Model Answers

Winter – 2019 Examinations

Subject & Code: Electrical Circuits & Networks (17323)

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Model Answers

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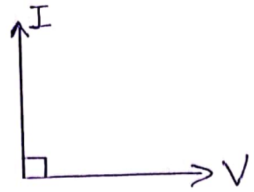
Subject & Code: Electrical Circuits & Networks (17323)

1 Attempt any TEN of the following: 20

1 a) Identify /state nature of the circuit of Figure No:1



Identify / State nature of circuit. 2 Mark

Fig. No. 1

Ans:

Given circuit is purely capacitive type.

1 b) Define: Frequency and Cycle for AC quantities**.**

Ans:

(i) Frequency: It is defined as number of cycles completed by an alternating quantity in one second**.** 1 Mark

(ii) Cycle:

A complete set of variation of an alternating quantity which is repeated at regular interval of time is called as a cycle. 1 Mark

OR

Each repetition of an alternating quantity recurring at equal intervals is known as a cycle.

1 c) Define: Apparent and Reactive power.

Ans:

i) Apparent Power (S):

This is simply the product of RMS voltage and RMS current.

Unit: volt-ampere (VA) or kilo-volt-ampere (kVA) or Mega-volt-ampere (MVA) 1 Mark

$S=VI=I^2Z$ volt-amp

ii) Reactive Power or Imaginary Power (Q):

Reactive power (Q) is given by the product of voltage, current and the sine of the phase angle between voltage and current.

Unit: volt-ampere-reactive (VAr), or kilo-volt-ampere-reactive (kVAr) or Mega-volt-ampere-reactive (MVAr) 1 Mark

$Q=VI\sin\emptyset=I^2X$ volt-amp-reactive

1 d) Define: Power factor and Quality factor in RC circuit.

Ans:

i) Power Factor:

It is the cosine of the angle between the applied voltage and the resulting current. 1 Mark

Power factor = cosø

where, ø is the phase angle between applied voltage and current.

It is the ratio of True or effective or real power to the apparent power.

$$\text{Power factor}=\frac{\text{True or effective or real power}}{\text{apparent power}}=\frac{VIcos\emptyset}{VI}= cos\emptyset$$

It is the ratio of circuit resistance to the circuit impedance.

$$\text{Power factor}=\frac{\text{circuit resistance}}{\text{circuit impedance}}=\frac{R}{Z}= cos\emptyset$$

ii) Quality factor: The ratio of capacitive reactance to the resistance is called as Quality factor for RC circuit. 1 Mark

$$\text{Q-factor} = \frac{X_C}{R} = \frac{1}{2\pi fCR} = \frac{1}{\omega CR} =$$

1 e) Write equations of resonant frequency and quality factor in terms of circuit components for a parallel circuit.

Ans:

i) Equation for resonance frequency in terms of circuit components for parallel circuit. 1 Mark

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

ii) Equation for quality factor in terms of circuit components for parallel circuit. 1 Mark

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

1 f) Define: Admittance and Conductance related to parallel circuit.

Ans:

i) Admittance (Y): Admittance is defined as the ability of the AC circuit to carry (admit) alternating current. It is also defined as reciprocal of impedance.

$$\text{Admittance (Y)} = \frac{1}{Z} \text{ mho } (\mho)$$ 1 Mark

ii) Conductance (G): It is defined as the real part of the admittance (Y). It is also defined as the ability of the purely resistive circuit to pass the alternating current.

OR

It is the ratio of resistance (R) to squared impedance (Z^2) 1 Mark

$$\text{Conductance(G)} = \frac{R}{Z^2} \text{ siemen}$$

1 g) State any two advantages of polyphase circuit over single phase circuit.

Ans:

i) Three-phase transmission is more economical than single-phase transmission. It requires less copper material.
ii) Parallel operation of 3-phase alternators is easier than that of single-phase alternators.
iii) Single-phase loads can be connected along with 3-ph loads in a 3-ph system.
iv) Instead of pulsating power of single-phase supply, constant power is obtained in 3-phase system.
v) Three-phase induction motors are self-starting. They have high efficiency, better power factor and uniform torque.
vi) The power rating of 3-phase machine is higher than that of 1-phase machine of the same size.
vii) The size of 3-phase machine is smaller than that of 1-phase machine of the same

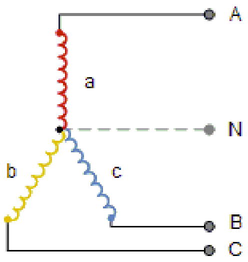
1 Mark for each of any two advantages = 2 Marks

power rating.

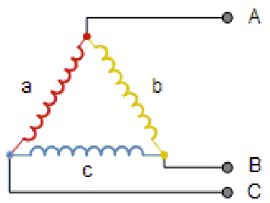
viii) Three-phase supply produces a rotating magnetic field in 3-phase rotating machines which gives uniform torque and less noise.

1 h) Draw types of three phase connection.

Ans:



Star-connection

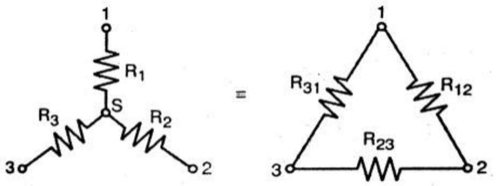


Delta-connection

1 Mark for each diagram = 2 Marks

1 i) State the formula for delta to star transformation.

Ans:



(a) Star Circuit (b) Delta Circuit

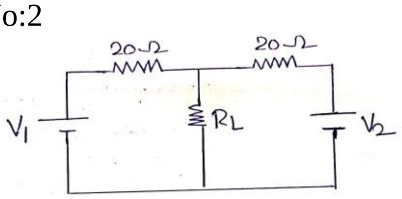
$$R_1 = \frac{R_{12} \times R_{31}}{R_{12}+R_{23}+R_{31}}$$

$$R_2 = \frac{R_{12} \times R_{23}}{R_{12}+R_{23}+R_{31}}$$

$$R_3 = \frac{R_{23} \times R_{31}}{R_{12}+R_{23}+R_{31}}$$

2 marks for formula

1 j) Find the R_{TH} From Figure No:2

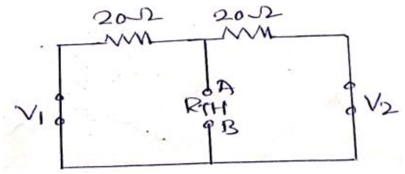


Calculate R_{TH}

Fig.No.2

Ans:

The Thevenin's equivalent resistance R_{TH} is the resistance seen between the open-circuited load terminals with all independent sources replaced by their internal resistances, as shown below:



1 Mark for diagram

$R_{TH} = R_{AB} = 20 \parallel 20 = \frac{20 \times 20}{20+20} = \mathbf{10\ \Omega}$

1 Mark for R_{TH}

1 k) State 'Norton's' Theorem for AC circuit.

Ans:

Norton's Theorem:

It states that any linear, active network containing one or more voltage and/or current source can be replaced by an equivalent circuit containing a single current source and equivalent impedance across the current source.

2 Marks for statement

The equivalent current source (Norton's current source) I_N is the current through the short circuited terminals of the load. The equivalent impedance Z_N is the impedance seen between the load terminals while looking back into the network with the load removed and internal sources replaced by their internal resistances.

If R_L is load resistance then current through it is $I_L = I_N R_N/(R_N + R_L)$.

1 l) State meaning of $t = 0^-$ and $t = 0^+$.

