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 a)	**Attempt any TEN of the following:**	**20**
1 a)	Define RMS value and average value related to sinusoidal AC waveform. **Ans:** **RMS Value of Sinusoidal AC Waveform:** 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 alternating quantity over one cycle. **And/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.	1 mark
	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. **And/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.	1 mark
1 b)	Define Impedance and reactance related to single-phase AC series circuit. Give the units of both. **Ans:** **Impedance:** The impedance (Z) of the circuit is defined as the total opposition of the circuit to the alternating current flowing through it. It is represented as Z = R ± jX. **Unit of impedance:** S. I. unit of impedance is ohm, represented as Ω. **Reactance:** The reactance (X_L or X_C) is defined as the opposition offered by an inductor or capcitor to an alternating current flowing through it. **Unit of reactance:** S. I. unit of reactance is ohm, represented as Ω.	1½ marks for definitions + ½ mark for unit
1 c)	Define quality factor of parallel AC circuit and give its formula. **Ans:** **Quality Factor of Parallel AC Circuit:** 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. It is the current magnification in parallel circuit.	1 mark
	Formula: Quality factor (Q-factor) = Current magnification $= \frac{1}{R}\sqrt{\frac{L}{C}}$ Where, R is the resistance of an inductor in Ω, L is the inductance of an inductor in henry, C is capacitance of capacitor in farad,	1 mark

1 d) What do you mean by balanced load and balanced supply in relation with polyphaser AC circuits?

Ans:

Balanced Load:

Balanced three phase load is defined as star or delta connection of three equal impedances having equal real parts and equal imaginary parts. 1 mark

e.g Three impedances each having resistance of 5Ω and inductive reactance of 15Ω connected in star or delta.

Balanced Supply:

Balanced supply is defined as three phase supply voltages having equal magnitude but displaced from each other by an angle of 120° in time phase. 1 mark

e.g $V_a = 230\angle 0°$ volt, $V_b = 230\angle -120°$ volt, $V_c = 230\angle 120°$ volt represents balanced supply.

1 e) Give four steps to solve nodal analysis.

Ans:

Steps to Solve Circuit Using Nodal Analysis:

i) Identify the independent nodes in the network.

ii) Select a convenient reference node and ground it. Preferably choose the node having the largest number of voltage sources connected to it as a reference node. ½ mark for each step (Max. 2 marks)

iii) Express the node voltages or their relationships in terms of known source voltages.

e.g. (i) When a voltage source, say 10V appears between a node 2 and reference node, then $V_2 = 10V$

(ii) When a voltage source, say 15V appears between a node 3 and node 4 with positive terminal connected to node 3 then $V_3 - V_4 = 15V$

iv) At each remaining node write KCL equations such that node voltages appear on one side of equation and constant appears on the other side.

v) Solve the set of simultaneous equations obtained in step (iii) and (iv).

1 f) Give statement of Superposition theorem.

Ans:

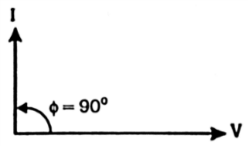
Superposition Theorem:

In any linear network containing several sources, the voltage across or the current through any branch is given by the **algebraic sum** of all the individual voltages or currents caused by the sources acting alone, with all other independent voltage sources replaced by short circuit (their internal resistances) and all other independent current sources replaced by open circuit. 2 marks

1 g) Draw a waveform and phasor diagram for purely capacitive load.

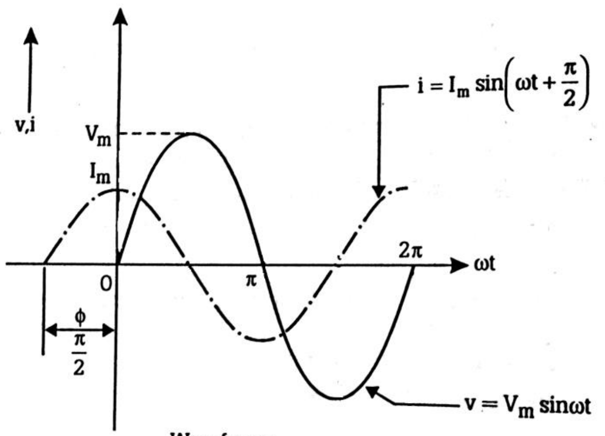
Ans:

Purely Capacitive Circuit:



Phasor Diagram

½ mark

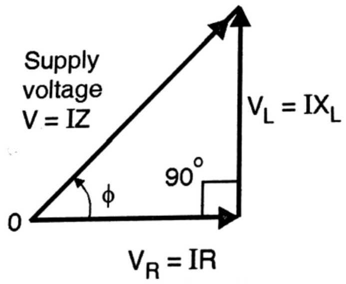


Waveforms

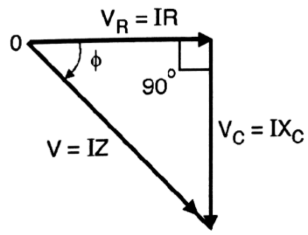
1½ mark

1 h) Draw voltage triangles for R-L and R-C single-phase AC series circuits.

Ans:



Voltage Triangle for R-L Series Circuit



Voltage Triangle for R-C Series Circuit

1 mark for each

1 i) Define admittance and conductance in relation with parallel circuits. Give formulae for the same.

Ans:

Admittance (Y):

Admittance is defined as the ability of the circuit to carry (admit) alternating current through it. It is the reciprocal of impedance Z. i.e Y = 1/Z. ½ mark

For parallel circuit consisting two branches having impedances Z_1 and Z_2 in parallel, the equivalent impedance of parallel combination is given by,

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2}$$
$$Y = Y_1 + Y_2$$

where, Y is the equivalent admittance of the parallel circuit

Y_1 and Y_2 are the admittances of the two branches respectively.

If impedance is expressed as $Z = R + jX$, then the admittance is obtained as,

$$Y = \frac{1}{Z} = \frac{1}{R + jX} = \frac{R - jX}{(R + jX)(R - jX)} = \frac{R - jX}{R^2 + X^2}$$ ½ mark

$$\therefore Y = \frac{R}{R^2 + X^2} - j\frac{X}{R^2 + X^2} = G - jB$$

Conductance (G):

Conductance is defined as the real part of the admittance. ½ mark

It is expressed as, $G = \frac{R}{R^2+X^2}$ ½ mark

In DC circuit, the reactance is absent, hence X=0 and conductance becomes equal to the reciprocal of resistance.

1 j) Give relation between line voltage and phase voltage in case of 3-phase star connection and 3-phase delta connection.

