CONFIDENTIAL

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2012/2013

COURSE	:	ELECTRICAL PRINCIPLES II
COURSE CODE	:	BNR 10303
PROGRAMME	:	1 BND
EXAMINATION DATE	:	JUNE 2013
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **TEN (17)** PAGES

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Q1 (a) Given a sinusoid, $5\sin(4\pi t - 60^o)$, calculate:
(i) phase,
(ii) angular frequency,
(iii) period, and
(iv) frequency.

(3 marks)

(b) Identify the phase angle between $i_1 = -4\sin(377t + 25^o)$ and $i_2 = 5\cos(377t - 40^o)$. Does i_1 lead or lag i_2?

(3 marks)

(c) Show the steps to your solution to evaluate the following complex numbers:

$$\frac{10 + j5 + 3\angle 40^\circ}{3 + j4} + 10\angle 30^\circ + j5$$

(6 marks)

(d) Determine the input impedance of the circuit in **Figure Q1 (d)** at ω =10 rad/s.

(8 marks)

Q2 (a) Use the superposition theorem to determine v_o in the circuit as shown in **Figure Q2 (a)**.

(12 marks)

(b) Find I_o in the circuit of **Figure Q2 (b)** using the concept of source transformation.

(8 marks)

Q3 (a) For circuit in **Figure Q3 (a)**, determine the maximum power delivered to the load $\mathbf{Z}_L$.

(14 marks)

(b) Calculate the *effective value* of the current waveform in **Figure Q3 (b)** and the *average power* delivered to a 12-Ω resistor when the current runs through the resistor.

(6 marks)

Q4 (a) If V_{ab} = 400V in a balanced Y-connected three-phase generator, identify the phase voltages, assuming the phase sequence is:

(i) *abc*
(ii) *acb*

(5 marks)

(b) In a balanced three-phase wye-wye system, the source is an *abc*-sequence of voltages and $V_{an} = 220\angle 20^\circ$ V rms. The line impedance per phase is 0.6 + j1.2Ω, while the per phase impedance of the load is 10 + j14Ω. Calculate the line currents and the load voltages.

(7 marks)

(c) In the balanced three-phase wye-delta system in **Figure Q4 (c)**, calculate the line current I_L and the average power delivered to the load.

(8 marks)

Q5 (a) Determine the real power absorbed by the load in **Figure Q5 (a)**,

(14 marks)

(b) Consider the delta-delta system shown in **Figure Q5 (b)**. Take Z_1 = 8+j6 Ω, Z_2 = 4.2 – j2.2 Ω, Z_3 = 10 + j0 Ω.

(i) Find the phase current I_{AB}, I_{BC}, and I_{CA}.

(ii) Calculate line currents I_{aA}, I_{bB}, and I_{cC}.

(6 marks)

Q6 (a) For the coupled coils in **Figure Q6 (a)**, show that

$$L_{eq} = L_1 + L_2 + 2M$$

(3 marks)

(b) For the coupled coils in **Figure Q6 (b)**, show that

$$L_{eq} = \frac{L_1L_2 - M^2}{L_1L_2 - 2M^2}$$

(7 marks)

(c) Consider the circuit in **Figure Q6 (c)**.

(i) Determine the coupling coefficient.
(ii) Calculate the energy stored in the coupled inductors at time t = 1s if $v = 60\cos(4t + 30^\circ)$ V.

