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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	ELECTRICAL PRINCIPLES II
COURSE CODE	:	BNR 10303
PROGRAMME CODE	:	BNF
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **EIGHTEEN (18)** PAGES

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Q1 (a) Given a sinusoidal voltage $v(t) = 5sin(40\pi t - 60^0\ )$V, compute:

(i) the amplitude $v(t)$,

(0.5 mark)

(ii) the phase ϕ,

(0.5 mark)

(iii) the period T,

(1 mark)

(iv) the frequency f.

(1 mark)

(b) Calculate these complex numbers and express your results in rectangular form.

(i) $(40\angle 50^0 + 20\angle -30^0)^{\frac{1}{2}}$

(2 marks)

(ii) $\dfrac{8\angle -20^0}{(2+j)(3-j4)}$

(3 marks)

(iii) $(8\angle 50^0)(5-j12)$

(2 marks)

(c) A voltage $v(t) = 100\cos(60t + 20^0\ )$V is applied to a parallel combination of a $40\ \text{k}\Omega$ resistor and a $50\ \mu\text{F}$ capacitor. Compute the steady-state currents through the resistor and the capacitor?

(3 marks)

(d) Calculate current i in the circuit of **Figure Q1 (d),** when $v_s(t) = 50\cos(200t\ )$V

(5 marks)

(e) Calculate current I in the circuit of **Figure Q1 (e).**

(7 marks)

Q2 (a) Determine V_x in the circuit of **Figure Q2 (a).**

(5 marks)

(b) Using the superposition principle, compute v_o in the circuit of **Figure Q2 (b).**

(12marks)

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

(8 marks)

Q3 (a) If $v(t) = 160\cos(50t)$V and $i(t) = -20\sin(50t - 30^0)$A, calculate the instantaneous power and the average power.

(3 marks)

(b) The Thevenin impedance of a source is $Z_{TH} = 120 + j60\Omega$, while the peak Thevenin voltage is $V_{TH} = 110 + j0$V. Determine the maximum available average power from the source.

(3 marks)

(c) Calculate the effective value of the voltage waveform in **Figure Q3 (c).**

(4 marks)

(d) For the entire circuit in **Figure Q3 (d),** calculate

(i) the power factor

(1 mark)

(ii) the average power delivered by the source

(1 mark)

(iii) the reactive power

(1 mark)

(iv) the apparent power

(1.5 marks)

(v) the complex power

(1.5 marks)

(e) Determine the value of parallel capacitance needed to correct a load of 140 kVAR at 0.85 lagging pf to unity pf. Assume that the load is supplied by a 110-V (rms), 60-Hz line.

(9 marks)

Q4 (a) Provide **TWO (2)** advantages of a three phase circuit?

(2 marks)

(b) If $V_{ab} = 4000$V in a balanced Y-connected three-phase generator, identify the phase voltages, assuming the phase sequence is:

(i) *abc*

(2.5 marks)

(ii) *acb*

(2.5 marks)

(c) A positive-sequence, balanced Δ-connected source supplies a balanced Δ-connected load. If the impedance per phase of load is $18 + j12\Omega$ and $I_a = 19.202\angle 35^0$A, calculate I_{AB} and V_{AB}.

(6 marks)

(d) Refer to the circuit in **Figure Q4 (d).** Determine the total average power, reactive power and complex power at the source and at the load.

(6 marks)

(e) The unbalanced Y-load of **Figure Q4 (e)** has balanced voltages of 100 V and the *acb* sequence. Calculate the line currents and the neutral current. Take $Z_A = 15\Omega$, $Z_B = 10 + j5\Omega$ and $Z_C = 6 - j8\Omega$.

(6 marks)

Q5 (a) Determine the voltage V_o in the circuit of **Figure Q5 (a).**

(5 marks)

(b) Consider the circuit in **Figure Q5 (b)**. Determine the coupling coefficient. Calculate the energy stored in the coupled inductors at time $t = 1$s if $v(t) = 60\cos(4t + 30^0)$V

(10 marks)

(c) Compute the input impedance of the circuit in **Figure Q5 (c)** and the current from voltage source.

(5 marks)

(d) The primary current to an ideal transformer rated at $3300/110$ V is a 5 A. Calculate

(i) the turns ratio

(1.5 marks)

(ii) the kVA rating

(1.5 marks)

(iii) the secondary current.

