# Previous Year Questions with Answers

## CIRCUIT & NETWORK THEORY
### (THEORY - 02)
### [Code : EET - 301]

Full Marks : 80      Time : 3 Hours

Answer any **five** questions including **Q.Nos.1 & 2**.

*Figures in the right-hand margin indicate marks.*

1. **Answer the following in short :**    [2 × 10

  (a) What is form factor ?

  (b) What do you mean by bandwidth ?

  (c) What is a band-stop Filter ?

  (d) Define Reciprocity theorem ?

  (e) Define Reluctance ?

  (f) Define Selectivity ?

  (g) Define co-efficient of coupling ?

  (h) What do you mean by apparent power ?

  (i) What do you mean by Transmission parameters ?

  (j) State Lenz's law ?

2. **Answer the following :**      [5 × 6

  (a) State and explain maximum power transfer theorem ?

  (b) State and explain relation between line and phase quantities in a Delta connection.

  (c) Using superposition theorem find the current flowing in 10 Ω resistor.
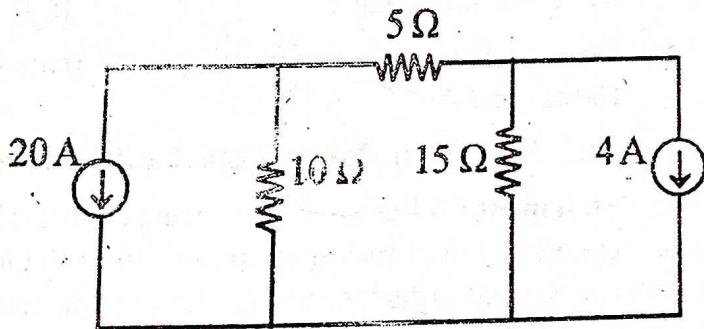


  (d) Draw the explain hysteresis loop of a magnetic material.

  (e) A circuit takes a current of 8A at 100 V, 50 Hz and the current lagging behind by $30°$ from applied voltage. Calculate the resistance and inductance of the circuit.
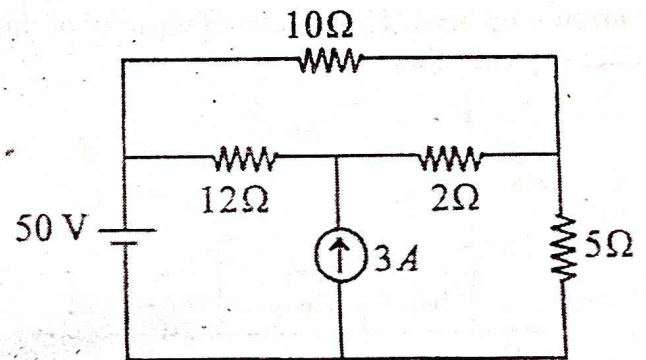
(f) Explain about different steps for solving a network by Norton's theorem.

3. Design a band stop constant-K type filter with cut-off frequencies of 4 KHz and 10 KHz and nominal characteristic impedance 500 ohm. [10

4. Find z parameters for the given network. All resistaces are in Ohm.      [10
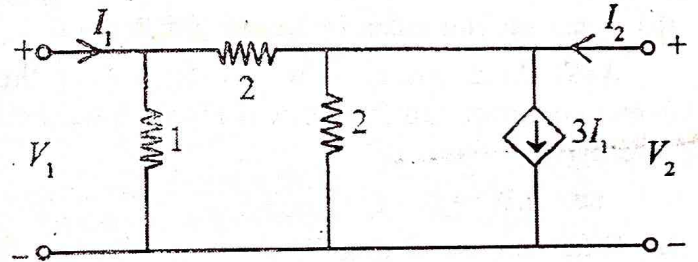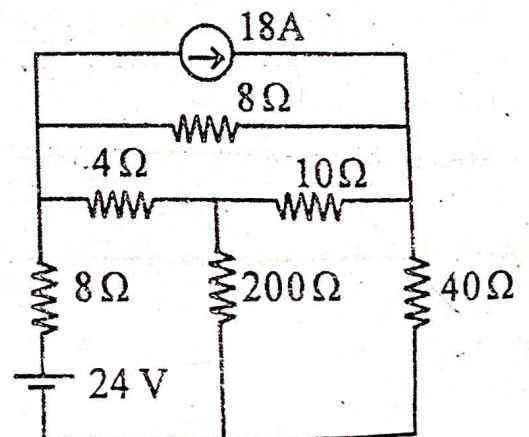


5. Using Thevenin's Theorem, find the current in 5Ω Resistance.      [10



6. Two impedance $z_1 = 10 + j\ 1.5\ \Omega$ and $z_2 = 8 + j\ 6\Omega$ are connected in parallel. If total current taken is 20A. Find the current taken by each branch and different power consumed by the circuit. [10

7. Use Nodal analysis to determine the voltage across 10 Ω resistor.      [10

## 1. Answer the following in short : [2 × 10]

**(a) What is form factor ?**

Ans. Form factor is defined as the ratio between rms value and average value of an alternating quantity.

i.e., $k_f = \dfrac{\text{RMS value}}{\text{Average value}}$

For ac sinusoidal quantity, $k_f = 1.11$

For half wave rectified wave, $k_f = 0.5$.

**(b) What do you mean by bandwidth ?**

Ans. Band width (B.W.) is defined as the difference of upper half frequency $(f_2)$ to the lower half frequency $(f_1)$.

i.e. $B.W. = f_2 - f_1$.

**(c) What is a band-stop Filter ?**

Ans. It is a filter that passes most frequencies unaltered, but attenuates these in a specific range to very low levels. It is the opposite of a band pass filter. It has narrow stop band. The gain vrs. frequency of this type filter is given below.
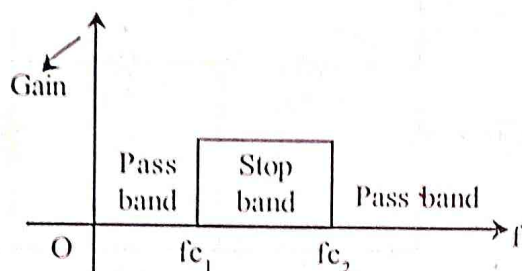


**(d) Define Reciprocity theorem ?**

Ans. It states that - In any branch of a network or circuit, the current due to a single source of voltage (V) in the network is equal to the current through that branch in which the source was originally placed when the source is again put in the branch in which the current was originally obtained.

**(e) Define Reluctance ?**

Ans. Reluctance : It is defined as the ratio of mmf to magnetic flux. It represents the opposition to magnetic flux and depends on the geometry and composition of an object. It's unit is AT/Wb i.e.

$\dfrac{\text{Ampere turn}}{\text{Weber}}$.

**(f) Define Selectivity ?**

Ans. Selectivity is defined as the ratio between band width (B.W.) and resonant frequency $(f_0)$.

i.e., $\text{selectivity} = \dfrac{BW}{f_0}$

It has no unit.

**(g) Define co-efficient of coupling ?**

Ans. Co-efficient of coupling (k) : The fraction of magnetic flux produced by the current in one coil that links with the other coil is called co-efficient of coupling (k). $k = 1$, when the flux produced by one coil completely links with the other coil and is called magnetically tightly coupled.

**(h) What do you mean by apparent power ?**

Ans. Apparent power (s) is defined as the product of circuit's voltage and current. It is also the combination of reactive poewr and true power. It's unit is VA.

**(i) What do you mean by Transmission parameters ?**

Ans. Transmission Parameters : These are the parameters which are used in transmission of power networks i.e. particularly in two-port networks. They are represented by A, B, C and D respectively.

**(j) State Lenz's law ?**

Ans. Lenz's Law : It states that the current induced in a circuit due to change or a motion in a magnetic field is so directed as to oppose the change in flux and to exert a mechanical force opposing the motion. It obeys Newton's 3rd law and the law of conservation of energy.

## 2. Answer the following : [5 × 6]

**(a) State and explain maximum power transfer theorem ?**

Ans. Maximum Power Transfer Theorem :

**Statement :** A Resistive load, being connected to a dc network receives maximum power when the load resistance is equal to the internal resistance of the source network as sum from the load terminals.

**Explanation :**

Let's consider a generator supplying electrical power over a transmission line a load resistor $R_L$ as shown in fig-1.
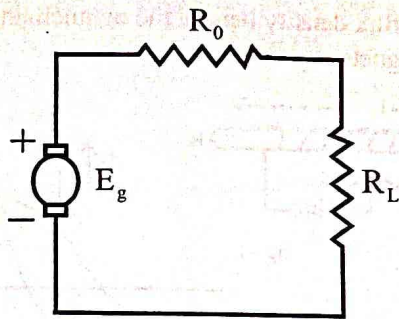
fig–1

Let $E_g$ = voltage generated inside the generator.

$R_0$ = the internal resistance of generator plus the resistance of the two line conductors.

The current delivered to load resistance.

$$I = \frac{E_g}{(R_0 + R_1)}$$

Power delivered to load resistance

$$P = I^2 R_L = \frac{E_g^2}{(R_0 + R_L)^2} \times R_L$$

$$= \frac{E_g^2 R_L}{(R_0 + R_L)^2}$$

The power will be maximum when

$$\frac{dP}{dR_L} = 0$$

So

$$\frac{dP}{dR_L} = \frac{E_g^2(R_0 + R_L^2) - 2R_L(R_0 + R_L)E_g^2}{(R_0 + R_L)^4} = 0$$

$$\Rightarrow E_g^2 (R_0+R_L)^2 - 2R_L(R_0+R_L) E_g^2 = 0$$

$$\Rightarrow E_g^2 (R_0+R_L)^2 = 2R_L (R_0+R_L) E_g^2$$

$$\Rightarrow (R_0+R_L) = 2R_L$$

$$\Rightarrow R_0 = 2R_L - R_L = R_L$$

$$\Rightarrow \boxed{R_0 = R_L}$$

The value of the maximum power transferred is

$$P_{max} = \frac{E_g^2 R_L}{(R_L + R_L)^2} = \frac{E_g^2 R_L}{4R_L^2} = \frac{E_g}{4R_L}$$

$$\Rightarrow \boxed{P_{max} = \frac{E_g^2}{4R_L}}$$

**(b) State and explain relation between line and phase quantities in a Delta connection.**

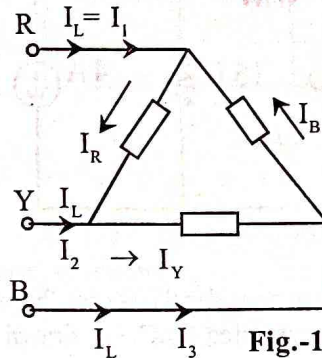Ans. Relation between line and phase quantities in a Delta connection :
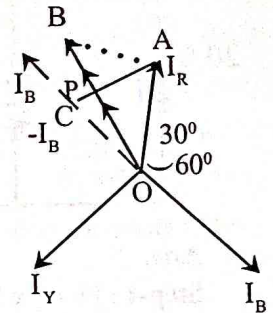


Fig.-1          Fig.-2

Let us consider a delta-connected load in which $I_R$, $I_Y$ and $I_B$ are the phase currents and $I_1 = I_2 = I_3 = I_L$ be the line currents for the balanced loads.

For balanced loads $I_R = I_Y = I_B$.

But the line current considered will be the phasor sum or difference.

$$\therefore I_1 = \overline{I_L} = \overline{I_R} - \overline{I_B}, \quad I_2 = \overline{I_R} - \overline{I_Y} = I_L,$$

$$\overline{I_3} = \overline{I_Y} - \overline{I_B} = I_L$$

Considering the fig-2,

OABC is a rhombous, AC diagonal is joined.