(10 marks)

-END OF QUESTION-

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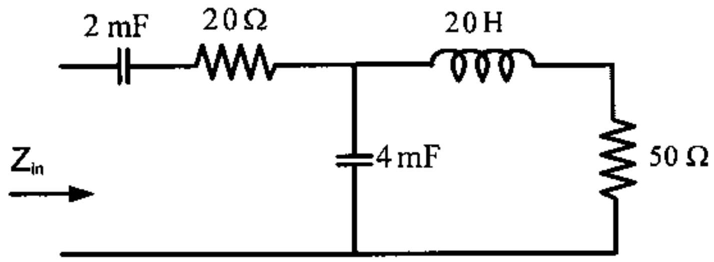

FIGURE Q1 (d)

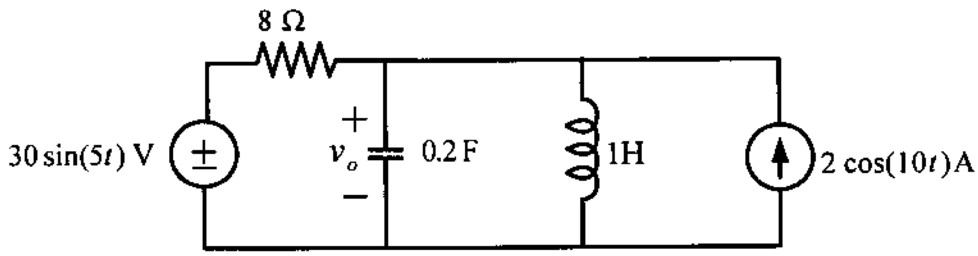

FIGURE Q2 (a)

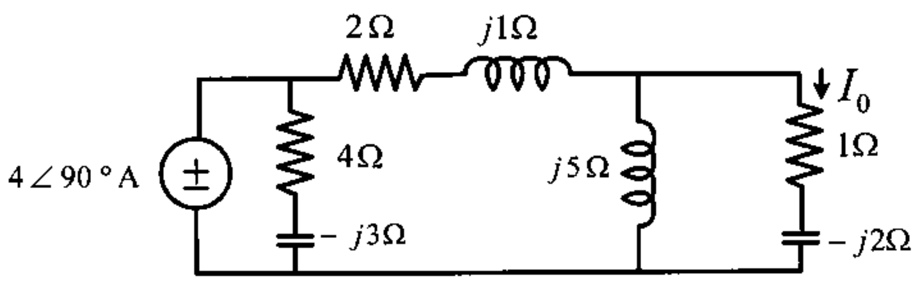

FIGURE Q2 (b)

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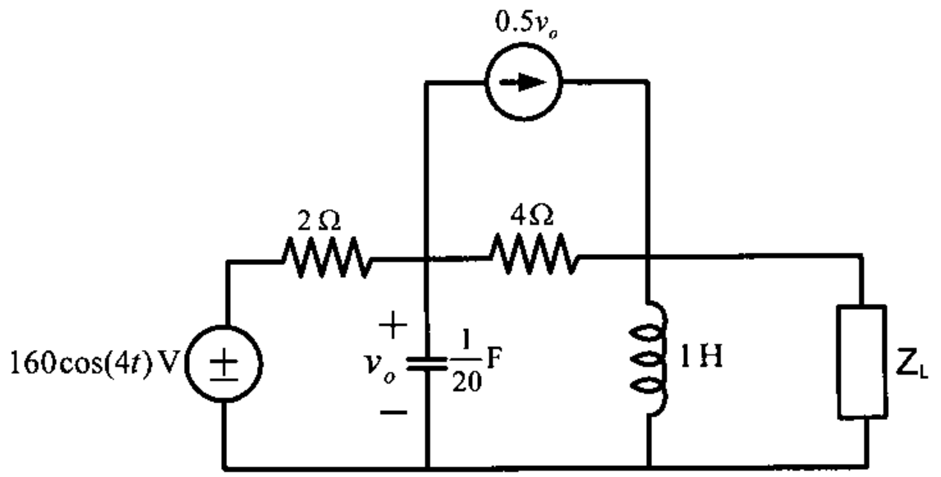

FIGURE Q3 (a)