(2 marks)

- **END OF QUESTION -**

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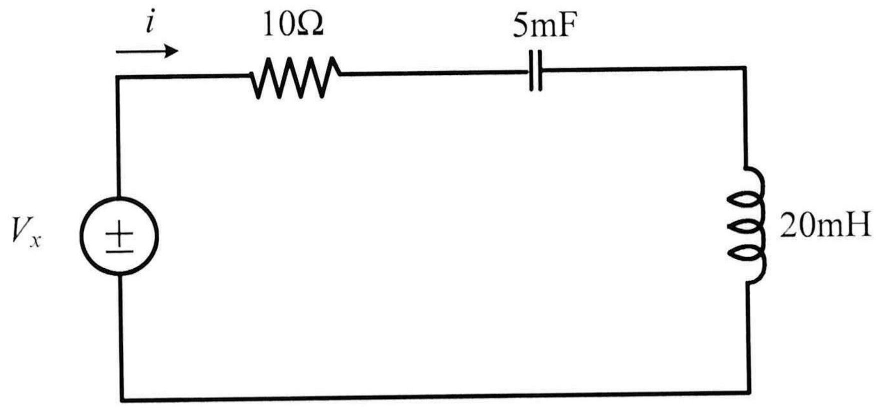

Figures Q1(d)

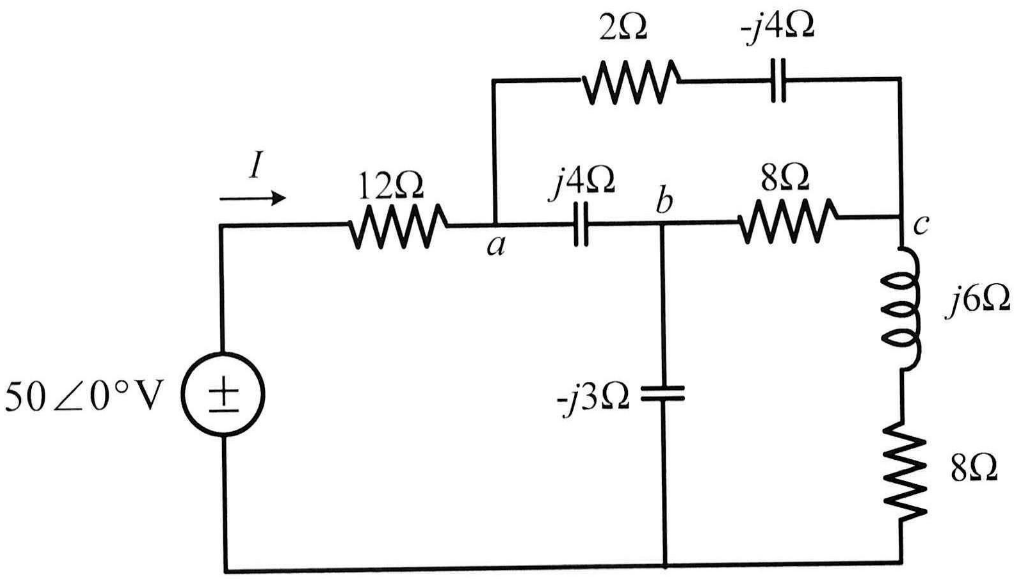

Figure Q1 (e)

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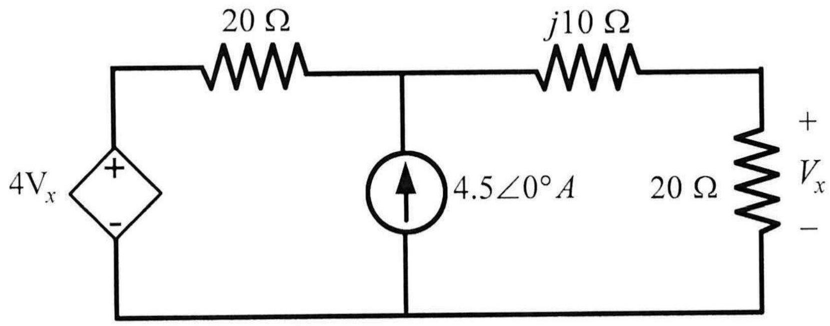

Figure Q2 (a)

