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. 2 X 10 = 20

1 a Define Cycle and time period related to a.c. waveform.

Ans-

Cycle: One complete set of positive & negative values of alternating quantity is known as 'cycle'. 01 mark

Period: Time taken by an alternating quantity to complete one cycle is called its time 'period'. 01 mark

1 b Find frequency and amplitude of the following waveform.

Refer Figure No. 1

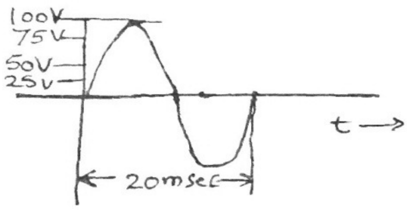


Fig. No. 1

Ans-

Frequency $f = \frac{1}{T} = \frac{1}{20 X 10^{-3}}$ = 0.05 X 10^3 = 50 Hz 01 mark

Amplitude V_m = 100 Volts 01 mark

1 c Define active and reactive power for R-L-C series circuit.

Ans-

Active Power (P):

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

Or 01 mark

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

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

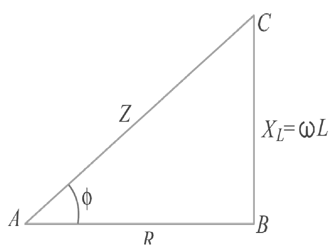
Reactive Power (Q):

Power drawn by the circuit due to reactive component (ISinϕ) is called as reactive power. 01 mark

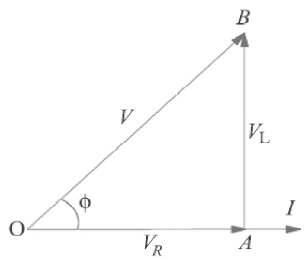
It is given by, Q = VI sin ϕ VAR (or kVAR).

1 d Draw impedance triangle and voltage phasor diagram for R-L series circuit.

Ans-



Impedance triangle



Phasor diagram

Each diagram 01 mark

1 e Define susceptance and admittances for a parallel circuit.

Ans-

Susceptance-

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 admit alternating current. 01 mark

or

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

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

Admittances-

Admittance of circuit is defined as reciprocal of impedance (Y). 01 mark

$$Y = \frac{1}{Z} = \frac{I}{V} \quad mho$$

1 f Define quality factor for parallel resonance and write its mathematical expression.

Ans-

Quality factor –

It is defined as the ratio of current circulating between its branches to the line current drawn from the supply Or simply current magnification

Mathematical expression for Q – factor $= \frac{1}{R}\sqrt{\frac{L}{C}}$

Or

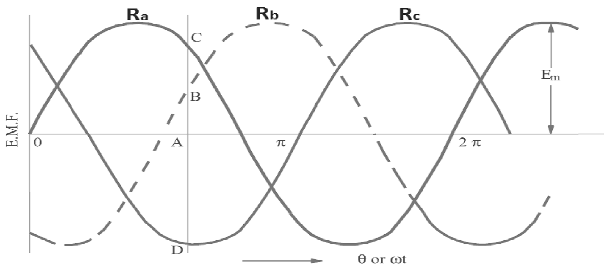
Current magnification in parallel resonant circuit is also known as Quality factor. It is given as under-

$$\text{current magnification} = \frac{\text{(Current through individual branch)}}{\text{total current}} = \frac{I_L}{I} \text{ or } = \frac{I_C}{I}$$

Definition 01 mark
Equation 01 mark

1 g Draw sinusoidal waveform of 3-phase emf and indicate the phase sequence.

Ans-

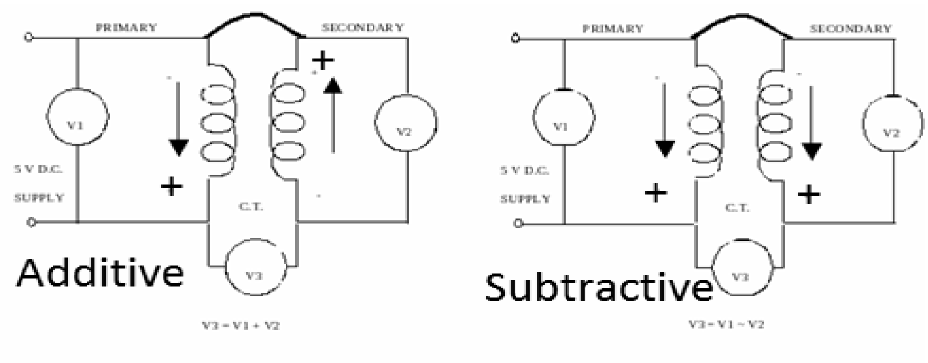


Waveform of 3-phase emf

Neat labeled diagram 02 mark

1 h Draw circuit diagrams showing additive polarity and subtractive polarity.

Ans-

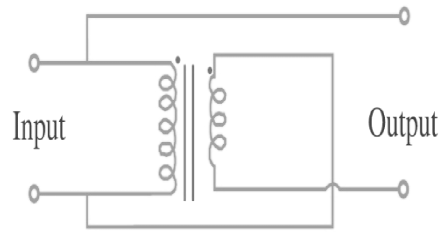


Each diagram 01 mark,

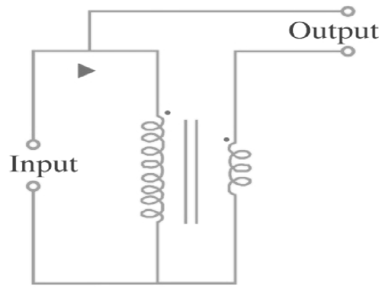
Total=02 mark

OR

additive polarity-



Subtractive polarity-



1 i Write the procedure of converting a current source into voltage source.

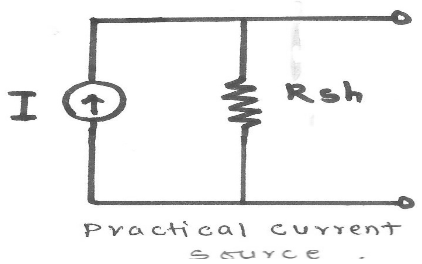
Ans-

Procedure for converting a current source into voltage source

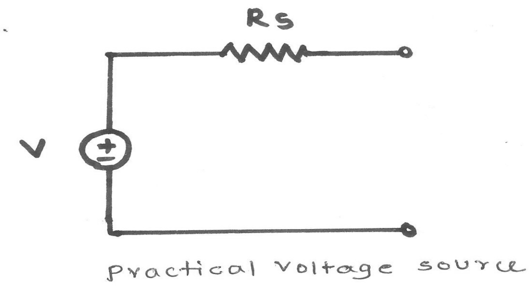
Step 1. Claculate equivalent voltage By using formula $V = IR_{sh}$.

Step 2. Series resistance value as Rs = Rsh

Step 3. Connect voltage source and reistance in series as shown below. Steps 01 mark



Given current source



Equivalent voltage source

Diagram 01 mark

1 j State superposition theorem applied to D.C. circuits.

Ans-

Superposition theorem:-

In any linear, bilateral, multisource network, the response (voltage across any element or current through any element) of any branch is equal to the sum of the responses produced in it with each source acting alone while other sources are replaced by their internal resistances. 02 mark

1 k State maximum power theorem applied to D.C. circuits.

Ans-

Maximum Power transfer theorem-

A resistive load will have maximum power in it when its value is equal to the resistance of the network as viewed from the terminals (it is connected across), with all energy sources removed leaving behind their internal resistances.

i.e. $R_L = R_{TH}$ 02 mark

1 1 State the behavior of following elements at the time of switching i.e. transient period.
i) Pure L
ii) Pure C.
Ans-

Pure L:
i) At the instant of switching (i.e. at t=0) the inductor acts as open circuit.
ii) At the instant of switching (i.e. at t=∞) the inductor acts as short circuit

01 mark

Pure C:
i) If uncharged capacitor is connected to an energy source, a capacitor acts as a short circuit at t=0.
ii) At the instant of switching (i.e. at t=∞) the capacitor acts as open circuit\ 01 mark

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

2 a An e.m.f. source represented by e=20 sin 314t is connected to a pure inductance having value 10mH. Find:
(i) The equation of current flowing through it.
(ii) Draw the waveforms of voltage and current.

