Summer – 2017 Examinations

Model Answer **Subject Code: 17323 (ECN)**

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 should assess the understanding level of the candidate.

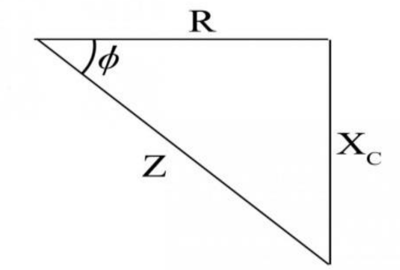
3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).

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 should give credit for any equivalent figure/figures drawn.

5) Credits to 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 (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment 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

1	**Attempt any TEN of the following:**	20
1 a)	Define frequency and amplitude. **Ans:** **i) Frequency:** It is defined as number of cycles completed by alternating quantity in one second. ii) **Amplitude:** A maximum value or peak value attained by an alternating quantity during positive or negative half cycle is called as its amplitude.	1 Mark 1 Mark
1 b)	Define crest factor and form factor for sinusoidal A.C. **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 $= \frac{Peak\ Value}{RMS\ Value}$ **ii) Form Factor:** It is defined as the ratio ofRMS value to average value of an alternating quantity. Form factor $= \frac{RMS\ Value}{Average\ Value}$	1 Mark 1 Mark
1 c)	Draw impedance triangle for R-C series circuit. Write nature of power factor. **Ans:** **Impedance triangle for R-C series circuit:**  The nature of power factor of RC series circuit is leading.	1 Mark 1 Mark
1 d)	Convert Z= 6+j8Ω in polar form. **Ans:** $Z = \sqrt{6^2 + 8^2} = 10 \quad and \quad \emptyset = \angle tan^{-1}\frac{8}{6} = 53.13$ $= 10 \angle 53.123^0\ \Omega$	1 Mark 1 Mark
1 e)	Define Q factor. Give equation of it. **Ans:** **Quality Factor:** The quality factor basically represents a figure of merit of a component (practical inductor or capacitor) or a complete circuit. It is a dimensionless number and defined as: $Q = 2\pi\left[\frac{Maximum\ energy\ stored}{Energy\ dissipated\ per\ cycle}\right]$ **OR**	1 Mark

In series circuit it is defined as voltage magnification in the circuit at resonance

OR

It is also defined as the ratio of the reactive power of either the inductor or the capacitor to the average power of the resistor.

OR

In parallel circuit it is defined as equal to the current magnification in the circuit at resonance

OR

The quality factor or Q-factor of parallel circuit is defined as the ratio of the current circulating between two branches of the circuit to the current taken by the parallel circuit from the source.

Expression of Q Factor:

$$Q\ factor = voltage\ magnification = \frac{1}{R}\sqrt{\frac{L}{C}}$$ 1 Mark

OR

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

1 f) Define admittance and state its unit.

Ans:

Admittance is defined as the ability of the circuit to carry (admit) alternating current through it. 1Mark for definition

OR

It is the reciprocal of impedance Z. i.e Admittance Y = 1/Z.

Unit: Its unit is siemen (S) or mho (℧). 1Mark for unit

1 g) Define balanced 3 phase load.

Ans:

Balanced 3 phase Load:

Balanced three phase load is defined as star or delta connection of three equal impedances having equal real parts and equal imaginary parts. 2Marks

It takes same current of equal magnitude and equal phase angle.

1 h) State the relation between line and phase values of voltage and current in 3 phase star connected system.

Ans:

Star Connection:

$$\text{Line voltage} = \sqrt{3}\ (\text{Phase Voltage})$$
$$\text{i.e.} V_L = \sqrt{3} V_{ph}$$ 1 Mark

$$\text{Line current} = \text{Phase current}$$
$$\text{i.e.}\ I_L = I_{ph}$$ 1 Mark

1 i) State Superposition Theorem.

Ans:

Superposition Theorem:

In any linear, bilateral, multisource network the voltage across or the current through any branch is given by algebraic sum of all individual 2 Marks voltages or currents caused by the separate independent sources acting alone with all other sources replaced by their internal resistances if any.

1 j) State Thevenin's Theorem.

Ans:

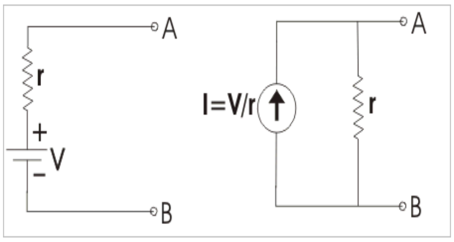
Thevenin's Theorem:

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 sources are replaced by their internal impedances. 2 Marks

1 k) How to convert voltage source into equivalent current source?

Ans:

Conversion of voltage source into equivalent current source:



1 Mark

Step I Calculate equivalent current by using formula $I = \frac{V}{r}$

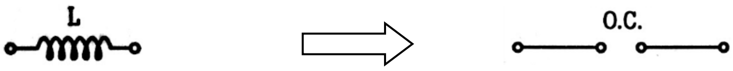
Step II Keep same resistance r in parallel with current source. 1 Mark

1 l) State the behavior of pure L at the time of switching.

Ans:

Behavior of pure L at the time of switching:

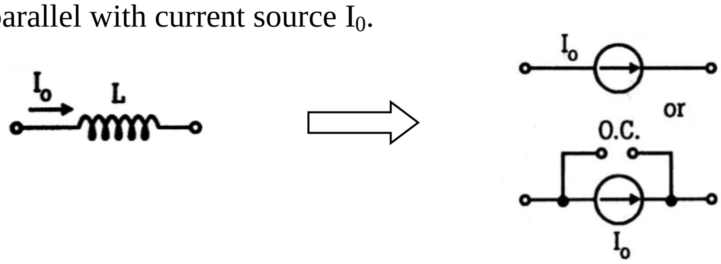
i) The pure inductor, carrying zero current prior to switching, acts as OPEN CIRCUIT.



1 Mark

OR

ii) The pure inductor, carrying some current, say I_0, prior to switching, acts as a current source I_0 or an Open Circuit in parallel with current source I_0.



1 Mark

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

2 a) Derive the expression for current in pure capacitive circuit when connected to AC supply. Draw phasor diagram.

