Electric Circuits and Networks

Time: 3 Hrs.] Prelim Question Paper Solution **[Marks : 70**

Q.1 Attempt any FIVE of the following : [10]

Q.1(a) What is Power factor and its significance? [2]

Ans.: Power factor

The cosine angle between current and voltage of the circuit is called Power factor.

p.f. = cos Φ

OR

It is the factor by which apparent power is multiplied to obtain the active (true) power.

OR

It is also defined as the ratio of true power to the apparent power.

OR

It is the ratio of resistance to impedance i.e. R/Z.

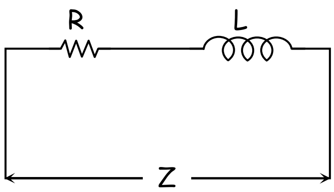
Significance of power factor:

(i) The power factor of a circuit gives the ability of a circuit to convert its apparent power into true power. Low power factor indicates that a very small percentage of total power is being actually utilized.

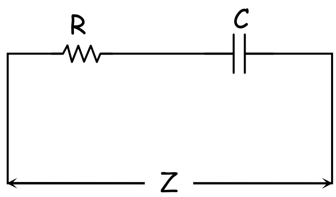
(ii) Greater the phase difference, lesser the power factor and lesser is the capability to utilize true power from available apparent power. If power factor is low, then a large power is required to be generated to delivered the required power to the load.

Q.1(b) Write a equation of impedance R_L and R_C circuit. [2]

Ans.:



$Z = R + jX_L$



$Z = R - jX_C$

Q.1(c) Draw power triangle for series circuit. [2]

Ans.: Apparent power

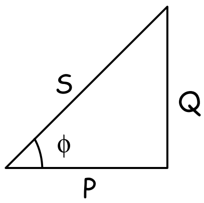
S = VI

Active power

P = VI cos ϕ

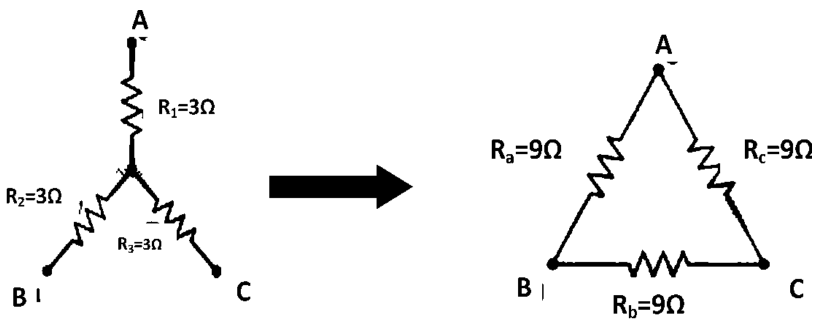
Reactive power

Q = V_Z sin ϕ



Q.1(d) Three resistances of 3Ω each are connected in star find equivalent resistance when connected in delta. [2]

Ans.:



(1) $R_{AB} = R_1 + 1\ R_2 + \frac{R_1 R_2}{R_3} = 3 + 3 + \frac{3 \times 3}{3} = 9\Omega$

Similarly,

(2) $R_{BC} = 9\Omega$

(3) $R_{CA} = 9\Omega$

Q.1(e) What are the advantage and disadvantages of Superposition theorem? [2]

Ans.: **Advantages :**

(i) Current through a particular branch can be found easily.

(ii) Can be used for circuits with constant voltage as well constant current sources.

Disadvantages :

(i) If currents through all branches are required then this method is lengthy.

(ii) The circuit must contain more than one source.

(iii) It cannot be applied to nonlinear circuits.

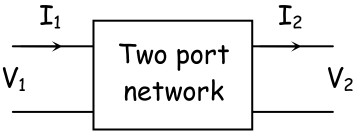
Q.1(f) Write the equation of Open circuit Z parameters. [2]

Ans.:

$V_1 = Z_{11} I_1 + Z_{12} I_2$

$V_2 = Z_{21} I_1 + Z_{22} I_2$

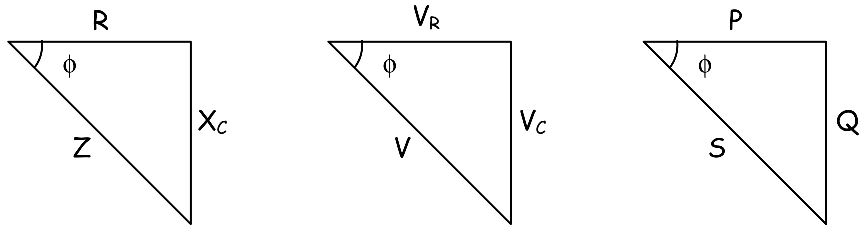
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$



Q.2 Attempt any THREE of the following : [12]

Q.2(a) Draw voltage triangle, power triangle, impedance triangle of series RC circuit. [4]

Ans.:



$Z = \sqrt{R^2 + X_C^2}$ $\qquad V = \sqrt{V_R^2 + V_C^2}$ $\qquad S = \sqrt{P^2 + Q^2}$

$PF = \frac{R}{Z} = \frac{P}{S} = \frac{V_R}{V}$

Q.2(b) State and explain the Norton's theorem. [4]

Ans.: The Norton's theorem as applied to d.c. circuits can be sated as follows :

'Any network having terminals A and B can be replaced by a single source of current I_N in parallel with a single resistance R_N.

