Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

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

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

1 Attempt any TEN of the following. 20

1 a) Define cycle and time period of an alternating quantity.

Ans-

(i) Cycle:A complete set of positive and negative values of an alternating quantity is termed a cycle. 01 mark

(ii) Time period: The time taken by an alternating quantity to complete one cycle is called time period.

It is given by: (if f = frequency in Hertz) 01 mark

$$T = \frac{1}{f} \text{ seconds}$$

1 b) Write down the units of R, L and G.

Ans-

R	Ohms (Ω)	½ mark
L	Henry (H)	½ mark
G	Mho or Siemens (℧)	01 mark

1 c) Define impedance of A.C. circuit and state its unit.

Ans-

Impedance- It is combined effect produced by the resistance, inductive reactance and capacitive reactance in the AC circuit. 01 mark

Unit- ohms (Ω) 01 mark

1 d) Define quality factor of series AC circuit.

Ans-

Quality factor-It is the voltage magnification in series circuit or ratio Of V_C/V or V_L/V. 02 mark

1 e) What is admittance of parallel A.C. circuit? State its unit.

Ans:

Admittance-for parallel AC circuit it is $Y = \sum \frac{1}{Zr}\ siemens$, z_r = r^{th} impedance in parallel. where r = 1, 2, 3 …, n 01 mark

Unit – Siemens or mho 01 mark

1 f) Define conductance and susceptance in case of parallel circuit.

Ans:

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

It is also defined as the ratio of resistance to the square of the impedance. 01 mark

In general, $conductance(G) = \frac{R}{Z^2}\ siemens$

Susceptance (B):It is imaginary part of the admittance (Y). It is defined as the ability of the purely reactive circuit (purely capacitive or purely inductive) to pass alternating current.

or

It is also defined as the ratio of reactance to the square of the impedance. 01 mark

In general, $Susceptance\ (B) = \frac{X}{Z^2}\ siemens$

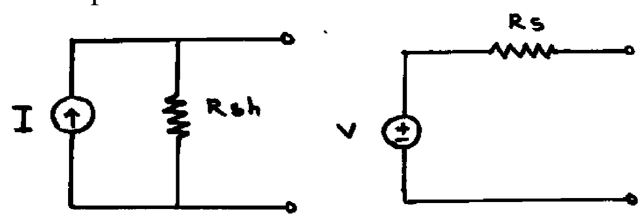
1 g) Define unbalanced three phase load.
Ans:
If impedances of one or more legs of a three phase load are different from other legs in respect of magnitude and their nature, it is said to be an unbalanced three phase load. i.e. magnitude of voltages and resulting currents are different either in phase or magnitude or both phase & magnitude. 02 mark

1 h) Write down relation between line and phase values of voltages and currents in three phase star connected system.
Ans-
Relation between Line voltage & phase voltage - $V_L = \sqrt{3} * V_{ph}$ 01 mark

Relation between Line current & phase current - $I_L = I_{ph}$ 01 mark

1 i) How current source can be converted into equivalent voltage source?

- Given practical current source will be as below-



Given current source equivalent voltage source

- Find magnitude of equivalent voltage source v = I x R_{sh} 01 mark
- Find magnitude of internal resistance of equivalent voltage source as R_s = $R_{sh.}$ 01 mark
- From computed parameters we can get equivalent voltage source.

1 j) Sate Thevenin's theorem.
Ans:
Statement- Any linear bilateral complex circuit can be represented by a simple equivalent circuit consisting of a single voltage source in series with a resistance, where the source voltage (V_{TH}) is equal to the open circuit voltage appearing across the load terminals when load is removed and the series resistance (R_{TH}) is equal to the equivalent resistance of the circuit seen between the load terminals, when voltage sources are replaced by short circuit and current sources are replaced by open circuit (the internal source impedances remaining in circuit). 02 mark

1 k) Find Z_L to transfer maximum amount of power from source to load in fig.A

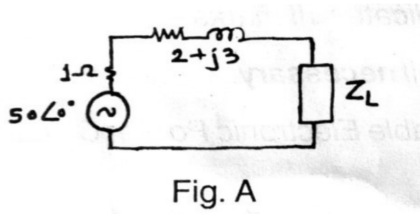


Fig. A

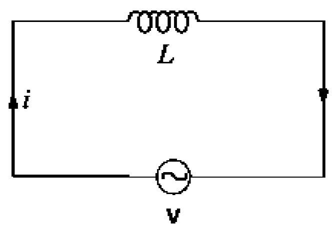
Ans- ½ mark
Open Z_L and find Z_{TH} = 1 +(2+j3) = 3+j3 Ω
In AC circuit, to deliver maximum amount of power to the load impedance, the load impedance (Z_L) must be complex conjugate of Z_{TH}. ½ mark 01 mark
Therefore, Z_L = (3-j3) Ω for maximum power transfer.

1 l) State the behavior of pure L at the time of switching.
Ans:
i) At the instant of switching (i.e. at t=0) the inductor acts as open circuit opposing any change in circuit current 01 mark

ii) At t = ∞ the inductor acts as short circuit. 01 mark

2 Attempt any FOUR of the following. 16
2 a) Explain the response of A.C. supply to pure inductance; draw wave diagram for the same.

Ans-



½ mark

Above fig shows purely inductive circuit.
Let i = Im Sin ωt…………………(1) ½ mark
Then voltage across inductor is given by;
v = −(indued emf)

$$e = -\left(-L.\frac{di}{dt}\right) \text{ by definition}$$ ½ mark

$$\therefore v = L.\frac{d}{dt}(I_m \sin \omega t)$$

$$= LI_m.\omega\cos\omega t$$

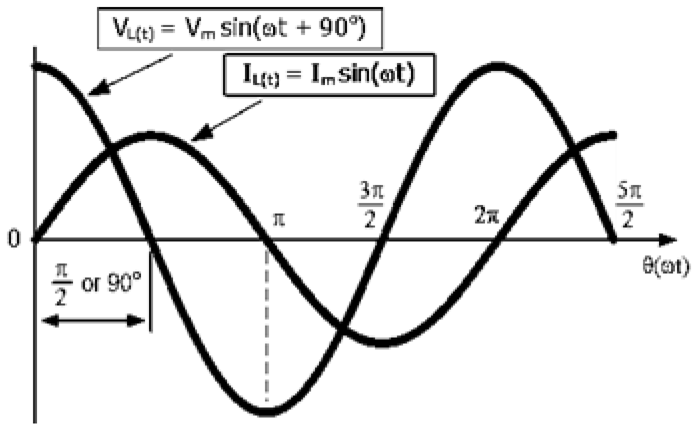
$$= I_m\omega L \sin\left(\omega t + \frac{\pi}{2}\right)$$ ½ mark

$$v = V_m \text{Sin}\left(\omega t + \frac{\pi}{2}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where - $V_m = I_m . \omega L$ 01 mark

From equation (1) and (2) it is clear that there is phase difference of $\varphi = \frac{\pi}{2} rad = 90°$ lagging. i.e. the current 'i' lags behind applied voltage 'v' by 90^0.

Waveform-



01 mark

2 b) Write down different powers in AC circuits; also write their equations and their units.

Ans-

Active Power (P):

The average power drawn by the AC circuit is called as Active power.

Or

It is the power which is actually dissipated in the circuit resistance.

It is given by,P = VI Cosϕ watts (or kilowatts).

Reactive Power (Q):

Power drawn by the circuit due to reactive component (ISinϕ) is called as reactive power.

It is given by, Q = VI sin ϕ VAR (or kVAR).