Ans:

Star Connection:

For star connection, $\text{Line voltage} = \sqrt{3}\,(\text{Phase Voltage})$ 1 mark

$$\text{i.e}V_L = \sqrt{3}V_{ph}$$

Delta Connection:

For delta connection, $\text{Line voltage} = \text{Phase Voltage}$ 1 mark

$$\text{i.e}V_L = V_{ph}$$

1 k) Give four steps to solve mesh analysis.

Ans:

Steps to Solve Circuit using Mesh Analysis:

i) For a given planar circuit, convert each current source, if any, into voltage source,

ii) Assign a mesh current to each mesh. The direction for each mesh current can be marked arbitrarily, however if same direction is considered for all mesh currents, then the resulting equations will have certain symmetry properties.

iii) Write KVL equation for each mesh. The equations will have terms with currents on one side and constant on the other side.

iv) Solve the resulting set of simultaneous algebraic equations and find the mesh currents.

v) Using mesh currents then find the branch currents and branch voltages.

½ mark for each step (Max. 2 marks)

1 l) An alternating quantity is given by $i = 14.14\sin 314t$. Find RMS value and angular frequency of the wave.

Ans:

$$i = 14.14\sin 314t$$

Since $i = I_m \sin\omega t$, the peak or maximum value is $I_m = 14.14$ amp.

For sinusoidal current, the RMS value is given by, $I = \frac{I_m}{\sqrt{2}} = \frac{14.14}{\sqrt{2}}$

$$\mathbf{I = 9.9985\ amp\ or\ 10\ A.}$$ 1 mark

Angular frequency is given by, $\boldsymbol{\omega = 314\ \ rad/sec}$ 1 mark

1 m) What do you mean by bilateral network and unilateral network?

Ans:

Bilateral Network:

An element whose response is independent of direction of current flowing through it is called Bilateral element and the network, which contains only bilateral elements, is called bilateral network. 1 mark

OR

A network whose electrical characteristic or response is independent of the direction of current flowing through it, is called bilateral network.

Unilateral Network:

An element whose response depends on the direction of current flowing through it, is called Unilateral element and the network, which contains at least one unilateral elements, is called unilateral network. 1 mark

OR

A network whose electrical characteristic or response depends on the direction of current flowing through it, is called unilateral network.

1 n) Define:

i) Active network

ii) Passive network

Ans:

An element capable of giving out power or energy to some external device is called an active element. e.g. battery, generator etc.

An element which is not an active element and capable of absorbing or storing power or energy is called as passive element.

Active Network:

A network consisting of at least one active element (source of energy) is called active network. 1 mark

Passive Network:

A network consisting of only passive elements i.e. no active element, is called passive network. 1 mark

2 Attempt any FOUR of the following: 16

2 a) An alternating current is represented by the equation $i = 100\sin(100\pi t)$. How long will it take for the current to attain values of 20A and 100A?

Ans:

i) Time to attain value of 20A: 1 mark for steps

Instantaneous value $i = 20 = 100\sin(100\pi t)$

$$\therefore \sin(100\pi t) = 0.2$$

$$\therefore 100\pi t = \sin^{-1}(0.2)$$

$$\therefore t = \frac{0.20136}{100\pi} = \mathbf{0.6409 \times 10^{-3}\ sec}$$

1 mark for final ans

Thus the current takes t = 0.6409×10^{-3} sec to attain 20A value.

ii) Time to attain value of 100A:

Instantaneous value $i = 100 = 100\sin(100\pi t)$ 1 mark for steps

$$\therefore \sin(100\pi t) = 1$$

$$\therefore 100\pi t = \sin^{-1}(1)$$

$$\therefore t = \frac{1.5708}{100\pi} = \mathbf{5 \times 10^{-3}\ sec}$$

1 mark for final ans

Thus the current takes t = 5×10^{-3} sec to attain 100A value.

2 b) Derive an expression for resonant frequency of a series RLC circuit.

Ans:

Resonant Frequency of Series RLC Circuit:

For series R-L-C circuit, the complex impedance is given by,

$$Z = R + jX_L - jX_C = R + jX$$

1 mark

where, inductive reactance is given by $X_L = 2\pi fL$ 1 mark for capacitive reactance is given by $X_C = \frac{1}{2\pi fC}$

At resonance, the inductive reactance is equal to the capacitive reactance.

Hence, $X_L = X_C$

$$2\pi f_r L = \frac{1}{2\pi f_r C}$$

$$f_r^2 = \frac{1}{(2\pi)^2 LC}$$

$\therefore$ Series Resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$Hz

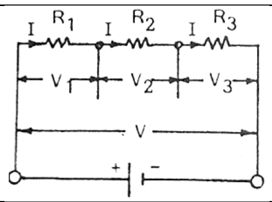
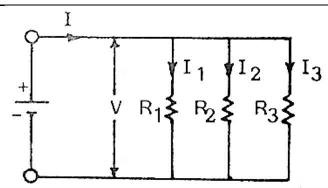
Resonant Angular frequency $\omega_r = \frac{1}{\sqrt{LC}}$ rad/sec

reactance equations + 1 mark for equality + 1 mark for final expression

2 c) Give 4 comparison of series and parallel circuits.

Ans:

Comparison between Series and Parallel Circuits:

Sr. No.	Series Circuit	Parallel Circuit
1		
2	A series circuit is that circuit in which the current flowing through each circuit element is same.	A parallel circuit is that circuit in 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. $\therefore$ $I = I_1+I_2+I_3$
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. $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

1 mark for each point = 4 marks

2 d) Give four advantages and of polyphase circuits over 1-phase circuits.

Ans:

Advantages and of polyphaser (3-phase) circuits over 1-phase circuits:

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.

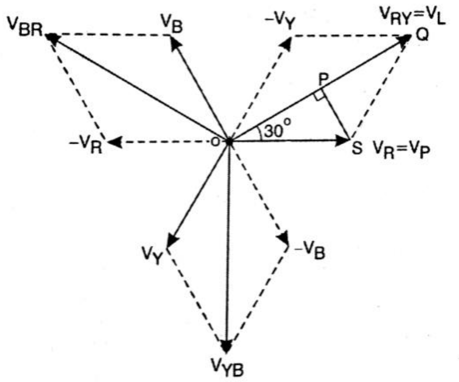
1 mark for each of any four.

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.

2 e) Derive the relationship between line voltage and phase voltage in star connected system with suitable phasor diagram.

