Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2013/2014

COURSE NAME : ELECTRICAL PRINCIPLES II

COURSE CODE : BNR10303

PROGRAMME : 1 BND/BNF

EXAMINATION DATE : JUN 2014

DURATION : 3 HOURS

INSTRUCTION : ANSWER **FIVE (5)** QUESTIONS ONLY

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

Q1 (a) A current source in a linear circuit has
$i_s = 8\cos(500\pi t - 25°)$ A

(i) Determine the amplitude of the current?
(ii) Determine the angular frequency?
(iii) Determine the frequency of the current.
(iv) Calculate i_s at $t = 2$ ms.

(5 marks)

(b) Two voltages v_1 and v_2 appear in series so that their sum is $v = v_1 + v_2$. If $v_1 = 10\cos(50t - \pi/3)$ V and $v_2 = 12\cos(50t + 30°)$ V. Calculate total of voltage, v.

(4 marks)

(c) A linear network has a current input $4\cos(\omega t + 20^o)$ A and a voltage output $10\cos(\omega t + 110^o)$ V. Calculate the associated impedance.

(3 marks)

(d) By analyzing the circuit shown in Figure **Q1(d)**, determine the value of $\mathbf{Z}_T$.

(8 marks)

Q2 (a) Using Nodal analysis, calculate $\mathbf{V}_1$ and $\mathbf{V}_2$ in the circuit shown in Figure **Q2(a)**.

(10 marks)

(b) Calculate current I_o in the circuit of Figure **Q2(b)** using mesh analysis.

(10 marks)

Q3 (a) Calculate the rms value of the current waveform in Figure **Q3(a)**. If the current is passed through a resistor, determine the average power absorbed by the resistor.

(7 marks)

(b) For the circuit in Figure **Q3(b)**, discover the wattmeter reading.

(6 marks)

(c) The variable resistor R in the circuit of Figure **Q3(c)** is adjusted until it absorbs the maximum average power. Calculate R and the maximum average power absorbed.

(7 marks)

Q4 (a) A 110-V rms, 60-Hz source is applied to a load impedance Z. The apparent power entering the load is 120 VA at a power factor of 0.707 lagging.

(i) Calculate the complex power.

(3 marks)

(ii) Calculate the rms current supplied to the load.

(2 marks)

(iii) Calculate the impedance, Z.

(2 marks)

(iv) Assuming that $Z = R + j\varpi L$, identified the values of R and L.

(3 marks)

(b) Three loads are connected in parallel to a $120\angle 0^{\circ}$ V rms source. Load 1 absorbs 60 kVAR at pf =0.85 lagging; load 2 absorbs 90 kW and 50 kVAR leading; and load 3 absorbs 100 kW at pf = 1.

(i) Find the equivalent impedance.

(7 marks)

(ii) Calculate the power factor of the parallel combination.

(1 mark)

(iii) Determine the current supplied by the source.

(2 marks)

Q5 For the unbalanced circuit in Figure **Q5**, calculate:

(a) the line currents,

(10 marks)

(b) the total complex power absorbed by the load, and

(5 marks)

(c) the total complex power absorbed by the source.

(5 marks)

Q6 (a) By Analyzing the circuit of Figure **Q6(a)**, determine the phasor currents I_1 and I_2

(7 marks)

(b) For the circuit in Figure **Q6(b)**, calculater the coupling coefficient and the energy stored in the coupled inductors at t = 1.5 s.

(13 marks)

- END OF QUESTION –

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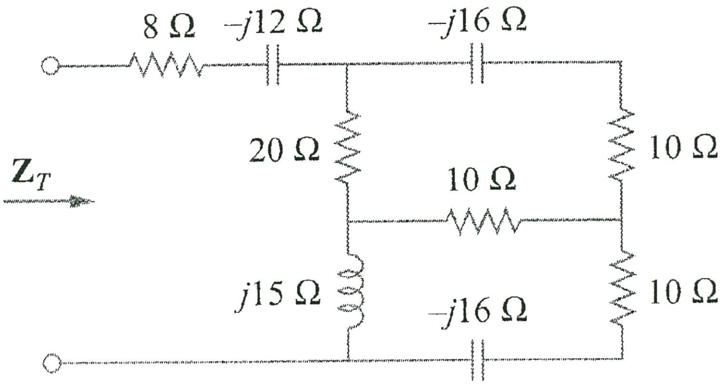

FIGURE Q1(d)

