Lab. of Applied ElectroMagnetics

전기기기I (Electric Machines)

- MAP : 수학 → 전자기학 (회로이론) → **전기기기** → 에너지변환,전력전자, u-Process, 제어공학, Robotics, 전력계통

- 전기기기, 전기기기실험, 전기기기설계
- 선수과목 : 전자기학(2학년교재 7~9장), 회로이론(Phasor와 3상회로)

- 전기기기 : 전기에너지 (P=VI) ----(전동기)----→ 기계에너지 (P=TW)
  ←----(발전기)----

- 형태별 분류 : 정지기 – 변압기
  회전기 – 직류기
  교류기 – 동기기, 유도기

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- 교재 및 부교재 :

  Electric Machines, Slemon, Addison Wesley
  Electric Machinery, Fitzgerald, Mc Graw Hill
  Electric Machinery Fundamentals, Chapman, Mc Graw Hill
  Principles of Electric Machines and Power Electronics, P.C.Sen, Wiley
  Electric Machines, C.I.Hubert, Prentice Hall
  Electric Machines, M. Sarma and M.Pathak, Cengage Learning

- 구성 :

  Part I : 1장 Phasor 2장 3상회로 3장 Magnetic Circuit
  4장 Transformer 5장 Energy Conversion 6장 Winding

  Part II : 7장 유도기 8장 동기기 9장 직류기

  Part III : Transient and Dynamics

Chap 1. Phasor

1.1 Phasor

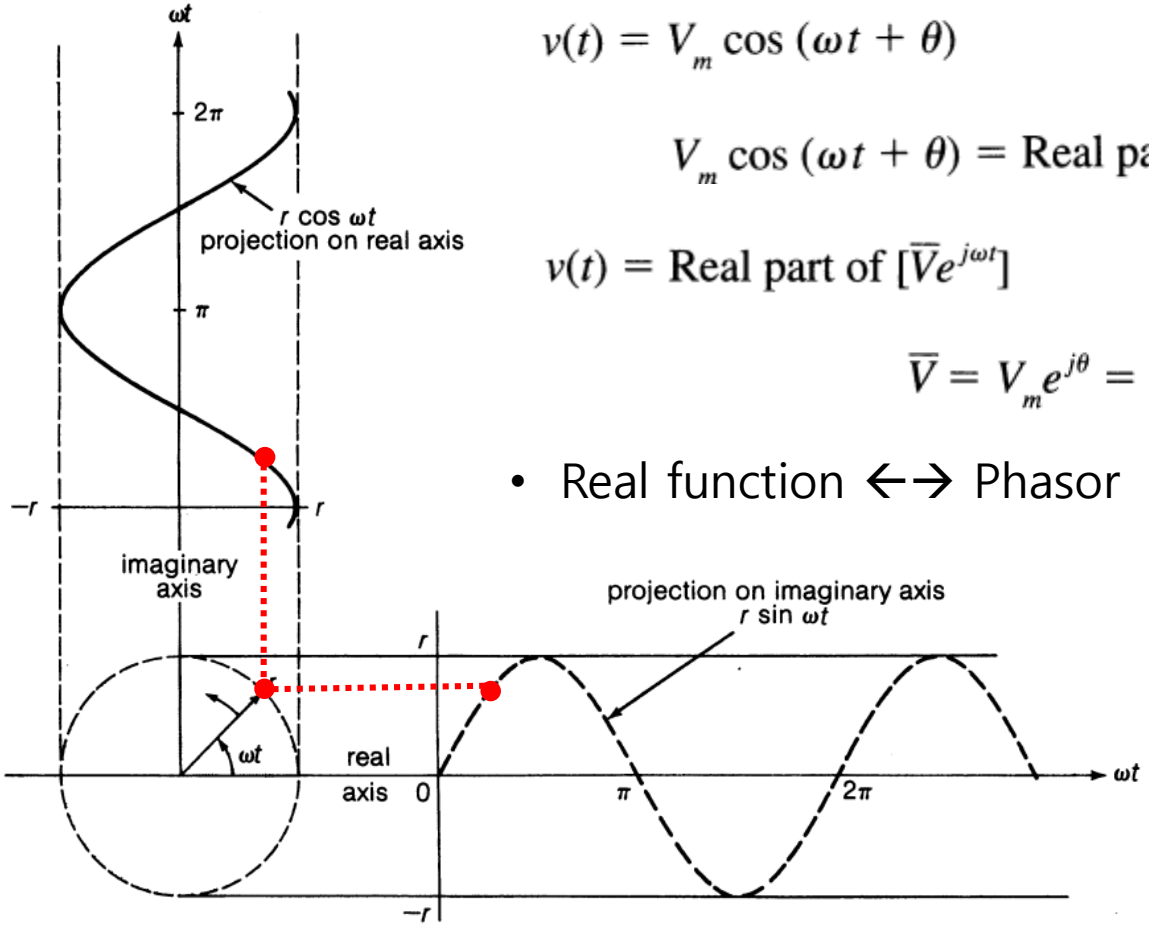
- Number & Function
- Function & Graph
- Real number & Real function
  Complex number & Complex function

$$f(t) = re^{j\omega t}$$

- Why complex ?
- Euler equation

$$f(t) = re^{j\omega t} = r(\cos \omega t + j \sin \omega t)$$

- What is real ? / What is imaginary ?
- How to handle COMPLEX function ?