Triangle OAP is considered, which is a right angled triangle.

$$\angle AOP = 30°,$$

$$\therefore OP = OA \cos 30° = I_R \times \frac{\sqrt{3}}{2}$$

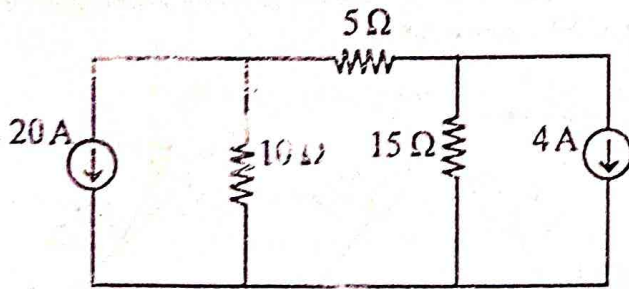$$\therefore OB = 2OP = 2 \times I_R \times \frac{\sqrt{3}}{2} = \sqrt{3} I_R$$

$$\therefore I_1 = \sqrt{3} I_R = I_L. \ (\text{Proved})$$

Similarly in other phasors also $\boxed{I_L = \sqrt{3} I_{ph}}$.

Next, as there is no neutral present and phase voltage, line voltages will be equal.
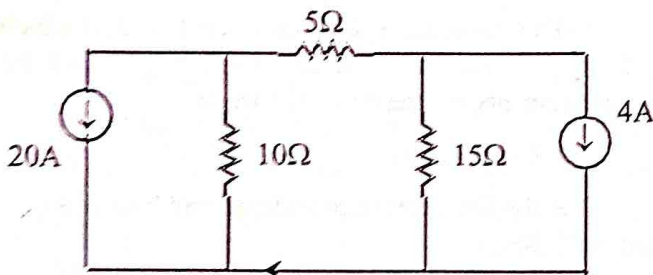
$$\therefore \boxed{V_R = V_L}.$$

**(c) Using superposition theorem find the current flowing in 10 Ω resistor.**
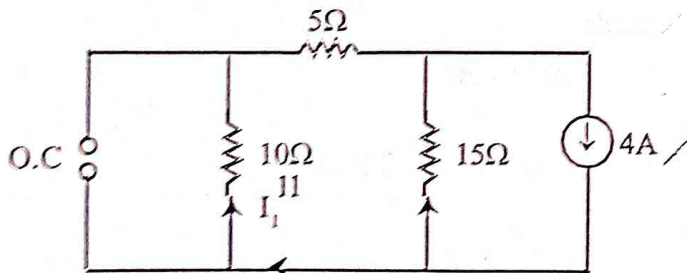


**Ans.**

**Step-1 :** First we have to consider the source 20A and other source 4A is open circuited (O.C.) as drawn below.



In the given circuit by applying current division technique,

$$I_j = 20A \times \frac{(15+5)}{(15+5+10)} = 20 \times \frac{20}{30} = 13.33 \ (\uparrow)$$

**Step-2 :** Then we consider the source 4A and the other source 20A is open circuited (O.C.) as given below.
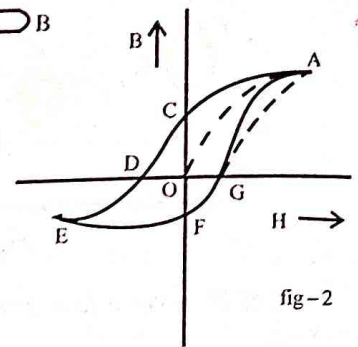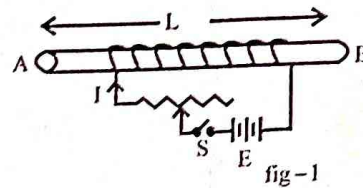


Applying current division formula,

$$I_j^{11} = 4A \times \frac{15}{15+10+5} = 4 \times \frac{15}{30} = 2A \ (\uparrow)$$

∴ Finally applying superposition theorem technique, current in 10Ω resistor = $I_j + I_j^{11}$

$$= 13.33 + 2 = 15.33A. \ (Ans)$$

**(d) Draw the explain hysteresis loop of a magnetic material.**

**Ans.** The phenomenon of lagging of magnetisation or induction flux density behind the magnetising force is called as magnetic hystersis.



Let's consider a core of specimen of iron be wound with a number of turns of wire and current be passed through the solenoid. A magnetic field of intensity 'H' proportional to the current folowing through the solenoid is produced. Let the magnetising force 'H' is increased from zero to maximum value and then gradually reduced to zero. If the value of flux density 'B' in the come to various values of magnetising force 'H' are determined, then we have found B-H curve.

If the direction of flow of current is reversed the magnetising force 'H' is reversed. Let the current be increased in the negative direction until the induction density 'B' becomes zero. At B=0, the demagnetising force H=OD which is required to neutralize the residual magnetism. If the demagnetising force 'H' is further increased to previous maximum value and again gradually decreased to zero further increased in origional or positive direction to the maximum value, there is a closed loop ACDEF is formed. This loop is called hystersis loop as shown is fig-2.

**(e) A circuit takes a current of 8A at 100 V, 50 Hz and the current lagging behind by 30° from applied voltage. Calculate the resistance and inductance of the circuit.**

**Ans. Given data :**
I = 8A, V = 100 volt, F = 50 Hz, $\phi$ = 30° (lagging)

In the following circuit $(Z) = \frac{V}{I} = \frac{100}{8} = 12.5 \ \Omega$.

PF = Power factor = $\cos \phi = \cos 30 = 0.866$

∴ Resistance (R) = $Z \cos \phi = 12.5 \times 0.866$
$$= 10.392 \ \Omega$$

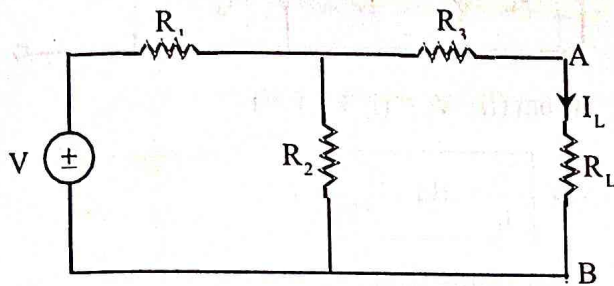Reactance $(X_L) = Z \sin \phi = 12.5 \times 0.5 = 6.25 \ \Omega$.
But $X_L = \omega L = 2\pi f L = 2 \times \pi \times 50 \times L$
∴ $6.25 = 100 \ \pi L$

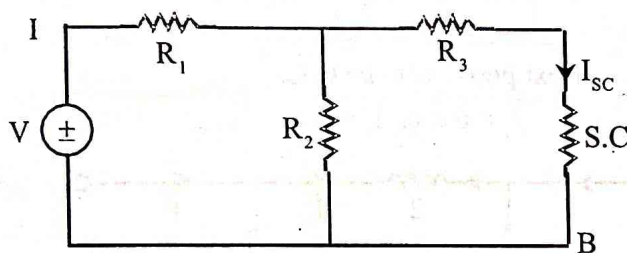∴ $L = \frac{6.25}{100\pi} = 0.0199 \ H. \ (Ans)$

**(f) Explain about different steps for solving a network by Norton's theorem.**

**Ans.** Different steps for solving a network by Norton's Theorem.



**Step-1 :** In order to find the current in the load resistance ($R_L$), we have to short circuit (S.C.) the resistor '$R_L$'.



The current flowing through short circuit terminal = $I_{SC}$ will be found out.

$$I_{SC} = I \times \frac{R_2}{R_2 + R_3}$$

$$\therefore I = \frac{V}{R_1 + (R_2 \| R_3)} = \frac{V}{R_1 + \frac{R_2 R_3}{R_2 + R_3}}$$

$$= \frac{V(R_2 + R_3)}{R_1 R_2 + R_2 R_3 + R_3 R_1}$$

$$\therefore I_{SC} = I \times \frac{R_2}{R_2 + R_3}$$

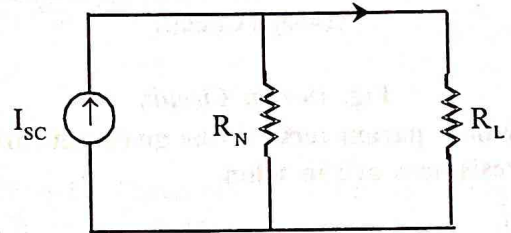$$= \frac{V(R_2 + R_3)}{R_1 R_2 + R_2 R_3 + R_3 R_1} \times \frac{R_2}{(R_2 + R_3)}$$

$$= \frac{V.R_2}{R_1 R_2 + R_2 R_3 + R_3 R_1}$$

**Step-2 :** Norton's equivalent resistance ($R_N$) will be found out by eliminating the energy source i.e. V is to be short circuited and we have to look into the circuit.



$$\therefore R_N = R_3 + \frac{R_1.R_2}{R_1 + R_2} = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1 + R_2}$$

**Step-3 :** The Norton's equivalent circuit is to be drawn as follows.



$$\therefore \text{ Current through } R_L = I_{SC} \times \frac{R_N}{R_N + R_L}$$

These are the steps to be followed for solving Norton's theorem.

3. **Design a band stop constant-K type filter with cut-off frequencies of 4 KHz and 10 KHz and nominal characteristic impedance 500 ohm.[10**

   **Ans.** Given

   $f_1 = 4 KHZ$

   $f_2 = 10 KHZ$

   $R_0 = 500 \Omega$

   $$R_0 = \sqrt{\frac{L_1}{C_2}} = \sqrt{\frac{L_2}{C_1}}$$

   $$C_1 = \frac{1}{4\pi R_0 (f_2 - f_1)}$$

   $$= 26.52 \times 10^{-9} F$$

   $$C_2 = \frac{f_2 - f_1}{\pi f_1 f_2 R_0} = 95.49 \times 10^{-9} F$$

   $$L_1 = C_2 R_0^2$$

   $$= 23.87 \text{ mH}$$

   $$L_2 = C_1 R_0^2$$

   $$= 6.63 \text{ mH}$$

Here $C_1 = 0.02652 \times 10^{-6}$ F $= 0.02652$ μF.