Ans –

1) $t = 0^-$ is the instant just before the switching instant t = 0
2) $t = 0^+$ is the instant just after the switching instant t = 0

1 Mark each = 2 Marks

2 Attempt any FOUR of the following: **16**

2 a) Instantaneous expression for voltage and current are given by:

$v = 141.4 \sin 314t$

$i = 28.28 \sin(314t + \frac{\pi}{3})$

Determine: (i) RMS value of voltage and current
(ii) Average value of voltage
(iii) Frequency
(iv) Power consumed

Ans:

Data Given:

V_m =141.4 V, $I_m = 28.28\ A$, ω=314 rad/sec , $\emptyset = \frac{\pi}{3}$ (leading)

½ Mark for each RMS value

i) RMS value of voltage= $V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{141.4}{\sqrt{2}}$ = **99.98 V**

RMS value of current= $I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{28.28}{\sqrt{2}}$ =**19.99 A**

ii) Average value of voltage = V_{avg} = 0.637× V_m = 0.637 × 141.4
=**90.07 V** (Over half-cycle)
=**0 V** (Over full-cycle)

1 Mark for average value

iii) Angular velocity = ω = 2πf

$314 = 2 \times 3.14 \times f$

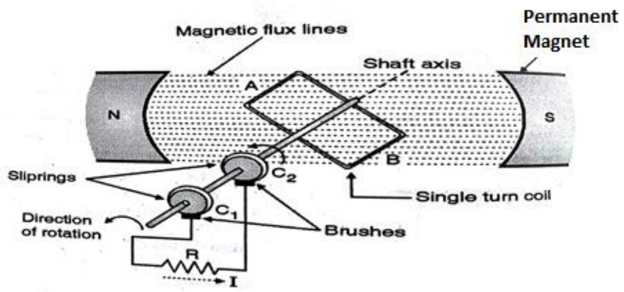
Frequency=$f = \mathbf{50\ Hz}$ — 1 Mark for frequency

iv) Power consumed= P = VIcosø = $99.98 \times 19.99 \times \cos(\frac{\pi}{3})$ = **999.30 W** — 1 Mark

2 b) For a single loop AC generator-
(i) Draw a neat sketch.
(ii) Identify components used.
(iii) Write equation of generated emf.
(iv) Draw waveform of the output voltage.

Ans:

(i) Neat sketch of single loop AC generator



1 Mark

OR any other equivalent sketch

(ii) Components used:
a) Permanent magnets.
b) Single turn coil.
c) Slip rings
d) Brushes
e) Shaft.

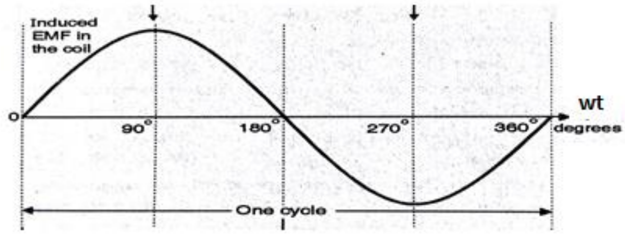
1 Mark

(iii) Equation of generated emf:

e = B. ℓ .v.sin(ωt) volt = E_m sin(ωt) volt — 1 Mark

where, e = Instantaneous value of the emf
B = Flux-density in Wb/m^2
ℓ = Active length of conductor in m
v = Linear velocity of conductor in m/s.
ω = Angular velocity of conductor in rad/sec
t = time in sec.

(iii) Waveform of output voltage.

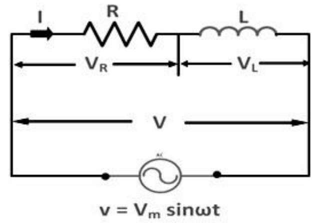


1 Mark

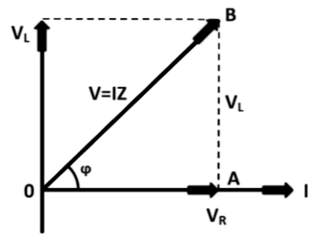
2 c) A series circuit has lagging power factor. Draw circuit, waveform and phasor diagram.

Ans:

Circuit diagrm:



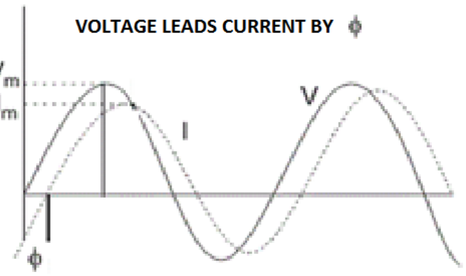
Phasor diagram :



1 Mark for circuit diagram

1 Mark for phasor diagram

Wave form of voltage and current



2 Marks for waveforms

2 d) State the values of power factor during resonance condition for RLC series circuit. Also state the importance of power factor.

Ans:

i) At resonance, the value of power factor is always **UNITY**. — 1 Mark

ii) Importance of Power Factor:

The power factor is important for operation of electrical system because its improvement has following effects:

- The kVA rating of electrical equipment is reduced, resulting small size and less cost.
- The current is reduced for same power and voltage, resulting in reduced cross section (size) requirement of the conductor and reduced cost of conductor.
- Copper losses are reduced.
- Voltage regulation is improved.
- There is full utilization of full capacity of electrical equipment.
- The kVA maximum demand is reduced, resulting in reduced demand charges.
- High kW output is obtained from generators, resulting in higher kWh energy production.

1 Mark for each of any three points = 3 Marks

2 e) A coil having a resistance of 20 Ω and inductive reactance of 47.1 Ω is connected in series with a capacitor of reactance 31.8 Ω across an AC supply of 230 V.

Determine: (i) Current drawn from the supply
(ii) Power factor
(iii) Active and reactive components of current
(iv) Voltage across the coil.

Ans:
Data Given:

$R = 20\ \Omega$, X_L =47.1 Ω , X_C =31.8 Ω , V=230 V , f = 50 Hz — ½ Mark for Z

Impedance= $z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{20^2 + (47.1 - 31.8)^2}$ = 25.18 Ω

i) Current= $I = \frac{V}{Z} = \frac{230}{25.18}$ = **9.13 A** — ½ Mark for I

ii) Power factor=cosø $= \frac{R}{Z} = \frac{20}{25.18}$ = **0.794 (lagging)** — 1 Mark for pf

iii) Phase angle =ø $= \cos^{-1}(0.794)$ =37.43

iv) Active component of current = Icosø $= 9.13 \times \cos(37.43) = \mathbf{7.25\ A}$ — ½ Mark

v) Reactive component of current = Isinø $= 9.13 \times \sin(37.43) = \mathbf{5.55\ A}$ — ½ Mark

vi) Voltage across the coil = $I \times Impedance\ of\ coil$

$= 9.13 \times \sqrt{R^2 + (X_L)^2} = 9.13 \times \sqrt{20^2 + (47.1)^2}$ = **467.18 V** — 1 Mark

2 f) An Inductive coil (10+ j40) Ω impedance is connected in series with a capacitor of 100 µF across 230 V, 50Hz, 1ph supply.

Find:(i) Current through circuit

(ii) Power factor

(iii) power dissipated in circuit

(iv) Draw phasor diagram.

Ans: Given

$R = 10\ \Omega$, X_L =40 Ω , C=100 µF=100 × 10^{-6} F , V=230 V ,f=50 Hz

Capacitive reactance =$X_C = \frac{1}{2\pi f C} = \frac{1}{2 \times 3.14 \times 50 \times 100 \times 10^{-6}}$ = 31.83 Ω — ½ mark

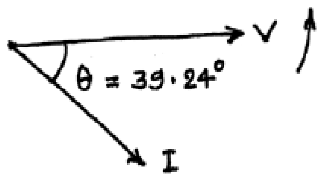
Impedance = $z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{10^2 + (40 - 31.84)^2}$ =12.91 Ω — ½ mark

Current = $I = \frac{V}{Z} = \frac{230}{12.91}$ =**17.82 A** — ½mark

Power factor = $cos\phi = \frac{R}{Z} = \frac{10}{12.91}$ = **0.7746 (lagging)** — ½ mark

Power dissipated in circuit= $P = VIcos\phi$ = 230 × 17.82 × 0.7746 =**3174.78 W** — 1 mark

Phasor Diagram=



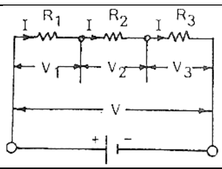
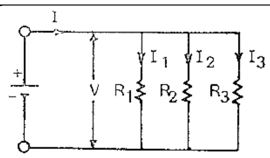
1 mark

3 Attempt any FOUR of the following: **16**

3 a) Compare series and parallel AC circuit.