$$v(t) = V_m \cos(\omega t + \theta)$$

$$V_m \cos(\omega t + \theta) = \text{Real part of } [V_m e^{j\theta} e^{\omega t}]$$

$$v(t) = \text{Real part of } [\overline{V} e^{j\omega t}]$$

$$\overline{V} = V_m e^{j\theta} = V_m \angle\theta \quad : \text{Phasor}$$

- Real function ←→ Phasor

그림 1.1.1 • 회전하는 페이저–실수축 사영은 코사인에 따라 변동하고 허수축 사영은 사인에 따라 변동

- Real function / Phasor
- Time domain / Frequency domain

- Sinusoidal Time function (V, I) : RMS value , Phase angle
  Sinusoidal Space function (B, Vm) : PEAK value , Space angle

- (Ex) Alternating Voltage :

<Real function>

$$v(t) = 100\sqrt{2}\cos(\omega t + 30^\circ)\ \text{V}$$

$$i(t) = 10\sqrt{2}\sin(\omega t + 30^\circ)\ \text{A}$$

<Phasor>

$$\bar{V} = 100\angle 30^\circ\ \text{V}$$

$$\bar{I} = 10\angle -60^\circ\ \text{A}$$

- Sinusoidal function :

$$\sin(\omega t + \alpha) = \cos\left(\omega t + \alpha - \frac{\pi}{2}\right)$$

$$\cos(\omega t + \beta) = \sin\left(\omega t + \beta + \frac{\pi}{2}\right)$$

$$\sin(\omega t + 30^\circ) = \cos(\omega t + 30^\circ - 90^\circ)$$
$$= \cos(\omega t - 60^\circ)$$