$C_2 = 0.09549 \times 10^{-6}$ F $= 0.09549$ μF.
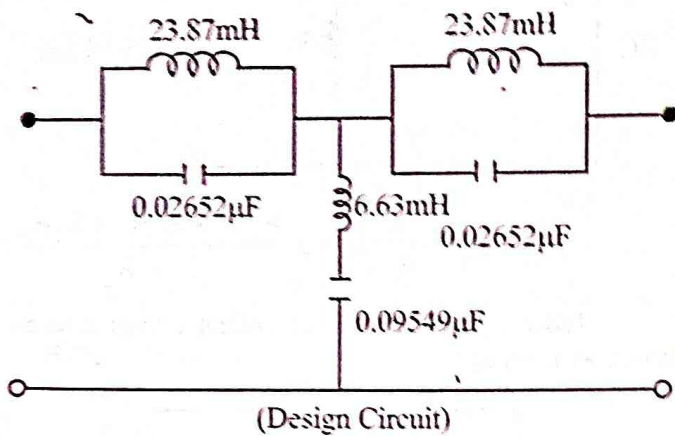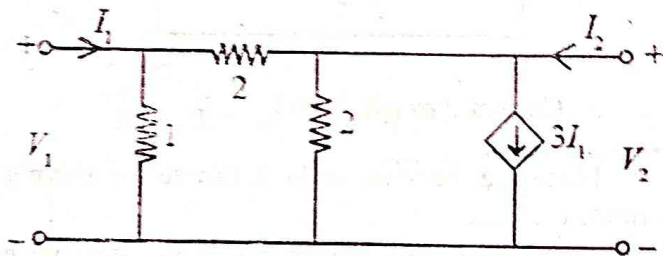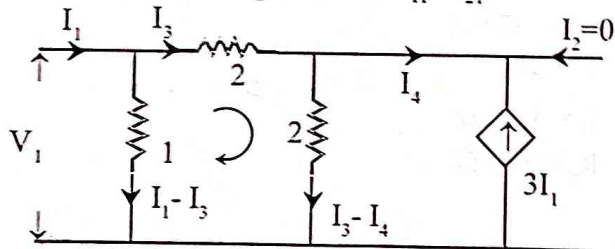


(Design Circuit)

Fig. *Design Circuit.*

4. **Find z parameters for the given network. All resistances are in Ohm.** |10



**Ans.**

**Step-1 :** Put $I_2 = 0$, find $Z_{11}$, $Z_{21}$.



$\therefore\ V_1 = (I_1 - I_3) \cdot 1.$ ....(i)

kVL in loop-1 will be,

$O = (I_3 - I_1) \times 1 + 2I_3 + (I_3 - I_4) \times 2$ ....(ii)

$V_2 = 2(I_3 - I_4)$ ....(iii)

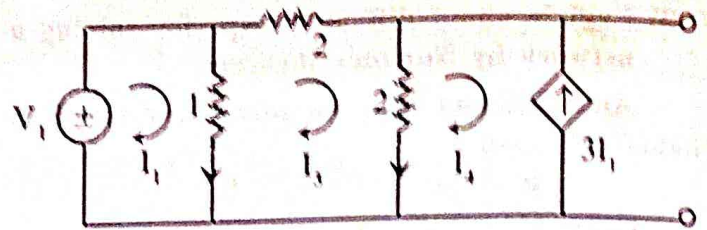$I_4 = -3I_1$ ....(iv)

From equation (ii) utilising (iv)

$O = I_3 - I_1 + 2I_3 + 2I_3 + 6I_1$

or, $5I_1 = -5I_3$

$\Rightarrow I_3 = -I_1$

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From (i) $V_1 = (I_1 + I_1) \times 1$

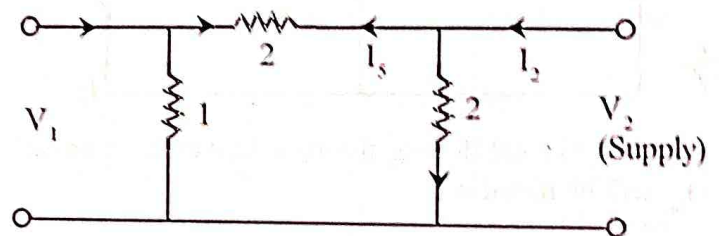$\Rightarrow \boxed{\dfrac{V_1}{I_1} = 2\Omega = Z_{11}}$

From (iii) and (iv),

$V_2 = 2(I_3 + 3I_1) = 2(-I_1 + 3I_1) = 4 \times I_1$

$\therefore \boxed{Z_{21} = \dfrac{V_2}{I_1} = 4\Omega}$

Next port-1 is to be O.C.

$I_1 = 0$ i.e. $I_1 = 0$



$V_2 = (I_2 - I_5) \times 2$ ....(v)

$O = 2(I_5 - I_2) + 3I_5$ ....(vi)

Thus from (v),

$V_2 = \left[ I_2 - I_2 \times \left( \dfrac{2}{2+2+1} \right) \right] \times 2$
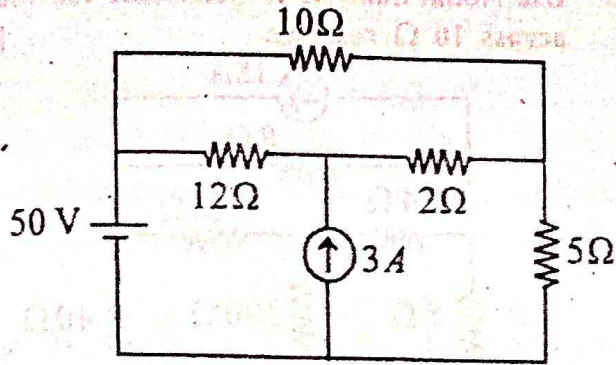
$= 2I_2 - \dfrac{4}{5}I_2 = \dfrac{6}{5}I_2$

Thus $\boxed{Z_{22} = \dfrac{V_2}{I_2} = \dfrac{6}{5} = 1.2\,\Omega}$
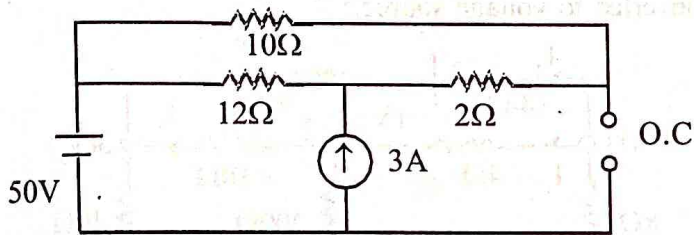
Also, $V_1 = I_5 \times 1 = \dfrac{2}{5}I_2$

$\Rightarrow \boxed{Z_{12} = \dfrac{V_1}{I_2} = \dfrac{2}{5} = 0.4\,\Omega}$.

5. **Using Thevenin's Theorem, find the current in 5Ω Resistance.** |10
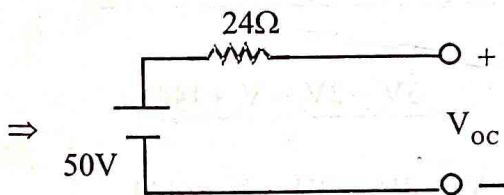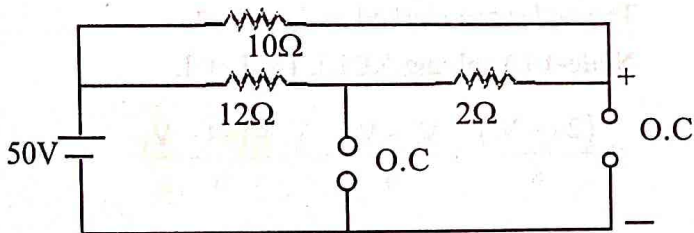
The circuit is drawn below.



**Ans.**

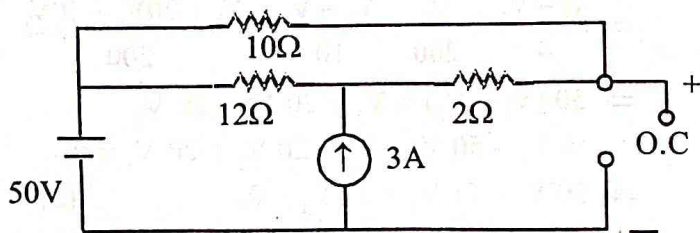**Step-1 :** The 5Ω resistor will be open circuited first and O.C. voltage $V_{OC}$ or $V_{Th}$ will be found out.



Now we have to apply super position principle.

Therefore one source is to be considered at once and other source is eliminated.



$\Rightarrow$



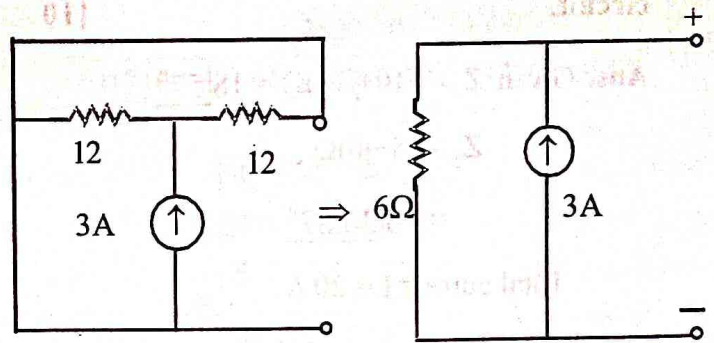$\therefore V_{OC_1}$ or $V_{Th_1} = 50$ V.

Next 3A is considered and 50V S.C.



12Ω and $(10+2)$ Ω are in parallel $= (12 \| 12) = 6$ Ω.
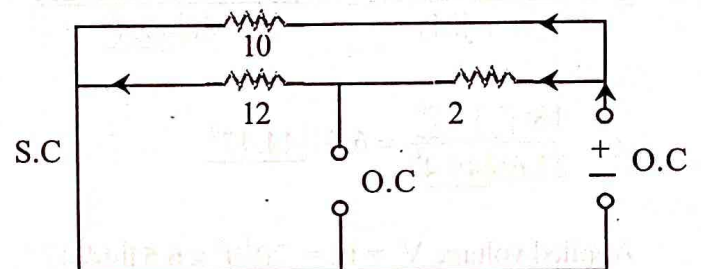
$\therefore$ Current in each path = 1.5 A.

i.e. in ZΩ, 10Ω current = 1.5 A.

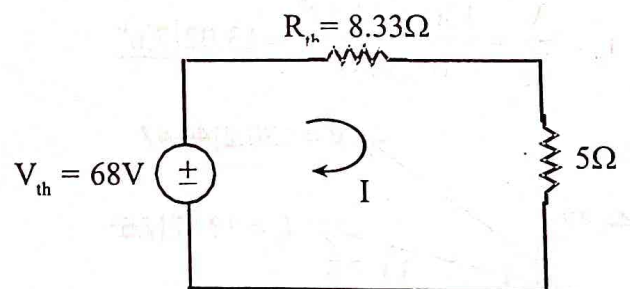$\therefore V_{OC_2} = 6 \times 3 = 18$ V

or $V_{Th_2} = 18$ V

$\therefore V_{Th} = V_{Th_1} + V_{Th_2} = 50 + 18 = 68$ V.

**Step-2 :** Thevenin's equivalent resistance $(R_{Th})$ can be found out accordingly,



$$R_{Th} = (12 + 2) \| (10) = \frac{14 \times 10}{14 + 10}$$

$$= \frac{140}{24} = 5.833 \ \Omega.$$

**Step-3 :** Thevenin's equivalent circuit.



$$\therefore I = \frac{V_{Th}}{R_{Th} + 5}$$

$$\therefore I = \frac{68}{8.33 + 5} = 15.101 \ \text{Amp.} \ (\text{Ans})$$

6.  Two impedance $z_1 = 10 + j \ 1.5$ Ω and $z_2 = 8 + j \ 6$Ω are connected in parallel. If total current taken is 20A. Find the current taken by each

branch and different power consumed by the circuit. [10

**Ans.** Given $Z_1 = (10+j15)\Omega = 18\underline{|57^0}$

$$Z_2 = (8+j6)\Omega$$

$$= 10\underline{|36.87^0}$$

Total current $I = 20$ A

$$\Rightarrow I = 20\underline{|0^0} \text{ A}$$

Total impedance

$$Z = \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{(10+j15)(8+j6)}{(10+j15+8+j6)}$$

$$= \frac{(10+j15)(8+j6)}{(18+j21)} = \frac{(18\underline{|57^0}) \times (10\underline{|36.87^0})}{27.66\underline{|49.4^0}}$$

$$Z = \frac{180\underline{|93.87^0}}{27.66\underline{|49.4^0}} = 6.51\underline{|44.47^0}$$

Applied voltage $V = IZ = 20\underline{|0^0} \times 6.51\underline{|44.47^0}$

$$= 130.2\underline{|44.47^0}$$

$$I_1 = \frac{V}{Z_1} = \frac{130.2\underline{|44.47^0}}{18\underline{|57^0}} = 7.23\underline{|-12.53^0}$$

$$I_2 = \frac{V}{Z_2} = \frac{130.2\underline{|44.47^0}}{10\underline{|36.87^0}} = 13.02\underline{|7.6^0}$$

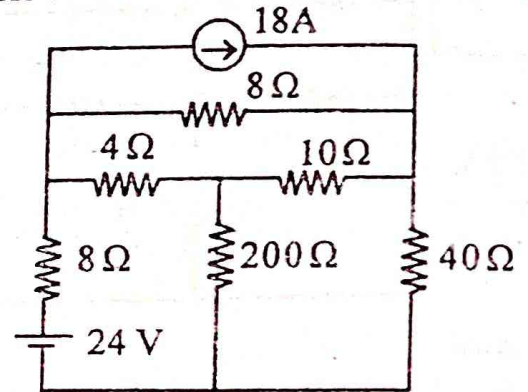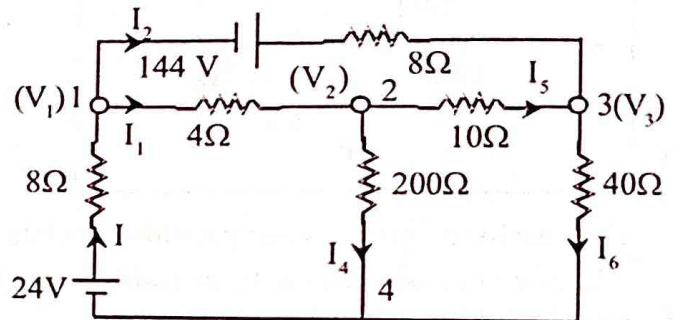

Power consumed

$$P = VI \cos\theta$$

$$= 130.2 \times 20 \times \cos 44.47^0$$

$$= 11858.26 \text{ watt}$$

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7. Use Nodal analysis to determine the voltage across 10 $\Omega$ resistor. [10



**Ans.** Now the current source 18A can be converted to voltage source.



The nodes are marked as 1, 2, 3, 4.