Ans:

Comparison between Series and Parallel AC Circuit:

Sr. No.	Series Circuit	Parallel Circuit
1		
2	A series circuit is that circuit in	A parallel circuit is that circuit in

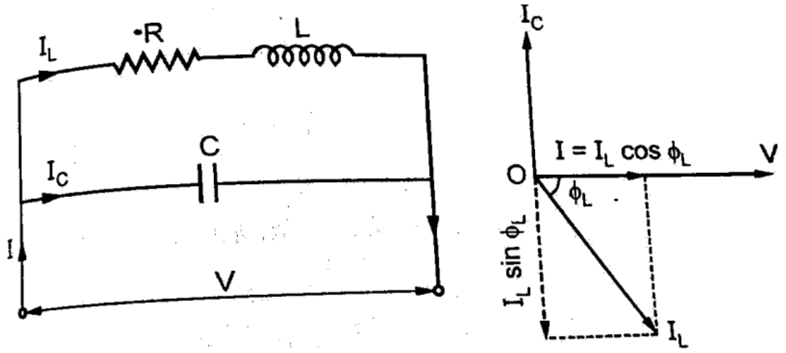
	which the current flowing through each circuit element is same.	which the voltage across each circuit element is same.	
3	The sum of the voltage drops in series resistances is equal to the applied voltage V. $\therefore V = V_1+V_2+V_3$	The sum of the currents in parallel resistances is equal to the total circuit current I. $\therefore I = I_1+I_2+I_3$	1 Mark for each of any four points = 4 Marks
4	The effective resistance R of the series circuit is the sum of the resistance connected in series. $R = R_1 + R_2 + R_3 + \cdots$	The reciprocal of effective resistance R of the parallel circuit is the sum of the reciprocals of the resistances connected in parallel. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$	
5	For series R-L-C circuit, the resonance frequency is, $f_r = \frac{1}{2\pi\sqrt{LC}}$	For parallel R-L-C circuit, the resonance frequency is, $f_r = \frac{1}{2\pi\sqrt{LC}}$	
6	At resonance, the series RLC circuit behaves as purely resistive circuit.	At resonance, the parallel RLC circuit behaves as purely resistive circuit.	
7	At resonance, the series RLC circuit power factor is unity.	At resonance, the Parallel RLC circuit power factor is unity.	
8	At resonance, the series RLC circuit offers minimum total impedance Z = R	At resonance, the parallel RLC circuit offers maximum total impedance Z =L/CR	
9	At resonance, series RLC circuit draws maximum current from source, I = (V/R)	At resonance, parallel RLC circuit draws minimum current from source, $I = \frac{V}{[L/CR]}$	
10	At resonance, in series RLC circuit, voltage magnification takes place.	At resonance, in parallel RLC circuit, current magnification takes place.	
11	The Q-factor for series resonant circuit is $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	The Q-factor for parallel resonant circuit is, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	
12	Series RLC resonant circuit is Accepter circuit.	Parallel RLC resonant circuit is Rejecter circuit.	

3 b) Derive the expression for resonant frequency for the series combination of RL in parallel C

Ans:

Resonance frequency for a RL-C parallel circuit:-

1 Mark for



circuit diagram

1 Mark for phasor diagram

The circuit is said to be in electrical resonance when the reactive component of line current becomes zero. The frequency at which this happens is known as resonance frequency.

Net reactive component = $I_c - I_L sin\emptyset_L$

As at resonance, its value is zero, hence

$I_c - I_L sin\emptyset_L = 0$ **OR** $I_c = I_L sin\emptyset_L$

Now, $I_L = \frac{V}{Z}$ and $I_c = \frac{V}{X_c}$

2 Marks for derivation

Hence condition for resonance becomes

$\frac{V}{X_c} = \frac{V}{Z} \times \frac{X_L}{Z}$ OR $X_c X_L = Z^2$ where Z = (R + j X_L)

Now, $X_L = \omega$L, $X_c = \frac{1}{\omega C}$

$\frac{\omega L}{\omega C} = Z^2$ OR $\frac{L}{C} = Z^2$

$\frac{L}{C} = R^2 + X_L{}^2 = R^2 + (2\pi f_0 L)^2$

$(2\pi f_0 L)^2 = \frac{L}{C} - R^2$

$2\pi f_0 = \sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

∴ The resonant frequency $\boldsymbol{f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}}$

3 c) An inductor of 0.5H inductance and 90Ω resistance is connected in parallel with a 20μF capacitor. This circuit supplied by 1ph, 230v, 50Hz AC supply. Find:

(i) The total current
(ii) P.F of Parallel circuit
(iii) Power taken from source
(iv) Draw the vector diagram

Ans:

Data Given:

Branch I: R = 90 Ω and L = 0.5 H

Branch II: C = 20μF = 20 x 10^{-6} F

V = 230V, f = 50Hz

Branch impedances (Z_1 and Z_2):

Inductive reactance $X_L = 2\pi fL$

$= 2 \times \pi \times 50 \times 0.5$

$\mathbf{X_L = 157.079\ \Omega}$

Capacitive reactance $X_C = 1 / (2\pi fC)$

$X_C = 1 / (2\pi \times 50 \times 20 \times 10^{-6})$

$\mathbf{X_C = 159.15\ \Omega}$

Impedance $Z_1 = (90 + j157.079)\ \Omega = \mathbf{181.035 \angle 60.18° \Omega}$ ½ Mark

Impedance $Z_2 = 0 – j159.15\ \Omega = \mathbf{159.15 \angle -90°\ \Omega}$ ½ Mark

(i) Branch currents (I_1 and I_2) :

Branch 1 current (I_1): $I_1 = V / Z_1 = 230\angle 0^o / 181.035 \angle 60.18^o$

$\mathbf{I_1 = 1.27\angle -60.18° A = (0.631 – j1.10) A}$

Branch 2 current (I_2): $I_2 = V / Z_2 = 230\angle 0^o / 159.15 \angle -90^o$

$\mathbf{I_2 = 1.44\angle 90° A = (0 + j1.44) A}$

Total Current (I): $I = I_1 + I_2 = (\mathbf{0.631 - j1.10}) + (\mathbf{0 + j1.44})$

$= \mathbf{0.631 + j\,0.34 = 0.7168\angle 28.31^0 A}$ 1 Mark

Angle between V and I is {0-(28.31)} = -28.31°

(ii) P.F of Parallel Circuit (cosϕ) :

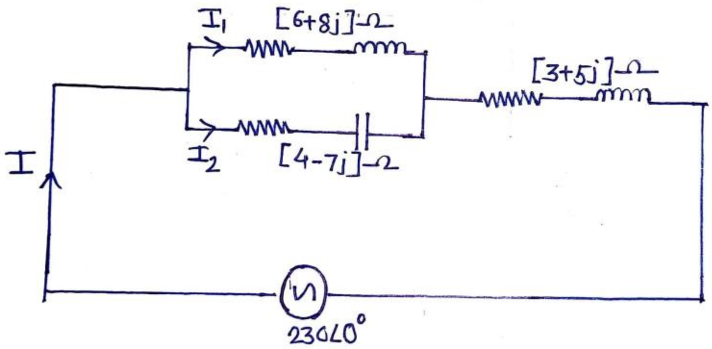
cosϕ = cos(-28.31°) = **0.8803 leading** 1 Mark

(iii) Power taken from source:

P = V × I ×cosϕ = 230 × 0.7168 × 0.8803

P = 145.129 watt 1 Mark

3 d) Find I, I_1, I_2 and power factor of ckt in Figure No:3.



Calculate I, I_1, I_2

Fig. No. 3

Ans:

Let us consider,

$Z_1 = (6 + j8) = 10\angle 53.13°\Omega$

$Z_2 = (4 – j7) = 8.06\angle -60.25°\Omega$

$Z_3 = (3 + j5) = 5.83\angle 59.03°\Omega$

Now Impedance Z_1 and impedance Z_2 are connected in parallel.

∴ Equivalent Impedance of Z_1 and Z_2

$$Z_{12} = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{10\angle 53.13° \times 8.06\angle -60.25°}{(6+j8)+(4-j7)}$$

$$= \frac{10\angle 53.13° \times 8.06\angle -60.25°}{10.04\angle 5.71^0}$$

$$= \mathbf{8.03\angle -12.83° = 7.83 - j1.78}\ \Omega$$

Now Z_{12} and Z_3 are in series,

∴ Equivalent Impedance of Z_{12} and Z_3

$Z_{Total} = Z_{12} + Z_3 = (7.83 - j1.78) + (3 + j5)$

$\mathbf{Z_{Total} = 10.83 + j\,3.22 = 11.3\angle 16.56°}$

(i) **I** = V/Z_{Total} — 1 Mark

$= \frac{230\angle 0°}{11.3\angle 16.56°} = \mathbf{20.35\angle -16.56°\ A = (19.51 - j5.8)\ A}$

(ii) $\mathbf{I_1} = I \times \frac{Z_2}{Z_1 + Z_2} = 20.35\angle -16.56° \times \frac{8.06\angle -60.25°}{6 + j8 + 4 - j7}$

$= 20.35\angle -16.56° \times \frac{8.06\angle -60.25°}{10.04\angle 5.71°}$ — 1 Mark

$\mathbf{= 16.34\angle -82.52°\ A = (2.13 - j16.2)\ A}$ — 1 Mark

(iii) $\mathbf{I_2} = I - I_1$

$= 19.51 - j5.8 - (2.13 - j16.2) = \mathbf{(17.38 - j10.4) = 20.25\angle -30.89°\ A}$

1 Mark

(iv) Power factor of the circuit: cos(-16.56°) = **0.9585 lagging**

3 e) Define crest factor and form factor. State value of each for a pure sine wave.