(i) The current I_N is the current that would flow thro' AB when A and B are short circuited (with the proper direction)

(ii) The resistance R_N is the resistance of the network measured between A and B with load, if any, removed and constant voltage sources being replaced by their internal resistance (or simply by zero resistance i.e. short circuit if internal resistance not given) and constant current sources replaced by ∞ resistance i.e. open circuit.

Thus, according to this theorem, any two terminal network, however complex, can be replaced by a single source of current I_N (with proper direction) called Norton's current source in parallel with a single resistance R_N called Norton's resistance.

(Norton's theorem is converse of Thevenin's theorem. This is because Norton's equivalent circuit uses a current source instead of voltage source and the resistance R_N is in parallel with the current source instead of being in series with it. Note that $R_N = R_{th}$)

Advantages :

(i) It reduces a complex circuit into a simple circuit of a single current source in parallel with a single resistance.

(ii) Current through a particular branch can be found easily.

(iii) Can be used for circuits having one or more constant voltage as well as constant current sources.

(iv) This theorem is best suited for finding current through such a load resistance which takes up several finite values viz R_{L_1} , R_{L_2} . . . .

Disadvantage :

If currents through all branches are required then this method is lengthy.

Q.2(c) What do you mean by redundant sources? [4]

Ans.: (a) If a voltage source and a current source are directly in parallel with each other then the voltage source dominates ⇒ we can simply O.C. i.e. remove the current source. Thus, (V || I) ≡ V

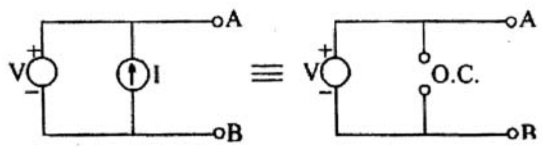


Fig. 1

(b) Conversely, if a voltage source and a current source are in series with each other then the current source dominates ⇒ we can simply S.C. the voltage source. Thus, (I + V) ≡ I

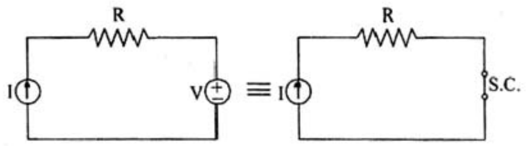


Fig. 2

Q.2(d) Define impedance. What is its unit? State the factors on which it depends. [4]

Ans.: **(i) Definition :**

Impedance (z) :

The combined opposition offered by Resistance, Inductance & capacitance of the circuit to the flow of Alternating Current is defined as Impedance.

It is denoted by 'Z' and its unit is ohm.

(ii) Impedance is given by following expression :

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

(2) where X_L is called inductive reactance = $2\pi fL$

& X_C is called capacitive reactance = $\frac{1}{2\pi fc}$

∴ Impedance depends upon

(1) Values of resistance (which is turn depends on material of the conductor length of the conductor, cross-sectional area of the conductor and the temperature of the conductor), inductance and capacitance

(2) Frequency of a.c. supply.

(3) Value of inductance and capacitance.

Q.3 Attempt any THREE of the following : [12]

Q.3(a) A 50 Hz voltage of 230 volt rms value is applied across a capacitor of 26.5 μF. Calculate : [4]
(i) The capacitive reactance
(ii) Write the time equation for voltage and the resulting current. Let the zero axis of the voltage be at t = 0

Ans.:

Given	Required
$f = 50\,V$, $V_{RMS} = 230\,V$, $C = 26.5\,\mu f$	X_C, equations for v and i

(1) $X_C = \dfrac{1}{2\pi fc} = \dfrac{1}{2 X \pi \times 50 \times 26.5 \times 10^{-6}}\ \Omega$

$X_C = 120\ \Omega$

(2) $V_m = V_{rms} \times \sqrt{2}$
$= 230 \times \sqrt{2} = 325.27\ V$

(3) $V = V_m \text{ Sin } \omega t$
$= V_m \text{ Sin } 2\pi ft$
$V = 325.27 \text{ Sin } 314.16\ t$

(4) $I_{rms} = \dfrac{v}{x_C} = \dfrac{230}{120} = 1.92A$

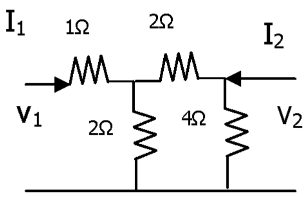
(5) $I_m = I_{rms} \times \sqrt{2} = 1.92 \times \sqrt{2} = 2.72\ A$