Ans:

Relationship Between Line voltage and Phase Voltage in Star Connected System:



1 mark for phasor diagram

Let V_R, V_Y and V_B be the phase voltages.
V_{RY}, V_{YB} and V_{BR} be the line voltages.
The line voltages are expressed as:
$V_{RY} = V_R – V_Y$
$V_{YB} = V_Y – V_B$
$V_{BR} = V_B – V_R$

2 marks for stepwise explanation

In phasor diagram, the phase voltages are drawn first with equal amplitude and displaced from each other by 120°. Then line voltages are drawn as per the above equations. It is seen that the line voltage V_{RY} is the phasor sum of phase voltages V_R and $–V_Y$. We know that in parallelogram, the diagonals bisect each other with an angle of 90°.
Therefore in ΔOPS, ∠P = 90° and ∠O = 30°.

$$[OP] = [OS] \cos 30°$$

Since $[OP] = V_L/2$ and $[OS] = V_{ph}$

$$\therefore \frac{V_L}{2} = V_{ph}\cos 30°$$

$$V_L = 2V_{ph}\frac{\sqrt{3}}{2}$$

$$\mathbf{V_L = \sqrt{3}V_{ph}}$$

1 mark for final ans

Thus Line voltage = $\sqrt{3}$ (Phase Voltage)

2 f) How initial and final conditions are used in switching circuits and in electronic circuits?

Ans:

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

i) Resistor:
At any time it acts like resistor only, with no change in condition.

ii) Inductor:
<u>The current through an inductor cannot change instantly.</u> 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.

As time passes the inductor current slowly rises and finally it becomes constant. Therefore the voltage across the inductor falls to zero $\left[v_L = L\frac{di_L}{dt} = 0\right]$. 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 I_0, making it as energy source, then finally inductor is represented by current source I_0 in parallel with a short circuit.

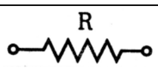
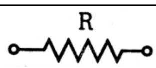
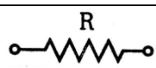
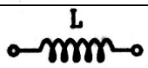
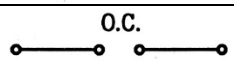
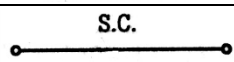
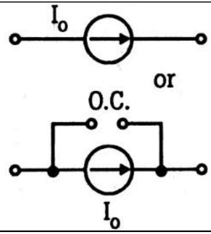
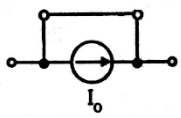
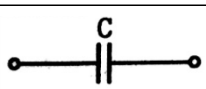
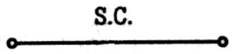
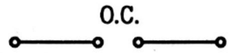
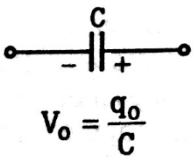
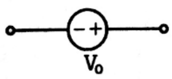
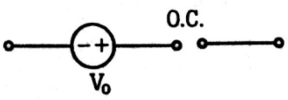
iii) Capacitor:

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.

2 marks for explanation

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 presence of voltage with zero current exhibits open circuit condition. Therefore, under steady-state constant voltage condition, the capacitor is represented by aopen circuit. If the initial capacitorvoltage is non-zero V_0, making it as energy source, then finally capacitor is represented by voltage source V_0 in series with aopen-circuit.

The initial and final conditions are summarized in following table:

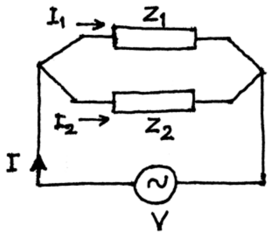
Element and condition at $t = 0^-$	Initial Condition at $t = 0^+$	Final Condition at $t = \infty$
		
		
		
		
		

2 marks for diagrams

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

3 a) Impedances $Z_1 = (10 + j5)\Omega$ and $Z_2 = (8 + j6)\Omega$ are connected in parallel across $V = (200 + j0)$. Using the admittance method, calculate circuit current and the branch currents.

Ans:



Data given:

$Z_1 = 10 + j5 = 11.18\angle 26.565°\Omega$

$Z_2 = 8 + j6 = 10\angle 36.87°\Omega$

$V = 200 + j0 = 200\angle 0°$ volt

The admittances of branches are given by

$Y_1 = \frac{1}{Z_1} = \frac{1}{11.18\angle 26.565°} = 0.0894\angle -26.565° = (0.08 - j0.04)$ S

$Y_2 = \frac{1}{Z_2} = \frac{1}{10\angle 36.87°} = 0.1\angle -36.87° = (0.08 - j0.06)$ S — 1 mark for Y_1& Y_2

Equivalent admittance of parallel combination is given by,

$Y = Y_1 + Y_2 = (0.08 - j0.04) + (0.08 - j0.06)$

$= (0.16 - j0.1) = 0.1887\angle -32.005°$ S — 1 mark for Y

Circuit current is given by,

$I = Y.V = (0.1887\angle -32.005°)(200\angle 0°) = \mathbf{37.74\angle -32.005°\ amp}$ — 1 mark for I

Branch currents are given by,

$I_1 = Y_1V = (0.0894\angle -26.565°)(200\angle 0°) = \mathbf{17.88\angle -26.565°\ amp}$

$I_2 = Y_2V = (0.1\angle -36.87°)(200\angle 0°) = \mathbf{20\angle -36.87°\ amp}$ — 1 mark for I_1& I_2

3 b) An inductive coil (10+j40)Ω impedance is connected in series with a capacitor of 100μF across 230V, 50Hz, 1-phase mains, find:

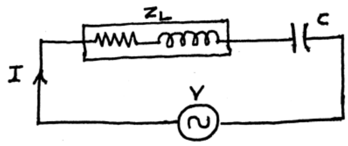
i) Current through the circuit
ii) P.F. of the circuit
iii) Power dissipated in the circuit
iv) Draw phasor diagram.