Ans:

i) Crest Factor:

It is defined as the ratio of the peak or crest value to the RMS value of an alternating quantity.

Crest factor $= \frac{Peak\ Value}{RMS\ Value}$ — 1 Mark

Value of Crest Factor for Pure Sine Wave is 1.414. — 1 Mark

ii) Form Factor:

It is defined as the ratio of RMS value to average value of an alternating quantity. — 1 Mark

Form factor $= \frac{RMS\ Value}{Average\ Value}$

Value of Form Factor for Pure Sine Wave is 1.11. — 1 Mark

3 f) A resistance of 100Ω and 50µF capacitor are connected in series across a 230V, 50Hz supply. Find:

i) Impedance
ii) Current flowing
iii) Voltage across R and C
iv) PF and power

Ans:

Data Given: R=100Ω, C=50µF, V=230V, f=50Hz.

The Capacitive reactance is given by, $X_C = \frac{1}{2\pi fC}$

$$= \frac{1}{2\pi(50)(50 \times 10^{-6})}$$

$$= 63.66\Omega.$$

i) The impedance of Circuit: — 1 Mark

$Z = \sqrt{(R^2 + (-X_C)^2} = \sqrt{(100)^2 + (-63.66)^2} = \mathbf{118.54}\ \Omega.$

ii) Current flowing through the circuit (I):

$I = \frac{V_S}{Z} = \frac{230}{118.54} = \mathbf{1.94A}$ — 1 Mark

iii) Voltage across Capacitance and Resistance

Voltage across capacitance=V_c=I × Xc
=1.94 x 63.66 ½ Mark
=**123.5V**

Voltage across Resistance=V_R=I × R
=1.94 x 100 ½ Mark
=**194V**

iv) Power factor and Power:

Phase angle between voltage and current (ϕ)

$\Phi = \tan^{-1}\frac{(-Xc)}{R} = \tan^{-1}\frac{(-63.66)}{100} = -32.48° = \mathbf{32.48}$ **leading.**

Power factor = cos Φ = cos 32.48 = **0.8436** ½ Mark

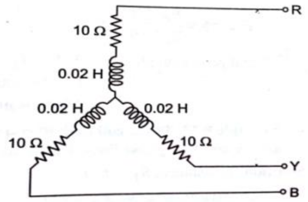
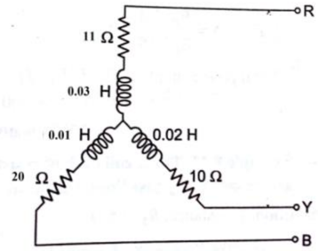
Power = VIcos Φ=230 x 1.94 x0.8436 = **376.41 W** ½ Mark

4 Attempt any FOUR of the following. 16

4 a) Compare balanced and unbalanced three phase load.

Ans:

Comparison of Balanced and Unbalanced Three Phase Load:

Sr. No.	Balanced load	Unbalanced load
1	Balanced three phase load is defined as star or delta connection of three equal impedances having equal real parts and equal imaginary parts.	When the magnitudes and phase angles of three impedances are differ from each other, then it is called as unbalanced load.
2	All the phase voltages have equal magnitude but displaced from each other by 120°. Similar is the case with phase currents.	All the phase voltages do not have equal magnitude and may not be displaced by 120°. Similar is the case with phase currents.
3	All the line voltages have equal magnitude but displaced from each other by 120°. Similar is the case with line currents.	All the line voltages do not have equal magnitude and may not be displaced by 120°. Similar is the case with line currents.
4	Phase angle of impedances are equal.	Phase angles of impedances are not equal.
5	Example circuit: 	Example circuit: 

1 Mark for each of any four points = 4 Marks

4 b) A balanced Y connected load with phase impedance of $14\angle 45°\Omega$ is connected to a 3 ph, 4 wire supply having phase voltage of 231 V at 50 Hz. Determine:

- (i) Line current
- (ii) Current in neutral wire
- (iii) Power drawn
- (iv) Power factor

Ans:

i) Line Current I_L:

Phase current $I_{ph} = V_{ph} / Z_{ph} = (231\angle 0°) / (14\angle 45°) = 16.5\angle -45°$ A

For star connection, Line current = Phase current — 1 Mark

$\therefore$ Line current = $\mathbf{I_L = 16.5\ A}$

ii) Current in neutral wire:

Since the 3-ph load is balanced and supply voltage is also balanced, the current in neutral wire $\mathbf{I_N = 0\ A}$ — 1 Mark

iii) Power factor:

Phase current is lagging behind the respective phase voltage by 45°.

$\therefore$ Power factor = cos(45°) = **0.707 lagging** — 1 Mark

iv) Power Drawn:

Power = $3V_{ph}I_{ph}cos\emptyset$ = 3 (231)(16.5)cos(45°) = **8084.19 W** — 1 Mark

4 c) A 3ph Y connected load having R= 15Ω, L=0.04H, C = 50μF in each phase. It is supplied by 440V, 3ph, 50Hz AC. Find:

- **i)** ~~2pH~~ Z_{ph}
- **ii)** Line current
- **iii)** Power factor
- **iv)** Power Consumed.

Ans:

Data Given: R=15Ω, L=0.04H, C=50μF, V= 440V, f=50Hz.

In star connected load $V_L = \sqrt{3}$ Vph and I_L = Iph.

$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{440}{\sqrt{3}} = 254.034$ V

The Capacitive reactance is given by, $Xc = \frac{1}{2\pi fC}$

$$= \frac{1}{2\pi(50)(50 \times 10^{-6})}$$

$$= 63.69\Omega.$$

The inductive reactance is given by, $X_L = 2\pi fL$

$= 2\times 3.14 \times 50 \times 0.04$

$= 12.56\Omega.$

i) Impedance per phase:

$Z_{ph} = R + j(X_L - X_C).$

$Z_{ph} = 15+j(12.56 - 63.69)$

$= \mathbf{15 - j51.13 = 53.28\angle -73.64°\Omega}$ — 1 Mark

ii) Line Current:

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{254.034\angle 0°}{53.28\angle -73.64°} = \mathbf{4.76\ \angle 73.64\ °A}$$

In Star connection Line current = Phase current

$\therefore$ Line current $\mathbf{I_L = I_{ph} = 4.76\ A}$ 1 Mark

iii) Power factor:

$\cos\phi = \frac{Rph}{Zph} = \frac{15}{53.28} =$ **0.28 (lead).** 1 Mark

iv) Power Consumed:

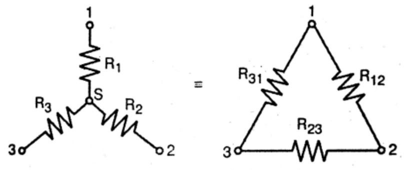
$P = \sqrt{3}\, V_L I_L \cos\phi = \sqrt{3}(440)(4.76)(0.28)$ 1 Mark

$=\mathbf{1015.73\ W}$

4 d) Derive the relation for star to delta transformation.

Ans:

Star-delta Transformation:



If the star circuit and delta circuit are equivalent, then the resistance between any two terminals of the circuit must be same.