Ans:

Expression for current in Pure Capacitance:

The alternating voltage causes alternating current in the capacitor.

Let an alternating voltage applied across capacitor be

$\boldsymbol{v = V_m \sin(\omega t)} \dots\dots\dots\dots\dots\dots\dots\dots (\boldsymbol{i})$ 1 Mark

The resulting current is given by,

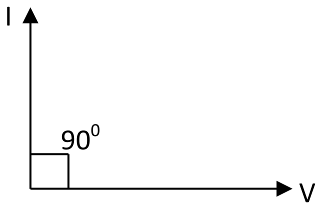
$$i = C\frac{dv}{dt}$$

$$i = C\frac{dv}{dt} = C\frac{d}{dt}(V_m\, sin\omega t)$$ 1 Mark

$$= \omega C V_m cos\omega t = (\omega C V_m)\sin\left(\omega t + \frac{\pi}{2}\right) = \frac{V_m}{\left(\frac{1}{\omega C}\right)}\sin\left(\omega t + \frac{\pi}{2}\right)$$

$$\therefore \boldsymbol{i = I_m sin\left(\omega t + \frac{\pi}{2}\right)} \quad \dots\dots\dots\dots\dots .(\boldsymbol{ii})$$ 1 Mark

Referring to eq. (i) and (ii), it is clear that in case of pure capacitor, the voltage lags behind the current by 90° or (π/2) rad or the current leads the voltage by 90° or (π/2) rad.



1 Mark

2 b) Define:-

i) Active Power
ii) Reactive Power
iii) Apparent Power
iv) Power factor

Ans:

(i) Active Power:

Active power (P) is the product of voltage, current and the cosine of the phase angle between voltage and current.
Unit: watt (W) or kilo-watt (kW) or Mega-watt (MW)

$$P = VIcos\emptyset = I^2R \text{ watt}$$

(ii) Reactive Power:

Reactive power (Q) is 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)

$$Q = VIsin\emptyset = I^2X \text{ volt-amp-reactive}$$

1 Mark for each definition

(iii) 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-vol-ampere (MVA)

$$S = VI = I^2Z \text{ volt-amp}$$

(iv) **Power Factor:**
It is the cosine of the angle between the applied voltage and the resulting current.
Power factor = cosϕ
where, ϕ is the phase angle between applied voltage and current.

OR

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

$$\text{Power factor} = \frac{\text{True Or Effective Or Real Power}}{\text{Apparent Power}} = \frac{\text{VIcos}\emptyset}{\text{VI}} = \cos\emptyset$$

OR

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

$$\text{Power factor} = \frac{\text{Circuit Resistance}}{\text{Circuit Impedance}} = \frac{R}{Z} = \cos\emptyset$$

2 c) Three identical impedances are connected in delta to a 3 phase, 400v. The line current is 35 Amp. And total power taken from supply is 15 KW. Calculate resistance and reactance of each phase.

Ans:

Data Given: V_L= 400v, I_L= 35Amp, Total power taken= 15 KW.

For delta connection $V_L = V_{ph}$ = 400v.

$$I_L = \sqrt{3}\, Iph$$

$$Iph = \frac{I_L}{\sqrt{3}} = \frac{35}{\sqrt{3}} = 20.2072 Amp$$ 1 Mark

Therefore $Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{400}{20.2072} = 19.7949\ \Omega$ 1 Mark

Total active power $P = 3I_{Ph}^2 R_{ph} = 15000\ W$

$$Resistance\ per\ phase\ \ (R_{ph}) = \frac{15000}{3I_{Ph}^2}$$

$$= \frac{15000}{3 \times 20.2072^2} \qquad = 12.2449\ \Omega$$ 1 Mark

$$Reactance\ per\ phase\ (X_{ph}) = \sqrt{Z_{Ph}^2 - R_{Ph}^2}$$

$$= \sqrt{19.7949^2 - 12.2449^2}$$ 1 Mark

$$= \sqrt{391.8380 - 150.0600} = \sqrt{241.778} = 15.5492\Omega$$

OR

Calculate cosØ then R= Z cosØ and X = Z sinØ

2 d) Compare series and parallel resonant circuit.

Ans:

Comparison between series and parallel resonant circuit:

Sr. No	Series resonant Circuit	Parallel resonant Circuit

1	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, $f_r = \frac{1}{2\pi\sqrt{LC}}$	
2	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	Any four points 1 Mark each = 4 Marks
3	At resonance, series RLC circuit draws maximum current from source, I = (V/R)	At resonance, parallel RLC circuit draws minimum current from source, $I = \frac{V}{[L/_{CR}]}$	
4	At resonance, in series RLC circuit, voltage magnification takes place.	At resonance, in parallel RLC circuit, current magnification takes place.	
5	The Q-factor for series resonant circuit is $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	The Q-factor for parallel resonant circuit is, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	
6	Series RLC resonant circuit is Accepter circuit.	Parallel RLC resonant circuit is Rejecter circuit.	

2 e) Define r.m.s. value and average value. An alternating voltage is e = 200sin314t. Calculate its r.m.s. value and average value

Ans:

RMS Value of Sinusoidal AC Waveform:

For an alternating current, the RMS value is defined as that value of steady current (DC) flowing through a resistor which produces the same heat as is produced by the alternating current during the same time under the same conditions. 1 Mark

OR

It is the square-root of the mean or average of squares of all the values of an alternating quantity over a period of one cycle.

Average Value of Sinusoidal AC Waveform:

The average value is defined as the arithmetical average or mean value of all the values of an alternating quantity over one cycle. 1 Mark

Given e = 200sin314t volts

$R.M.S.value = 0.707 \times Max.value = 0.707 \times 200 = 141.4\ volts$ 1 Mark

$Averagevalue = 0.637 \times Max.value = 0.637 \times 200 = 127.4\ volts$ 1 Mark

2 f) State any four advantages of Polyphase circuits over single phase circuit.

Ans:

Advantages and of Polyphase circuits over Single phase circuit:

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 power rating.

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

1 Mark for each (any 4) = 4 Marks

3 **Attempt any <u>TWO</u> of the following:** 16

3 a) A resistance of 20 Ω, an inductance of 0.2 H and a capacitance of 100µf are connected in series across 220 V, 50 Hz supply. Determine (i) impedance, (ii) current, (iii) active power, (iv) apparent power.

