$$\frac{L_{가동} = \overset{10}{L_1} + \overset{10}{L_2} + 2M}{L_{차동} = \underset{10}{L_1} + \underset{10}{L_2} - 2\underset{0.9\sqrt{10\times10}}{M}} = \frac{38}{2}$$

∴ 19 : 1
(최대) (최소)

12. 코일이 같은 방향 감겨

↳ 가동결합

$\therefore L = L_1 + L_2 + 2M$

300[HZ]에서 L과 C 공진

$\omega^2 = \frac{1}{LC}$ 에서 $L = \frac{1}{\omega^2 C}$

$$L_1 + L_2 + 2M = \frac{1}{\omega^2 C}$$

$$2M = \left(\frac{1}{\omega^2 C} - L_1 - L_2\right)$$

$$M = \frac{1}{2}\left(\frac{1}{\omega^2 C} - L_1 - L_2\right)$$

$$M = \frac{1}{2}\left(\frac{1}{(2\pi \times 300)^2 \times 30 \times 10^{-6}} - 4\times10^{-3} - 4\times10^{-3}\right)$$

$$M = \underbrace{6.9 \times 10^{-4}}_{\downarrow \times 10^3} \ \underset{\downarrow m}{[H]}$$

$$M = 0.69 \ [mH]$$

13. a,b 단자에서 본 임피던스

$= Z_1$

조건 ⇒ $n_1 : n_2 = 1 : 3$

$$\frac{n_1}{n_2} = \frac{1}{3}$$

변압기 권수비$(n) = \frac{n_1}{n_2} = \sqrt{\frac{Z_1}{Z_2}}$

$$n = \frac{1}{3} = \sqrt{\frac{Z_1}{900}}$$

$$\frac{1}{9} = \frac{Z_1}{900} = \frac{100}{900} = \frac{1}{9}$$

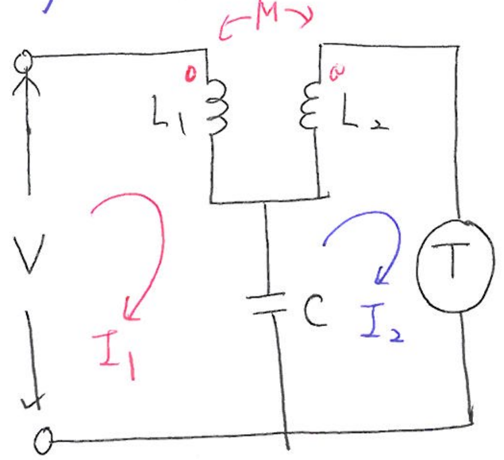
$\therefore Z_1 = 100 [\Omega]$

14 변압기 권수비(n)

$$n = \frac{n_1}{n_2} = \frac{V_1}{V_2} = \frac{i_2}{i_1} = \sqrt{\frac{Z_1}{Z_2}}$$

$$= \sqrt{\frac{\cancel{j}\omega L_1}{\cancel{j}\omega L_2}} = \sqrt{\frac{L_1}{L_2}}$$

15



<정석풀이는 9번 보다 머리가 아픈문제 이므로 답으로가야함>

(캠벨) 브리지 나오면 공진조건식

$\omega L = \frac{1}{\omega C}$ 에서 L대신에 M

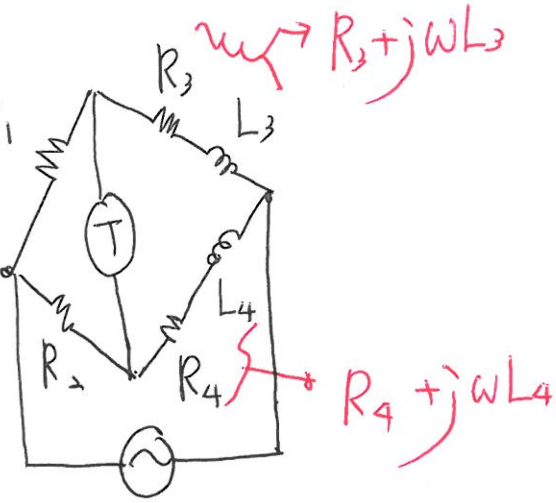
$$\omega L = \frac{1}{\omega C}$$

$\omega^2 = \frac{1}{MC}$ 에서 $\underset{2\pi f}{\underset{\downarrow}{\omega}} = \sqrt{\frac{1}{MC}}$

$$\therefore f = \frac{1}{2\pi}\sqrt{\frac{1}{MC}}$$

$$f = \frac{1}{2\pi}\cdot\frac{1}{\sqrt{MC}}$$

16.



평형 조건

$$R_1 \times (R_4 + j\omega L_4) = R_2 \times (R_3 + j\omega L_3)$$

$$\underbrace{R_1R_4}_{} + j\,\underbrace{R_1\cdot\omega L_4}_{} = \underbrace{R_2R_3}_{} + j\,\underbrace{R_2\omega L_3}_{}$$

$$R_1R_4 = R_2R_3 \qquad R_1\cdot\omega L_4 = R_2\omega L_3$$

① $R_1R_4 = R_2R_3 \Rightarrow R_4 = \frac{R_2R_3}{R_1}$

② $R_1\cdot\cancel{\omega}L_4 = R_2\cancel{\omega}L_3$

$$L_4 = \frac{R_2\cdot L_3}{R_1}$$

6장

1. 이상적인 전압원 내부저항 0

이상적인 전류원 내부저항 ∞

2. 키르히호프 법칙은

선형, 비선형 모두해석 가능

3. 중첩원리 : 2개 이상의 전원이 동시에 존재할때 전압원, 전류원이 각각단독 으로 존재할때 전압, 전류의 합을 구해 임의 점 전압, 전류 구한다

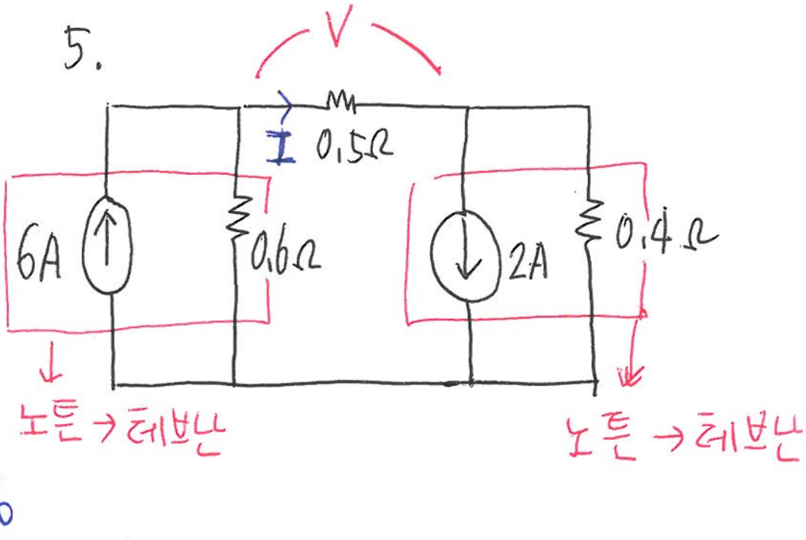
(선형 회로에서만 적용가능)

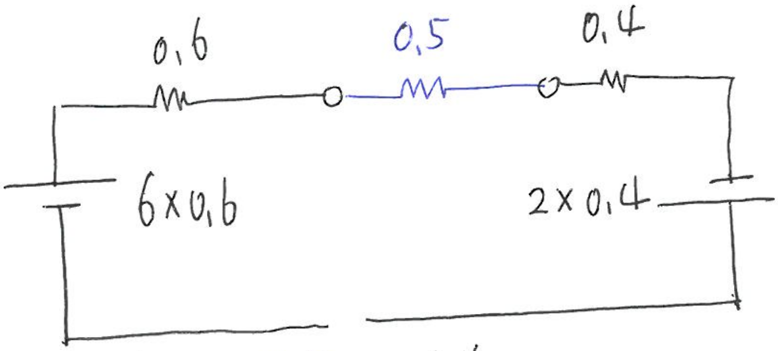
4. 선형회로

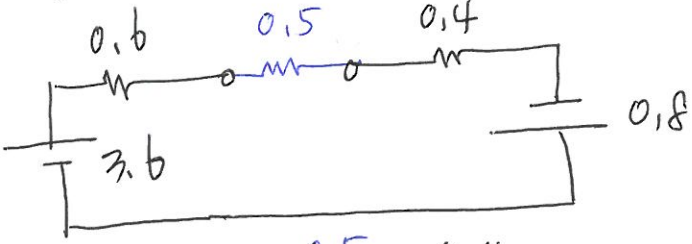
중첩의 원리

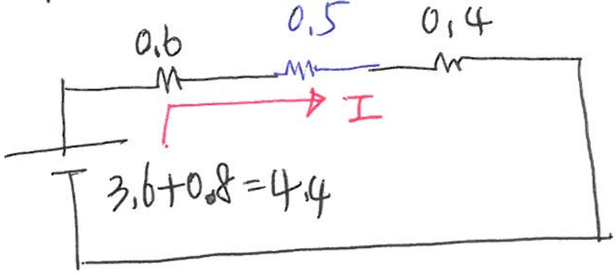
$V = IR$

5.







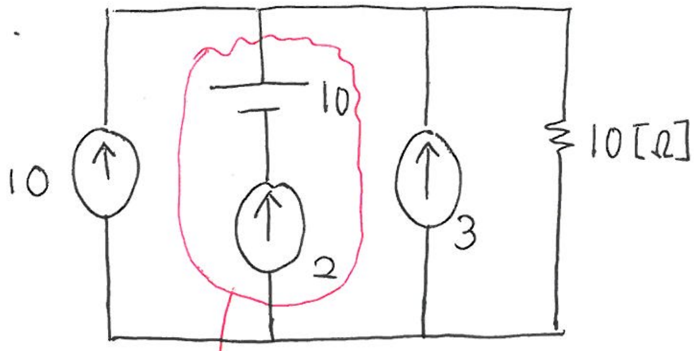


$$I = \frac{4.4}{0.6+0.5+0.4} = 2.93[A]$$

$$V_{0.5} = 2.93 \times 0.5$$

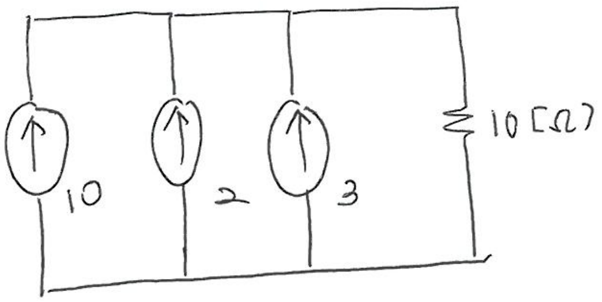
$$= 1.465[V]$$

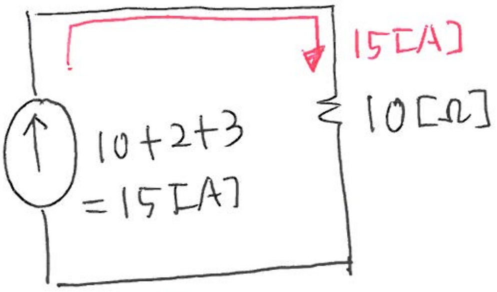
6.



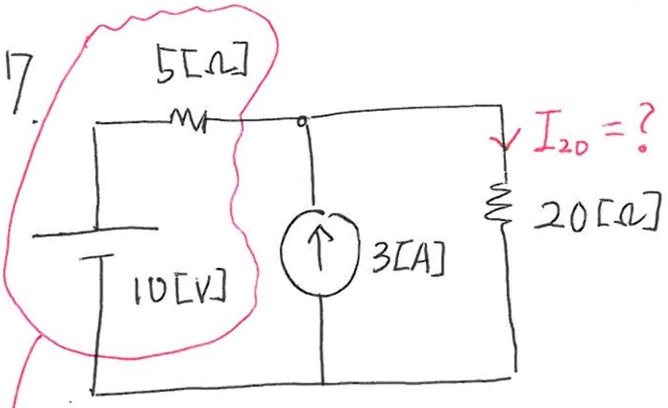
전압원과 전류원

직렬연결시 ⇒

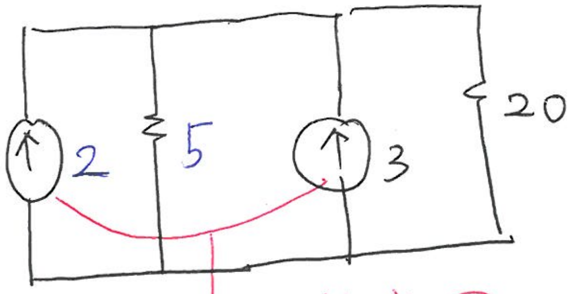




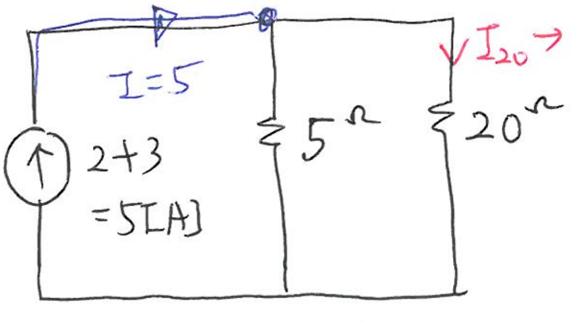
7.



→ 테브난 ⇒ 노튼



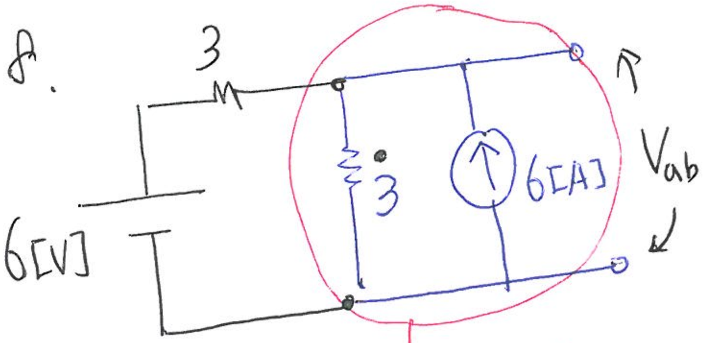
→ 동일 방향 ⊕



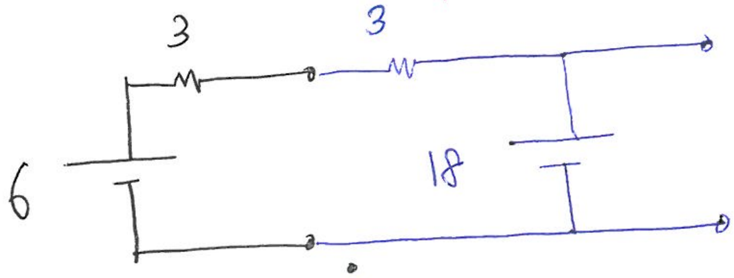
→ 병렬 분배 전류

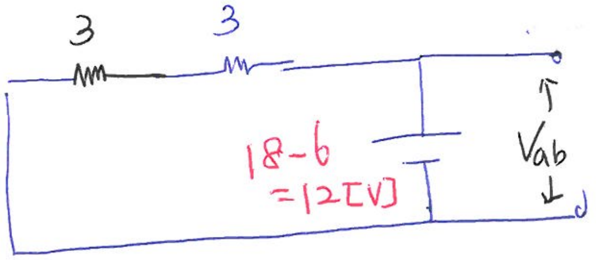
$$I_{20} = \frac{5}{5+20} \times 5 = 1[A]$$

8.

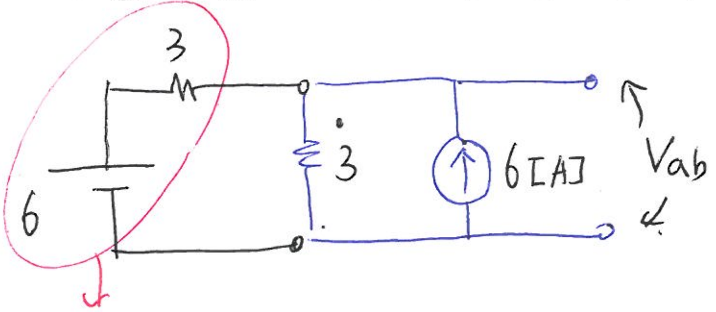


노튼을 테브난

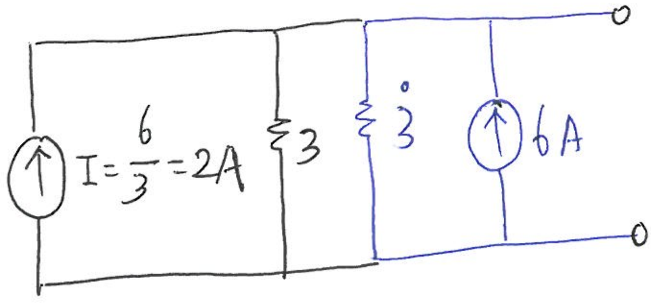


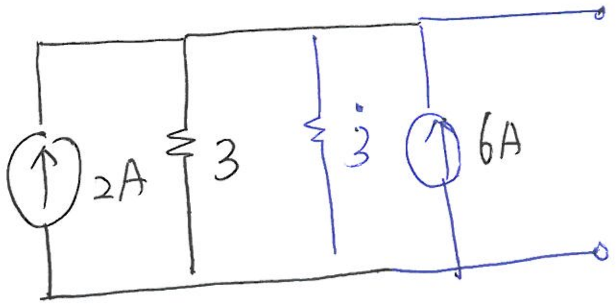


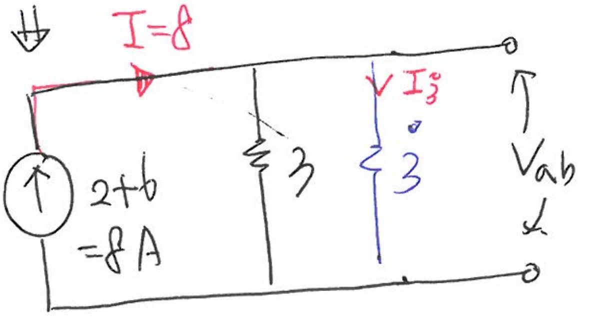
또는 Vab = $\dot{3}$[Ω] 전압강하



노튼으로





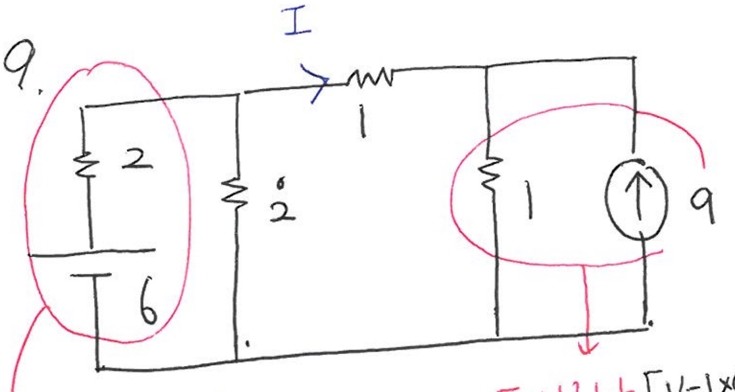


$$V_{ab} = I_{\dot{3}} \times \dot{3}$$

$$= \frac{3}{3+\dot{3}} \times 8 \times \dot{3}$$

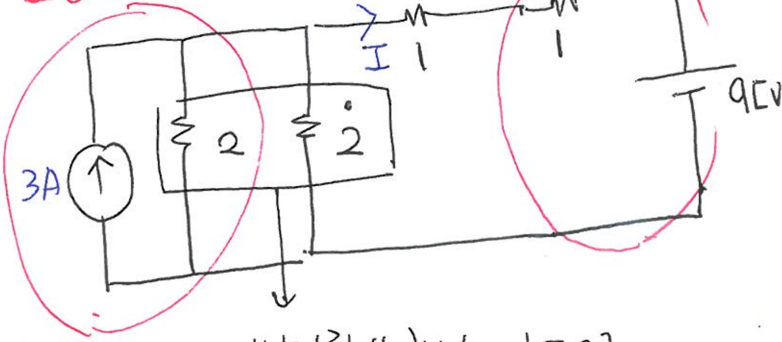
$$= 12[V]$$

9.

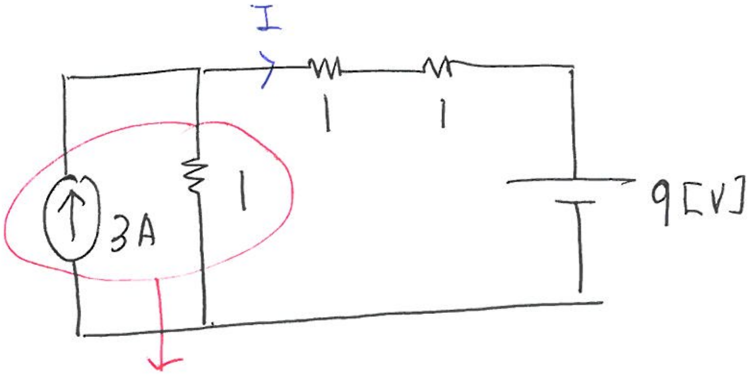


테브난 [V=1×9
=9[

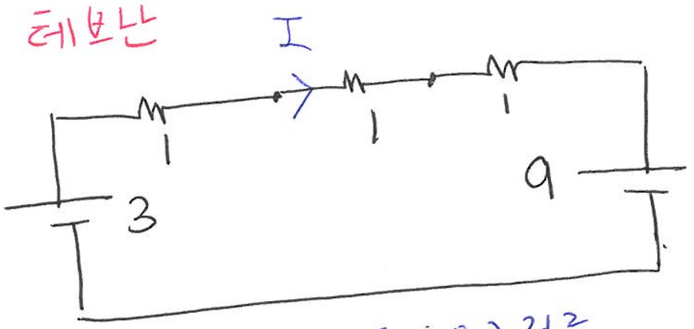
노튼으로 ($I = \frac{6}{2} = 3A$)



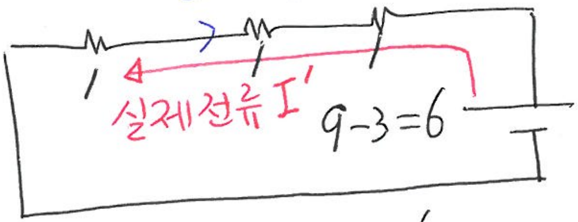
병렬합성하면 = 1[Ω]



테브난



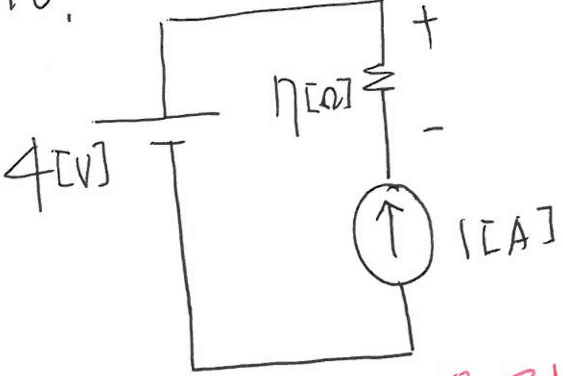
I = 문제요구전류



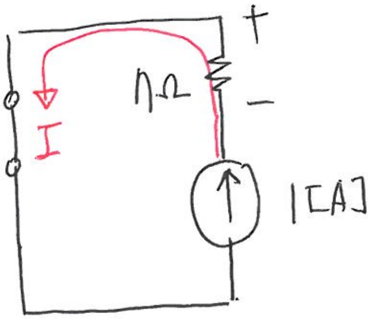
$$I = -I' = -\frac{6}{1+1+1}$$

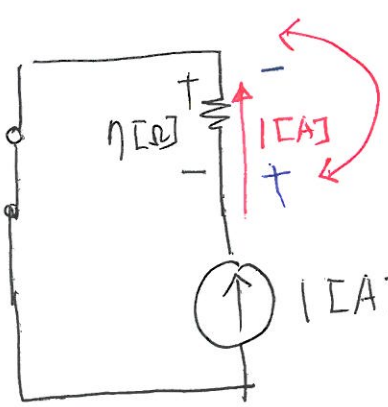
$I = -2[A]$

10.



⇓ 전압원 전류원 직렬





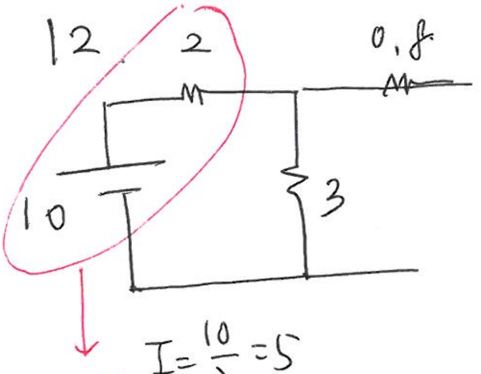
$V = 1 \times 7$
$= -7[V]$ 인데 전류 들어가는 쪽이 (+) 이므로

초기조건과 반대이므로

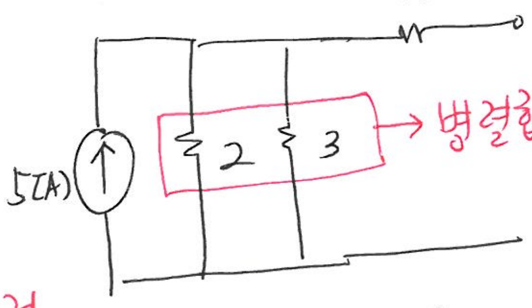
답은 $-7[V]$

11. 테브난과 쌍대는 노튼

12

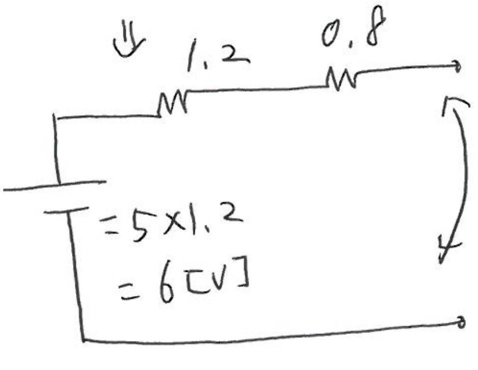


노튼 $I = \frac{10}{2} = 5$



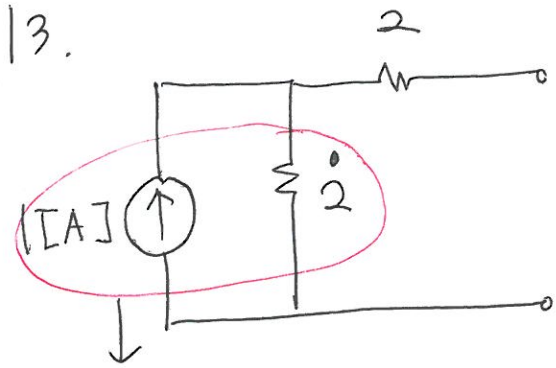
$\rightarrow$ 병렬합성 $= \frac{2\times3}{2+3}$
$= 1.2[Ω]$

⇓

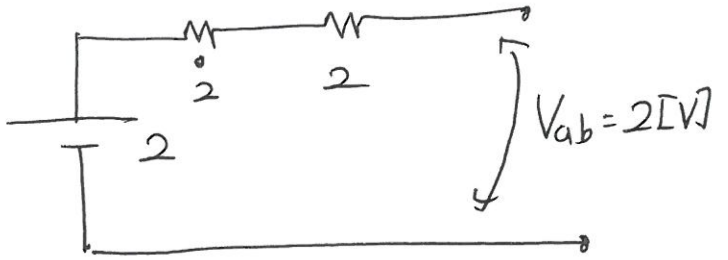


$V = 6$
$R = 1.2 + 0.8$
$= 2[Ω]$

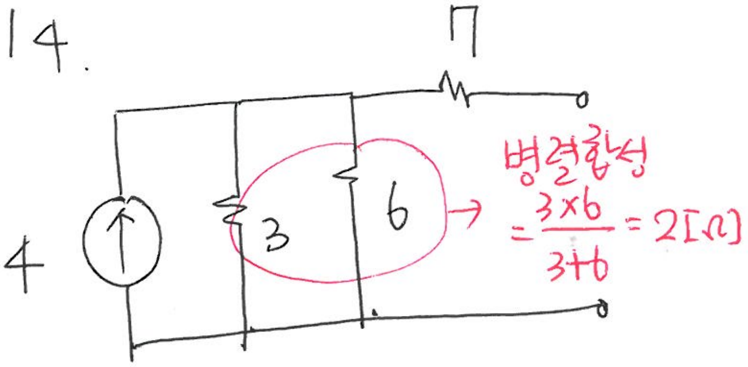
13.

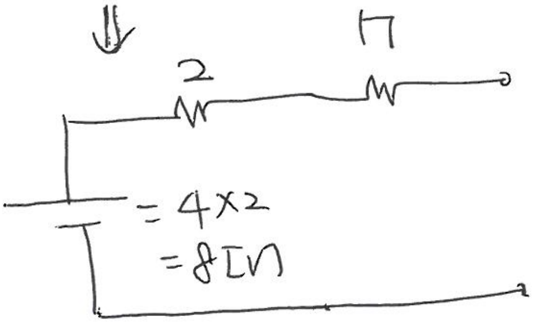


테브난 (V= 1×2=2 V)



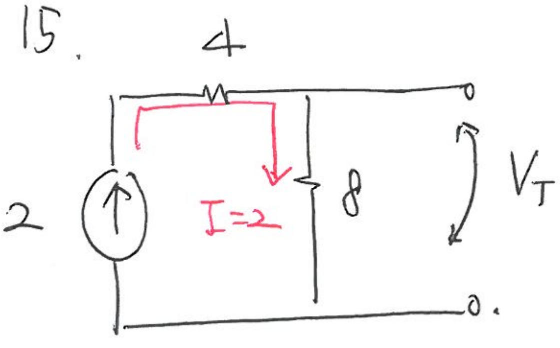
14.