Ans:

Data given:

Impedance of inductive coil $Z_L = R + jX_L = 10 + j40 = 41.231\angle 75.96°\Omega$

Capacitance of capacitor $C = 100\mu F = 100 \times 10^{-6}F$



RMS supply voltage V = 230 volt

Supply frequency f = 50 Hz

Assuming supply voltage as reference phasor, let

$V = 230\angle 0°$ volt

Capacitive reactance $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(50)(100\times 10^{-6})} = 31.831\ \Omega$

Total impedance of series combination is given by,

$Z = R + jX_L - jX_C = 10 + j40 - j31.831 = 10 + j8.169 = \mathbf{12.91\angle 39.24°\Omega}$

i) Current through the circuit:

$$I = \frac{V}{Z} = \frac{230\angle 0°}{12.91\angle 39.24°} = \mathbf{17.816\angle -39.24°}$$ 1 mark

ii) P.F. of the circuit:

It is seen that the circuit current lags behind supply voltage by 39.24°.
Therefore, power factor of the circuit is, 1 mark

$$\cos\theta = \cos(39.24°) = \mathbf{0.7745\ lagging}$$

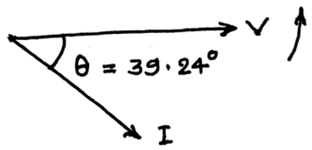
iii) Power dissipated in the circuit:

$P = I^2R$ OR $P = VI\cos\theta$

$$= (17.816)^2(10) = (230)(17.816)(0.7745)$$
$$= 3174.1 \text{ watt} = 3173.65 \text{ watt}$$ 1 mark

(The error is because of rounding off the intermediate results)

iv) Phasor Diagram:



1 mark

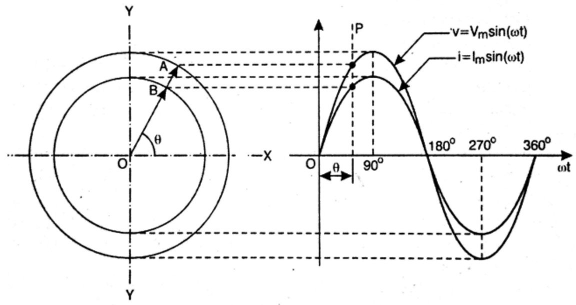
3 c) What are in phase quantities? What is phase sequence?

Ans:

In-phase Quantities:

Two alternating quantities if attain their respective zero or maximum values simultaneously, then such quantities are called "in-phase" quantities.

e.g. The voltage $v = V_m\sin(\omega t)$ and current $i = I_m\sin(\omega t)$ are two alternating quantities. From their waveforms it is seen that both these quantities attain their respective zero values or positive peak values or negative peak values simultaneously. Hence these quantities are in-phase quantities. In phasor representation, for in-phase quantities, phasors appear in the same direction.



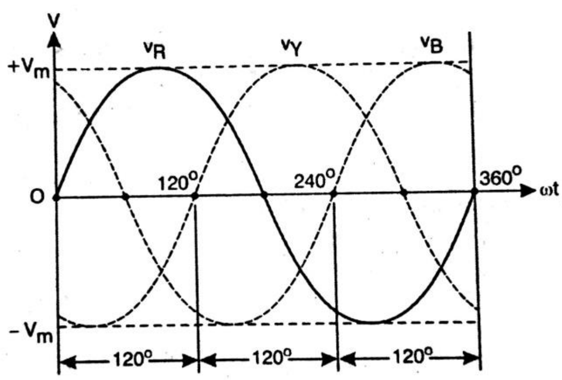
In-Phase Sinusoidal Quantities

1 mark for definition + 1 mark for diagram

Phase Sequence:

Phase sequence is defined as the order in which the voltages (or any other alternating quantity) of the three phases attain their positive maximum values.

In the following waveforms, it is seen that the R-phase voltage attains the positive maximum value first, and after angular distance of 120°, Y-phase voltage attains its positive maximum and further after 120°, B-phase voltage attains its positive maximum value. So the phase sequence is R-Y-B.



1 mark for definition + 1 mark for diagram

3 d) What is the importance of initial and final conditions of elements in a network?

Ans:

Importance of Initial and Final Conditions:

A stable electric circuit when left undisturbed always attains a state of equilibrium.

However, when the circuit configuration is modified, by changing some parameters or adding or removing the branches, new circuit conditions are imposed and circuit approaches to new state of equilibrium. The instant of disturbance or imposing new circuit conditions is usually designated as t = 0. The circuit behavior is determined by solution of governing differential equations. Some arbitrary constants appear in the solution. To evaluate these arbitrary constants, it is essential that the circuit initial conditions at t = 0 must be known.

Knowing and understanding initial conditions help: — 1 mark for each of any four points

i) To understand the behavior of the elements at the instant of switching.
ii) To understand non-linear switching circuits.
iii) To determine one or more derivatives of the response.
iv) To anticipate the form of the response.
v) To analyze the electric circuit.

On occurrence of disturbance, the circuit changes its state and approaches to new state of equilibrium, i.e steady-state, which is referred as final condition of the circuit. The time required for this settlement depends upon the circuit parameters and disturbance. Usually the condition at $t = \infty$ is considered as a final condition. The final condition helps to understand the steady-state behavior of the circuit.

3 e) Give statement for:

(1) Thevenin's theorem and
(2) Norton'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 internal independent voltage sources are replaced by short-circuits and independent current sources by open circuits. — 2 marks

Norton'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 current source I_N in parallel with an impedance Z_N across the two terminals, where the source current I_N is equal to the short circuit current caused by internal sources when the two terminals are short circuited and the value of the parallel impedance Z_N 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

3 f) Find the value of Z in rectangular form:

$$Z = \frac{(3 + j4)5\angle 30^\circ}{(6 + j8)}$$

Ans:

$$Z = \frac{(3+j4)5\angle 30^\circ}{(6+j8)} = \frac{(5\angle 53.13^\circ)(5\angle 30^\circ)}{(10\angle 53.13^\circ)}$$

1 mark for each R to P

$$= \frac{(5)(5)}{10}\angle(53.13^\circ + 30^\circ - 53.13^\circ)$$

1 mark

$$\therefore Z = 2.5\angle 30^\circ = (\mathbf{2.165 + j1.25})$$

1 mark

4 Attempt any FOUR of the following: 16

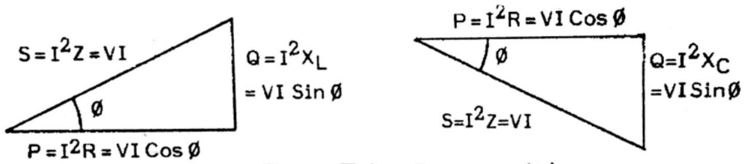
4 a) Draw power triangle. State formulae for active power, reactive power and apparent power.

Ans:

Power Triangle:

The power triangles for inductive circuit and capacitive circuit are shown in the fig. (a) and (b) respectively.

1 mark for any one diagram



Power Triangles

Apparent power (S) is given by simply the product of voltage & current.

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

1 mark for each formula

Active power (P) is given by the product of voltage, current and the cosine of the phase angle between voltage and current.