Ans:

(i) L = 0.2H, $X_L = 2\pi f L = 2 \times \pi \times 50 \times 0.2 = 62.83\ \Omega$ — $X_L = 1$ M

C= 100 µF, $X_c = \frac{1}{2\pi f C} = \frac{1}{2\times\pi\times 50\times 100\times 10^{-6}} = 31.83\ \Omega$ — X_c =1 M

Z= $\sqrt{R^2 + (X_L - X_C)^2}$ = 36.891 Ω — Z = 1M

(ii) $I = \frac{V}{Z} = \frac{220}{36.891}$ = 5.96 Amp — I = 2 M

Cos φ = $\frac{R}{Z} = \frac{20}{36.891}$ = 0.542 — PF = 1 M

(iii) Active Power= P= VI Cos φ = 220 x5.96 x 0.542 = 710.67 watts — P =1 M

Or $P = I^2R = 5.96^2 x20$ = 710.43 watts

(iv) Apparent Power = S = VI = 1311.2 VA — S = 1 M

3 b) Two impedances (12 + j16) and (10 - j20) Ω are connected in parallel across a supply of 200∠60° using admittance method. Calculate branch current, total current and power factor of whole circuit.

Ans:

V= 200∠60° volts

$$Y_1 = \frac{R_1}{R_1^2 + X_L^2} - j\frac{X_L}{R_1^2 + X_L^2} = \frac{12}{12^2 + 16^2} - j\frac{16}{12^2 + 16^2}$$

= 0.03 - j0.04 = 0.05∠-53.13° — Y_1=1M

$$Y_2 = \frac{R_2}{R_1^2 + X_C^2} + j\frac{X_c}{R_1^2 + X_C^2} = \frac{10}{10^2 + 20^2} + j\frac{20}{10^2 + 20^2}$$

$= 0.02 + j0.04 = 0.044 \angle 63.43°$ Y_2 = 1M

$Y = Y_1 + Y_2 = G + jB = 0.03 - j0.04 + 0.02 + j0.04 = 0.05 - j0 = 0.05 \angle 0°$

(i) Current I_1 flowing through admittance Y_1,
$= V \times Y_1 = (200\angle 60°) \times (0.05\angle -53.13°)$ Y = 1M
$I_1 = 10\angle 6.87°$ amp

(ii) Current I_2 flowing through admittance Y_2,
$= V \times Y_2 = (200\angle 60°) \times (0.044\angle 63.63°)$ I_1 = 1 M
$I_2 = 8.8\angle 123.23°$ amp

Total Current $I = V \times Y = (200\angle 60°) \times (0.05\angle 0°) = 10\angle 60°$ amp
OR $I = I_1 + I_2$ I_2 = 1 M

Power factor angle Ø = voltage ref. angle - current angle = 60 – 60 = 0°
Therefore, Power factor = cos (0°) =1 I = 1 M

Ø = 1 M
Pf = 1 M

3c) Using Nodal Analysis, find current in the 3 Ω resistor for circuit A. Refer Fig. No. 1.

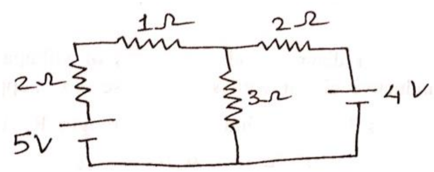
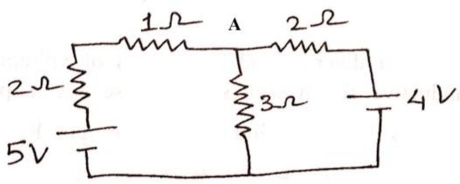


Fig. No. 1

Ans:



1 Mark

By applying KCL to Node A

$$\frac{V_A - 5}{2+1} + \frac{V_A}{3} + \frac{V_A - 4}{2} = 0$$ 2 Marks

$$\frac{V_A - 5}{3} + \frac{V_A}{3} + \frac{V_A - 4}{2} = 0$$

$$\frac{2V_A - 10 + 2V_A + 3V_A - 12}{6} = 0$$ 1 Mark

$$\frac{7V_A - 22}{6} = 0$$ 2 Mark

$$V_A = \frac{22}{7} = 3.14 \text{ volts}$$

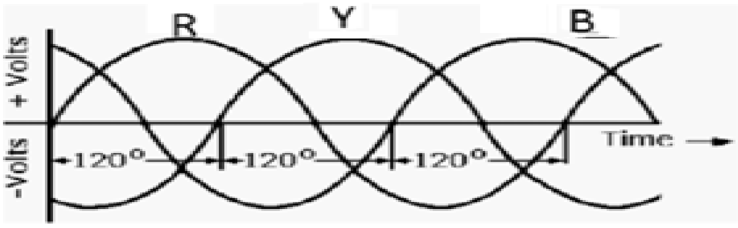
Current flowing through resistance 3 Ω = $\frac{V_A}{3} = 1.04$ Amp 2 Mark.

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

4 a) What is Phase sequence? Draw waveforms of 3 phase emf.

Ans:

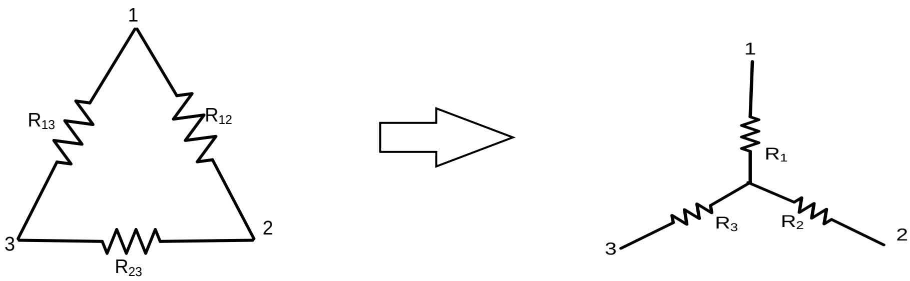
Phase sequence: It is the order in which the three phases reach their peak or maximum values. It is shown in below fig. the phase sequence is A-B-C (or R-Y-B). In the following waveforms, it is seen that the R-phase voltage attains the positive maximum value first, and after angular distance of 120º, Y-phase voltage attains its positive maximum and further after 120º, B- phase voltage attains its positive maximum value. So the phase sequence is R-Y-B. 2Marks



Waveforms 2 Marks

4 b) Derive the formulae for delta to star transformation.