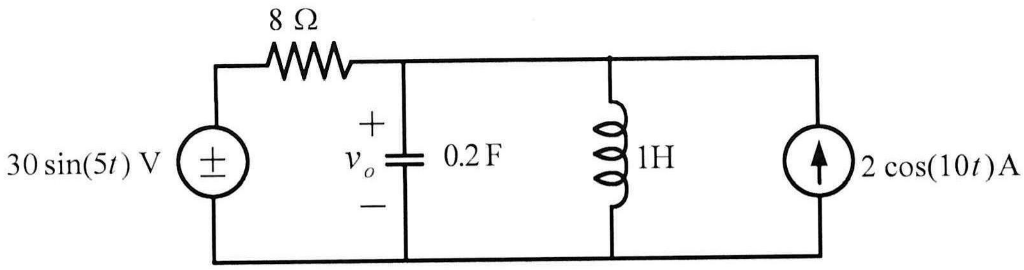

Figure Q2 (b)

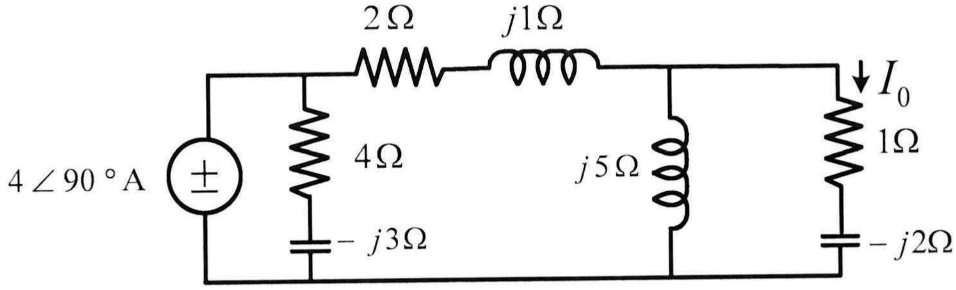

Figure Q2 (c)

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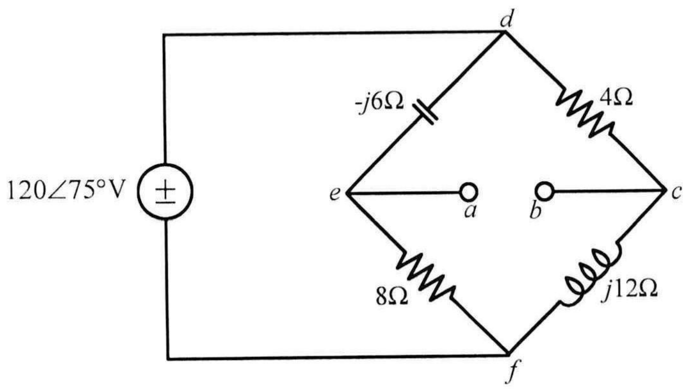

Figure Q2 (d)

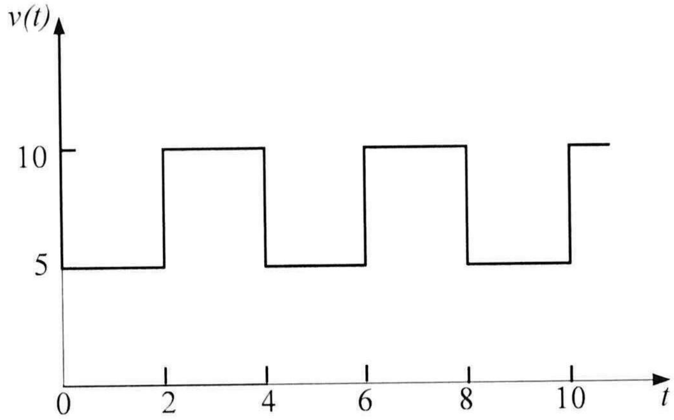

Figure Q3 (c)

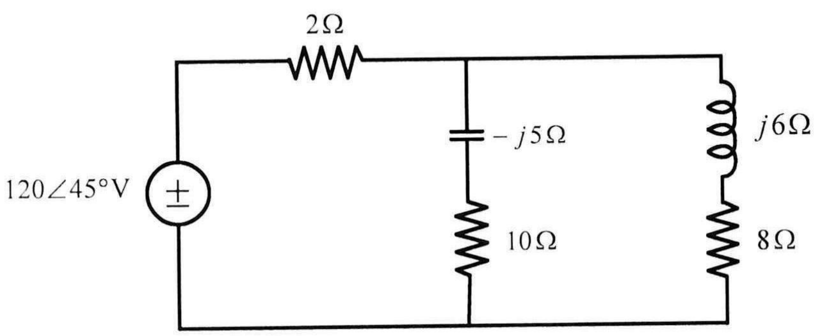

Figure Q3 (d)