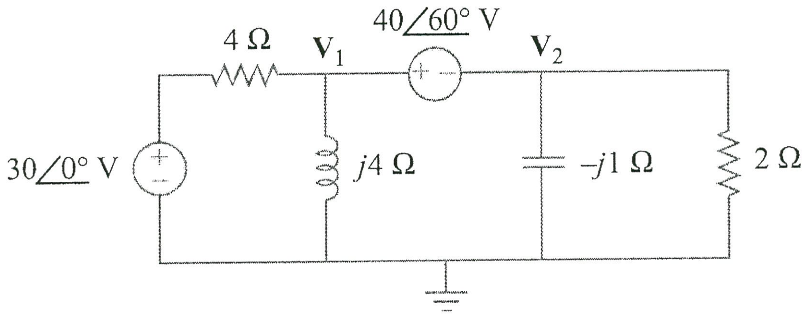

FIGURE Q2(a)

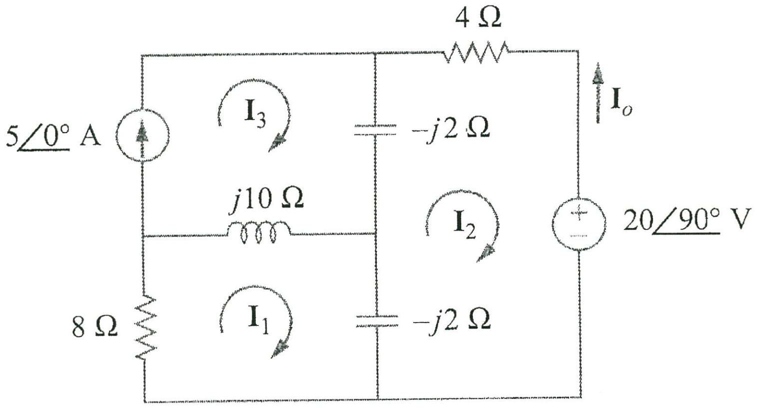

FIGURE Q2(b)

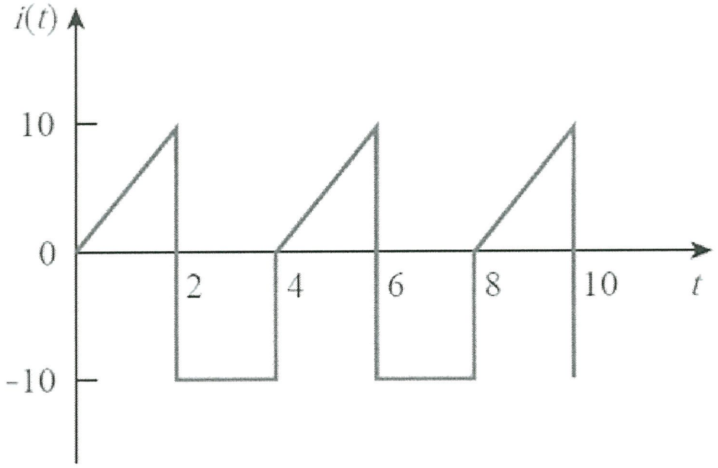

FIGURE Q3(a)

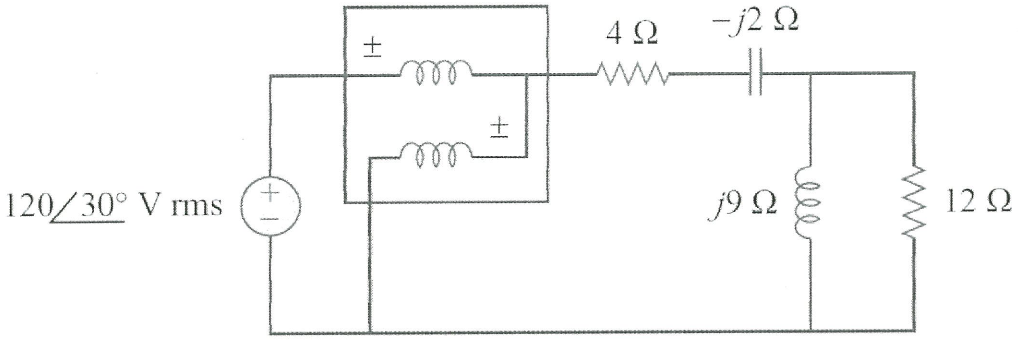

FIGURE Q3(b)