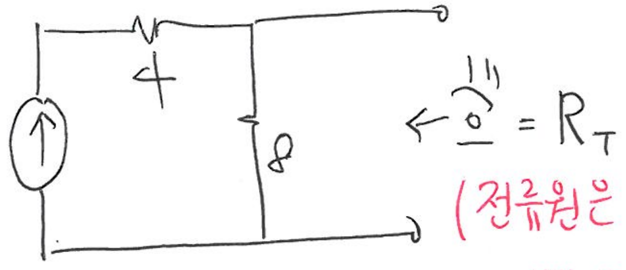


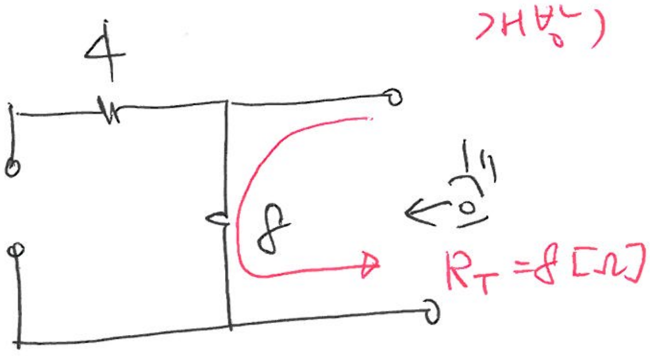
E = 8[V], R = 2+7=9[Ω]

15.



$V_T = I \times 8^{\Omega} = 2 \times 8 = 16[V]$

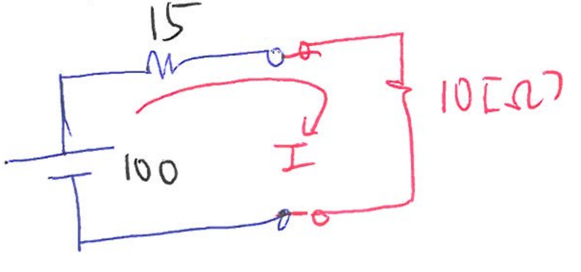




16. 문제의 조건은 테브난회로이다

a, b 단자의 전압 = 100[V]

a, b 에서 본 임피던스 = 15[Ω]



$$I = \frac{100}{15+10} = 4[A]$$

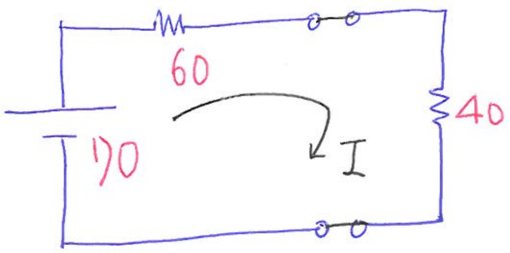
6장

17 한쌍의 단자전압 측정 : 70[V]

→ 테브난 전압

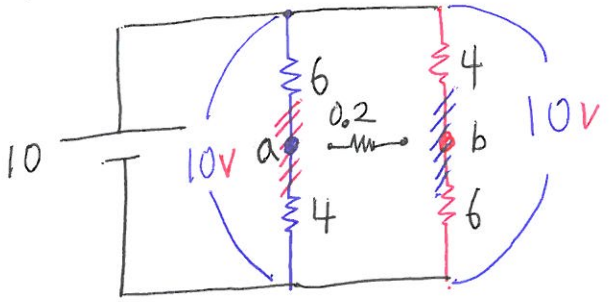
단자에서 본 회로의 임피던스 : 60[Ω]

→ 테브난 합성저항

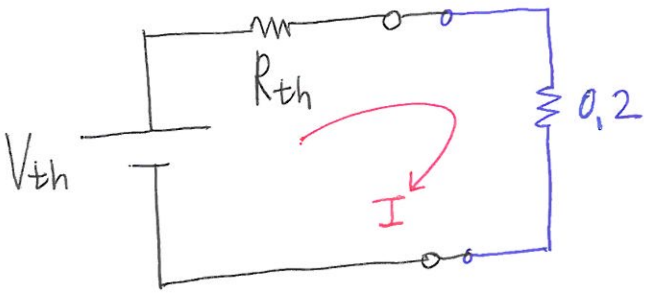


$$I = \frac{70}{60+40} = 0.7[A]$$

18



⇓



$$V_{th} = V_b - V_a = \frac{6}{4+6} \times 10 - \frac{4}{6+4} \times 10$$

$$= 2[V]$$

R_{th} ⇒ 전압원 단락후 저항값은

$$R_{th} = \frac{4 \times 6}{4+6} + \frac{4 \times 6}{4+6} = 4.8[\Omega]$$

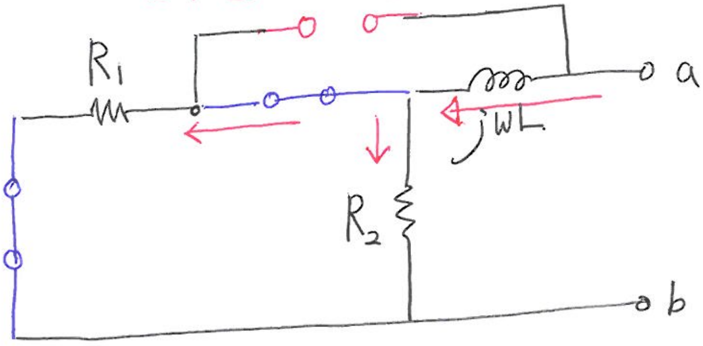
0.2[Ω]에 흐르는전류(I)

$$I = \frac{2}{4.8+0.2} = \frac{2}{5} = 0.4[A]$$

19. a-b에서 바라본 임피던스

⇒ 전압원 = 단락

전류원 = 개방



$$Z_{ab} = j\omega L + \frac{R_1 \cdot R_2}{R_1 + R_2}$$

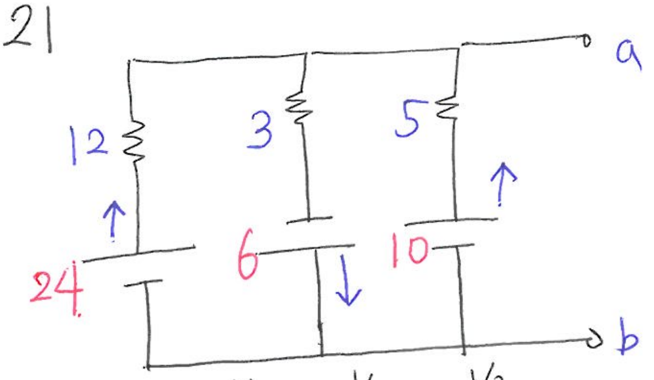
$$= 2S + \frac{15 \times 10}{15+10} = 2S + 6$$

20 밀만의 공식 적용하면

$$V_{ab} = \frac{\frac{E_1}{R_1} + \frac{E_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$= \frac{\frac{110}{1} + \frac{120}{2}}{\frac{1}{1} + \frac{1}{2} + \frac{1}{5}} = 100[V]$$

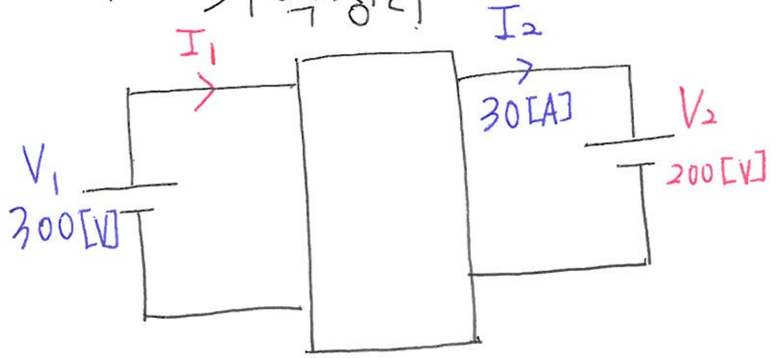
21



$$V_{ab} = \frac{\frac{V_1}{R_1} - \frac{V_2}{R_2} + \frac{V_3}{R_3}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$= \frac{\frac{24}{12} - \frac{6}{3} + \frac{10}{5}}{\frac{1}{12} + \frac{1}{3} + \frac{1}{5}} = \frac{120}{37}$$

22. 가역정리

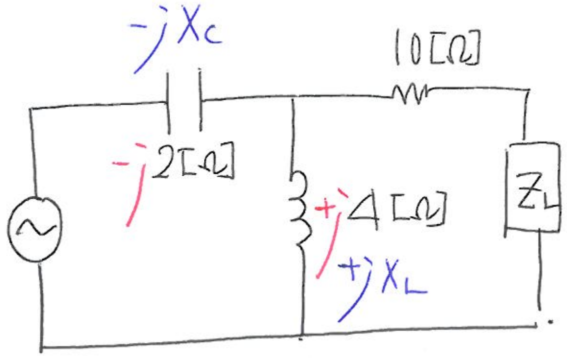


$$V_1 \cdot I_1 = V_2 \cdot I_2$$

$$↳ I_1 = \frac{V_2 \cdot I_2}{V_1} = \frac{200 \times 30}{300} = 20[A]$$

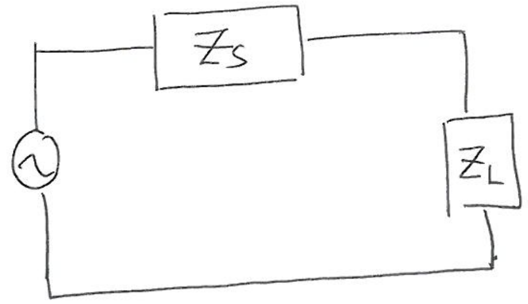
<추가>

그림과 같은 회로에서 부하임피던스 Z_L을 얼마로 할때 최대전력이 공급되는가?



전원측 임피던스 계산시

전압원 단락, C-L 병렬 이므로



$$Z_s = 10 + \frac{+j4 \times (-j2)}{+j4 - j2}$$

$$= 10 + \frac{-j^2 8}{j2} \quad j^2 = -1 \quad \text{단)} \; -j^2 = +1$$

$$= 10 + \frac{\cancel{8}^4}{j\cancel{2}} = 10 - j4$$

최대공급전력 Z_L의 조건

$$Z_L = Z_s^* = (10 - j4)^*$$

$$= 10 + j4$$

보기

① $4 - j10$ ② $4 + j10$

③ $10 - j4$ ④ $10 + j4$

답

7장

1. Y결선 선전류(I_L)

$$I_L = \frac{V_L}{\sqrt{3}Z} = \frac{220}{\sqrt{3}\times\sqrt{6^2+8^2}} = 12,7[A]$$

2. Δ결선 선전류(I_L)

$$I_L = \frac{\sqrt{3}\cdot V_L}{Z} = \frac{\sqrt{3}\cdot 220}{\sqrt{6^2+8^2}} = 38,1[A]$$

3. Δ결선에 선전류(I_L)는 상전류(I_p)에 크기는 √3배 각은 30° 늦다

$$I_L = \sqrt{3}\cdot I_p \angle -30$$

I_c의 상전류는 $I_{ca} = 4\angle -276$

$$I_c = 4\times\sqrt{3}\angle -276 -30$$

$$= 6.93\angle -306$$

4. Y결선 선간전압(V_L)

$I_L = \frac{V_L}{\sqrt{3}Z}$에서 $V_L = \sqrt{3}\cdot I_L\cdot Z$

$$V_L = \sqrt{3}\times 10\times\sqrt{16^2+12^2} = 346,4[V]$$

* Y결선은 $I_p = I_L$ (직렬이므로)

5. Y결선 … X=?

$$P_{3\phi} = 3\cdot I_p^2\times R = \sqrt{3}\cdot VI\cdot\cos\theta$$

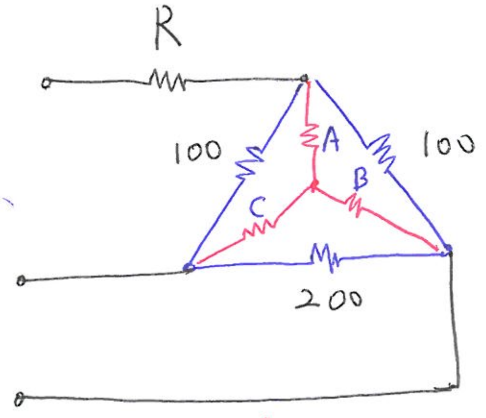
$$P_{r3\phi} = 3 I_p^2\times X = \sqrt{3}VI\sin\theta$$

↓

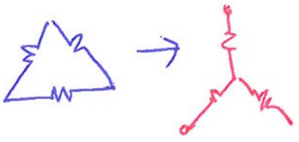
$$\sqrt{3}\times 300\times 40\times 0,6 = 3\times 40^2\times X$$

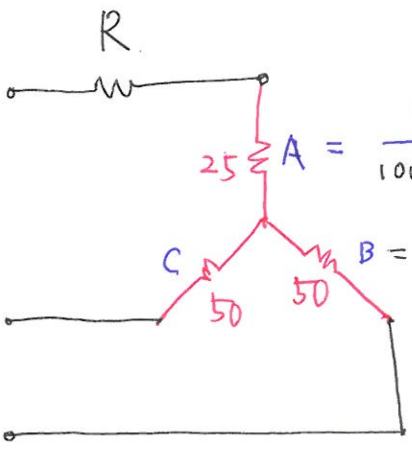
$$X = \frac{\sqrt{3}\times 300\times 40\times 0,6}{3\times 40^2} = 2,59[\Omega]$$

6.



①





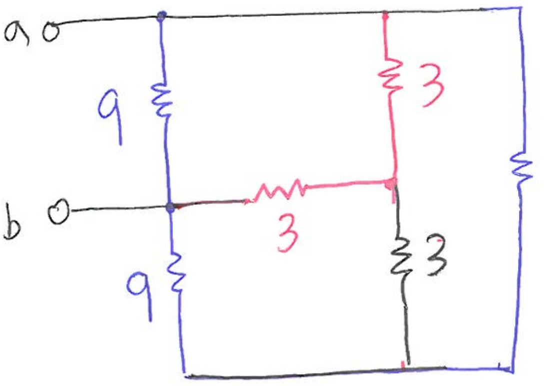
$$A = \frac{100\times 100}{100+100+200} = 25$$

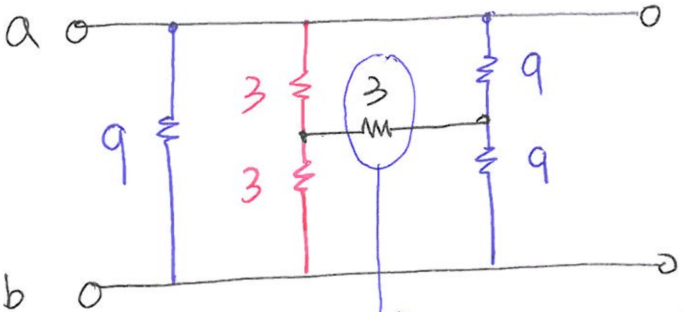
$$B = C = \frac{100\times 200}{100+100+200} = 50[\Omega]$$

대칭이 되려면 R+A = 50 이되어야 하므로 R = 50−A = 50−25

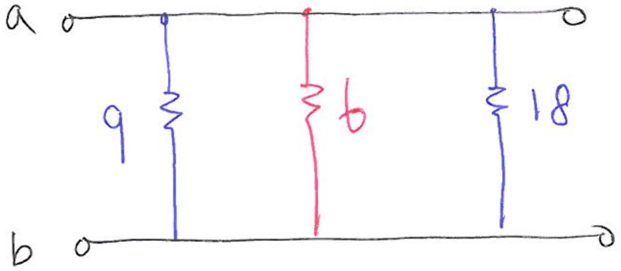
R = 25[Ω]

7.



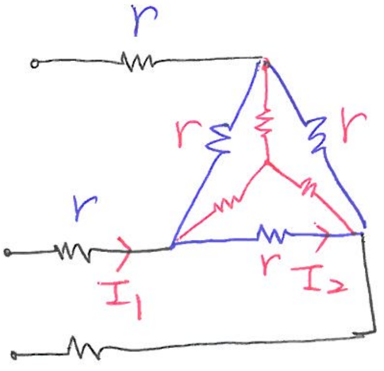


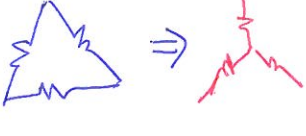
평형조건이므로 개방처리하면



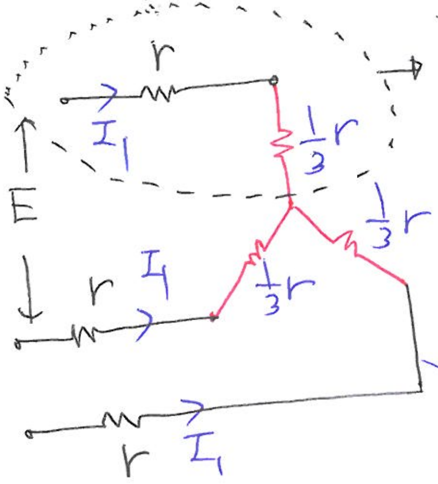
$$R_{ab} = \frac{1}{\frac{1}{9}+\frac{1}{6}+\frac{1}{18}} = 3[\Omega]$$

8.





변경하여 I_1을 구하고 I_2는 Δ결선 상전류값으로 구하면 됨



한상의 Z
$= r + \frac{1}{3}r = \frac{4}{3}r$

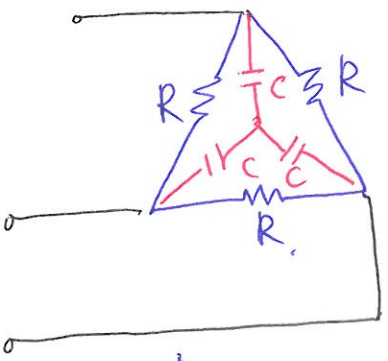
Y결선 선전류$(I_1) = \frac{V_L}{\sqrt{3}\cdot Z}$

$$I_1 = \frac{E}{\sqrt{3}\cdot\frac{4}{3}r} = \frac{\cancel{3}E}{\cancel{\sqrt{3}}\cdot 4\cdot r} \times \frac{\sqrt{3}}{\cancel{\sqrt{3}}}$$

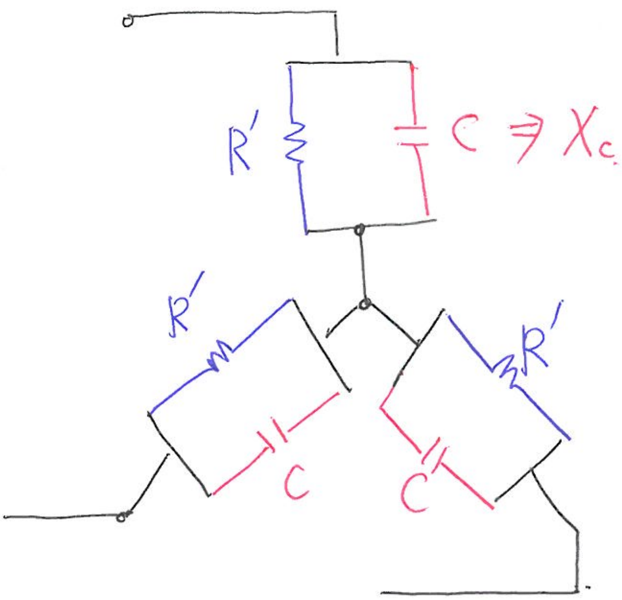
$I_1 = \frac{\sqrt{3}E}{4\cdot r}$, 여기서 I_2는 Δ결선 상전류이므로 $I_2 = \frac{I_1}{\sqrt{3}}$

$$I_2 = \frac{\frac{\sqrt{3}E}{4r}}{\sqrt{3}} = \frac{E}{4\cdot r}$$

9.



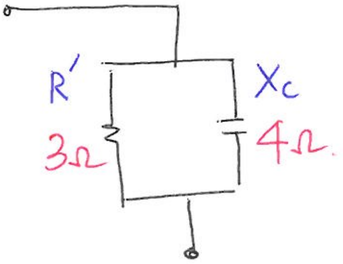
로 변경하면 2중 Y결선됨



$R' = \frac{R}{3} = \frac{9}{3} = 3[\Omega]$

$X_c = \frac{1}{\omega C} = 4[\Omega]$

↳ 문제 조건에.



R-C 병렬에서 역률은

$$\frac{X}{\sqrt{R^2+X^2}} = \frac{4}{\sqrt{3^2+4^2}} = 0,8$$

10. 성상결선 = 성형결선

조건 <

$I_L = I_p$

$V_L = 2\cdot\sin\frac{\pi}{n}\cdot V_p \angle\left(\frac{\pi}{2}-\frac{\pi}{n}\right)$

선간전압 는 성상전압의 몇배

상전압

$$\begin{array}{cccc} \downarrow & \downarrow & & \downarrow \\ V_L & = & V_p \times & \left(2\sin\frac{\pi}{n}\right) \end{array}$$

11. 위상차

$$\theta = \left(\frac{\pi}{2}-\frac{\pi}{n}\right)$$

$$= \frac{\pi}{2}\left(1-\frac{2}{n}\right)$$

12. 12상 Y결선 (?)

12상 성형결선 이 옳은 말

단자전압 = 선간전압(V_L)

$$V_L = 2\cdot\sin\frac{\overset{180}{\pi}}{\underset{12}{n}}\times \overset{100}{V_p}$$

$$V_L = 2\times\sin\frac{180}{12}\times 100$$

= 복소수 나오면 S⇔D 누르면 51,76[V]

13. 위상차 (θ)

$$\theta = \left(\frac{\pi}{2} - \frac{\pi}{\underset{\uparrow 5}{n}}\right)$$

$$= 90 - \frac{180}{5} = 54^\circ$$

14. 10 [KW] = 유효전력 = 소비전력 = P

$$P = \sqrt{3} \times V_L \times I_L \times \cos\theta$$

$$10 \times 10^3 [W] = \sqrt{3} \times 200 \times I_L \times 0,8$$

$$I_L = \frac{10 \times 10^3}{\sqrt{3} \times 200 \times 0,8} = 36,08 [A]$$

* 3상 나오고 전압 주어주면
선간전압 이다

15. $\underset{-j}{\underline{\text{뒤진}}}$ 역률 80% 일때 선전류

보기가 복소수 임을 확인

① 먼저 선전류를 구한다. (3상이므로)

$$I_L = \frac{P[W]}{\sqrt{3} \cdot V \cdot \cos\theta} = \frac{10 \times 10^3 [W]}{\sqrt{3} \times 200 \times 0,8}$$

$$= 36,08 [A]$$

복소수 표현시 $\underline{\text{뒤진}}$역률 → $-j$

$$I = I \cdot \cos\theta \underset{\text{뒤진}}{-j} I \cdot \sin\theta$$

$$= 36,08 \times 0,8 - j\, 36,08 \times 0,6$$

$$= 28,86 - j\, 21,65$$

16. 1 [HP] = 746 [W]

$$I_L = \frac{P}{\sqrt{3} \times V \times \cos\theta \times \eta} = \frac{5 \times 746}{\sqrt{3} \times 220 \times 0,85 \times 0,8}$$

$$= 14,39 [A]$$

17. Δ결선 → P

$$P = 3 \cdot I_p^2 \times R = 3 \times \frac{V_L^2}{R^2 + X^2} \times R$$

$$P = 3 \times \frac{200^2}{14^2 + 48^2} \times 14$$

$$= 672 [W]$$

18. Y결선 ⇒ P

$$P = 3\cdot I_p^2 \times R = \frac{V_L^2}{R^2+X^2}\times R$$

$$P = \frac{100^2}{24^2+7^2}\times 24$$

$= 384$ [W], 답 = ④번

19. Y결선, 각상의 저항 (R)

$P = 3\cdot I_p^2 \times R$ 에서

$$R = \frac{P}{3\cdot I_p^2} = \frac{4\times 10^3\ [W]}{3\times 10^2}$$

$= 13{,}3\ [\Omega]$

20. Y결선 → P_r

$$P_r = 3\cdot I_p^2\cdot X = \frac{V_L^2}{R^2+X^2}\times X$$

$$P_r = 3\times 20^2\times 4$$

$= 4800$ [Var]

21. 무효전력 (P_r) ---> cosθ

$$P_r = \sqrt{3}\cdot V_L\cdot I_L\cdot \sin\theta$$

$$\sin\theta = \frac{P_r}{\sqrt{3}\cdot V_L\cdot I_L} = \frac{1788}{\sqrt{3}\times 200\times 8{,}6}$$

$= 0{,}6$

$$\cos\theta = \sqrt{1-\sin^2\theta} = \sqrt{1-0{,}6^2} = 0{,}8$$

22. 3상 피상전력 (P_a)

$$P_a = 3\cdot I_p^2\cdot Z = \sqrt{3}\,VI$$

$$= 3\times 20^2\times\sqrt{3^2+4^2} = 6000\ [VA]$$

23. 같은 저항일때

Y결선 $I_L = \dfrac{V_L}{\sqrt{3}\cdot Z}$

Δ결선 $I_L' = \dfrac{\sqrt{3}\cdot V_L}{Z}$

$$\frac{I_L'}{I_L} = \frac{\dfrac{\sqrt{3}\cdot \cancel{V_L}}{\cancel{Z}}}{\dfrac{\cancel{V_L}}{\sqrt{3}\,\cancel{Z}}} = 3$$

24. Δ → Y

① 소비전력 $\frac{1}{3}$로 줄어든다

② 선전류 $\frac{1}{3}$로 줄어든다

③ 임피던스 $\frac{1}{3}$로 줄어든다

25.

n상의 유효전력

$$P = n \cdot V_p \cdot I_p \cdot \cos\theta$$

㉠ 성형결선 $\left[\begin{array}{l} I_L = I_p \\ V_L = 2\sin\frac{\pi}{n}\cdot V_p \end{array}\right.$

$$\therefore V_p = \frac{1}{2\cdot\sin\frac{\pi}{n}}\cdot V_L$$

$$P = n\cdot\frac{1}{2\cdot\sin\frac{\pi}{n}}\times V_L\times I_L\times\cos\theta$$

㉡ 환상결선 $\left[\begin{array}{l} V_L = V_p \\ I_L = 2\cdot\sin\frac{\pi}{n}\cdot I_p \end{array}\right.$

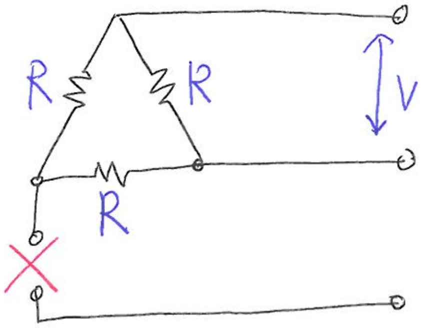
$$I_p = \frac{1}{2\cdot\sin\frac{\pi}{n}}\cdot I_L$$

$$P = n\cdot V_L\cdot\frac{1}{2\cdot\sin\frac{\pi}{n}}\cdot I_L\cdot\cos\theta$$

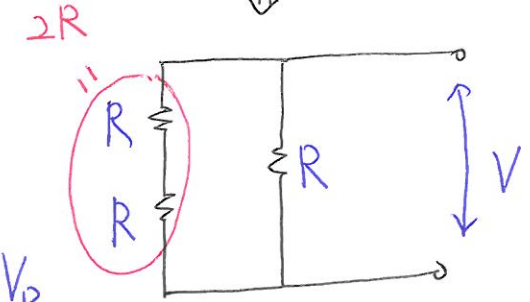
② 번 보기에 n이 없으므로 잘못됨

26.

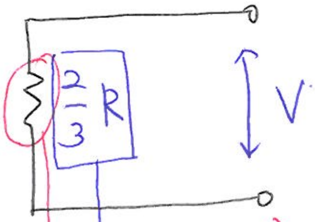
1선 단선되었을때 전력 (P)



⇓



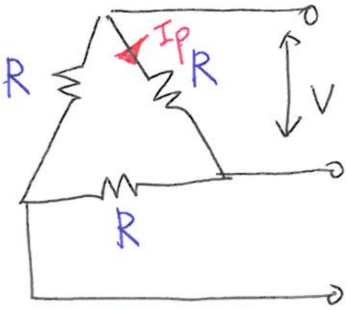
⇓



$$\frac{2R\times R}{2R+R} = \frac{2R^2}{3R} = \frac{2}{3}R$$

$$P = \frac{V^2}{R} = \frac{V^2}{\frac{2}{3}R} = \frac{3}{2}\cdot\frac{V^2}{R}$$

처음의 전력 (P)



3∅ Δ결선 전력

$$P = 3\cdot I_p^2\cdot R = 3\cdot\left(\frac{V}{R}\right)^2\cdot R = 3\cdot\frac{V^2}{R}$$

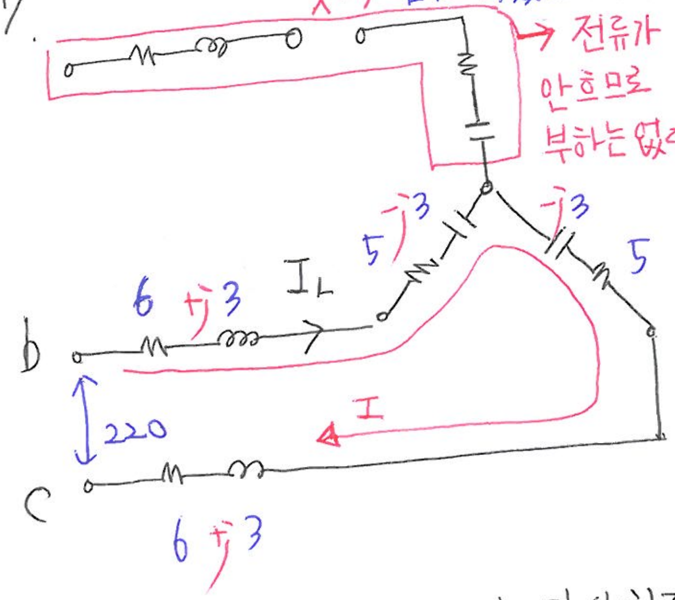
$$I_p = \frac{V}{R}$$

1선단선시 소비전력 은 처음전력의 몇배

$$\frac{3}{2}\frac{V^2}{R} = 3\cdot\frac{V^2}{R} \times (\,?\,)$$

$$\frac{3}{2}\frac{V^2}{R} = \frac{3V^2}{R} \times \left(\underbrace{\frac{1}{2}}_{\text{답}}\right)$$

27.