Ans:
Given- e =20 sin 314t volts; L = 10 mH
(i) Equation of current-
ω = 2πf = 314

$$\therefore f = \frac{314}{2\pi} = 50\ Hz$$

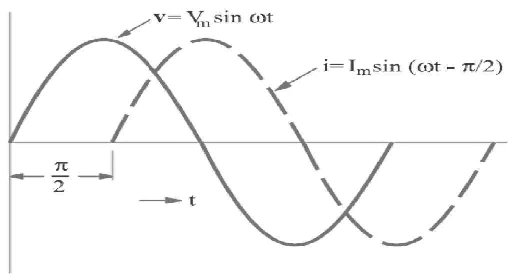
$X_L = 2\pi fL = 2\pi \times 50 \times 10 \times 10^{-3} = 3.14\ \Omega$

$$Im = \frac{Vm}{X_L} = \frac{20}{3.14} = 6.36\ Amp\ldots$$

01 mark

As the circuit is pure inductive Circuit ;
$i = I_m \sin(\omega t - 90^0)$ Amp
$i = 6.36 \sin(314t - \pi/2)\ldots$ 01 mark

(ii) Waveforms of voltage and current-

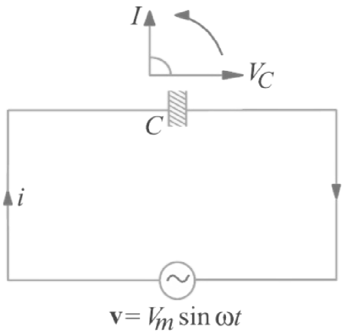


2 marks

2 b Derive the expression for current in pure capacitive circuit when connected to sinusoidal a.c. source. Draw the phasor diagram.

Ans:

When an alternating voltage is applied to the plates of the capacitor, the capacitor is charged first in one direction and then in opposite direction.



From the above fig.

Let v=p.d. developed between plates at any instant

q= charge on plates at that instant.

Then, q= C v ………… where C is capacitance

$q = C V_m \sin \omega t$ …………putting the values of v.

Now, current 'i' given by the rate of flow of charge.

$$i = \frac{dq}{dt} = \frac{d}{dt}(CVm\sin\omega t)$$

01 mark

$$i = CVm\,\omega Cos\omega t.$$

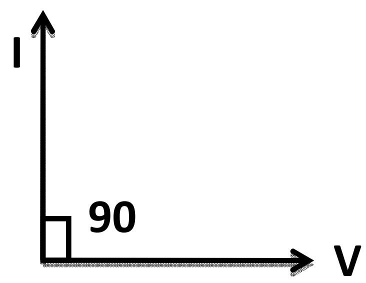
$$i = \frac{Vm}{1/\omega C}\cos\omega t$$

$$i = \frac{Vm}{Xc}\cos\omega t$$ ………………..Where $Xc = \frac{1}{\omega C}\ \Omega$ 01mark

$$i = Im\sin\left(\omega t + \frac{\pi}{2}\right)$$ …………...Where $Im = \frac{Vm}{Xc}$ Amp 01 mark

This is the expression for current in pure capacitive circuit.

Phasor diagram-



01 mark

2 c For a given waveform. Refer figure No.2:
(i) Identify type of circuit
(ii) State nature of power factor
(iii) Draw phasor diagram
(iv) Write expressions for voltage and current

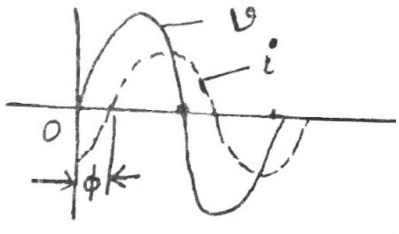
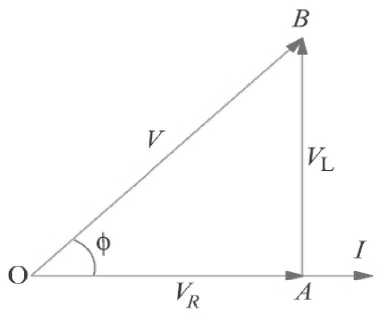


Fig. No. 2

Ans:
(i) Type of circuit: the type of circuit for above waveforms is R-L series circuit. 01 mark
(ii) Nature of power factor: Power factor is lagging. 01 mark
(iii) Phasor diagram:

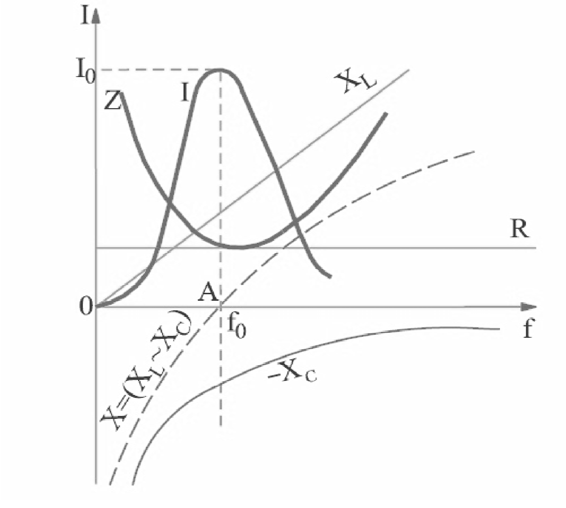


01 mark

(iv) Expression for voltage and current:

$v = Vm \sin \omega t$ ½ mark
$i = Im \sin (\omega t - \emptyset)$ ½ mark

2 d Draw graphical representation of resistance, inductive reactance, capacitive reactance and impedance related to frequency for series resonance circuit.



Labeled diagram 04 marks, unlabeled 2 marks

2 e An alternating voltage of 250V, 50Hz is applied to a coil which takes 5 A of current. The power absorbed by the circuit is 1 kW. Find the resistance and inductance of the coil.

Ans:

Given – V= 250 V, f=50 Hz, I=5A, P=1 kW.

$Z = \frac{V}{I} = \frac{250}{5} = 50\ \Omega$ 01 mark

We have, $P = VI\cos\emptyset$

$\therefore\ \cos\emptyset = \frac{P}{VI} = \frac{1X10^3}{250\ X\ 5} = 0.8$ 01 mark

$\therefore \sin\emptyset = 0.6$

$R = Z\cos\emptyset = 50\ X\ 0.8 = 40\ \ \Omega$ 01 mark

$X_L = Z\sin\emptyset = 50\ X 0.6 = 30\ \Omega$.

$L = \frac{X_L}{2\pi f} = \frac{30}{2\pi\ X\ 50} = 0.09549\ H\ \ or\ \ 95.49\ mH$ 01 mark

2 f A R-L-C series circuit with a resistance of 20 Ω, inductance of 0.25 H and capacitance of 100 µF is supplied with 240 V variable a.c. supply calculate:

(i) Resonance frequency
(ii) Current at this condition
(iii) Power factor
(iv) Quality factor.

Ans:

Given- R= 20 Ω, L= 0.25 H, C= 100 µF, V=240 Volts.