**Node-1** (Applying KCL), $I = I_1 + I_2$

$$\Rightarrow \frac{(24-V_1)}{8} = \frac{V_1 - V_2}{4} + \frac{V_1 + 144 - V_3}{8}$$

$$\Rightarrow \frac{24 - V_1}{8} = \frac{2V_1 - 2V_2 + V_1 + 144 - V_3}{8}$$

$$= \frac{3V_1 - 2V_2 - V_3 + 144}{8}$$

$$\Rightarrow 24 - V_1 = 3V_1 - 2V_2 - V_3 + 144$$

$$\Rightarrow 4V_1 - 2V_2 - V_3 = -120 \qquad ....(1)$$

**Node-2** (Applying KCL), $I_1 = I_4 + I_5$

$$\Rightarrow \frac{V_1 - V_2}{4} = \frac{V_2}{200} + \frac{V_2 - V_3}{10} = \frac{V_2 + 20V_2 - 20V_3}{200}$$

$$\Rightarrow 50(V_1 - V_2) = V_2 + 20V_2 - 20V_3$$

$$\therefore 50V_1 - 50V_2 - V_2 - 20V_2 + 20V_3 = 0.$$

$$\Rightarrow 50V_1 - 71V_2 + 20V_3 = 0. \qquad ....(2)$$

**Node-3** (Applying KCL), $I_2 + I_5 = I_6$

$$\Rightarrow \frac{V_1 + 144 - V_3}{4} + \frac{V_2 - V_3}{10} = \frac{V_3}{40}$$

$$\Rightarrow \frac{5V_1 + 720 - 5V_3 + 4V_2 - 4V_3}{40} = \frac{V_3}{40}$$

$$\Rightarrow 5V_1 + 4V_2 - 9V_3 + 720 = V_3$$

$$\Rightarrow 5V_1 + 4V_2 - 10V_3 = -720. \qquad ....(3)$$

Equating equation (1), (2) and (3) we have,

By applying Cramer's rule,

$$\begin{bmatrix} 4 & -2 & -1 \\ 50 & -71 & 20 \\ 5 & 4 & -10 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} -120 \\ 0 \\ -720 \end{bmatrix}.$$

$$\therefore V_2 = \frac{\begin{vmatrix} 4 & -120 & -1 \\ 50 & 0 & 20 \\ 5 & -720 & -10 \end{vmatrix}}{\begin{vmatrix} 4 & -2 & -1 \\ 50 & -71 & 20 \\ 5 & 4 & -10 \end{vmatrix}}$$

$$= \frac{4(0 + 720 \times 20) + 120(-500 - 100)}{4(710 - 80) + 2(-500 - 100) - 1(200 + 355)} = 11.52 \text{ V}$$

$$V_3 = \frac{\begin{vmatrix} 4 & -2 & -120 \\ 50 & -71 & 0 \\ 5 & 4 & -720 \end{vmatrix}}{1875}$$

$$= \frac{4(-71 \times -720) + 2(50 \times -720) - 120(50 \times 4 + 71 \times 5)}{1875}$$

$$= 112.256 \text{ V}$$

$\therefore$ Voltage drop across $10\Omega$ resistor

$$= V_3 - V_2 = 112.256 - 11.52$$

$$= 100.736 \text{ volt (Ans.)}$$

❑◆❑

## SET – 1

**Full Marks : 80    (Code - EET-301)   Time : 3 Hours**

Answer any **five** questions including Q.Nos. **1 & 2**
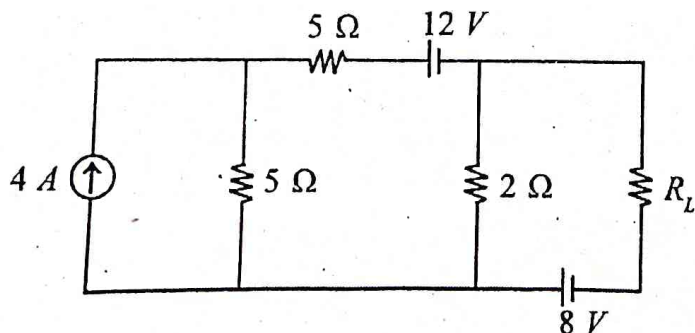
*The figures in the right-hand margin indicate marks.*

**1. Answer all questions :**                                   [2×10

(a) What do you mean by supermode ? Explain.

(b) Define Selectivity ?

(c) What is a band-pass filter ?

(d) What is a band-stop Filter ?

(e) Find the hybrid parameters for the two port network.

(f) Define co-efficient of coupling ?

(g) What is resonance condition ?

(h) What do you mean by form factor ? State its value for sinusoidal waveform.

(i) What do you mean by ideal constant voltage source and current source ?

(j) What is form factor ?

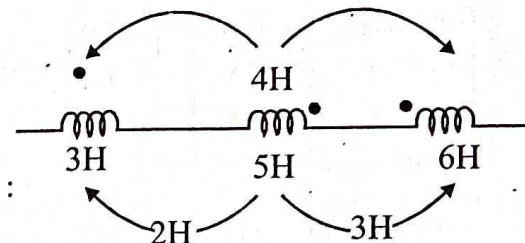**2. Answer any six questions :**                              [5×6

(a) Find the number of turns required to produce a flux density of 2T in a core of mean magnetic length of 260 cm when the coil carries a current of 5A. Assume the permeability of the core is 1000.

(b) Obtain the value of $R_L$ so that maximum power has to be transferred to the load and find the amount of the power in the figure below :
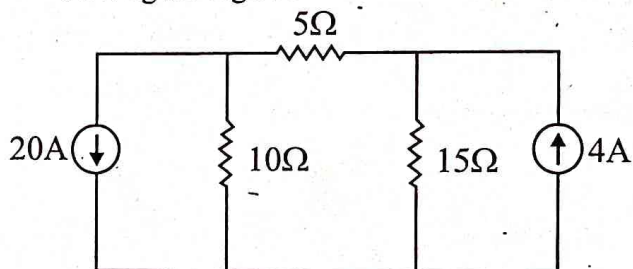


(c) State and explain relation between line and phase quantities in a Delta connection.

(d) Find the equivalent inductance of the following circuit :



(e) Draw the power triangle for R-L series circuit. State the expression for active, reactive and apparent power.

(f) Using superposition theorem, find the current flowing through 10 Ω resistor.



(g) A circuit takes a current of 8A at 100 V, 50 Hz and the current lagging behind by 30° from applied voltage. Calculate the resistance and inductance of the circuit.

(h) Explain hysteresis loop with diagram.

**3.** A circuit consisting of a coil of resistance 12 Ω and inductance 0.15 H is series with a capacitor of 12 μF is connected to a variable frequency supply which has a constant voltage of 24V calculate.

(i) The resonant frequency

(ii) The current in the circuit at resonance

(iii) The voltage across the capacitor and coil at resonance.                                              [10

**4.** Determine the z-parameters of the network shown in fig.                                               [10
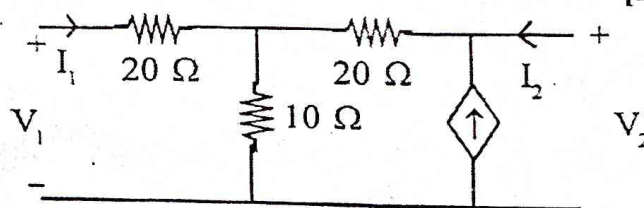
5. Two impedances of which are given by $Z_1 = 15 + j10\ \Omega$ and $Z_2 = 8 - j6\ \Omega$ are connected in parallel. If the total current supply is 15 A, what is the power taken by each branch ? Find also the p.f. of individual circuit. [10

6. Design a band stop constant-K type filter with cut-off frequencies of 4 KHz and 10 KHz and nominal characteristic impedance 500 ohm. [10

7. Calculate the loop currents using mesh analysis in circuit shown in the figure below and indicate the polarity of currents ? [10
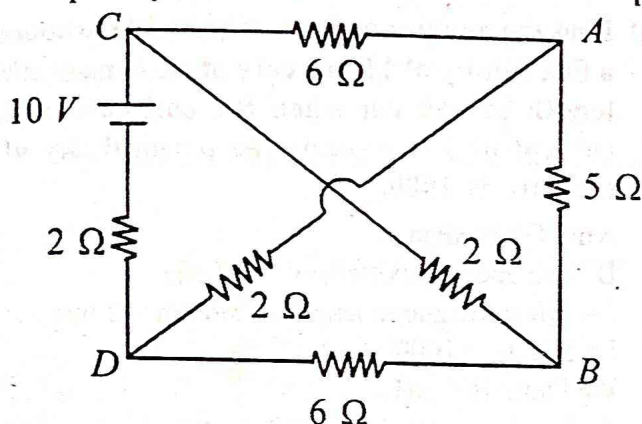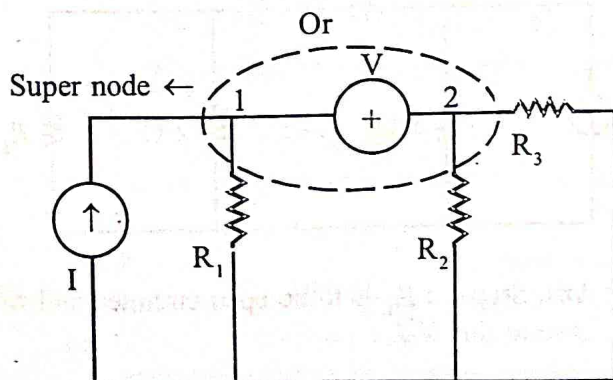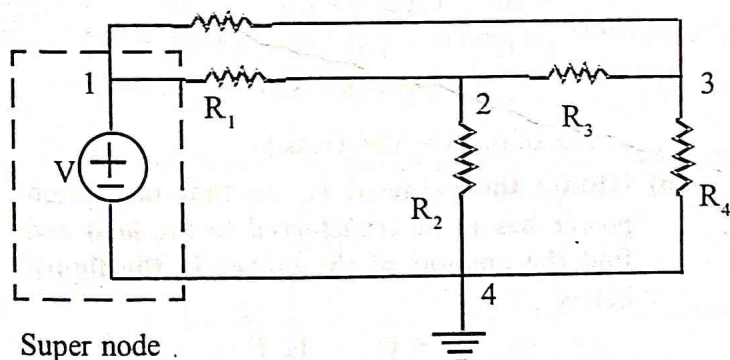


## ANSWERS TO SET-1

1. Answer all questions : [2×10

(a) What do you mean by supermode ? Explain.

