EECE 167 Basic Electrical Technology

Date 11/05/23
S S M T W T F

Cr Hr: 03

Cont. Hr: 03

Text book: Fundamentals of Electrical Circuits
- Alexander & Sadiku

Introductory Circuit Analysis -
- Boylestade

Electronic device and circuit Theory
- Boylestade

A Textbook of Electrical Technology (vol 2)
- B.L. Theraja

1st 7 weeks → Circuits | 5, 7, 8 অধ্যায় পর্যন্ত

Node analysis

Mesh —

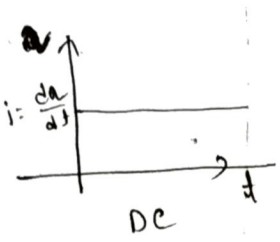
Floral paper products
a concern of HEARTY

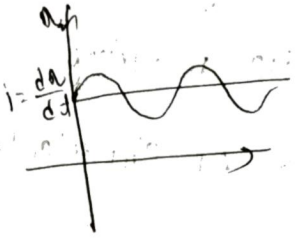
System of Units → six

Electric Charges

Currents

- $i = \frac{dq}{dt}$
- DC
- AC





- Direction of current flow

Voltage

- $v_{ab} = \frac{dw}{dq}$
- $v_{ab} = v_a - v_b$ [not $v_b - v_a$]

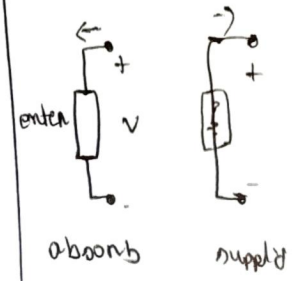
Power and Energy

- $p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = vi$
- absorbing power: + vi

  supplying power: - vi

Passive sign convention

Active

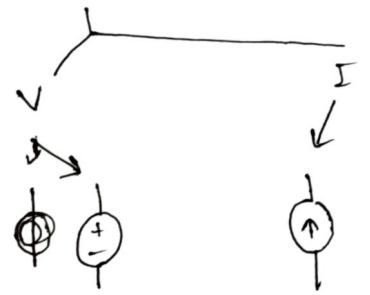


- The law of conservation energy

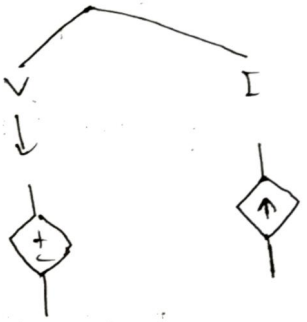
$$\sum P = 0$$

Circuit Elements

- Active elements: (a) -> (d): (source)
- Passive ——— : (e) -> (g): (R, L, C): power absorb
- Independent sources



- Dependent sources





- Dependent source 4 types : CCCS, CCVS, VCCS, VCVS

Date

(S) (S) (M) (T) (W) (T) (F)

Chapter 2: Basic laws

Ohm's Law

- $V = IR$
- $R = 0 \rightarrow$ short circuit

  $R = \infty \rightarrow$ open circuit
- Conductance
  - $G = \frac{I}{R} = \frac{1}{V}$
- $p = vi = i^2R = \frac{V^2}{R}$

Branch, Nodes & Loops

- $b = l + n - 1$
  - b: branch count
  - n: node count
  - l: independent loop count → mesh

Kirchhoff's Laws

- KCL
- KVL

Series resistor & voltage resistor

Series: connected sequentially and no middle branch in between.

$$R_{eq} = R_1 + R_2 + \cdots + R_N = \sum_{n=1}^{N} R_n$$

Parallel:

Voltage drop: $V_n = \frac{R_n}{R_1 + R_2 \cdots + R_n} \times V_{in}$

Parrel: connected to the same two nodes

$$R_{eq} = \left[\frac{1}{R_1} + \frac{1}{R_2} + \cdots + R_n\right]^{-1}$$

$$i_1 = \frac{R_2 i}{R_1 + R_2}, \quad i_2 = \frac{R_1 i}{R_1 + R_2} \qquad \left[i_1 = \frac{V}{R_1}\right]$$