(i) Resonance frequency-

$$\mathrm{Fo} = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(0.25X100X10^{-6})}} = 31.83\ \Omega$$ 01 mark

(ii) Current at resonance-

$$\mathrm{Io} = \frac{V}{R} = \frac{240}{20} = 12\ \mathrm{Amp}$$ 01 mark

(iii) Power Factor-
at resonance is unity, $\therefore\ \cos\emptyset = 1$ 01 mark

(iv) Quality factor-

$$\mathrm{Q-factor} = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{20}\sqrt{\frac{0.25}{100X10^{-6}}} = 2.5$$ 01 mark

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

a Compare series resonance to parallel resonance on the basis of:

i) Resonant frequency
ii) Impedance
iii) Current and
iv) Magnification

Ans:

Parameter	Series resonant circuit	Parallel resonant circuit
Resonant frequency	$fo = \frac{1}{2\pi\sqrt{LC}}$ Hz	$fo = \frac{1}{2\pi\sqrt{LC}}$ Hz
Impedance	Minimum Z=R ohms	Maximum $Z_D = \frac{L}{CR}$ ohms
Current	Maximum $Io = \frac{V}{R}$ Amps	Minimum $Io = \frac{V}{L/CR}$ Amps
Magnification	Voltage magnification	Current magnification

Each parameter 01 mark

3 b Derive an expression for resonance frequency for a R-L-C parallel circuit.

Ans-

Resonance frequency for a R-L-C parallel circuit:-

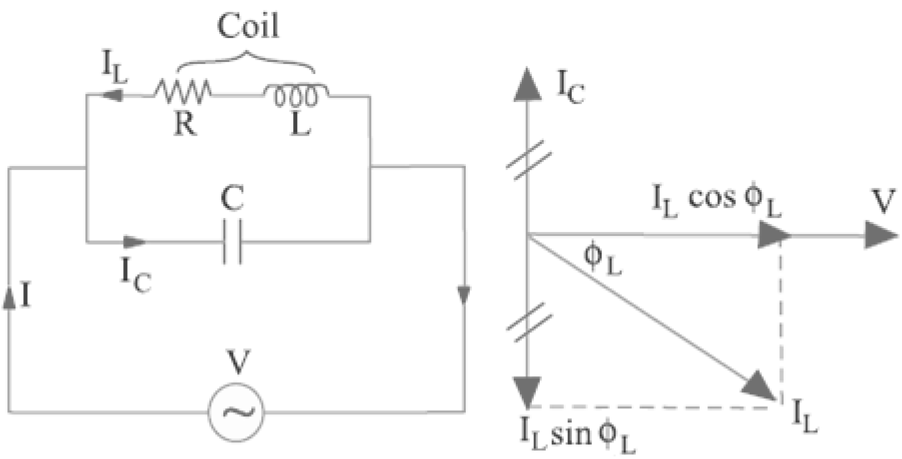


Diagram 01 mark

We will consider the practical case of a coil in parallel with a capacitor, as shown in above fig. Such a circuit is said to be in electrical resonance when the reactive component of line current becomes zero. The frequency at which this happens is known as resonance frequency.

Net reactive component = $I_C - I_L \sin Ø_L$

As at resonance, its value is zero, hence

$I_C - I_L \sin Ø_L = 0$ or $I_C = I_L \sin Ø_L$

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

Hence condition for resonance becomes

$\frac{V}{X_c} = \frac{V}{Z} \times \frac{X_L}{Z}$ or $X_c X_L = Z^2$

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

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

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

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

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

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

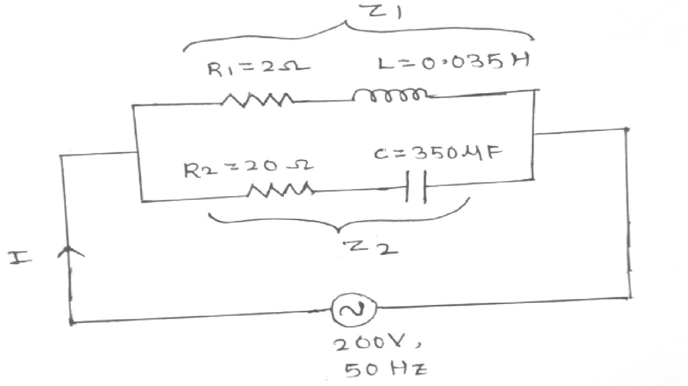
Correct Derivation 03 mark

This is the resonance frequency (f_0) in Hz, R in ohm, L in Henry and C in farad.
If R is negligible, then $f_0 = \frac{1}{2\pi\sqrt{LC}}$

3 c A choke coil has resistance of 2Ω and an inductance of 0.035 H is connected in parallel with a 350µF capacitor which is in series with a resistance of 20 Ω. When the combination is connected across a 200 V, 50 Hz supply. Calculate:

I) The total current taken and
II) Power factor of whole circuit.

Ans-
Given; $R_1 = 2\ \Omega$, $L = 0.035$ H, $C = 350\ \mu F$, $R_2 = 20\ \Omega$, $V = 200V$ & $f = 50Hz$



$Z_1 = R_1 + jX_L$

Find $X_L = 2\pi fL = 2\pi X50X0.035 = 11\ \Omega$

Therefore, $Z_1 = 2 + j11\ \Omega$…

In polar form, $Z_1 = 11.18 \angle 79.89°\ \Omega$

Similarly, $Z_2 = R_2 - jX_C$

Find $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi X 50 X 350 X 10^{-6}} = 9.09\ \Omega$

$Z_2 = 20 - j9.09\ \Omega$…

In polar form, $Z_2 = 21.96 \angle -24.44°\ \Omega$

Correct impedances Z_1 & Z_2 = 1 mark

Equivalent impedance of parallel branch;

$$Zeq = \frac{Z_1\ z_2}{Z_1 + z_2} = \frac{(11.18\angle 79.89°) x\ (21.96\ \angle -24.44°)}{(2 + j11) + (20 - j9.09)}$$

$$= \frac{245.51\angle 55.45°}{22+j1.91} = \frac{245.51\angle 55.45°}{22.08\angle 4.96°}$$

$Zeq = 11.11\ \angle 50.49°\ \Omega$… 01 mark

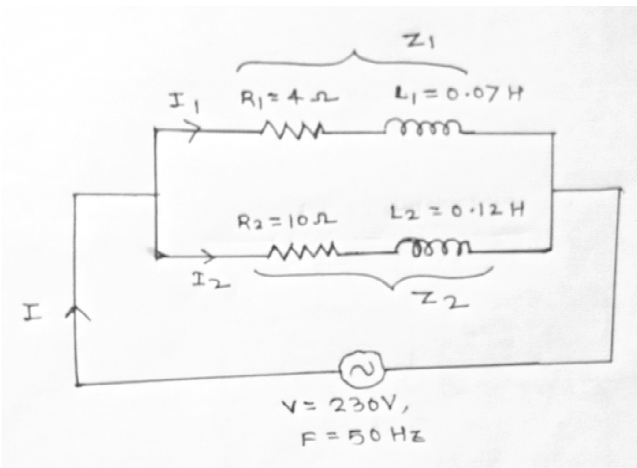
I) $I = \frac{V}{Z_{eq}} = \frac{200\angle 0°}{11.11\ \angle 50.49°} = 18.00\angle -50.49°$Amp 01 mark

II) $Cos\text{Ø} = Cos(50.49) = 0.6362$ Lagging 01 mark

3 d A coil resistance 4Ω and inductance 0.07 H is connected in parallel with another coil of resistance 10Ω and inductance 0.12 H. The combination is connected across 230V, 50Hz supply. Determine the total current & current through each branch.