Ans. Supernode is formed is a network when there is a voltage source along with presence of two nodes or a node with reference node. This is given below :-



Super node

Or



Super node ←

(b) Define Selectivity ?

Ans. Selectivity is defined as the ratio between band width (B.W.) and resonant frequency ($f_0$).

i.e., $\text{selectivity} = \dfrac{BW}{f_0}$

It has no unit.

(c) What is a band-pass filter ?

Ans. Those filters which allow transmission of frequencies between two designated cut-off frequencies and reject all other frequencies is knows as Band pass filters.

(d) What is a band-stop Filter ?

Ans. It is a filter that passes most frequencies unaltered, but attenuates these in a specific range to very low lovels. It is the opposite of a band pass filter. It has narrow stop band. The gain vrs. frequency of this type filter is given below.
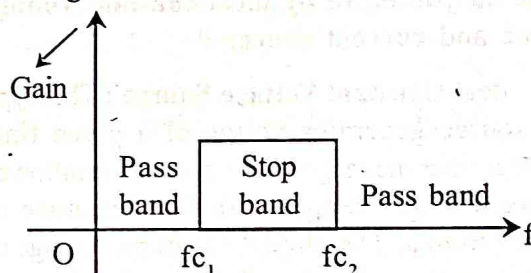


(e) Find the hybrid parameters for the two port network.

Ans. Hybrid parameters in the two-port network are $h_{11}, h_{12}, h_{21}, h_{22}$.

$V_1 = h_{11} I_1 + h_{12} V_2$ ................. (i)

$I_2 = h_{21} I_1 + h_{22} V_2$ ................... (ii)

$\therefore h_{11} = \dfrac{V_1}{I_1}\bigg|_{V_2=0}$ , $h_{12} = \dfrac{V_1}{V_2}\bigg|_{I_1=0}$

$h_{21} = \dfrac{I_2}{I_1}\bigg|_{V_2=0}$ , $h_{22} = \dfrac{I_2}{V_2}\bigg|_{I_1=0}$

Unit of $h_{11}$ is 'ohm', $h_{12}$ and $h_{21}$ has no unit and $h_{22}$ is 'mho'

(f) Define co-efficient of coupling ?

Ans. Co-efficient of coupling (k) : The fraction of magnetic flux produced by the current in one coil that links with the other coil is called co-efficient of coupling (k). k = 1, when the flux produced by one coil completely links with the other coil and is called magnetically tightly coupled.

**(g) What is reasonance condition ?**

Ans. Resonant conditions in a series RLC circuit are as follows :-

Here the circuit will draw maximum current and inductive reactance is equal to capacitive reactance. Also voltage drop across inductor is equal to voltage drop across capacitor and the power factor is unity.

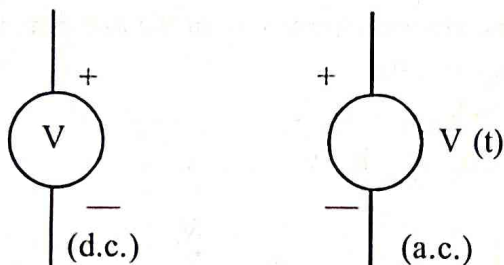**(h) What do you mean by form factor ? State its value for sinusoidal waveform.**

Ans. Form factor is defined as the ratio between rms value and average value of an alternating quantity.

i.e. $k_f$ = form factor = $\dfrac{I_{rms}}{I_{av}} = \dfrac{(I_m/\sqrt{2})}{(2I_m/\pi)} = 1.11$

i.e. for sinusoidal wave form, form factor = 1.11.

**(i) What do you mean by ideal constant voltage source and current source ?**

Ans. **Ideal Constant Voltage Source :** This type of energy source generates voltge of a given time variation but neither the magnitude nor time variation of the generated voltage chenges with the megnitude of current drawn from it. Therefore the terminal voltage of this source remains constant for all values of o/p current from zero current to blunt S.C.



(d.c.)    (a.c.)

**Ideal Current Source :** This type of energy source generates current of a given variation but neither the magnitude nor the time variation of the generated current with the load i.e o/p current remains constant for all values of load range from zero resistance to '∞' resistance
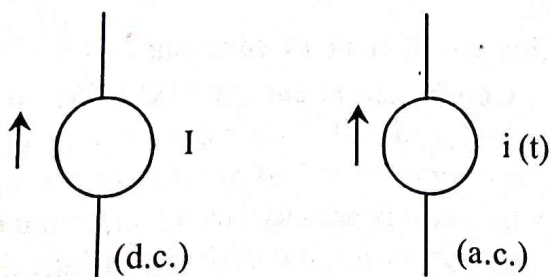


(d.c.)    (a.c.)

**(j) What is form factor ?**

Ans. Form factor is defined as the ratio between rms value and average value of an alternating quantity,

i.e., $k_f = \dfrac{\text{RMS value}}{\text{Average value}}$

For ac sinusoidal quantity, $k_f = 1.11$

For half wave rectified wave, $k_f = 0.5$.

**2. Answer any six questions :** [5×6

**(a) Find the number of turns required to produce a flux density of 2T in a core of mean magnetic length of 260 cm when the coil carries a current of 5A. Assume the permeability of the core is 1000.**

Ans. Given data

B = Magnetic flux density = 2 Tesla
$l$ = Mean magnetic length = 260 cm = 2.6m
I = 5A, $\mu_r$ = 1000,
We know B = $\mu$H.

$\Rightarrow$ B = $\mu_0 \mu_r$.H.

or H = $\dfrac{B}{\mu_0\mu_r} = \dfrac{2}{4\pi \times 10^{-7} \times 1000} = \dfrac{10^4 \times 2}{4\pi}$

$= 1592.35 \ \dfrac{AT}{m}$

MMf = H$l$ = NI
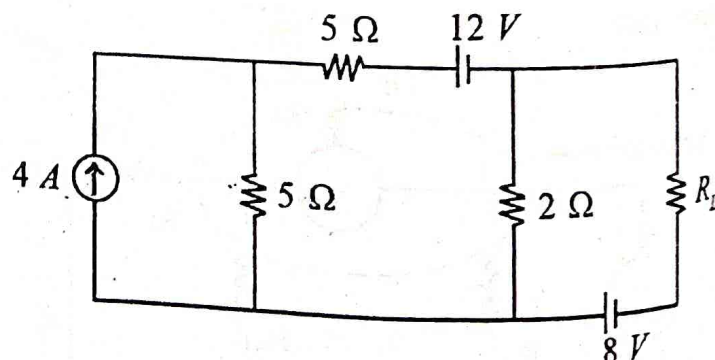
or, N = $\dfrac{Hl}{I} = \dfrac{1592.35 \times 2.6}{5}$
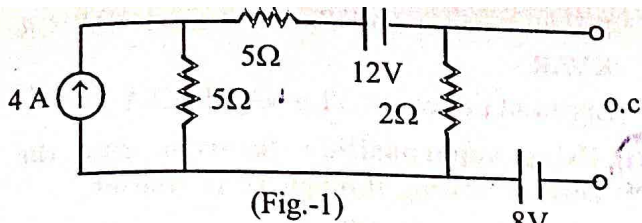
$= 828.1$ say '829'

∴ No. of turns = 829. (Ans.)

**(b) Obtain the value of $R_L$ so that maximum power has to be transferred to the load and find the amount of the power in the figure below :**
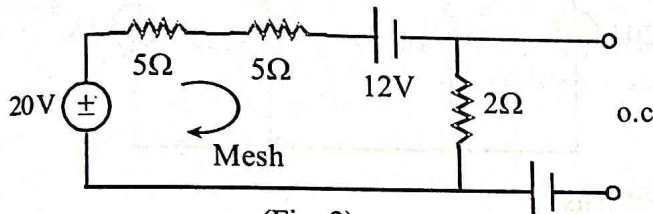


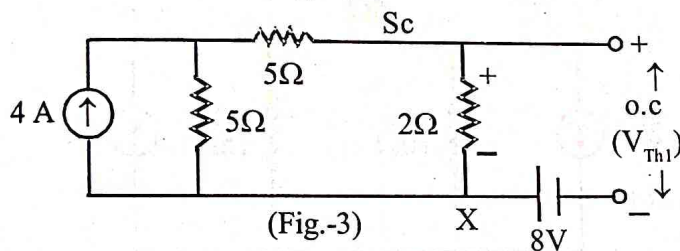Ans. **Step-1 :** $R_L$ is to be open circuited and we have to find $V_{Th}$.

(Fig.-1)

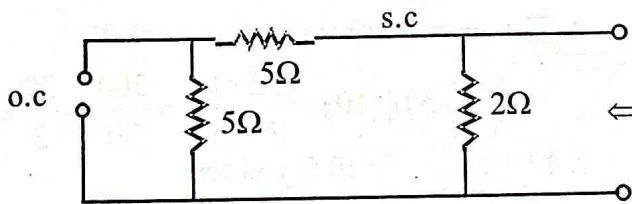**Step-2 :** Now we have to convert 4A source into voltage source



(Fig.-2)



(Fig.-3)

Applying KVL in the mesh (fig.-2)

$$-5I - 5I - 12 - 2I + 20 = 0$$

$$\Rightarrow -12I = -8 \text{ or } I = \frac{8}{12} = \frac{2}{3}A = 0.67A$$

$$\therefore V_{Th} = 2I + 8 = 2I + 8 = 2 \times \frac{2}{3} + 8 = 9.33V$$

**Step-3 :** Then we have to find '$R_{Th}$' by eliminating the energy sources and looking from the o.c. end,



$$\therefore R_{Th} = (5+5) \| (2) = \frac{10 \times 2}{10+2} = \frac{20}{12} = 1.66\ \Omega$$

∴ According to maximum power transferred theorem,

$R_L = R_{Th} = 1.66\ \Omega$ (Ans.)

Maximum amount of power transferred to the

$$\text{load} = \frac{V_{Th}^2}{4R_L} = \frac{9.33^2}{4 \times 1.66} = 13.1 \text{ Watt (Ans.)}$$

**(c) State and explain relation between line and phase quantities in a Delta connection.**

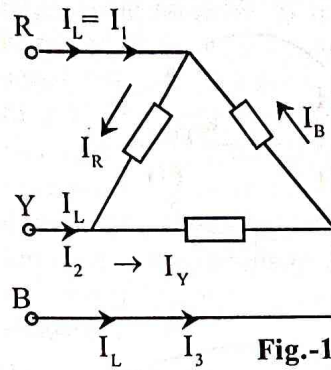**Ans.** Relation between line and phase quantities in a Delta connection :
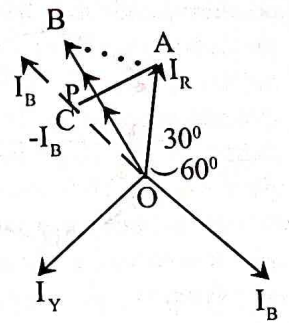


Fig.-1        Fig.-2

Let us consider a delta-connected load in which $I_R$, $I_Y$ nd $I_B$ are the phase currents and $I_1 = I_2 = I_3 = I_L$ be the line currents for the balanced loads.

For balanced loads $I_R = I_Y = I_B$.