Current Equation is,

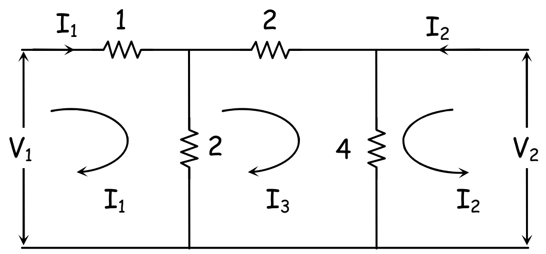
(6) $i = I_m \text{ Sin } \left(\omega t + \dfrac{\pi}{2}\right)$

$i = 2.72 \text{ Sin } \left(314.16t + \dfrac{\pi}{2}\right)$

Q.3(b) Find the z parameters for the network shown in Figure. [4]



Ans.:



Applying KVL to mesh–I
$V_1 = 3I_1 - 2I_3$ … (1)
Applying KVL to mesh–II
$V_2 = 4I_2 + 4I_3$ … (2)
Applying KVL to mehs–III
$-2I_1 + 4I_2 + 8I_3 = 0$

$I_3 = \frac{2}{8}I_1 - \frac{4}{8}I_2$

$I_3 = \frac{1}{4}I_1 - \frac{1}{2}I_2$ … (3)

Put equation (3) in (1)

$V_1 = 3I_1 - 2\left[\frac{1}{4}I_1 - \frac{1}{2}I_2\right]$

$V_1 = \frac{5}{2}I_1 + 1I_2 \quad = Z_{11} I_1 + Z_{12} I_2$

Put equation (3) in (2)

$V_2 = 4I_2 + 4I_3$

$V_2 = 4I_2 + 4\left[\frac{1}{4}I_1 - \frac{1}{2}I_2\right]$

$V_2 = 1I_1 + 2I_2 = Z_{21} I_1 + Z_{22} I_2$

$$\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 5/2 & 1 \\ 1 & 2 \end{bmatrix}$$

Q.3(c) Prove that $\omega_0 = \sqrt{\omega_1\omega_2}$. **[4]**

Ans.: With the usual notations, we know that in the case of AC series circuit under resonance,

$\omega_1 = \omega_0 - \frac{R}{2L}$ and $\omega_2 = \omega_0 + \frac{R}{2L}$

$\therefore \omega_1\omega_2 = \left(\omega_0 - \frac{R}{2L}\right)\left(\omega_0 + \frac{R}{2L}\right)$

$\omega_1 . \omega_2 = \omega_0^2 - \frac{R^2}{4L^2}$

But we know that resistance R is very small compared to X_L

$\therefore$ We neglect R or $\frac{R^2}{4L^2} = 0$

$\therefore \omega_0 = \pm \sqrt{\omega_1\omega_2}$

Clearly taking + ve sign only

$\omega_0 = \sqrt{\omega_1\omega_2}$ hence the proof.

$\because \omega_0 = \sqrt{\omega_1\omega_2}$

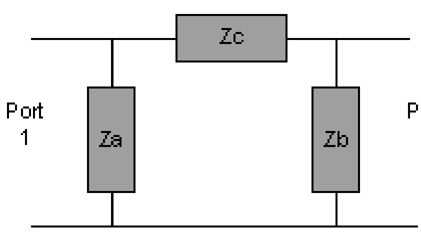
$\therefore 2\pi f_0 = \sqrt{2\pi f_1 . 2\pi f_2}$

$\therefore 2\pi f_0 = 2\pi\sqrt{f_1 f_2}$ or $f_0 = \sqrt{f_1 f_2}$

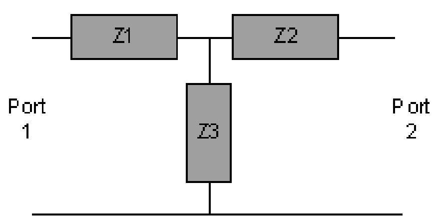
Q.3(d) How to convert from Pi to T and vice versa? **[4]**

Ans.: **Transforming from Pi to T and vice versa**

Any pi network can be transformed to an equivalent T network. This is also known as the Wye-Delta transformation, which is the terminology used in power distribution and electrical engineering. The pi is equivalent to the Delta and the T is equivalent to the Wye (or Star) form.



Pi Network



T Network

The impedances of the pi network (Za, Zb, and Zc) can be found from the impedances of the T network with the following equations:

Za = ((Z1*Z2) + (Z1*Z3) + (Z2*Z3)) / Z2

Zb = ((Z1*Z2) + (Z1*Z3) + (Z2*Z3)) / Z1

Zc = ((Z1*Z2) + (Z1*Z3) + (Z2*Z3)) / Z3

Note the common numerator in all these expressions which can prove useful in reducing the amount of computation necessary.