Ans-

Given; $R_1 = 4\ \Omega$, $L_1 = 0.07$ H, $R_2 = 10\Omega$, $L_2 = 0.12$ H, V = 230V & f = 50Hz



Branch-1

$X_{L1} = 2\pi fL_1 = 2\pi X50X0.07 = 22\ \Omega$

$Z_1 = R_1 + j\ X_{L1}\ \Omega$

$Z_1 = 4 + j22\Omega$

$Z_1 = 22.36\angle 79.69°\ \Omega$

Branch-2

$X_{L2} = 2\pi fL_2 = 2\pi X50X0.12 = 37.69\ \Omega$

$Z_2 = R_2 + jX_{L2}\Omega$

$Z_2 = 10 + j37.69\ \Omega$

$Z_2 = 39\angle 75.14°\Omega$

Correct impedances Z_1 & Z_2 = 1 mark

$$Zeq = \frac{Z_1\ z_2}{Z_1\ + z_2} = \frac{(22.36\angle 79.69°)x(\ 39\angle 75.14°)}{22.36\angle 79.69° + 39\angle 75.14°}$$

$$= \frac{872.04\angle 154.83°}{61.30\angle 76.80°}$$

$Zeq\ = 14.22\ \angle 78.03°\ \Omega$

Total current $I = \frac{V}{Z_{eq}} = \frac{230\angle 0°}{14.22\ \angle 78.03°} = 16.17\angle -78.03°$ Amp — 01 mark

Branch currents ;

$I_1 = \frac{V}{Z_1} = \frac{230\angle 0°}{22.36\angle 79.69°} = 10.28\angle -79.69°$ Amps — 01 mark

$I_2 = \frac{V}{Z_2} = \frac{230\angle 0°}{39\angle 75.14°} = 5.89\angle -75.14°$ Amps — 01 mark

3 e Define the following terms:

i) Lagging quantity
ii) Leading quantity

Also represent the above terms for voltage and current in pure inductance and pure capacitance circuit.

Ans-

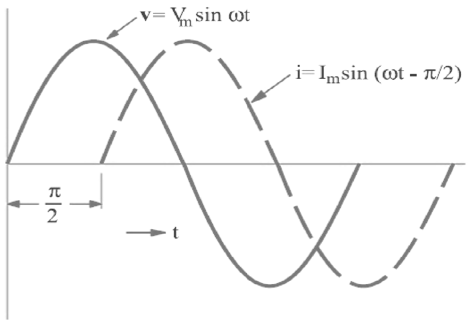
Lagging quantity –

Lagging alternating quantity is one which reaches its maximum (or zero) value later than other quantity. — 01 mark

Leading quantity-

Leading alternating quantity is one which reaches its maximum (or zero) value earlier as compared to other quantity. — 01 mark

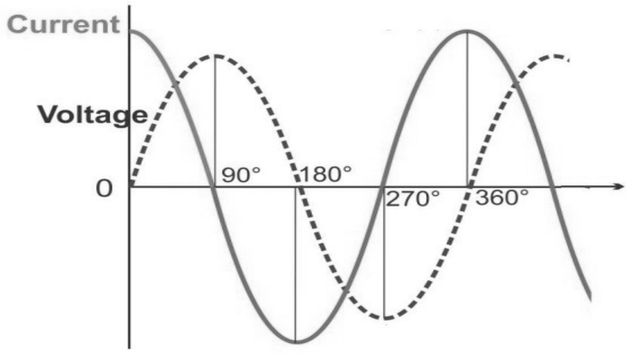
For pure inductive circuit-



01 mark

For pure inductive circuit, current 'i' lags behind applied voltage 'v' by 90^0 (or $\pi/2)rad$

For pure capacitive circuit-



1 mark

For pure capacitive circuit, 'i' leads applied voltage 'v' by 90^0 $(\pi/2)rad$

3 f A 200W, 100V lamp is connected in series with a capacitor to a 120V, 50Hz a.c. supply calculate:

i) The capacitance required
ii) The phase angle between voltage and current.

Ans-
Given: 200W &V_1=100V lamp

(i) Capacitance required:

$P = I^2R = \frac{V1^2}{R}$ watts

Thus $R = \frac{V1^2}{P} = \frac{100^2}{200} = 50\ \Omega$ 01 mark

$V_1 = IR$

$I = \frac{V_1}{R} = \frac{100}{50} = 2$ Amp

$z = \frac{V}{I} = \frac{120}{2} = 60\ \Omega.$ 01 mark

$\cos\varnothing = \frac{R}{Z} = \frac{50}{60} = 0.83$ lead

$\sin\varnothing = 0.55$

$X_c = Z\sin\varnothing = 60 \times 0.55$

$X_c = 33\ \Omega$.

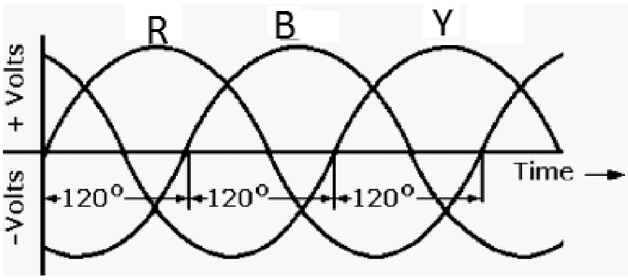
$C = \frac{1}{2\pi f X_c} = \frac{1}{2\pi \times 50 \times 33} = 96.45\ \mu F$. 01 mark

(ii) Phase angle between voltage and current-
Since power factor, $\cos\phi = 0.83$
$\therefore\ \varnothing = \cos^{-1}(0.83) = 33.90^0$ 01 mark

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

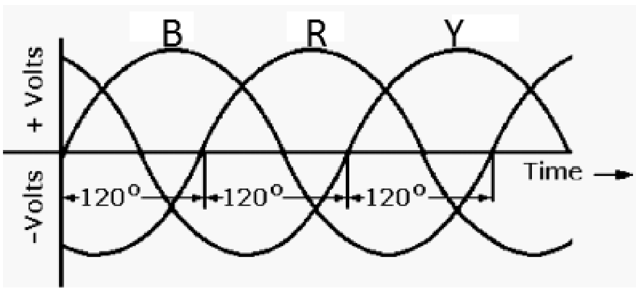
4 a Draw the waveforms of a 3-phase emf. With following phase sequence.
i) R-B-Y
ii) B-R-Y

Solution:
I) R-B-Y



02 marks

II) B-R-Y



02 marks

4 b Three coils each with a series resistance of 10Ω and inductance of 0.35mH are connected in star to a 3-phase, 440V, 50Hz supply. Calculate the line current and total power taken per phase.

Ans-
Given data : R=10Ω, L=0.35mH, V_L=440V and f=50Hz

$X_L = 2\pi f L = 2\pi \times 50 \times 0.35 \times 10^{-3} = 0.1099\ \Omega$ 01 mark
$Z_{ph} = R + j X_L = 10 + j\ 0.10\ \Omega$

Magnitude, Z_{ph}=10Ω.

$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{440}{\sqrt{3}} = 254.03V$ 01 mark

Line Current-

$I_L = I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{254.03}{10} = 25.40 \text{ Amp}$ 01 mark

Total Power taken per phase:

Cos ø = R/Z = 10/10 = 1

$P = V_{ph} I_{ph} \cos ø$ = 254.03 X 25.40 X 1 = 6452.362 Watts 01 mark

4 c A delta connected induction motor is supplied by 3-phase, 400 V, 50Hz supply. The line current is 43.3 A and the total power taken from the supply is 24 KW. Find the resistance and reactance per phase of motor winding.

Ans :
Given data: Delta load, V_L=Vph=400V, F=50Hz, I_L=43.3A, P=24KW.

We have,

$P = \sqrt{3}\ V\,I \cos \emptyset$,

$\therefore \cos \emptyset = \frac{P}{\sqrt{3}\ X\ V\ I} = \frac{(24\ X\ 10^3)}{\sqrt{3}X400\ X43.3} = 0.8$ lag. 01 mark

Thus ,Sinø=0.6.

Now, for delta-

$Iph = \frac{I_L}{\sqrt{3}} = \frac{43.3}{\sqrt{3}} = 25 \text{ Amp}$.