Ans:



1 Mark

Delta connection Equivalent star connection

R_{12} , R_{23} and R_{32} connected in delta fashion between terminals 1, 2 and 3.

It is possible to replace delta by its equivalent star circuit.

Considering terminals 1 and 2, Resistance R_{12} parallel with ($R_{23}+R_{31}$) , Hence resistance between terminals 1 and 2 1 Mark

$$\frac{R_{12}(R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

In Case of Star Network Resistance between terminals 1 and 2 is

$$= R_1 + R_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

For equivalence between two networks, equating Equation (1) & (2)

$$R_1 + R_2 = \frac{R_{12}(R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$R_2 + R_3 = \frac{R_{23}(R_{31}+R_{12})}{R_{12}+R_{23}+R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$R_3 + R_1 = \frac{R_{31}(R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

By subtracting equation (4) from (3)

$$R_1 - R_3 = \frac{R_{12}R_{23} + R_{12}R_{31} - R_{23}R_{31} - R_{23}R_{12}}{R_{12} + R_{23} + R_{31}}$$

$$R_1 - R_3 = \frac{R_{12}R_{31} - R_{23}R_{31}}{R_{12}+R_{23}+R_{31}} \ldots\ldots\ldots\ldots\ldots\ldots(6)$$ 1 Mark

By adding equation (5) & (6)

$$2R_1 = \frac{R_{31}R_{12} + R_{31}R_{23} + R_{12}R_{31} - R_{23}R_{31}}{R_{12} + R_{23} + R_{31}}$$

Equivalent star resistances for delta connection

$$R_1 = \frac{R_{12}R_{31}}{R_{12} + R_{23} + R_{31}}$$ 1 Mark

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

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

4 c) A voltage $v = 100 \sin 314t$ is applied across a circuit containing 25 Ω resistor and 80 μF capacitor in series. Determine (i) The expression for instantaneous current (ii) Power consumed

Ans:

$$v = 100 \sin 314t$$

$$X_c = \frac{1}{\omega C} = \frac{1}{314 \times 80 \times 10^{-6}} = \mathbf{39.80\ \Omega}$$ ½ Mark

$$\mathbf{Z} = \sqrt{R^2 + {X_C}^2} = \sqrt{25^2 + 39.80^2} = \mathbf{47.00\ \Omega}$$ ½ Mark

$$\boldsymbol{I_m} = \frac{V_m}{Z} = \frac{100}{47} = \mathbf{2.12\ Amp}$$ ½ Mark

$$\emptyset = tan^{-1}\left(\frac{X_c}{R}\right) = tan^{-1}\left(\frac{39.80}{25}\right) = 57.86 = 57°86'(\boldsymbol{lead})$$ ½ Mark

i) Instantaneous current

$$\boldsymbol{i} = I_m \sin(\omega t + \emptyset)$$

$$\boldsymbol{i} = \mathbf{2.12 \sin(314}\boldsymbol{t} \mathbf{+ 57°86')}$$ 1Mark

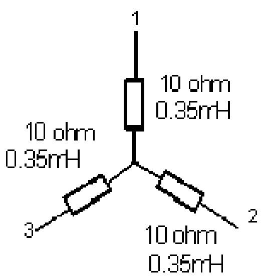
ii) Power Consumed

P = $I^2 R = (\frac{2.12}{\sqrt{2}})^2(25)$= **56.18 watts** or 1Mark

P = Vrms x Irms x Cos∅ = (100/√2) x (2.12/√2) x cos(57.86)
= 56.18watts.

4 d) Three coils each with a resistance of 10 Ω and inductance of 0.35 mH are connected in star to a 3-phase, 400V, 50Hz supply. Calculate line current and total power consumed.

Ans: L=0.2H, $\boldsymbol{X_L} = 2\pi f L = 2\pi \times 50 \times 0.35 \times 10^{-3} = \mathbf{0.11\ \Omega}$ ½ Mark



Zph = $\sqrt{R^2 + {X_L}^2} = \sqrt{10^2 + 0.11^2} = \mathbf{10.00\ \Omega}$ ½ Mark

$$V_{ph} = \frac{400}{\sqrt{3}} = 231 \text{ Volts}$$ ½ Mark

i) $I_{ph} = \frac{V_{PH}}{Z_{PH}} = \frac{231}{10} = \mathbf{23.1\ amp}$ ½ Mark

Line current = Phase current

$$\mathbf{I_L = 23.1\ amp}$$ ½ Mark

Cos ϕ = 1 resistive load ½ Mark

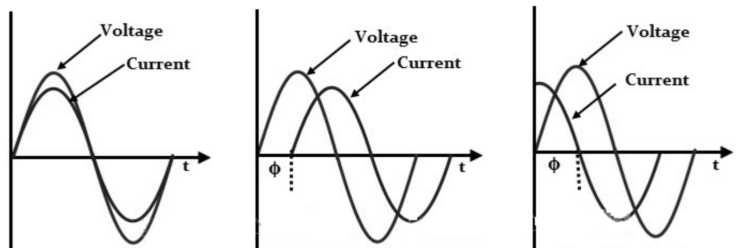
ii) Total Power consumed = P $=\sqrt{3} \times 400 \times 23.1 \times 1$

$P = \mathbf{1600.4\ watts}$ *or* 1 Mark

P =3 x I^2R= 3 x 23.1^2x 10 = 1600.8 watts

4 e) Explain lagging quantity and leading quantity, explain this concept with voltage and current waveform

Ans:



Resistive circuit
ϕ = 0, Unity Power factor
Voltage and current are in phase

Inductive circuit
Lagging Power factor
Current is lagging behind voltage

Capacitive circuit
Leading Power factor
Current is leading volatge

2 Marks

When two alternating quantities attain their respective zero or peak values simultaneously, the quantities are said to be in-phase quantities.

When the quantities do not attain their respective zero or peak values simultaneously, then the quantities are said to be ou-of-phase quantities.

The quantity which attains the respective zero or peak value first, is called ‘Leading Quantity’.