The impedances of the T network (Z1, Z2, Z3) can be found from the impedances of the equivalent pi network with the following equations:

Z1 = (Za * Zc) / (Za + Zb + Zc)

Z2 = (Zb * Zc) / (Za + Zb + Zc)

Z3 = (Za * Zb) / (Za + Zb + Zc)

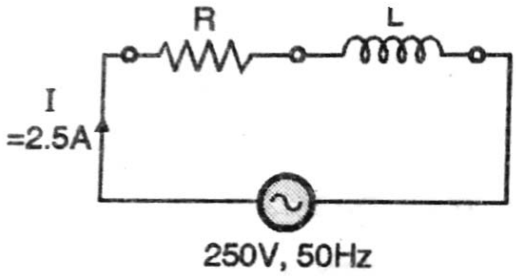
Q.4 Attempt any THREE of the following : [12]

Q.4(a) A choke coil takes a current of 2.5 Amp when connected across 250 V, 50 Hz a.c. supply and consumes 400 Watts. Calculate : [4]

(i) Power factor (ii) Resistance of coil and (iii) Inductance of coil

Ans.: **Given :** I = 2.5 A, V = 250 V, f = 50 Hz, P = 400 W

Step 1 : Draw the circuit



Step 2 : Power factor

Power consumed is the real power.

$\therefore \quad P = VI\cos\phi$

$\therefore \quad 400 = 250 \times 2.5 \times \cos\phi$

$\therefore \quad \cos\phi = 0.64$ (lagging)

Step 3 : Resistance of coil (R)

$$\text{Impedance } Z = \frac{V}{I} = \frac{250}{2.5} = 100\ \Omega$$

But $\quad R = Z\cos\phi$

$\therefore \quad R = 100 \times 0.64 = 64\ \Omega$

Step 4 : Inductance of coil (L)

$$X_L = \sqrt{Z^2 - R^2} = \sqrt{(100)^2 - (64)^2}$$

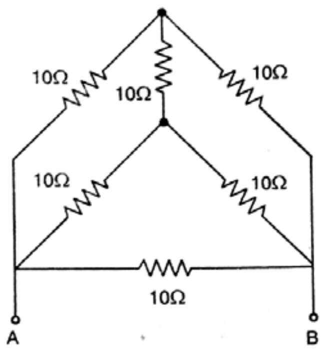
$$= 76.84\ \Omega$$

But $\quad X_L = 2\pi f L$

$\therefore \quad 76.84 = 2\pi \times 50 \times L$

$\therefore \quad L = 0.2446$ H

Q.4(b) Calculate equivalent resistance R_{AB} using delta star transformation (Refer figure). **[4]**

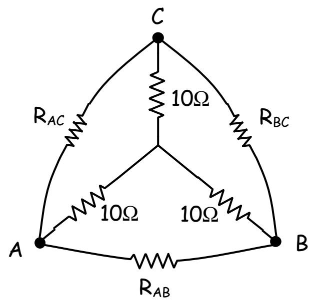


Ans.: **Step 1 : Convert inner star into delta**

$R_{AB} = R_{AC} = R_{BC}$

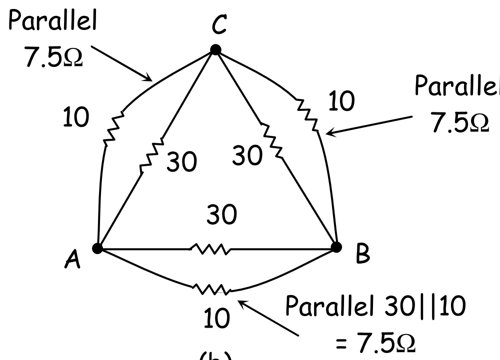
$= \dfrac{(10 \times 10) + (10 \times 10) + (10 \times 10)}{10}$

$= 30\ \Omega$

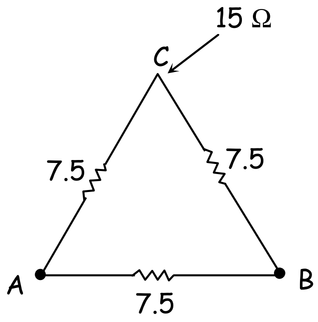


(a)

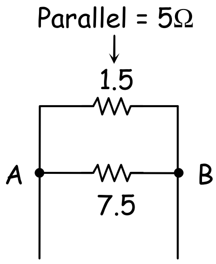
Step 2 : Redraw the circuit and find R_{AB}



(b)



(c)

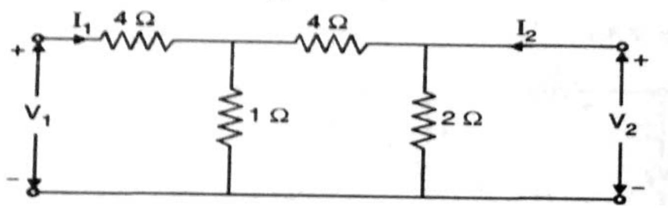


(d)