$Zph = \frac{Vph}{Iph} = \frac{400}{25} = 16\ \Omega$. 01 mark

Resistance -

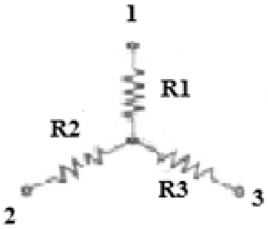
$R = Z \cos \emptyset = 16\ X\ 0.8 = 12.8\ \Omega$. 01 mark

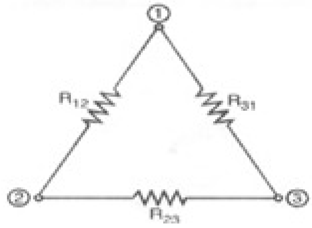
Reactance-

$X = Z \sin \emptyset = 16\ X\ 0.6 = 9.6\ \Omega$. 01 mark

4 d 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.





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) 2 marks

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

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

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

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

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

1 mark

Using (6) $R_{12} = R_1\left(\frac{R_2}{R_3} + \frac{R_2}{R_1} + 1\right) = \left(\frac{R_1R_2}{R_3} + R_2 + R_1\right).$

Similarly we can write,

$R_{23} = (\frac{R_3R_2}{R_1} + R_2 + R_3)$ and $R_{31} = (\frac{R_3R_1}{R_2} + R_3 + R_1)$ 1 mark

4 e Using mesh analysis calculate voltage drop across 10 Ω resistance in following circuit. Refer figure No.3

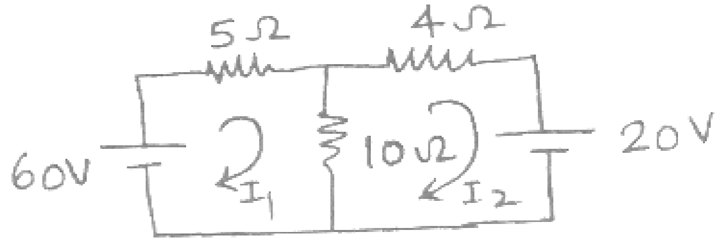
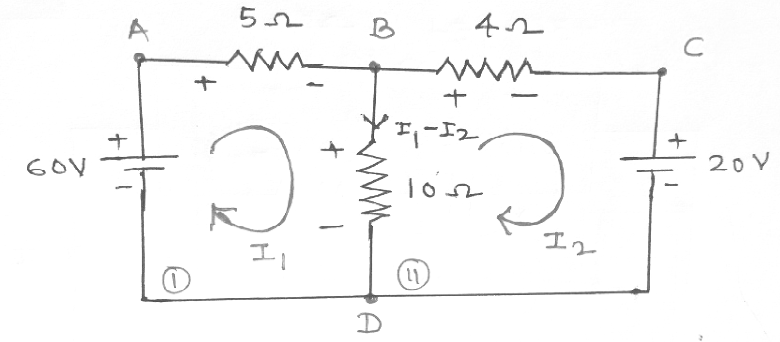


Fig. No. 3

Ans-



Apply KVL for loop I- (A-B-D-A)

$-5 I_1 - 10 (I_1-I_2)+60 = 0$

$-5 I_1 - 10 I_1 + 10 I_2 = - 60$

$-15 I_1 +10 I_2 = -60$

$-3 I_1 +2 I_2 = - 12$---------------------equation (1) 01 mark

Apply KVL for loop (II) – (B-C-D-B)

$- 4 I_2 – 20 +10 (I_1-I_2) =0$

$-4 I_2 – 20 + 10 I_1 – 10 I_2 =0$

$10 I_1 – 14 I_2 = 20$

$5 I_1 - 7 I_2 = 10$-------------------- equation (2) 01 mark

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

$I_1 =$ 5.81 Amp,

And $I_2 =$ 2.71 Amp

Both currents correct = 1 mark

Thus current through 10 Ω resistance = $I_1 - I_2$ = 5.81 – 2.72 = 3.09 Amps 01 mark

4 f For following circuit calculate resistance R. Using Node analysis. Refer Figure No.4

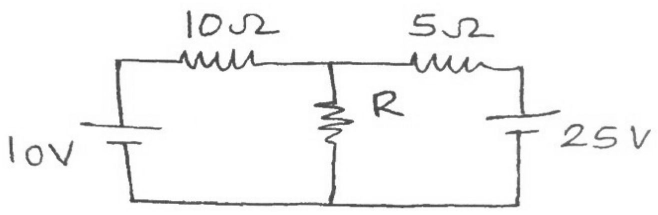
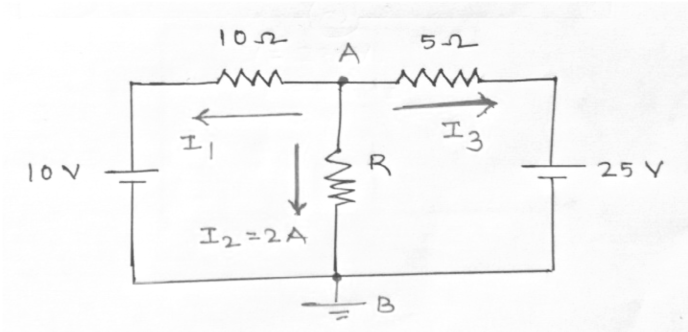


Fig. No. 4

Ans:



As current through R is not given students may assume suitable value eg. 2 A and proceed. Other values are also to be considered and answer to assessed for steps.

Apply KCL at node A;

$\boldsymbol{I_1 + I_2 + I_3 = 0}$

***Assume I_2 = 2 Amp

$$\frac{V_A - 10}{10} + 2 + \frac{V_A - 25}{5} = 0$$ 01 mark

$$\frac{\left(5\,(V_A - 10) + 10\,(V_A - 25)\right)}{10\,x\,5} + 2 = 0$$

$$\frac{5\,V_A - 50 + 10V_A - 250}{50} + 2 = 0$$

$$15\,V_A - 300 = -100$$

$$15V_A = 200$$

$$\boldsymbol{V_A = \frac{200}{15} = 13.33\,Volts}$$ 02 mark

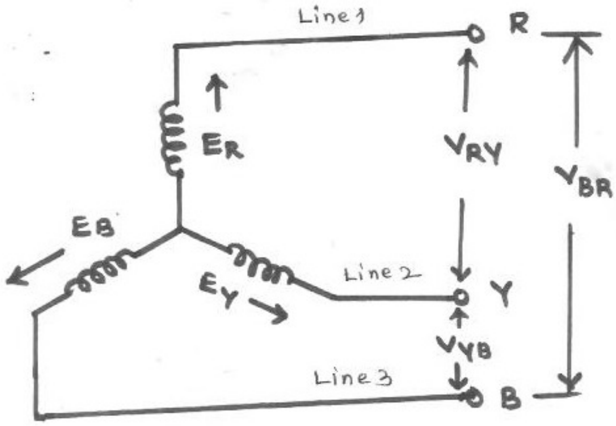
now,

$$\boldsymbol{R = \frac{V_A}{I_2} = \frac{13.33}{2}} = 6.67\ \Omega$$ 01 mark

5 Attempt any one of the following. 16

a With the help of phasor diagram, derive the relationship between line and phase values in balanced star connected 3-phase suppy.

Ans:



Neat labeled diagram 02 mark

As seen from the above diagram, in this form of interconnection, there are two phase windings between each pair of terminals but since there similar ends have joined together, they are in opposition.

Thus the potential difference between any two terminals is the phasor difference of the two phase emf's.