For star circuit, resistance between terminals 1 & 2, say $R_{1\text{-}2} = R_1 + R_2$

For delta circuit, resistance between terminals 1 & 2, $R_{1\text{-}2} = R_{12}||(R_{31} + R_{23})$

$$\therefore R_1 + R_2 = R_{12}||(R_{31}+R_{23}) = \frac{R_{12}(R_{31}+R_{23})}{R_{12} + (R_{31}+R_{23})} = \frac{R_{12}(R_{31}+R_{23})}{R_{12}+R_{23} + R_{31}}$$

$$\therefore R_1 + R_2 = \frac{R_{12}R_{31}+R_{12}R_{23}}{R_{12}+R_{23} + R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Similarly, the resistance between terminals 2 & 3 can be equated as,

$$\therefore R_2 + R_3 = \frac{R_{12}R_{23} + R_{23}R_{31}}{R_{12}+R_{23} + R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

And the resistance between terminals 3 & 1 can be equated as,

$$\therefore R_3 + R_1 = \frac{R_{23}R_{31} + R_{12}R_{31}}{R_{12}+R_{23} + R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Subtracting eq. (2) from eq.(1),

$$\therefore R_1 - R_3 = \frac{R_{12}R_{31} - R_{23}R_{31}}{R_{12}+R_{23} + R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Adding eq.(3) and eq.(4) and dividing both sides by 2,

$$\therefore R_1 = \left[\frac{R_{12}R_{31}}{R_{12}+R_{23} + R_{31}}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

1 mark for (eq.5, 6 & 7)

Similarly, we can obtain,

$$\therefore R_2 = \left[\frac{R_{12}R_{23}}{R_{12}+R_{23} + R_{31}}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\therefore R_3 = \left[\frac{R_{31}R_{23}}{R_{12}+R_{23} + R_{31}}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Multiplying each two of eq.(5), (6) and (7),

$$\therefore R_1R_2 = \left[\frac{(R_{12})^2R_{31}\,R_{23}}{(R_{12}+R_{23}+R_{31})^2}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

$$\therefore R_2R_3 = \left[\frac{(R_{23})^2R_{31}\,R_{12}}{(R_{12}+R_{23}+R_{31})^2}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

$$\therefore R_3R_1 = \left[\frac{(R_{31})^2R_{12}\,R_{23}}{(R_{12}+R_{23}+R_{31})^2}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

1 mark for (eq.8, 9 & 10)

Adding the three equations (8), (9) and (10),

$$\therefore R_1R_2 + R_2R_3 + R_3R_1 = \frac{(R_{12})^2R_{31}\,R_{23}+(R_{23})^2R_{31}\,R_{12}+(R_{31})^2R_{12}\,R_{23}}{(R_{12}+R_{23}+R_{31})^2}$$

$$= \frac{R_{12}R_{31}\,R_{23}(R_{12}+R_{23}+R_{31})}{(R_{12}+R_{23}+R_{31})^2}$$

$$\therefore R_1R_2 + R_2R_3 + R_3R_1 = \frac{R_{12}R_{31}\,R_{23}}{R_{12}+R_{23}+R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

1 mark for eq. 11

Dividing eq.(11) by eq.(6), (dividing by respective sides)

$$\therefore R_1 + R_3 + \frac{R_3R_1}{R_2} = R_{31}$$

$$\therefore R_{31} = R_3 + R_1 + \frac{R_3R_1}{R_2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(12)$$

Similarly, we can obtain,

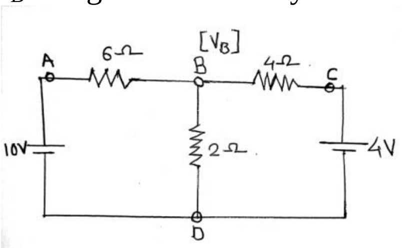
$$\therefore R_{12} = R_1 + R_2 + \frac{R_1R_2}{R_3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(13)$$

$$\therefore R_{23} = R_2 + R_3 + \frac{R_2R_3}{R_1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(14)$$

1 mark for (eq. 12, 13 & 14)

Thus using known star connected resistors R_1, R_2 and R_3, the unknown resistors R_{12}, R_{23} and R_{31} of equivalent delta connection can be determined.

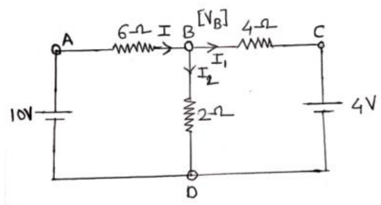
4 e) Calculate the node voltage V_B using the nodal analysis. Refer Figure No.4.



Find V_B By using (Nodal analysis).

Fig. No. 4

Ans:



1 Mark

Let the voltage at Node B be V_B

$I = I_1 + I_2$ — 1 Mark

$\frac{10-V_B}{6} = \frac{V_B-4}{4} + \frac{V_B}{2}$

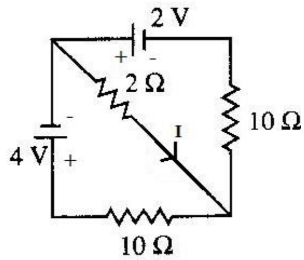
$\frac{10}{6} - \frac{V_B}{6} = \frac{V_B}{4} - 1 + \frac{V_B}{2}$

$\frac{10}{6} + 1 = \frac{V_B}{4} + \frac{V_B}{2} + \frac{V_B}{6}$ — 1 Mark

$\therefore \frac{16}{6} = \frac{11}{12} V_B$

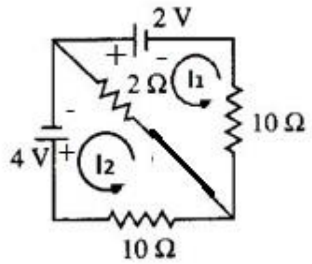
$\therefore V_B = 2.91$ volt — 1 Mark

4 f) Find current I through 2Ω using mesh analysis. Refer figure No: 5.



Find current I (By using Mesh analysis).
Fig. No. 5

Ans:
Analysis:



i) There are two meshes in the network.

ii) Mesh currents I_1 and I_2 are marked anti-clockwise as shown.

iii) By tracing mesh 1 anticlockwise, KVL equation is,

$2 - 2(I_1 - I_2) - 10I_1 = 0$

$\therefore 2 - 12I_1 + 2I_2 = 0$

$\therefore 12I_1 - 2I_2 = 2 \ldots\ldots\ldots\ldots\ldots (1)$ — 1 mark for Eq. (1)

By tracing mesh 2 anticlockwise, KVL equation is,

$4 - 10I_2 - 2(I_2 - I_1) = 0$

$4 - 12I_2 + 2I_1 = 0$

$\therefore 2I_1 - 12I_2 = -4 \ldots\ldots\ldots\ldots\ldots (2)$ — 1 mark for Eq. (2)

iv) Expressing eq.(1) and (2) in matrix form,

$$\begin{bmatrix} 12 & -2 \\ 2 & -12 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 2 \\ -4 \end{bmatrix}$$

$$\therefore \Delta = \begin{vmatrix} 12 & -2 \\ 2 & -12 \end{vmatrix} = -144 - (-4) = -140$$

By Cramer's rule,

$$I_1 = \frac{\begin{vmatrix} 2 & -2 \\ -4 & -12 \end{vmatrix}}{\Delta} = \frac{(2 \times -12) - (-4 \times -2)}{-140} = \frac{-24 - 8}{-140} = \mathbf{0.2286A}$$

1 mark for finding loop currents

$$I_2 = \frac{\begin{vmatrix} 12 & 2 \\ 2 & -4 \end{vmatrix}}{\Delta} = \frac{(12 \times -4) - (2 \times 2)}{-140} = \frac{-48 - 4}{-140} = \mathbf{0.3714\ A}$$ 1 Mark

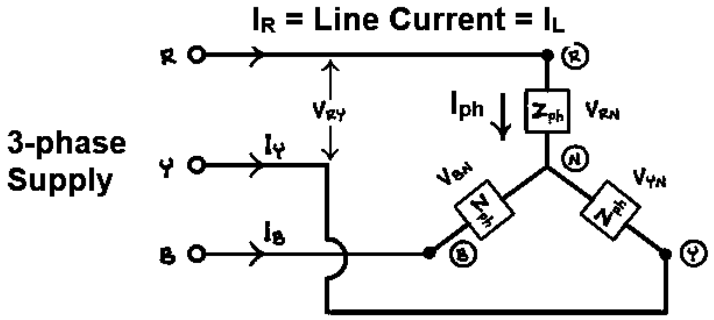
v) The current flowing through 2Ω is,
$I = I_1 - I_2 = 0.2286 - 0.3714 = -\mathbf{0.1428\ A}$
I = 0.1428 A in the direction of I_2.