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

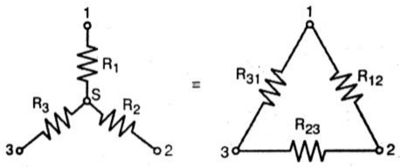
Reactive power (Q) is given by the product of voltage, current and the sine of the phase angle between voltage and current.

$$P = VI\cos\emptyset = I^2X \text{ volt-amp-reactive}$$

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

Ans:

Star-delta Transformation:



(a) Star Circuit (b) Delta Circuit

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,

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

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

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

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

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

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

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

Similarly, we can obtain,

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

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

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

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

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

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

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

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

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

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

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

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

1 mark for eq. 11

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

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

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

Similarly, we can obtain,

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

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

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 c) Find I, I_1 and I_2 of the circuit in fig.(1)

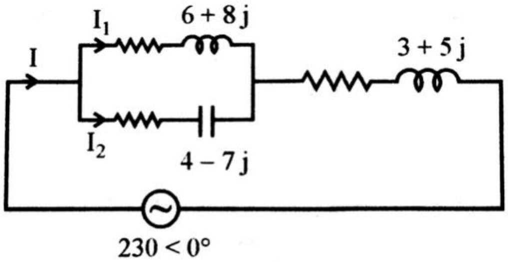


Fig. – 1

Ans:

Let $Z_1 = 6 + j8 = 10\angle 53.13°$

And $Z_2 = 4 - j7 = 8.062\angle -60.26°$

Total impedance of parallel branch,

$$Z_p = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{(10\angle 53.13°)(8.062\angle -60.26°)}{6 + j8 + 4 - j7} = \frac{80.62\angle -7.13}{10 + j1}$$

$$= \frac{80.62\angle -7.13}{10.05\angle 5.71}$$

$= 8.022\angle -12.84 = 7.82 - j1.78$

Therefore, total impedance of the circuit,

$Z = 7.82 - j1.78 + 3 + j5 = 10.82 + j3.22 = \mathbf{11.29\angle 16.57°\Omega}$ …………….. 1 mark

The supply current is given by,

$I = \frac{V}{Z} = \frac{230\angle 0°}{11.29\angle 16.57°} = \mathbf{20.37\angle -16.57° = (19.52 - j5.81) amp}$ ………. 1 mark

The branch currents can be obtained by using current division formula,

$$I_1 = I\frac{Z_2}{Z_1 + Z_2} = (20.37\angle -16.57°)\frac{8.062\angle -60.26°}{10.05\angle 5.71°}$$

$\therefore I_1 = \mathbf{16.34\angle -82.54°} = \mathbf{(2.12 - j16.20) amp}$ ……………………………… 1 mark

$I_2 = I - I_1 = (19.52 - j5.81) - (2.12 - j16.20)$

$\therefore I_2 = \mathbf{17.4 + j10.39 = 20.27\angle 30.84°\ amp}$ …………………………………… 1 mark

4 d) Find the current in 6Ω resistor in the circuit shown in fig.(2) using mesh analysis.

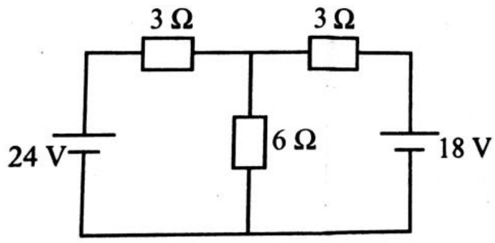


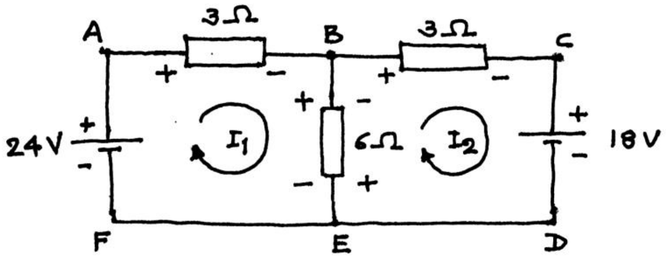
Fig. – 2

Ans:

Mesh Analysis:

i) There are two meshes in the network.
Mesh 1: ABEF
Mesh 2: BCDE

ii) Mesh currents I_1 and I_2



are marked clockwise as shown.

iii) The polarities of voltage drops across resistors are also shown with reference to respective mesh currents.

iv) By tracing mesh 1 clockwise, KVL equation is,

$24 - 3I_1 - 6(I_1 - I_2) = 0$

$\therefore 9I_1 - 6I_2 = 24 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$

By tracing mesh 2 clockwise, KVL equation is,

$-3I_2 - 18 - 6(I_2 - I_1) = 0$

$\therefore 6I_1 - 9I_2 = 18 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$

1 mark for each mesh equation (2 marks)

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

$$\begin{bmatrix} 9 & -6 \\ 6 & -9 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 24 \\ 18 \end{bmatrix}$$

$$\therefore \Delta = \begin{vmatrix} 9 & -6 \\ 6 & -9 \end{vmatrix} = -81 - (-36) = -45$$

By Cramer's rule,

$$I_1 = \frac{\begin{vmatrix} 24 & -6 \\ 18 & -9 \end{vmatrix}}{\Delta} = \frac{(24 \times -9) - (18 \times -6)}{-45} = \frac{-216 + 108}{-45} = \mathbf{2.4\ A}$$

$$I_2 = \frac{\begin{vmatrix} 9 & 24 \\ 6 & 18 \end{vmatrix}}{\Delta} = \frac{(18 \times 9) - (24 \times 6)}{-45} = \frac{162 - 144}{-45} = \mathbf{-0.4\ A}$$

1 mark for (I_1& I_2)

vi) The current flowing through 6Ω resistor is,

$$I = I_1 - I_2 = 2.4 - (-0.4) = \mathbf{2.8\ A}$$

1 mark

4 e) Find the value of variable load resistance R_L, so that maximum power is transferred to R_L shown in fig.(3)

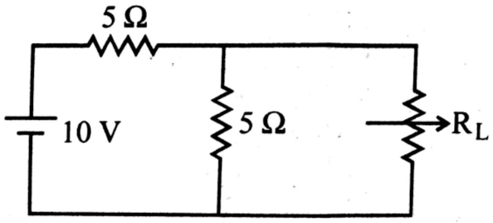
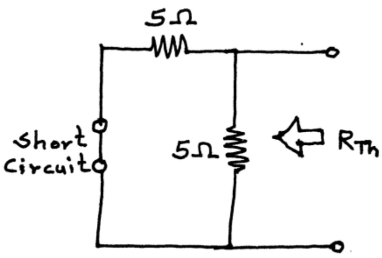


Fig. – 3

Ans:

According to maximum power transfer theorem, the maximum power will be transferred to load R_L only when R_L is equal to Thevenin's equivalent resistance (R_{Th}) of the network, while looking back into the network between the load terminals, when the internal independent voltage sources are replaced by short-circuit and independent current sources are replaced by open-circuit. Here, only voltage source is present, hence it is replaced by short circuit as shown.