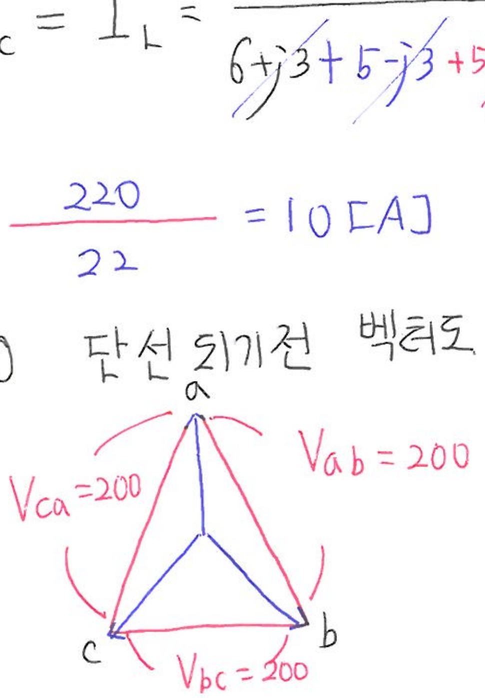
X → 단선 되었으므로 → 전류가 안흐므로 부하는 없다고 생각하면 됨

전류는 b 에서 C 로흐르는 단상회로 가 된다

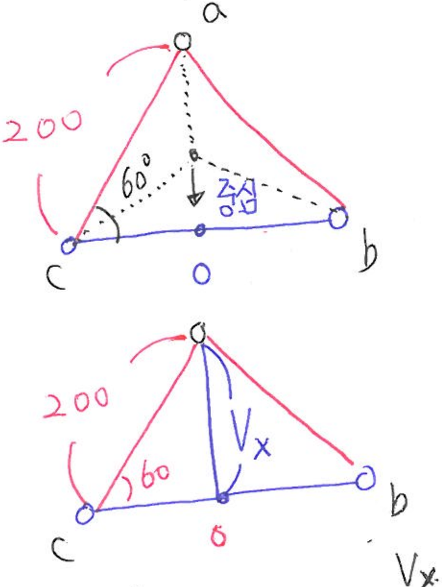
$$I_{bc} = I_L = \frac{220}{6+\cancel{j3}+5-\cancel{j3}+5-\cancel{j3}+6+\cancel{j3}}$$

$$= \frac{220}{22} = 10\,[A]$$

28. ① 단선되기전 벡터도



② 단선후 벡터도.



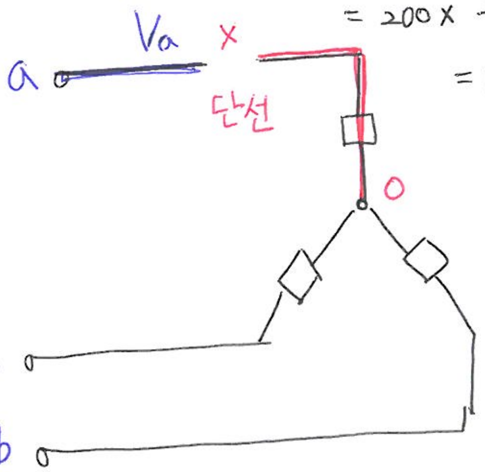
↳ $\sin 60 = \frac{V_x}{200}$

$V_x = 200 \times \sin 60$

$= 200 \times \frac{\sqrt{3}}{2}$

$= 100\sqrt{3}$

③

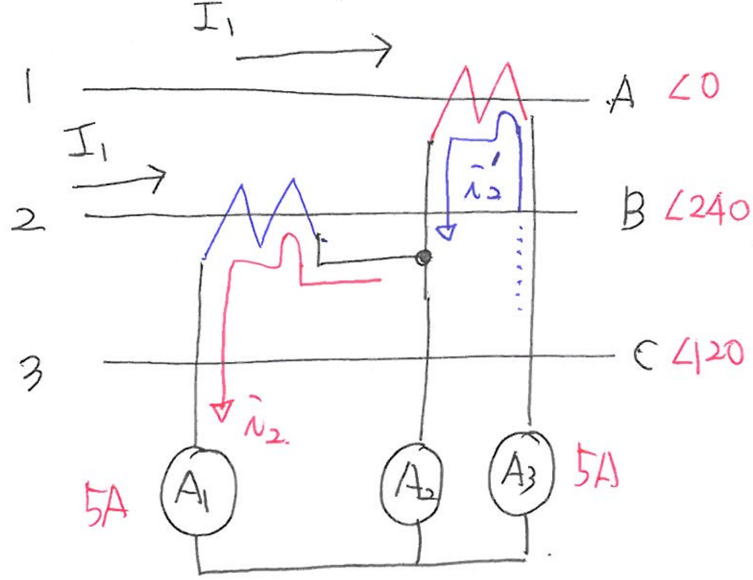


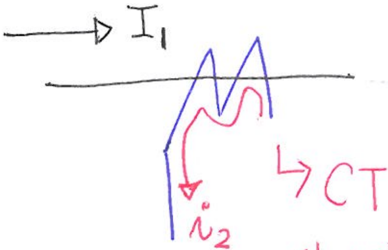
* 단선 왼쪽은 V_a 이고 단선 오른쪽은 O 점 즉 중성점 전위이고 중성점전위는 b와 C 의 중간이므로. 단선시 양단의 전압은 ② 그림의 V_x 와같다.

따라서

V_x = 선간전압 × $\frac{\sqrt{3}}{2}$ 을 기억

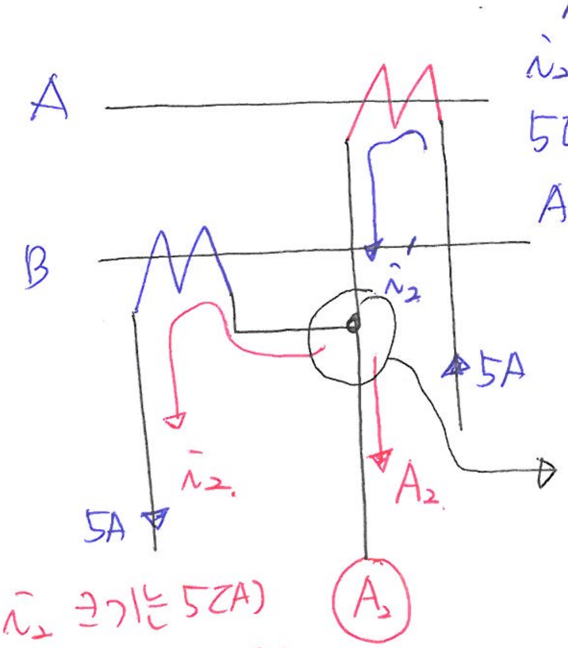
29: 문제 그림의 화살표 지워주세요





↳ CT = 변류기 이며 실기 형태 문제임

*CT는 감극성 이므로 I_1 과 i_2는 방향=반대.



i_2' 크기는 5[A]인데 A상이므로 5∠0

i_2 크기는 5[A] 인데 B상이므로 5∠240

KCL 적용하면

$$i_2' = i_2 + A_2$$

$$A_2 = i_2' - i_2$$

$$= 5\angle0 - 5\angle240$$

= 복소수 ⇒ 크기로 바꾸면 $\boxed{5\sqrt{3}}$ 답

30. 2전력계법

$$P = P_1 + P_2 = 500 + 300 = 800W$$

31. 2전력계법

$$P_a = 2\times\sqrt{P_1^2+P_2^2-(P_1\times P_2)}$$

$$= 2\times\sqrt{800^2+1600^2-(800\times1600)}$$

$$= 2771.2 \text{ [VA]}$$

32. 역률 $= \cos\theta = \frac{P}{P_a}$

$$\cos\theta = \frac{P_1+P_2}{2\sqrt{P_1^2+P_2^2-(P_1\times P_2)}}$$

33. 조건 2전력계법 전력계 2배차이

$P_1 = 1$, $P_2 = 2$

$$\cos\theta = \frac{P_1+P_2}{2\sqrt{P_1^2+P_2^2-P_1P_2}} = \frac{1+2}{2\sqrt{1^2+2^2-(1\times2)}}$$

$$= \frac{\cancel{3}}{2\sqrt{\cancel{3}}}\times\frac{\sqrt{3}}{\cancel{\sqrt{3}}} = \frac{\sqrt{3}}{2}$$

$= 0.866$

$= 86.6\ \%$

34. 조건 두전력계중하나가 0

$P_1 = P$, $P_2 = 0$

$$\cos\theta = \frac{P_1 + P_2}{2\sqrt{P_1^2 + P_2^2 - (P_1 \cdot P_2)}} = \frac{P + 0}{2\sqrt{P^2 + 0^2 - (\cancel{P} \times 0)}}$$

$$= \frac{P}{2P} = \frac{1}{2} = 0.5$$

35. 조건 $\left\{ \begin{array}{l} P_1 = 200 \\ P_2 = 400 \end{array} \right.$ ↲ 2배차이

$\cos\theta = 0.866$ 임

36. 부하가 R 이므로 $\cos\theta = 1$

2전력계법에서 $\cos\theta = 1$, $\langle P_1 = P_2 \rangle$

유효전력 $(P) = P_1 + P_2 = W + W = 2W$

「C 상전류는 Y 결선 이므로 $(I_L = I_p)$」

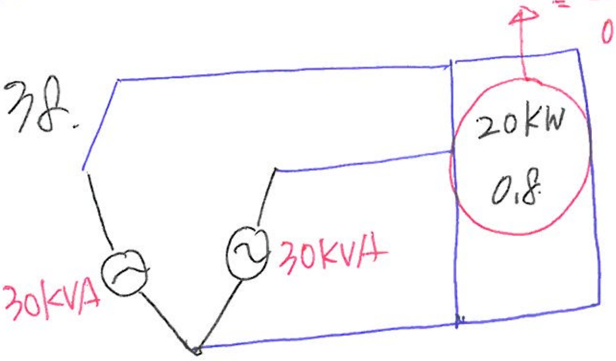
$$P = 2W = \sqrt{3} \cdot V_L \cdot I_L \cdot \underbrace{\cos\theta}_{=1}$$

$$I_L = \frac{2W}{\sqrt{3} \cdot \underbrace{V_L}_{=V} \cdot \underbrace{\cos\theta}_{=1}} = \frac{2W}{\sqrt{3} \cdot V}$$

37. V결선 이용률 $= \dfrac{\sqrt{3} \cdot \cancel{TR}}{2 \cdot \cancel{TR}}$

$$= \frac{\sqrt{3}}{2} = 0.866 = 86.6\%$$

38.



전체 피상전력 $= \dfrac{20}{0.8}$

변압기 1대가 분담하는 피상전력

↓

P_1

V결선에 3상 부하 연결.

↓

$$\sqrt{3} \cdot P_1 = \frac{20}{0.8}$$

$$P_1 = \frac{20}{\sqrt{3} \times 0.8} = \underbrace{14.4}_{\text{1대 분담용량}} \text{ [KVA]}$$

39.

회전자계 $\left\{ \begin{array}{l} \text{대칭 : 원형} \\ \text{비대칭 : 타원} \end{array} \right.$

8장

1. 대칭좌표법 용어중 < 정상분 / 역상분 / 영상분

3상 공통성분 → V_a, V_b, V_c

① $V_a = V_0 + V_1 + V_2$

② $V_b = V_0 + a^2 V_1 + a V_2$

③ $V_c = V_0 + a V_1 + a^2 V_2$

→ 공통성분=영상분

2. 조건 세전류 합은 = 0

$I_a + I_b + I_c = 0$

영상분 $(I_0) = \frac{1}{3}(\underbrace{I_a + I_b + I_c}_{=0})$

$I_0 = 0$ ⇒ 영상분은 0이다

3. 영상분 = 0 ⇒ { Δ결선 / 비접지 Y

4. 영상분 존재 { 3Ø4W Y결선

5. 3상 4선식 에 중성선 제거 → 비접지 Y결선

평형상태에서는 중성점 전위 0

전류가 흐르지 않는다 ⇒ $I_a + I_b + I_c = 0$

6. 잘못된것

① 비접지 회로에서는 영상분 존재 안한다

7. 잘못된것

④ 접지식 회로에서는 영상분 존재한다

8. 비접지 Y결선 ⇒ $I_a + I_b + I_c = 0$

$I_c = -(I_a + I_b)$

$= -(15 + j2 + \underbrace{(-20 - j14)}_{-20 - j14})$

$= -(-5 - j12)$

$= 5 + j12$

8장

9. $I_b = I_0 + a^2\cdot I_1 + a\cdot I_2$

10. a 상 전압 = V_a

$V_a = V_0 + V_1 + V_2$

$= -8 \boxed{+j3} + 6 \boxed{-j8} + 8 \boxed{+j12}$

$= 6 - j7$

11. V_0 = 영상전압 = $\frac{1}{3}(V_a + V_b + V_c)$

12. V_1 = 정상전압 = $\frac{1}{3}(V_a + a\cdot V_b + a^2\cdot V_c)$

13. V_2 = 역상전압 = $\frac{1}{3}(V_a + a^2\cdot V_b + aV_c)$

14. V_{a1} = a상을 기준한 정상분전압

$V_{a1} = \frac{1}{3}\cdot(V_a + a\cdot V_b + a^2\cdot V_c)$

$= \frac{1}{3}\cdot(V_a + V_b\cdot\angle 120 + V_c\cdot\angle 240)$

$= \frac{1}{3}\cdot(V_a + V_b\angle -240 + V_c\angle -120)$

$= \frac{1}{3}(V_a + V_b\angle 120 + V_c\angle -120)$

15. ① 영상분 ② 정상분 ③ 역상분

16. $V_0 = \frac{1}{3}\cdot(V_a + V_b + V_c)$

$= \frac{1}{3}(3 + 2 \cancel{-j3} + 4 \cancel{+j3})$

$= \frac{1}{3}\cdot 9 = 3$ [V]

17. 조건

· 컨덕턴스 (실수취급)
- a상 0.3℧ = Y_a
- b상 0.3℧ = Y_b

· 유도서셉턴스 = $\frac{1}{\text{유도리액턴스}}$

$= \frac{1}{+jX_L}$

$= -j\frac{1}{X_L}$ [℧]

유도서셉턴스 C상 0.3 [℧]

$= -j0.3 = Y_c$

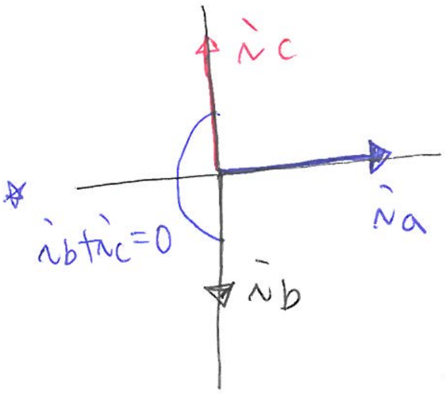
· 영상어드미턴스 = Y_0

$Y_0 = \frac{1}{3}(Y_a + Y_b + Y_c)$

$= \frac{1}{3}(0.3 + 0.3 - j0.3)$

$= 0.2 - j0.1$

18. 각상의 전류를 벡터로표현



영상분전류 $(I_0) = \frac{1}{3}(I_a + \underbrace{I_b + I_c}_{=0})$

$I_0 = \frac{1}{3}\cdot I_a$

$= \frac{1}{3}\times 30\cdot \sin\omega t = 10\sin\omega t$

19. 정상분전류 $(I_1) = \frac{1}{3}\cdot(I_a + a\cdot I_b + a^2\cdot I_c)$

단) $a = 1\angle 120$, $a^2 = 1\angle 240$

$I_1 = \underbrace{\frac{1}{3}}_{④}\cdot\left(\underbrace{7+j2}_{③} + \underbrace{(1\angle120)\times(-8-j10)}_{①} + \underbrace{(1\angle240)\times(-4+j6)}_{②}\right)$

↓계산기

⇒ (1∠120)×(−8−10i) $\boxed{=}$ +

ANS + ((1∠240)×(−4+6i)) $\boxed{=}$ +

ANS + (7+2i) $\boxed{=}$ ÷3

ANS ÷3 = 8,952 +j0,1786

Shift $\boxed{2}$ $\boxed{3}$ $\boxed{=}$ ⇒ $\underbrace{8{,}95}_{답}\angle 1{,}14$

20. 역상분전류 (I_2)

$I_2 = \frac{1}{3}\cdot(I_a + a^2\cdot I_b + a\cdot I_c)$

단) $a^2 = 1\angle240$, $a = 1\angle120$

$I_2 = \underbrace{\frac{1}{3}}_{④}\cdot\left(\underbrace{15+j2}_{③} + \underbrace{(1\angle240)\cdot(-20-j14)}_{①} + \underbrace{(1\angle120)\cdot(-3+j10)}_{②}\right)$

⇒ (1∠240)×(−20−14i) $\boxed{=}$ +

ANS + ((1∠120)×(−3+10i)) $\boxed{=}$ +

ANS + (15+2i) $\boxed{=}$ ÷3

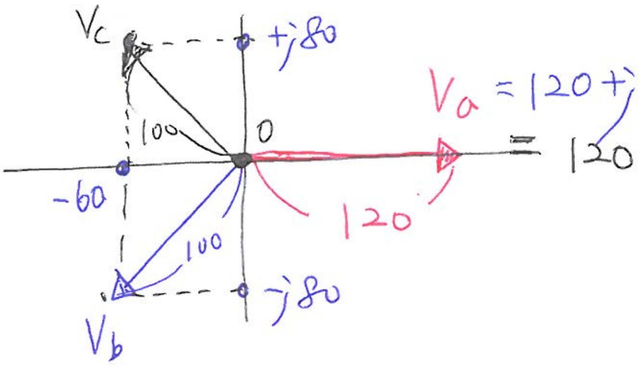
ANS ÷3 $\boxed{=}$

↳ 1,905 +j6,24

21. 선간전압 나오고 역상전압 구할때는 선간전압의 복소수 값을 구한다

선간전압 $V_a=120$, $V_b=100$, $V_c=100$ 에서

$V_a+V_b+V_c=0$ 을 이용



$V_b=-60-j80$, $V_c=-60+j80$

$$역상전압=V_2=\frac{1}{3}\cdot\left(V_a+a^2\cdot V_b+a\cdot V_c\right)$$

$$=\underbrace{\frac{1}{3}}_{④}\cdot\left(\underbrace{120}_{③}+\underbrace{(1\angle 240)\times(-60-j80)}_{①}+\underbrace{(1\angle 120)\times(-60+j80)}_{②}\right)$$

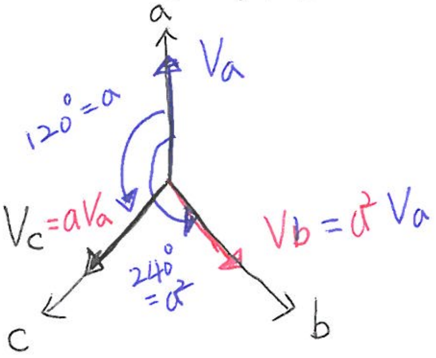
⇒ $(1\angle 240)\times(-60-80i)$ ▤ +

ANS + $((1\angle 120)\times(-60+80i))$ ▤ +

ANS + 120 ▤ ÷3

ANS ÷3 ⇒ 13.81 [V]

22. a상을 기준으로 대칭분



a상을 기준으로하면

V_a, $V_b=a^2\cdot V_a$, $V_c=a\cdot V_a$

가 되어 이것을 대칭분적용하면

$$V_0=\frac{1}{3}\cdot\left(V_a+V_b+V_c\right)$$

$$=\frac{1}{3}\cdot\left(V_a+a^2V_a+aV_a\right)$$

$$=\frac{1}{3}\cdot\left([\underbrace{1+a^2+a}_{=0}]\cdot V_a\right)$$

$$=0$$

$$V_1=\frac{1}{3}\cdot\left(V_a+a\cdot V_b+a^2\cdot V_c\right)$$

$$=\frac{1}{3}\cdot\left(V_a+\underbrace{a\times a^2}_{a^3=1}V_a+\underbrace{a^2\cdot a}_{a^3=1}V_a\right)$$

$$=\frac{1}{3}\cdot\left([1+1+1]\cdot V_a\right)$$

$$=V_a$$

$$V_2=\frac{1}{3}\left(V_a+a^2\cdot V_b+a\cdot V_c\right)$$

$$=\frac{1}{3}\cdot\left(V_a+\underbrace{a^2\cdot a^2}_{\substack{a^4=a^3\times a^1\\=1\times a=a}}V_a+\underbrace{a\cdot a}_{a^2}V_a\right)$$

$$=\frac{1}{3}\cdot\left(V_a+a\cdot V_a+a^2\cdot V_a\right)$$

$$=\frac{1}{3}\cdot\left([\underbrace{1+a+a^2}_{=0}]\cdot V_a\right)$$

$$=0$$

23. a상을 기준한 대칭분 전압중 정상분 (V_1)

→ 22번해설확인, $V_1 = V_a$

24. $불평형률 = \frac{역상분}{정상분} \times 100[\%]$

25. $불평형률 = \frac{역상분}{정상분} = \frac{50}{200}$

$= 0,25$

26. $불평형률 = \frac{역상분(V_2)}{정상분(V_1)} = \frac{\cancel{\frac{1}{3}}\cdot(V_a + a^2 V_b + aV_c)}{\cancel{\frac{1}{3}}\cdot(V_a + a\cdot V_b + a^2\cdot V_c)}$

$$불평형률 = \frac{V_a + a^2 V_b + aV_c}{V_a + a\cdot V_b + a^2\cdot V_c}$$

$$= \frac{120 + (1\angle 240)\times(-60-j80) + (1\angle 120)\times(-60+j80)}{\underset{③}{120} + \underbrace{(1\angle 120)\times(-60-j80)}_{①} + \underbrace{(1\angle 240)\times(-60+j80)}_{②}}$$

분모 먼저 풀면

$(1\angle 120)\times(-60-80i)$ 目 +

ANS + $((1\angle 240)\times(-60+80i)$ 目 +

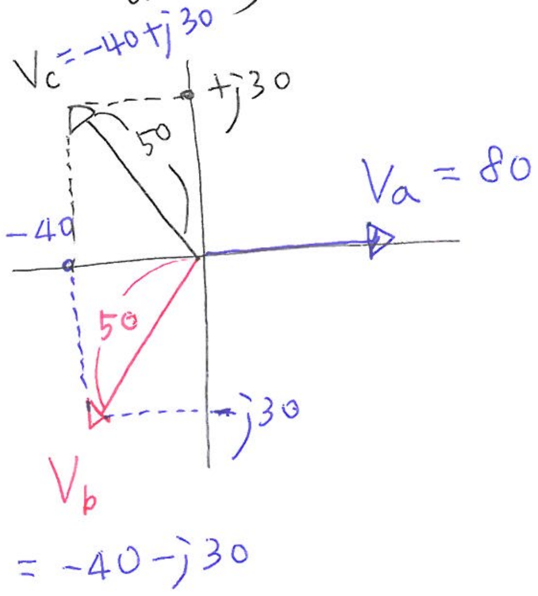
ANS + 120 目 ⇒ 318,56

$$\frac{\boxed{분자}}{\boxed{ANS}} = \frac{120 + ((1\angle 240)\times(-60-80i)) + ((1\angle 120)\times(-60+80i))}{ANS}$$ 目

$= 0,13 = 13\%$

27. 선간전압 나오고 불평형률

↳ $V_a = 80$, $V_b = 50$, $V_c = 50$



28. 발전기 기본식

$$V_0 = -Z_0 \cdot I_0$$

$$V_1 = E_a - Z_1 \cdot I_1$$

$$V_2 = -Z_2 \cdot I_2$$

벡터도에 의해

$V_a = 80$, $V_b = -40-j30$

$V_c = -40+j30$ 을 이용하여

$$\text{불평형률} = \frac{V_2}{V_1} = \frac{\cancel{\frac{1}{3}} \cdot (V_a + a^2 \cdot V_b + a \cdot V_c)}{\cancel{\frac{1}{3}} \cdot (V_a + a \cdot V_b + a^2 \cdot V_c)}$$

$$= \frac{80 + [(1\angle 240) \times (-40-30i)] + [(1\angle 120) \times (-40+30i)]}{80 + [(1\angle 120) \times (-40-30i)] + [(1\angle 240) \times (-40+30i)]}$$

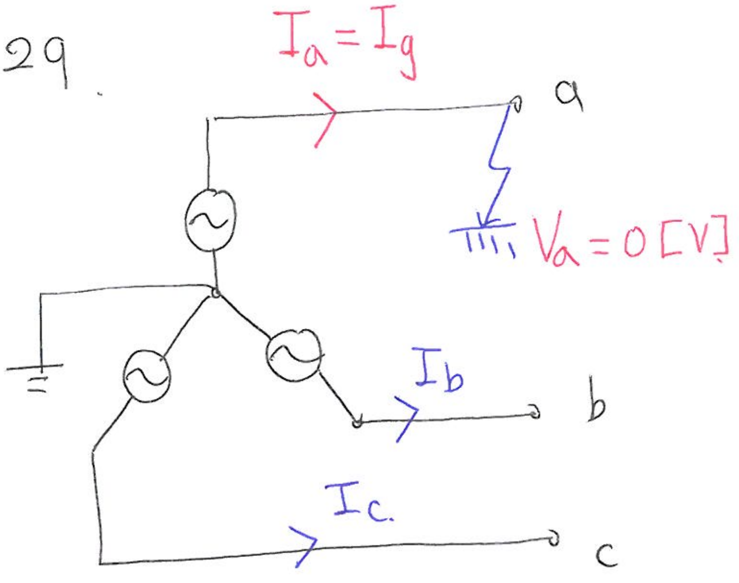
⇓ 계산기에 전체식을 넣어 계산하면

= 0.3956

↓ ×100

= 39.56 [%]

29.



↳ 이문제는 답만 외우세요.

1선지락사고시 조건 ⇒

$V_a = 0, \quad I_b = 0, \quad I_c = 0$

① 대칭분

$$I_0 = \frac{1}{3}\cdot(I_a + \overset{0}{I_b} + \overset{0}{I_c}) = \frac{1}{3}I_a$$

$$I_1 = \frac{1}{3}\cdot(I_a + \underbrace{a\cdot\overset{0}{I_b}}_{=0} + \underbrace{a^2\cdot\overset{0}{I_c}}_{=0}) = \frac{1}{3}I_a$$

$$I_2 = \frac{1}{3}(I_a + \underbrace{a^2\cdot\overset{0}{I_b}}_{=0} + \underbrace{a\cdot\overset{0}{I_c}}_{=0}) = \frac{1}{3}I_a$$

⇒ $\underline{I_0 = I_1 = I_2}$, $I_a = 3I_0 = I_g$

② $V_a = 0$

$$V_a = \overset{-Z_0I_0}{V_0} + \overset{E_a - Z_1I_1}{V_1} + \overset{-Z_2I_2}{V_2} = 0$$

발전기 기본식 적용하면

$$-Z_0I_0 + E_a - Z_1\overset{I_0}{I_1} - Z_2\overset{I_0}{I_2} = 0$$

$$E_a = Z_0I_0 + Z_1\overset{I_0}{I_1} + Z_2\overset{I_0}{I_2}$$

$$E_a = (Z_0 + Z_1 + Z_2)\cdot I_0$$

$$I_0 = \frac{E_a}{Z_0 + Z_1 + Z_2}$$

$$I_a = 3I_0 = \frac{3\cdot E_a}{Z_0 + Z_1 + Z_2}$$

30 2선지락사고 조건

$V_0 = V_1 = V_2 \neq 0$

31. 천전력은 복소전력을이용한다

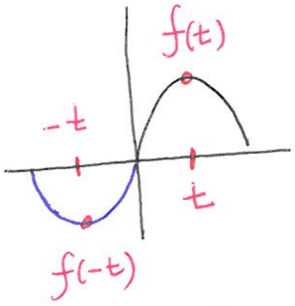
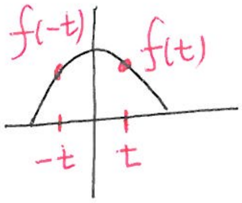
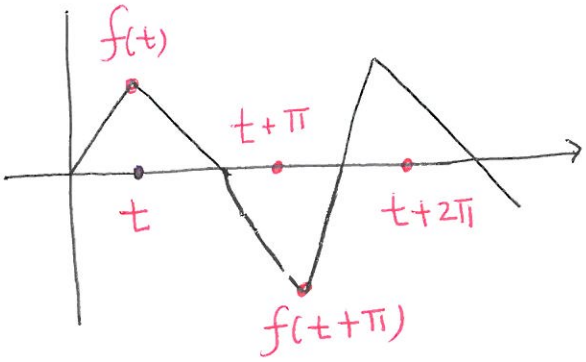
$= 3\cdot(\overline{V_0}I_0 + \overline{V_1}I_1 + \overline{V_2}I_2)$

$= 3\cdot(V_0\overline{I_0} + V_1\overline{I_1} + V_2\overline{I_2})$

9장

<교재 p107>

2. 대칭성

	정현대칭	여현대칭	반파대칭
특징	원점대칭	Y축대칭	반주기 마다 파형이 +, - 값을 갖는다
적용예	Sin	COS	삼각파 , 구형파
			
특성식	$f(t) = -f(-t)$	$f(t) = f(-t)$	$f(t) = -f(t+\pi)$
존재항	Sin항	cos항, 상수항	홀수(기수)항
부존재	상수항, cos항	Sin항	짝수(우수)항

9장

1. 비정현파를 여러개의 정현파 합

↳ 푸리에 분석

2. 비정현파식

$$f(t) = a_0 + \sum_{n=1}^{\infty} a_n \cdot \cos n\omega t + \sum_{n=1}^{\infty} b_n \sin\omega t.$$

= 직류분 + 기본파 + 고조파

3. 푸리에 급수 형태

① 직류분 + 기본파 + 고조파

② $a_0 + \sum_{n=1}^{\infty} a_n \cdot \cos n\omega t + \sum_{n=1}^{\infty} b_n \sin n\omega t$

4. 구형파 신호는

↳ 무수히 많은 주파수 성분 가진다

5. 문제그림 구형 반파.

a_0 → 직류분 = 평균값

구·반·평 = $\frac{I_m}{2} = \frac{10}{2} = 5$

6. 문제 조건

반파대칭 ⇒ $a_0 = 0$

a_n, b_n ⇒ 홀수만 존재

7. 반파대칭

$y(x) = -y(x+\pi)$

8. 반파대칭 ⇒ 홀수 만 존재

보기③ 5고조파

9. 문제조건

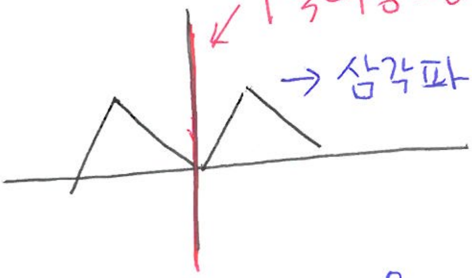
반파대칭 , 정현대칭

↓

$f(x) = -f(x+\pi)$, $f(x) = -f(-x)$

또는 $-f(x) = f(x+\pi)$, $-f(x) = f(-x)$

10



(cos항, 상수)

Y축대칭 = 여현대칭

→ 삼각파 ⇒ 반파대칭 (홀수)

① sin항 없다 (옳은말)

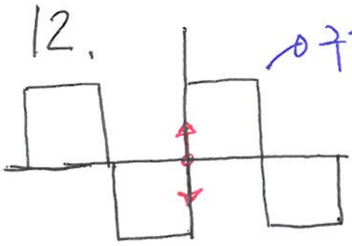
11. 반파, 여현대칭

↳ 홀수, ↳ cos항, 상수항

문제조건에

b_n (n = 홀수)

12.