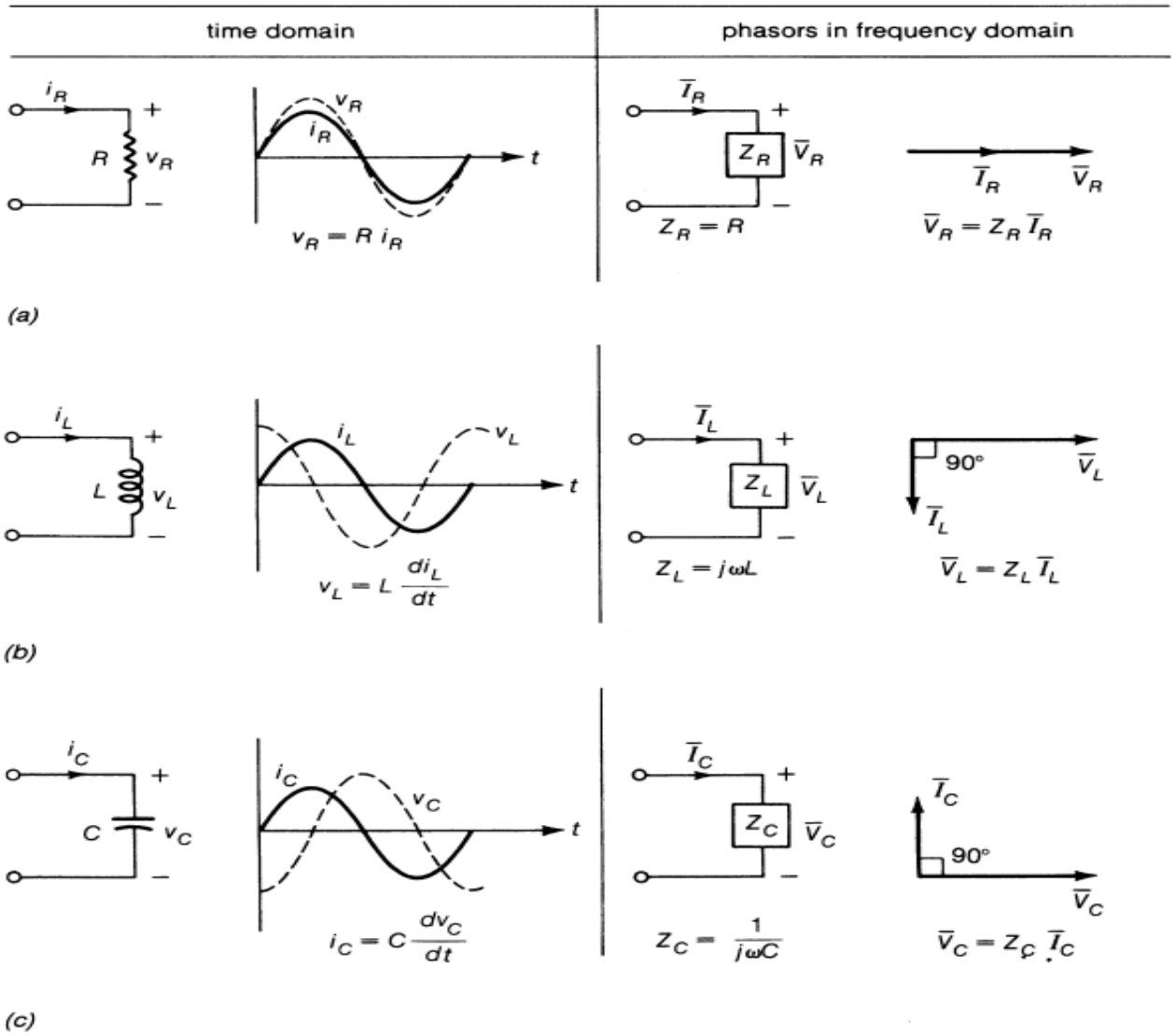


그림 1.1.2 • 회로 요소 R, L, C에 대한 시간 및 주파수 영역에서 전압과 전류의 관계. (a) 전압, 전류가 동위상(단위 역률), (b) 전류 위상이 전압 위상보다 90° 지상(0 지상역률), (c) 전류 위상이 전압 위상보다 90° 진상 (0 진상역률).

- Real function / Phasor
- , Time domain / Frequency domain

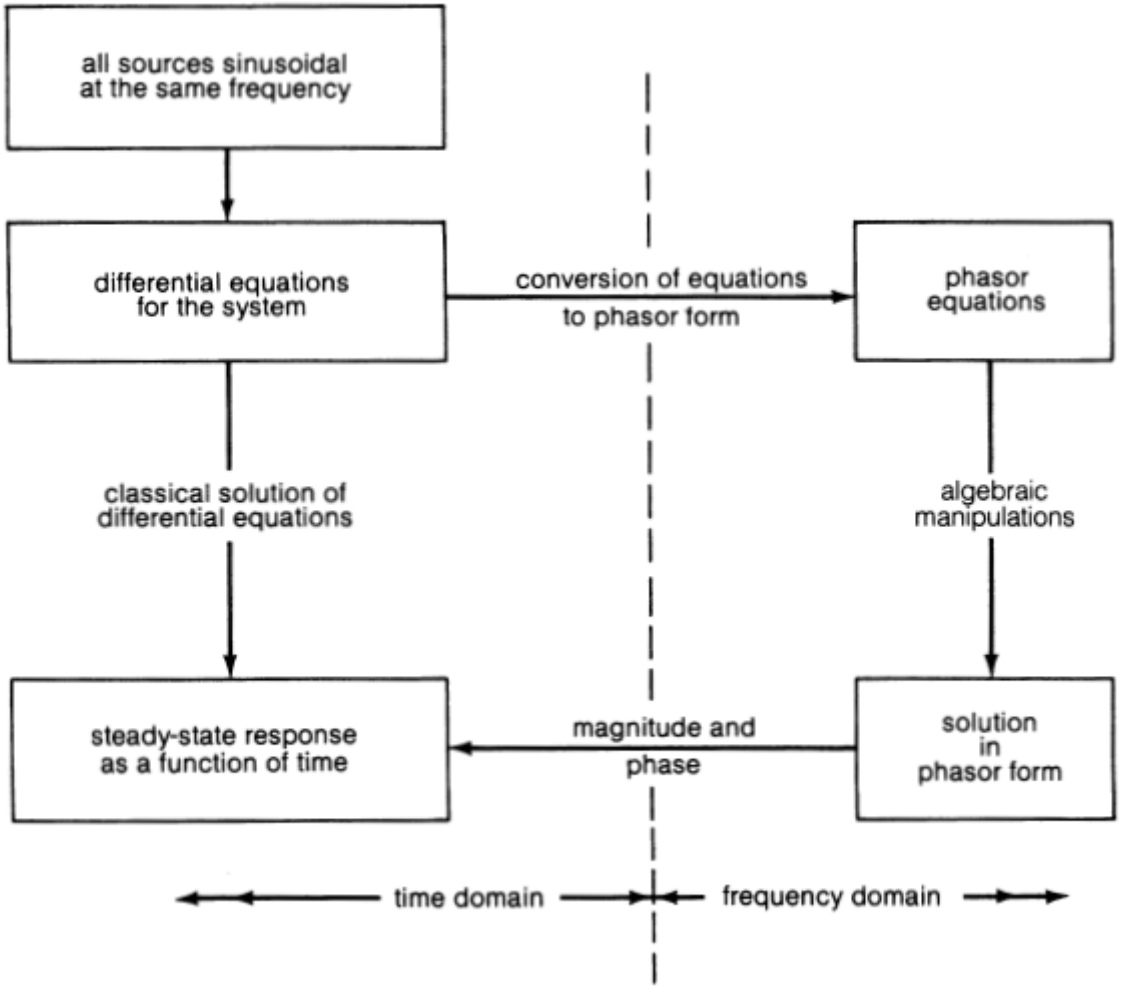
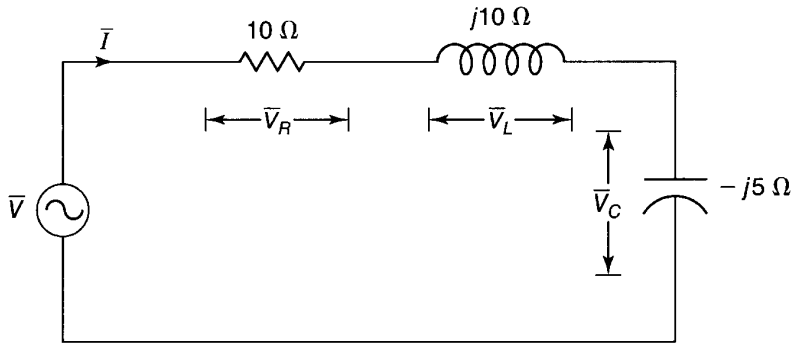