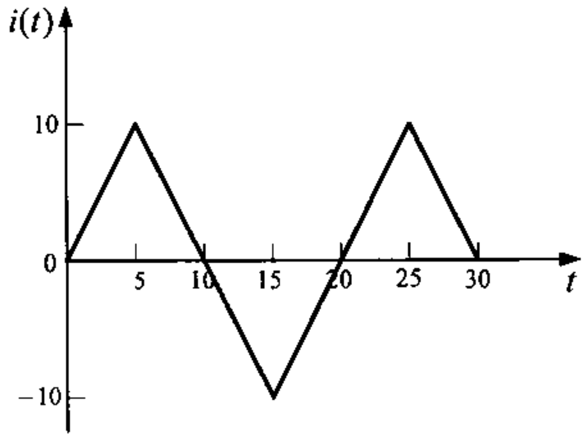

FIGURE Q3 (b)

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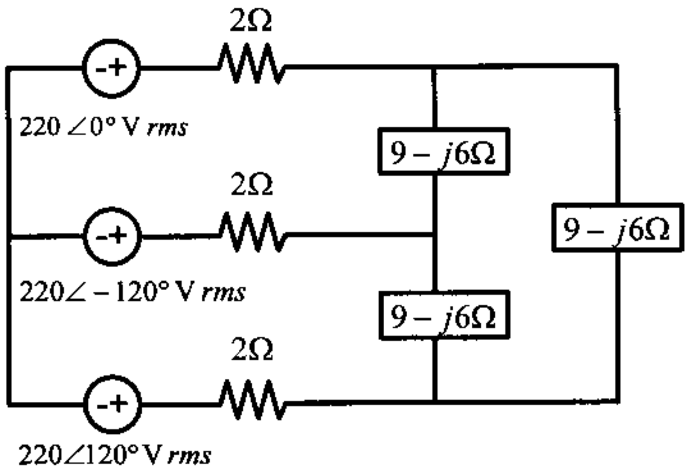

FIGURE Q4 (c)

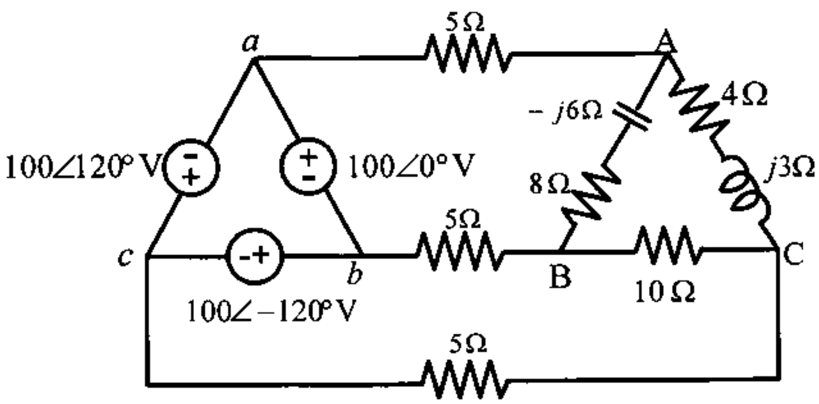

FIGURE Q5 (a)

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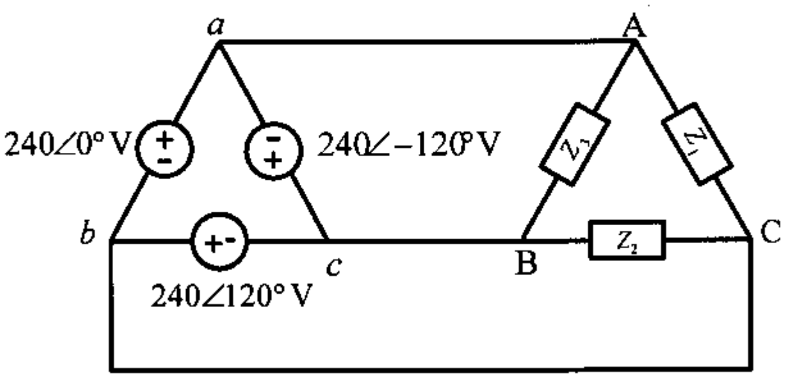