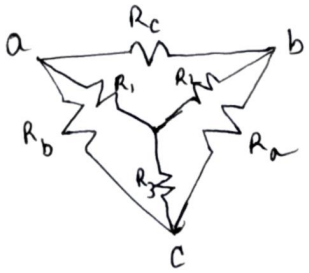
Wye-Delta → next class

Date: 21/05/23
(s) (m) (t) (w) (t) (f)

Delta wye circuit

Δ/ℸ

Y/T/ star



$\Delta \rightarrow Y$: Known = R_a, R_b, R_c

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_a R_c}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

$R_1 = R_2 = R_3$

$R_a = 3R_Y$

$R_b = 3R_Y$

$R_c = 3R_Y$

$\rightarrow R_\Delta = 3R_Y$

$Y \rightarrow \Delta$: Known = R_1, R_2, R_3

$$R_a = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1}$$

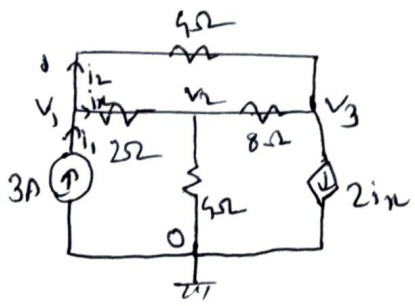
$$R_b = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_2}$$

Methods of Analysis

Node Analysis

SA

25/05/23



Apply KCL at node - 1

$i_1 = i_2 + i_x$

$\Rightarrow 3 = \frac{V_1 - V_2}{2} + \frac{V_1 - V_3}{4}$

$\Rightarrow \quad = \square V_1 + \square V_2 + \square V_3 = \square$ —— (I)

Apply KCL at node-2

$\frac{V_1 - V_2}{2} = \frac{V_3 - V_2}{8} + \frac{V_2}{4}$

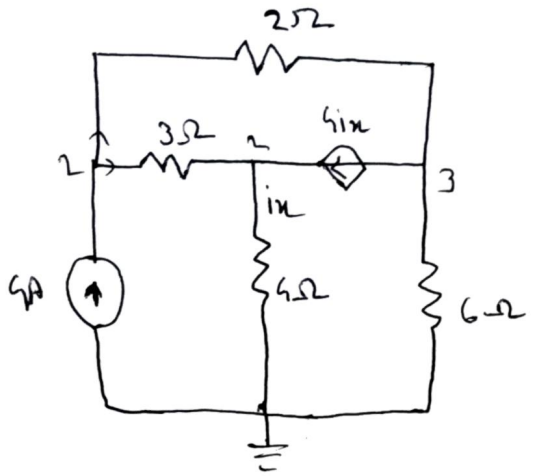
$\Rightarrow \square V_1 + \square V_2 + \square V_3 = \square$ —— (II)

Apply KCL at node — 3

$i_2 + i_3 = 2i_x$

$\Rightarrow \frac{V_1 - V_3}{4} + \frac{V_2 - V_3}{8} = \frac{V_1 - V_2}{2} \times 2$

$\Rightarrow \quad - - -$ —— (III)



node 1

$$4 = \frac{v_1 - v_2}{3} + \frac{v_1 - v_3}{2}$$

node 2

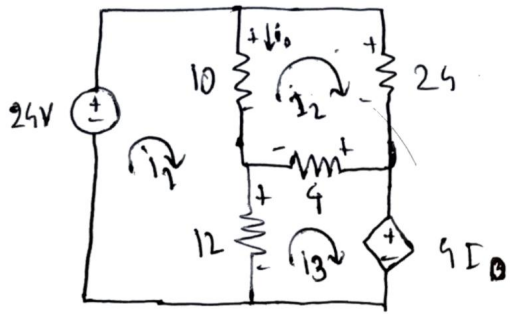
$$\frac{v_1 - v_2}{3} = -4i_x + i_x$$

node 3

$$\frac{v_2 - v_1}{3} + \frac{v_1 - v_3}{2} = 4i_x + \frac{v_3}{6}$$

SA 28/05/23

Mesh Analysis



Mesh: loops that doesn't contain nested loops.