Assume a balanced system where,

$$E_R = E_Y = E_B = E_{ph} = phase\ voltage$$

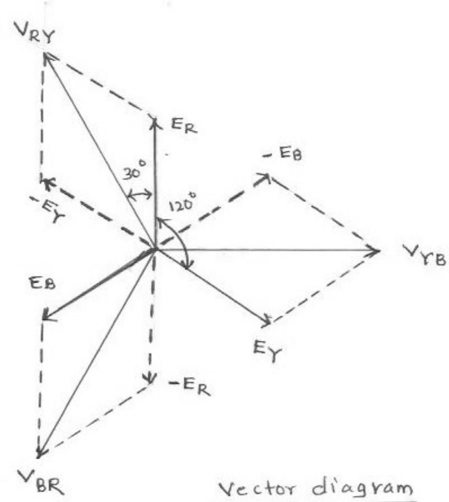
$$V_{RY} = V_{YB} = V_{BR} = V_L = line\ voltage$$ 02 mark

According To Above

Statement;line voltage V_{RY} between line 1 and 2 is vector difference of E_R&E_Y

line voltage V_{YB} between line 2 and 3 is vector difference of E_Y&E_B

line voltage V_{BR} between line 3 and 1 is vector difference of E_B&E_B 02 mark



Labeled vector diagram 04 mark

Unlabeled 2 marks

Then ,

The p.d. between line 1 & 2 is ; $V_{RY} = E_R - E_Y$

$V_{RY}$is found by compounding E_R and E_Y reversed and its value is given by diagonal of theparallelogram. Its magnitude is calculated as below-

$$V_{RY} = 2 \times Eph \times \cos\left(\frac{60°}{2}\right)$$ 02 mark

$$= 2 \times Eph \times \cos 30°$$

$$= 2 \times Eph \times \frac{\sqrt{3}}{2}$$

$$\therefore V_{RY} = \sqrt{3}.Eph$$

Similarly,

$$V_{YB} = E_Y - E_B = \sqrt{3}.Eph$$ 02 mark

$$V_{BR} = E_B - E_R = \sqrt{3}.Eph$$

In general we can write;

$\boldsymbol{V_L = \sqrt{3}.Eph}$ or $\boldsymbol{V_L = \sqrt{3}.Vph}$

i.e. line voltage = $\sqrt{3}$ × phase voltage 02 mark

5 b State Norton's theorem. Also write stepwise procedure for applying Norton's theorem to simple circuit.

Ans:

Norton's Theorem:

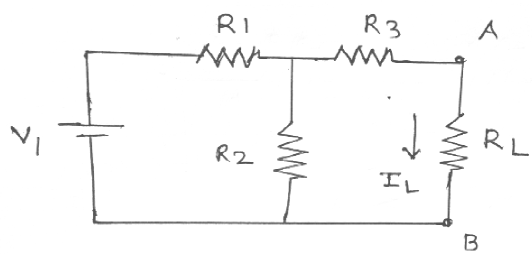
Norton's theorem states that, any complex linear, bilateral active network can be converted into simple network consisting of a single current source (I_{SN}) and a single resistance (R_{TH}/ R_N). 02 marks

Where, I_{SN} = it is the short circuit current flowing through the load terminals when load terminals are shorted.

And R_{TH}/ R_N = Thevenin's or Norton's equivalent resistance, which is total resistance of the network seen through load terminals when voltage sources are replaced by short circuit and current sources are replaced by open circuit. 02 marks

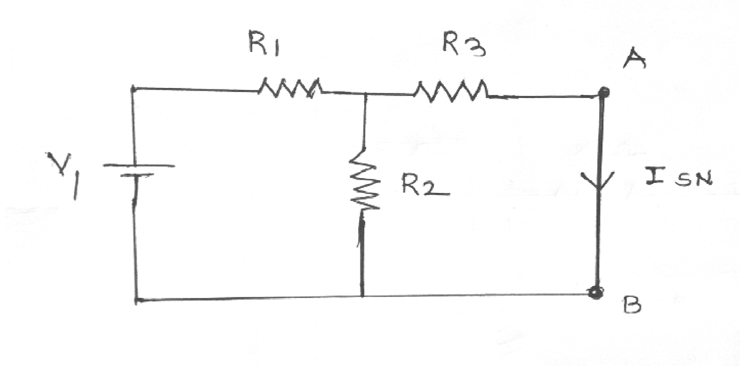
Stepwise procedure for applying Norton's theorem-

Consider the simple general circuit as shown in below figure.



Step-1) To find I_{SN} :

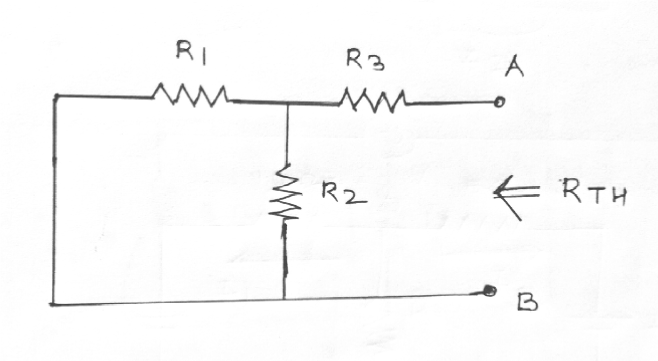
- Remove load resistance R_L, and then short the load terminals A & B.
- Find the short circuit current (I_{SN}) flowing through the short circuited branch by using any one of the network simplification technique. 02 marks



02 marks

Step-2) To find R_{TH} :

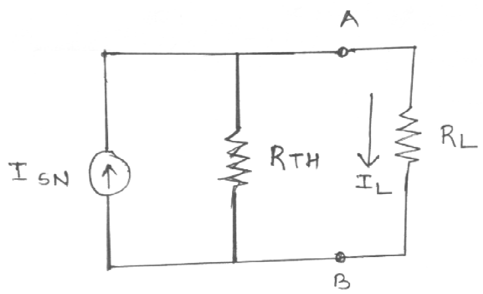
- Remove load resistance (R_L).
- Short circuit all voltage sources in the given network (or replace those voltage sources with their internal resistances if given). 02 marks
- Open circuit all current sources in the given network (or replace those current sources with their internal resistances if given).
- Now network contain only resistance in it. Find equivalent resistance of the network seen through the load terminals A & B. 02 marks



02 marks

Step-3) Norton's Equivalent Network:

- Draw Norton's equivalent diagram as below.



Determine the load current (I_L) using equation,

$$I_L = I_{SN} \, X \frac{R_{TH}}{R_{TH} + R_L} \text{ Amp}$$ 02 mark

5 c Calculate current through each branch using superposition theorem. Refer figure No.5

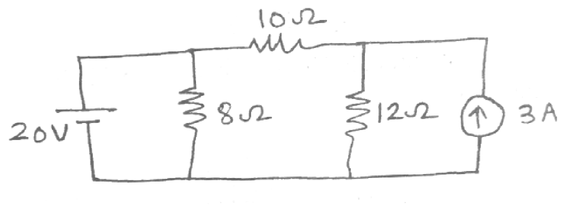
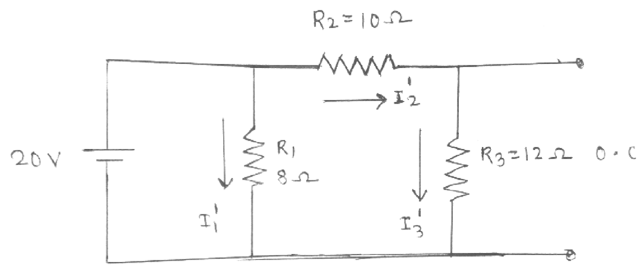


Fig. No. 5

Ans:

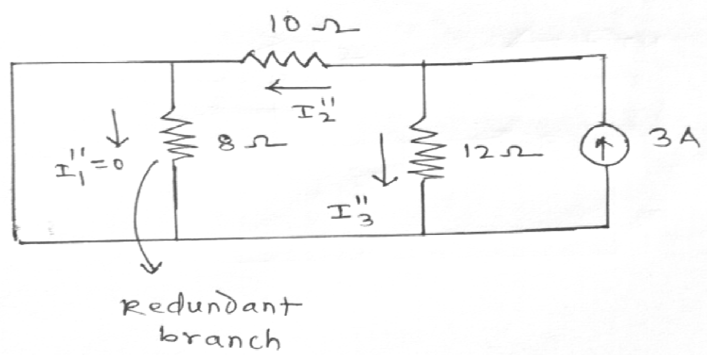
- Consider 20 V source acting alone –



$$I_1' = \frac{V}{R_1} = \frac{20}{8} = 2.5\ Amp.$$ 02 marks

$$I_2' = I_3' = \frac{V}{(R_2 + R_3)} = \frac{20}{(10+12)} = 0.90\ Amp.$$ 02 mark

Consider 3 Amp source acting alone -



Simplified diagram-

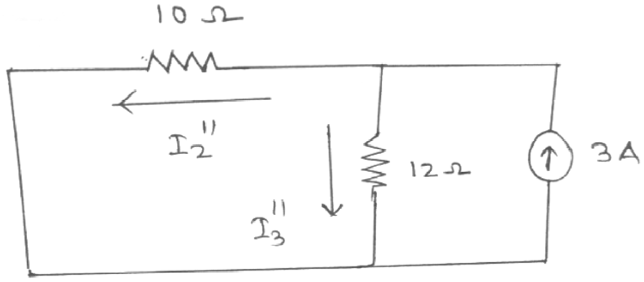


diagram 02 mark

$I_1'' = 0\ Amp$. 02 mark

$$I_2'' = \frac{3\ X\ 12}{(10+12)} = 1.63\ Amp.$$

$$I_3'' = \frac{3\ X\ 10}{(10+12)} = 1.36\ Amp.$$ 02 mark

- By superposition theorem –
  $I_1 = I_1' + I_1'' = 2.5 + 0 = 2.5\ Amp.$ 02 marks
  $I_2 = I_2' + I_2'' = 0.90 - 1.63 = -0.73\ Amp.$ 02 marks

  *difference of two currents is taken because both currents are opposite to each other

$$I_3 = I_3' + I_3'' = 0.90 + 1.36 = 2.26\ Amp\ .$$ 02 marks

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

6 a Convert following circuit into Thevenin's circuit across A & B. refer figure No.6

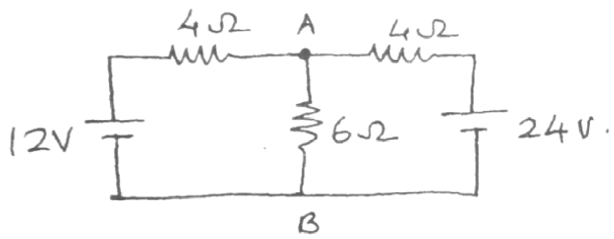
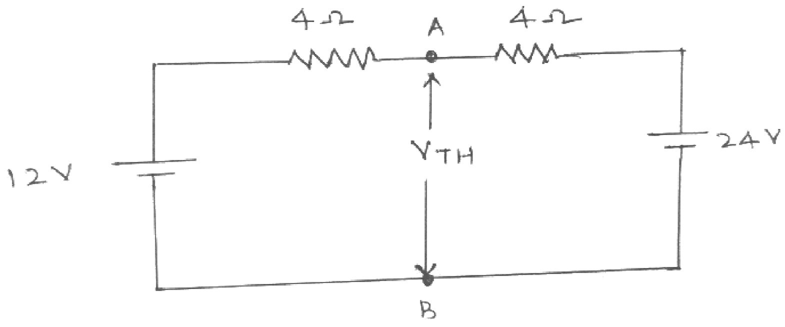


Fig. No. 6

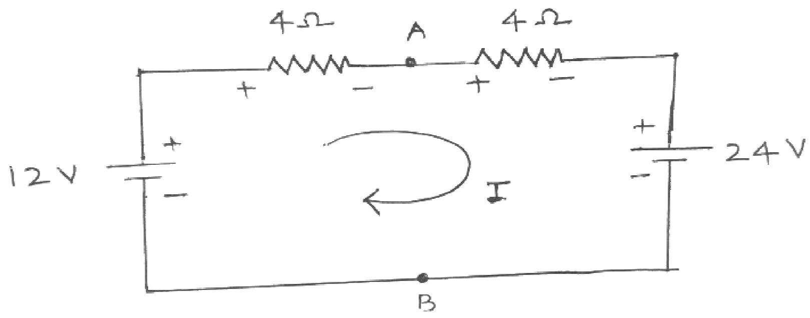
Ans:

To Find V_{TH} remove load resistance R_L and calculate open circuit voltage available between load terminals A & B-



V_{TH} = 24 V + voltage across 4 Ω

Applying KVL to determine voltage drop across 4 Ω :



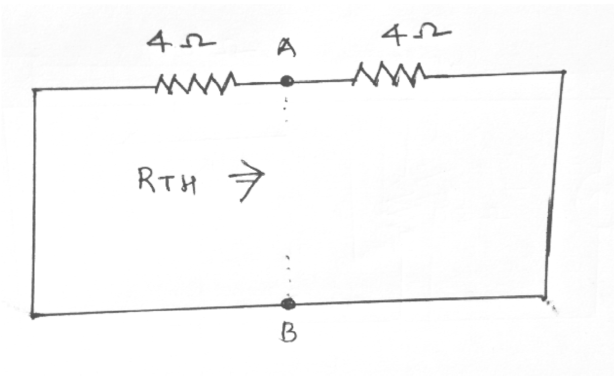
$$-4I - 4I - 24 + 12 = 0.$$
$$-8I - 12 = 0.$$
$$8I = -12.$$
$$I = -\frac{12}{8} = -1.5\ Amp.$$ 01 mark

Now V_{TH} = 24 + voltage across 4 Ω

= 24 + (-1.5 X 4)

= 18 Volts 01 mark

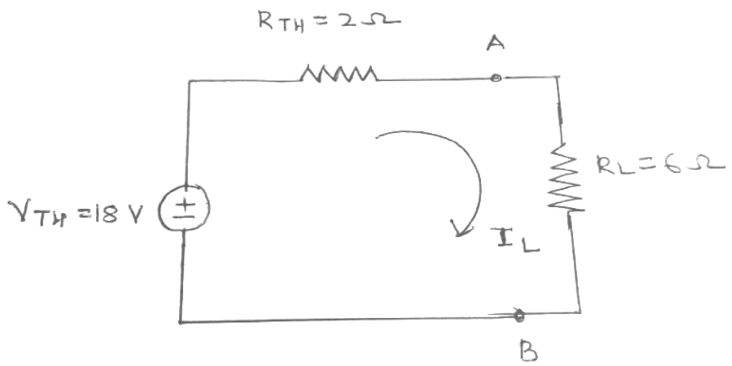
Find R_{TH} :



**4 Ω and 4 Ω are in parallel to each other-

$$R_{TH} = \frac{4X4}{4+4} = 2\ \Omega$$ 01 mark

Equivalent diagram-



$$I_L = \frac{V_{TH}}{R_{TH} + R_L} = \frac{18}{2+6} = 2.25\ A.$$ 1 mark

6 b Calculate the value of R_L in the following circuit using maximum power transfer theorem for the transfer of maximum power to the load. Refer figure No.7

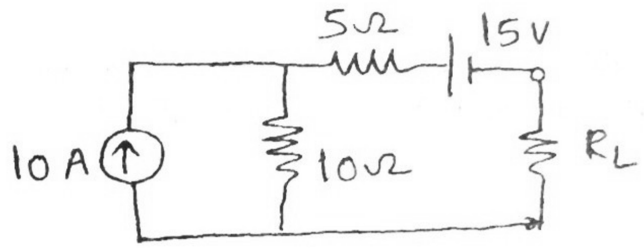
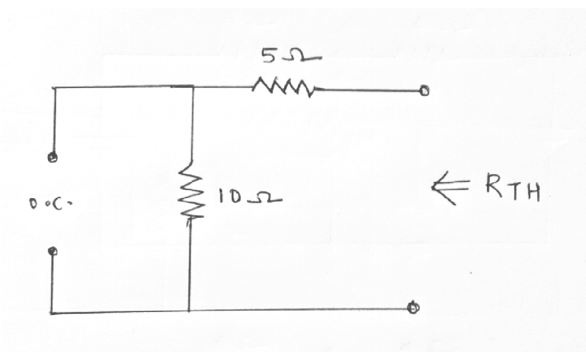