→ 구형파 ⇒ 반파 대칭

원점대칭 = 정현 대칭

∴ 반파 정현대칭

↳ sin항 앞에 홀수

홀수

③ $\frac{4A}{\pi}(\underline{\sin} x + \frac{1}{3}\underline{\sin} 3x + \cdots$

홀수 ⇒ 반파 (구형파)

13 $i(t) = \frac{4I_m}{\pi}(\underline{\sin}\omega t + \frac{1}{3}\underline{\sin} 3\omega t +$

sin항 ⇒ 정현대칭 = 원점대칭

보기에서 구형파이면서 원점대칭은

②번

14. $i(t) = \frac{4I_m}{\pi}\left(\cos\omega t + \frac{1}{3}\cos 3\omega t\right.$

홀수 ⇒ 반파대칭 (구형파)

↳ cos항 ⇒ 여현대칭 (Y축대칭)

* 보기에서 구형파이면서
Y축대칭 ⇒ ① 번

15. 비정현파 실효값

$$I = \sqrt{I_0^2 + I_1^2 + I_2^2 + \cdots}$$

= 각파형 실효값 제곱 합의 제곱근

16. $V = \underbrace{\sqrt{2}\cdot 100}_{V_{m1}}\cdot\sin\omega t + \underbrace{\sqrt{2}\cdot 50}_{V_{m2}}\cdot\sin 2\omega t + \underbrace{\sqrt{2}\cdot 30}_{V_{m3}}\sin 3\omega t\ [V]$

실효값 전압 $V = \sqrt{V_1^2 + V_2^2 + V_3^2}$

$$= \sqrt{100^2 + 50^2 + 30^2} = 115.75[V]$$

17. $i = \overset{I_{m1}}{\boxed{30}}\sin\omega t + \overset{I_{m2}}{\boxed{50}}\sin(3\omega t + 60)$

$$I = \sqrt{I_1^2 + I_2^2} = \sqrt{\left(\frac{30}{\sqrt{2}}\right)^2 + \left(\frac{50}{\sqrt{2}}\right)^2}$$

$$= 41.23[A]$$

18. $V = \overset{V_0}{\boxed{10}} + \overset{V_{m1}}{\boxed{10\sqrt{2}}}\sin\omega t + \overset{V_{m3}}{\boxed{10\sqrt{2}}}\sin 3\omega t + \overset{V_{m5}}{\boxed{10\cdot\sqrt{2}}}\sin 5\omega t$

$$V = \sqrt{V_0^2 + V_1^2 + V_3^2 + V_5^2}$$

$$= \sqrt{10^2 + \left(\frac{10\sqrt{2}}{\sqrt{2}}\right)^2 + \left(\frac{10\sqrt{2}}{\sqrt{2}}\right) + \left(\frac{10\sqrt{2}}{\sqrt{2}}\right)^2}$$

$$= 20[V]$$

19. 인덕터 축적에너지 (W_L)

$$W_L = \frac{1}{2}\times L \times I^2\ [J]$$

↳ 비정현파 전류

실효값

$$W_L = \frac{1}{2}\times 1\times(12.24)^2 = 74.9[J]$$

$$i = 5 + 10\sqrt{2}\sin 100t + 5\sqrt{2}\sin 200t$$

$$I = \sqrt{5^2 + 10^2 + 5^2}$$

$$= 12.24[A]$$

* $\left[\begin{array}{l} R = 4[\Omega] \\ \omega L = 1[\Omega] \end{array}\right.$

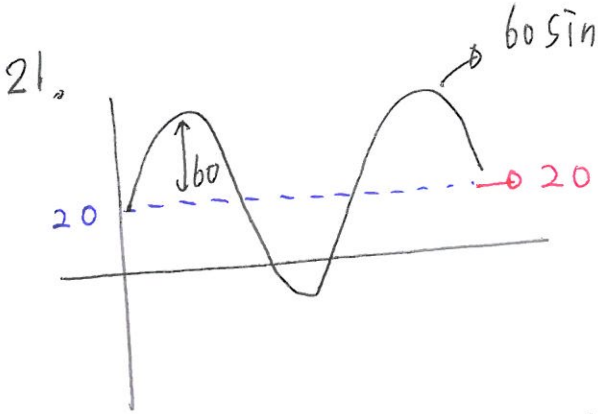
20. $V = 100\sqrt{2}\sin\omega t + \overset{V_{m3}}{\boxed{75\sqrt{2}}}\sin 3\omega t + 20\sqrt{2}\sin 5\omega t$

3고조파 전류 실효값 (I_3)

$$I_3 = \frac{V_3}{Z_3} = \frac{75}{\underset{4}{R} + j3\times\underset{1}{\omega L}} = \frac{75}{4+j3} = \frac{75}{\sqrt{4^2+3^2}}$$

$I_3 = 15[A]$

21.



$V(t) = 20 + 60\sin\omega t$

$$V = \sqrt{20^2 + \left(\frac{60}{\sqrt{2}}\right)^2}$$

$= 46.9[V]$

22. $R = 3\Omega$, $X_L = 4[\Omega] = \omega L$

$e = 141.4\sin\omega t + 42.4\sin 3\omega t$

$V_{m1} \rightarrow I_1$ $\quad V_{m3} \rightarrow I_3$

① $I_1 = \frac{V_1}{Z_1} = \frac{\frac{141.4}{\sqrt{2}}}{R + j\omega L} = \frac{\frac{141.4}{\sqrt{2}}}{3 + j4}$

$= \frac{\frac{141.4}{\sqrt{2}}}{\sqrt{3^2 + 4^2}} = 20 = (19.99)$

② $I_3 = \frac{V_3}{Z_3} = \frac{\frac{42.4}{\sqrt{2}}}{R + j3\times\omega L} = \frac{\frac{42.4}{\sqrt{2}}}{3 + j12}$

$= \frac{\frac{42.4}{\sqrt{2}}}{\sqrt{3^2 + 12^2}} = 2.42$

③ $I = \sqrt{I_1^2 + I_3^2}$

$= \sqrt{20^2 + 2.42^2} = 20.14[A]$

23. $R = 3$, $\omega L = 4$

$V = 60 + \sqrt{2}\cdot 100\sin(\omega t - 30)$

$V_0 \rightarrow I_0$ $\quad V_{m1} \rightarrow I_1$

① $I_0 = \frac{V_0}{R} = \frac{60}{3} = 20[A]$

② $I_1 = \frac{V_1}{Z_1} = \frac{\frac{V_{m1}}{\sqrt{2}}}{R + j\omega L} = \frac{\frac{100\sqrt{2}}{\sqrt{2}}}{3 + j4}$

$= \frac{100}{\sqrt{3^2 + 4^2}} = \frac{100}{5} = 20[A]$

③ $I = \sqrt{I_0^2 + I_1^2}$

$= \sqrt{20^2 + 20^2} = 28.28[A]$

24. n고조파의 공진주파수

$n\omega L = \frac{1}{n\omega C}$

$\omega^2 = \frac{1}{n^2 LC}$

$\omega = \sqrt{\frac{1}{n^2 LC}} = \frac{1}{n}\cdot\frac{1}{\sqrt{LC}}$

↓

$2\pi f = \frac{1}{n\sqrt{LC}} \Rightarrow f = \frac{1}{2\pi n\sqrt{LC}}$

25. 왜형률$(\varepsilon) = \dfrac{\text{전고조파 실효값}}{\text{기본파 실효값}}$

26. $i = 30\sin\omega t + 10\cos 3\omega t + 5\sin 5\omega t$

$$\varepsilon = \frac{\sqrt{\left(\frac{10}{\sqrt{2}}\right)^2 + \left(\frac{5}{\sqrt{2}}\right)^2}}{\frac{30}{\sqrt{2}}} = 0{,}372$$

27. $V = \overset{V_{m1}}{\boxed{100\sqrt{2}}}\sin\omega t + \overset{V_{m2}}{\boxed{50\sqrt{2}}}\sin 2\omega t + \overset{V_{m3}}{\boxed{30\sqrt{2}}}\sin 3\omega t$

$$\varepsilon = \frac{\sqrt{V_2^2 + V_3^2}}{V_1} = \frac{\sqrt{50^2 + 30^2}}{100} = 0{,}58$$

28. 기본파의 30%인 3고조파

$V_3 = 0{,}3$

기본파의 20%인 5고조파

$V_5 = 0{,}2$

$$\varepsilon = \frac{\sqrt{V_3^2 + V_5^2}}{V_1} = \frac{\sqrt{0{,}3^2 + 0{,}2^2}}{1} = 0{,}36$$

29. ④ $P_r = \sum_{n=1}^{\infty} V_n \cdot I_n \cdot \sin\theta_n$

30.

$V = 100\sin(\omega t - 90)$

$i = 10\sin(3\omega t + 30)$

* 주파수가 다르므로 $P = 0$

31. $V = \underbrace{100}_{V_0} + \underbrace{50}_{V_{m1}}\sin 377t$

$i = \underbrace{10}_{I_0} + \underbrace{3{,}54}_{I_{m1}}\sin(377t - 45)$

$$P = V_0 I_0 + \frac{1}{2} \times V_{m1} \times I_{m1} \times \cos\theta_1$$

$$= 100 \times 10 + \frac{1}{2} \times 50 \times 3{,}54 \times \cos(0 - (-45))$$

$$= 1000 + \frac{1}{2} \times 50 \times 3{,}54 \times \cos 45$$

$$= 1062{,}5\ [W]$$

32.

$V = \underline{100\sin\omega t} + 40\sin 2\omega t + \underline{30\sin(3\omega t + 60)}$

$i = \underline{10\sin(\omega t - 60)} + \underline{2\sin(3\omega t + 105)}$

$$P = \frac{1}{2} \times V_{m1} \times I_{m1} \times \cos\theta_1 + \frac{1}{2} \times V_{m3} \times I_{m3} \times \cos\theta_3$$

$$= \frac{1}{2} \times 100 \times 10 \times \cos(0 - (-60))$$

$$+ \frac{1}{2} \times 30 \times 2 \times \cos(105 - (60))$$

$$P = \frac{1}{2} \times 100 \times 10 \times \cos 60 + \frac{1}{2} \times 30 \times 2 \times \cos 45$$

$$= 271{,}2 \text{ [W]}$$

33. $V = \underline{100 \sin \omega t} \; \underline{-50 \sin(3\omega t + 30)}$

$\underline{+20 \sin(5\omega t + 45)}$

$i = \underline{20 \sin(\omega t + 30)} \; \underline{+10 \sin(3\omega t - 30)}$

$\underline{+5 \cos 5\omega t}$

$= 5 \cdot \sin(5\omega t + 90)$

$$P = \frac{1}{2} \times V_{m1} \times I_{m1} \times \cos\theta_1 + \frac{1}{2} \times V_{m3} \times I_{m3} \times \cos\theta_3 + \frac{1}{2} \times V_{m5} \times I_{m5} \times \cos\theta_5$$

$$= \frac{1}{2} \times 100 \times 20 \times \cos(30 - (0)) + \frac{1}{2} \times (-50) \times 10 \times \cos(30 - (-30)) + \frac{1}{2} \times 20 \times 5 \times \cos(90 - (45))$$

$$= \frac{1}{2} \times 100 \times 20 \times \cos 30 + \frac{1}{2} \times (-50) \times 10 \times \cos 60 + \frac{1}{2} \times 20 \times 5 \times \cos 45$$

$$= 776{,}38 \text{ [W]}$$

$R = 5 \, [\Omega]$

34. $i = 5 + 14{,}14 \sin 100t + 7{,}07 \sin 200t$

$P = \boxed{I}^2 \cdot R \text{ [W]}$

$\hookrightarrow I = \sqrt{5^2 + \left(\frac{14{,}14}{\sqrt{2}}\right)^2 + \left(\frac{7{,}07}{\sqrt{2}}\right)^2}$

$= 12{,}24$

$\therefore P = 12{,}24^2 \times 5 = 749{,}8 \text{ [W]}$

35. $V = \underline{100 \sin(\omega t + 30)}$

$\underline{-50 \sin(3\omega t + 60)}$

$\underline{+25 \sin(5\omega t)}$

$i = \underline{20 \sin(\omega t - 30)} \; \underline{+15 \sin(3\omega t + 30)}$

$\underline{+10 \cos(5\omega t - 60)}$

$= 10 \cdot \sin(5\omega t + 30)$

$$P = \frac{1}{2} \times V_{m1} \times I_{m1} \times \cos\theta_1 + \frac{1}{2} V_{m3} \times I_{m3} \times \cos\theta_3 + \frac{1}{2} \times V_{m5} \times I_{m5} \times \cos\theta_5$$

$$= \frac{1}{2} \times 100 \times 20 \times \cos(30 - (-30)) + \frac{1}{2} \times (-50) \times 15 \times \cos(60 - (30)) + \frac{1}{2} \times 25 \times 10 \times \cos(30 - 0)$$

$$=\frac{1}{2}\times100\times20\times\cos60$$

$$+\frac{1}{2}\times(-50)\times15\times\cos30$$

$$+\frac{1}{2}\times25\times10\times\cos30$$

$$=283,49\,[W]$$

비정현파 전압 실효값

전류 " "

3고조파 전압 최대값 -50 이나 제곱하면 + 이니까 50 대입

$$P_a=V\cdot I$$

$$=\sqrt{\left(\frac{100}{\sqrt{2}}\right)^2+\left(\frac{50}{\sqrt{2}}\right)^2+\left(\frac{25}{\sqrt{2}}\right)^2}\times\sqrt{\left(\frac{20}{\sqrt{2}}\right)^2+\left(\frac{15}{\sqrt{2}}\right)^2+\left(\frac{10}{\sqrt{2}}\right)^2}$$

$$=1542,37\,[VA]$$

36. $R=4,\ \omega L=3$

$$V=\underbrace{100\sqrt{2}}_{\to V_{m1}\to I_1}\sin\omega t+\underbrace{50\sqrt{2}}_{\to V_{m3}\to I_3}\sin3\omega t$$

$$P=I^2\cdot R$$ ✓

⓪ $I_1=\frac{V_1}{Z_1}=\frac{100}{R+j\omega L}=\frac{100}{4+j3}$

$$=\frac{100}{\sqrt{4^2+3^2}}=\frac{100}{5}=20\,[A]$$

⓪ $I_3=\frac{V_3}{Z_3}=\frac{50}{\underset{4}{R}+j3\times\underset{3}{\omega L}}=\frac{50}{4+j9}$

$$I_3=\frac{50}{\sqrt{4^2+9^2}}=5,07\,[A]$$

⓪ $I=\sqrt{I_1^2+I_3^2}$

$$=\sqrt{20^2+(5,07)^2}=20,63$$

⓪ $P=I^2\cdot R=(20,63)^2\times4$

$$=1702,3\,[W]$$

37. $V=V_m\cdot\sin\omega t$

$$i=I_m\left(\sin\omega t-\frac{1}{\sqrt{3}}\sin3\omega t\right)$$

$$=I_m\sin\omega t-\frac{I_m}{\sqrt{3}}\sin3\omega t$$

$$\cos\theta=\frac{P}{P_a}=\frac{\frac{1}{2}\times V_{m1}\times I_{m1}\times\cos\theta_1}{V\cdot I}$$

① $p=\frac{1}{2}\times V_{m1}\times I_{m1}\times\cos\theta_1$

$$P=\frac{1}{2}\times V_{m1}\times I_{m1}\times\underbrace{\cos0^\circ}_{=1}$$

$$P=\frac{1}{2}\times V_{m1}\times I_{m1}$$

② $P_a=V\times I$

$$P_a = V \times I$$

$$= \frac{V_m}{\sqrt{2}} \times \sqrt{\left(\frac{I_m}{\sqrt{2}}\right)^2 + \left(\frac{I_m}{\sqrt{3}\cdot\sqrt{2}}\right)^2}$$

문제 조건에 $-\frac{1}{\sqrt{3}}$ 이나 제곱하면 ⊕ 이므로 $\frac{1}{\sqrt{3}}$ 대입

$$= \frac{V_m}{\sqrt{2}} \times \sqrt{\left(\frac{I_m}{\sqrt{2}}\right)^2 \times \left[1 + \left(\frac{1}{\sqrt{3}}\right)^2\right]}$$

$$= \frac{V_m}{\sqrt{2}} \times \frac{I_m}{\sqrt{2}} \sqrt{1 + \frac{1}{3}}$$

$$= \frac{V_m \cdot I_m}{2} \times \sqrt{\frac{4}{3}}$$

$$= \frac{V_m \times I_n}{2} \times \frac{\sqrt{4}}{\sqrt{3}}$$

$$= \frac{V_m \times I_m}{\cancel{2}} \times \frac{\cancel{2}}{\sqrt{3}} = \frac{V_m \cdot I_m}{\sqrt{3}}$$

분자.

$$\cos\theta = \frac{P}{P_a} = \text{분모} \frac{\frac{1}{2} \times V_m \times I_m}{\frac{1}{\sqrt{3}} \times V_m \times I_m}$$

$$= \frac{\sqrt{3}}{2}$$

38. $V = 20\sin\omega t + 30\sin 3\omega t$

$i = 30\sin\omega t + 20\sin 3\omega t$

$$\cos\theta = \frac{P}{P_a}$$

$$= \frac{\frac{1}{2} \times 20 \times 30 \times \cos 0^\circ + \frac{1}{2} \times 30 \times 20 \times \cos 0^\circ}{\sqrt{\left(\frac{20}{\sqrt{2}}\right)^2 + \left(\frac{30}{\sqrt{2}}\right)^2} \times \sqrt{\left(\frac{30}{\sqrt{2}}\right)^2 + \left(\frac{20}{\sqrt{2}}\right)^2}}$$

$= 0,923$

39. $(3n+1) \rightarrow$ 기본파 (1) 이들어가므로 상회전 기본파와 동일

40. 상순이 기본파와 동일

$(3n+1) \rightarrow 1, 4, \boxed{7} \cdots$

$\uparrow n = 0, 1. 2. 3$

41. 상회전이 기본파와 반대

$(3n-1) \rightarrow 2, \boxed{5}, 8 \cdots$

$\uparrow n = 1. 2. 3 \cdots$

42 문제조건 기본파 위상이 10° 늦은 → 20°로수

* 기본파 위상을 20°늦은 $= -20^\circ$

(100t)

* (200t) 는 $-40^\circ = -20 \times 2$

* (400t)는 $-80^\circ = -20 \times 4$

$$i = 2 + 5\sin(100t \underset{-20}{+30}) + 10\sin(200t \underset{-40}{-10}) - 5\cos(400t \underset{-80}{+10})$$

$$i = 2 + 5\sin(100t + 10) + 10\sin(200t - 50) - 5\cos(400t - 70)$$

10 장

1. 구동점 임피던스 ($Z_{(s)}$)

영점 → 분자=0

$$Z(s) = \frac{V(s)}{I(s)} = 0$$

$Z(s) = 0[\Omega] \Rightarrow$ 회로상태 "단락"

2. 구동점 임피던스 ($Z_{(s)}$)

극점 → 분모=0

$$Z(s) = \frac{V(s)}{I(s)} = \frac{V(s)}{0} = \infty[\Omega]$$

$Z(s) = \infty[\Omega] \Rightarrow$ 회로상태 "개방"

3. $$Z(s) = \frac{(S+1)(S+2)}{(S+3)(S+4)}$$

영점 ⇒ 분자=0

$$(S+1)\cdot(S+2)=0$$

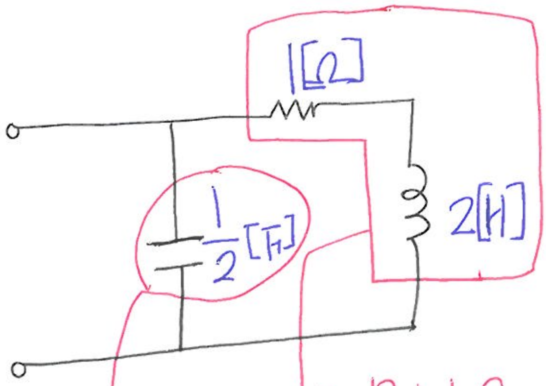
$$\underbrace{\hookrightarrow -1,\ \hookrightarrow -2}_{\text{영점}}$$

극점 ⇒ 분모=0

$$(S+3)\cdot(S+4)=0$$

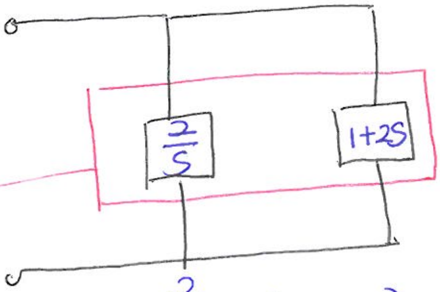
$$\underbrace{\hookrightarrow -3,\ \hookrightarrow -2}_{\text{극점}}$$

4.



$$\frac{1}{CS} = \frac{1}{\frac{1}{2}\cdot S} = \frac{2}{S}$$

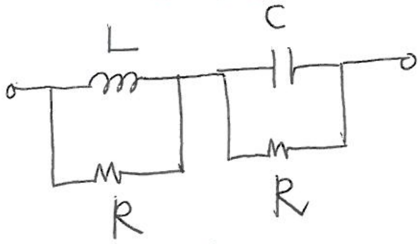
$$R+LS = 1+2S$$



$$= \frac{\frac{2}{S}\times(1+2S)}{\frac{2}{S}+1+2S} = \frac{2(1+2S)}{2S^2+S+2}$$

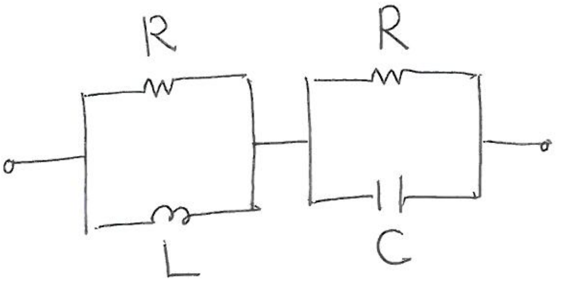
5. 주파수 무관계하게 R의 값

↳ 정저항 조건



$$* \quad R^2 = \frac{L}{C}$$

6.



정저항 조건 ⇒ $R^2 = \frac{L}{C}$ 에서

$$C = \frac{L}{R^2} = \frac{100\times10^{-3}}{10^2} = 1\times10^{-3}[F]$$

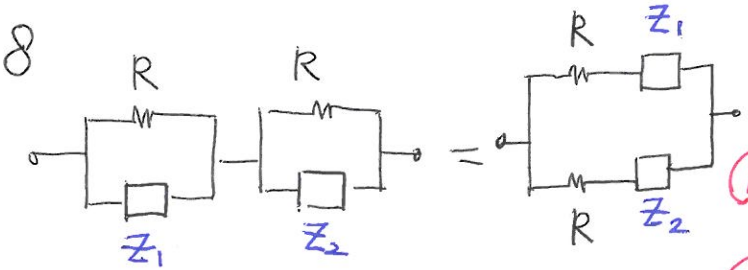
$$= \boxed{1\times10^{-3}}[F] \xrightarrow{\times10^{6}} = 1000[\mu F]$$

7. 정저항 조건 ⇒ $R^2 = \frac{L}{C}$ 에서

$$L = R^2C = 10^2\times100\times10^{-6}$$

$$= 0.01[H]$$

8



↳ 정저항 조건 ⇒ $R^2 = Z_1\times Z_2$

9. 주파수에 무관하게 일정

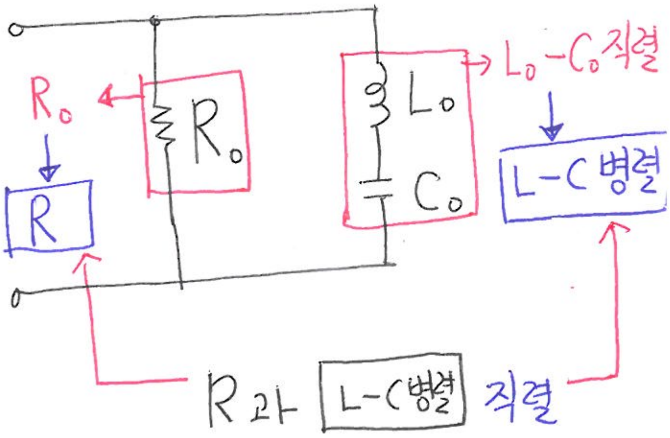
↳ 정저항 회로

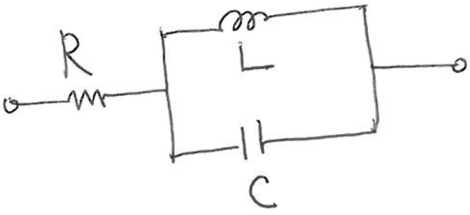
10. 쌍대회로

직렬 ⟷ 병렬

L ⟷ C

R_0 ⟷ G(본 문제는 R)





11. $Z(s) = \frac{3s}{s^2+15}$

① 분모가 복잡하면 ⇒ 병렬

② 분자를 "1"로 만든다

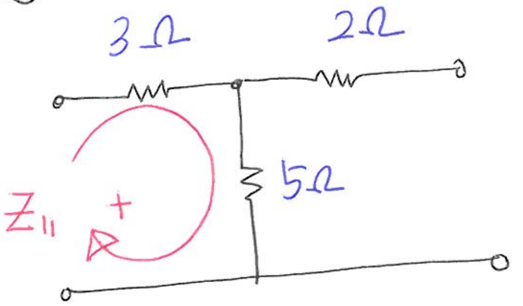
$$\frac{3s}{s^2+15} = \frac{1}{\frac{s^2}{3s}+\frac{15}{3s}} = \frac{1}{\frac{1}{3}s+\frac{5}{s}}$$

$$\frac{1}{\frac{1}{3}s+\frac{1}{\frac{1}{5}s}} = \frac{1}{\frac{1}{Ls}+Cs}$$

$L=\frac{1}{5}$, $C=\frac{1}{3}$ L과 C는 병렬

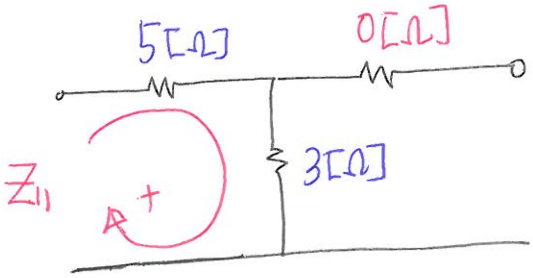
11장

1.



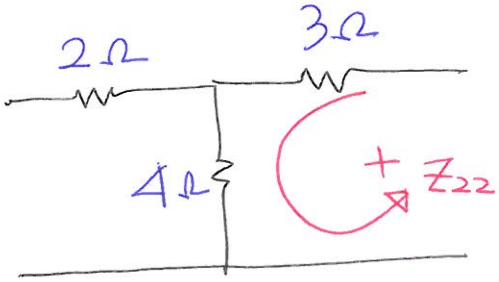
$Z_{11} = 3+5 = 8\,[\Omega]$

2.