But the line current considered will be the phasor sum or difference.

$$\therefore I_1 = \overline{I_L} = \overline{I_R} - \overline{I_B},\ \overline{I_2} = \overline{I_R} - \overline{I_Y} = \overline{I_L},$$

$$\overline{I_3} = \overline{I_Y} - \overline{I_B} = I_L$$

Considering the fig-2,

OABC is a rhombous, AC diagonal is joined.

Triangle OAP is considered, which is a right angled triangle.

$$\angle AOP = 30°,$$

$$\therefore OP = OA \cos 30° = I_R \times \frac{\sqrt{3}}{2}$$

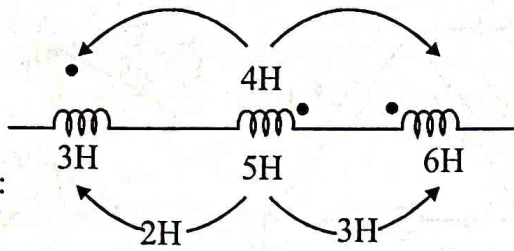$$\therefore OB = 2OP = 2 \times I_R \times \frac{\sqrt{3}}{2} = \sqrt{3}\, I_R$$

$$\therefore I_1 = \sqrt{3}\, I_R = I_L.\ \left(\text{Proved}\right)$$

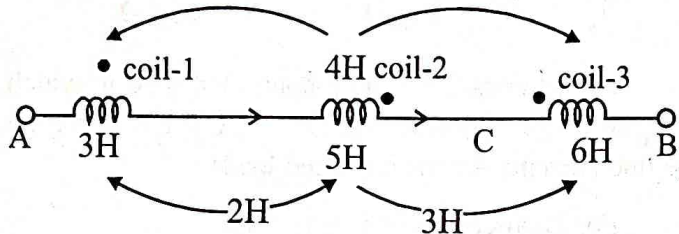Similarly in other phasors also $\boxed{I_L = \sqrt{3}\, I_{ph}}$.

Next, as there is no neutral present and phase voltage, line voltages will be equal.

$$\therefore \boxed{V_R = V_L}.$$

**(d) Find the equivalent inductance of the following circuit :**



**Ans.**



$L_1 = 3H$, $L_2 = 5H$, $L_3 = 6H$,
$M_{13} = 4H$, $M_{12} = 2H$, $M_{23} = 3H$

The equivalent inductance between A, B
$$= L_1 + L_2 - 2 M_{12}$$
$$= 3H + 5H - 2 \times 2 = 4H.$$

Equivalent inductance between B, C
$$\therefore \ L_{BC} = L_2 + L_3 - 2 M_{23} = 5 + 6 - 2 \times 3 = 5H$$
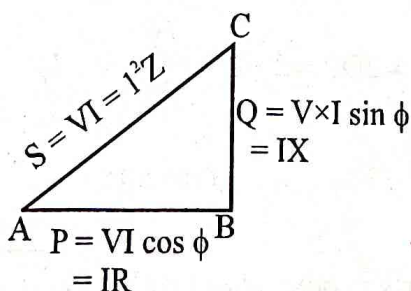
Equivalent inductance between A, C
$$= L_1 + L_3 + 2 M_{13}$$
$$\therefore \ L_{AC} = 3 + 6 + 2 \times 4 = 17 \ H.$$
$$\therefore \ L_{eq} = L_{AC} + L_{BC} + L_{AB} = 17 + 5 + 4 = 26 \ H$$

**(e) Draw the power triangle for R-L series circuit. State the expression for active, reactive and apparent power.**

**Ans.** Power triangle for R – L series circuit.



In triangle ABC
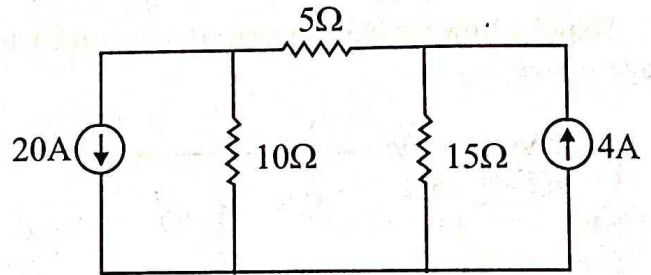AB = P = VI cos $\phi$ = Active power
BC = Q = VI sin $\phi$ = Reactive power
AC = S = VI = Appanent power.

Active power $P = I^2R = VI \cos \phi$ watt OR KW.

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Reactive power $Q = P_{X_L} = VI \sin \phi$ VAR OR KVAR

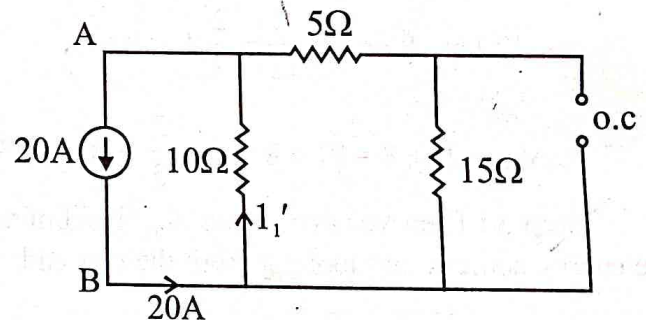Appanent power S = VI = VA OR KVA

**(f) Using superposition theorem, find the current flowing through 10 Ω resistor.**



**Ans.**



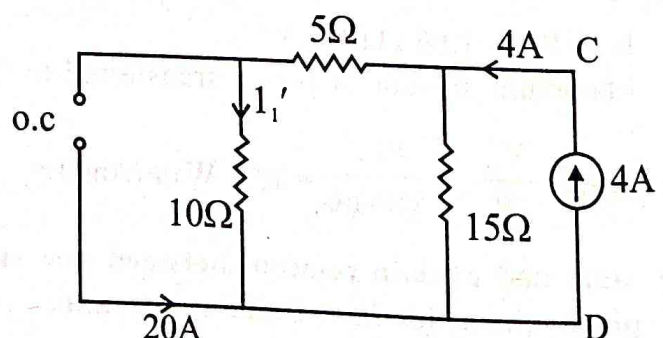**Step-1 :** The 20A source is considered and 4A source is deactivated i.e., open circuited (o.c.).



$\therefore$ The equivalent resistance across AB

$$= (15+5) \| (10) = \frac{22 \times 10}{20 + 10} = \frac{200}{30} = \frac{20}{3} \ \Omega$$

$\therefore \ I_1' =$ current in 10 Ω resistor

$$= 20A \times \frac{(15 + 5)}{(15 + 5 + 10)} = \frac{40}{3} A (\uparrow)$$

**Step-2 :** 4A source is considered and 20A is o/c.

Equivalent resistance across CD.

$$= (10+5) \| (15) = \frac{15 \times 15}{15+15} = \frac{15}{2} = \frac{15}{2} \, \Omega$$

$$\therefore I_1^{11} = 4A \times \frac{15}{10+5+15} = \frac{4 \times 15}{30} = 2A (\downarrow)$$

**Step-3 :** Net current in 10 Ω resistor

$$= I_1^1 - I_1^{11} = \frac{40}{3} - 2 = \frac{34}{3} = 11.33A. \; (Ans)$$

**(g)** A circuit takes a current of 8A at 100 V, 50 Hz and the current lagging behind by 30° from applied voltage. Calculate the resistance and inductance of the circuit.

**Ans. Given data :**

I = 8A, V = 100 volt, F = 50 Hz, $\phi$ = 30° (lagging)

In the following circuit $(Z) = \frac{V}{I} = \frac{100}{8} = 12.5 \, \Omega$.

PF = Power factor = $\cos \phi = \cos 30 = 0.866$

$\therefore$ Resistance (R) = $Z \cos \phi = 12.5 \times 0.866$
$= 10.392 \, \Omega$

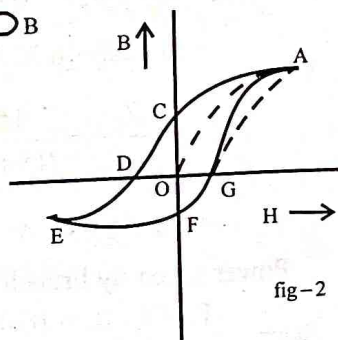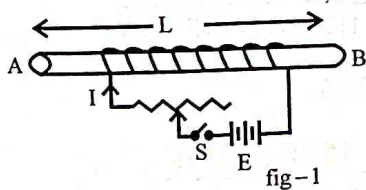Reactance $(X_L) = Z \sin \phi = 12.5 \times 0.5 = 6.25 \, \Omega$.

But $X_L = \omega L = 2\pi f L = 2 \times \pi \times 50 \times L$

$\therefore 6.25 = 100 \, \pi L$

$$\therefore L = \frac{6.25}{100\pi} = 0.0199 \, H. \; (Ans)$$

**(h)** Explain hysteresis loop with diagram.

**Ans.** The phenomenon of lagging of magnetisation or induction flux density behind the magnetising force is called as magnetic hystersis.


fig–1

fig–2

Let's consider a core of specimen of iron be wound with a number of turns of wire and current be passed through the solenoid. A magnetic field of intensity 'H' proportional to the current folowing through the solenoid is produced. Let the magnetising force 'H' is increased from zero to maximum value and then gradually reduced

to zero. If the value of flux density 'B' in the come to various values of magnetising force 'H' are determined, then we have found B-H curve.

If the direction of flow of current is reversed the magnetising force 'H' is reversed. Let the current be increased in the negative direction until the induction density 'B' becomes zero. At B=0, the demagnetising force H=OD which is required to neutralize the residual magnetism. If the demagnetising force 'H' is further increased to previous maximum value and again gradually decreased to zero further increased in origional or positive direction to the maximum value, there is a closed loop ACDEF is formed. This loop is called hystersis loop as shown is fig-2.

3. A circuit consisting of a coil of resistance 12 Ω and inductance 0.15 H is series with a capacitor of 12 µF is connected to a variable frequency supply which has a constant voltage of 24V calculate.

(i) The resonant frequency

(ii) The current in the circuit at resonance

(iii) The voltage across the capacitor and coil at resonance. [10

**Ans.** In the following question, given that :

R = 12Ω , L = 0.15 H, C = 12µF. = 12 × 10⁻⁶ F.

V = 24 Volt.

$$\therefore \text{Resonent frequency } (f_0) = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{0.15 \times 12 \times 10^{-6}}}$$

$$= 118.7 \, Hz$$

Current in the resonant circuit

$$= I_0 = \frac{V}{R} = \frac{24}{12} = 2A.$$

Voltage across 'C' = $V_C = I_0 X_C$

$$= 2 \times \frac{1}{\omega_0 C}$$

$$= 2 \times \frac{1}{2\pi f_0 . C}$$

$$\Rightarrow V_C = \frac{1}{\pi \times 118.7 \times 12 \times 10^{-6}} = 223.6 \, V.$$
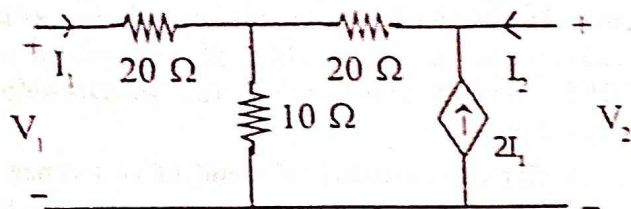
∴ Voltage across the coil = Voltage across '$R_L$'

$Z_L = R + jX_L$

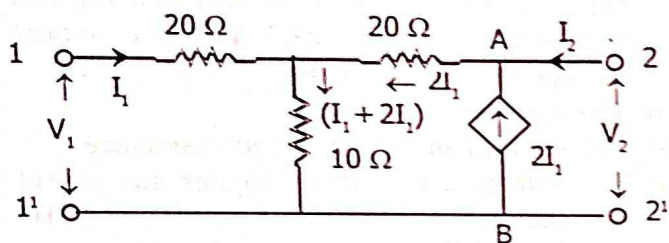$X_L = \omega_0 L = 2\pi f_0 L = 2\pi \times 118.7 \times 0.15 = 111.8\,\Omega$

∴ $Z_L = \sqrt{R^2 + X_L^2} = \sqrt{12^2 + 111.8^2} = 112.44\,\Omega$

∴ $V_{Coil} = I_0 \cdot X_L = 2 \times 112.44 = 224.88\,V$.