The quantity which attains the respective zero or peak value later, is called ‘Lagging Quantity’.

In above diagram, it is seen that for inductive circuit, the current is lagging behind the voltage or the voltage is said to be leading the current.

Similarly, for capacitive circuit, the current is leading the voltage or the voltage is said to be lagging behind the current.

2 Marks

4f) Find current through 6 Ω resistor using Mesh Analysis, for circuit B refer Fig. No. 2

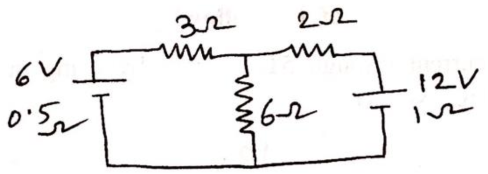
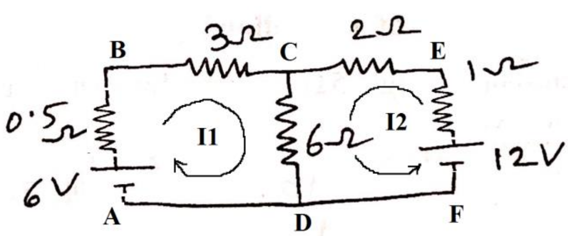


Fig. No. 2

Ans:



1 Mark

By applying KVL to loop ABCDA

$$6 - 0.5I_1 - 3I_1 - 6(I_1 + I_2) = 0$$
$$9.5I_1 + 6I_2 = 6 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

By applying KVL to Loop FECDF

$$12 - I_2 - 2I_2 - 6(I_1 + I_2) = 0$$ 1 Mark
$$6I_1 + 9I_2 = 12 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

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

$$\begin{bmatrix} 9.5 & 6 \\ 6 & 9 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 6 \\ 12 \end{bmatrix}$$

$$\therefore \Delta = \begin{vmatrix} 9.5 & 6 \\ 6 & 9 \end{vmatrix} = 85.5 - 36 = 49.5$$

By Cramer's rule,

$$I_1 = \frac{\begin{vmatrix} 6 & 6 \\ 12 & 9 \end{vmatrix}}{\Delta} = \frac{(6 \times 9) - (12 \times 6)}{49.5} = \frac{54 - 72}{49.5} = \mathbf{-0.363\ A}$$ 1 Mark

$$I_2 = \frac{\begin{vmatrix} 9.5 & 6 \\ 6 & 12 \end{vmatrix}}{\Delta} = \frac{(9.5 \times 12) - (6 \times 6)}{49.5} = \frac{114 - 36}{49.5} = \mathbf{1.58\ A}$$

1 Mark

Current flowing through resistance of 6Ω = $I_1 + I_2$ = **1.212** amp,

5 **Attempt any <u>FOUR</u> of the following** 16

5 a) Derive the expression for resonance frequency in R-L-C series circuit.

Ans:

The frequency at which the net reactance of the series circuit is zero is called the resonant frequency f_o.

Its value can be found as under:

At resonance X_L-X_C = 0 or X_L=X_C 1 Mark

$\omega_o L = 1/\omega_o C$

$\omega_o^2 = 1/LC$ 1 Mark

∴ $(2\pi f_0)^2$ = LC 1 Mark

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$ 1 Mark

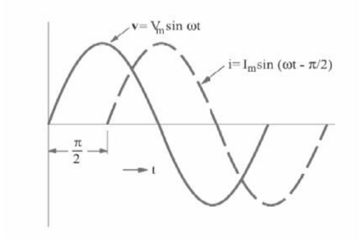
5 b) Draw the phasor diagram and waveforms of voltage, current and power in a pure inductive circuit supplied by a single phase a.c. source.

Ans

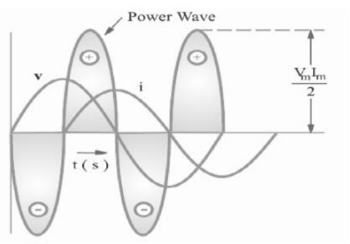
Phasor diagram of pure inductive circuit:

Phasor diagram 1 Mark

Voltage And Current Waveforms:



Power waveform



Waveform of V,I,P 1Mark each

5 c) Using Norton's Theorem, find current through R_L in Fig. No.3.

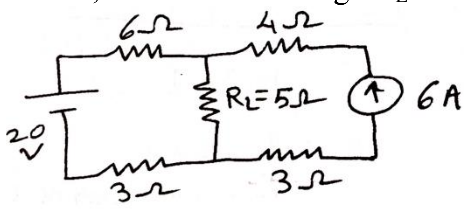
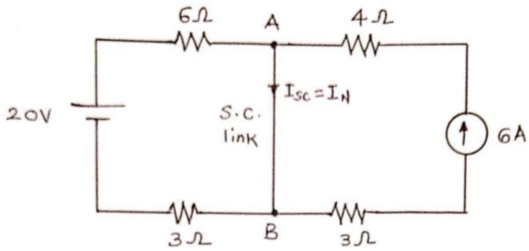


Fig. No. 3

Ans:

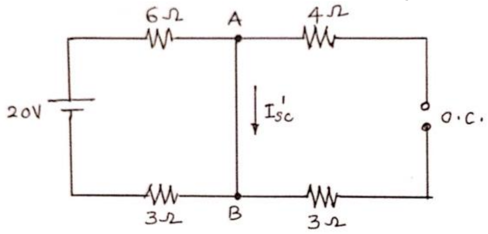
Solution by Norton Theorem:

Remove R_L and short the path, now circuit becomes as shown below



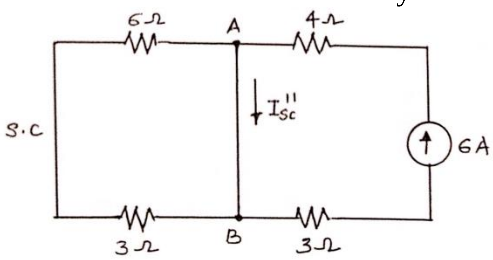
Apply Superposition theorem to find out the $I_{SC} = I_N$