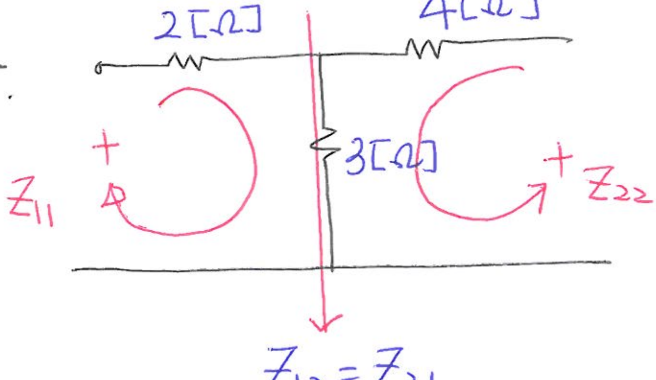
$Z_{11} = 5+3 = 8\,[\Omega]$

3.



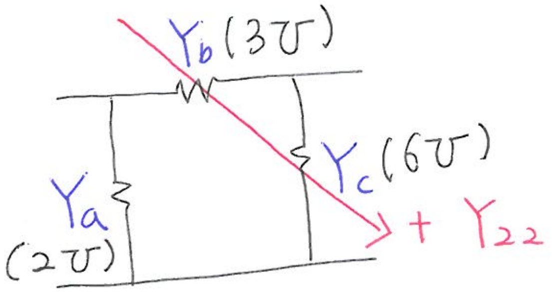
$Z_{22} = 3+4 = 7\,[\Omega]$

4.



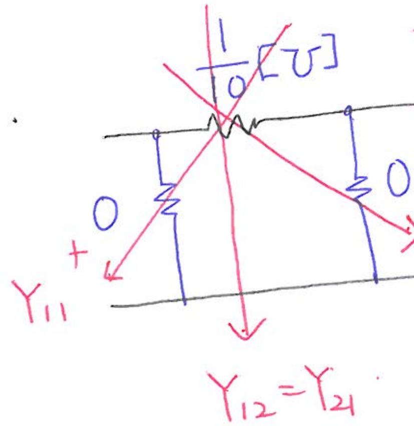
- $Z_{11} = 2+3 = 5\,[\Omega]$
- $Z_{22} = 4+3 = 7\,[\Omega]$
- $Z_{12} = Z_{21} = 3\,[\Omega]$

5.



$Y_{22} = Y_b + Y_c = 3+6 = 9\,[\mho]$

6.



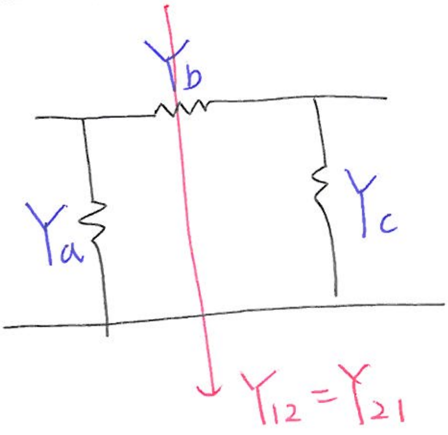
* 어드미턴스 파라미터 단위 [℧] 확인

$Y_{11} = \frac{1}{10} + 0 = \frac{1}{10}\,[\mho]$

$Y_{22} = \frac{1}{10} + 0 = \frac{1}{10}\,[\mho]$

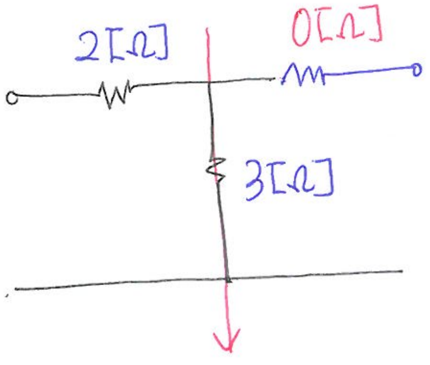
$Y_{12} = Y_{21} = \frac{1}{10}\,[\mho]$

7.



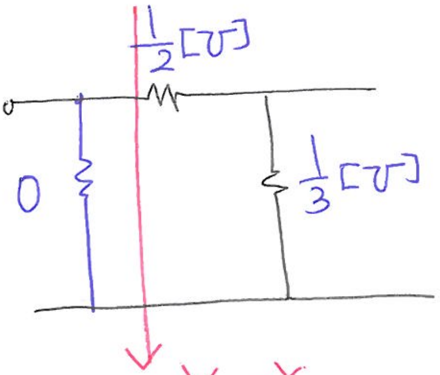
$Y_{21} = Y_b$

8.



$Z_{12}=Z_{21}$

∘ $Z_{12}=Z_{21}=3[\Omega]$



$Y_{12}=Y_{21}$

∘ $Y_{12}=Y_{21}=\boxed{-}\frac{1}{2}$

→ (−) 될수있다

「보기에 $\frac{1}{2}$, $-\frac{1}{2}$ 같이 나올수 없다, 따라서 $Y_{12}=Y_{21}$는 (−) 값이 될수 있다고 기억」

9. $A=$ 전압비 $=\frac{V_1}{V_2}\Big|_{I_2=0}$

출력측 개방

$B=$ 임피던스 $=\frac{V_1}{I_2}\Big|_{V_2=0}$

출력측 단락

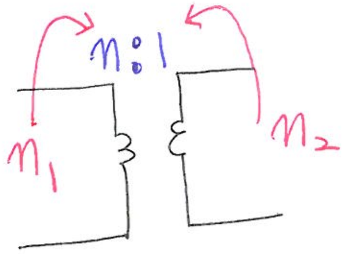
$C=$ 어드미턴스 $=\frac{I_2}{V_2}\Big|_{I_2=0}$

출력측 개방

$D=$ 전류비 $=\frac{I_1}{I_2}\Big|_{V_2=0}$

출력측 단락

10.



변압기 4단자정수

$A=$ 권수비 $=\frac{n_1}{n_2}=\frac{n}{1}=n$

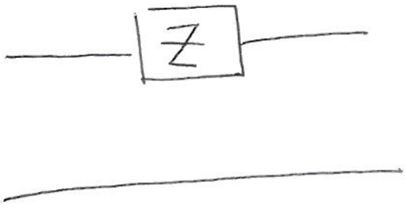
$B=0$

$C=0$

$D=$ 권수비역수 $=\frac{n_2}{n_1}=\frac{1}{n}$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}=\begin{bmatrix} n & 0 \\ 0 & \frac{1}{n} \end{bmatrix}$$

11.



$A=1$

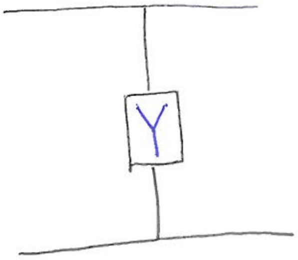
$B=Z$

$C=0$

$D=1$

$$\begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$$

12



$A = 1$

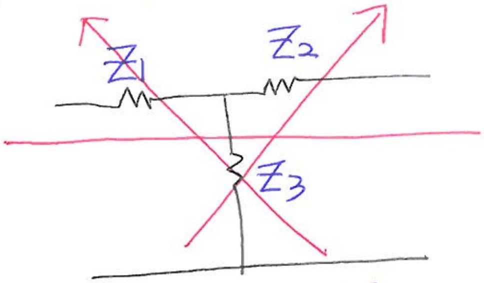
$B = 0$

$C = Y$

$D = 1$

$$\begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix}$$

13.



$A = 1 + \nwarrow = 1 + \frac{Z_1}{Z_3}$

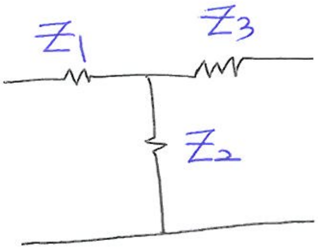
$B = Z_1 + Z_2 + \frac{Z_1 \cdot Z_2}{Z_3}$

$= \frac{Z_1 Z_3 + Z_2 Z_3 + Z_1 Z_2}{Z_3}$

$C = \frac{1}{Z_3}$

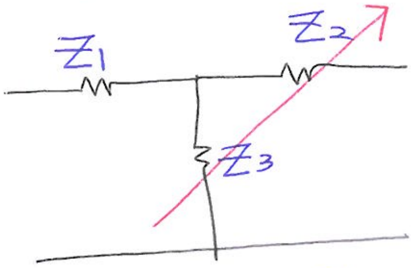
$D = 1 + \nearrow = 1 + \frac{Z_2}{Z_3}$

14.



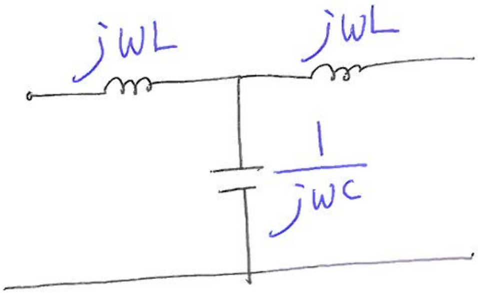
$C = \frac{1}{Z_2}$

15.



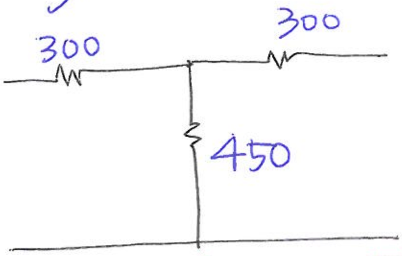
$D = 1 + \nearrow = 1 + \frac{Z_2}{Z_3}$

16.



$C = \frac{1}{\frac{1}{jwc}} = jwc$

17.



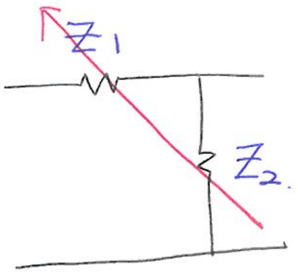
$A = D = 1 + \frac{300}{450} = \frac{5}{3}$

$C = \frac{1}{450}$

$B = 300 + 300 + \frac{300 \times 300}{450}$

$= 800$

18

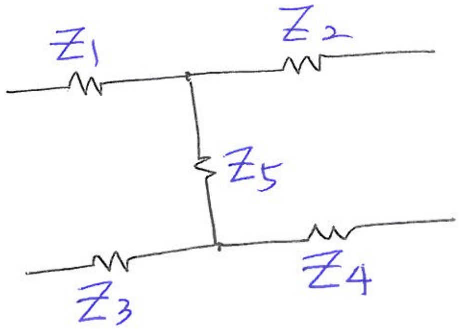


$A = 1 + \nwarrow = 1 + \frac{Z_1}{Z_2}$

$B = Z_1$

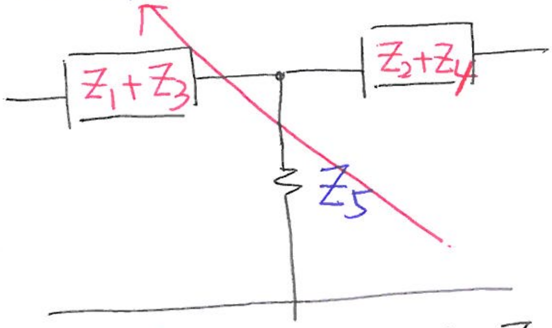
$C = \frac{1}{Z_2}$, $D = 1$

19.



Z_1 과 Z_3 는 직렬요소라 더할수있다

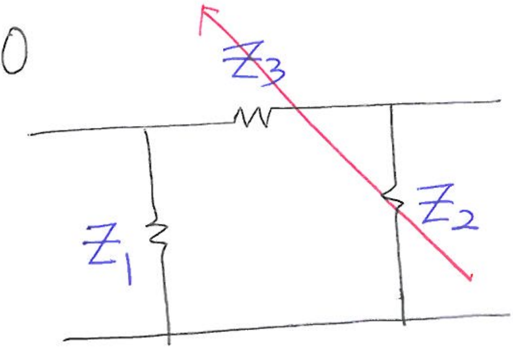
Z_2 와 Z_4



$A = 1 + \nwarrow = 1 + \frac{Z_1+Z_3}{Z_5}$

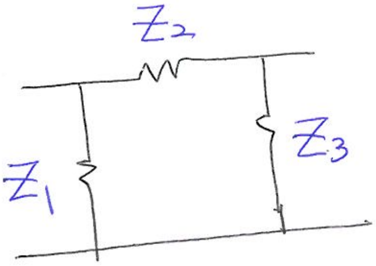
$= \frac{Z_1+Z_3+Z_5}{Z_5}$

20



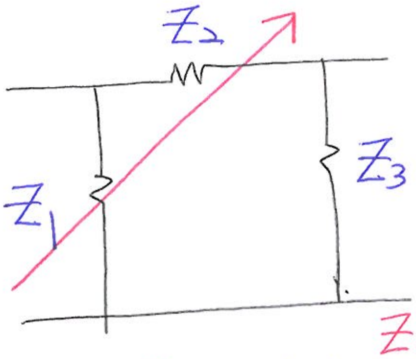
$A = \frac{V_1}{V_2} = 1 + \nwarrow = 1 + \frac{Z_3}{Z_2}$

21.



$B = Z_2$

22.



$D = 1 + \nearrow = 1 + \frac{Z_2}{Z_1}$

23. 조건 [출력측 개방 ($I_2=0$)

$V_1 = 12$, $I_1 = 2$, $V_2 = 4$

[출력측 단락 ($V_2=0$)

$V_1 = 16$, $I_1 = 4$, $I_2 = 2$

$A = \frac{V_1}{V_2}\Big|_{I_2=0} = \frac{12}{4} = 3$

$B = \frac{V_1}{I_2}\Big|_{V_2=0} = \frac{16}{2} = 8$

$$C = \left.\frac{I_1}{V_2}\right|_{I_2=0} = \frac{2}{4} = 0.5$$

$$D = \left.\frac{I_1}{I_2}\right|_{V_2=0} = \frac{4}{2} = 2$$

24. $AD - BC = 1$ 이용

$$AD - 1 = BC \Rightarrow C = \frac{AD-1}{B}$$

$$C = \frac{8\times(3+j2) - 1}{j2}$$

⇓ 계산기

$$C = \frac{8\times(3+2i) - 1}{2i}$$

$$C = 8 - 11.5i = 8 - j11.5$$

25.

$$Z_{01} = \sqrt{\frac{AB}{CD}} = \sqrt{Z_{1S} \times Z_{10}}$$

단) Z_{1S} = 2차측은 단락하고 1차측에서 본 임피던스 합

Z_{10} = 2차측은 개방하고 1차측에서 본 임피던스 합

$$Z_{02} = \sqrt{\frac{D\cdot B}{CA}} = \sqrt{Z_{2S} \times Z_{20}}$$

단) Z_{2S} = 1차측은 단락하고 2차측에서 본 임피던스 합

Z_{20} = 1차측은 개방하고 2차측에서 본 임피던스 합

26.

$$\frac{Z_{01}}{Z_{02}} = \frac{\sqrt{\frac{AB}{CD}}}{\sqrt{\frac{DB}{CA}}} = \sqrt{\frac{\frac{AB}{CD}}{\frac{DB}{CA}}}$$

$$= \sqrt{\frac{A^2 \cancel{BC}}{D^2 \cancel{BC}}} = \frac{A}{D}$$

27

$Z_{01} \times Z_{02} = \frac{B}{C}$ 이용

$$\frac{20}{3} \times \left(\frac{1}{4}\right) = \frac{\frac{5}{3}}{1} = \frac{5}{3}$$

28. $Z_{01} = Z_{02}$ 조건

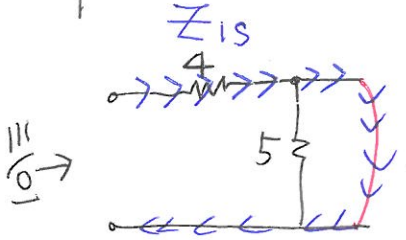
" $A = D$ "

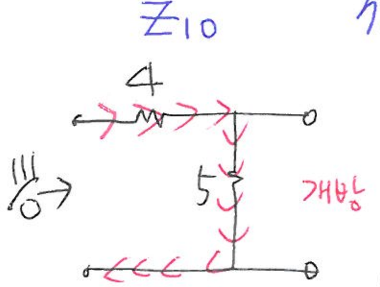
$$Z_{01} = \sqrt{\frac{\cancel{A}B}{C\cancel{D}}} = \sqrt{\frac{B}{C}}$$

$$Z_{02} = \sqrt{\frac{\cancel{D}B}{C\cancel{A}}} = \sqrt{\frac{B}{C}}$$

⊜

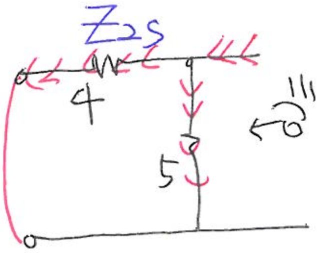
29

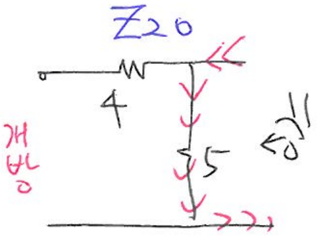




$Z_{1s}=4$ $\quad$ $Z_{1o}=4+5=9$

$$Z_{01}=\sqrt{Z_{1s}\times Z_{1o}}=\sqrt{4\times 9}=\sqrt{36}=6$$





$Z_{2s}=\frac{4\times 5}{4+5}=\frac{20}{9}$ $\quad$ $Z_{2o}=5$

$$Z_{02}=\sqrt{Z_{2s}\times Z_{2o}}=\sqrt{\frac{20}{9}\times 5}=\sqrt{\frac{100}{9}}$$

$$=\frac{10}{3}$$

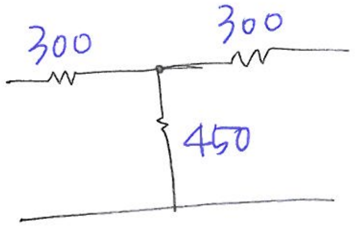
30. 대칭 ⇒ $A=D$

$$Z_{01}=Z_{02}=\sqrt{\frac{B}{C}}$$

31. 영상전달정수 $=\theta$

$$\theta=\log_e(\sqrt{AD}+\sqrt{BC})$$
$$=\ln(\sqrt{AD}+\sqrt{BC})$$
$$=\cosh^{-1}\sqrt{AD}$$
$$=\sinh^{-1}\sqrt{BC}$$

32.



$$\theta=\log_e(\sqrt{AD}+\sqrt{BC})$$

「 $A=1+\frac{300}{450}=\frac{5}{3}$

$B=300+300+\frac{300\times 300}{450}$

$=800$

$C=\frac{1}{450}$

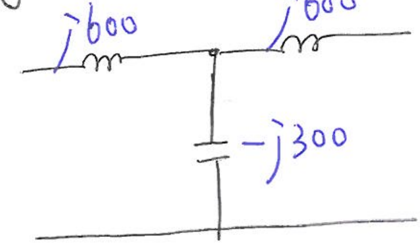
$D=1+\frac{300}{450}=\frac{5}{3}$ 」

$$\theta=\log_e\left(\sqrt{\frac{5}{3}\times\frac{5}{3}}+\sqrt{\boxed{800\times\frac{1}{450}}}\right)$$
↳ $\frac{16}{9}$

$$=\log_e\left(\frac{5}{3}+\frac{4}{3}\right)$$

$$=\log_e\frac{5+4}{3}=\log_e\frac{9}{3}=\log_e 3$$

33.



$$\theta=\cosh^{-1}\sqrt{A\times D}=\cosh^{-1}\sqrt{(-1)\times(-1)}$$
$$=\cosh^{-1}1=0$$

「 $A=D=1+\frac{\cancel{j}\cancel{600}^{(2)}}{-\cancel{j}\cancel{300}}=1-2=-1$ 」

11장

34. Z_{01}, Z_{02}, θ 와 4단자 정수 관계

① $A = \sqrt{\frac{Z_{01}}{Z_{02}}} \cdot \cosh\theta$

② $B = \sqrt{Z_{01} \cdot Z_{02}} \cdot \sinh\theta$

③ $C = \frac{1}{\sqrt{Z_{01} \cdot Z_{02}}} \cdot \sinh\theta$

④ $D = \sqrt{\frac{Z_{02}}{Z_{01}}} \cdot \cosh\theta$

35. 4단자 정수 D

$D = \sqrt{\frac{Z_{02}}{Z_{01}}} \cdot \cosh\theta$ 이용

$= \sqrt{\frac{2}{50}} \times \cosh 0$

↓

$\boxed{hyp}$ → ① sinh ② cosh

↓

$\cosh(0) = 1$

$= \sqrt{\frac{2}{50}} \times 1$

$= 0,2$

36.

정 K형 필터 조건

$K^2 = Z_1 \cdot Z_2$

단) K = 주파수와 무관한 양의실수 저항과 같은 성질을 갖는 상수 공칭 임피던스라고 함

12장 분포 정수

1. 특성 임피던스 (Z_0)

$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{r+j\omega L}{g+j\omega C}}$

2. 특성 임피던스 (Z_0)

$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{r+j\omega L}{g+j\omega C}}$

3. 인덕턴스 L [H]

커패시턴스 C [μF]

∘ 특성임피던스 (Z_0)

$Z_0 = \sqrt{\frac{r+j\omega L}{g+j\omega C}}$

$Z_0 = \sqrt{\frac{\cancel{j\omega} L}{\cancel{j\omega} C}} = \sqrt{\frac{L}{C}}$

* 문제 조건에 L, C 만 주어졌다는 것은

$r \ll j\omega L$

$g \ll j\omega C$

$$Z_0 = \sqrt{\frac{L}{C \times 10^{-6}}} = \sqrt{\frac{L}{C} \times 10^{6}}$$

$$= \sqrt{\frac{L}{C}} \times 10^{3} \ [\Omega]$$

4. 전파 정수(γ)

$$\gamma = \sqrt{Z \cdot Y} = \sqrt{(r + j\omega L) \cdot (g + j\omega C)}$$

5. 특성 임피던스(Z_0) = $\sqrt{\frac{Z}{Y}}$

전파정수(γ) = $\sqrt{Z \cdot Y}$

직렬 임피던스 = Z

• $\underbrace{Z_0 \times \gamma} = \sqrt{\frac{Z}{Y}} \times \sqrt{Z \times Y}$

$$= \sqrt{\frac{Z}{\cancel{Y}} \times Z \cancel{Y}}$$

$$= \sqrt{Z^2} = Z$$

6. 무손실 선로 ⇒ $\begin{cases} r = 0 \\ g = 0 \end{cases}$

7. 무손실 선로 $\begin{cases} r = 0 \\ g = 0 \end{cases}$

① 전파정수 $\gamma = \sqrt{Z \times Y}$

$$\gamma = \sqrt{(\cancel{r} + \underbrace{j\omega L) \times (\cancel{g} + j\omega C}_{(j\omega)^2 LC})}$$

$$\gamma = j\omega\sqrt{LC}$$

② 전파속도 $V = \overset{2\pi}{\lambda} \cdot \overset{\frac{1}{2\pi\sqrt{LC}}}{f}$

$$V = \frac{1}{\sqrt{LC}}$$

③ 특성 임피던스 Z_0

$$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{\cancel{r}_{=0} + \cancel{j\omega} L}{\cancel{g}_{=0} + \cancel{j\omega} C}} = \sqrt{\frac{L}{C}}$$

④ 파장 λ

$$\underbrace{V = \lambda \cdot f = \frac{1}{\sqrt{LC}}}$$

↳ $\lambda = \frac{1}{f \cdot \sqrt{LC}}$

* 특성 임피던스(Z_0)

$$Z_0 = \sqrt{\frac{\cancel{r} + \cancel{j\omega} L}{\cancel{g} + \cancel{j\omega} C}} = \sqrt{\frac{L}{C}} = \sqrt{\frac{96 \times 10^{-3}}{0{,}6 \times 10^{-6}}} = 400 [\Omega]$$

8. 무손실 선로 ⇒ $r = 0,\ g = 0$

전파정수 γ

$$\gamma = \sqrt{Z \cdot Y} = \sqrt{(\underset{=0}{\cancel{r}} + j\omega L) \times (\underset{=0}{\cancel{g}} + j\omega C)}$$

$$= \sqrt{(j\omega)^2 LC} = j\underbrace{\omega\sqrt{LC}}_{\beta}$$

$\gamma = \alpha + j\beta$ 꼴

↳ $\alpha = 0$ ← 감쇠정수

$\beta = \omega\sqrt{LC}$ ← 위상정수

9. 무손실 조건

① $Z_0 = \sqrt{\dfrac{L}{C}}$

② $\gamma = \sqrt{Z \cdot Y}$

③ $\alpha = 0$

④ $v = \dfrac{1}{\sqrt{LC}}$

10. $\left\{ \begin{matrix} r = 0 \\ g = 0 \end{matrix} \right.$ ⇒ 무손실선로 ⇒ $\gamma = j\omega\sqrt{LC}$ (전파정수 ↙)

11. 무손실 선로

위상속도 = 전파속도 = $V = \dfrac{1}{\sqrt{LC}}$

12. 파장 λ

$$V = \lambda \cdot f = \frac{1}{\sqrt{LC}} = \frac{\omega}{\omega\sqrt{LC}} = \frac{\omega}{\beta}$$

⓪ $\lambda \cdot f = \dfrac{\overset{\shortparallel\, 2\pi f}{\omega}}{\beta} \Rightarrow \lambda = \dfrac{2\pi \cancel{f}}{\cancel{f} \cdot \beta}$

$$\lambda = \frac{2\pi}{\beta}$$

$$\lambda = \frac{2\pi}{\beta}$$

↳ 위상정수

13. 파장 $\lambda = \dfrac{2\pi}{\beta} = \dfrac{2\pi}{\frac{\pi}{4}} = 8$

14. 전파속도 $= V = \dfrac{\overset{= 2\pi f}{\omega}}{\beta}$

$$V = \frac{\omega}{\beta} = \frac{2\pi \cdot f}{\frac{\pi}{8}} = 16 \cdot \overset{\overset{1\times10^6\,[HZ]}{\shortparallel}}{f}$$

$$= 16 \times 10^6 = 1.6 \times 10^7$$

15. 위상정수 β

$V = \dfrac{\omega}{\beta}$ 에서 $\beta = \dfrac{\overset{\overset{2\pi f}{\shortparallel}}{\omega}}{V} = \dfrac{2\pi \times 4 \times 10^6}{3 \times 10^8}$

$\beta = 0.0837$

16. 무왜 = 무왜형 ⇒ $L\cdot g = r\cdot C$

$= \sqrt{\underbrace{\frac{LG}{C}}_{R}\cdot G} + j\sqrt{LC}\cdot w$

$= \sqrt{GR} + jw\sqrt{LC}$

17. $RC = GL$ → 무왜형선로 조건

$Z_0 = \sqrt{\frac{Z}{Y}} = \sqrt{\frac{R+jwL}{G+jwC}}$ 단) $R = \frac{GL}{C}$

$= \sqrt{\frac{\frac{GL}{C}+jwL}{G+jwC}} = \sqrt{\frac{\frac{L}{C}\cancel{(G+jwC)}}{\cancel{G+jwC}}}$

$Z_0 = \sqrt{\frac{L}{C}}$

18. $LG = RC$ 조건일때 전파정수 γ

$\gamma = \sqrt{Z\cdot Y} = \sqrt{(R+jwL)\cdot(G+jwC)}$ 단) $R = \frac{LG}{C}$

$= \sqrt{\left(\frac{LG}{C}+jwL\right)\cdot(G+jwC)}$

$= \sqrt{\frac{L}{C}(G+jwC)\cdot(G+jwC)}$

$= \sqrt{\frac{L}{C}}\,(G+jwC)$

$= \sqrt{\frac{L}{C}}\times G + j\sqrt{\frac{L}{C}}\times wC$

$= \sqrt{\frac{L\cdot G^2}{C}} + j\sqrt{\frac{L\cdot \cancel{C^2}}{\cancel{C}}}\cdot w$

19. 무왜형선로 일때 $g = ?$

$Lg = r\cdot C$ 에서

$g = \frac{r\cdot C}{L} = \frac{0.5\times 6\times\cancel{10^{-6}}}{1\times\cancel{10^{-6}}} = 3$

* 단위길이를 적용(거리와 무관) 하므로 10km 곱하지 않는다

20.