Apparent power(S):

It isgiven by product of rms value of applied voltage and circuit current.

$\therefore \mathbf{S = VI\ volt\ ampere\ (\ or\ KVA)}$

each definition - 1/2 mark = 1.5 mark

equations-1/2 mark = 1.5 mark

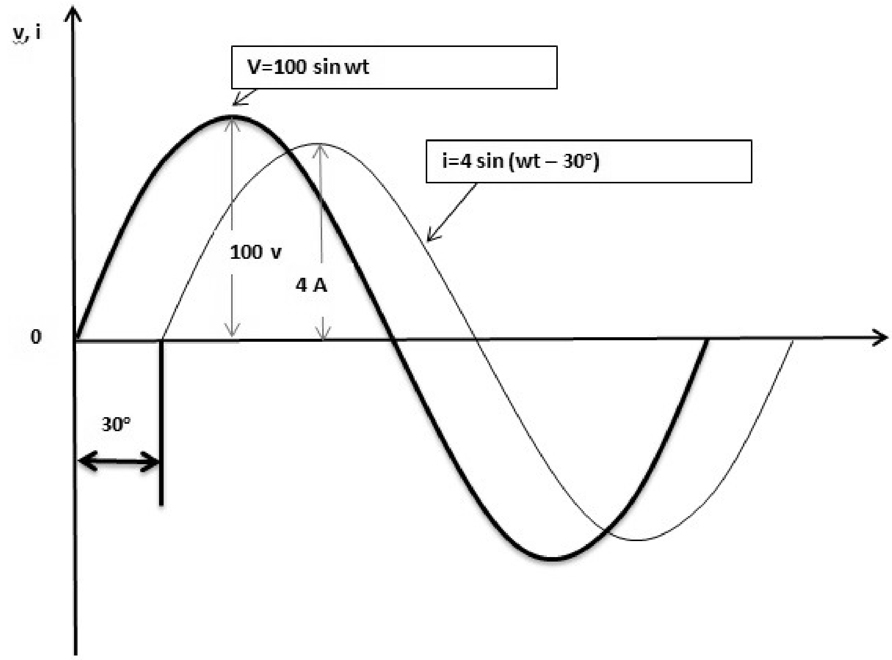
units=01 mark

2 c) Draw waveform and vector diagram to show following voltage and current.

$\boldsymbol{V = 100 \sin \omega t}$ And $\boldsymbol{i = 4 \sin(\omega t - 30°)}$

Ans-

Waveform-

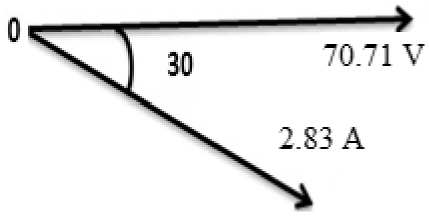


02 mark

Vector diagram- (only RMC values to be used)

02 marks

If RMS values not shown give only ½ mark



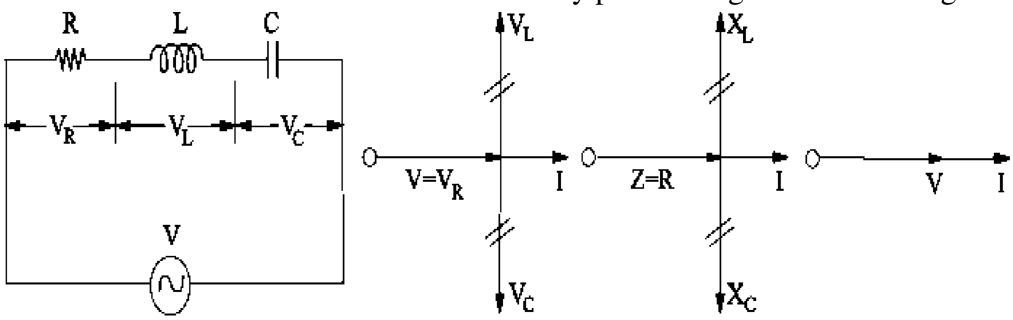
2 d) Explain resonance in series AC circuit and also derive equations for resonant frequency for the same.

Ans-

Resonance in series RLC circuit-

The series RLC circuit is said to be in electrical resonance when it exhibits unity power factor or the applied voltage and resulting current become in phase with each other.

i.e. at certain frequency X_L equal to X_C in magnitude.in that case $X=X_L-X_C = 0$ and Z=R; under this condition circuit behaves as a purely resistive circuit and thus it is said to be in Electrical resonance. It is shown by phasor diagram in below figure. 02 marks



Equations for resonant frequency-

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

At resonance; $X_L - X_C = 0$

$$\therefore X_L = X_C$$

$$or \quad \omega_o L = \frac{1}{\omega_o C}$$

$$\therefore \omega_O^2 = \frac{1}{LC}$$

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

$$or \ fo = \frac{1}{2\pi(\sqrt{LC})}$$

02 marks

2 e) Compare series and parallel circuits on any six points.

Ans-

Sr. no.	Parameter	Series circuit	Parallel circuit
1	Impedance	Minimum Z=R	Maximum $Z_D = L/RC$
2	Nature of circuit	Resistive	Resistive
3	Power factor	Unity	Unity
4	Current	Maximum $I_o = V/R$	Minimum $I_o = V/Z_D$
5	Type of circuit	Accepter circuit	Rejecter circuit
6	Magnification	Voltage magnification	Current magnification
7	Resonant frequency	$fo = \frac{1}{2\pi\sqrt{LC}}$	$fo = \frac{1}{2\pi\sqrt{LC}}$
8	Q-factor	$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$	$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

1 = 2 pts 1 mark,

3 – 4 pts 2 marks,

5 pts = 3 marks,

6 pts = 4 marks.

2 f) State any four advantages of polyphase circuits over a single phase circuits.

Ans-

Advantages of polyphase circuits over single phase circuits:

- Balanced polyphase systems are most efficient ones for transmission & distribution. 1 mark each
- For equal power to be transmitted polyphase systems require less copper.

- For equal power to be transformed polyphase transformers are less in weight i.e save materials.
- The problem of heavy neutral currents (due to single phase loads) can be overcome only in polyphase systems by load balancing.
- Polyphase induction motors are self-starting, whereas single phase induction motors are not self-starting machines unless provided with an extra starting winding.
- Polyphase motors have higher efficiency as compared to single phase motors.
- Poly phase motors have better power factor.
- Polyphase machines are very suitable for huge power applications whereas single phase ones are unsuitable.
- The size of polyphase motors is small as compared to single phase motors of same rating.
- Polyphase system is much cheaper with regards to generation of power and its transmission and distribution compared to a single phase system.

Any four points = 04 marks

3 Attempt any two 16

3 a) A coil of resistance 50 Ω and inductance of 0.1 H is connected in series with 100 µf capacitor. A combination is supplied with 230 volt 50Hz AC supply. Calculate voltage across each, current through the circuit, power factor & draw complete vector diagram.