Fig. No. 7

Ans:

Maximum amount of power will be delivered to load when load resistance equal to Thevenin's resistance-
Find R_{TH} :



02 mark

5Ω and 10 Ω are in series with each other-

$R_{TH}= 5\Omega + 10\ \Omega = 15\ \Omega$

Thus, $R_L = R_{TH} = 15\ \Omega$ 02 mark

c Determine current through 10Ω resistance using mesh analysis. Refer fig No. 8

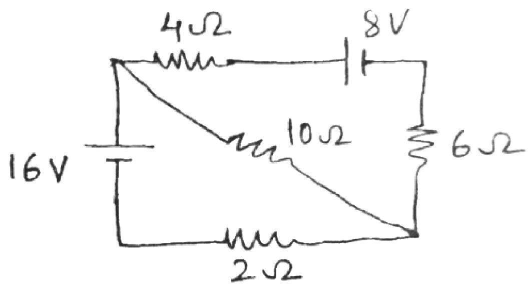
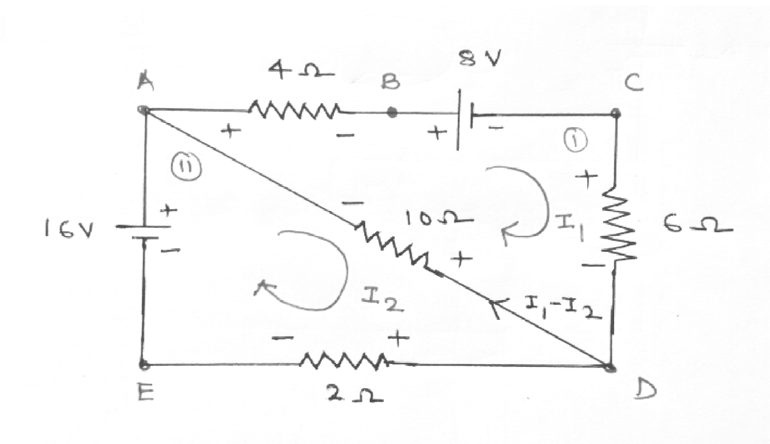


Fig. No. 8

Ans:



Apply KVL to loop (I) – (A-B-C-D-A)

$-4\ I_1 -8-6I_1-10(I_1-I_2) = 0$

$-4I_1-8-6I_1-10I_1+10I_2 = 0$

$-20I_1+10I_2 = 8$

$-10I_1+5I_2 = 4$……………………………………………(1) 01 mark

Apply KVL to loop (II) – (D-E-A-D)

$-2I_2 + 16+ 10(I_1 - I_2) = 0$

$-2I_2 + 16 + 10I_1 - 10I_2 = 0$

$10I_1 - 12I_2 = -16$…………………………………………..(2) 01 mark

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

$I_1 = 0.455$ Amp,
$I_2 = 1.71$ Amp, 01 mark

Current through 10 Ω = $I_1 - I_2 = 0.455 - 1.71 = -1.255$ Amp 01 mark

6 d Derive the expression for resonance frequency in R-L-C series circuit.
Ans:

The frequency at which the net reactance of the series circuit is zero is called the resonant frequency fo. Its value can be found as under:
$X_L - X_C = 0$ Or $X_L = X_C$

01 mark

$$\omega_o L = \frac{1}{\omega_0 C}.$$

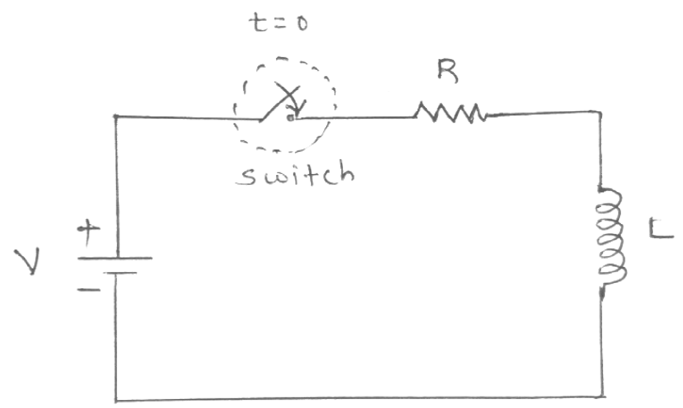
$$\omega_o^2 = \frac{1}{LC}.$$ 01 mark

$$\therefore (2\pi fo)^2 = \frac{1}{LC}$$ 01 mark

$$\therefore \boldsymbol{fo} = \frac{\mathbf{1}}{\mathbf{2\pi\sqrt{LC}}}$$ 01 mark

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

Concept of initial condition:
Consider the network as shown in fig. below-



01 marks

A voltage source is connected to resistor and inductor using a switch. When a switch is closed, voltage V is applied to resistor and inductor. For the switch, t=0 is mentioned. It indicates switch is closed at time instant t=0. The time t=0 is called reference time. In any switching network it is assumed that closing of switch takes place instantaneously. That means the switch takes zero time to close from open condition. 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.
Inductor: at the time of switching inductor acts as an open circuit. 01 mark
Capacitor: at the time of switching inductor acts as an short circuit

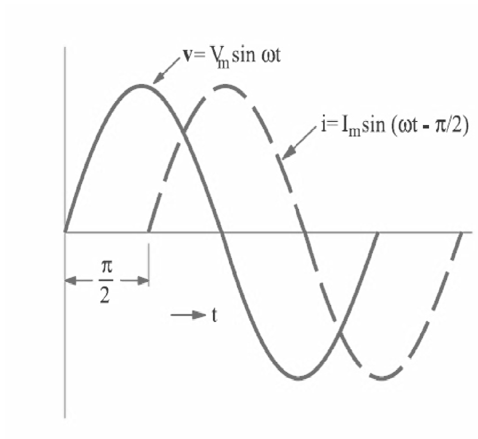
Concept of final condition:
If the switch is on, the switch at t=0 and then the network remains without switching action for a long time then the network conditions corresponding to this situation is known as the final condition or the steady state condition.
The final condition or steady state condition is also known as the network condition at =∞. 01 mark
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=∞) inductor acts as an short circuit. 01 mark
Capacitor: at the time of switching (i.e. at t=∞) the capacitor acts as open circuit.

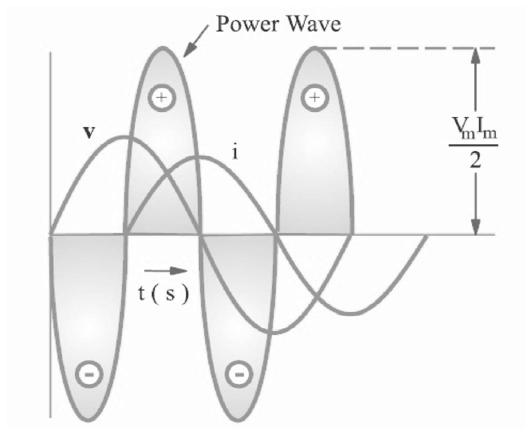
6 f Draw the phasor diagram and waveforms of voltage, current and power in a pure inductance circuit supplied by a single phase a.c. source.
Ans:

Phasor Diagram of Pure Inductive Circuit-

Phasor diag 01 mark

Voltage And Current Waveforms: Power waveform





V & I waveform 01 mark

Power waveform 02 mark