1 mark for explanation

1 mark for circuit diagram

$$\mathbf{R_{Th}} = 5||5 = \frac{5 \times 5}{5 + 5} = \mathbf{2.5\ \Omega}$$

1 mark for R_{Th}

Therefore, for maximum power transfer, required load resistance will be,

$$\mathbf{R_L} = R_{Th} = \mathbf{2.5\ \Omega}$$

1 mark for R_L

4 f) Calculate the current in 1Ω resistance in the network shown in fig.(4) using Norton's theorem.

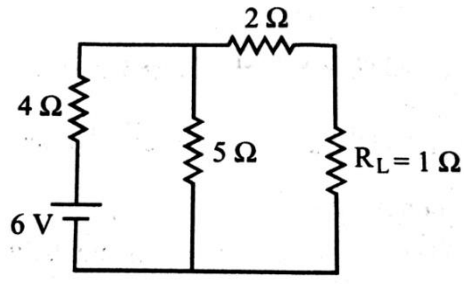
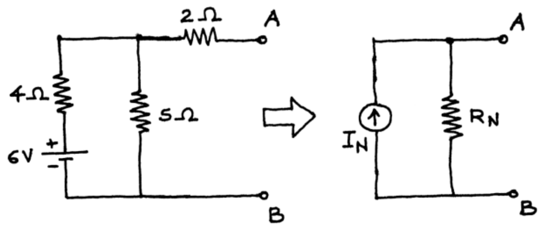


Fig. – 4

Ans:

Using 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 fig.(a).

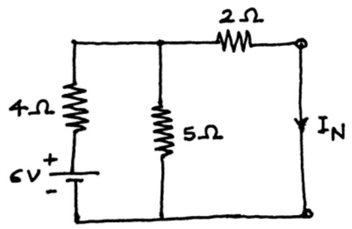


(a)

1 mark for circuit diagrams

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.(b).



(b)

Total resistance across 6V source is,

$R = 4 + (5||2) = 4 + \frac{5\times2}{5+2} = 5.43\ \Omega$

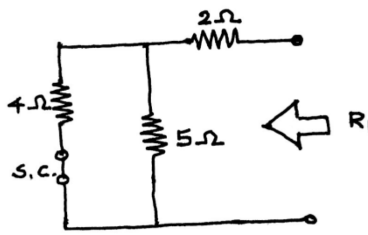
Therefore, current supplied by source,

$I = \frac{V}{R} = \frac{6}{5.43} = 1.105\ A$

The resistances 2Ω and 5Ω are in parallel. By current division, the current flowing through 2Ω is same as I_N.

$\mathbf{I_N} = I\frac{5}{2+5} = (1.105)\frac{5}{7} = \mathbf{0.789\ A}$

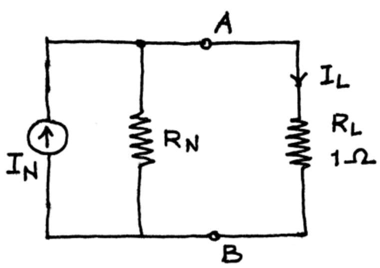
1 mark for I_N



(c)

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.(c),



(d)

$$\mathbf{R_N} = 2 + (5||4) = 2 + \frac{5\times4}{5+4} = \mathbf{4.22\ \Omega}$$

1 mark for R_N

Determination of Load Current (I_L):
Referring to fig.(d), the load current is 1 mark for I_L

$$\mathbf{I_L} = I_N \frac{R_N}{R_N + R_L} = 0.789 \frac{4.22}{4.22 + 1} = \mathbf{0.638\ A}$$

5 Attempt any FOUR of the following: 16

5 a) If A = 4 + j7
B = 8 + j9
C = 5 - j6

Find (a) $\frac{A+B}{C}$ (b) $\frac{AB}{C}$

Ans:

(a) $\frac{A+B}{C} = \frac{(4+j7)+(8+j9)}{5-j6} = \frac{12+j16}{5-j6} = \frac{20\angle 53.13°}{7.81\angle -50.19°}$ 1 mark

$$= \frac{20}{7.81}\angle[53.13° - (-50.19°)]$$

$$\therefore \frac{A+B}{C} = \mathbf{2.56\angle 103.32° = -0.59 + j2.49}$$ 1 mark

(b) $\frac{AB}{C} = \frac{(4+j7)(8+j9)}{5-j6} = \frac{(8.06\angle 60.25)(12.04\angle 48.37)}{7.81\angle -50.19°}$ 1 mark

$$= \frac{(8.06)(12.04)}{7.81}\angle[60.25 + 48.37 - (-50.19)]$$

$$\therefore \frac{AB}{C} = 12.43\angle 158.81 = -11.59 + j4.493$$ 1 mark

5 b) Find I_L for the circuit shown in fig.(5) using superposition theorem.

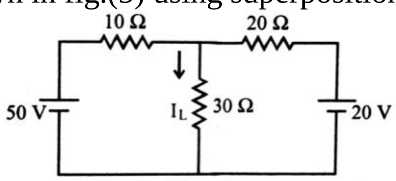
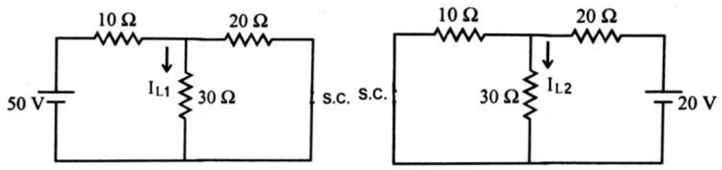


Fig. – 5

Ans:

According to Superposition theorem, the current in any branch is given by the algebraic sum of the currents caused by the independent sources acting alone while the other voltage sources replaced by short circuit and current sources replaced by open circuit.