FIGURE Q5 (b)

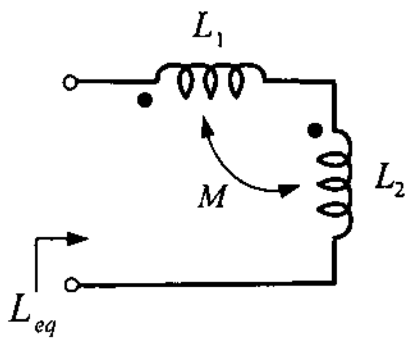

FIGURE Q6 (a)

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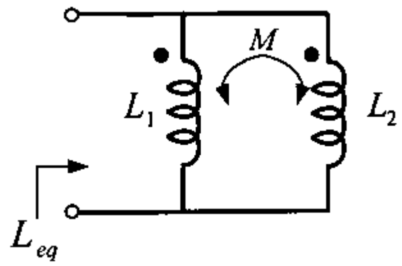

FIGURE Q6 (b)

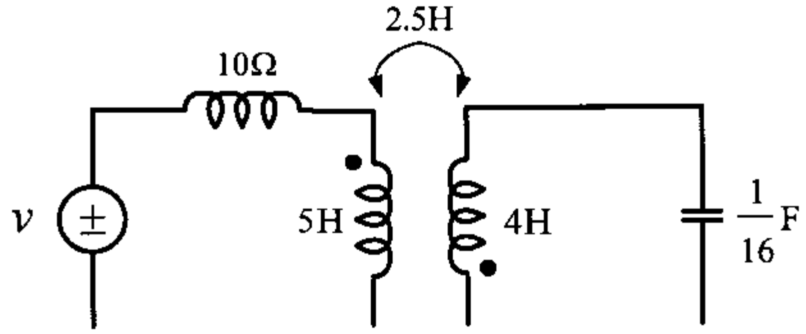

FIGURE Q6 (c)

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Chapter 1

A general expression for the sinusoid

Frequency: $f = \frac{1}{T} Hz$

Angular frequency: $\omega = 2\pi f$ Hz

Trigonometric identities

$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$
$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$
$\sin(\omega t \pm 180^\circ) = -\sin \omega t$
$\cos(\omega t \pm 180^\circ) = -\cos \omega t$
$\sin(\omega t \pm 90^\circ) = \pm \cos \omega t$
$\cos(\omega t \pm 90^\circ) = \mp \sin \omega t$

Mathematic operation of complex number

Addition: $z_1 + z_2 = (x_1 + x_2) + j(y_1 + y_2)$
Subtraction: $z_1 - z_2 = (x_1 - x_2) + j(y_1 - y_2)$
Multiplication: $z_1 z_2 = r_1 r_2 \angle \phi_1 + \phi_2$
Division: $\frac{z_1}{z_2} = \frac{r_1}{r_2} \angle \phi_1 - \phi_2$
Reciprocal: $\frac{1}{z} = \frac{1}{r} \angle -\phi$
Square root: $\sqrt{z} = \sqrt{r} \angle \phi/2$
Complex conjugate: $z^* = x - jy = r \angle -\phi = re^{-j\phi}$
Euler's identity: $e^{\pm j\phi} = \cos\phi \pm j\sin\phi$

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Summary of voltage-current relationship		
Element	**Time domain**	**Frequency domain**
R	$v = Ri$	$V = RI$
L	$v = L\frac{di}{dt}$	$V = j\omega LI$
C	$i = C\frac{dv}{dt}$	$V = \frac{I}{j\omega C}$

Impedances and admittances of passive elements		
Element	**Impedance**	**Admittance**
R	$Z = R$	$Y = \frac{1}{R}$
L	$Z = j\omega L$	$Y = \frac{1}{j\omega L}$
C	$Z = \frac{1}{j\omega C}$	$Y = j\omega C$