From figure (d) we get,

$R_{AB} = 15\ ||\ 75\ = \dfrac{15 \times 7.5}{15 + 7.5} = 5\ \Omega$

Q.4(c) Obtain ABCD parameters for the network shown in figure. **[4]**

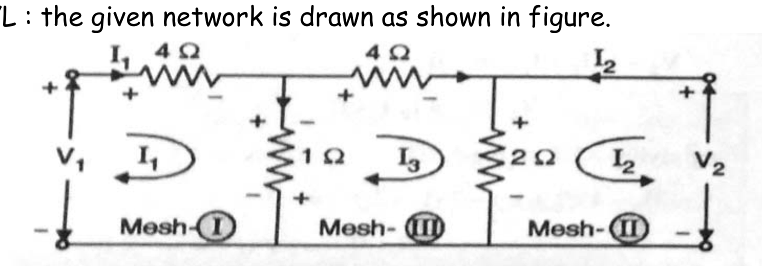


Ans.: We have defining equations of ABCD parameters.

$V_1 = AV_2 - B\,I_2$ … (1)

and $I_1 = CV_2 - D\,I_2$ … (2)

To apply KVL : the given network is drawn as shown in figure.



Applying KVL to mesh (I),

$V_1 - 4I_1 - 1(I_1 - I_3) = 0 \quad \therefore \quad V_1 - 5I_1 + I_3 = 0$

$\therefore \quad V_1 = 5I_1 - I_3 \qquad \dots (3)$

Applying KVL to mesh (II),

$V_2 - 2(I_2 + I_3) = 0$

$\therefore \quad V_2 = 2I_2 + 2I_2 \qquad \dots (4)$

Applying KVL to mesh (III),

$-4I_3 - 2(I_3 + I_2) - 1(I_3 - I_1) = 0$

$\therefore \quad -4I_3 - 2I_3 - 2I_2 - I_3 + I_1 = 0$

$\therefore \quad -7I_3 - 2I_2 + I_1 = 0$

$\therefore \quad 7I_3 = I_1 - 2I_2$

$\therefore \quad I_3 = \frac{1}{7}I_1 - \frac{2}{7}I_2 \qquad \dots (5)$

Put equation (5) in equation (13)

$V_1 = 5I_1 - \frac{1}{7}I_1 + \frac{2}{7}I_2 = \frac{34}{7}I_1 + \frac{2}{7}I_2 \qquad \dots (6)$

Put equation (5) in equation (4)

$V_2 = 2I_2 + 2\left(\frac{1}{7}I_1 - \frac{2}{7}I_2\right)$

$= 2I_2 + \frac{2}{7}I_1 - \frac{4}{7}I_2 = \frac{2}{7}I_1 + \frac{10}{7}I_2 \qquad \dots (7)$

Observe equation (1) we want V_1 in terms of V_2 and I_2. From equation (7).

$\frac{2}{7}I_1 = V_2 - \frac{10}{7}I_2$

$\therefore \quad I_1 = \frac{7}{2}V_2 - 5I_2 \qquad \dots (8)$

Put equation (8) in equation (6)

$V_1 = \frac{34}{7}\left(\frac{7}{2}V_2 - 5I_2\right) + \frac{2}{7}I_2$

$= 17\,V_2 - \frac{170}{7}I_2 + \frac{2}{7}I_2 = 17\,V_2 - 24\,I_2 \qquad \dots (9)$

Comparing equation (9) and (1) we get,

A = 17 and B = 24

Now observe equation (2), we want I_1 in terms of V_2 and I. This is equation (8). So comparing equations (8) and (2) we get,

$C = \frac{7}{2}$ and D = 5

In the matrix from we can write,

$$[T] = \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 17 & 24 \\ \frac{7}{2} & 5 \end{bmatrix}$$

Q.4(d) v = 150 sin (314t) and i = 10 sin$\left(314 + \frac{\pi}{4}\right)$. Find circuit component connected in series. **[4]**

Ans.: From the expressions of v and i it is clear that current leads voltage by $(\pi/4)^c$ i.e. 45°. So the circuit is RC series circuit.