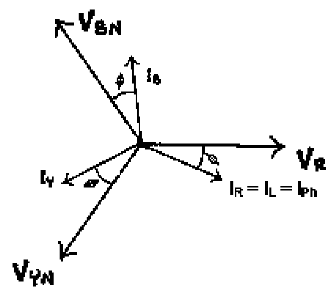
5 Attempt any TWO of the following: 16

5 a) With the help of necessary phasor diagram derive the relationship between line and phase current in balanced Y connected load, connected to 3ph AC supply.

Ans:

Relationship Between Line Current and Phase Current in Balanced Star Connected load:





2 Marks for circuit diagram

3 Marks for Phasor diagram

Let V_{RN}, V_{YN} and V_{BN} be the phase voltages.
V_{RY}, V_{YB} and V_{BR} be the line voltages.

Referring to the circuit diagram above, it is clear that the supply current I_R is the current flowing through line R, hence it is also termed as line current I_L. However, it is also clear that the same current further flows through the phase impedance Z_{ph} across which the phase voltage is V_{RN}. Therefore, this current is also termed as phase current I_{ph}. In phasor diagram, the phase voltages are drawn first with equal amplitude and displaced from each other by 120°. Then phase currents are drawn lagging behind the respective phase voltage by some angle ϕ, assuming inductive load. 3 Marks for explanation

Thus Line Current = Phase Current

$$I_L = I_{Ph}$$

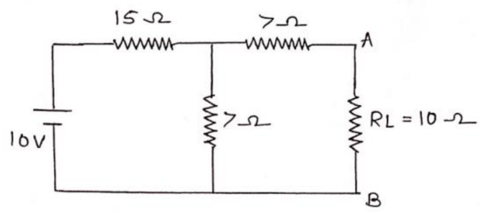
5 b) i) State Thevenins theorem and write its procedural steps to find current in a branch.(Assume any simple ckt)

Ans:

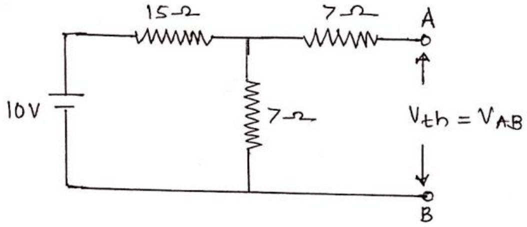
Thevenin's Theorem:

Any two terminal circuit having number of linear impedances and sources (voltage, current, dependent, independent) can be represented by a simple equivalent circuit consisting of a single voltage source V_{Th} in series with an impedance Z_{Th}, where the source voltage V_{Th} is equal to the open circuit voltage appearing across the two terminals due to internal sources of circuit and the series impedance Z_{Th} is equal to the impedance of the circuit while looking back into the circuit across the two terminals, when the internal independent voltage sources are replaced by short-circuits and independent current sources by open circuits. 2 Marks for statement

Procedural steps to find current in a branch using Thevenin's theorem:
Consider a simple circuit shown below in which we need to find the current flowing through 10Ω resistor.

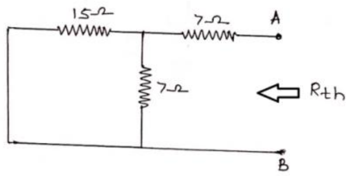


Step I: Identify the load branch: It is the branch whose current is to be determined.
Step II: Calculation of V_{Th}: Remove R_L and find open circuit voltage across the load terminals A and B.

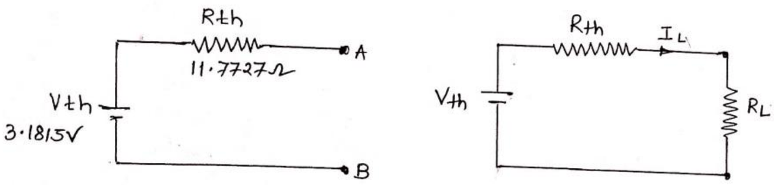


2 Marks for stepwise procedure

Current through circuit will be =10/(15+7)=0.45 Amp
$V_{OC} = V_{Th} = V_{AB} = 0.45 \times 7 = 3.18$ V
Step III: Calculation of R_{Th}:

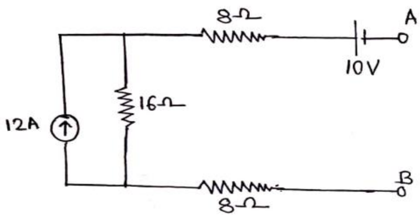


Resistances 15 & 7 are in parallel =15 x 7/(15+7)=4.77 Ω
R_{Th}= 7+4.77=11.77 Ω
Step IV: Thevenin's equivalent circuit:



Step V: Determination of Load current:
$I_L = V_{Th}/(R_{Th}+R_L) = 3.18/(11.77+10) = 0.146$ Amp

5 b) ii) Develop Thevenins equivalent across A and B in the network shown in Figure No:6

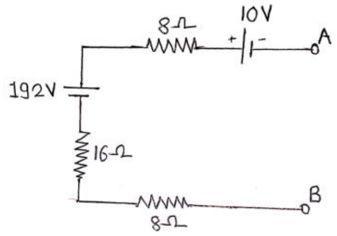


Find Thevenin's equivalent circuit
Fig. No. 6

Model Answers
Winter – 2019 Examinations
Subject & Code: Electrical Circuits & Networks (17323)

Ans:

1) Converting current source of 12A with 16Ω as internal resistance into voltage source V = 12×16 = 192V.

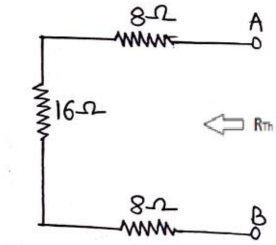


1 Mark

2) Determination of Thevenin's equivalent voltage V_{Th}:
Due to open circuit between A & B, the current is zero and voltage drop across all resistors is zero. The open circuit voltage between A & B can be obtained by KVL as,
$V_{AB} = 8(0) + 16(0) + 192 + 8(0) – 10 = 182$
$\therefore V_{Th} = V_{AB} = 182V$.

1 Mark

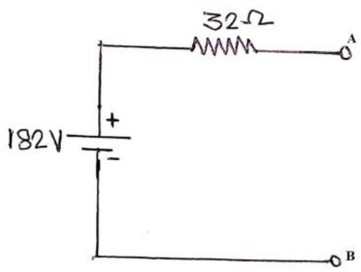
3) Determination of Thevenin's equivalent resistance R_{Th}:
It is the resistance seen between the open circuited terminals A & B with all internal independent voltage sources replaced by short circuit and all internal independent current sources by open circuit.



1 Mark

$R_{Th} = 8 + 16 + 8 = 32Ω$

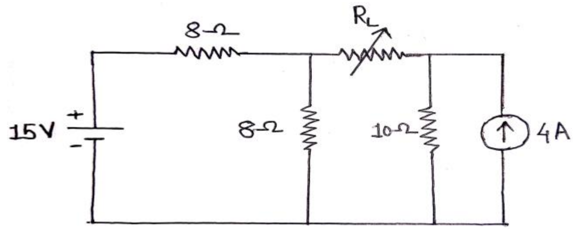
4) Thevenin's Equivalent Circuit:



1 Mark

Model Answers
Winter – 2019 Examinations
Subject & Code: Electrical Circuits & Networks (17323)

5 c) State the maximum power transfer theorem. In following network shown in Figure No: 7, find the value of R_L so that maximum power will transfer through it and also calculate this power.



Calculate R_L (By using Max power transfer theorem)
Fig. No. 7

Ans:

Maximum Power Transfer Theorem:

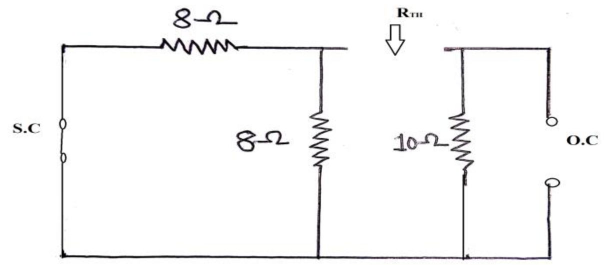
The maximum power transfer theorem states that the source or a network transfers maximum power to load only when the load resistance is equal to the internal resistance of the source or the network.