Relationship between differential, integral operation in phasor listed as follow:

$$v(t) \to V = V\angle\phi$$

$$\frac{dv}{dt} \to j\omega V$$

$$\int v dt \to \frac{V}{j\omega}$$

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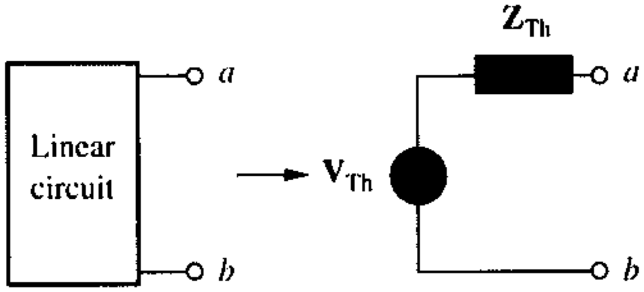
Chapter 2

Superposition Theorem

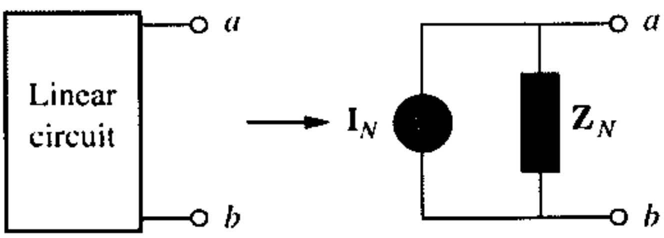
When a circuit has sources operating at different frequencies,

- ***The separate phasor circuit for each frequency must be solved independently,***
- ***Thet otal response is the sum of time-domain responses of all the individual phasor circuits.***

Thevenin and Norton Equivalent Circuits



Thevenin transform



Norton transform

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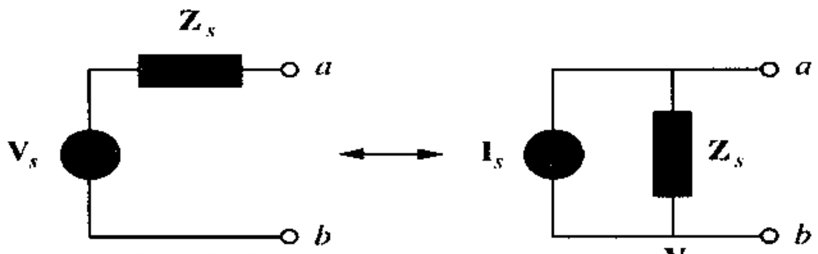
Source Transformation



$$\mathbf{V}_s = \mathbf{Z}_s \mathbf{I}_s \qquad \mathbf{I}_s = \frac{\mathbf{V}_s}{\mathbf{Z}_s}$$

Chapter 3

Average Power: $P = \frac{1}{T}\int_0^T p(t)\,dt = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$

Load Impedance: $Z_L = Z_{TH} = R_{TH} + jX_{TH}$

$Z_{TH}^{*} = R_{TH} - jX_{TH}$

Maximum Average Power: $P_{max} = \frac{|V_{TH}|^2}{8R_{TH}}$

If the load is purely real : $R_L = \sqrt{R_{TH}^2 + X_{TH}^2} = |Z_{TH}|$

Effective Current: $I_{eff} = \sqrt{\frac{1}{T}\int_0^T i^2\,dt} = I_{rms}$

The rms value of a sinusoid *i(t) = I* $i(t) = I_m\cos(wt)$ **is given by:** $I_{rms}^2 = \frac{I_m}{\sqrt{2}}$

The average power can be written in terms of the rms values:

$I_{eff} = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) = V_{rms} I_{rms} \cos(\theta_v - \theta_i)$