Given : $\phi = 45°$, $V_m = 150$ V, $I_m = 10$ A, f = 50 Hz

$|Z| = \frac{V_m}{I_m} = \frac{150}{10} = 15\,\Omega$

We know that,

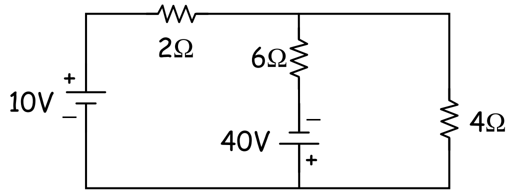
$$\frac{R}{|Z|} = \cos\phi \quad \text{and} \quad \frac{X_C}{|Z|} = \sin\phi$$

$\therefore$ $R = |Z|\cos\phi = 15\cos 45 = 10.6\ \Omega$

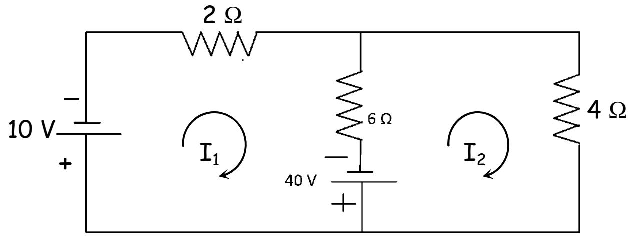
$X_C = |Z|\sin\phi = 15\sin 45 = 10.6\ \Omega$

$$\therefore\ C = \frac{1}{2\pi f X_C} = \frac{1}{2\pi \times 50 \times 10.6} = 300.3\ \mu F$$

Q.4(e) Determine the current in 2Ω resistance in figure using Mesh analysis. **[4]**



Ans.:



(1) Apply KVL to i_1 loop :

$\therefore$ $-2I_1 - 6(I_1 - I_2) + 40 + 10 = 0$

or $8I_1 - 6I_2 = 50$ … (1)

(2) Apply KVL to i_2 loop :

$\therefore$ $-6(I_2 - I_1) - 40 - 4I_2 = 0$

or $-6I_1 + 10I_2 = -40$ … (2)

Solving equation (1) & (2)

$$\begin{pmatrix} 8 & -6 \\ -6 & 10 \end{pmatrix}\begin{pmatrix} i1 \\ i2 \end{pmatrix} = \begin{pmatrix} 50 \\ -40 \end{pmatrix}$$

$$\Delta = \begin{pmatrix} 8 & -6 \\ -6 & 10 \end{pmatrix} = 80 - 36 = 44$$

$$\Delta_1 = \begin{pmatrix} 50 & -6 \\ -40 & 10 \end{pmatrix} = 500 - 240 = 260$$

$$\therefore\ I_{2\Omega} = I_1 = \frac{\Delta I_1}{\Delta} = \frac{260}{44} = 5.9\ A \rightarrow$$

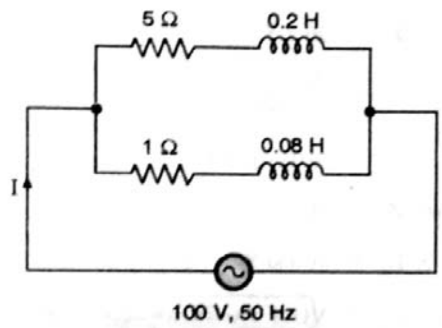
$I_1 = 5.9$ Amp $\rightarrow$

Q.5 Attempt any TWO of the following : **[12]**

Q.5(a) A coil having resistance of 5Ω and inductance of 0.2 H is arranged in parallel with another coil having resistance of 1Ω and inductance of 0.08 H. Calculate the current through the combination and power absorbed when a voltage of 100 V, 50 Hz is applied. Use impedance method. **[6]**

Ans.: **To find :** Current and power absorbed.

Step 1 : Draw the circuit diagram



Two coils
Coil 1 : $R_1 = 5\ \Omega$, $L_1 = 0.2$ H
Coil 2 : $R_2 = 1\ \Omega$, $L_2 = 0.08$ H

For coil 1

$X_1 = 2\pi f L_1 = 2\pi \times 50 \times 0.2 = 62.84\ \Omega$

$Z_1 = R_1 + jX_1 = 5 + j\,62.84$

$= 63.03 \angle 85.45^\circ\ \Omega$

For coil 2

$X_2 = 2\pi f L_2 = 2\pi \times 50 \times 0.08 = 25.13\ \Omega$

$Z_2 = R_2 + jX_2 = 1 + j\,25.13$

$= 25.15 \angle 87.72^\circ\ \Omega$

Step 2 : Calculate Z_{eq} and total current

$$Z_{eq} = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

$$= \frac{(63.03\angle 85.45^\circ)(25.15\angle 87.72^\circ)}{(63.03\angle 85.45^\circ) + (25.15\angle 87.72^\circ)}$$

$\therefore\ Z_{eq} = (17.98 \angle 87.07^\circ)\ \Omega$

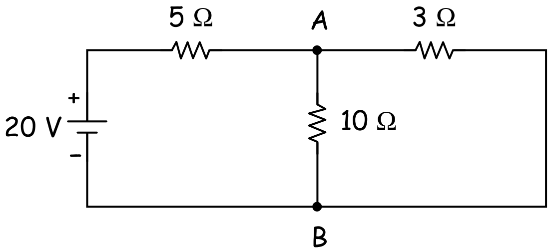
Total current $I = \dfrac{V}{Z_{eq}} = \dfrac{100\angle 0^\circ}{17.98\angle 87.07^\circ}$