① $\frac{R}{L} = \frac{G}{C}$ ⇒ $LG = RC$ ⇒ 무왜회로

② $R = G = 0$ ⇒ 무손실

③ 무손실 ⇒ $\alpha = 0$ ← 감쇠정수
무왜형 ⇒ $\alpha = \sqrt{G\cdot R}$

④ [무손실, 무왜형] ⇒ $V = \frac{1}{\sqrt{LC}}$

21. 무왜형 조건

① 감쇠량 최소된다

② 감쇠량은 주파수와 무관

$\alpha = \sqrt{r \cdot g}$ f와 무관

③ 전파속도는 감소 한다

$\downarrow V = \frac{1}{\sqrt{\uparrow L C}}$ 에서 보통 C > L 조건에서

무왜형은 C = L↑

따라서 L↑, V↓

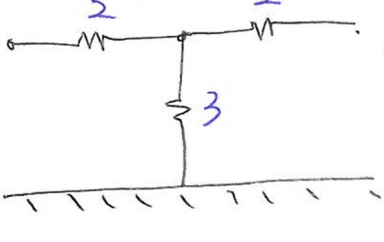
④ 위상정수는 주파수에 비례

$\beta = \omega\sqrt{LC} \Rightarrow \beta \propto \omega \propto 2\pi f$

$\beta \propto f$

22. 특성임피던스는 무한히 접속해도 동일 특성임피던스를 갖는다

따라서 T형으로 Z_0를 구한다



$B = 2 + 2 + \frac{2\times2}{3}$

$= \frac{16}{3}$

$C = \frac{1}{3}$

특성임피던스 $Z_0 = \sqrt{\frac{B}{C}} = \sqrt{\frac{\frac{16}{3}}{\frac{1}{3}}}$

$= 4$

23. 전압 반사계수 ρ

$\rho = \frac{Z_2 - Z_1}{Z_1 + Z_2} = \frac{300-100}{100+300} = \frac{200}{400} = 0{,}5$

Z_2 → 부하임피던스

Z_1 → 선로 임피던스

13장 라플라스

1. 라플라스 1단계

$\mathcal{L}\, f(t) = \int_0^\infty f(t) \cdot e^{-st}\, dt = F(s)$

	시간함수	라플라스
①	1 또는 u(t)	$\frac{1}{s}$
②	e^{-at}	$\frac{1}{s+a}$
③	e^{bt}	$\frac{1}{s-b}$
④	t^n	$\frac{n!}{s^{n+1}}$

단) $n! = n \times (n-1) \times (n-2) \times \cdots\cdots$

$2! = 2 \times 1 = 2$

$3! = 3 \times 2 \times 1 = 6$

⑤	$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$

시간함수 라플라스

⑥ $\cos\omega t$ $\dfrac{s}{s^2+\omega^2}$

하이퍼블릭

* $\sinh\omega t \rightarrow \dfrac{\omega}{s^2-\omega^2}$

$\cosh\omega t \rightarrow \dfrac{s}{s^2-\omega^2}$

라플라스 2단계

① $1+e^{-at} \rightarrow \dfrac{1}{s}+\dfrac{1}{s+a}$

$= \dfrac{s+a+s}{s\cdot(s+a)} = \dfrac{2s+a}{s(s+a)}$

② $1-e^{at} \rightarrow \dfrac{1}{s}-\dfrac{1}{s+a}$

$= \dfrac{s+a-s}{s(s+a)} = \dfrac{s}{s(s+a)}$

③ $e^{-at}\cdot t \rightarrow \dfrac{1}{s^2}\Big|_{s=s+a}$

$= \dfrac{1}{(s+a)^2}$

* 곱의 형태는 s의 차수가 높은것을
기준 잡고 s의 차수가 낮은 분모값을
s 대신에 대입

④ $e^{-at}\cdot\sin\omega t \rightarrow \dfrac{\omega}{s^2+\omega^2}\Big|_{s=s+}$

$= \dfrac{\omega}{(s+a)^2+\omega^2}$

⑤ $e^{-at}\cdot\cos\omega t \rightarrow \dfrac{s}{s^2+\omega^2}\Big|_{s=s+a}$

$= \dfrac{s+a}{(s+a)^2+\omega^2}$

티 안나게 사인

* $t\cdot\sin\omega t \rightarrow$ 복소미분정리로
정석은 너무어려움

$= \dfrac{\boxed{2\omega s}}{(s^2+\omega^2)^2}$ 월드시리즈
2차전 행운
2포카

티 코

* $t\cdot\cos\omega t$

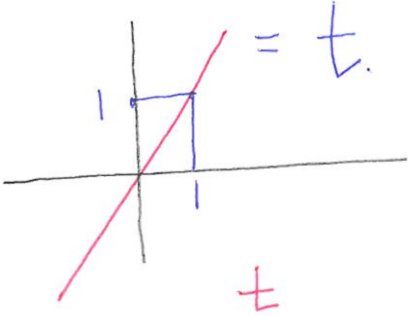
$= \dfrac{s^2-\omega^2}{(s^2+\omega^2)^2}$

투^2 마(−) 리^2 에

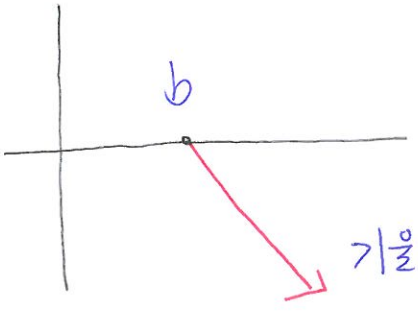
이(2) 오(5) 까지

③ 경사(램프) 함수 t

↳ 기울기가 "1" 인함수

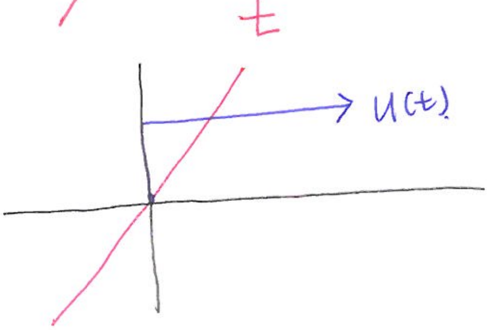


$= t.$

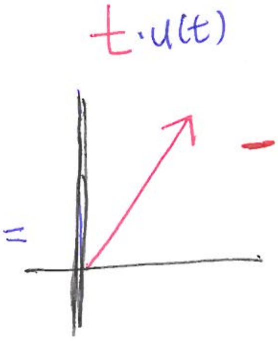


기울기 $-\frac{E}{T}$

$= -\frac{E}{T}(t-b)\cdot u(t-b)$



$=$



$$-\frac{E}{T}(t-b)\cdot \underbrace{u(t-b)}_{\mathcal{L}\text{ 대상 아님}} \xrightarrow{\mathcal{L}} -\frac{E}{T}\cdot\frac{1}{s^2}\cdot e^{-bs}$$

$$= -\frac{E}{Ts^2}\cdot e^{-bs}$$

$$t\cdot \underbrace{u(t)}_{} \xrightarrow{\mathcal{L}} \frac{1}{s^2}$$

↳ 보조함수 이므로 $\mathcal{L}$ 영향 없다

그외

⓪ 실미분 정리

↳ 정석 어렵다 편법으로.

· $\frac{d}{dt}\cos\omega t$

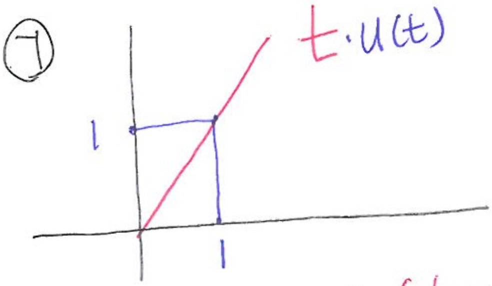
$= -\omega\cdot \sin\omega t$ ↳ $\mathcal{L}$

$= -\omega\cdot\frac{\omega}{s^2+\omega^2} = \frac{-\omega^2}{s^2+\omega^2}$

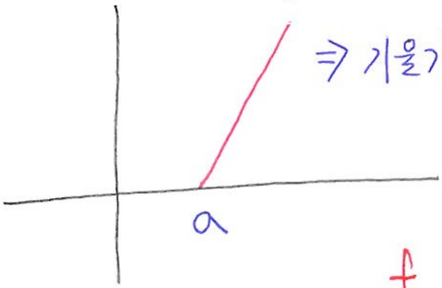
$\frac{d}{dt}$ 미분 코싸인 $\cos\omega t$

$= \frac{-\omega^2}{s^2+\omega^2}$ $\quad \frac{-\omega^2}{s^2+\omega^2}$

㉠



→ $(t-a)u(t-a)$



⇒ 기울기 "1"

$$(t-a)\cdot\underbrace{u(t-a)}_{\mathcal{L}\text{ 대상아님}} \xrightarrow{\mathcal{L}} \frac{1}{s^2}\cdot e^{-as}$$

* 미코; 빼어난 (-) 미모

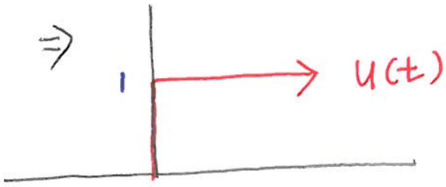
가슴 두개 (ω^2)

라플라스 3단계

① 단위계단 함수 $u(t)$

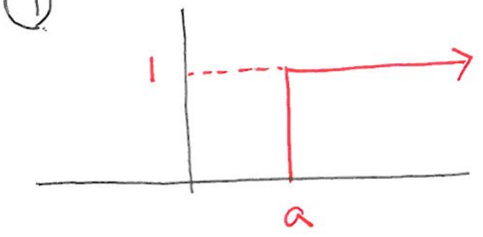
↳ 크기가 "1" 인 함수

$u(t)$ ⇒



$$u(t) \xrightarrow{\mathcal{L}} \frac{1}{s}$$

㉠



$\underset{\sim\sim\sim}{u(t-a)}$

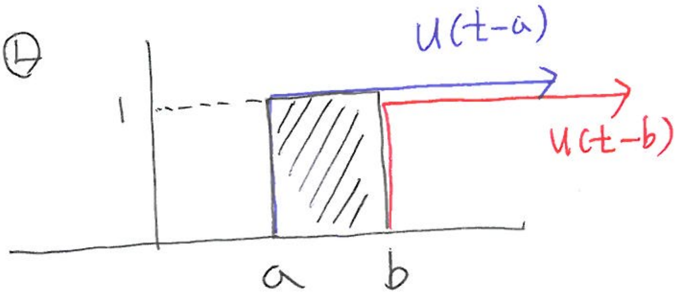
↳ a만큼 늦은 $u(t)$

$$u(t-a) \xrightarrow{\mathcal{L}} \frac{1}{s} \cdot e^{-as}$$

↳ 시간추이 정리로 요령은 $\mathcal{L}$를 두번한다 $-a$ 가리고 $u(t) \xrightarrow{\mathcal{L}}$ 를 하면 $\frac{1}{s}$

$u(t)$를 가리고 $-a$는 ⇒ e^{-as} 를 곱한다.

㉡

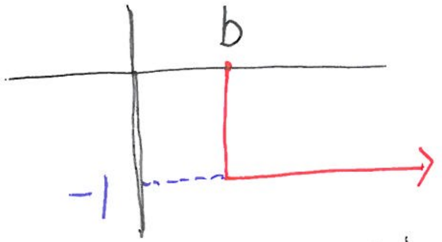


$$u(t-a) - u(t-b)$$

$$= \frac{1}{s} \cdot e^{-as} - \frac{1}{s} \cdot e^{-bs}$$

$$= \frac{1}{s} \cdot (e^{-as} - e^{-bs})$$

㉢

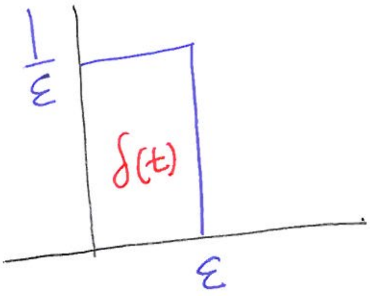


$-u(t-b)$

$$-u(t-b) \xrightarrow{\mathcal{L}} -\frac{1}{s} \cdot e^{-bs}$$

② 임펄스 함수 $\delta(t)$

↳ 면적이 "1" 인 함수



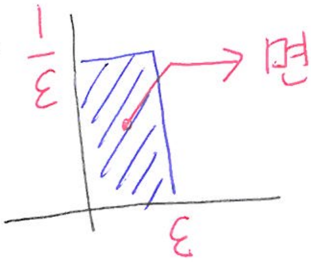
단) $\varepsilon \to 0$

$$\delta(t) \xrightarrow{\mathcal{L}} 1$$

㉠ $2\delta(t) \xrightarrow{\mathcal{L}} 2$

13장

1. 라플라스 공식 = $\int_0^\infty f(t)\cdot e^{-st}\,dt$

2.


→ 면적($\frac{1}{\varepsilon}\times\varepsilon=1$)

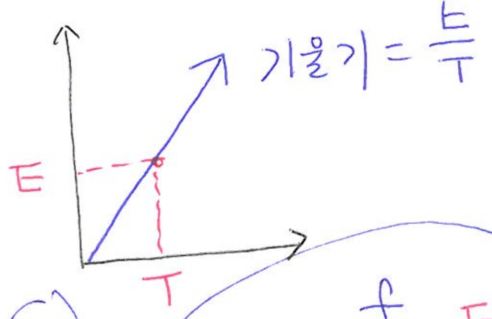
면적 1 이면 ⇒ $\overset{f(t)}{\delta(t)} \xrightarrow{\mathcal{L}} \overset{F(s)}{1}$

3. 단위계단함수 ⇒ $\overset{f(t)}{u(t)} \xrightarrow{\mathcal{L}} \overset{F(s)}{\frac{1}{s}}$

4. $f(t) = 3\cdot\boxed{t^2}$ → $t^n \xrightarrow{\mathcal{L}} \frac{n!}{s^{n+1}}$

$\xrightarrow{\mathcal{L}} = \frac{2}{s^3}$

$= 3\times\frac{2}{s^3} = \frac{6}{s^3}$

5.


$= \frac{E}{T}\cdot t\cdot \underbrace{u(t)}_{\text{라플라스 대상 아님}} \xrightarrow{\mathcal{L}} \frac{E}{T}\cdot\frac{1}{s^2}$

$= \frac{E}{Ts^2}$

6. $= \cos\omega t \xrightarrow{\mathcal{L}} \frac{s}{s^2+\omega^2}$

7. $= \cosh\omega t \xrightarrow{\mathcal{L}} \frac{s}{s^2-\omega^2}$

8. ⓐ $\cos\omega t \xrightarrow{\mathcal{L}} \frac{s}{s^2+\omega^2}$

ⓑ $\sin at \xrightarrow{\mathcal{L}} \frac{a}{s^2+a^2}$

9. $= 1-e^{-at} \xrightarrow{\mathcal{L}} \frac{1}{s}-\frac{1}{s+a}$

$= \frac{\cancel{s}+a-\cancel{s}}{s\cdot(s+a)}$

$= \frac{a}{s\cdot(s+a)}$

10. $= \sin t + 2\cos t$

$\mathcal{L}\downarrow$

$= \frac{1}{s^2+1} + 2\times\frac{s}{s^2+1}$

$= \frac{2s+1}{s^2+1}$

11. $= \sin t \cdot \cos t$

$$\sin t \cdot \cos t = \boxed{\frac{1}{2}} \cdot \sin 2t \xrightarrow{f} \frac{1}{2} \times \frac{2}{s^2+2^2} = \frac{1}{s^2+4}$$

*

$$\sin(\alpha+\beta) = \sin\alpha \cdot \cos\beta + \cos\alpha \cdot \sin\beta$$

* $\sin(t+t) = \sin t \cdot \cos t + \cos t \cdot \sin t$

$$\downarrow$$

$$\sin 2t = 2 \cdot \sin t \cdot \cos t$$

$$\sin t \cdot \cos t = \frac{1}{2} \cdot \sin 2t.$$

12. $\sin(\omega t + \theta) = \sin\omega t \cdot \cos\theta + \cos\omega t \cdot \sin\theta$

$$f \downarrow \quad \frac{\omega}{s^2+\omega^2} \times \cos\theta + \frac{s}{s^2+\omega^2} \times \sin\theta$$

$$= \frac{\omega \cdot \cos\theta}{s^2+\omega^2} + \frac{s \cdot \sin\theta}{s^2+\omega^2}$$

$$= \frac{\omega\cos\theta + s \cdot \sin\theta}{s^2+\omega^2}$$

13. $= t \cdot e^{-at}$

$$e^{-at} \to \frac{1}{\boxed{s+a}}$$

$$t \downarrow$$

$$\left.\frac{1}{s^2}\right|_{s=\boxed{s+a}} = \frac{1}{(s+a)^2}$$

14. $= \underbrace{t^2}_{} \cdot e^{at}$

$$\frac{2!}{s^3} = \frac{2}{s^3}\Bigg|_{s=s-a} \qquad \frac{1}{\boxed{s-a}}$$

$$= \frac{2}{(s-a)^3}$$

15. $= e^{-at} \cdot \underbrace{\cos\omega t}_{}$

$$\frac{1}{\boxed{s+a}} \qquad \frac{s}{s^2+\omega^2}\Bigg|_{s=s+a}$$

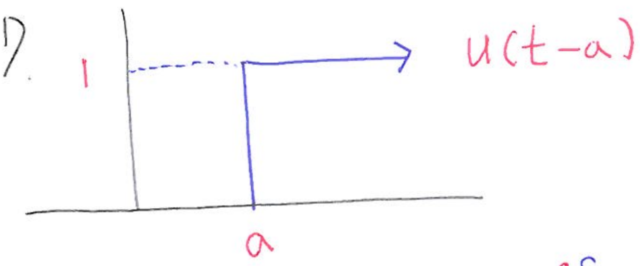
$$= \frac{(s+a)}{(s+a)^2+\omega^2}$$

16. $= e^{-at} \cdot \underbrace{\sin\omega t}_{}$

$$\frac{1}{s+a} \qquad \frac{\omega}{s^2+\omega^2}\Bigg|_{s=s+a}$$

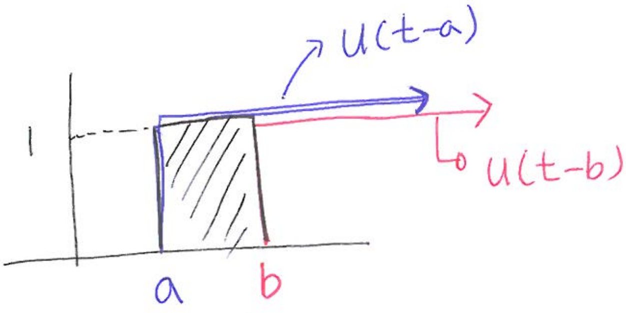
$$= \frac{\omega}{(s+a)^2+\omega^2}$$

17.



$$u(t-a) \xrightarrow{\mathcal{L}} \frac{1}{s}\cdot e^{-as}$$

18

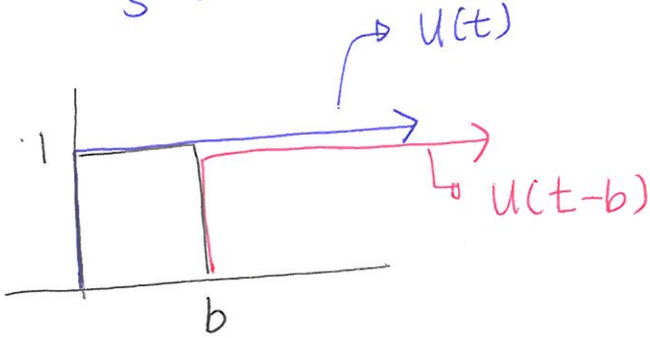


$$= \underbrace{u(t-a)}_{} - \underbrace{u(t-b)}_{}$$

$$\downarrow \mathcal{L} \quad = \frac{1}{s}\cdot e^{-as} - \frac{1}{s}\cdot e^{-bs}$$

$$= \frac{1}{s}\left(e^{-as} - e^{-bs}\right)$$

19



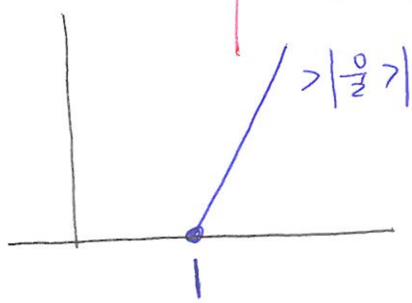
$$= \underbrace{u(t)}_{} - \underbrace{u(t-b)}_{}$$

$$\downarrow \mathcal{L} \quad = \frac{1}{s} - \frac{1}{s}\cdot e^{-bs}$$

$$= \frac{1}{s}\left(1 - e^{-bs}\right)$$

20.

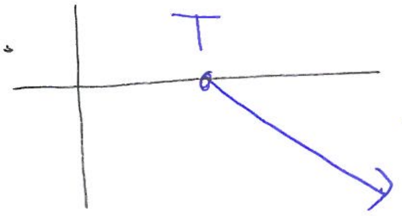
$= (t-1) \cdot u(t-1)$



$= \underbrace{(t-1)}_{\downarrow} \cdot \underbrace{u(t-1)}_{\text{라플라스 영향없음}}$

$\mathcal{L} \quad \dfrac{1}{s^2} \cdot e^{-s}$

21.

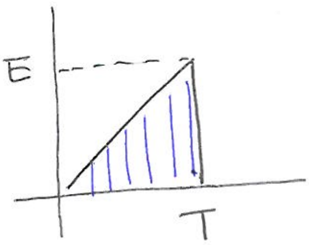


$= \left(-\dfrac{E}{T}\right) \cdot \underbrace{(t-T)}_{\downarrow} \cdot \underbrace{u(t-T)}_{\text{라플라스 영향없음}}$

$= -\dfrac{E}{T} \cdot \dfrac{1}{s^2} \cdot e^{-Ts}$

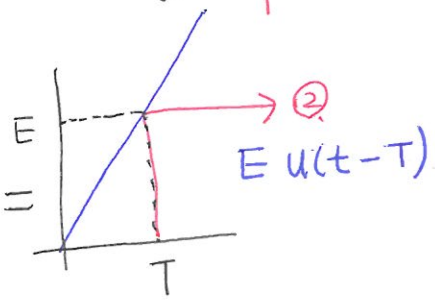
$= -\dfrac{E}{Ts^2} \cdot e^{-Ts}$

22.



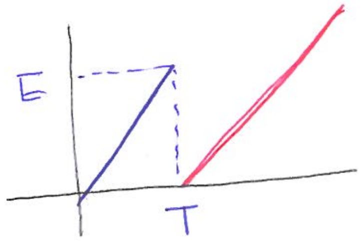
=

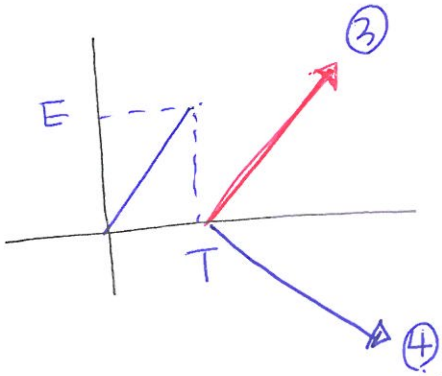
$① = \dfrac{E}{T} t \, u(t)$



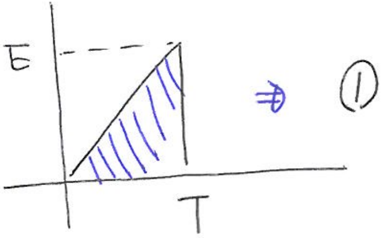
$E \, u(t-T)$

$* \quad ① - ② = \dfrac{E}{T} t \, u(t) - E \, u(t-T$





$* \quad ③ + ④ = -\dfrac{E}{T}(t-T) \, u(t-T)$



$\Rightarrow ① - ② + ④$

$= \dfrac{E}{T} t \, u(t) - E \, u(t-T) \overset{-}{+} \left(-\dfrac{E}{T}(t-T) u(t-T\right.$

$\mathcal{L} \downarrow = \dfrac{E}{T} \cdot \dfrac{1}{s^2} - \dfrac{E}{s} \cdot e^{-Ts} - \dfrac{E}{T} \cdot \dfrac{1}{s^2} \cdot e^{-Ts}$

$= \dfrac{E}{Ts^2}\left(1 - Ts \, e^{-Ts} - e^{-Ts}\right)$

$= \dfrac{E}{Ts^2}\left(1 - (Ts+1) \cdot e^{-Ts}\right)$

23.

$= t^1 \cdot \sin wt$

*

$$\mathcal{L}[t^n f(t)] = (-1)^n \cdot \frac{d^n}{ds^n} F(s)$$

$$= (-1)^1 \cdot \frac{d}{ds}\left[\frac{w}{s^2+w^2}\right]$$

$$= -1 \cdot \frac{-2ws}{(s^2+w^2)^2}$$

$$= \frac{2ws}{(s^2+w^2)^2}$$

「 * 분수 미분

$$\frac{d}{ds} \cdot \frac{w}{(s^2+w^2)}$$

$$= \frac{\underbrace{\frac{d}{ds} w \times (s^2+w^2)}_{0} - \left[w \times \overset{2s}{\boxed{\frac{d}{ds}(s^2+w^2)}}\right]}{(s^2+w^2)^2}$$

$$= \frac{-2ws}{(s^2+w^2)^2}$$

「 $\frac{d}{ds} w = 0$, $\frac{d}{ds}(s^2+w^2) = 2s$ 」

24.

$= \frac{d}{dt} \cos wt$

$\mathcal{L} \downarrow$

$= -w \cdot \sin wt$

$$= -w \times \frac{w}{s^2+w^2}$$

$$= \frac{-w^2}{s^2+w^2}$$

25.

초기값 정리

$$\lim_{t \to 0} f(t) = \lim_{s \to \infty} s \cdot F(s)$$

최종값 정리

$$\lim_{t \to \infty} f(t) = \lim_{s \to 0} s \cdot F(s)$$

26.

초기값 정리

$$\lim_{s \to \infty} \cancel{s} \cdot \frac{12(s+8)}{4\cancel{s}(s+6)}$$

$$= \lim_{s \to \infty} \frac{12s+96}{4s+24}$$

[s 대신에 ∞ 대입
하면 $\frac{\infty}{\infty}$ 꼴
따라서 s의 차수
가 가장 큰 s로
분모, 분자 나눈다 」

$$\lim_{s\to\infty} \frac{12+\cancel{\frac{96}{s}}^{\to 0}}{4+\cancel{\frac{26}{s}}^{\to 0}} \quad \left[\begin{array}{l} \frac{96}{s}\Big|_{s=\infty} \Rightarrow \frac{96}{\infty}=0 \\ \frac{26}{s}\Big|_{s=\infty} \Rightarrow \frac{26}{\infty}=0 \end{array} \right.$$

$$=\frac{12}{4}=3$$

$$* \quad \lim_{t\to\infty} \cancel{s}\,\frac{12}{\cancel{s}(s+6)}$$

$$\lim_{t\to\infty} \frac{12}{s+6} \quad \left[\begin{array}{l} s \text{ 대신에} \\ \infty \text{ 대입} \end{array} \right.$$

$$=\frac{12}{\infty+6}=\frac{12}{\infty}=0$$

27. $= \dfrac{30s+40}{2s^3+2s^2+5s}$ 에서 $\underbrace{t=\infty}_{\text{최종값}}$

$$=\lim_{s\to 0} s\cdot\frac{30s+40}{2s^3+2s^2+5s}$$

$$=\lim_{s\to 0} \cancel{s}\cdot\frac{30s+40}{\cancel{s}(2s^2+2s+5)}$$

$$=\lim_{s\to 0} \frac{\cancel{30s}+40}{\cancel{2s^2}+\cancel{2s}+5} \Bigg|_{s=0 \text{ 대입}}$$

$$=\frac{40}{5}=8$$

28. 정상값 = 최종값

$$\lim_{s\to 0} \cancel{s}\cdot\frac{5}{\cancel{s}(s^2+s+2)}$$

$$\lim_{s\to 0} \frac{5}{\cancel{s^2}+\cancel{s}+2} \quad \left[s=0 \text{ 대입} \right]$$

$$=\frac{5}{2}$$

29. $= \boxed{\dfrac{1}{s\cdot(s+1)}}$

$$* \quad \frac{A\cdot\alpha}{s(s+\alpha)} \xrightarrow{f^{-1}} A\cdot(1-e^{-\alpha t})$$

$$\frac{1}{s\cdot(s+1)} = \frac{\overset{A}{1}\times\overset{\alpha}{1}}{s(s+1)}$$

$$f^{-1}\downarrow \quad 1\cdot(1-e^{-t})$$

$$=1-e^{-t}$$

30.

$$= \frac{s+1}{s^2+2s} = \frac{s+1}{s(s+2)}$$

$$\frac{s+1}{s(s+2)} = \frac{K_1}{s} + \frac{K_2}{s+2}$$

① $K_1 \Rightarrow$ 양변에 $\times S$

$$\left.\frac{s+1}{(s+2)} = K_1 + \frac{s \cdot K_2}{(s+2)}\right|_{s=0 \text{ 대입}}$$

↓ ↓

$$\frac{1}{2} = K_1 \qquad 0$$

② $K_2 \Rightarrow$ 양변에 $\times (S+2)$

$$\left.\frac{s+1}{s} = \frac{(s+2)\cdot K_1}{s} + K_2\right|_{s=-2 \text{ 대입}}$$

↓ ↓ ↓

$$\frac{1}{2} = \quad 0 \quad K_2$$

③ 원식에 $K_1 = \frac{1}{2}$, $K_2 = \frac{1}{2}$ 대입

$$\frac{\frac{1}{2}}{s} + \frac{\frac{1}{2}}{s+2}$$

$$= \frac{1}{2} \cdot \frac{1}{s} + \frac{1}{2} \cdot \frac{1}{s+2}$$

$$= \frac{1}{2}\left(\frac{1}{s} + \frac{1}{s+2}\right)$$

$$= \frac{1}{2}\left(\frac{1}{s} + \frac{1}{s+2}\right)$$

↓ $\mathcal{L}^{-1}$

$$\frac{1}{2}\cdot\left(1 + e^{-2t}\right)$$

31.

$$= \frac{5s+3}{s(s+1)}$$

편법

분자에 $5S+3$ 이면

결과식 $\bigcirc + \bigcirc e^{-t}$.