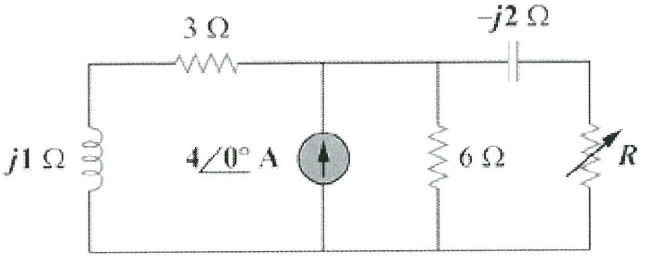

FIGURE Q3(c)

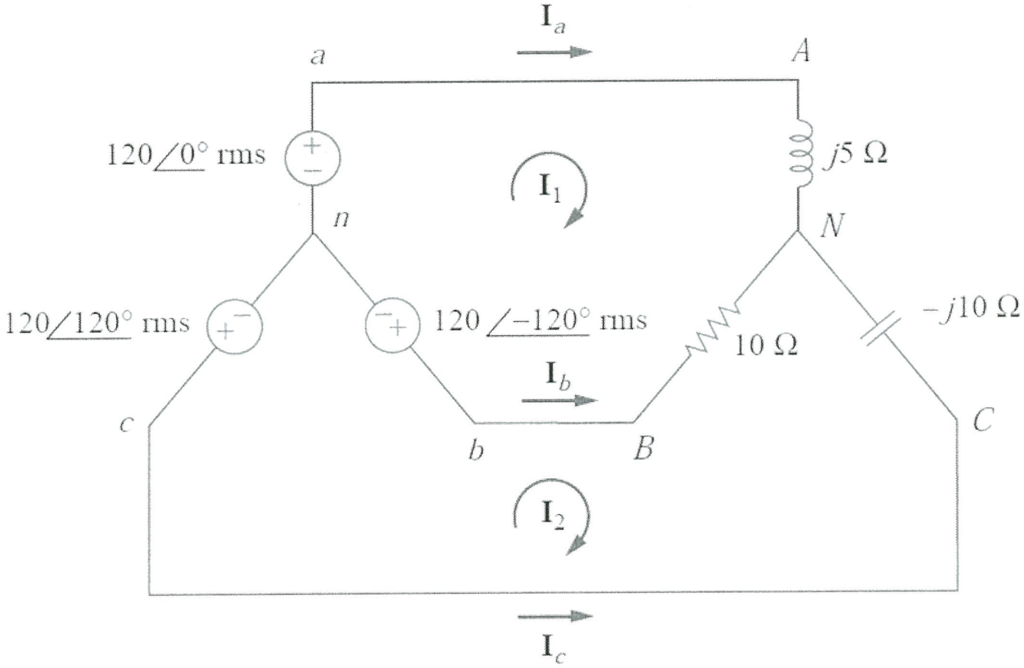

FIGURE Q5

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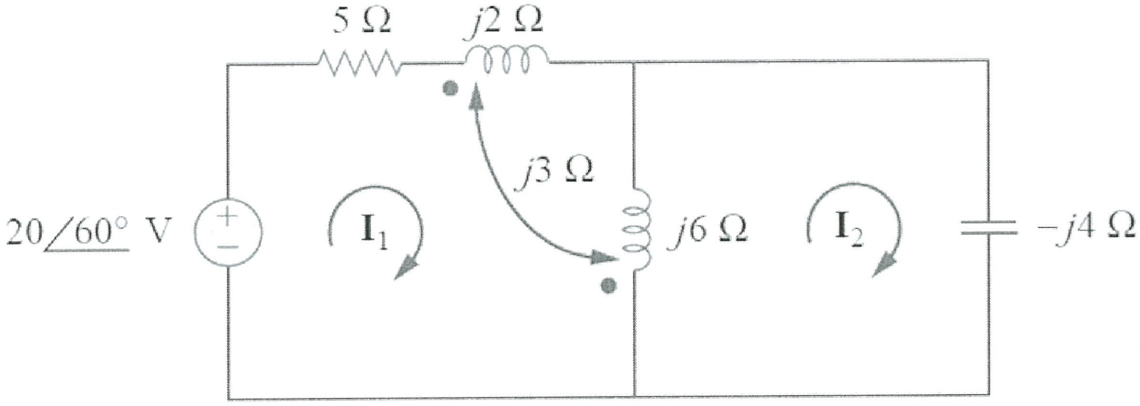

FIGURE Q6(a)