Consider 20 V source only



I_{SC}'=20/(6+3)=20/9=2.22 Amp from A to B — ½ Mark

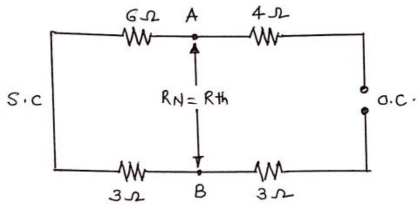
Consider 6 A source only



I_{SC}"=6 Amp from A to B — ½ Mark

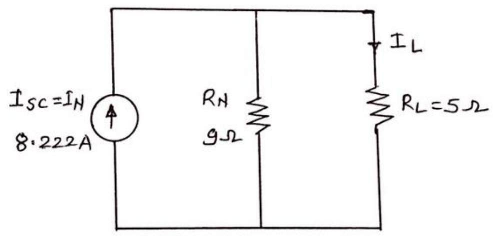
$I_{SC}=I_N= I_{SC}'+ I_{SC}''$=2.22+6=8.22 Amp from A to B — 1 Mark

Now calculate $R_N = R_{th}$



R_{th}=6+3=9 Ω — 1 Mark

Norton's equivalent circuit becomes



Therefore current through R_L is I_L= 8.22 x 9/(9+5)= 5.28 Amp — 1 Mark

5d) Series RLC circuit of R=10 Ω, L=0.1 H, and C= 10 μF is connected to 230V variable frequency supply. Calculate (i) The frequency at which circuit behaves as purely resistive circuit (ii) Quality factor

Ans:

(i) RLC series circuit behaves as purely resistive circuit at resonance and frequency at Resonance is

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$ 1 Mark

Therefore $f_0 = \frac{1}{2\pi\sqrt{(0.1\times10\times10^{-6})}}$ = **159.15 Hz** 1 Mark

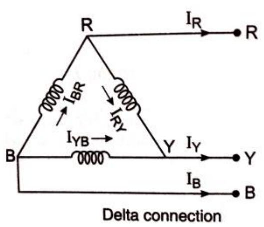
(ii) Quality factor can be found by using

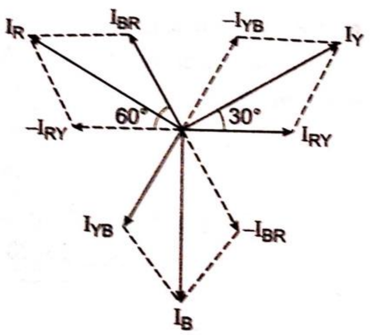
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$ 1 Mark

$$Q = \frac{1}{10}\sqrt{\frac{0.1}{10\times10^{-6}}} = \mathbf{10}$$ 1 Mark

5e) Derive the relation between line and phase current in 3 phase delta connected balanced load. Draw phasor diagram.

Ans:





2 Mark

From above diagram current in each lines are vector difference of the two phase currents flowing through that line.

For example:

Current in line R is $I_R = I_{BR} - I_{RY}$

Current in line Y is $I_Y = I_{RY} - I_{YB}$

Current in line B is $I_B = I_{YB} - I_{BR}$ 1 Mark

Current in line R is found by compounding I_{BR} and I_{RY} and value given

by parallelogram in phasor diagram.
Angle between I_{BR} and $-I_{RY}$ is $60°$,
where $|I_{BR}| = |I_{RY}|$ = Phase current I_{ph}

$$I_R = I_{BR} - I_{RY} = 2I_{ph}\cos\left(\frac{60}{2}\right) = 2I_{ph}\frac{\sqrt{3}}{2} = \sqrt{3}I_{ph}$$ 1 Mark

$$I_Y = I_{RY} - I_{YB} = 2I_{ph}\cos\left(\frac{60}{2}\right) = 2I_{ph}\frac{\sqrt{3}}{2} = \sqrt{3}I_{ph}$$

$$I_B = I_{YB} - I_{BR} = 2I_{ph}\cos\left(\frac{60}{2}\right) = 2I_{ph}\frac{\sqrt{3}}{2} = \sqrt{3}I_{ph}$$

As $I_R = I_Y = I_B = I_L$

$$\mathbf{I_L = \sqrt{3}I_{ph}}$$

5 f) Express (i) $Z=10\angle 60^0$ in rectangular form (ii) Z=16 + j8 in polar form

Ans:

(i) $Z=10\angle 60^0$

Real part=10 x cos60°=5 ; Imaginary part= 10 x sin60°= 8.66 2 Marks

Therefore in Rectangular form Z = 5 + j8.66

(ii) Z=16 +j8

Magnitude=$\sqrt{16^2+8^2}$=17.88; Angle $\varphi=\tan^{-1}(8/16)=26.56^0$ 2 Marks

Therefore in Polar form $Z = 17.88\angle 26.56^0$

6 **Attempt any <u>FOUR</u> of the following** 16

6 a) Calculate current through 5 Ω resistor by using superposition theorem in Fig. No. 4.

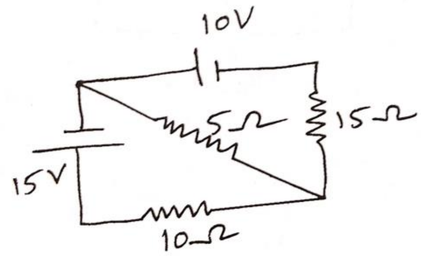
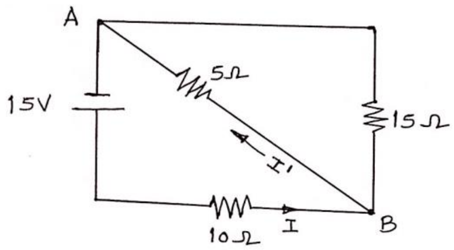


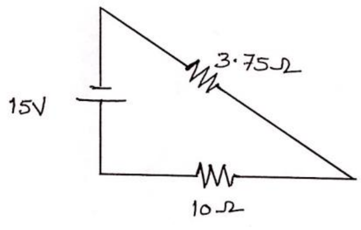
Fig. No. 4

Ans:

Consider 15 V source only



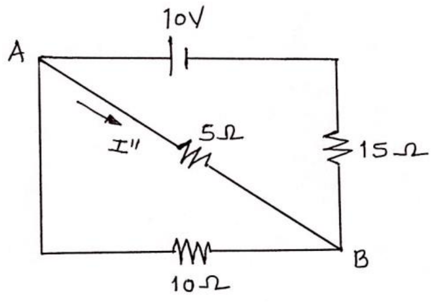
Resistances of 5 & 15 are in parallel = 5 x15/(5+15) = 3.75 Ω ½ Mark