그림 1.1.3 • 페이저를 사용한 정현파 정상상태 해석.

<Ex 1.1.1> i(t) = 14.14 sin wt, R=10 Ω , wL=10 Ω , 1/wC = 5 Ω



(a) v(t) :

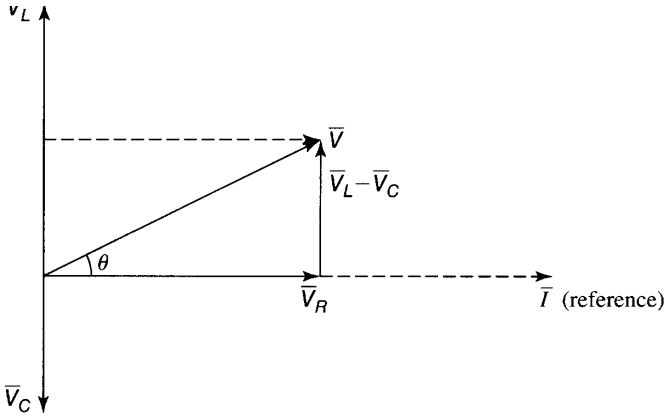
I = 14.14/√2 ∠0 °= 10 ∠0 °

Z = 10 + j10 – j5 = 11.18 ∠26°33

V = I·Z = 111.18 ∠26°33

→ v(t)=√2x111.18 sin(wt+26°33)

(b) Phasor diagram :



(c) pf= cos 26°33 = 0.894 (lagging)

S=V x I=111.8∠26°33 x 10∠0° = 1118 ∠26°33 = 1000+j500

P = 1000 [W]

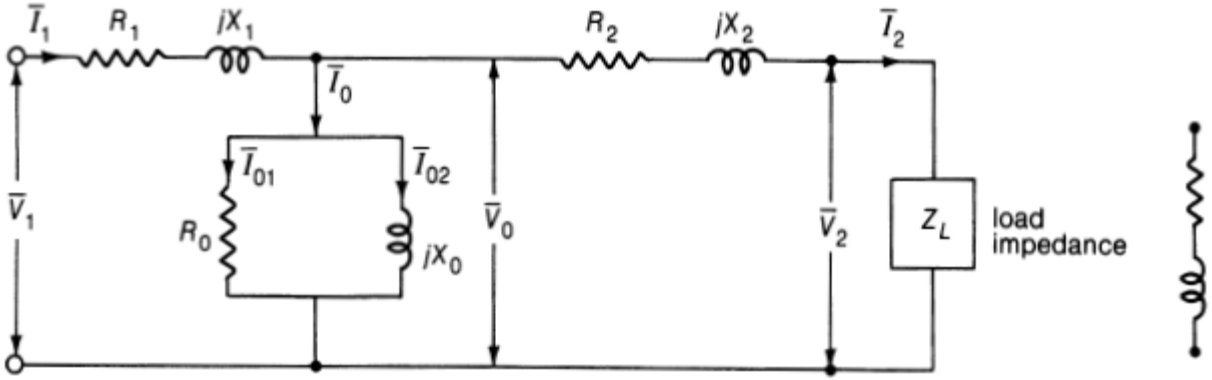
Q = 500 [VAR]