Application of KVL

Apply KVL at mesh-1

$\Rightarrow -24 + 10(i_1 - i_2) + 12(i_1 - i_3) = 0$ —— (i)

Apply KVL at mesh-2

$\Rightarrow 10(i_2 - i_1) + 24(i_2) + 4(i_2 - i_3) = 0$ —— (ii)

Ap— — mesh-3

$\Rightarrow 12(i_3 - i_1) + 4(i_3 - i_2) + 4I_o = 0$

$\Rightarrow$ - - $+ 4(i_1 - i_2)$ —— (iii)

Chapter 6

A capacitor:

- an open circuit to dc ($\frac{dv}{dt} = 0$)

Inductor:

- The equation changes

- a short circuit to dc

Chap 9

Sinusoids

$v(t) = V_m \sin(\omega t + \phi)$

in-phase out-of-phase

SA

$-\cos(377t+40^\circ)$
$\sin(377t+50^\circ)$

01/06/23

Phasor → represents amplitude & phase of a sinusoid

→ a complex number

→ $z = x + jy$

$z = r\angle\phi$; $r = \sqrt{x^2+y^2}$

$\phi = \tan^{-1}\frac{y}{x}$

$z = re^{j\phi}$

$v(t) = V_m \sin(\omega t + \phi)$

$V = \frac{V_m}{\phi}$

$\omega V_m / \theta + 90^\circ$

~~$\omega V_m / \theta$~~

$\omega V_m \angle 0$ lagging

$j\omega V_m \angle 0^\circ$

$j\omega V$

$\int V dt = \frac{V}{j\omega}$

- $v(t)$ is time domain

V " frequency "

- $v(t)$ is $\mathbb{C}$

09/06/23

Phasor relationships for circuits

Element → time domain → frequency domain

$R \longrightarrow v = Ri \longrightarrow V = RI$ → resistance

$L \longrightarrow v = L\frac{di}{dt} \longrightarrow V = \boxed{j\omega L} I$ → x_L

$C \longrightarrow i = C\frac{dv}{dt} \longrightarrow V = \boxed{\frac{1}{j\omega C}} I$ → x_C

Ac

Resistance → Impedance

$Z = R + jx$

R: resistance

x: reactance → x_L (inductive reactance), x_C (capacitive reactance)

$x_L = j\omega L$

$x_C = \frac{1}{j\omega C} = -j\frac{1}{\omega C}$

$j \rightarrow +$ → inductive reactance

$\rightarrow -$ → capacitive "

$$Z = \frac{V}{I} = R + jX$$

Impedance and Admittance

steps to analyze AC circuits

Time to Freq ⟶ solve ⟶ Freq to time

Example.

$20\cos 4t \Rightarrow 20\angle 0^\circ; \quad \omega = 4 \text{ rad/s}$

$1H \Rightarrow j\omega L = j4\,\Omega$

$0.1F \Rightarrow \frac{1}{j\omega L} = \frac{1}{j4(0.1)} = -j2.5\,\Omega$

$6\,\Omega \Rightarrow j2$

Supernode

08/06/23

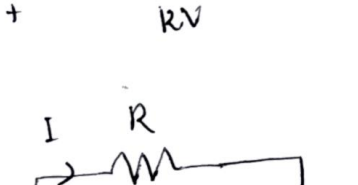
Linearity Property :

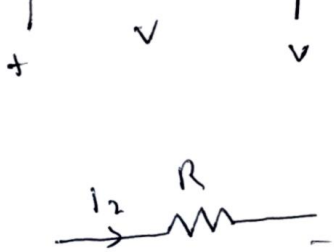
homogeneity prop $V = iR \longrightarrow KV = KiR$

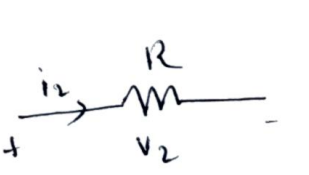
$V_1 = i_1 R, \quad V_2 = i_2 R$

additive prop $\Rightarrow V = V_1 + V_2$

$\Rightarrow V_1 + V_2 = (i_1 + i_2) R$







Superposition Theorem

multiple voltage across / current through → algebric sum.