Solution- Given- R=50 Ω, L=0.1 H, C=100µf, V=230 V, f= 50Hz

$$X_L = 2\,\pi f L = 2\pi * 50 * 0.1 = 31.41\,\Omega$$ 01 mark

$$Xc = \frac{1}{2\pi fC} = \frac{1}{2\pi * 50 * 100 * 10^{-6}} = 31.83\,\Omega$$ 01 mark

$Z=R+j\,(X_L-X_C)$
$=50+j(31.41-31.83)$
$Z=50-j\,0.42\,\Omega$
$Z = 50\angle -0.48°\,\Omega$ 01 mark

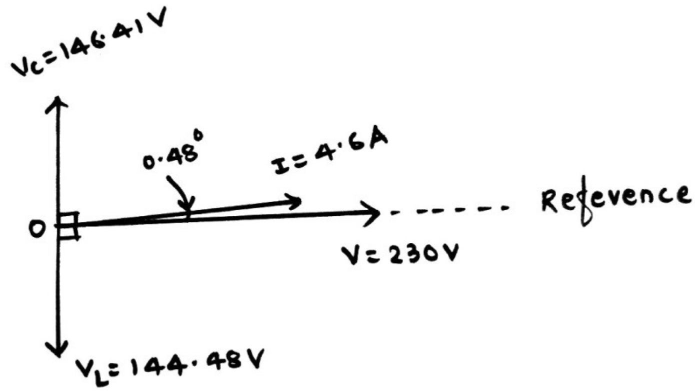
Current through circuit;

$$I = \frac{V}{Z} = \frac{230\angle 0^0}{50\angle -0.48°}$$

$I = 4.6\angle\, 0.48°\,Amps$ 01 mark

Voltage across each element -
V_R=IR =14.6 X 50 = 230V 01 mark
V_L=IX_L= 4.6 X31.41 =144.48 V 01 mark
V_C= IX_C=4.6 X 31.83 =146.41 V 01 mark

Vector diagram-



01 mark

3 b) A balanced delta consists of per phase impedance of 5+j7 ohm. It is supplied with 200V, 50Hz, 3phase AC supply. Calculate line current, phase current, Phase voltage, total power absorbed and power factor of the combination. Also draw complete vector diagram.

Solution-
Given - Z_{ph} =5+j7 Ω = 8.60∠54.46^0 , V_L= 200V, f=50Hz

Phase voltage-
For delta connection,
$$V_L = Vph = 200V$$
01 Mark

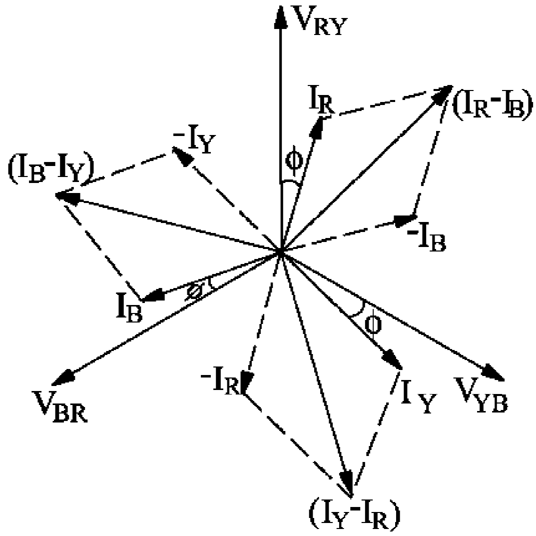
Phase current-
$$Iph = \frac{Vph}{Zph} = \frac{200\angle 0}{8.60\angle 54.46} = 23.25\angle(-54.46)\ A$$
02 mark

Line current-
$$I_L = \sqrt{3}\ X\ Iph = \sqrt{3} * 23.25 = 40.27\ A$$
01 mark

Power Factor-
$$Cos\varphi = \frac{R}{Zph} = \frac{5}{8.60} = 0.58\ lag$$
01 Mark

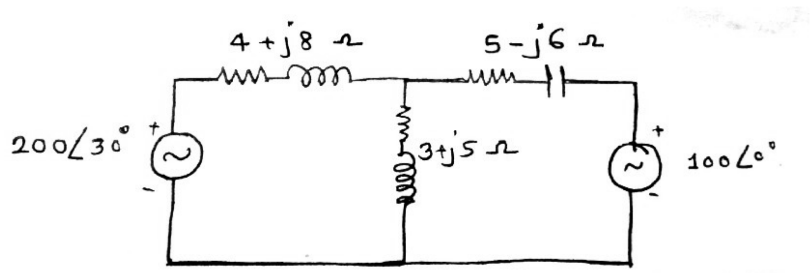
Total Power absorbed-
$$P = \sqrt{3} * V_L * I_L * Cos\varphi = \sqrt{3} * 200 * 40.27 * 0.58 = 8090.96\ watts$$
01 mark

Vector Diagram-
For vector diagram: V_{RY} = V_{YB} = V_{BR}; phase currents are $|I_R|$ = $|I_Y|$= $|I_B|$ line currents are $|(I_R - I_B)| = |(I_B - I_Y)| = |(I_Y - I_R)|$.
Phase power factor angle = Ø =54.46 lag.



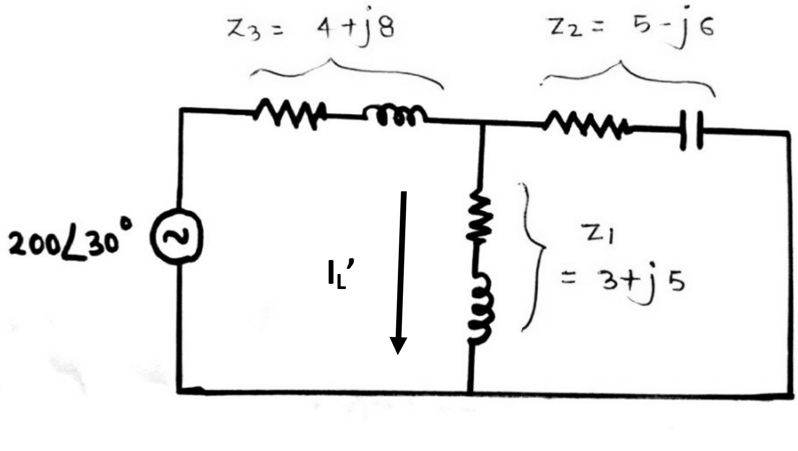
Phasor diagram 02 mark

3 c) Find current through impedance 3+j5 using superposition theorem in the following circuit,



Ans:

Case-1) consider $200\angle 30^0$ V, source acting alone:



01 mark

$Z_1 \| Z_2 = (3+j5) \| (5-j6)\ \Omega \quad = \quad \frac{(3+j5)X(5-j6)}{(3+j5)+(5-j6)}$

$$= \frac{(5.83\angle 59.03^0)(7.81\angle -50.19^0)}{8-j1}$$

$$= \frac{45.53\angle 8.84}{8.06\angle -7.12}$$

$= 5.64\angle 15.96\ \Omega$

$Z_{eq} = Z_3 + (Z_1 \parallel Z_2)$
$= (4+j8) + (5.64\angle 15.96)$
$=(4+j8) + (5.42+j1.55)$
$= 9.42+j9.55$

$$Zeq = 13.41\angle 45.39^0$$

$$I = \frac{V}{Z_{eq}} = \frac{200\angle 30^0}{13.41\angle 45.39^0}$$

$$I = 14.91\angle -15.39^0$$

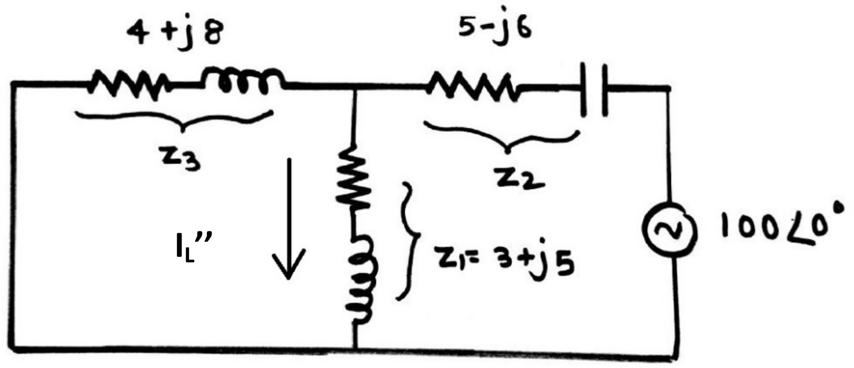
Using current division rule-

Current through $(3+j5)$

$$I'_L = I * \frac{Z_2}{Z_1 + Z_2} = 14.91\angle -15.39^0 * \frac{5-j6}{(3+j5)+(5-j6)}$$