1.2 Phasor Analysis

- Steinmetz(1865~1923), GE

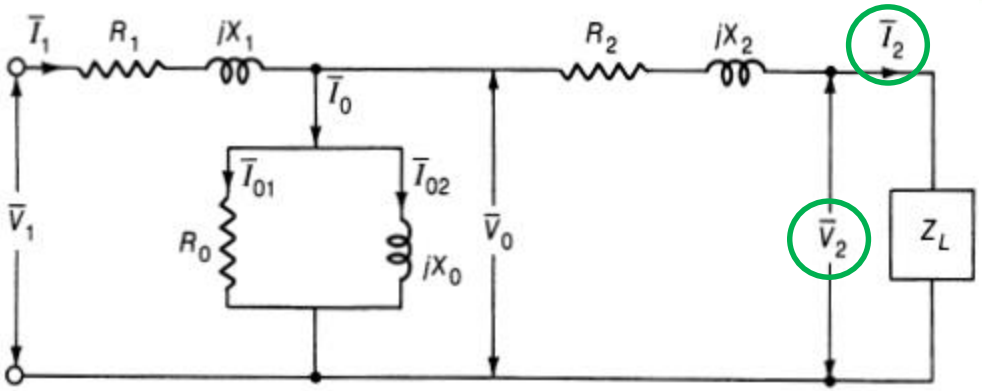
$$R_1 \simeq R_2; \qquad X_1 \simeq X_2;$$

$$R_1 < X_1; \qquad R_0 > R_1; \qquad X_0 > X_1$$



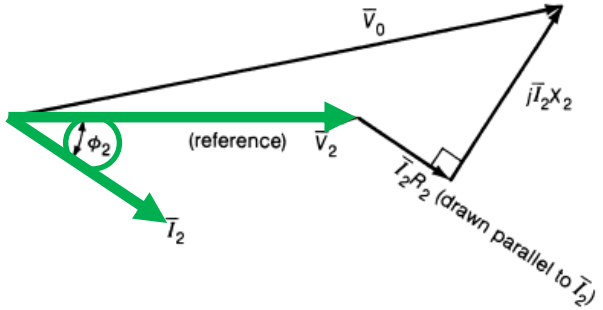
$$\bar{V}_1 = \bar{V}_0 + \bar{I}_1 R_1 + j\bar{I}_1 X_1 \qquad \bar{V}_0 = \bar{V}_2 + \bar{I}_2 R_2 + j\bar{I}_2 X_2$$

$$\bar{I}_1 = \bar{I}_0 + \bar{I}_2 \qquad \bar{I}_0 = \bar{I}_{01} + \bar{I}_{02}$$

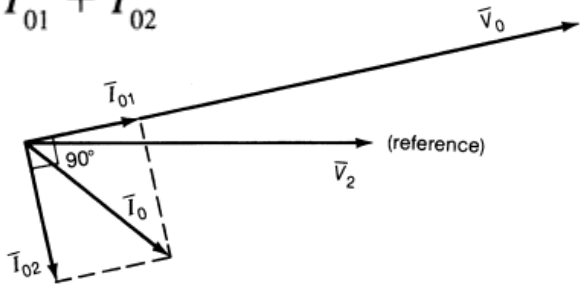


- given : V_2, I_2
- reference : V_2

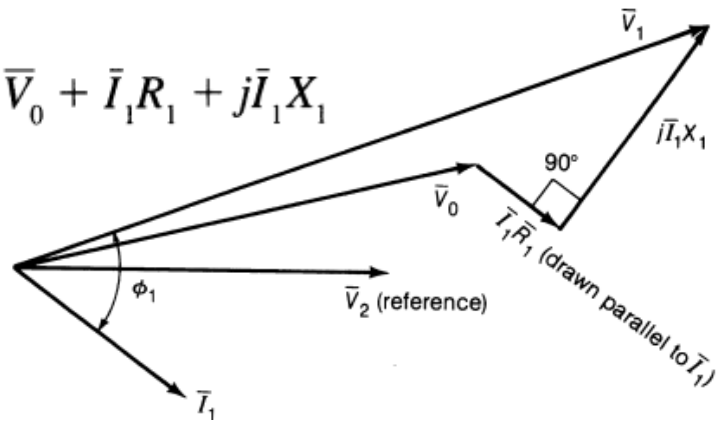
$$\bar{V}_0 = \bar{V}_2 + \bar{I}_2 R_2 + j\bar{I}_2 X_2$$



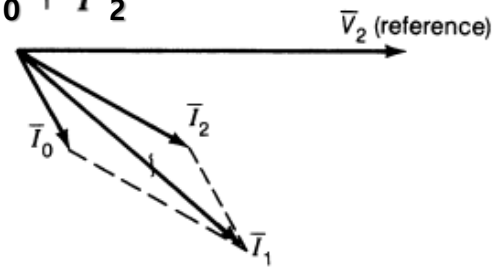
$$\bar{I}_0 = \bar{I}_{01} + \bar{I}_{02}$$