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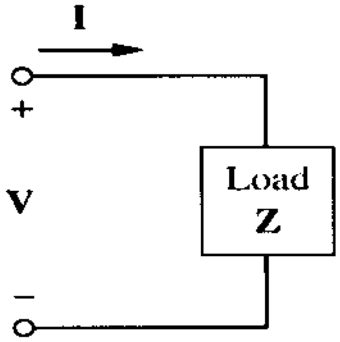
Apparent Power and Power Factor:

$$P = V_{rms} I_{rms} \cos(\theta_v - \theta_i) = S \cos(\theta_v - \theta_i)$$

Apparent Power, S Power Factor, pf

Complex power S is the product of the voltage and the complex conjugate of the current:



$\mathbf{V} = V_m \angle \theta_v$ $\mathbf{I} = I_m \angle \theta_i$

$$\frac{1}{2} \mathbf{V} \mathbf{I}^* = V_{rms} I_{rms} \angle \theta_v - \theta_i$$

$$S = V_{rms} I_{rms} \cos(\theta_v - \theta_i) + j V_{rms} I_{rms} \sin(\theta_v - \theta_i)$$

$$S = P + jQ$$

P: is the <u>average power in watts</u> delivered to a load and it is the only useful power.
Q: is the <u>reactive power exchange</u> between the source and the reactive part of the load. It is measured in VAR.

- $Q = 0$ for *resistive loads* (unity pf).
- $Q < 0$ for *capacitive loads* (leading pf).
- $Q > 0$ for *inductive loads* (lagging pf).

Power Absorbed: $P = I_{rms}^2 R = \frac{V_{rms}^2}{R}$

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Conservation of AC Power : $\overline{S} = \frac{1}{2}\overline{V}\,\overline{I^*} = \frac{1}{2}\overline{V}(\overline{I_1^*} + \overline{I_2^*}) = \frac{1}{2}\overline{V}\,\overline{I_1^*} + \frac{1}{2}\overline{V}\,\overline{I_2^*} = \overline{S_1} + \overline{S_2}$

Power Factor Correction : $C = \frac{Q_c}{\omega V_{rms}^2} = \frac{P(\tan\theta_1 - \tan\theta_2)}{\omega V_{rms}^2}$

$Q_c = Q_1 - Q_2$, $Q_1 = S_1 \sin\Theta_1 = P\tan\Theta_1$, $Q_2 = P\tan\Theta_2$

<u>Chapter 4</u>

The voltages can be expressed in phasor form as

$V_{an} = 200\angle 10°V$

$V_{bn} = 200\angle -230°V$

$V_{cn} = 200\angle -110°V$

A balanced Y-Y system

$V_L = \sqrt{3}V_p$, where

$V_p = |V_{an}| = |V_{bn}| = |V_{cn}|$

$V_L = |V_{ab}| = |V_{bc}| = |V_{ca}|$

A balanced Y-Δ system

$I_L = \sqrt{3}I_p$, where

$I_L = |I_a| = |I_b| = |I_c|$

$I_p = |I_{AB}| = |I_{BC}| = |I_{CA}|$

Power loss in a single-phase system: $P'_{loss} = 2R\frac{P_L^2}{V_L^2}$

Power loss in a three-phase system: $P'_{loss} = R'\frac{P_L^2}{V_L^2}$

Unbalanced Three-Phase Systems:

$I_a = \frac{V_{AN}}{Z_A}$, $I_b = \frac{V_{BN}}{Z_B}$, $I_c = \frac{V_{CN}}{Z_C}$,

$I_n = -(I_a + I_b + I_c)$

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Summary of phase and line voltages/currents for balanced three-phase system