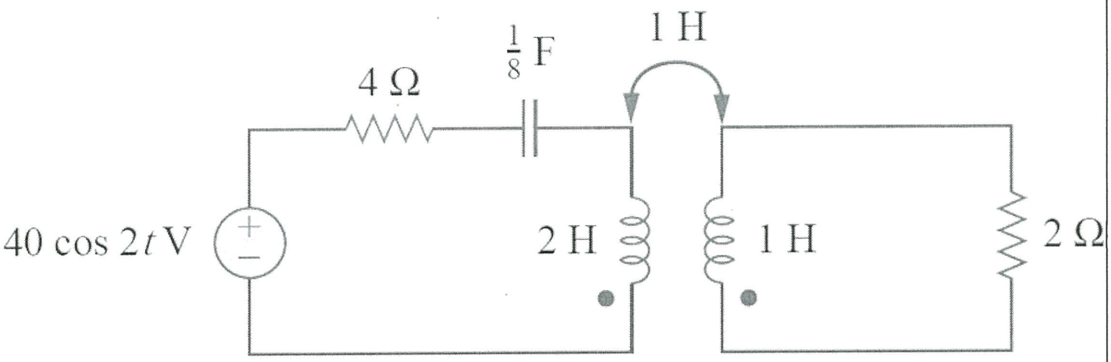

FIGURE Q6(b)

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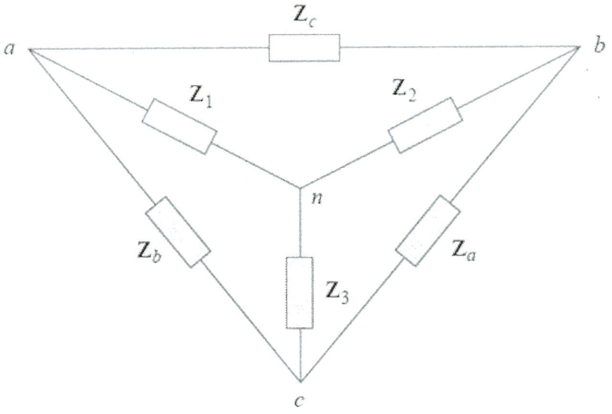
Chapter 1



Y – Delta Conversion

$$Z_a = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_1}$$

$$Z_b = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_2}$$

$$Z_c = \frac{Z_1Z_2 + Z_2Z_3 + Z_3Z_1}{Z_3}$$

Delta – Y Conversion

$$Z_1 = \frac{Z_bZ_c}{Z_a + Z_b + Z_c}$$

$$Z_2 = \frac{Z_cZ_a}{Z_a + Z_b + Z_c}$$

$$Z_3 = \frac{Z_aZ_b}{Z_a + Z_b + Z_c}$$

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A general expression for the sinusoid

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

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

Trigonometric identities

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

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	$v = L\dfrac{di}{dt}$	$V = j\omega LI$
C	$i = C\dfrac{dv}{dt}$	$V = \dfrac{I}{j\omega C}$

Impedances and admittances of passive elements

Element	**Impedance**	**Admittance**
R	$Z = R$	$Y = \dfrac{1}{R}$
L	$Z = j\omega L$	$Y = \dfrac{1}{j\omega L}$
C	$Z = \dfrac{1}{j\omega C}$	$Y = j\omega C$

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

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

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

$$\int v\,dt \rightarrow \frac{V}{j\omega}$$

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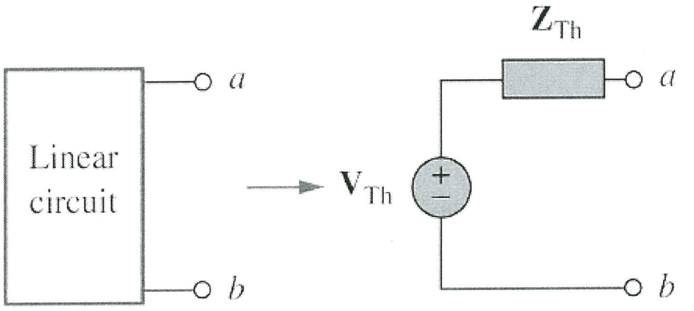
Chapter 2

Superposition Theorem

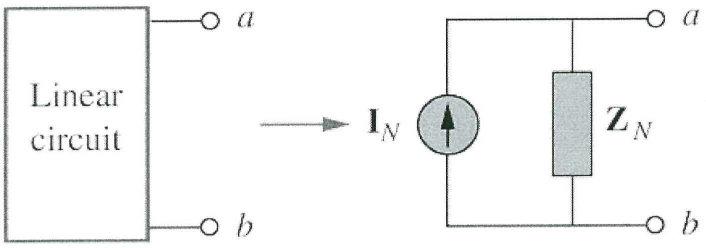
When a circuit has sources operating at different frequencies,