The internal resistance of the network is the Thevenin equivalent resistance of the network seen between the terminals at which the load is connected when:

2 Marks for statement

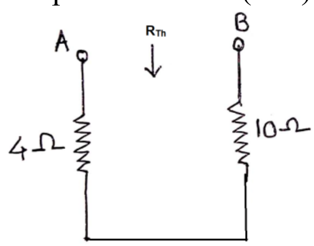
i) The load is removed (disconnected)
ii) All internal independent sources are replaced by their internal resistances.

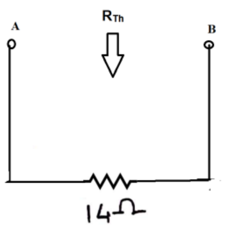
Maximum power will be transferred when load resistance is equal to internal resistance i.e. R_L=R_{Th}



Resistances of 6&4 are in parallel = 8×8/(8+8)= 4 Ω and circuit is simplified as

2 Marks for finding R_L = R_{Th}





R_{Th}=4+10= 14 Ω

Hence in the given circuit maximum power will be transferred when

R_L= R_{Th}=14Ω

Maximum Power Calculations:

Maximum power transferred to load resistance R_L can be obtained by first simplifying the circuit into its Thevenin's equivalent circuit.

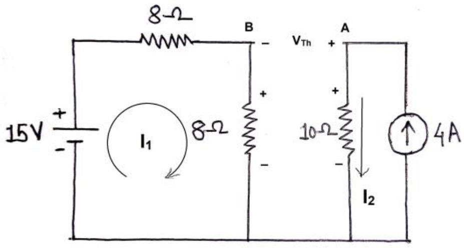
A) Determination of Thevenin's equivalent source V_{Th}:

Current through 8Ω is I_1 = 15/(8+8) = 15/16 = 0.9375A

Current through 10Ω is I_2 = 4A

By KVL, we can write $V_{Th} = V_{AB} = 10\ I_2 - 8\ I_1 = 10(4) - 8(0.9375) = 40 - 7.5$ — 2 Marks for finding V_{Th}

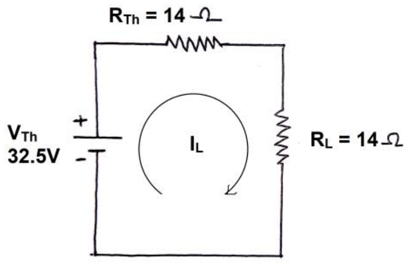
$$\mathbf{V_{Th} = 32.5V}$$



B) Determination of Thevenin's equivalent resistance T_{Th}:

It is already determined. R_{Th} = 14Ω

C) Thevenin's Equivalent Circuit:



The load current is given by, $I_L = V_{Th}/(R_{Th}+R_L) = 32.5 / (14+14)$ — 1 Mark for I_L

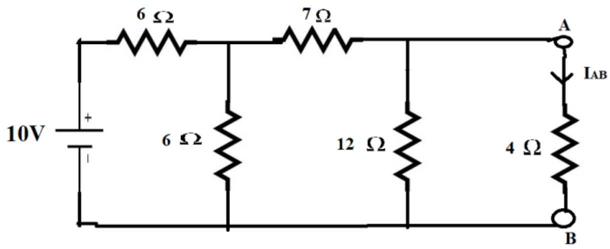
= 1.16 A

Maximum power transferred to load is given by, $P_{max} = I_L^2 \times R_L$ — 1 Mark for P_{max}

$P_{max} = (1.16)^2(14) =$ **18.84 W**

6 Attempt any FOUR of the following: 16

6 a) Find current I_{AB} flowing through 4Ω resistance using Norton's theorem as shown in Figure No. 8



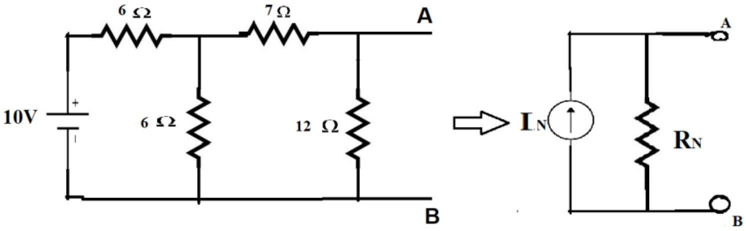
Calculate I_{AB} (By using Norton's theorem)

Fig. No. 8

Ans:

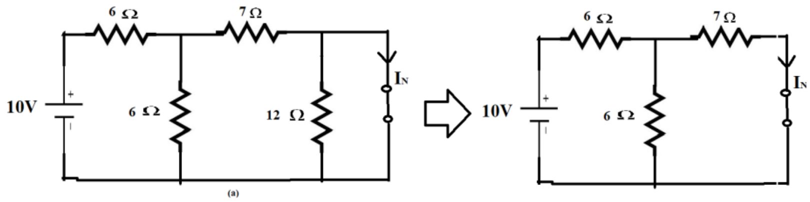
Norton's Theorem:

According to Norton's theorem, the circuit between load terminals excluding load resistance can be represented by simple circuit consisting of a current source I_N in parallel with a resistance R_N, as shown in the following figure.



Determination of Norton's Equivalent Current Source (I_N):

Norton's equivalent current source I_N is the current flowing through a short-circuit across the load terminals due to internal sources, as shown in fig.(a).



1 Mark

Total resistance across 10V source is,

$$R = 6 + (6||7) = 6 + \frac{(7 \times 6)}{6 + 7} = 9.23\,\Omega$$

Therefore, current supplied by source,

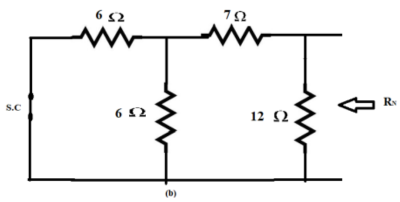
$$I = \frac{V}{R} = \frac{10}{9.23} = 1.083\text{ A}$$

The resistances 7Ω and 6Ω are in parallel. By current division, the current flowing through 7Ω is same as I_N.

$$\mathbf{I_N} = I\frac{6}{7+6} = (1.083)\frac{6}{13} = \mathbf{0.5A}$$ 1 Mark for I_N

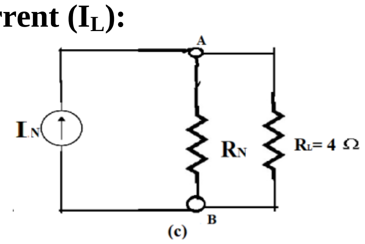
Determination of Norton's Equivalent Resistance (R_N):

Norton's equivalent resistance is the resistance seen between the load terminals while looking back into the network, with internal independent voltage sources replaced by short-circuit and independent current sources replaced by open-circuit. Referring to fig.(b),



$$\mathbf{R_N} = 12||(7 + (6||6)) = 12||(7+3) = 12||10 = \frac{12 \times 10}{12 + 10} = \mathbf{5.45\Omega}$$ 1 Mark for R_N

Determination of Load Current (I_L):

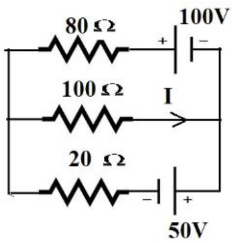


1 Mark for I_L

Referring to fig.(c), the load current is

$$\mathbf{I_L} = I_N\frac{R_N}{R_N + R_L} = 0.5\frac{5.45}{5.45+4} = \mathbf{0.288\ A}$$

6 b) Apply superposition theorem shown in Figure No. 9 for determinig the current I in 100Ω resistance.

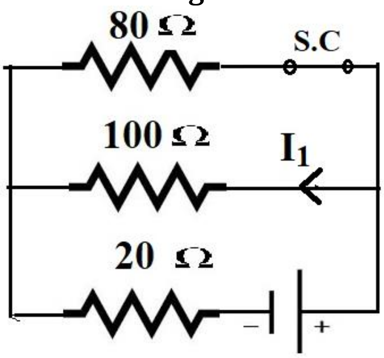


Calculate I (By using Superposition theorem)

Fig. No. 9

Ans:

(A) Consider Voltage source of 50V acting alone:



½ Mark for circuit diagram

The total resistance appearing in series with 20Ω is given by

$=80||100=\frac{80\times100}{80+100}=44.44\Omega$.