$I'_L = 14.44\angle -58.46^0\ A$ = (7.55 – j12.3) A — Correct I_L' = 02 mark

Case II) Consider $100\angle 0^0$ source acting in network



01 mark

$$Z_1 \parallel Z_3 = \frac{(3+j5)*(4+j8)}{(3+j5)+(4+j8)} = \frac{(5.83\angle 59.03^0)(8.94\angle 63.43^0)}{14.46\angle 61.7}$$

$$= \frac{(52.12\angle 122.46^0)}{(14.76\angle 61.7^0)}$$

$$Z_1 \,||\, Z_3 = 3.6\angle 60.77^0$$

$$Z_{eq} = Z_2 + (Z_1 \,||\, Z_3)$$

$$Z_{eq} = (5 - j6) + (3.53\angle 60.77^0)$$

$$Z_{eq} = (5 - j6) + (1.76 + j3.14)$$

$$Z_{eq} = (6.76 - j2.86)$$

$$Z_{eq} = 7.34\angle -22.9^0$$

$$I = \frac{V}{Z_{eq}} = \frac{100\angle 0^0}{7.34\angle -22.9^0} = 13.62\angle 22.9^0$$

Using current division rule-

Current through 3+j5,

$$I''_L = I * \frac{Z_3}{Z_1 + Z_3} = (13.62\angle 22.9^0) * \frac{(4 + j8)}{(3 + j5) + (4 + j8)}$$

$$= \quad 13.62\angle 22.9 * \frac{8.94\angle 63.43}{7 + j13}$$

$$= \quad \frac{121.76\angle 86.33}{14.76\angle 61.69}$$

$I_L'' = 8.25 \angle 24.64^o = (7.5 + j3.44)$ A. Correct I_L'' = 02 mark

Current through load impedance,

$I_L = I_L' + I_L''$ 1 mark

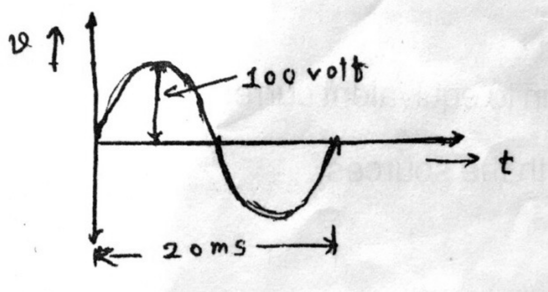
$= (14.44\angle -58.46) + (8.25\angle 24.64)$

$= (7.55 - j12.30) + (7.5 + j3.44)$

$I_L = 15.05 - j8.86$ A. 1 mark

4 Attempt any FOUR of the following. 4 X 4 = 16

4 a) Calculate frequency, RMS value , Average Value and Amplitude of the wave form.



$$Given \quad V_m = 100 volt, T = 20\ ms$$

i) $f = \frac{1}{T}$

$$= \frac{1}{20X\ 10^{-3}} = 50Hz$$ 01 mark

ii) $V_{rms} = \frac{V_m}{\sqrt{2}}$

$$= \frac{100}{\sqrt{2}} = 70.71\ volt$$ 01 mark

iii) $V_{avg} = 2\ \frac{V_m}{\pi}$

$$= 2\ \frac{100}{\pi} = 63.60\ volt$$ 01 mark

iv) $Amplitude - V_m = 100\ volt$ 01 mark

4 b) A series circuit consisting of R=100 Ω and C=200 μF connected across 200V, 50Hz supply. Calculate V_R, V_c , I and power absorbed by the circuit.

Solution-
Given- $R = 100\ \Omega$, $C = 200\ \mu F$, $V = 200\ volt$, $f = 50Hz$

$$X_c = \frac{1}{2\pi fC} = \frac{1}{2\pi * 50 * 200 * 10^{-6}} = 15.91\ \Omega$$

$$Z = \sqrt{R^2 + {X_c}^2} = \sqrt{100^2 + 15.91^2} = 101.25\ \Omega$$

$$I = \frac{V}{Z} = \frac{200}{101.25} = 1.975\ Amp$$ 01 mark

$$V_R = IR = 1.975 * 100 = 197.5\ volt$$ 01 mark

$$V_c = IX_c = 1.975 * 15.91 = 31.42\ volt$$ 01 mark

$$cos\emptyset = \frac{R}{Z} = \frac{100}{101.25} = 0.981$$

$$P = VIcos\phi$$

$$P = 200 * 1.975 * 0.981 = 387.495\ watt$$

01 mark

4 c) Calculate current I_1 , I_2 and Total current I in the circuit shown fig.(B)

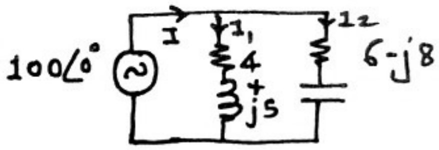


Fig. B

Ans:

$$Z_1 = 4 + j5 = 6.40 \angle 51.34^0$$

$$Z_2 = 6 - j8 = 10 \angle - 53.13^0$$

$$I_1 = \frac{V}{Z_1} = \frac{100\angle 0^0}{6.40 \angle 51.34^0} = 15.625 \angle - 51.34^0\ A$$ 01 mark

$$I_2 = \frac{V}{Z_2} = \frac{100\angle 0^0}{10 \angle -53.13^0} = 10 \angle 53.13^0 \text{ A}$$ 01 mark

Total I

Now, $Z_{eq} = Z_1 \mid\mid Z_2 = 6.13 \angle 14.92^0\ \Omega$ (01 mark

$$I = \frac{V}{Z_{eq}} = \frac{100\angle 0^0}{6.13\angle 14.92^0} = 16.31 \angle - 14.92^0$$ 01 mark)

Or

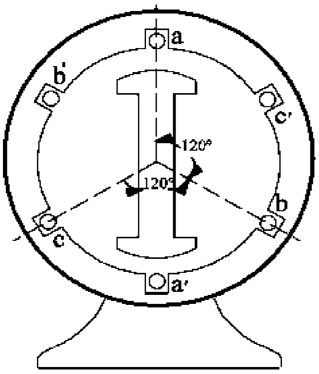
Or

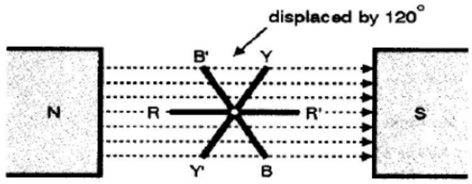
$I = I_1 + I_2 = 15.625\angle\text{-}51.34 + 10\angle 53.13 = 16.31\angle 14.92$ A 02 marks

4 d) Explain how 3 phase emf can be generated? Write voltage equations and the meaning of the phase sequence.