Steps: one at a time, then sum

a) turn off all but one

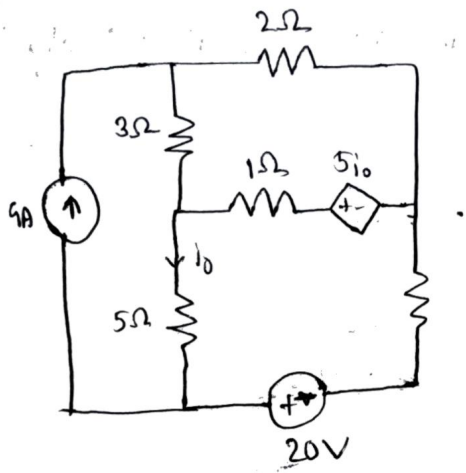
b) solve for each

c) sum

—

Note:

1. turning off all independent source:
   - Vol → 0V → short circuit
   - Amp → 0A → open "
2. Dependents are kept.



H.W

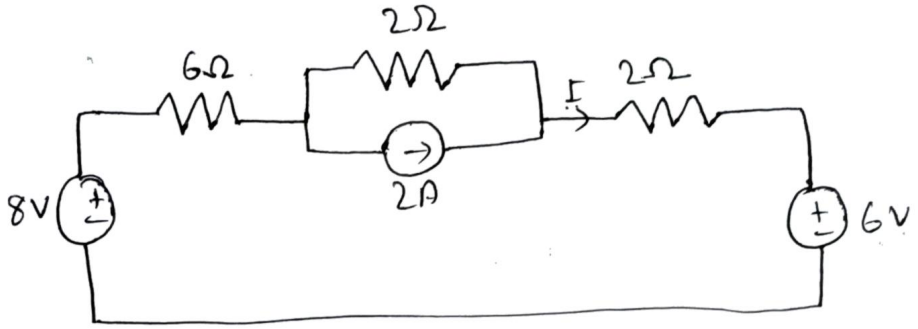
~~3 examples 4.5 ~ 3~~

Practice prob 4.5

5th ver

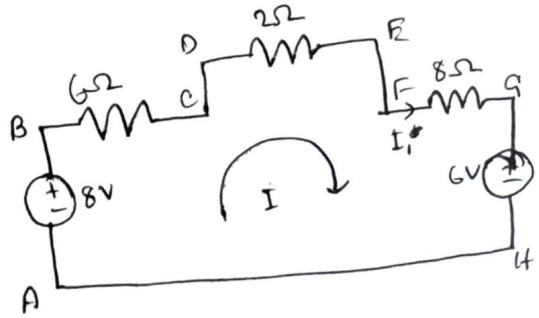
P.P. 4.5

Q. Find I in the following circuit of using the super position principle.



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① Turn off the 2A current source.



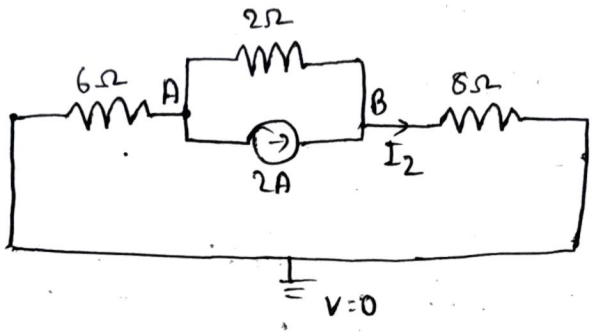
Apply KVL at ~~KVL~~ loop ABCDEFGHA:

$$-8 + 6I_1' + 2I_1' + 8I_1' + 6 = 0$$

$$\Rightarrow 16I_1' - 2 = 0$$

$$\therefore I_1' = \frac{1}{8} A$$

(II) Turn off 8V and 6V voltage sources:



Apply KCL at node A:

$$-\frac{0-V_A}{6} + \frac{V_A - V_B}{2} + 2 = 0$$

$$\Rightarrow +V_A + 3V_A - 3V_B + 12 = 0$$

$$\Rightarrow -4V_A + 3V_B = 12 \quad \text{——} (I)$$

Apply KCL at node B:

$$\frac{V_A - V_B}{2} + 2 - \frac{V_B}{8} = 0$$

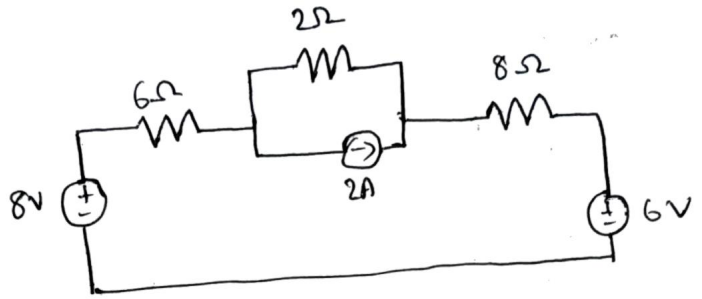
$$\Rightarrow 4V_A - 4V_B + 16 = V_B$$

$$\Rightarrow 4V_A - 5V_B = -16 \quad \text{——} (II)$$

By solving (I) & (II) $\Rightarrow V_B = 2V$, $V_A = -1.5V$

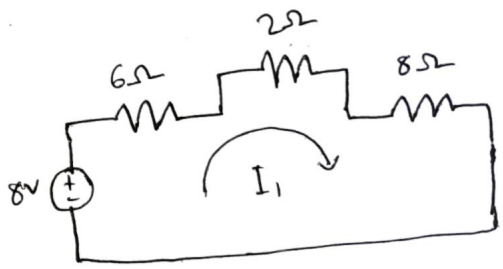
$$\therefore I = I_1 + I_2 = \frac{1}{8} + \frac{V_B - 0}{8} = 2\frac{1}{8} + \frac{1}{4} = 0.375A$$

Q. Find I in the circuit using the superposition principle.



Ans.

Turning off all but 8V independent voltage across:

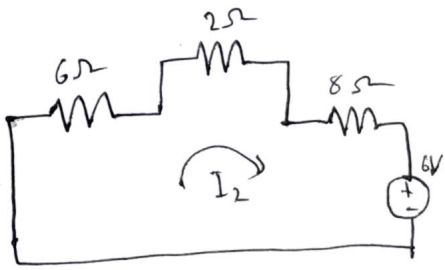


Apply KVL:

$$-8+6I_1+2I_1+8I_1=0$$

$$\therefore I_1 = +\frac{1}{2}\,A$$

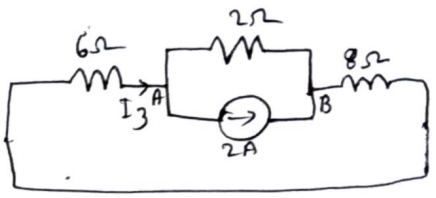
Turning off all but 6V independent voltage across:



$$6I_2+2I_2+8I_2+6=0$$

$$\therefore I_2 = -\frac{3}{8}\,A$$

Turning off all but 2A:



Apply KCL at node A:

$$I_3 = \frac{V_A - V_B}{2} + 2$$

$$\Rightarrow \frac{-V_A}{6} = \frac{V_A - V_B}{2} + 2$$

$$\Rightarrow -V_A = 3V_A - 3V_B + 12$$

$$\Rightarrow 4V_A - 3V_B = -12 \quad \text{— (i)}$$

Apply KCL at node B:

$$\frac{V_B}{8} = \frac{V_A - V_B}{2} + 2$$

$$\Rightarrow V_B = 4V_A - 4V_B + 16$$

$$\Rightarrow 4V_A - 5V_B = -16 \quad \text{— (ii)}$$

By solving (i) & (ii) $\Rightarrow$

$$V_A = -1.5\ V$$

$$V_B = 2V$$

$$\therefore I_3 = \frac{-1.5}{6} = \frac{1}{4}\ A$$

$$\therefore I = I_1 + I_2 + I_3 = \frac{3}{8}\ A = 0.375\ A$$

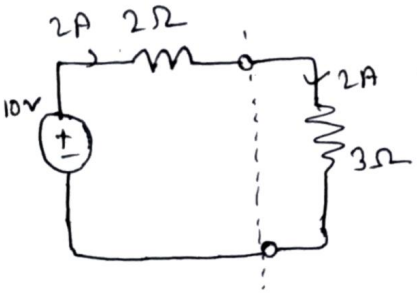
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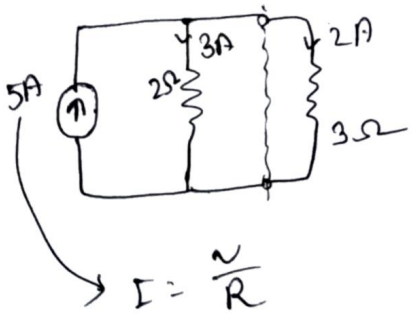
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Thevenin's Theorem