여기까지 조건은 보기 ①, ②

① 번을 $\mathcal{L}$

$$2 + 3 \cdot e^{-t} \xrightarrow{\mathcal{L}} \frac{2}{s} + \frac{3}{s+1}$$

$$= \frac{2(s+1) + 3s}{s(s+1)}$$

$$= \frac{2s+2+3s}{s(s+1)}$$

$$= \frac{5s+2}{s(s+1)}$$

원식이 아니므로 답아님

③ $3 + 2\cdot e^{-t} \xrightarrow{f} \frac{3}{s} + \frac{2}{s+1}$

답

$$= \frac{3(s+1) + 2s}{s(s+1)}$$

$$= \frac{3s+3+2s}{s(s+1)}$$

$$= \boxed{\frac{5s+3}{s(s+1)}}$$

32. $= \frac{s}{(s+1)\cdot(s+2)}$

분자에 s 만 있으면

$$\boxed{e^{-t}} - \boxed{e^{-2t}}$$

이런 꼴을 갖는것은 보기②, ④

보기④ 번을 라플라스하면

$$= 2\cdot e^{-2t} - e^{-t}$$

$$\downarrow \qquad \downarrow$$

$$\frac{2}{s+2} - \frac{1}{s+1}$$

$$= \frac{2(s+1) - 1(s+2)}{(s+2)(s+1)}$$

$$= \frac{2s+2-s-2}{(s+2)(s+1)}$$

$$= \frac{s}{(s+2)(s+1)}$$

답 보기④

33. $= \frac{2s+3}{s^2+3s+2}$

$$= \frac{2s+3}{(s+2)\cdot(s+1)}$$

*분자에 $2s+3$ 이면

$$\boxed{e^{-2t}} + \boxed{e^{-t}}$$

보기를 보면 ②, ③ 이므로

② 번을 라플라스 하면

$$= e^{-t} + e^{-2t}$$

$$\downarrow \qquad \downarrow$$

$$\frac{1}{s+1} + \frac{1}{s+2}$$

$$= \frac{s+2+s+1}{(s+1)(s+2)} = \frac{2s+3}{(s+1)(s+2)}$$

정답 보기②

34 $= \dfrac{s+2}{(s+1)^2}$

$= \dfrac{s+1+1}{(s+1)^2} = \dfrac{s+1}{(s+1)^2} + \dfrac{1}{(s+1)^2}$

$= \dfrac{\cancel{s+1}}{(s+1)^{\cancel{2}}} + \dfrac{1}{(s+1)^2}$

$= \dfrac{1}{s+1} + \dfrac{1}{(s+1)^2}$

$\downarrow \mathcal{L}^{-1}$

$e^{-t} + t \cdot e^{-t}$

35. $= \dfrac{1}{s^2+2s+2}$

$= \dfrac{1}{\underbrace{(s+1)^2}_{s^2+2s+1} + 1} = \dfrac{1}{(s+1)^2 + 1^2}$

$\downarrow \mathcal{L}^{-1}$

$\sin t \cdot e^{-t}\, u(t)$

36. $= \dfrac{2(s+1)}{s^2+2s+5} = \dfrac{2(s+1)}{\underbrace{(s+1)^2}_{s^2+2s+1}+4}$

$= \dfrac{2(s+1)}{(s+1)^2 + 2^2}$

$= 2 \cdot \dfrac{(s+1)}{(s+1)^2 + 2^2}$

$= 2 \cdot \cos 2t \cdot e^{-t}$

37. $= \dfrac{1}{s^2+2s+5} = \dfrac{1}{\underbrace{(s+1)^2}_{s^2+2s+1}+4}$

$= \dfrac{1}{(s+1)^2 + 2^2}$

$= \dfrac{1}{2} \times \dfrac{2}{(s+1)^2 + 2^2}$

$= \dfrac{1}{2} \cdot \sin 2t \cdot e^{-t}$

38. $= \frac{1}{s^2+6s+10} = \frac{1}{\underbrace{(s+3)^2}_{s^2+6s+9}+1}$

$= \frac{1}{(s+3)^2+1^2} \xrightarrow{f^{-1}} \sin t \cdot e^{-3t}$

39. $\frac{d}{dt}x(t) + 3x(t) = 5$

$s \cdot X(s) + 3X(s) = \frac{5}{s}$

「 $\frac{d}{dt} \xrightarrow{f} s$

상수 $\xrightarrow{f}$ $\frac{\text{상수}}{s}$ 」

$(s+3) \cdot X(s) = \frac{5}{s}$

$X(s) = \frac{5}{s(s+3)}$

40. $\frac{d}{dt}i(t) + 4i(t) + 4\int i(t)\,dt = 50u(t)$

「 $\frac{d}{dt} \to s$, $\int dt \to \frac{1}{s}$, $50u(t) \to \frac{50}{s}$ 」

$\frac{d}{dt}i(t) + 4i(t) + 4\int i(t)\,dt = 50u(t)$

$sI(s) + 4I(s) + \frac{4}{s}I(s) = \frac{50}{s}$

$(s+4+\frac{4}{s})I(s) = \frac{50}{s}$

$I(s) = \frac{50}{s(s+4\frac{4}{s})} = \frac{50}{s^2+4s+4}$

$I(s) = \frac{50}{s^2+4s+4} = \frac{50}{\underbrace{(s+2)^2}_{s^2+4s+4}}$

$I(s) = \frac{50}{(s+2)^2} = 50 \cdot \frac{1}{(s+2)^2}$

$f^{-1} = 50 \cdot t \cdot e^{-2t}$

14 장

$G(s)$

1. 비례요소 K

미분요소 KS

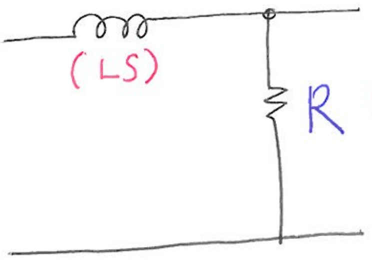
적분요소 $\frac{K}{S}$

1차 지연요소 $\frac{K}{1+TS}$

2. 부동작 시간 요소

$$K \cdot e^{-LS} = \frac{K}{e^{LS}}$$

3.

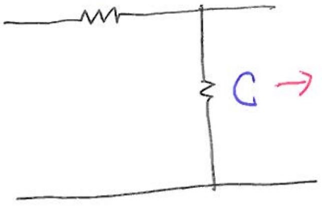


$$G(s) = \frac{R}{LS+R} \quad \text{단) } T = \frac{L}{R}$$

$$= \frac{\frac{R}{R}}{\frac{LS}{R} + \frac{R}{R}} = \frac{1}{TS+1}$$

4.

$R \times CS = RCS$



$C \rightarrow \frac{1}{CS} \times CS = 1$

$$G(s) = \frac{1}{RCS+1} \quad \text{단) } T = RC$$

$$= \frac{1}{TS+1}$$

5.

$C \rightarrow \frac{1}{CS} \times CS = 1$

$R \times CS = RCS$

$$G(s) = \frac{RCS}{1+RCS}$$

$\div RCS$

$$= \frac{1}{\frac{1}{RCS}+1}$$

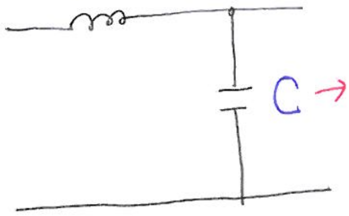
$\div RC$

$$= \frac{S}{\frac{1}{RC}+S}$$

$$= \frac{jw}{\frac{1}{RC}+jw} \quad (\text{보기}3)$$

6.

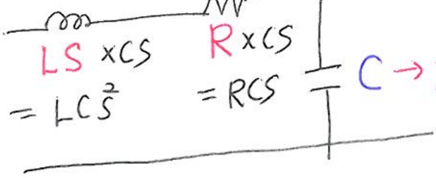
$L \rightarrow LS \times CS = LCS^2$



$C \rightarrow \frac{1}{CS} \times CS = 1$

$$G(s) = \frac{1}{LCS^2+1}$$

7



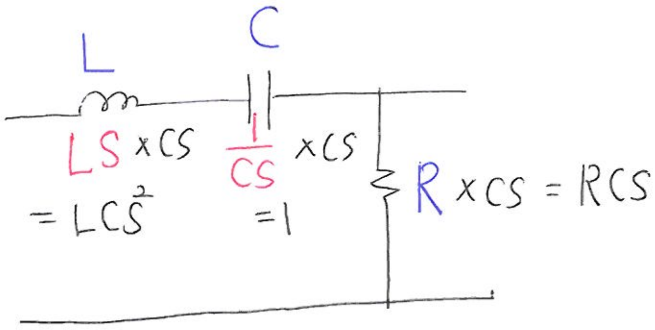
$LS \times CS = LCS^2$

$R \times CS = RCS$

$C \rightarrow \frac{1}{CS} \times CS = 1$

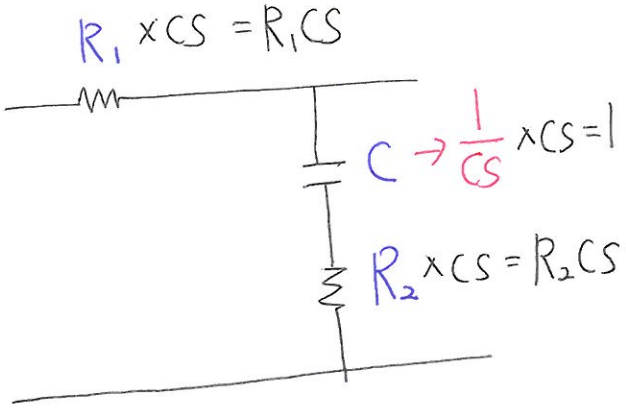
$$G(s) = \frac{1}{LCS^2+RCS+1}$$

8.



$$G(s) = \frac{RCS}{LCS^2 + RCS + 1}$$

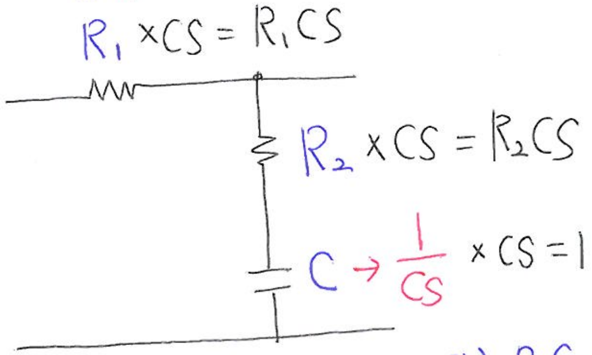
9.



$$G(s) = \frac{R_2CS + 1}{R_1CS + R_2CS + 1}$$

$$= \frac{R_2CS + 1}{S(R_1 + R_2)C + 1}$$

10.



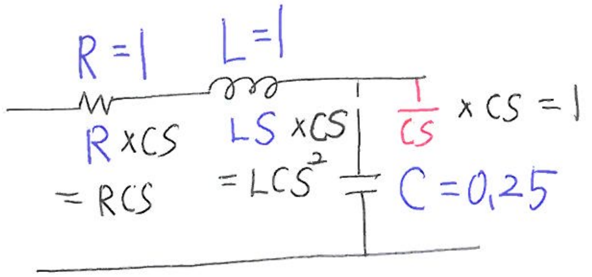
$$G(s) = \frac{\overset{T_1 \leftrightarrow}{\boxed{R_2C}}S + 1}{\underbrace{R_1CS + R_2CS}_{\hookrightarrow} + 1}$$

단) $R_2C = T_1$

$(R_1 + R_2)C = T_2$

$$= \frac{T_1S + 1}{(R_1 + R_2)CS + 1} = \frac{T_1S + 1}{T_2S + 1}$$

11.



$$G(s) = \frac{1}{LCS^2 + RCS + 1}$$

$$= \frac{1}{(1 \times 0.25)S^2 + (1 \times 0.25)S + 1}$$

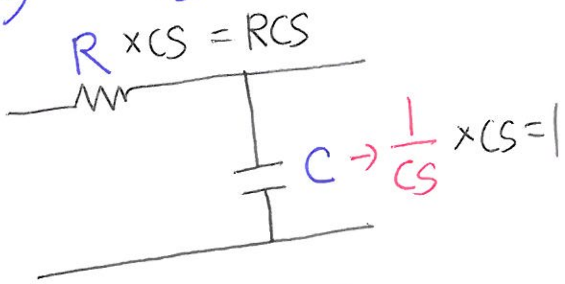
$$= \frac{1}{0.25S^2 + 0.25S + 1}$$

분모, 분자에 ×4

$$= \frac{4}{S^2 + S + 4}$$

$$= \frac{4}{(j\omega)^2 + j\omega + 4}$$

12.



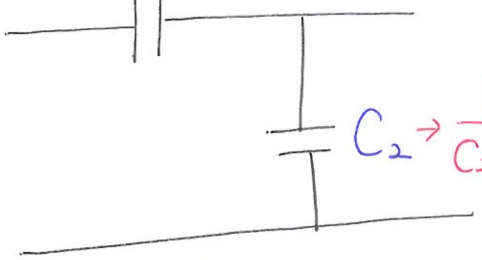
$$G(s) = \frac{1}{RCS + 1}\Bigg|_{s = j\omega}$$

$$G(j\omega) = \frac{1}{1 + j\omega \times R \times C}\Bigg|_{\omega = 0}$$

$$= \frac{1}{1 + 0} = \frac{1}{1} = 1$$

13,

$C_1 \rightarrow \frac{1}{C_1 S} \times C_1 C_2 S = C_2$

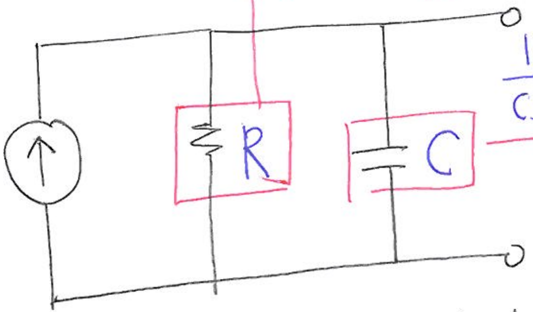


$C_2 \rightarrow \frac{1}{C_2 S} \times C_1 C_2 S = C_1$

$$G(s) = \frac{C_1}{C_1 + C_2}$$

14

$Y_1(s) = \frac{1}{R}$ [℧]



$\frac{1}{CS}$[Ω] → $Y_2(s) = CS$ [℧]

문제의 그림은 병렬 확인.

$$G(s) = \frac{V(s)}{I(s)} = Z(s) = \frac{1}{Y(s)}$$

즉 $Y(S)$ = 먼저 값을 구한다.

$$Y(s) = Y_1(s) + Y_2(s)$$

$$= \frac{1}{R} + CS$$

$$\therefore G(s) = \frac{V(s)}{I(s)} = Z(s) = \frac{1}{Y(s)}$$

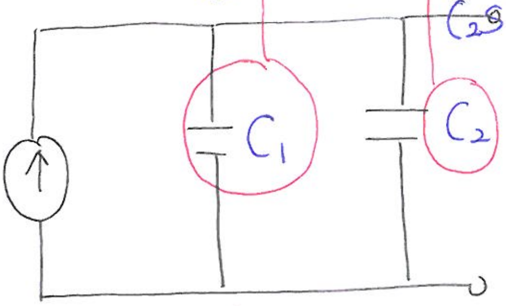
$$= \frac{1}{\frac{1}{R} + CS} = \frac{R}{1+RCS}$$

15.

$Y_1(s) = C_1 S$

$Y_2(s) = C_2 S$

$\frac{1}{C_1 S}$[Ω] $\frac{1}{C_2 S}$[Ω]



$$G(s) = \frac{V(s)}{I(s)} = Z(s) = \frac{1}{Y(s)}$$

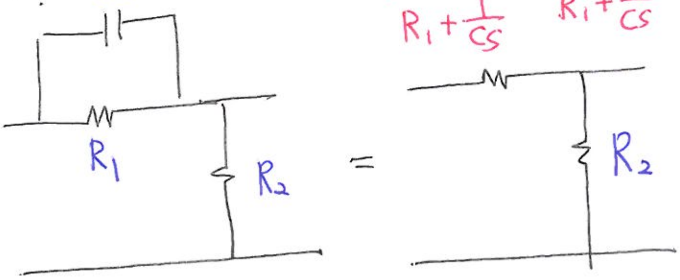
$$= \frac{1}{Y(s)} = \frac{1}{Y_1(s) + Y_2(s)}$$

$$= \frac{1}{C_1 S + C_2 S} = \frac{1}{(C_1 + C_2) S}$$

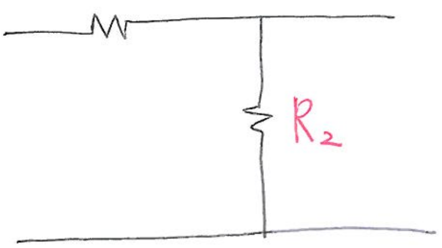
16.

$\frac{1}{CS}$

$$\frac{R_1 \times \frac{1}{CS}}{R_1 + \frac{1}{CS}} = \frac{\frac{R_1}{CS}}{R_1 + \frac{1}{CS}}$$



$$\frac{\frac{R_1}{Cs}}{R_1+\frac{1}{Cs}}$$



$$G(s) = \frac{R_2}{\frac{\frac{R_1}{Cs}}{R_1+\frac{1}{Cs}} + R_2}$$

$$= \frac{\frac{R_2}{1}}{\frac{\frac{R_1}{Cs} + R_2\left(R_1+\frac{1}{Cs}\right)}{\left(R_1+\frac{1}{Cs}\right)}}$$

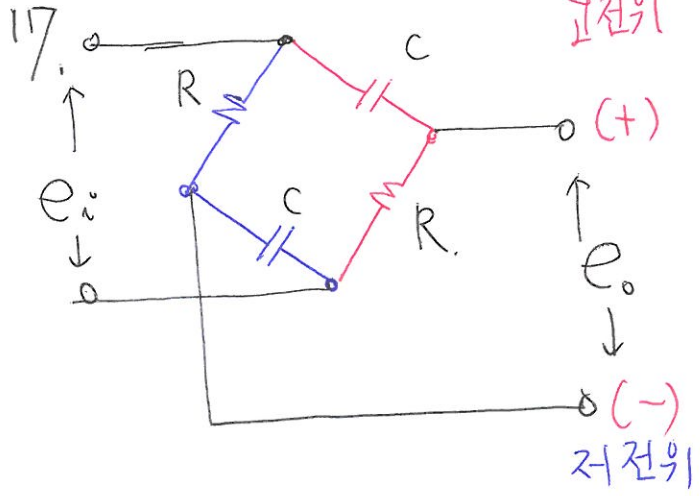
분모

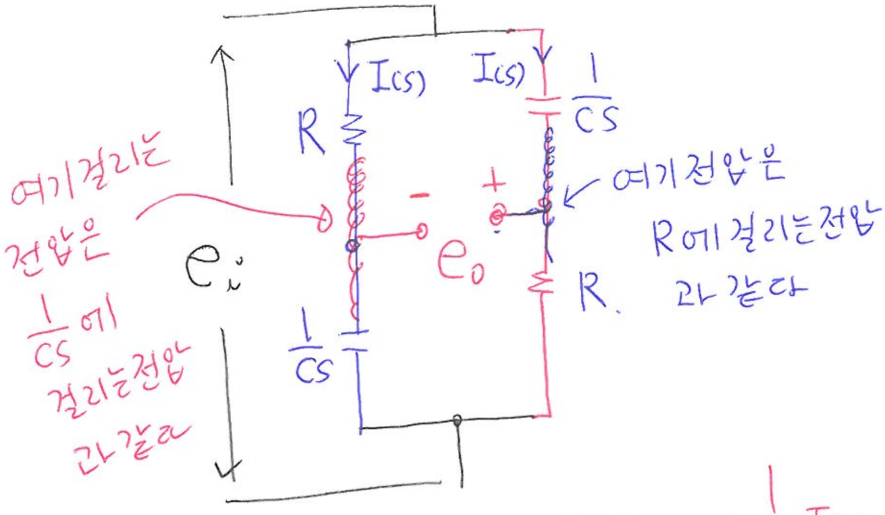
분자

$$= \frac{R_1R_2 + \frac{R_2}{Cs}}{\frac{R_1}{Cs} + R_1R_2 + \frac{R_2}{Cs}}$$

$$= \frac{R_1R_2Cs + R_2}{R_1 + R_1R_2Cs + R_2}$$

17.

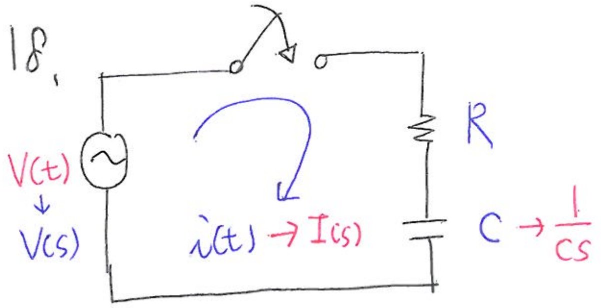




$$G(s) = \frac{E_o(s)}{E_I(s)} = \frac{R\,I(s) - \frac{1}{Cs}I(s)}{\left(R+\frac{1}{Cs}\right)I(s)}$$

$$= \frac{\left(R-\frac{1}{Cs}\right)\cancel{I(s)}}{\left(R+\frac{1}{Cs}\right)\cancel{I(s)}} = \frac{RCs-1}{RCs+1}$$

18.



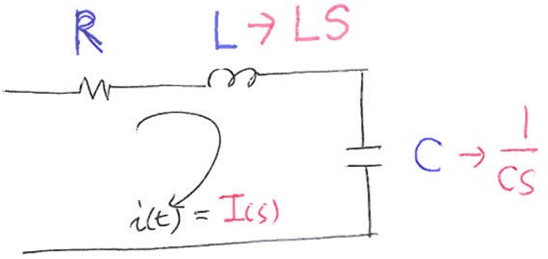
$$G(s) = \frac{I(s)}{V(s)} = Y(s) = \frac{1}{Z(s)}$$

$$= \frac{1}{Z(s)} = \frac{1}{R+\frac{1}{Cs}}$$

$$= \frac{Cs}{RCs+1} = \frac{s}{RS+\frac{1}{C}}$$

$$= \frac{s}{R\left(s+\frac{1}{RC}\right)}$$

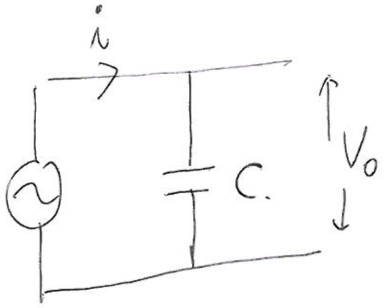
19.



$$G(s) = \frac{I(s)}{E_I(s)} = Y(s) = \frac{1}{Z(s)}$$

$$= \frac{1}{R+LS+\frac{1}{CS}} = \frac{CS}{LCS^2+RCS+1}$$

20.



$$G(s) = \frac{V_o(t)}{i(t)} = \frac{V_o(s)}{I(s)} = Z(s)$$

$$G(s) = Z(s) = \frac{1}{CS}$$

21.

$$\underset{\downarrow}{\frac{d^2}{dt^2}}y(t) + 3\underset{\downarrow}{\frac{d}{dt}}y(t) + \underset{\downarrow}{2y(t)} = \underset{\downarrow}{\frac{d}{dt}}x(t) + \underset{\downarrow}{x(t)}$$

$$S^2Y(s) + 3SY(s) + 2Y(s) = Sx(s) + X(s)$$

$$(S^2+3S+2)Y(s) = (S+1)X(s)$$

$$G(s) = \frac{Y(s)}{X(s)} \cancel{=} \frac{S+1}{S^2+3S+2}$$

22.

$$\frac{V_o(s)}{V_I(s)} \cancel{=} \frac{1}{s^2+3s+1}$$

$$V_o(s)(s^2+3s+1) = 1 \cdot V_I(s)$$

$$\underset{\downarrow}{s^2V_o(s)} + \underset{\downarrow}{3SV_o(s)} + \underset{\downarrow}{1 \cdot V_o(s)} = 1\,V_I(s)$$

$$\frac{d^2}{dt^2}V_o(t) + 3\frac{d}{dt}V_o(t) + V_o(t) = V_i(t)$$

23.

$$\underset{\downarrow}{\frac{d}{dt}}y(t) + \underset{\downarrow}{y(t)} = \underset{\downarrow}{x(t-T)}$$

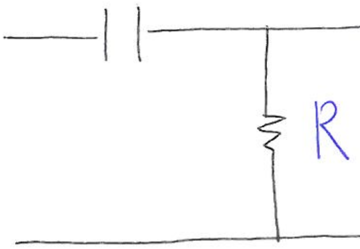
$$SY(s) + Y(s) = X(s) \cdot e^{-TS}$$

$$(S+1)Y(s) = X(s) \cdot e^{-TS}$$

$$G(s) = \frac{Y(s)}{X(s)} = \frac{e^{-TS}}{S+1}$$

24

$C \rightarrow \frac{1}{CS} \times CS = 1$



$R \times CS = RCS$

$$G(s) = \frac{RCS}{1+RCS}$$

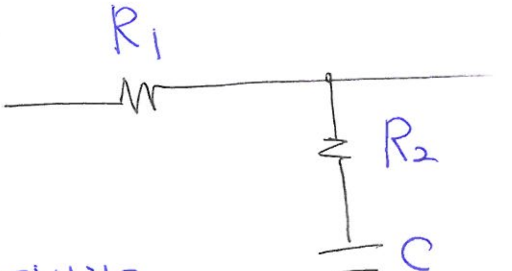
$$= \boxed{\frac{1}{1+RCS}} \times \boxed{RCS}$$

$$= \frac{K}{1+TS} \times KS$$

1차지연요소 미분요소

∴ 1차지연 미분요소

25.



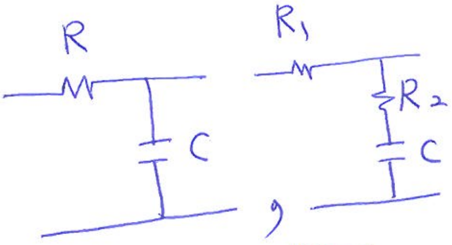
적분회로.

* 적 립 미 출

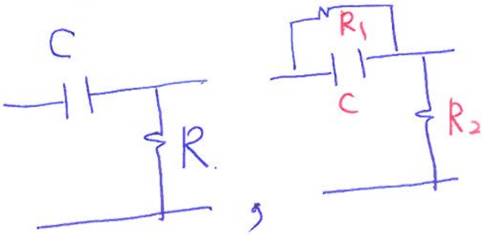
= 적분회로는 입력이 앞서고

미분회로는 출력이 앞선다

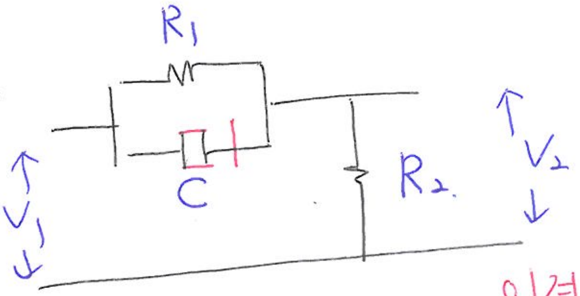
적분회로 ⇒
(지상회로)



미분회로 ⇒
(진상회로)

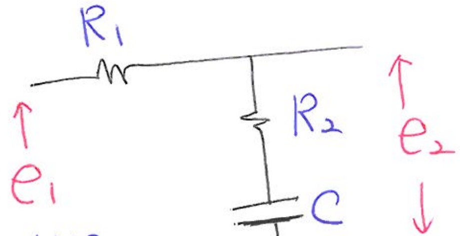


26.



미분회로 ⇒ 출력 (V2) 이(가) 입력 (V1) 보다 앞선다.

27.



적분회로

입력 (e1) 이 출력 (e2) 보다 앞선다

28. 진상 보상기 조건 (θ>0)

$$\left.\frac{s+b}{s+a}\right|_{s=jw}$$

$$= \frac{b+jw}{a+jw} = \frac{\tan^{-1}\frac{w}{b}}{\tan^{-1}\frac{w}{a}}$$

$$\frac{\tan^{-1}\frac{w}{b}}{\tan^{-1}\frac{w}{a}} = \tan^{-1}\frac{w}{b} - \tan^{-1}\frac{w}{a}$$

$$= \tan^{-1}\left(\frac{w}{b} - \frac{w}{a}\right)$$

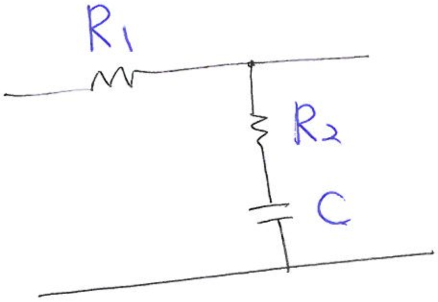
진상조건 = $\frac{w}{b} - \frac{w}{a} > 0$

$$\frac{\cancel{w}}{b} > \frac{\cancel{w}}{a}$$

$$\frac{1}{b} > \frac{1}{a}$$

∴ $a > b$ [분모 > 분자]

29.



↳ 적분회로 = 지상회로망

30.