$I = 5.56 \angle -87.07^\circ$ Amp

Step 3 : Calculate power absorbed

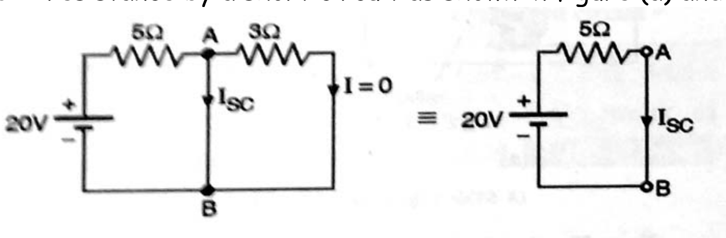
$P = V I \cos\phi = 100 \times 5.56 \times \cos(-87.07)$

Q.5(b) Calculate the current in 10 Ω resistance using Norton's theorem shown in figure. [6]



Ans.: Step 1 : Find I_{SC}

Replace the 10 Ω resistance by a short circuit as shown in figure (a) and find I_{SC}.



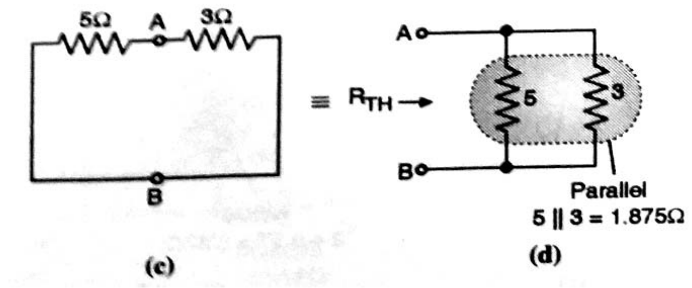
(a) (b)

As shown in figure (a), the 3 Ω resistance is short circuited when points A and B are shorted.

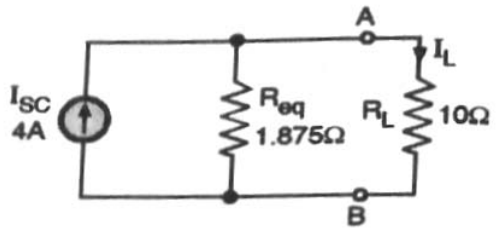
From figure (b) we get,

$$I_{SC} = \frac{20\ V}{5} = 4\ \text{Amp} \qquad \ldots (1)$$

Step 2 : Fid R_{eq} or R_{TH}



Step 3 : Find I_L



(e) : Norton's equivalent circuit

From figure (e),

$$I_L = \frac{R_{eq}}{(R_{eq} + R_L)} \times I_{SC}$$

$$= \frac{1.875}{(1.875 + 10)} \times 4$$

$\therefore$ I_L = 0.632 Amp

Q.5(c) A coil of resistance 15 Ω and inductance of 0.05 H connected in series with 100 μF capacitor across 230 V, 50 Hz ac supply find : **[6]**

(i) Current **(ii) Power factor of circuit**

(iii) Voltage drop across coil **(iv) Voltage across capacitor**

Ans.: **Given :** R = 15 Ω, L = 0.05 H, C = 100 μF,
Series circuit, V = 230 Volts, f = 50 Hz

(i) Current I

$$X_L = 2\pi fL = 2\pi \times 50 \times 0.05 = 15.7\ \Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}} = 31.83\ \Omega$$

$\therefore$ $X_L - X_C = 15.7 - 31.83 = -16.13\ \Omega$

$$\therefore\ |Z| = \sqrt{R^2 + (X_L - X_C)^2}$$

$$= \sqrt{(15)^2 + (16.13)^2}$$

$\therefore$ $|Z| = 22\ \Omega$

$$\therefore\ I = \frac{V}{|Z|} = \frac{230}{22} = 10.46 \text{ Amp}$$

(ii) Power factor

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

$$= \tan^{-1}\left(\frac{-16.13}{15}\right) = -47^\circ$$

$\therefore$ PF $\cos\phi$ = cos (– 47)
= 0.68 (leading)

(iii) Voltage across coil

$V_L = IX_L = 10.46 \times 15.7 = 164.2$ Volts

(iv) Voltage across capacitor

$V_C = IX_C = 10.46 \times 31.83 = 332.94$ Volts

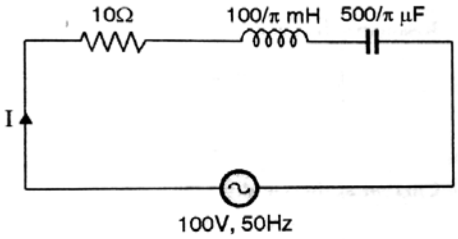
Q.6 Attempt any TWO of the following : [12]

Q.6(a) A series circuit has the following characteristics R = 10 Ω, L = $\frac{100}{\pi}$ mH, C = $\frac{500}{\pi}$ μF. Find : [6]

(i) The current flowing when the applied voltage is 100 V at 50 Hz.
(ii) The power factor of the circuit
(iii) What value of supply frequency would produce series resonance?