Ans-

Generation of three phase EMF-





Generation of a 3-phase voltage

Diagram= 01 mark

Above fig shows a 2-pole, stationary armature, rotating field type three phase alternator. It has three armature coils aa', bb' and cc' displaced 120 degree from one another. With present position and clockwise rotation of the poles as indicated in fig. it is found that the emf induced in conductor 'a' for coil aa' is maximum. The emf in conductor 'b' of coil bb' would be maximum when the N- pole has turned through 120 degree i.e. when N-S axis lies along bb'. It is clear that the induced emf in conductor 'b' reaches its maximum value 120 degree later than the maximum value in conductor 'a'. in the similar manner, the maximum emf induced in conductor 'c' would occur 120 degree later than in 'b' or 240 degree later than in 'a'.
Thus three coils have three emfs induced in them which are similar in all respect with a time phase difference of 120 degrees with one another.

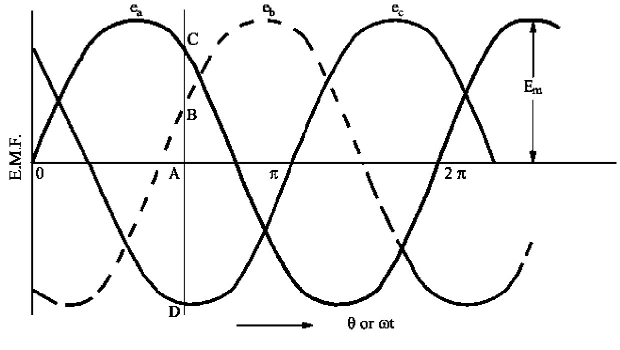
01 mark

The instantaneous values of three emfs given by equations-
e_a= Em sin wt
e_b = Em sin (wt-120^o)
e_c = Em sin (wt-240^o)

Equations=01 mark

Phase Sequence-
It is the order in which the three phases reach their maximum values. It is shown in below fig. the phase sequence is A-B-C (or say R-Y-B)

Waveforms 01 mark



4 e) A star connected balanced load consumes 1500 watt power when connected to 3-phase 400V,50Hz supply.If the power factor is $1/\sqrt{2}$ lagging, Calculate the value of

resistance and impedance of each phase.

Ans:

Given-

$$P = 1500\,W$$
$$V_L = 400\,V$$
$$F = 50Hz$$

$$\cos\phi = \frac{1}{\sqrt{2}} = 0.707\ lag$$

$$P = \sqrt{3}V_L I_L \cos\phi$$

$$\therefore I_L = \frac{P}{\sqrt{3}V_L I_L} = \frac{1500}{\sqrt{3}X400X0.707}$$ 01 mark

$$I_L = 3.06\,A$$

$$Z = \frac{V_{ph}}{I_{ph}} = \frac{400}{\sqrt{3} * 3.06} = 75.47\,\Omega$$

$$R = Z\cos\phi = 75.47\ X\ 0.707$$ 01 mark

$$R = 53.35\,\Omega$$

01 mark

$$X_L = Z\sin\phi = 75.47\ X\ 0.707 = 53.35\,\Omega$$

or

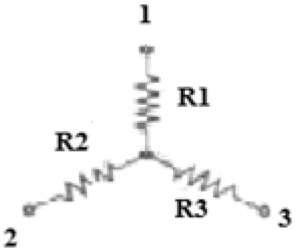
$$X_L = \sqrt{Z^2 - R^2} = \sqrt{75.47^2 - 53.35^2} = 53.35\,\Omega$$

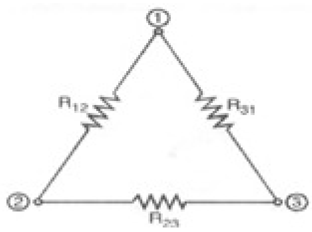
01 mark

$$L = \frac{X_L}{2\pi f} = \frac{53.35}{2\pi X50} = 0.1698\,H$$

4 f) Derive the formulae for star to delta transformation

Ans-
Star to delta conversion:
Consider the star connected network as shown in below fig. it will be replaced by the equivalent delta connected network.





1 mark

We write expressions for equivalent resistances between corresponding terminals of the two networks and proceed.

Resistance between 1 and 2

for star = $R_1 + R_2$ = (for delta) $= \frac{R_{12}\,(R_{23} + R_{31})}{(R_{12} + R_{23} + R_{31})}$ ------(1)

Resistance between 2 and 3

for star = $R_2 + R_3$ = (for delta) $= \frac{R_{23}\,(R_{12} + R_{31})}{(R_{12} + R_{23} + R_{31})}$ ------(2)

Resistance between 3 and 1

for star = $R_3 + R_1$ = (for delta) $= \frac{R_{31}\,(R_{12} + R_{23})}{(R_{12} + R_{23} + R_{31})}$ ------(3)

Subtracting (2) from (3) we get,

$$R_1 - R_2 = \frac{R_{12}\,(R_{31} - R_{23})}{(R_{12} + R_{23} + R_{31})}$$ ---------------------------(4)

Adding (1) and (4) and simplifying we get

$2R_1 = \frac{2R_{12}R_{31}}{(R_{12} + R_{23} + R_{31})}$, hence $R_1 = \frac{R_{12}R_{31}}{(R_{12} + R_{23} + R_{31})}$,

Similarly $R_2 = \frac{R23\ R12}{R12+R23+R31}$ $R_3 = \frac{R31\ R23}{R12+R23+R31}$ --------------------(5) 1 mark

From above expressions

$$\frac{R_1}{R_2} = \frac{R_{31}}{R_{23}},\ \frac{R_2}{R_3} = \frac{R_{12}}{R_{31}} \text{ and } \frac{R_3}{R_1} = \frac{R_{23}}{R_{12}}$$ ---------------------(6)

From (5) $R_{12} = [R_1(R_{12} + R_{23} + R_{31})/R_{31}]$

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

Using (6) $R_{12} = R_1(\frac{R_2}{R_3} + \frac{R_2}{R_1} + 1) = (\frac{R_1 R_2}{R_3} + R_2 + R_1)$. 1 mark

Similarly we can write,

$R_{23} = (\frac{R_3 R_2}{R_1} + R_2 + R_3)$ and $R_{31} = (\frac{R_3 R_1}{R_2} + R_3 + R_1)$ 1 mark

5 Attempt any FOUR. 16

5 a) A series RLC consist of R=10Ω, L=0.2 H and C= 50μF supplied with 200 V variable frequency supply. Find

1) Frequency at which the circuits behaves as purely resistive circuit and
2) Quality factor

Ans:

1) Frequency at which the circuits behaves as purely resistive circuit

$$fo = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(0.2 * 50 * 10^{-6})}} = 50.32\ Hz$$ 02 mark

2) Quality factor-

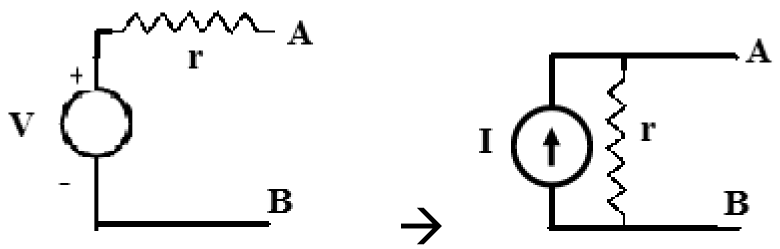
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{0.2}{50 * 10^{-6}}} = 6.32$$ 02 mark

5 b) How voltage source can be converted in to equivalent current source? Where it is used? Draw neat diagrams of both the sources.

Ans-

Steps to transform Voltage source to Current source:

1) Calculate equivalent current source as the short circuit current through the voltage source terminals: (I = V / r) 1 mark
2) The Shunt Resistance of current source: (R_{sh}= r) 1 mark
3) Draw the equivalent source.