**4.** Determine the z-parameters of the network shown in fig.



Ans.



First We have to O.C. $(2 - 2^1)$ terminal such that $I_2 = 0$

∴ $Z_{11} = \dfrac{V_1}{I_1}\Big|_{I_2=0}$

∴ from i/p port side,

$V_1 = 20\,I_1 + 10 \times 3 I_1$

$V_1 = 50\,I_1 \quad \Rightarrow Z_{11} = \dfrac{V_1}{I_1} = 50\,\Omega$

∴ $V_2$ = V.d across AB

$= 20 \times 2I_1 + 10 \times 3\,I_1 = 70\,I_1$

$\Rightarrow Z_{21} = \dfrac{V_2}{I_1} = 70\,\Omega$

Next the port $(1 - 1^1)$ is O.C

$I_1 = 0$

∴ $V_2 = 20(2I_1 + I_2) + 10(2I_1 + I_2)$

$V_2 = 20I_2 + 10I_2\ (\because I_1 = 0)$

$V_2 = 30\,I_2$

or $Z_{22} = \dfrac{V_2}{I_2} = 30\,\Omega$
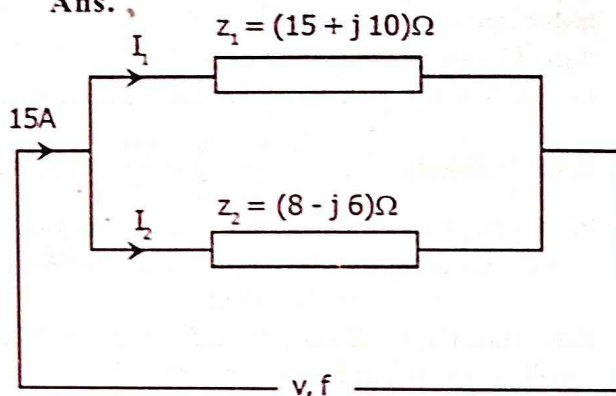
Similarly,

$V_1 = 20I_1 + 10(I_2 + 3I_1)$

but $I_1 = 0$

$V_1 = 10I_2$

or, $Z_{12} = \dfrac{V_1}{I_2} = 10\,\Omega$ (Ans.)

**5.** Two impedances of which are given by $Z_1 = 15 + j10\,\Omega$ and $Z_2 = 8 - j6\,\Omega$ are connected in parallel. If the total current supply is 15 A, what is the power taken by each branch ? Find also the p.f. of individual circuit. [10

Ans.



Given that

$Z_1 = (15 + j10)\Omega = 18\lfloor 33.69^0$

$Z_2 = (8 - j6)\,\Omega = 10\lfloor -36.87^0$

$I = 15\,A$

$= 15\lfloor 0^0$

∴ $I_1 = \dfrac{I\,Z_1}{(Z_1 + Z_2)} = \dfrac{15 \times (8 + j6)}{(15 + j10) + (8 - j6)}$

$= 6.425\lfloor -46.73\,A$.

$I_2 = \dfrac{I\,Z_1}{Z_1 + Z_2} = \dfrac{15 \times (15 + j10)}{(15 + j10) + (8 - j6)}$

$= 11.6\lfloor 23.82^0\,A$

Power taken by branch (1) is

$P_1 = I_1^2\,R_1 = (6.425)^2 \times 15 = 619.2$ watt

Power factor of branch 1 is

Cos $\theta_1$ = log (33.69) = 0.832 (log)

Power taken by branch (2) is

$P_2 = I_2^2\,R_2 = (11.6)^2 \times 8 = 1076.78$ watt.

Power factor of branch 2 is

Cos $\theta_2$ = log (36.87) = 0.8 (lead)

**6.** Design a band stop constant-K type filter with cut-off frequencies of 4 KHz and 10 KHz and nominal characteristic impedance 500 ohm. **[10**

**Ans.** Given

$f_1 = 4$ KHZ

$f_2 = 10$ KHZ

$R_0 = 500 \, \Omega$

$$R_0 = \sqrt{\frac{L_1}{C_2}} = \sqrt{\frac{L_2}{C_1}}$$

$$C_1 = \frac{1}{4\pi R_0 (f_2 - f_1)}$$

$$= 26.52 \times 10^{-9} \, F$$

$$C_2 = \frac{f_2 - f_1}{\pi f_1 f_2 R_0} = 95.49 \times 10^{-9} \, F$$

$$L_1 = C_2 R_0^2$$

$$= 23.87 \, mH$$

$$L_2 = C_1 R_0^2$$

$$= 6.63 \, mH$$

Here $C_1 = 0.02652 \times 10^{-6} \, F = 0.02652 \, \mu F.$
$C_2 = 0.09549 \times 10^{-6} \, F = 0.09549 \, \mu F.$
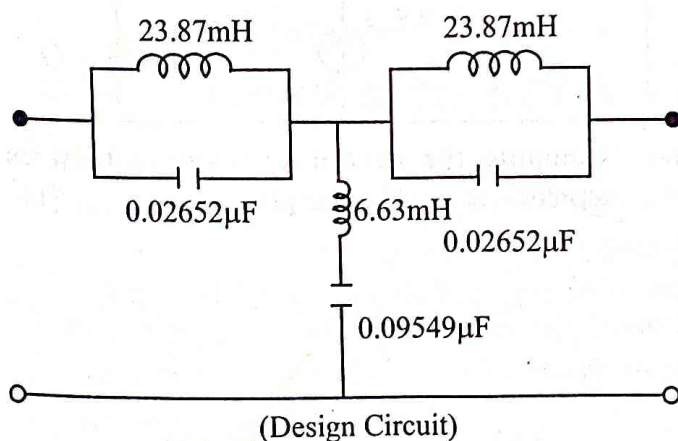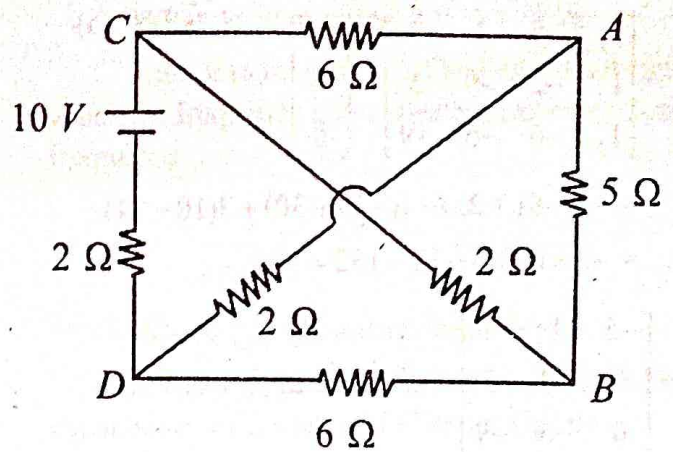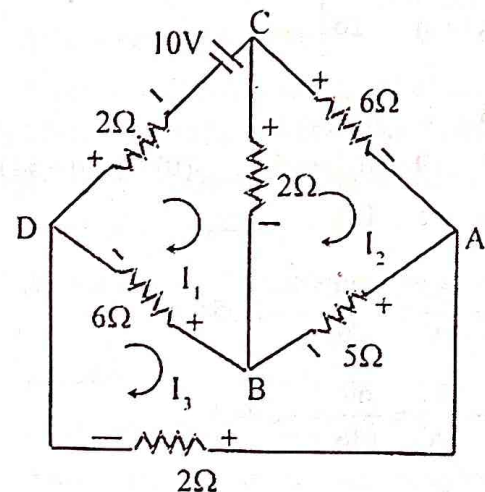


(Design Circuit)

**Fig. *Design Circuit.***

**7.** Calculate the loop currents using mesh analysis in circuit shown in the figure below and indicate the polarity of currents ?    **[10**



**Ans.** The following circuit can now be represented in wheatstone bridge as drawn below :



Now we have to take different loops as shown in the figure, i.e. DCBD, CABC and DBAD.

Loop DCBD, the KVL equation or meh equation is,

$$-2(I_1 - I_2) - 6(I_1 - I_3) - 2I_1 + 10 = 0$$

or,   $-2I_1 + 2I_2 - 6I_1 + 6I_3 - 2I_1 = = 10$

$-10I_1 + 2I_2 + 6I_3 = -10$

or,   $-5I_1 + I_2 + 3I_2 = -10$ .................. (i)

Loop-2 i.e. 'CABC' applying Mesh equation,

$$-6I_2 - 5(I_2 - I_3) + 2(I_2 - I_1) = 0$$

or,   $-6I_2 - 5I_2 + 5I_3 + 2I_2 - 2I_1 = 0$

or,   $-2I_1 - 9I_2 + 5I_3 = 0$ .................. (ii)

Loop-3 'DBAD', applying Mesh equuation

$$+6(I_3 - I_1) + 5(I_3 - I_2) - 2I_3 = 0$$

or,   $6I_3 - 6I_2 + 5I_3 - 5I_3 - 2I_3 = 0$

or,   $-6I_1 - 5I_2 + 9I_3 = 0$ .................. (iii)

Solving the three equations using Cramer's rule,

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} \begin{bmatrix} -5 & 1 & 3 \\ -2 & -9 & 5 \\ -6 & -5 & +9 \end{bmatrix} = \begin{bmatrix} -5 \\ 0 \\ 0 \end{bmatrix}$$

$\Delta \quad = -5(-81+25) - 1(-18+30) + 3(10-54)$

$\quad\quad = -5 \times (-56) - 12 - 132 = 136$

$\Delta_1 = \begin{bmatrix} -5 & 1 & 3 \\ 0 & -9 & 5 \\ 0 & -5 & +9 \end{bmatrix} = -5(-81+25) - 1(0) + 3(0)$

$\Delta_2 = \begin{bmatrix} -5 & -10 & 3 \\ -2 & 0 & 5 \\ -6 & 0 & +9 \end{bmatrix} = -5(0) + 5(-18+30) + 3(0) = 60$

$\Delta_3 = \begin{bmatrix} -5 & 1 & -5 \\ -2 & -9 & 0 \\ -6 & -5 & 0 \end{bmatrix} = -5(0) - 1(0) - 5(10-54) = 220$

$\therefore \quad I_1 = \dfrac{\Delta_1}{\Delta} = \dfrac{-280}{136} = -2.05A$

$I_2 = \dfrac{\Delta_2}{\Delta} = \dfrac{60}{136} = -0.44A$

$I_3 = \dfrac{\Delta_3}{\Delta} = \dfrac{220}{136} = -1.61A$

-Ve Signs indicate that the direction of loop currents choosen are opposite.

## SET – 2

Full Marks : 80    (Code - EET-301)  Time : 3 Hours

Answer any **five** questions including Q.Nos. **1 & 2**

*The figures in the right-hand margin indicate marks.*

**1. Answer all questions :**                    [2×10

(a) What do you mean by apparent power ?

(b) Express the given voltage (5+3*j*)V to polar form.

(c) What is resonance ?

(d) What is active element and passive element?

(e) Draw the circuit constant k high pass filter.

(f) What do you mean by bandwidth ?

(g) Define Reluctance ?

(h) State K.V.L.

(i) State maximum power transfer theorem.