(a) (b)

½ mark for each circuit diagram

i) The 50V source acting alone:(20V source replaced by short-circuit)

Referring to fig.(a), total circuit resistance appearing across 50V source is,

$$R_{T1} = 10 + (20||30) = 10 + \frac{20 \times 30}{20 + 30} = 22\,\Omega$$

Current supplied by 50V source is,

$$I_{S1} = \frac{V_1}{R_{T1}} = \frac{50}{22} = 2.273\text{ A}$$

By current division formula,

$$\mathbf{I_{L1}} = I_{S1}\frac{20}{20+30} = 2.273(0.4) = \mathbf{0.9092\ A\ (from\ A\ to\ B)}$$

ii) The 20V source acting alone:(50V source replaced by short-circuit)

Referring to fig.(b), total circuit resistance appearing across 20V source is,

$$R_{T2} = 20 + (10||30) = 20 + \frac{10\times 30}{10+30} = 27.5\ \Omega$$

1 mark for I_{L1}

Current supplied by 20V source is,

$$I_{S2} = \frac{V_2}{R_{T2}} = \frac{20}{27.5} = 0.727\text{ A}$$

By current division formula,

$$\mathbf{I_{L2}} = I_{S2}\frac{10}{10+30} = 0.727(0.25) = \mathbf{0.182\ A\ (from\ A\ to\ B)}$$

1 mark for I_{L2}

iii) Load Current (I_L):

By superposition theorem, load current is given by,

$$\mathbf{I_L} = I_{L1} + I_{L2} = 0.9092 + 0.182 = \mathbf{1.0912\ A}$$

1 mark for I_L

5 c) Write and solve the node voltage equation for the circuit shown in Fig.(6) using nodal analysis.

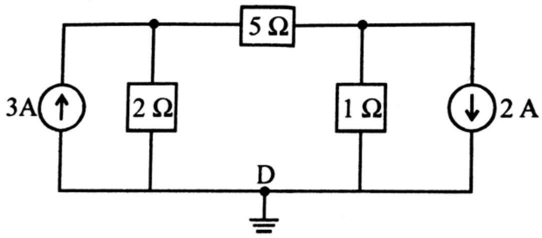
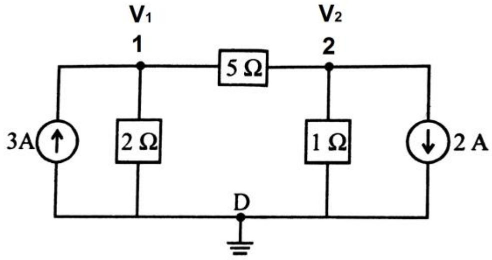


Fig. – 6

Ans:

Nodal Analysis:

i) Nodes and respective node voltages with respect to reference node D are shown in the diagram.



1 mark for circuit diagram with node and node voltage marking

ii) At node 1, by KCL,

$$-3 + \frac{V_1}{2} + \frac{V_1 - V_2}{5} = 0$$

$$\therefore V_1\left[\frac{1}{2}+\frac{1}{5}\right] - V_2\left[\frac{1}{5}\right] = 3$$

$$0.7V_1 - 0.2V_2 = 3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

iii) At node 2, by KCL,

$$2 + \frac{V_2}{1} + \frac{V_2 - V_1}{5} = 0$$

$$\therefore V_2\left[1+\frac{1}{5}\right] - V_1\left[\frac{1}{5}\right] + 2 = 0$$

$$0.2V_1 - 1.2V_2 = 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(2)$$

½ mark for each of eq. 1 & 2

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

$$\begin{bmatrix} 0.7 & -0.2 \\ 0.2 & -1.2 \end{bmatrix}\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 3 \\ 2 \end{bmatrix}$$

$$\therefore \Delta = \begin{vmatrix} 0.7 & -0.2 \\ 0.2 & -1.2 \end{vmatrix} = -0.84 - (-0.04) = -0.8$$

1 mark for calculating Δ

By Cramer's rule,

$$V_1 = \frac{\begin{vmatrix} 3 & -0.2 \\ 2 & -1.2 \end{vmatrix}}{\Delta} = \frac{(-3.6) - (-0.4)}{-0.8} = \frac{-3.2}{-0.8} = \mathbf{4\ volt}$$

$$V_2 = \frac{\begin{vmatrix} 0.7 & 3 \\ 0.2 & 2 \end{vmatrix}}{\Delta} = \frac{(1.4) - (0.6)}{-0.8} = \frac{0.8}{-0.8} = \mathbf{-1\ volt}$$

½ mark for each of node voltages

5 d) What is the need of polarity marking in polyphase AC circuits?

Ans:

Need of Polarity Marking in Polyphase AC Circuits:

i) Polarity marking of terminals provides reference polarity for better understanding of system, even if the polarity of ac voltage changes continuously with respect to time.

ii) Making connections for parallel operation of transformer becomes easy if the terminals are polarity marked, otherwise winding may get connected with additive polarity and high circulating currents may damage the windings.

iii) Polarity marking is a convenient way of stating how the leads are brought out.

iv) Without polarity marking, it is difficult to understand the terminals, phase displacement, phase sequence in polyphase circuit.

v) Without polarity marking in polyphase circuit, there will be lot of confusion in making the connections.

vi) Without polarity marking in polyphase circuit, making connections of current transformers in relay protection circuit and getting desired performance is very difficult.

1 mark for each of any four points

5 e) Define in relation with AC waveform:

(i) Time period
(ii) Cycle
(iii) Amplitude
(iv) Crest factor

Ans:

i) Time Period (T):

Time period of an alternating quantity is defined as the time required for an alternating quantity to complete one cycle.

1 mark for each definition = 4 marks

ii) Cycle:

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

OR

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

iii) Amplitude:

It is the maximum value attained by an alternating quantity in a cycle. It is also known as Peak value or Crest value or Maximum value.

iv) Crest Factor:

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

$$\text{Crest factor} = \frac{Peak\ Value}{RMS\ Value}$$

5 f) State the value of p.f. during resonance condition. Define p.f. State the importance of p.f.

Ans:

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

ii) **Definition of Power Factor:**

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

Power factor = $\cos\phi$

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

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

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

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

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

iii) Importance of Power Factor:

If power factor is improved:

- 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.

Any two points 1 mark each

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

6 a) Derive an expression for resonant frequency of a series RLC circuit.

Ans:

Resonant Frequency of Series RLC Circuit:

For series R-L-C circuit, the complex impedance is given by,

$$\text{Z} = \text{R} + \text{jX}_\text{L} - \text{jX}_\text{C} = \text{R} + \text{jX}$$ 1 mark

where, inductive reactance is given by $\text{X}_\text{L} = 2\pi\text{fL}$

capacitive reactance is given by $\text{X}_\text{C} = \frac{1}{2\pi\text{fC}}$

At resonance, the inductive reactance is equal to the capacitive reactance.