1 mark

Uses-

- Source transformation is used to find and simplifying a circuit solution when circuit with mixed sources present.
- Source transformation is an application of Thevenin's Theorem and Norton's theorem. 1 mark

5 c) Find line and phase current through each line of the combination show in fig.C

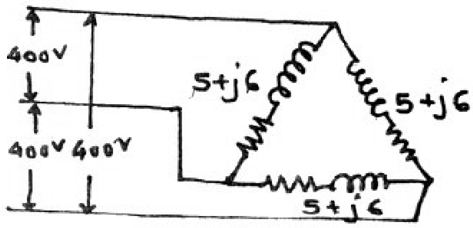


Fig. C

Solution:

Zph = 5 +j 6 Ω , it is balanced delta connected load.

$$Zph = \sqrt{5^2 + 6^2} = 7.81\ \Omega$$ 01 mark

For delta connected load;
V_L = Vph = 400 Volts

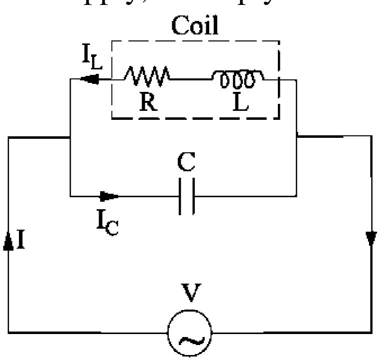
Phase current-

$$Iph = \frac{Vph}{Zph} = \frac{400}{7.81} = 51.21\ A$$ 01 mark

Line current-

$$I_L = \sqrt{3} * Iph = \sqrt{3} * 51.21 = 88.69\ A$$ 02 mark

5 d) Explain Q-factor for parallel RLC circuit.
Ans-
It is defined as the ratio of the current circulating between its two branches to the line current drawn from the supply, or simply current magnification.



As seen from above figure circulating current between capacitor & coil branches is I_C.

Hence Q-factor = I_C/I 01 mark

Now $I_C = V/X_C = V/(1/\omega c) = \omega cV$

And $I = V/Z_D = V/(L/CR) = VCR/L$

Therefore $\boldsymbol{Q - factor = \frac{\omega cV}{\frac{VCR}{L}} = \frac{\omega L}{R} = \frac{2\pi foL}{R}}$ 01 mark

$$\boldsymbol{Since, fo = \frac{1}{2\pi\sqrt{LC}}}$$ 1 mark

Substituting , fo in above equation of Q-factor we get;

$$\boldsymbol{Q - factor = \frac{1}{R}\sqrt{\frac{L}{C}}}$$ 1 mark

5 e) Using Norton's theorem find current through R_L in fig.D

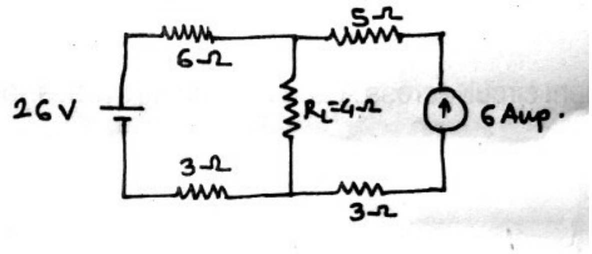
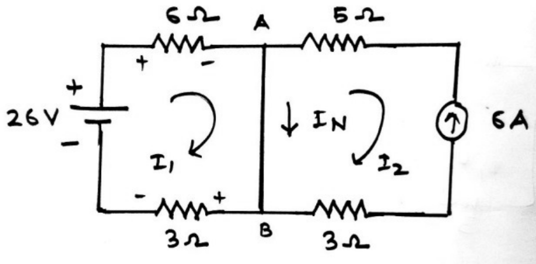


Fig. D

Ans:

Step-1) To determine I_N –

- Remove Load resistance R_L and short circuit load terminals.
- Determine current through short circuited branch using any one of the technique.



Using mesh analysis-

For loop-I

$-6I_1-3I_1+26 = 0$

$9I_1=26$

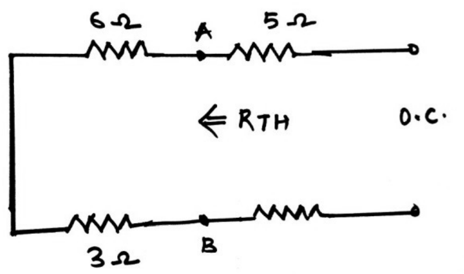
I_1=2.88 Amp

For loop-II
I_2= -6 A…….(current source exist in second loop so no need to write loop equations)

Current through short circuited branch –

$I_N = I_1 - I_2 = 2.88 - (-6) = 8.88$ Amp. 01 mark

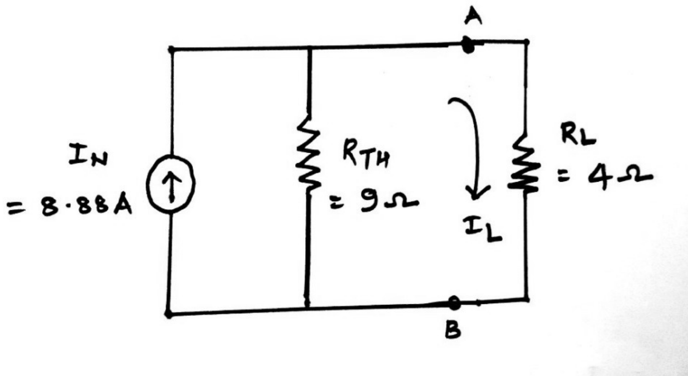
Step-2) To determine R_{TH} –



01 mark

$R_{TH} = 6\Omega + 3\,\Omega = 9\,\Omega$

Equivalent diagram-



01 mark

$$I_L = I_N * \frac{R_{TH}}{R_{TH} + R_L} = 8.88 * \frac{9}{9+4} = 6.14\ Amp$$ 01 mark

5 f) Using superposition theorem find current through R_L in fig.E

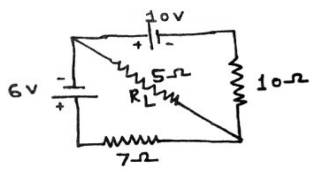
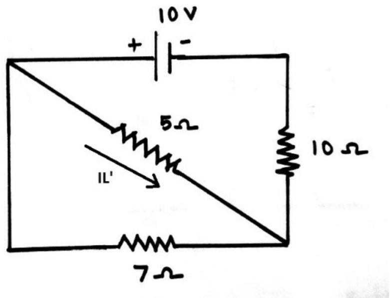
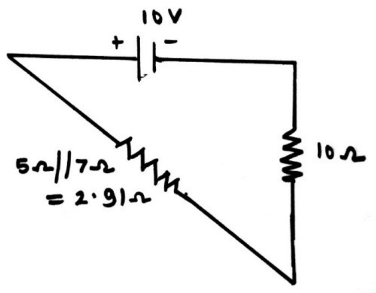


Fig. E

Solution-
Step-1) consider 10V source acting in the network.