제동계수 = 제동비 = δ

① $\delta > 1$ = 과제동

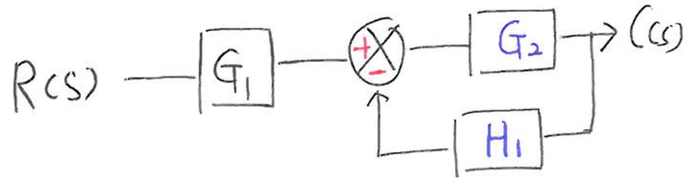
② $\delta = 1$ = 임계제동

③ $0 < \delta < 1$ = 부족(감쇠)제동

④ $\delta = 0$ = 무제동

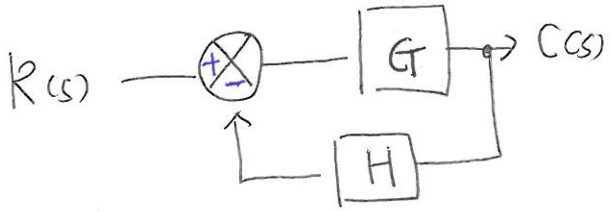
< 추가 내용 >

①



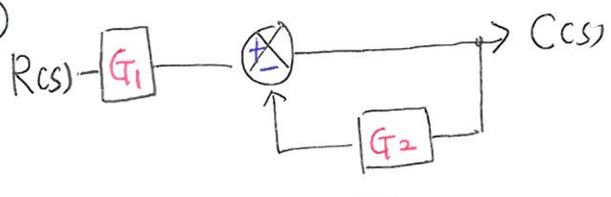
$$G(s) = \frac{C(s)}{R(s)} = \frac{G_1 \times G_2}{1 + G_2 H_1}$$

②



$$G(s) = \frac{C(s)}{R(s)} = \frac{G}{1 + GH}$$

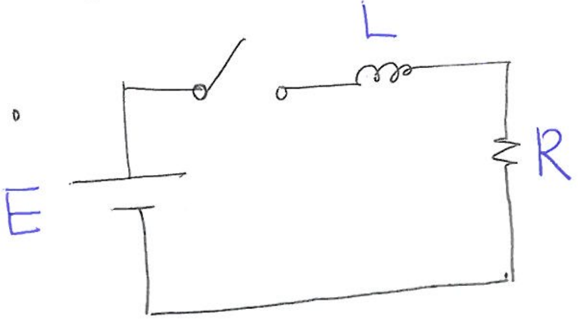
③



$$G(s) = \frac{C(s)}{R(s)} = \frac{G_1}{1 + G_2}$$

15장

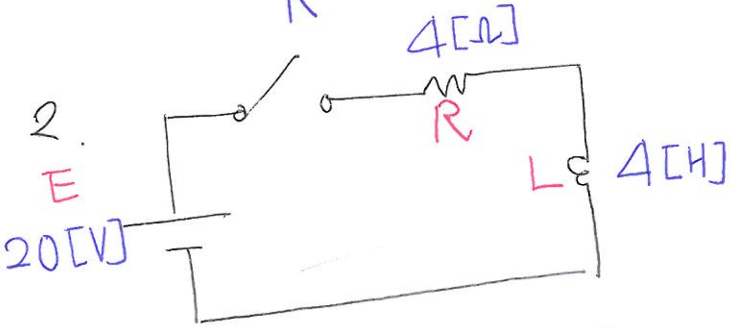
1.



R-L 회로 (S/w closed)

$$i(t) = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$

2.



R-L 회로(S/w closed)

t=1[s] 일때 i(t)

$$i(t) = \frac{E}{R}\left(1 - e^{-\frac{R}{L}\overset{1}{t}}\right)$$

$$= \frac{E}{R}\left(1 - e^{-\frac{R}{L}}\right)$$

$$= \frac{20}{4}\left(1 - e^{-\frac{4}{4}}\right)$$

$$= 5\left(1 - e^{-1}\right)$$

$$= 5\left(1 - 0{,}367\right)$$

$$= 5 \times 0{,}633 = 3{,}165$$

3. R-L 회로

직류 전압원 연결 = S/w closed

$$i(t) = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)\Bigg|_{t=0}$$ 대입

$$= \frac{E}{R}\left(1 - e^{-0}\right)$$

$$= \frac{E}{R}\left(1 - \frac{1}{e^{0}}\right)$$

$$= \frac{E}{R}\left(1 - \frac{1}{1}\right)$$

$$= 0\,[A]$$

→ 이 회로에 전류 흐르지 않는다

4. $Ri(t) + L\frac{d\,i(t)}{dt} = E$ 에서

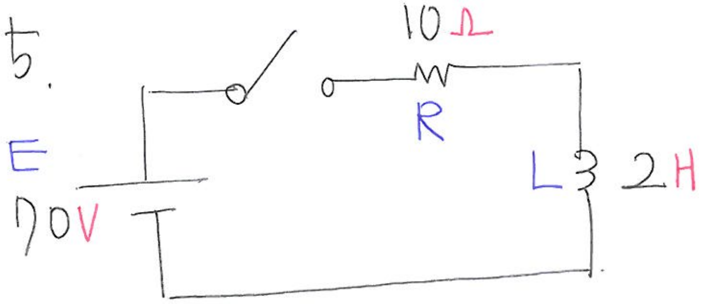
정상 전류 ⇒ 정상전류 조건은 $\frac{di}{dt} = 0$

$$Ri(t) + L\overset{=0}{\underbrace{\boxed{\frac{d\,i(t)}{dt}}}_{=0}} = E$$

$$Ri(t) = E$$

$$i(t) = \frac{E}{R}$$

5.



정상전류 = 최종값 전류 = t=∞

S/W → closed i(t)

$$i(t) = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)\Big|_{t=\infty}$$

$$= \frac{E}{R}\left(1 - e^{-\infty}\right)$$

$$= \frac{E}{R}\left(1 - \boxed{\frac{1}{\infty}}=0\right)$$

$$i(\infty) = \frac{E}{R}\,[A]$$

$$= \frac{70}{10} = 7\,[A]$$

6. $i(t) = 20 - 20 \cdot e^{-200t}$

정상값 = t=∞

$$= 20 - 20 \cdot e^{-200\times\infty}$$

$$= 20 - 20 \cdot e^{-\infty}$$

$$= 20 - 20 \times \frac{1}{e^{\infty}}$$

$$= 20 - \underbrace{20 \times \boxed{\frac{1}{\infty}}=0}_{=0}$$

$$= 20$$

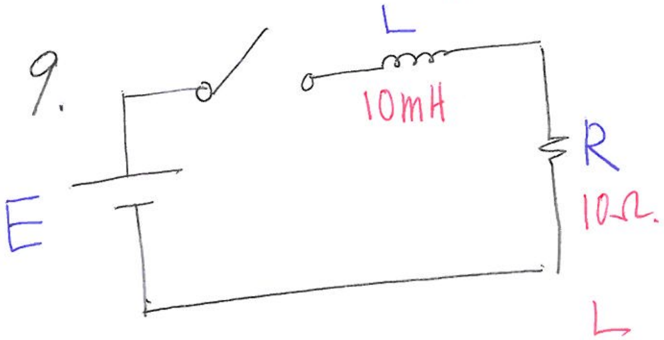
7. R-L 회로 시정수(τ)

$$\tau = \frac{L}{R}$$

8. 시정수(τ) 와 특성근(α)

$\tau = \frac{1}{|\alpha|}$ ⇒ 시정수는 특성근 절대값 역수

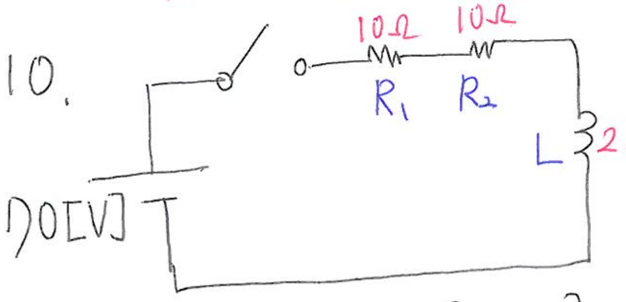
9.



시정수 → R-L회로 = $\frac{L}{R}$

$$\tau = \frac{L}{R} = \frac{10\times10^{-3}\,[H]}{10\,[\Omega]} = 10^{-3}\,[S]$$

10.



① 시정수 $= \frac{L}{R_1+R_2} = \frac{2}{10+10} = \frac{2}{20}$

$= 0{,}1\,[S]$

② 특성근$(\alpha) = -\frac{R_1+R_2}{L}$

$$= -\frac{10+10}{2} = -10$$

④ 정상전류 = L 단락 하면

$$= \frac{E}{R_1+R_2} = \frac{70}{10+10}$$

$$= 3.5[A]$$

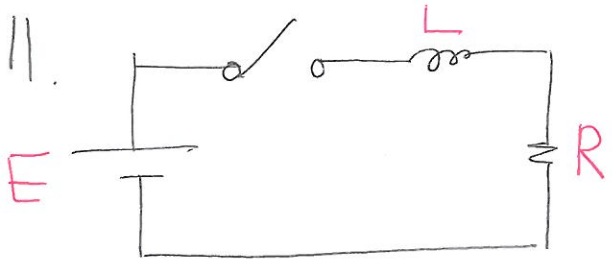
또는 $i(t) = \frac{E}{R_1+R_2}\cdot\left(1-e^{-\frac{R_1+R_2}{L}\cdot t}\right)\Big|_{t=\infty}$

$$= \frac{E}{R_1+R_2}\left(1-e^{-\infty}\right)$$

$$= \frac{E}{R_1+R_2}\left(1-\boxed{\frac{1}{\infty}}^{=0}\right)$$

정상전류 $= \frac{E}{R_1+R_2}$

11.



R-L 회로 S/W open 시

$$i(t) = \frac{E}{R}\cdot e^{-\frac{R}{L}t}\ [A]$$

12. R-L 회로, S/W colsed

$\frac{L}{R}$ [s] 후의 전류

$$i(t) = \frac{E}{R}\left(1-e^{-\frac{R}{L}t}\right)\Big|_{t=\frac{L}{R}}$$

$$= \frac{E}{R}\left(1-e^{-\frac{R}{L}\times\frac{L}{R}}\right)$$

$$= \frac{E}{R}\left(1-e^{-1}\right)$$

$$= \frac{E}{R}\left(1-\frac{1}{e^{1}}\right)$$

$$= \frac{E}{R}\left(1-0.367\right)$$

$$= 0.632\frac{E}{R}$$

13. R-L 회로 전압 가했을때

$t=0.01$ [s] 후의 전류

$$i(t) = \frac{E}{R}\left(1-e^{-\frac{R}{L}t}\right)\Big|_{t=0.0}$$

$$= \frac{100}{100}\left(1-e^{-\frac{100}{1}\times 0.01}\right)$$

$$= 1\left(1-e^{-1}\right)$$

$$= 1\left(1-0.367\right) = 0.632$$

14. S/W open $i(t)$

$$i(t) = \frac{E}{R} \cdot e^{-\frac{R}{L}t} \Big|_{t = \frac{L}{R}}$$

$$= \frac{E}{R} \cdot e^{-\frac{R}{L} \times \frac{L}{R}}$$

$$= \frac{E}{R} \cdot e^{-1} = \frac{E}{R} \times 0.367$$

$$= 0.367 \times \frac{E}{R}$$

15. S/W closed $i(t)$

$$i(t) = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$

→ 정상전류의 63.2 [%]

즉 정상전류는 $\frac{E}{R}$

정상전류의 63.2% 라는것은

$0.632 \frac{E}{R}$ 가 될려면

$t = \frac{L}{R}$ [s]

16. 시정수 와 과도현상

* 시정수 가 크면 과도현상 길어진다

* 시정수 역이 크면 (시정수가 작다)

과도현상 빨리 사라진다.

* 시정수가 크면 과도현상 천천히 사라진다

17. S/W closed L에 걸리는전압.

$$E = E_R + E_L$$

$$E = E - E \cdot e^{-\frac{R}{L}t} + \left(E \cdot e^{-\frac{R}{L}t}\right)$$

단) $E_R = R \cdot i(t)$

$$= R \times \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$

$$= E\left(1 - e^{-\frac{R}{L}t}\right)$$

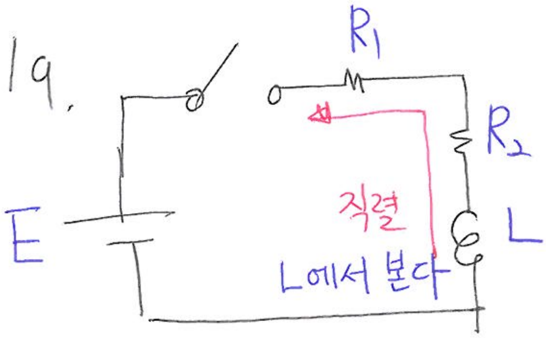
$$= E - E \cdot e^{-\frac{R}{L}t}$$

18. $V_L = L \cdot \frac{di}{dt}$

$\downarrow \quad \downarrow \quad \downarrow$

$60 = (\underbrace{2}_{L}) \times 30$

19.



$$시정수(\tau) = \frac{L}{R} = \frac{L}{\underbrace{R_1+R_2}_{직렬이므로}}$$

20. $L \cdot I = N \cdot \phi$ 에서

$L = \frac{N \cdot \phi}{I} = \frac{1000 \times 3 \times 10^{-2}}{10}$

$L = 3$ [H]

$시정수(\tau) = \frac{L}{R} = \frac{3}{20}$

$= 0.15$

21. R-C회로 전류

$i(t) = \frac{E}{R} \cdot e^{-\frac{1}{RC}t}$ [A]

22. R-C 회로 $t=0.1$ 초

$i(t) = \frac{E}{R} \cdot e^{-\frac{1}{RC}t}$ $t=0.1$

$= \frac{10}{1000} \times e^{-\frac{1}{1000 \times 50 \times 10^{-6}} \times 0.1}$

$= \frac{1}{100} \times e^{-2}$

$= 1.35 \times 10^{-3}$ [A]

$= 1.35$ [mA]

23. R-C 회로 $t=0^+$ (초기값)

$i(t) = \frac{E}{R} \cdot e^{-\frac{1}{RC}t}$ $t=0$

$= \frac{E}{R} \cdot e^{-\frac{1}{RC} \times 0}$

$= \frac{100}{1000} \times \boxed{e^{-0}} = 1$

$= \frac{1}{10} \times \boxed{\frac{1}{e^0}} = 1$

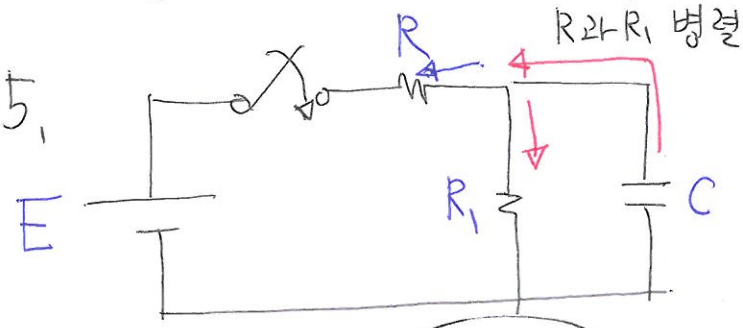
$= 0.1$ [A]

24. R-C 회로 시정수(τ)

$\tau = RC$ [S]

25.

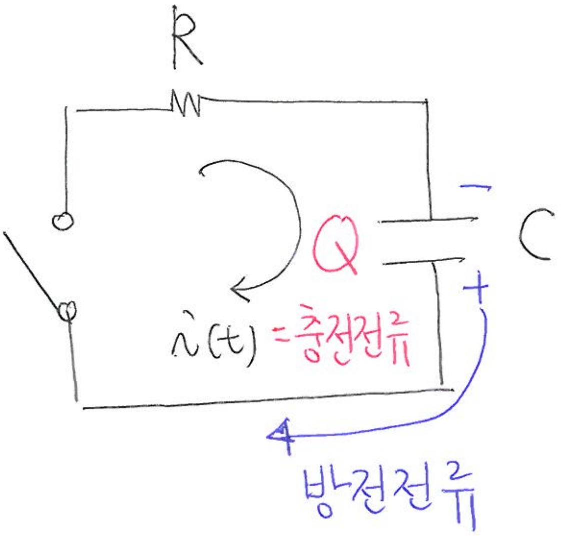
C에서 바라보면
R과 R_1 병렬



시정수 = R·C 단) $R = \frac{R \cdot R_2}{R+R_1}$

$$\tau = \frac{R \cdot R_2}{R+R_1} \cdot C$$

26.



충전전류 와 방전전류 방향 같다

방전전류 = 충전전류 [$i(t)$]

$$= \frac{E}{R} \cdot e^{-\frac{1}{RC}t}$$

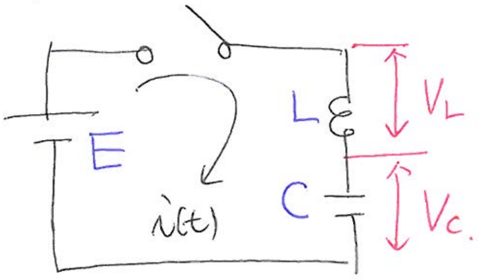
단) $Q = CE$

$E = \frac{Q}{C}$

$$= \frac{\frac{Q}{C}}{R} \cdot e^{-\frac{1}{RC}t}$$

$$= \frac{Q}{RC} \cdot e^{-\frac{1}{RC}t}$$

27. LC 회로.



L-C 회로

① $i(t) = \frac{E}{\sqrt{\frac{L}{C}}} \cdot \sin \frac{1}{\sqrt{LC}} t$

② $V_L = L \cdot \frac{d}{dt} i(t)$

$$= L \cdot \frac{d}{dt}\left(\frac{E}{\sqrt{\frac{L}{C}}} \cdot \sin \frac{1}{\sqrt{LC}} t \right)$$

$$= L \times \frac{E}{\sqrt{\frac{L}{C}}} \underbrace{\frac{d}{dt} \sin \frac{1}{\sqrt{LC}} t}$$

$$= L \times \frac{E}{\sqrt{\frac{L}{C}}} \times \frac{1}{\sqrt{LC}} \cos \frac{1}{\sqrt{LC}} t$$

$$= E \times L \times \frac{1}{\sqrt{\frac{L}{\cancel{C}} \times L\cancel{C}}} \cdot \cos \frac{1}{\sqrt{LC}} t$$

$$= E \times \cancel{L} \times \frac{1}{\cancel{\sqrt{L^2}}} \cdot \cos \frac{1}{\sqrt{LC}} t$$

$$V_L = E \cdot \cos \underbrace{\frac{1}{\sqrt{LC}} t}$$

$\cos$함수 $\left[\begin{array}{l} 최대(1) \\ 최소(-1) \end{array}\right.$

$$V_L \Rightarrow \left[\begin{array}{l} 최대(E) \\ 최소(-E) \end{array}\right.$$

V_C 는 $\Rightarrow$ $E = V_L + V_C$ 이용

$$E = E \cdot \cos \frac{1}{\sqrt{LC}} t + (\underbrace{E - E\cos\frac{1}{\sqrt{LC}} t}_{V_C})$$

$$V_L = E - E\cos\frac{1}{\sqrt{LC}} t$$

$$= E\left(1 - \underbrace{\cos\frac{1}{\sqrt{LC}} t}\right)$$

$\cos$함수 $\left[\begin{array}{l} 최대(1) \\ 최소(-1) \end{array}\right.$

$$\left[\begin{array}{l} E(1-(-1)) = \underbrace{2E}_{최대} \\ E(1-(1)) = \underbrace{0}_{최소} \end{array}\right.$$

$$V_C = \left[\begin{array}{l} 최대 = 2E \\ 최소 = 0 \end{array}\right.$$

28, L-C 회로

* 불변의 진동 전류

29. L-C 회로 최대전압

$$V_m = \sqrt{\frac{L}{C}} \times I_0$$

$$= \sqrt{\frac{50 \times 10^{-3}}{20 \times 10^{-6}}} \times 200$$

$$= 10{,}000\ [V]$$

$$= 10\ [KV]$$

30. R-L-C 회로

$R^2 > 4\frac{L}{C}$ 비진동

$R^2 < 4\frac{L}{C}$ 진동

$R^2 = 4\frac{L}{C}$ 임계진동

31. 진동 조건

$$R^2 < 4\frac{L}{C}$$

또는 $R < 2\sqrt{\frac{L}{C}}$

32. $R^2 - 4\frac{L}{C} > 0$

$R^2 > 4\frac{L}{C}$ 비진동

33. $R^2 - 4\frac{L}{C} < 0$

$R^2 < 4\frac{L}{C}$ 진동

34. 임계제동

$R^2 = 4\frac{L}{C}$

또는 $R = 2\sqrt{\frac{L}{C}}$

35. 과도현상 발생하지 않으려면 전압위상 = 임피던스 각

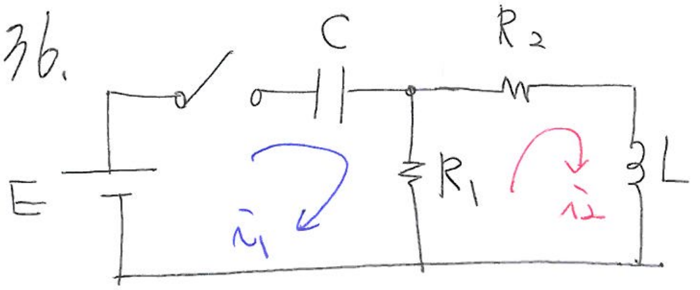
$= \tan^{-1}\left(\frac{허수}{실수}\right)$

$= \tan^{-1}\left(\frac{\omega L}{R}\right)$

$= \tan^{-1}\left(\frac{2\pi \times 60 \times 79{,}6 \times 10^{-3}}{30}\right)$

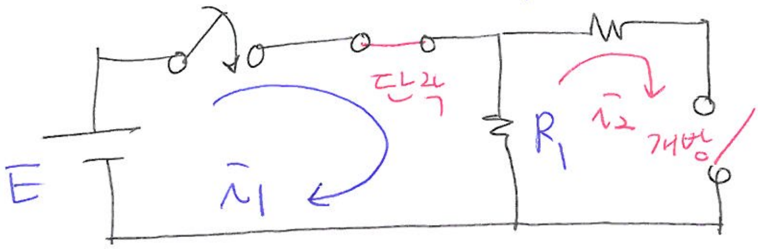
$= 45^{\circ}$

36.



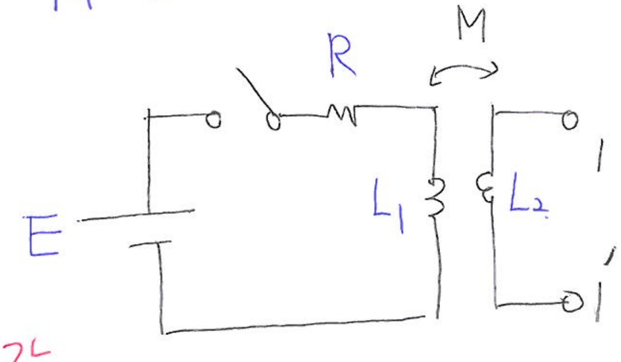
$i_1(0_+)$, $i_2(0_+)$ ⇒ 초기값

초기값 [L = 개방
C = 단락



$i_1 = \frac{E}{R_1}$, $i_2 = 0$

37.



* s/w closed 1차측 흐르는전류 i_1

$\underbrace{i_1(0)}_{i_1\text{의 초기값}} = 0$ (R-L 회로 이므로)

$i_1(\infty) = \frac{E}{R}$

$\tau = \frac{L_1}{R}$

$$i_1(t) = i_1(\infty) + [i_1(0) - i_1(\infty)] \cdot e^{-\frac{t}{\tau}}$$

$$= \frac{E}{R} + \left(0 - \frac{E}{R}\right) \cdot e^{-\frac{t}{\frac{L_1}{R}}}$$

$$= \frac{E}{R} - \frac{E}{R} \cdot e^{-\frac{R}{L_1}t}$$

$$= \frac{E}{R}\left(1 - e^{-\frac{R}{L_1}t}\right)$$

* 1-1′ 전압 = e_2 = 2차측전압

$$e_2 = \underbrace{L_2 \cdot \frac{di_2}{dt}}_{\substack{\text{2차측개방} \\ i_2 = 0 \\ = 0}} + \underbrace{M \cdot \frac{di_1}{dt}}$$

$$e_2 = M \cdot \frac{d}{dt} i_1$$

$$= M \cdot \frac{d}{dt} \cdot \frac{E}{R}\left(1 - e^{-\frac{R}{L_1}t}\right)$$

$$= M \cdot \frac{E}{R} \frac{d}{dt}\left(\underbrace{1}_{\substack{\text{상수} \\ \text{미분} \\ = 0}} - \underbrace{e^{-\frac{R}{L_1}t}}_{\text{지수함수미분}}\right)$$

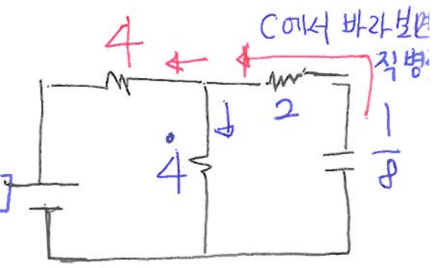
$$-\left(-\frac{R}{L_1}\right) \cdot e^{-\frac{R}{L_1}t}$$

$$= \frac{R}{L_1} \cdot e^{-\frac{R}{L_1}t}$$

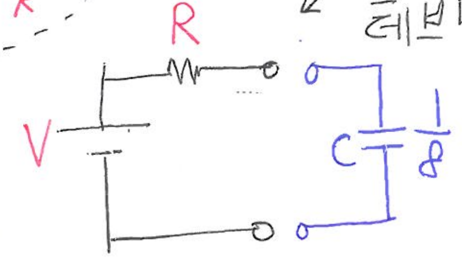
$$= M \times \frac{E}{\cancel{R}} \times \frac{\cancel{R}}{L_1} \cdot e^{-\frac{R}{L_1}t}$$

$$= \frac{ME}{L_1} \cdot e^{-\frac{R}{L_1}t}$$

38.



테브난회로

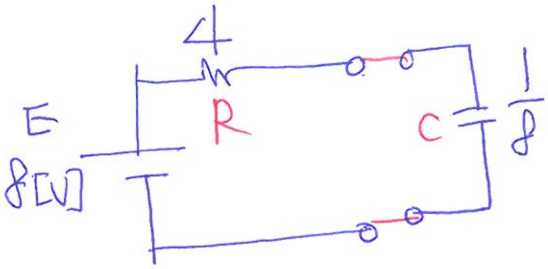


R = C에서 바라본 합성

$$= 2 + \frac{4 \times 4}{4 + 4} = 4[\Omega]$$

V = $\dot{4}$ 에 걸리는전압 (4와 $\dot{4}$ 직렬)

$$= \frac{\dot{4}}{4 + \dot{4}} \times 16 = 8[V]$$



R-C 회로이다

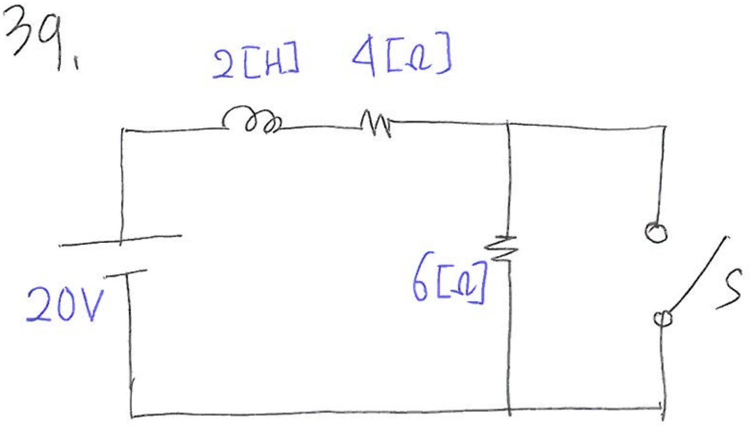
$$i(t) = \frac{E}{R} \cdot e^{-\frac{1}{RC}t}$$

$$= \frac{8}{4} \cdot e^{-\frac{1}{4 \times \frac{1}{8}}t}$$

$$= 2 \cdot e^{-\frac{1}{\frac{1}{2}}t}$$

$$= 2 \cdot e^{-2t}$$

39.



$$\tau = \frac{L}{R} = \frac{2}{4+6} = 0,2 = \frac{1}{5}$$

$$i(t) = i(\infty) + [i(0) - i(\infty)] \cdot e^{-\frac{t}{\tau}}$$

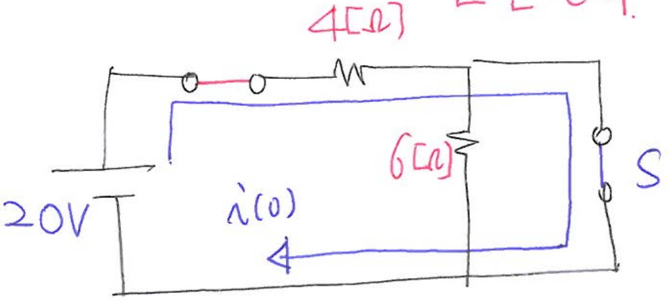
$$= 2 + [5-2] \cdot e^{-\frac{t}{\frac{1}{5}}}$$

$$= 2 + 3 \cdot e^{-5t}$$

① S/W Closed 상태

정상전류

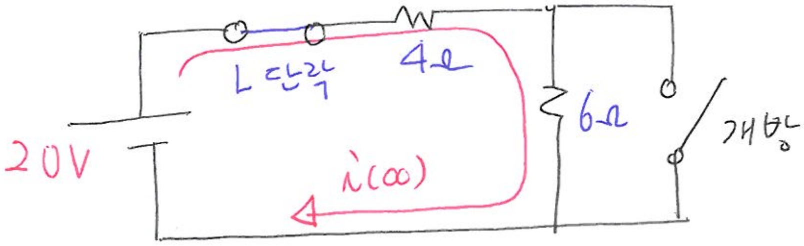
L은 단락



$$i(0) = \frac{20}{4} = 5[A]$$

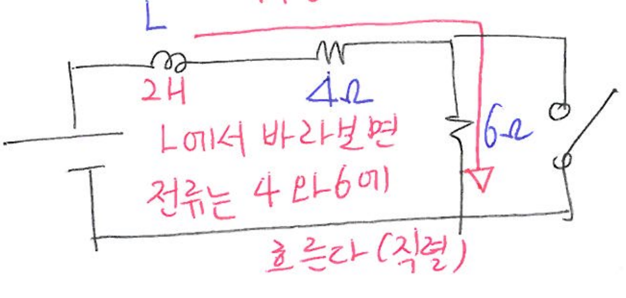
② 정상상태에서 S/W open

L 단락



$$i(\infty) = \frac{20}{4+6} = 2[A]$$

③



L에서 바라보면 전류는 4와6에 흐른다 (직렬)