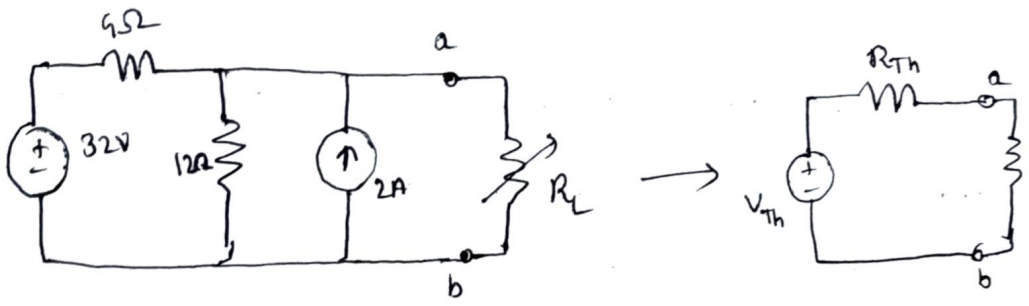
holds Resistance as R_{TH} and Voltage as V_{TH} of a rather complex circuit in its simplest form for faster calculation.

Source transformation theorem





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



Case 2: dependent src in present:

- add a psedo $V_o = 1V$ at terminal

Ex. 4.9

Norton's Theorem

Maximum Power transfer theorem

$$P_{R_L} = I^2 R_L = \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 R_L$$

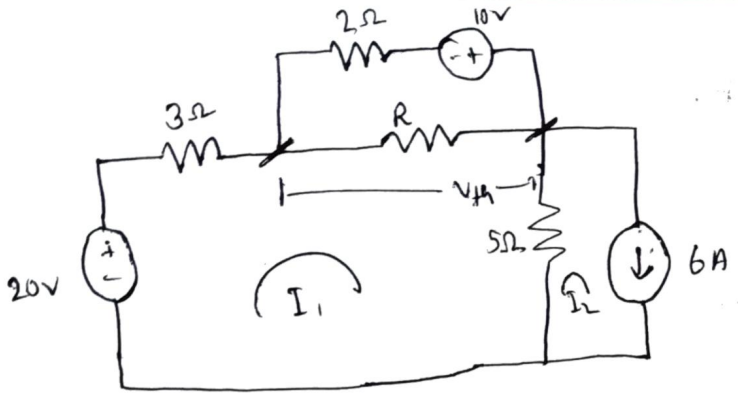
for maxim power, $\frac{dP}{dR_L} \left(\frac{V_{th}}{R_{th} + R_L}\right)^2 R_L$

$$R_{th} = R_L$$

$$P_{max} = \frac{(V_{th})^2}{4 R_{th}^2} R_{th}$$

$$= \frac{(V_{th})^2}{4 R_{th}}$$

18/06/23



$-20 + 3I_1 + 2I_1 - 10 + 5(I_1 - I_2) = 0$

$I_2 = 6A$

$I_1 = \ldots$

H.W

Super-pos theo

Thevenins

Max power

Related all probs

Example, P.P, exercise

↳ (at least 4 from each topics)

Submit by last class before eid

Syllabus for CT-2

Chapter ~~4 to~~ 4

SA/EECE 08/08/2023

Compulsory question

Q.1 (a) Superposition Theorem / Thevenin's Theorem (DC/AC)

(b) Nodal Analysis / Mess Analysis

Q.2 (a) Thevenin's Theorem / Superposition Theorem (AC/DC)

(b) Mesh Analysis / Nodal Analysis

Q.3 (a) Series-parallel circuit / Δ-Y Networks Problems

(b) Basic AC Circuit equations / Problems related Math

Q.4 (a) RMS / Average value of AC signals

(b) Balanced 3-Φ Network math

Compolaury – Chap. 3, § 10

Ex. 10.6

DC	AC
R	R
	$L \rightarrow j\omega L$
	$C \rightarrow \frac{1}{j}\omega C = -j\omega C$
v	
I	

Chapter 12

Avg. power:

$$P = \frac{1}{T}\int_0^T p(t)\,dt$$

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

Rms value

Chap 12.1 — 12.4

Solve
11.7, 11.8