$$5 \parallel 7 = \frac{5*7}{5+7} = \frac{35}{12} = 2.91\ \Omega$$



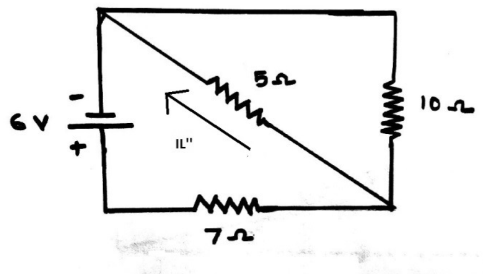
$$Req = 10 + 2.91 = 12.91\ \Omega$$

$$I = \frac{V}{Req} = \frac{10}{12.91} = 0.7745\ Amp$$

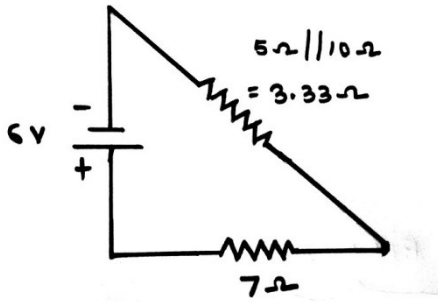
Using current division rule-

$$I_L' = 0.7745 * \frac{7}{7+5} = 0.4517\ Amp$$ 1 mark

Step-2) consider 6 V source acting in the network.



$$5 \parallel 10 = \frac{5*10}{5+10} = \frac{50}{15} = 3.33\ \Omega$$



$$Req = 7 + 3.33 = 10.33\ \Omega$$

$$I = \frac{V}{Req} = \frac{6}{10.33} = 0.5808\ A$$

Using current division rule-

$$I_L'' = 0.5808 * \frac{10}{10+5} = 0.3866\ A$$ 1 mark

Step-3) current through R_L is ;

$$I_L = I_L' - I_L''$$ 01 mark

(since, both currents flows in opposite direction to each other, thus their difference is taken)

$$I_L = 0.4517 - 0.3866 = 0.0651\ A$$ 1 mark

6 Attempt any FOUR of the following. 16

6 a) Using mesh analysis for Fig.F find the values R1 and R2.

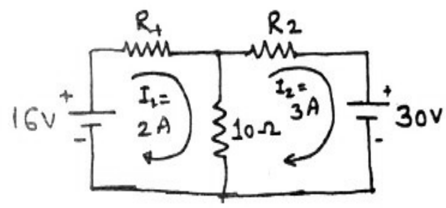
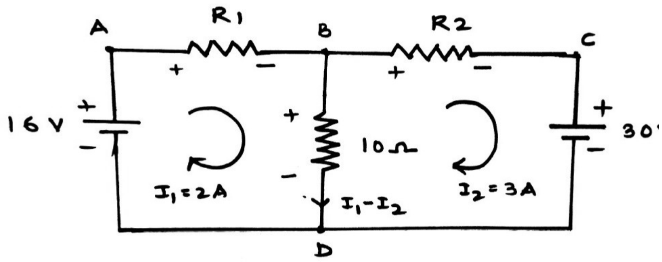


Fig. F

Ans:



Apply KVL to loop –I (A-B-D-A)

$-2R_1-10(I_1-I_2)+16 = 0$ 1 mark
$-2R_1-10(2-3)+16 = 0$
$-2R_1-10(-1)+16 = 0$
$-2R_1+10+16=0$
$2R_1 = 26$
$R_1=13\ \Omega$ 01 mark

Apply KVL to loop-II (B-C-D-B)

$-3R_2-30+10(2-3) =0$ 1 mark
$-3R_2-30-10=0$
$-3R_2-40=0$
$3R_2= -40$
$R_2= -13.33\ \Omega$ 01 mark
For assessors :(negative resistance is only hypothetical cannot exist)

6 b) Find current through 8Ω resistance using nodal analysis in fig.G

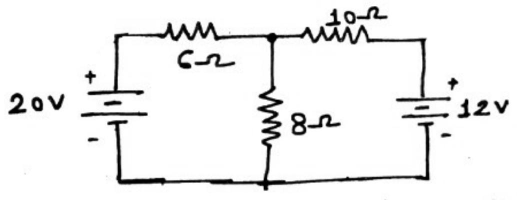
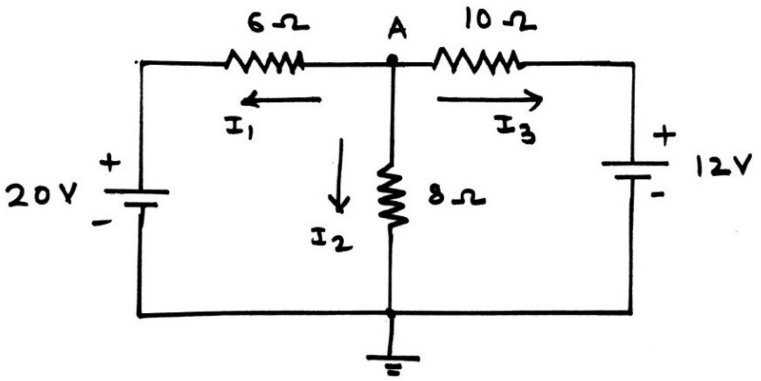


Fig. G

Ans:



01 mark

Apply KCL at node-A

$$I_1 + I_2 + I_3 = 0$$
$$\frac{V_A - 20}{6} + \frac{V_A}{8} + \frac{V_A - 12}{10} = 0$$ 1 mark

$$\frac{8(V_A-20)+6V_A}{6*8}+\frac{V_A-12}{10}=0$$

$$\frac{8V_A-160+6V_A}{48}+\frac{V_A-12}{10}=0$$

$$\frac{14V_A-160}{48}+\frac{V_A-12}{10}=0$$

$$10(14V_A-160)+\ 48(V_A-12)=0$$

$$140V_A-1600+\ 48V_A-576=0$$

$$188V_A=2176$$

$$V_A=11.57\ Volts$$ 1 mark

$$current\ through\ 8\Omega=\frac{V_A}{8}=\frac{11.57}{8}=1.44625\ A$$ 2 marks

6 c) Develop thevenin's equivalent circuit across A and B in the network shown in fig.H.

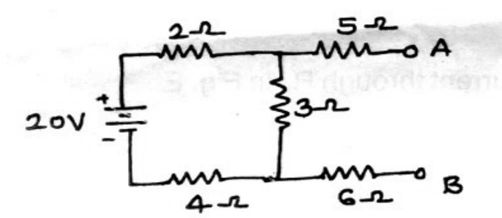
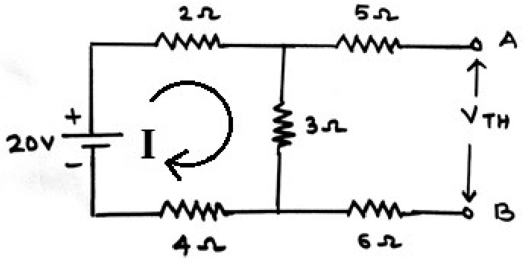


Fig. H

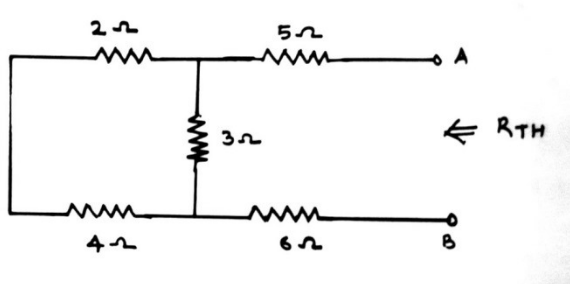
Ans:
Step-1) to determine V_{TH} -



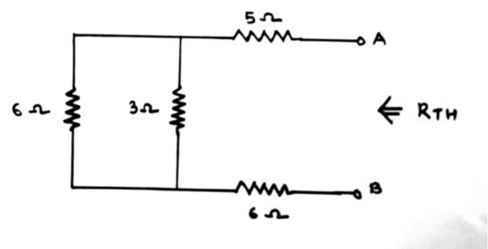
$$I=\frac{V}{Req}=\frac{20}{2+3+4}=\frac{20}{9}=2.22\ A$$ 1 mark