Hence, $\text{X}_\text{L} = \text{X}_\text{C}$

1 mark for reactance equations +

$$2\pi f_r L = \frac{1}{2\pi f_r C}$$

$$f_r^2 = \frac{1}{(2\pi)^2 LC}$$

$\therefore$ Series Resonant frequency $f_r = \frac{1}{2\pi\sqrt{LC}}$Hz

Resonant Angular frequency $\omega_r = \frac{1}{\sqrt{LC}}$rad/sec

1 mark for equality + 1 mark for final expression

6 b) Write the steps for finding the current through an element by Thevenin's theorem.

Ans:

Steps for finding Branch Current by Thevenin's Theorem:

i) Identify the load branch whose current is to be found.

ii) Redraw the circuit with load branch separated from the rest of the circuit such that the the load branch appears between terminals, say A and B, which are connected to rest of the circuit by two wires.

iii) Remove the load branch from terminals A and B, so that the rest of the circuit appears between these terminals A and B.

1 mark for separation of load from circuit

iv) Find the open circuit voltage appearing across the terminals A and B (after load removal) due to internal independent sources, using any circuit analysis technique. Let this open circuit voltage be V_{Th}.

1 mark for V_{Th}

v) Determine the equivalent impedance of the circuit seen between the open terminals A and B, while looking back into the circuit, with all internal independent volatge sources replaced by short-circuit and all internal independent current soutrces replaced by open-circuit. Let this equivalent impedance be Z_{Th}.

1 mark for Z_{Th}

vi) The circuit appearing between open circuited terminals A and B (due to removal of load branch) is now represented by simple circuit consisting of a voltage source, having magnitude V_{Th} in series with an impedance Z_{Th}.

vii) If the load impedance is Z_L, then connecting it between terminals A and B gives rise to load current $I_L = V_{Th} / (Z_{Th} + Z_L)$

1 mark for I_L determination

6 c) Explain with suitable example to convert a practical current source into an equivalent voltage source.

Ans:

Source Transformation: Current Source to Voltage Source:

Two sources are said to be equivalent only if their terminal voltage current characteristic is same for same load.

Let I_S be the practical current source magnitude and

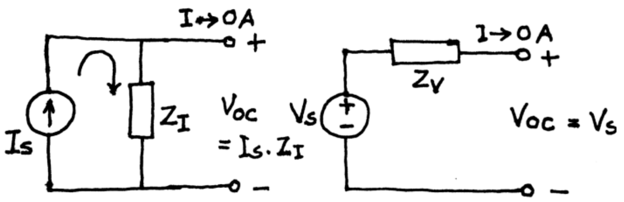
Z_I be the internal parallel impedance.

V_S be the equivalent practical voltage source magnitude and

Z_V be the internal series impedance of the voltage source.

Their equivalence is checked for extreme loading conditions.

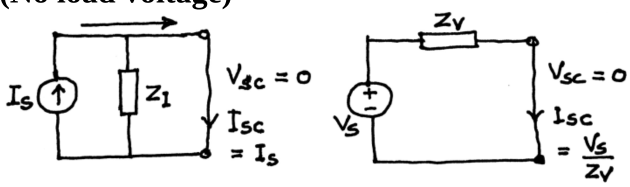
i) Open circuit: (No load Current)



1 mark for eq.(1) + 1 mark for eq.(2) + 1 mark for eq.(3) + 1 mark for example

The open circuit terminal voltage of current source is $V_{OC} = I_S \times Z_I$
The open circuit terminal voltage of voltage source is $V_{OC} = V_S$
If the two sources are equivalent, then open-circuit voltage must be same.
Therefore, we get $V_S = I_S \times Z_I$ …………………………(1)

ii) Short circuit: (No load voltage)



The short circuit output current of current source is $I_{SC} = I_S$
The short circuit output current of voltage source is $I_{SC} = V_S / Z_V$
If the two sources are equivalent, then short-circuit current must be same.
Therefore, we get $I_S = V_S / Z_V$ …………………………(2)
On comparing eq. (1) and (2), it is clear that $Z_I = Z_V = Z$ ……….. …..(3)
Thus the internal impedance of both the sources is same, and the magnitudes of the source voltage and current are related by Ohm's law.

iii) Example:
A current source of 10A with internal resistance of 2 Ω can be converted to equivalent voltage source of magnitude $V_S = I_S \times Z_I = (10)(2) = 20$ volt and internal resistance same as $Z_V = Z_I = 2\Omega$

6 d) Write the expression for impedance and power when an AC circuit contains:
(i) pure R (ii) pure L

Ans:

i) AC circuit containing Pure R:
Impedance $Z = R + j0 = R = |R|\angle 0°\Omega$
Power $P = VI\cos(0°) = VI = I^2R = \frac{V^2}{R}$ watt
where, R is the resistance in ohm.
V is the voltage across the resistance in volt.
I is the current flowing through the resistance in A.

1 mark for each of Z and P of R

ii) AC circuit containing Pure L:
Impedance $Z = 0 + jX_L = 0 + j(2\pi fL) = |X_L|\angle 90°\Omega$
Active Power $P = VI\cos(90°) = 0$ watt.
Reactive Power $Q = VI\sin(90°) = VI = I^2X_L$var
where, L is the inductance in henry.
V is the voltage across the inductance in volt.
I is the current flowing through the inductance in A.
F is the supply frequency in Hz.

1 mark for each of Z and P of L

6 e) Define: (i) Circuit (ii) Loop (iii) Node (iv) Branch

Ans:

i) Circuit:
It is a combination of different paths or branches through which electric currents are set up.

ii) Loop:
A closed path in an electric circuit through which an electric current can flow is called as loop.

iii) Node:
A point or junction in an electric circuit at which two or more branches are connected, is called a node.

iv) Branch:
A path between two nodes for an electric current in an electric circuit is called a branch. It may contain one or more circuit elements.

1 mark for each definition.

6 f) State the reason for using star connection particularly for large capacity alternators?

Ans:

Reason for using Star Connection for Large Capacity alternators:

i) In case of star connection, the phase voltage is related to line voltage by equation $V_{ph} = (V_L/\sqrt{3})$. For large capacity alternator, even if the line voltage is high, the phase voltage appearing across the phase winding will be comparatively less in star connection. Hence less insulation will be required for winding, resulting less space for housing of winding and saving in the cost of insulation.

ii) When the alternator is star connected, the neutral point is available for earthing, balancing of phase voltages and protection purposes.

2 marks for each of any two reasons