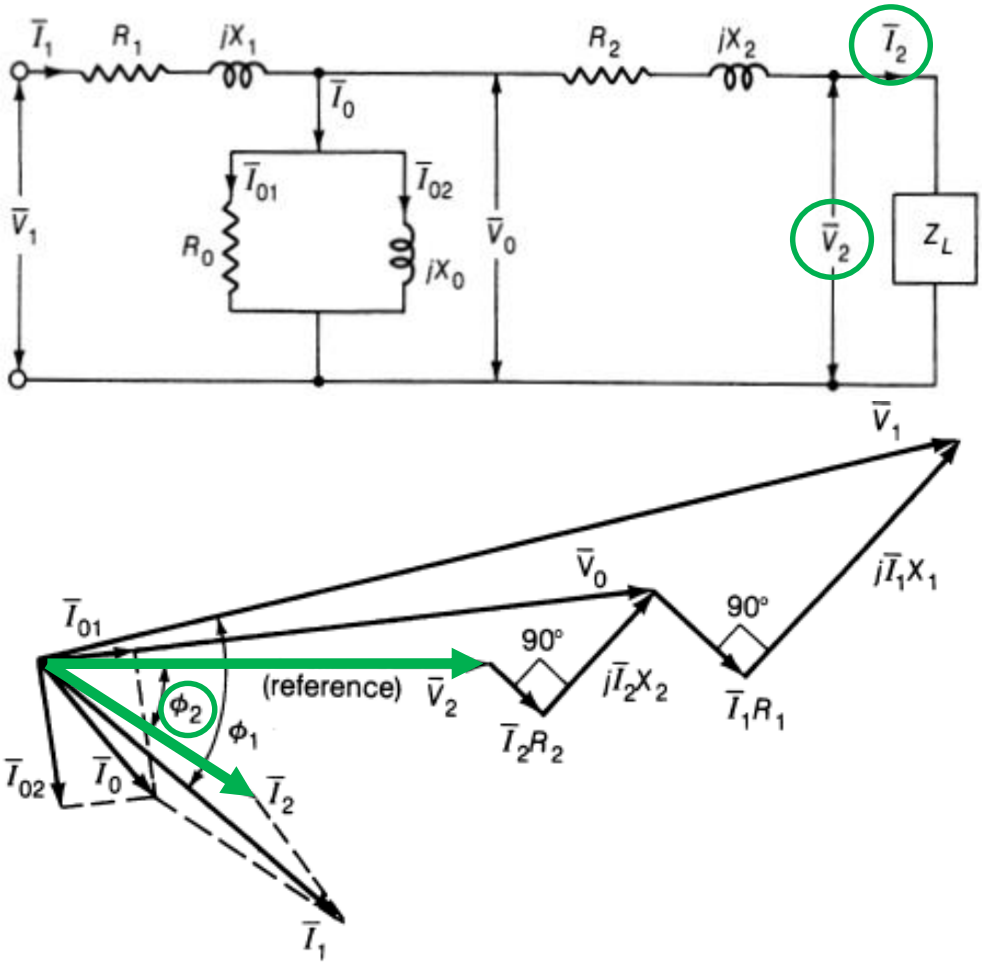
$$\bar{V}_1 = \bar{V}_0 + \bar{I}_1 R_1 + j\bar{I}_1 X_1$$



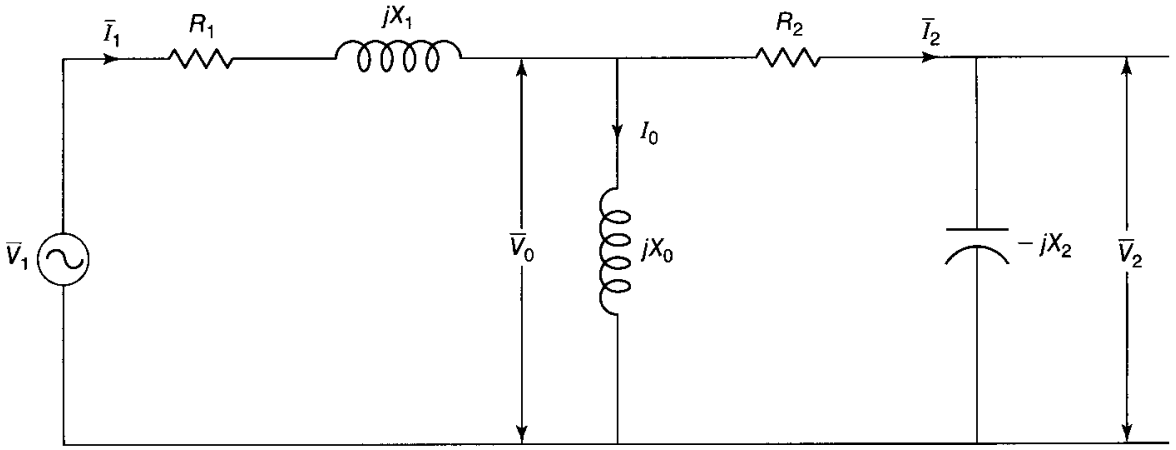
$$\bar{I}_1 = \bar{I}_0 + \bar{I}_2$$



- Sum :