Ans.: **Given :** R = 10 Ω, $L = \frac{100}{\pi}$ mH, $C = \frac{500}{\pi}$ μF

To find : I, cos φ, f_r



(i) Current

$$X_L = 2\pi fL = 2 \times \pi \times 50 \times \frac{100}{\pi} \times 10^{-3} = 10\ \Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times \frac{500}{\pi} \times 10^{-6}} = 20\ \Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{10^2 + (10-20)^2} = 14.14\ \Omega$$

$$I = \frac{V}{Z} = \frac{100}{14.14} = 7.07\ A$$

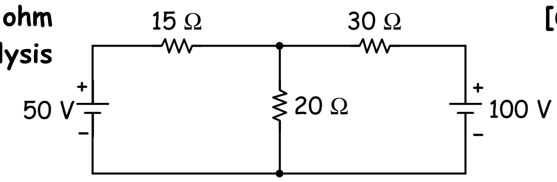
(ii) Power factor

$$\cos\phi = \frac{R}{Z} = 0.707 \text{ lead (as } X_C > X_L)$$

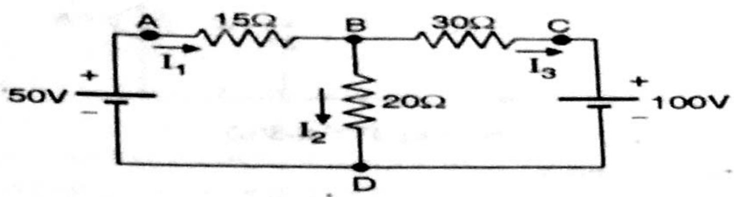
(iii) Supply frequency at which resonance occurs

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{\frac{100}{\pi} \times 10^{-3} \times \frac{500}{\pi} \times 10^{-6}}} = 70.71\ Hz$$

Q.6(b) Determine the current through 20 ohm resistance in figure using node analysis method. [6]



Ans.: **Step 1 : Name various nodes and branch currents**



Step 2 : Apply KCL at node B

At node "B" apply KCL to write,

$I_1 = I_2 + I_3$

But $I_1 = \frac{V_A - V_B}{15}$, $I_2 = \frac{V_B}{20}$ and $I_3 = \frac{V_B - V_C}{30}$

$\therefore \frac{V_A - V_B}{15} = \frac{V_B}{20} + \frac{V_B - V_C}{30}$

But $V_A = 50$ V, $V_C = 100$ V

$\therefore \frac{50 - V_B}{15} = \frac{V_B}{20} + \frac{V_B - 100}{30}$

$\therefore \frac{(50 - V_B)}{15} = \frac{3V_B + 2V_B - 200}{60}$

$\therefore 4(50 - V_B) = 5V_B - 200$

$\therefore 200 - 4V_B = 5V_B - 200$

$\therefore 9V_B = 400$

$\therefore V_B = 44.44$ Volts

Step 3 : Find current through 20 Ω resistance I_2

$I_2 = \frac{V_B}{20} = \frac{44.44}{20} = 2.222$ Amp

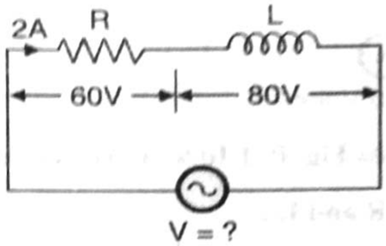
Q.6(c) For a circuit shown in figure. Find : **[6]**

(i) Values of R and L

(ii) Total voltage

(iii) Impedance

(iv) Power factor



Ans.: ***Given :***

Voltage across R = 60 V,

Voltage across L = 80 V,

I = 2A, f = 60 Hz

To find :

(i) Values of R and L (ii) Total voltage (iii) Impedance (iv) Power factor

Step 1 : Calculate R

$R = \frac{V_R}{I} = \frac{60}{2} = 30\ \Omega$

Calculate X_L, L and Z

$X_L = \frac{V_L}{I} = \frac{80}{2} = 40\ \Omega$

But $X_L = 2\pi fL$

$\therefore 40 = 2\pi \times 60 \times L$

$\therefore L = 0.106$ H

$Z = \sqrt{R^2 + X_L^2}\angle\tan^{-1}(X_L / R) = \sqrt{(30)^2 + (40)^2}\angle\tan^{-1}(40/30)$

$\therefore Z = 50 \angle 53.13°\ \Omega$

Step 2 : Calculate power factor

Power factor $= \cos\phi = \frac{R}{|Z|} = \frac{30}{50} = 0.6$ (lagging)

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