- *The separate phasor circuit for each frequency must be solved independently,*
- *The 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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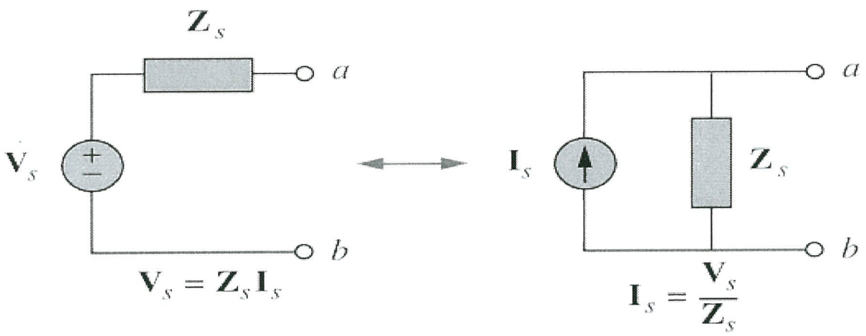
Source Transformation



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

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$_m$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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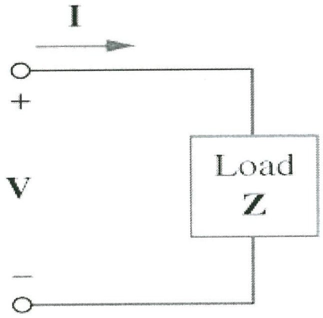
Apparent Power and Power Factor:

$$P = V_{rms}\, I_{rms} \cos(\theta_v - \theta_i) = \underset{\substack{\uparrow \\ \text{Apparent Power, S}}}{S}\underbrace{\cos(\theta_v - \theta_i)}_{\text{Power Factor, pf}}$$

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



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

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

$$S = \underbrace{V_{rms}\, I_{rms} \cos(\theta_v - \theta_i)}_{P} + j\, \underbrace{V_{rms}\, I_{rms} \sin(\theta_v - \theta_i)}_{Q}$$

$$S = P + jQ$$

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: $P = I_{rms}^2 R = \dfrac{V_{rms}^2}{R}$

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

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

Chapter 4

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: $P'_{loss} = 2R\dfrac{P_L^2}{V_L^2}$

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

Unbalanced Three-Phase Systems:

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

$I_n = -(I_a + I_b + I_{c)}$

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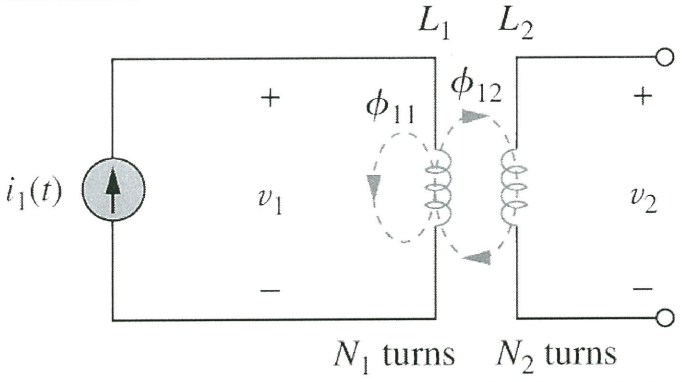
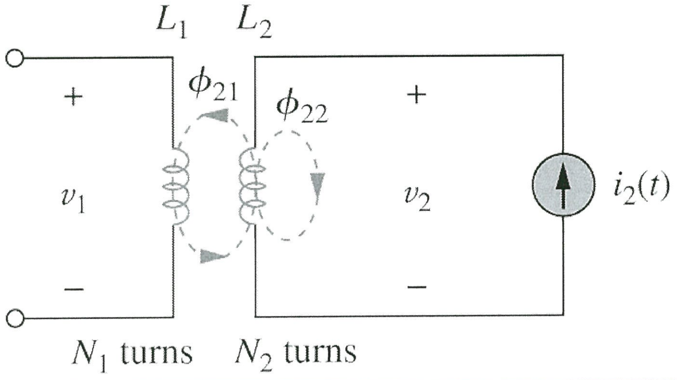
Δ-Y	$V_{ab} = V_p\angle 0°$ $V_{bc} = V_p\angle -120°$ $V_{ca} = V_p\angle +120°$ Same as line currents	Same as phase voltages $I_a = \frac{V_p\angle -30°}{\sqrt{3}Z_Y}$ $I_b = I_a\angle -120°$ $I_c = I_a\angle +120°$

Chapter 5



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



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

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