$\bar{I}_1$
R_1
jX_1
$\bar{I}_0$
R_2
jX_2
$\bar{I}_2$
$\bar{I}_{01}$
$\bar{I}_{02}$
$\bar{V}_1$
R_0
jX_0
$\bar{V}_0$
$\bar{V}_2$
Z_L
$\bar{V}_1$
$\bar{V}_0$
$j\bar{I}_1X_1$
$\bar{I}_{01}$
90°
90°
(reference)
$\bar{V}_2$
$j\bar{I}_2X_2$
$\bar{I}_1R_1$
$\bar{I}_2R_2$
ϕ_2
ϕ_1
$\bar{I}_{02}$
$\bar{I}_0$
$\bar{I}_2$
$\bar{I}_1$

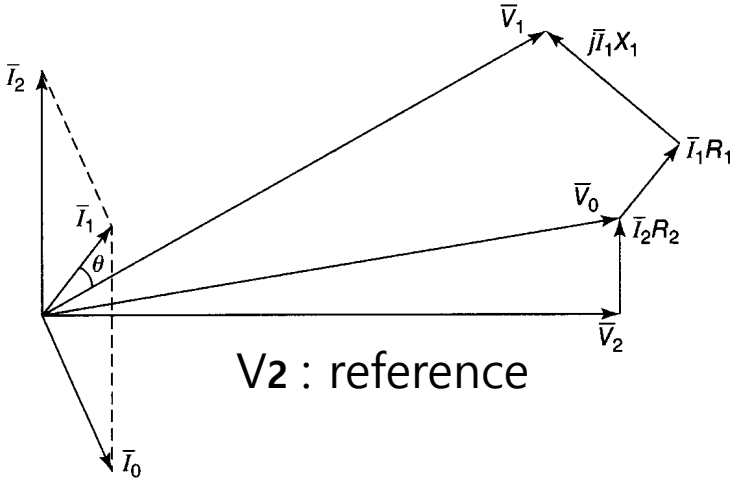
<Ex 1.2.1>



- $I_2 = V_2/(-jX_2)$
  $I_0 = V_0/(jX_0)$

  $I_1 = I_2 + I_0$

- $V_0 = V_2 + I_2R_2$
  $V_1 = V_0 + I_1(R_1 + jR_1)$