Connection	Phase voltages/currents	Line voltages/currents
Y-Y	$V_{an} = V_p \angle 0°$ $V_{bn} = V_p \angle -120°$ $V_{cn} = V_p \angle +120°$ Same as line currents	$V_{ab} = \sqrt{3} V_p \angle 30°$ $V_{bc} = V_{ab} \angle -120°$ $V_{ca} = V_{ab} \angle +120°$ $I_a = \dfrac{V_{an}}{Z_Y}$ $I_b = I_a \angle -120°$ $I_c = I_a \angle +120°$
Y-Δ	$V_{an} = V_p \angle 0°$ $V_{bn} = V_p \angle -120°$ $V_{cn} = V_p \angle +120°$ $I_{AB} = \dfrac{V_{AB}}{Z_\Delta}$ $I_{BC} = \dfrac{V_{BC}}{Z_\Delta}$ $I_{CA} = \dfrac{V_{CA}}{Z_\Delta}$	$V_{ab} = V_{AB} = \sqrt{3} V_p \angle 30°$ $V_{bc} = V_{BC} = V_{ab} \angle -120°$ $V_{ca} = V_{CA} = V_{ab} \angle +120°$ $I_a = I_{AB} \sqrt{3} \angle -30°$ $I_b = I_a \angle -120°$ $I_c = I_a \angle +120°$
Δ-Δ	$V_{ab} = V_p \angle 0°$ $V_{bc} = V_p \angle -120°$ $V_{ca} = V_p \angle +120°$ $I_{AB} = \dfrac{V_{ab}}{Z_\Delta}$ $I_{BC} = \dfrac{V_{bc}}{Z_\Delta}$ $I_{CA} = \dfrac{V_{ca}}{Z_\Delta}$	Same as phase voltages $I_a = I_{AB} \sqrt{3} \angle -30°$ $I_b = I_a \angle -120°$ $I_c = I_a \angle +120°$

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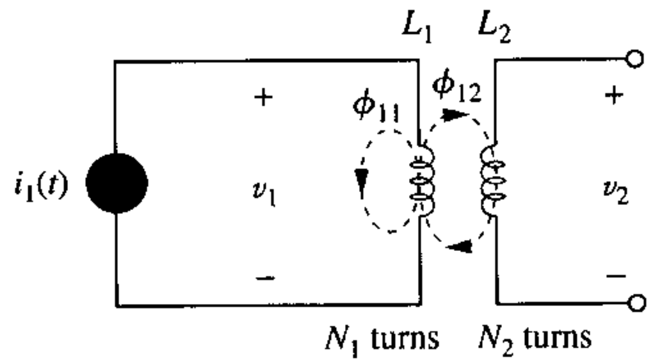
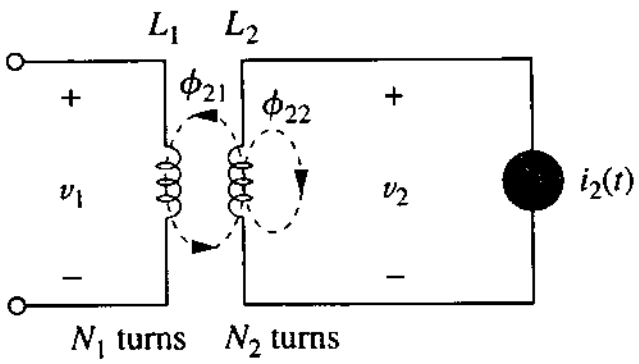
Δ-Y	$V_{ab} = V_p\angle 0°$ $V_{bc} = V_p\angle -120°$ $V_{ca} = V_p\angle +120°$ Same as line currents	Same as phase voltages $I_a = \dfrac{V_p\angle -30°}{\sqrt{3}Z_Y}$ $I_b = I_a\angle -120°$ $I_c = I_a\angle +120°$

Chapter 5



The open-circuit mutual voltage across coil 2: $v_2 = M_{21}\dfrac{di_1}{dt}$



The open-circuit mutual voltage across coil 1: $v_1 = M_{12}\dfrac{di_2}{dt}$

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Series-Aiding Connection: $L = L_1 + L_2 + 2M$

Series-Opposing Connection $L = L_1 + L_2 - 2M$

Coefficient of Coupling *k*: $M = k\sqrt{L_1 L_2}$

Instantaneous Energy Stored: $w = \frac{1}{2}L_1 i_1^2 + \frac{1}{2}L_2 i_2^2 \pm M I_1 I_2$