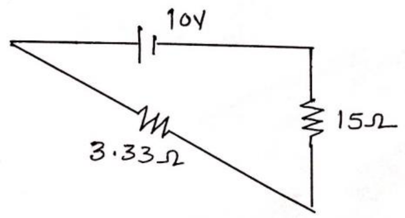


Total current I= 15/(10+3.75)=15/13.75=1.09 Amp ½ Mark

Therefore I'=1.09 x 15/(15+5)=0.82 Amp from B to A ½ Mark

Now consider 10 V source only





Resistances of 10 & 5 are in parallel=10 x5/(10+5)=3.33 Ω ½ Mark

Therefore current I =10/(15+3.33)=0.54 Amp ½ Mark

I"= 0.54 x 10/(10+5)=0.36 Amp from A to B ½ Mark

I=I'+I"=0.82-0.36=0.46 Amp from B to A 1 Mark

6b) Develop Thevenin equivalent circuit between points A and B in Fig. No. 5 and find current in R_L=10 Ω.

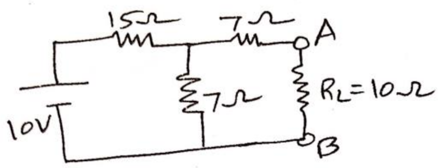
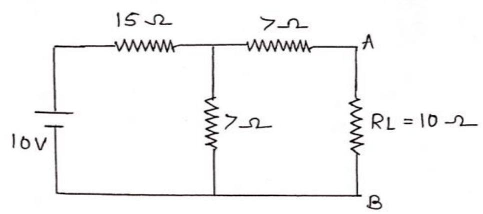


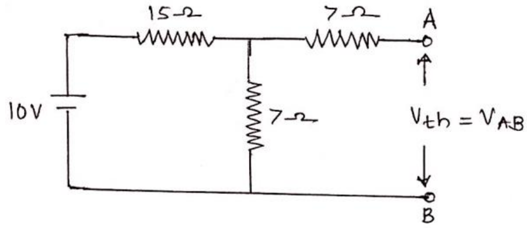
Fig. No. 5

Ans:



1Mark

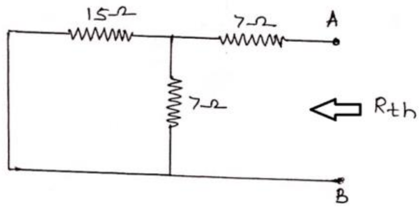
i) Calculation of V_{TH}: Remove R_L and find open circuit voltage across it.



Current through circuit will be =10/(15+7)=0.45 Amp ½ Mark

V_{OC} = V_{TH} = V_{AB} = 0.45 x 7 = 3.18 V ½ Mark

ii) 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 1Mark
Thevenin equivalent circuit:

I_L= V_{TH}/(R_{TH}+R_L)=3.18/(11.77+10)=0.146 Amp 1Mark

6 c) Find value of R_L in Fig. No.6 for maximum power transfer.

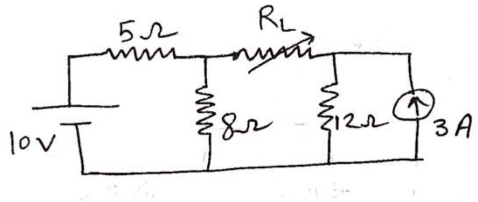
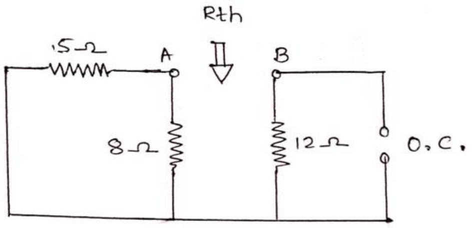
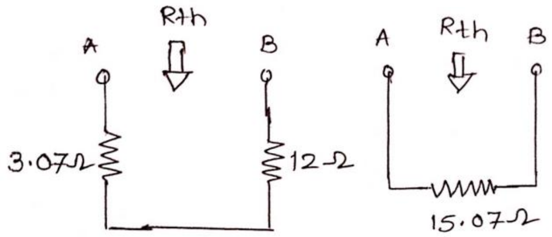


Fig. No. 6

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



Resistances of 5 & 8 are in parallel = 5x8/(5+8)= 3.07 Ω and circuit is simplified as 1 Mark



1 Mark

1 Mark

R_{TH}=12+3.07= 15.07 Ω
Hence in the given circuit maximum power will be transferred when R_L= R_{TH}=15.07 Ω 1 Mark

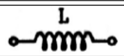
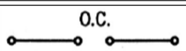
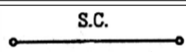
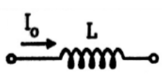
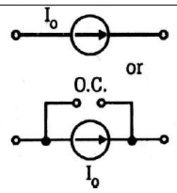
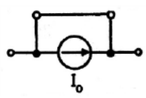
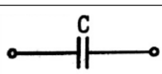
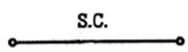
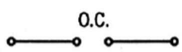
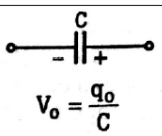
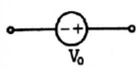
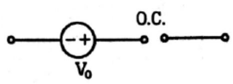
6 d) Explain the concept of initial and final conditions in switching for L and C.
Ans:
i) Inductor:
The current through an inductor cannot change instantly. If the inductor current is zero just before switching, then whatever may be the applied voltage, just after switching the inductor current will remain zero. i.e the inductor must be acting as open-circuit at instant t = 0. If the inductor current is I0 before switching, then just after switching the inductor

current will remain same as I0, and having stored energy hence it is represented by a current source of value I0 in parallel with open circuit.
As time passes the inductor current slowly rises and finally it becomes constant. Therefore the voltage across the inductor falls to zero [$v_L = L di_L/dt = 0$]. The presence of current with zero voltage exhibits short circuit condition. Therefore, under steady-state constant current condition, the inductor is represented by a short circuit. If the initial inductor current is non-zero I0, making it as energy source, then finally inductor is represented by current source I0 in parallel with a short circuit.

ii) Capacitor:

The voltage across capacitor cannot 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 V0, then also after switching at t = 0, the voltage across capacitor remains same V0. Since the energy is stored in the capacitor, it is represented by a voltage source V0 in series with short-circuit. 2Marks
As time passes the capacitor voltage slowly rises and finally it becomes constant. Therefore the current through the capacitor falls to zero[$i_C = C dv_C/dt = 0$]. The presence of voltage with zero current exhibits open circuit condition. Therefore, under steady-state constant voltage condition, the capacitor is represented by a open circuit. If the initial capacitor voltage is non-zero V0, making it as energy source, then finally capacitor is represented by voltage source V0 in series with an open-circuit.