V_{TH} = Voltage drop across 3Ω resistor
= 3 * 2.22
= 6.66 volts 1 mark

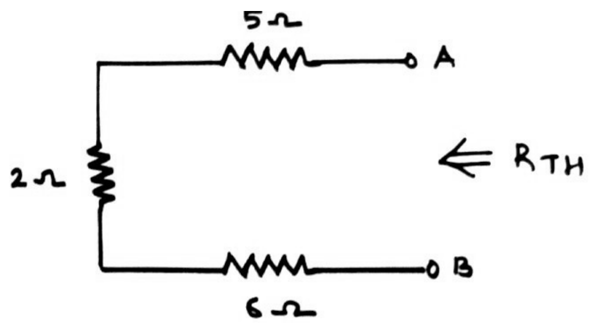
Step-2) To determine R_{TH} –



2Ω in series with 4Ω resistance; 2Ω+ 4Ω = 6 Ω



$$6\Omega \parallel 3\Omega = \frac{6*3}{6+3} = \frac{18}{9} = 2\ \Omega$$



R_{TH} = 5Ω+ 2Ω + 6 Ω = 13 Ω 01 mark

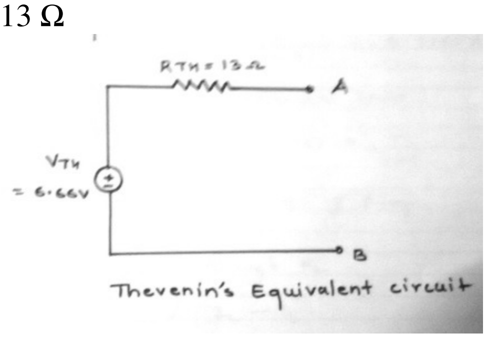


Fig 1 mark

6 d) Find the value of RL to transfer maximum power in the network shown in fig.I

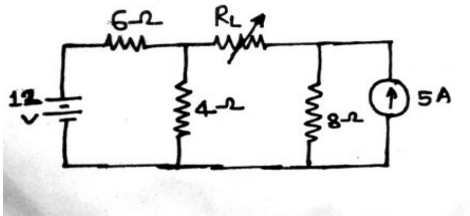


Fig. I

Solution-

To transfer maximum amount of power to load, $R_L = R_{TH}$

Thus, determining R_{TH}

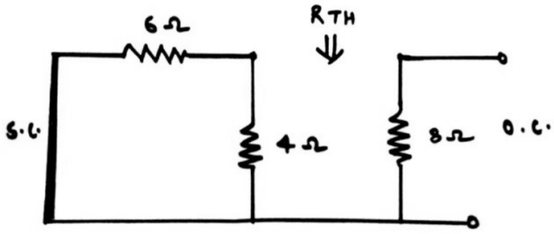


Fig 01 mark

$$6\Omega \parallel 4\Omega = \frac{6*4}{6+4} = \frac{24}{10} = 2.4\ \Omega$$ 01 mark

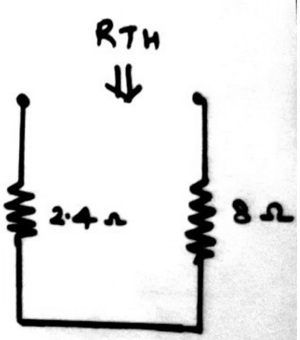


Fig 1 mark

Therefore, $R_{TH} = 8 + 2.4 = 10.4\ \Omega$

For max power transfer $R_L = R_{TH} = 10.4\ \Omega$ 1 mark

6 e) Find the voltages at node A and B in the network shown in fig.J

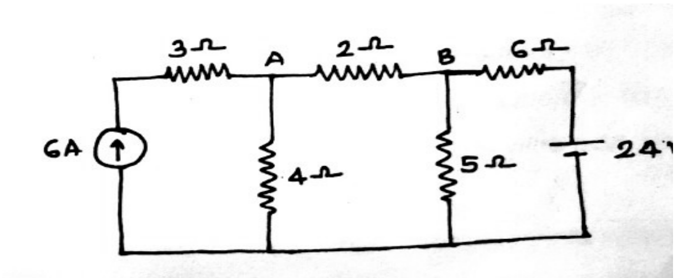
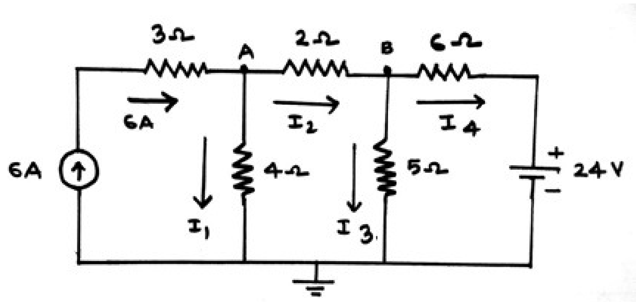


Fig. J

Ans:



01 mark

Apply KCL at node –A

$$\boldsymbol{I_1 + I_2 = 6}$$

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

$$\boldsymbol{\frac{2V_A + 4(V_A - V_B)}{4 * 2} = 6}$$ 01 mark

$$\boldsymbol{2V_A + 4V_A - 4V_B = 48}$$

$$\boldsymbol{3V_A - 2V_B} = 24 \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1)$$

Apply KCL at node –B

$$I_2 = I_3 + I_4$$

$$I_3 + I_4 - I_2 = 0$$

$$\frac{V_B}{5} + \frac{V_B - 24}{6} - \frac{V_A - V_B}{2} = 0$$

$$\frac{V_B}{5} + \frac{2(V_B - 24) - 6(V_A - V_B)}{6 * 2} = 0$$

$$\frac{V_B}{5} + \frac{2V_B - 48 - 6V_A + 6V_B}{12} = 0$$

$$\frac{V_B}{5}+\frac{8V_B-6V_A-48}{12}=0$$

$$12V_B+5(8V_B-6V_A-48)=0$$

$$12V_B+40V_B-30V_A-240=0$$

$$-30V_A+52V_B=240\ \ldots\ldots\ldots\ldots\ldots\ldots.(2)$$ 1 mark

Solving equation (1) and (2) we get;

VA = 18 volts 1 mark

VB = 15 volts 1 mark

6 f) Explain the concept of initial and final conditions in switching circuits for the elements R,L and C.

Ans-

Concept of initial condition:

A voltage source is connected to these elements using a switch. At instant of changing the switch position either from on to off or vice versa time t=0 is called reference time. In any switching network it is assumed that closing/opening of switch takes place instantaneously. Thus at time t=0; the condition of network is changed due to switching action. The network conditions at this instant are called as initial conditions.

Initial conditions:

Resistor: initial conditions in resistor are not present, as the equation (v=iR) is time independent. 2 marks

Inductor: at the time of switching inductor acts as an open circuit.

Capacitor: at the time of switching inductor acts as an short circuit

Concept of final condition:

If the switch is on, the switch at t=0 and then the network remains without switching action for a long time then the network conditions corresponding to this situation is known as the final condition or the steady state condition.

The final condition or steady state condition is also known as the network condition at $t \rightarrow \infty$.

Final Conditions:

Resistor: final conditions in resistor are not present, as the equation (v=iR) is time independent. Final conditions for resistor are zero.

Inductor: At the time of ($t \rightarrow \infty$) inductor acts as an short circuit.

Capacitor: at the time of switching (i.e. at $t \rightarrow \infty$) the capacitor acts as open circuit. 2 marks