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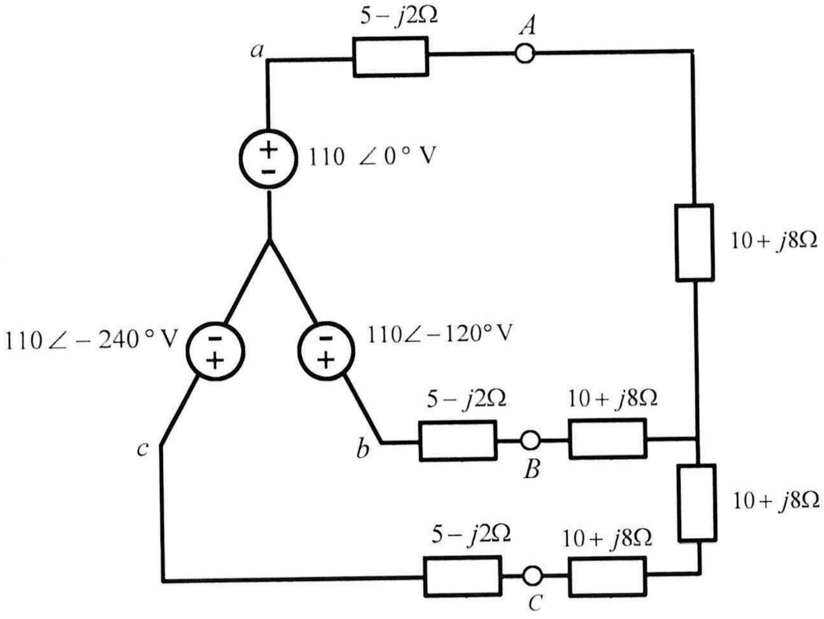

Figure Q4 (d)

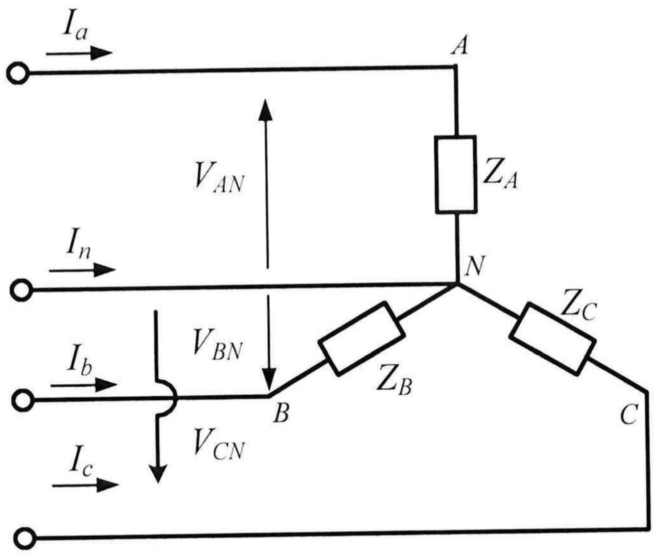

Figure Q4 (e)

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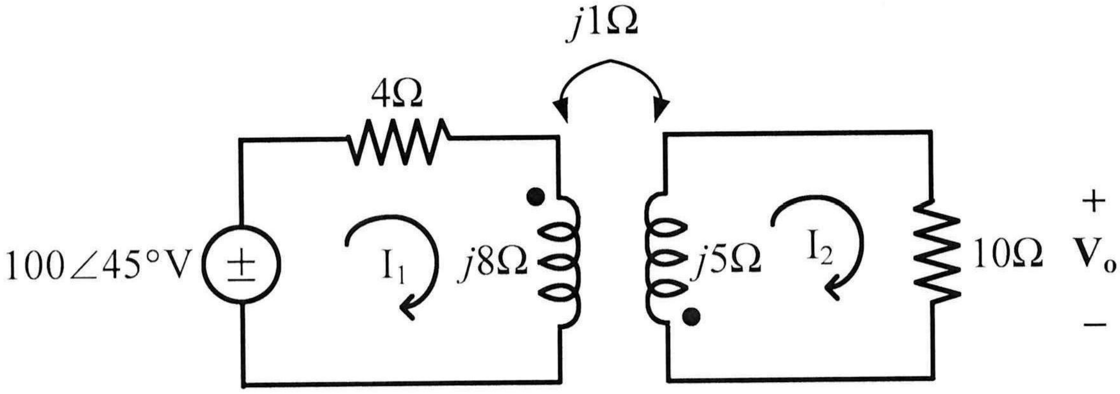