The initial and final conditions are summarized in following table:

Element and condition at $t = 0^-$	Initial Condition at $t = 0^+$	Final Condition at $t = \infty$
		
		
		
		

2Marks

6 e) Find voltages at nodes A and B in Fig. No. 7.

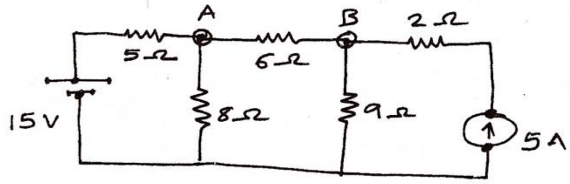
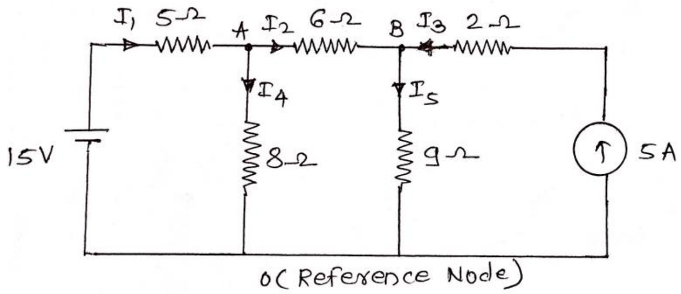


Fig. No. 7

Ans:



Apply KCL at node A

$I_1 = I_4 + I_2$

$(15-V_A)/5 = (V_A/8) + (V_A - V_B)/6$

$(15-V_A)/5 = (6V_A + 8V_A - 8V_B)/48$

$720 - 48\,V_A = 30V_A + 40V_A - 40V_B$

$118V_A - 40V_B = 720$ ....(1) 1 Mark

Apply KCL at node B

$I_5 = I_2 + I_3$

$V_B/9 = (V_A - V_B)/6 + 5$

$V_B/9 = (V_A - V_B + 30)/6$

$6\,V_B = 9V_A - 9V_B + 270$

$-9V_A + 15\,V_B = 270$ ....(2) 1 Mark

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

$$\begin{bmatrix} 118 & -40 \\ -9 & 15 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \end{bmatrix} = \begin{bmatrix} 720 \\ 270 \end{bmatrix}$$

$$\therefore \Delta = \begin{vmatrix} 118 & -40 \\ -9 & 15 \end{vmatrix} = 1770 - 360 = 1410$$ 1 Mark

By Cramer's rule,

$$V_A = \frac{\begin{vmatrix} 720 & -40 \\ 270 & 15 \end{vmatrix}}{\Delta} = \frac{(720 \times 15) - (270 \times -40)}{1410}$$

$$= \frac{10800 + 10800}{1410} = \mathbf{15.32\ volt}$$

$$V_B = \frac{\begin{vmatrix} 118 & 720 \\ -9 & 270 \end{vmatrix}}{\Delta} = \frac{(118 \times 270) - (-9 \times 720)}{1410} = \frac{31860 + 6480}{1410}$$

$$= \mathbf{27.19\ volt}$$

1 Mark for final answers

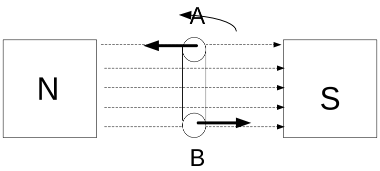
6f) Explain how sinusoidal AC voltage is generated by using simple one loop generator.

Ans:

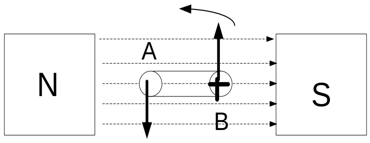
An electric current produced by means of electrical machine is known as generator which converts mechanical energy into electrical energy.

When conductor cuts the magnetic flux, emf induced in it. (Faraday's Law of electromagnetic induction). Thus, for generation of emf relative motion between magnetic field and conductor is required.

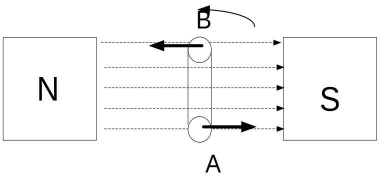
1 Mark for explanation



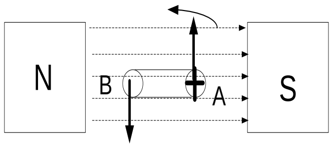
Position 1: (θ =0º)minimum $\frac{d\emptyset}{dt}$



Position 2: (θ =90º) maximum$\frac{d\emptyset}{dt}$

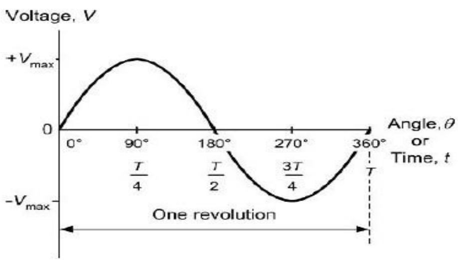


Position 3: (θ =180º)minimum $\frac{d\emptyset}{dt}$



Position 4: (θ =270º) maximum$\frac{d\emptyset}{dt}$

2 Marks for diagram



1 Mark for waveform

Here single turn rectangular elementary coil (AB) is made up of conducting material. The coil is so placed that it can be rotated about its own axis with constant speed in a uniform magnetic field provided by permanent magnet.

Assume that the coil (AB) rotates in anticlockwise direction and cuts magnetic flux. According Faraday's law of electromagnetic induction, emf is induced and magnitude of generated emf depends upon position of armature. The nature of emf is alternating as shown by the waveform.