Total resistance acrioss 509V source is = 20+44.44=64.44Ω

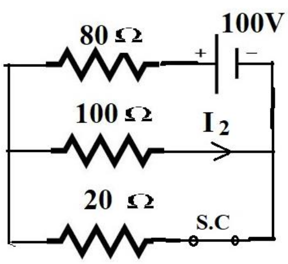
The current I = 50/64.44=0.7759A.

∴ Current flowing through 100Ω resistor is

$$I_1= I\times\frac{80}{80+100}=0.7759\times\frac{80}{180}=\mathbf{0.3448}\boldsymbol{A}$$

1 Mark for I_1

(B) Consider Voltage source of 100V Acting alone:



½ Mark for circuit diagram

The total resistance appearing in series with 80Ω is given by

$=20||100=\frac{20\times100}{20+100}=16.67\Omega$.

Total resistance across 100V source is = 80+16.67 =96.67Ω

The current I = 100/96.67=1.0344A.

∴ Current flowing through 100Ω resistor is

$$I_2= I\times\frac{20}{20+100}=1.0344\times\frac{20}{120}=\mathbf{0.172}\boldsymbol{A}$$

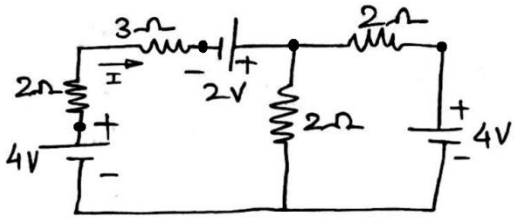
1 Mark for I_2

By Superposition theorem, the current through 100Ω due to both sources is given by,

$I=I_2-I_1=(0.172 - 0.3448) = $ **- 0.1724A**

1 Mark for I

6 c) Using Nodal voltage method, find the current I in the 3Ω resistance in Figure No: 10

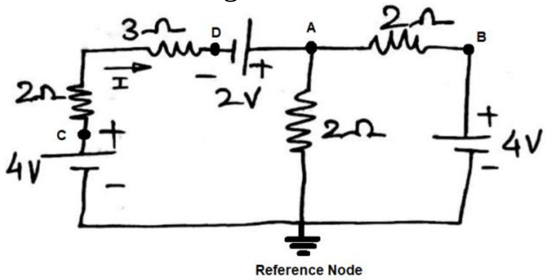


Calculate I (By using Node voltage method)

Fig. No. 10

Ans:

The nodes are marked on the circuit diagram as follows:



½ Mark for node marking

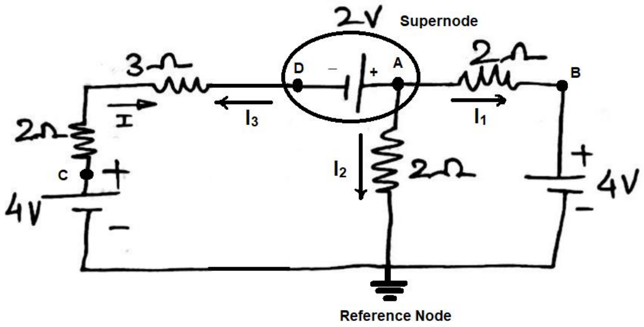
The node voltage can be identified as:

$V_C = 4V$ $V_B = 4\ V$ $V_{AD} = V_A - V_D = 2V$

½ Mark for node voltage identification

$\therefore V_D = (V_A - 2)$

Considering **Supernode** consisting of node A, node D and 2V source as shown below, the node voltage equation at supernode can be written as:



1 Mark for diagram

$$I_1+I_2+I_3=0$$

$$\frac{V_A - V_B}{2} + \frac{V_A}{2} + \frac{V_D - V_C}{(2+3)} = 0$$

$$\frac{V_A - 4}{2} + \frac{V_A}{2} + \frac{(V_A - 2) - 4}{(2+3)} = 0$$

$$V_A\left[\frac{1}{2} + \frac{1}{2} + \frac{1}{5}\right] - \frac{4}{2} - \frac{6}{5} = 0$$

$$V_A\left[\frac{12}{10}\right] = \frac{4}{2} + \frac{6}{5}$$

$$V_A[1.2] = 3.2$$

$$\therefore V_A = 2.67\ V$$

1 Mark for stepwise calculation of V_A

$\therefore V_D = (V_A - 2) = (2.67 - 2) = 0.67\ V$

Current through 3 Ω resistor, $I = (V_C - V_D)/(2+3) = (4 - 0.67)/5 = 0.666A$

I = 0.666A

1 Mark for stepwise solutuion of I

6 d) Current drawn by a 3ph Y connected load of 10Amp, 0.87 PF lagging when connected across 3ph, 440V AC supply. Find active, reactive and apparent power.

Ans:

Data given:

Line Voltage V_L = 440V

Line current I_L = Phase current I_{Ph} = 10 A for star connection

Power factor cosϕ = 0.87 lagging $\therefore$ sinϕ = 0.493 — 1 Mark

i) Active power P = $\sqrt{3}V_L I_L cos\emptyset = \sqrt{3}(440)(10)(0.87) = \mathbf{6630.29\ W}$ — 1 Mark

ii) Reactive power Q = $\sqrt{3}V_L I_L sin\emptyset = \sqrt{3}(440)(10)(0.493) = \mathbf{3757.16\ VAr}$ — 1 Mark

iii) Apparent power S = $\sqrt{3}V_L I_L = \sqrt{3}(440)(10) = \mathbf{7621.023\ VA}$ — 1 Mark

6 e) Explain the concept of initial condition switching circuit for the R, L & C.

Ans:

For the three basic circuit elements the initial conditions are used in following way:

i) Resistor:

At any time it acts like resistor only, with no change in condition. — ½ Mark

ii) Inductor:

The current through an inductor cannot change instantly. If the inductor current is zero just before switching, then whatever may be the applied voltage, just after switching the inductor current will remain zero. i.e the inductor must be acting as open-circuit at instant t = 0. If the inductor current is I_0 before switching, then just after switching the inductor current will remain same as I_0, and having stored energy hence it is represented by a current source of value I_0 in parallel with open circuit. — 1½ Mark

As time passes the inductor current slowly rises and finally it becomes constant. Therefore the voltage across the inductor falls to zero$\left[v_L = L\frac{di_L}{dt} = 0\right]$.

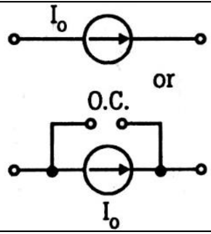
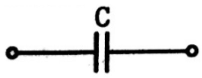
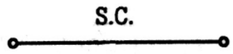
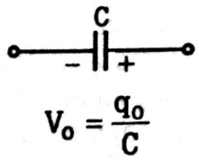
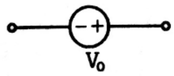
iii) Capacitor:

The voltage across capacitorcannot change instantly.If the capacitor voltage is zero initially just before switching, then whatever may be the current flowing, just after switching the capacitor voltage will remain zero. i.e the capacitor must be acting as short-circuit at instant t = 0. If capacitor is previously charged to some voltage V_0, then also after switching at t = 0, the voltage across capacitor remains same V_0. Since the energy is stored in the capacitor, it is represented by a voltage source V_0 in series with short-circuit. — 1½ Mark

As time passes the capacitor voltage slowly rises and finally it becomes constant. Therefore the current through the capacitor falls to zero$\left[i_C = C\frac{dv_C}{dt} = 0\right]$.

The initial conditions are summarized in following table:

Element and condition at $t = 0^-$	Initial Condition at $t = 0^+$
R	R
L	O.C.

6 f) Define RMS value and average value of AC quantities. State the ~~RMV~~ RMS value and average value in terms of maximum value of sinusoidal waveform.

Ans:

1) **RMS Value:** The RMS value is the Root Mean Square value. It is defined as the square root of the mean value of the squares of the instantaneous values of alternating quantity over one cycle. 1Mark

OR

For an alternating current, the RMS value is defined as that value of steady current (DC) which produces the same power or heat as is produced by the alternating current during the same time under the same conditions.

RMS Value = 0.707 × Maximum value 1 Mark

2) **Average Value**: The Average value is defined as the arithmetical average or mean of all the instantaneous values of an alternating quantity over one cycle. 1 Mark

OR

For an alternating current , the average value is defined as that value of steady current (DC) which transfers the same charge as is transferred by the alternating current during the same time under the same conditions.

Average Value = 0.637 × Maximum value 1 Mark