Figure Q5 (a)

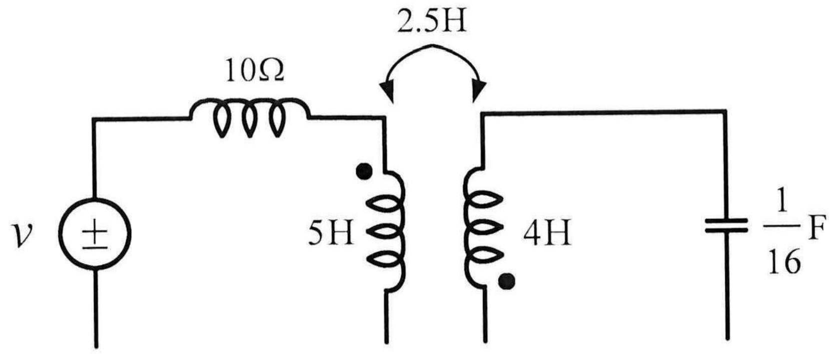

Figure Q5 (b)

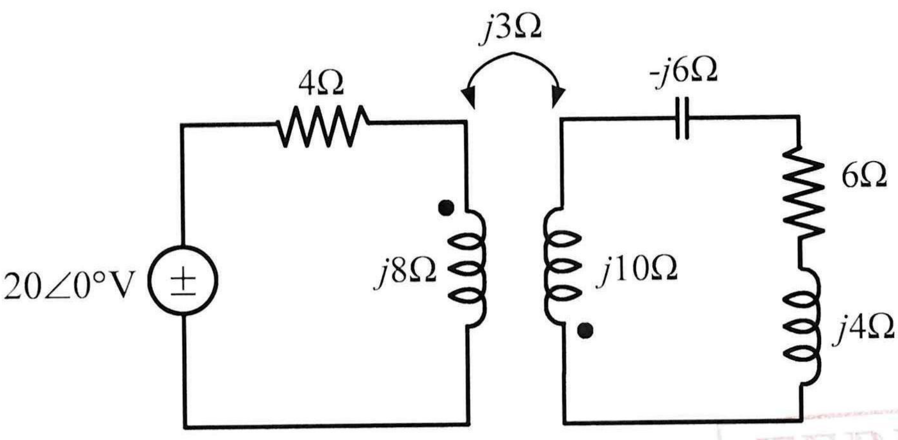

Figure Q5 (c)

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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

$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$

$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$

$\sin(\omega t \pm 180°) = -\sin \omega t$

$\cos(\omega t \pm 180°) = -\cos \omega t$

$\sin(\omega t \pm 90°) = \pm \cos \omega t$

$\cos(\omega t \pm 90°) = \mp \sin \omega t$

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	$v = L\frac{di}{dt}$	$V = j\omega LI$
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:

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

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

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

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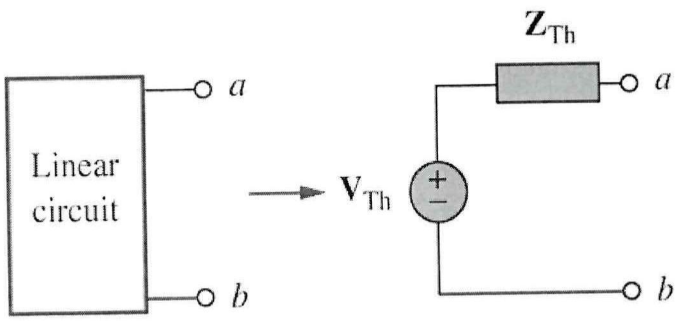
Chapter 2