V_2 : reference

<Problems>

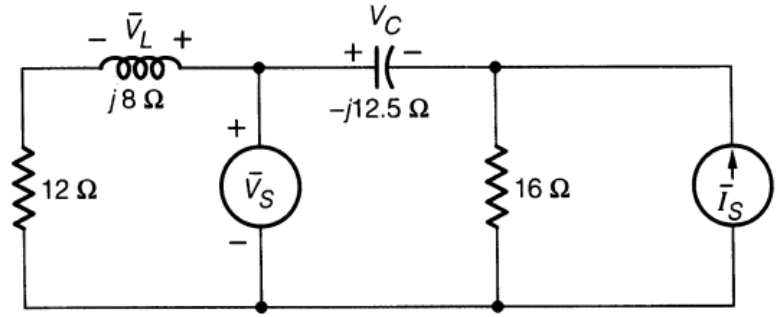


그림 P1-6

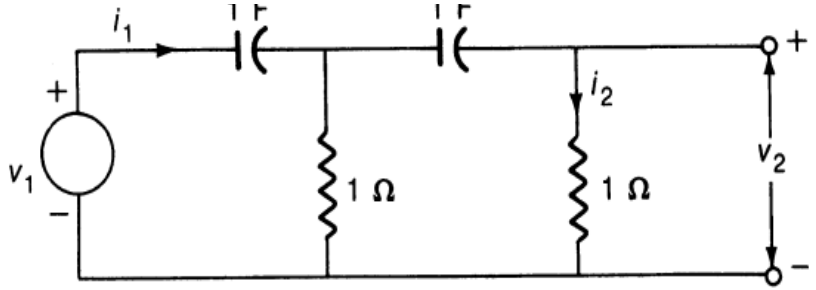


그림 P1-7

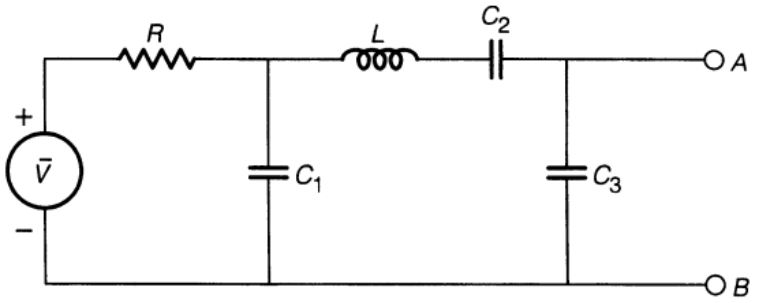


그림 P1-11

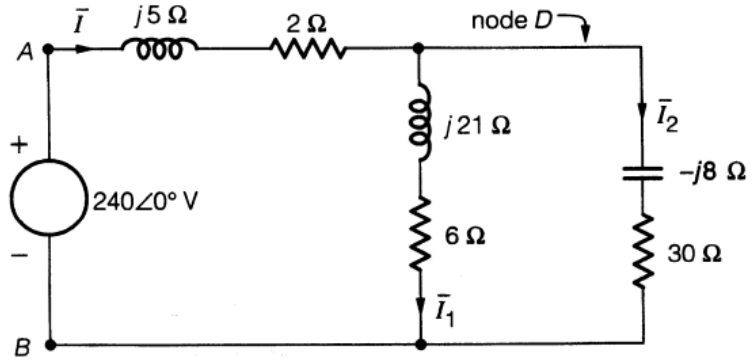


그림 P1-10

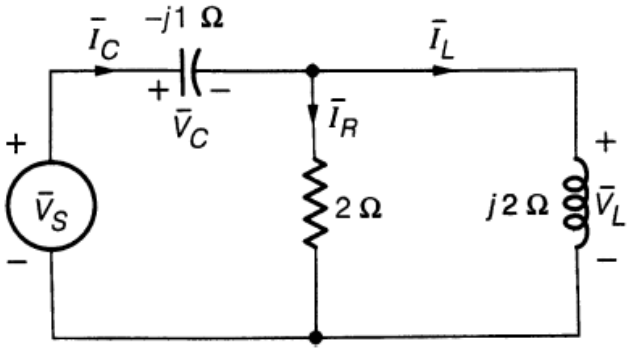


그림 P1-8

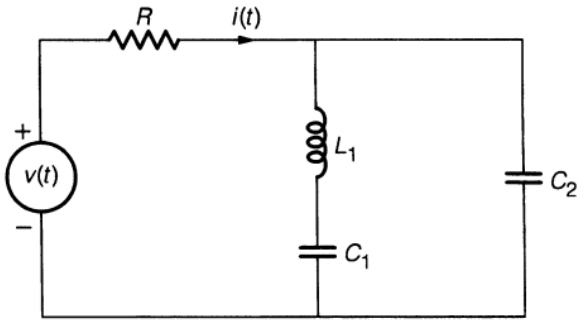


그림 P1-12

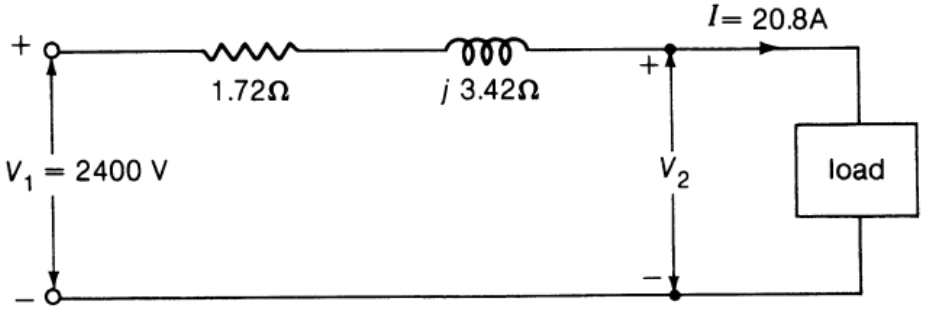


그림 P1-15

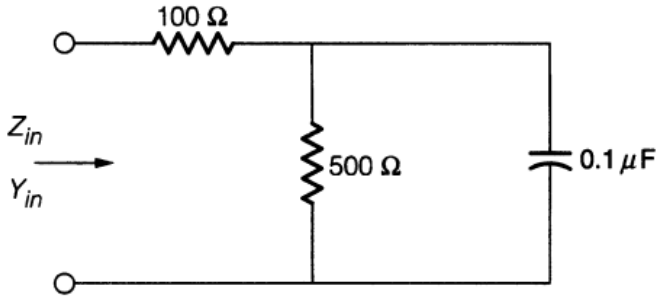


그림 P1-13

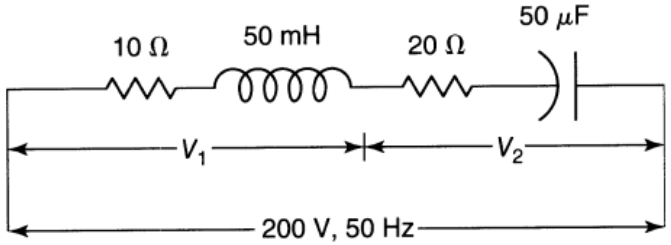


그림 P1-19