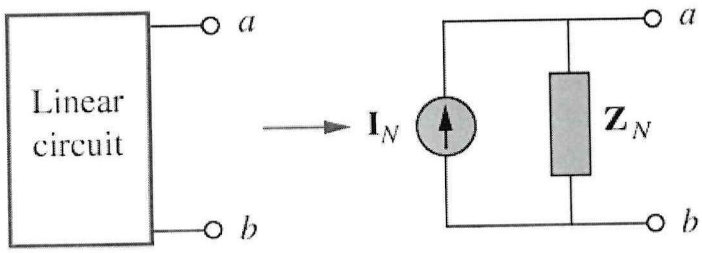
Superposition Theorem

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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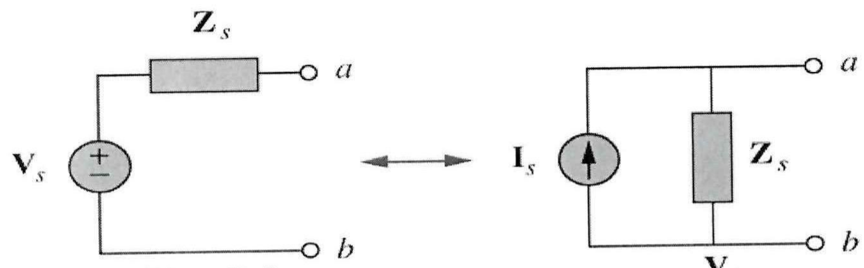
Source Transformation



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

Chapter 3

Average of Instantaneous 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_mcos(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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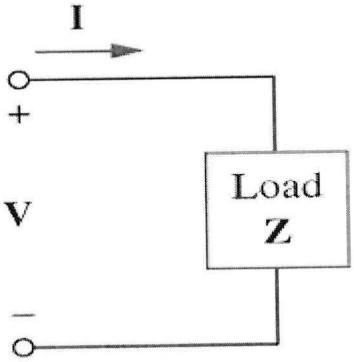
Apparent Power and Power Factor:

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

Apparent Power, S Power Factor, pf

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



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

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

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

$$S = P + jQ$$

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).

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

Conservation of AC Power : $\bar{S} = \frac{1}{2}\bar{V}\bar{I}^* = \frac{1}{2}\bar{V}(\bar{I}_1^* + \bar{I}_2^*) = \frac{1}{2}\bar{V}\bar{I}_1^* + \frac{1}{2}\bar{V}\bar{I}_2^* = \bar{S}_1 + \bar{S}_2$

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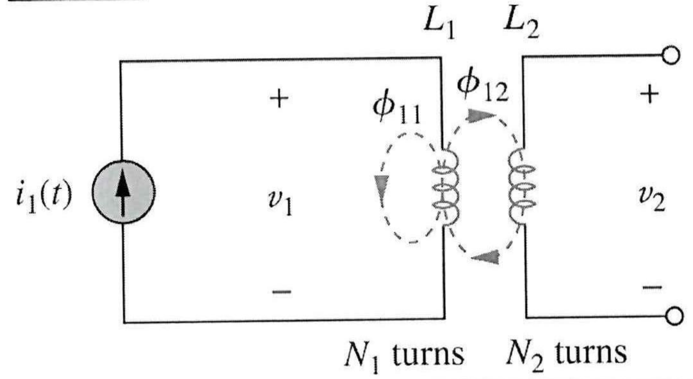
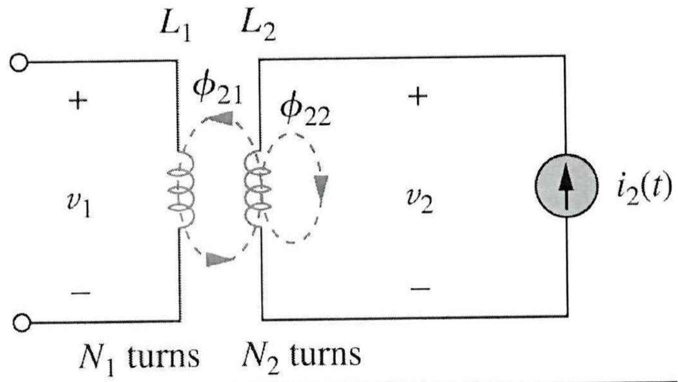
Δ-Y	$V_{ab} = V_p\angle 0°$ $V_{bc} = V_p\angle -120°$ $V_{ca} = V_p\angle +120°$ Same as line currents	Same as phase voltages $I_a = \frac{V_p\angle -30°}{\sqrt{3}Z_Y}$ $I_b = I_a\angle -120°$ $I_c = I_a\angle +120°$

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