(j) What is Node and Mesh ?

**2. Answer any six questions :**                    [5×6

(a) The potential difference measured across a coil is 4.5 V, when it carries a d.c. of 9 A, again it carries 9 A at 50 Hz a.c. supply of 25 V. Find out the inductive reactance and apparent power consumed by the coil if supply voltage is 25 V.

(b) Write the analogy between electric and magnetic circuit

(c) Explain about different steps for solving a network by Norton's theorem.

(d) A circuit consisting of a coil of resistance of 24Ω and inductance of 0.15 H in series with a capacitor of 20 μF connected to a variable frequency supply which has a supply voltage of 24 V. Calculate [5

(i) Resonant Frequency

(ii) Current in the circuit at resonance

(iii) Voltage across the capacitor and coil at resonance.

(e) Discuss briefly the B-H curve of ferro-magnetic material.

(f) Explain constant k-high-pass filter with diagram.

(g) State and explain maximum power transfer theorem ?

(h) Design T-section of the high-pass filter having an infinite frequency characteristics impedance of 300Ω and cut-off frequency of 2000 Hz.
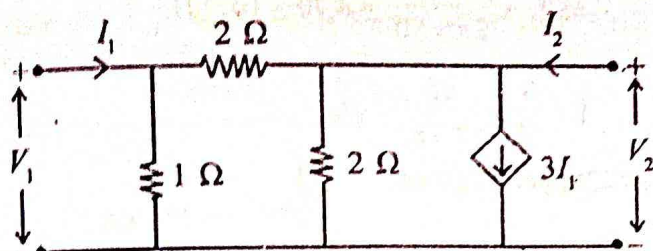
3.    Using superposition principle, find the current 3Ω resistance.                    [10
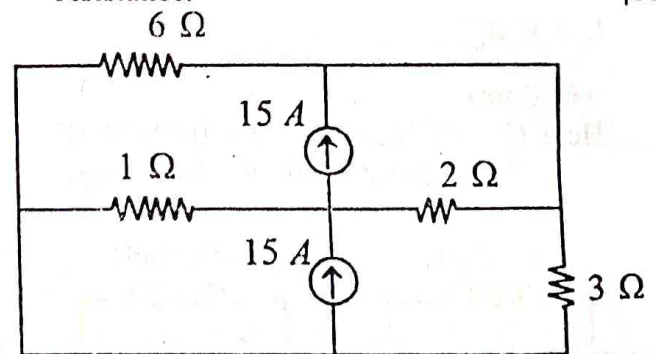


4.    Compute the network resistance between terminals B and C in the given figure.                    [10
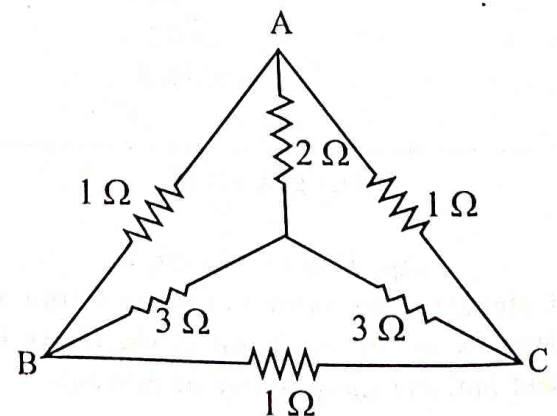
**5.** Find z parameters for the giving network. [10



**6.** In the circuit shown in figure below, the battery has remained switched on for a long time. Suddenly the switch is closed. Find an expression for current in the circuit as a function of time, the Values of $R_1 = 2\Omega$, $R_2 = 4\Omega$, $L = 2H$ and $V = 12V$. [10
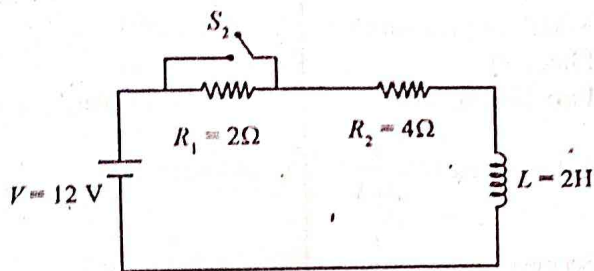


**7.** Using source conversion technique reduce the following circuit to a single current source across AB. [10
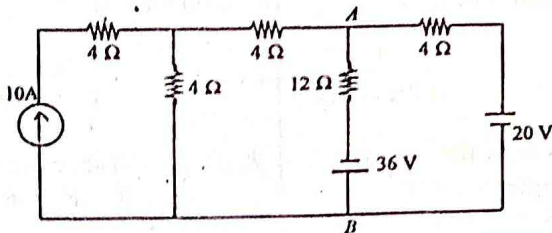


## ANSWERS TO SET-2

**1. Answer all questions :** [2×10

**(a) What do you mean by apparent power ?**

**Ans.** Apparent power (s) is defined as the product of circuit's voltage and current. It is also the combination of reactive poewr and true power. It's unit is VA.

**(b) Express the given voltage $(5+3j)V$ to polar form.**

**Ans.** Let $V = (5+j3)$ Volt which is in rectangular form.

∴ In polar form,

$V = 5.83 \underline{|30.96^0}$

say $5.83 \underline{|31^0}$ volts.

**(c) What is resonance ?**

**Ans. Resonance** is defined as a Phenomenon in which the frequency is not constant but is oscillating at a frequency

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

Where $f_0$ = Resonant frequency.

Where L and C are the inductance and capacitance of the said RLC series Circuit.

∴ Under resonance, in a series RLC circuit, current = max. but in parallel resonance, current = min.

**(d) What is active element and passive element?**

**Ans. Active Element :**

A circuit element is said to be active if it has the ability to supply energy that activates a circuit.

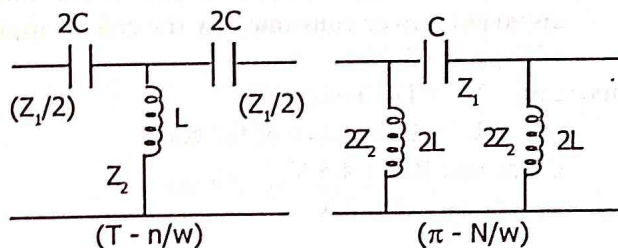Example - Generators and Batteries.

**Passive Element :**

A circuit element is said to be passive if it absorbs energy.

Example - Resistor, Capacitor, Inductor.

**(e) Draw the circuit constant k high pass filter.**

**Ans.** The circuit diagram of constant-k Hp filter in T and π network is given below :



**(f) What do you mean by bandwidth ?**

**Ans.** Band width (B.W.) is defined as the difference of upper half frequency $(f_2)$ to the lower half frequency $(f_1)$.

i.e. B.W. $= f_2 - f_1$ .

**(g) Define Reluctance ?**

**Ans. Reluctance :** It is defined as the ratio of mmf to magnetic flux. It represents the opposition to magnetic flux and depends on the geometry and composition of an object. It's unit is AT/Wb i.e.

$$\frac{Ampere\ turn}{Weber}$$

**(h) State K.V.L.**

**Ans.** Kirchhoff's Mesh Law :- (KVL) :

In any closed circuit or mesh the algebraic sum of emfs acting in that circuit or mesh is equal to the algebraic sum of the products of the current and resistances of each part of the circuit.

**Kirchhoff's Current Law (KCL) :**

In any network of wires carrying currents, the algebraic sum of all currents meeting at a point is zero.

**(i) State maximum power transfer theorem.**

**Ans.** This theorem states that in a d.c. circuit maximum power is transfered from a source to load when the load resistance is made equal to the internal resistance of the source as viewed from the load terminals with load removed and all emf sources replaced by their internal resistances.

**(j) What is Node and Mesh ?**

**Ans. Node :** A node of a network is an equipotential surface at which two or more circuit elements are joined.

**Mesh :** A mesh is the most elementary form of a loop and it cannot be further divided into other loops.

**2. Answer *any six* questions :** |5×6

**(a) The potential difference measured across a coil is 4.5 V, when it carries a d.c. of 9 A, again it carries 9 A at 50 Hz a.c. supply of 25 V. Find out the inductive reactance and apparent power consumed by the coil if supply voltage is 25 V.**

**Ans.** Let  R = DC resistance
         L = Inductance of the coil
Given that P.D = 4.5 V
         I = 9 A

For DC  $R = \dfrac{V}{I} = \dfrac{4.5}{9} = 0.5\,A$

When AC current at 50 Hz

$Z = \dfrac{V}{I} = \dfrac{25}{9} = 2.78\,\Omega$

So Inductive reactance $X_L = \sqrt{Z^2 - R^2}$

$= \sqrt{(2.78)^2 - (0.5)^2}$

$= 2.734\,\Omega$

So $X_L = 2\pi fL$

$= 2\pi \times 50 \times L$

$\Rightarrow L = \dfrac{X_L}{2\pi \times 50} = 8.70 \times 10^{-3}\,H.$

$I = \dfrac{V}{Z} = \dfrac{25}{2.78} = 9A$

Apparent power S = VI

$= 25 \times 9 = 225\,VA$

**(b) Write the analogy between electric and magnetic circuit**

**Ans.**

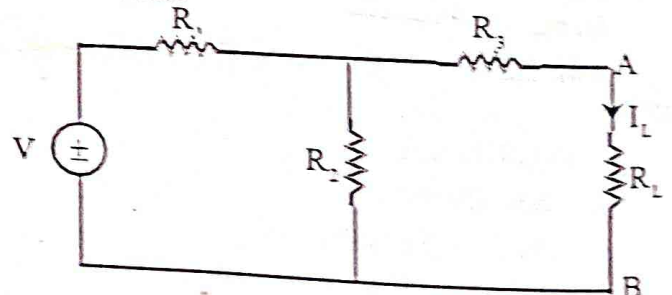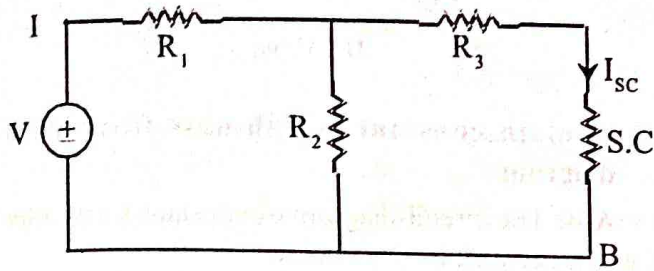| Magnetic Circuit | Electric Circuit |
|---|---|
| 1. Flux $= \dfrac{mmf}{Reluctance}$ | 1. Current $= \dfrac{emf}{resistance}$ |
| 2. MMF (ampere-turn) | 2. EMF (volt) |
| 3. Flux $(\theta)$ | 3. Current (I) |
| 4. Flux Density B | 4. Current Density |
| 5. Reluctances $S = \dfrac{L}{\mu A}$ | 5. Resistance $R = f\dfrac{1}{A}$ |
| 6. Permeance $= \dfrac{1}{reluctance}$ | 6. Conductance $= \dfrac{1}{resistance}$ |
| 7. Reluctivity | 7. Resistevity |
| 8. Permeability $= \dfrac{1}{reluctivity}$ | 8. Conductivity $= \dfrac{1}{resistivity}$ |
| 9. Here in the series magnetic circuit, $= S_1 + S_2 + S_3 + ... + S_n$ and for parallel, S = Reluctance $\dfrac{1}{S} = \dfrac{1}{S_1} + \dfrac{1}{S_2} + \dfrac{1}{S_3} + ... + \dfrac{1}{S_n}$ | 9. In the series electric circuit, $R = R_1 + R_2 + S R_3 + ..... + R_n.$ In parallel R = Resistance $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + ... + \dfrac{1}{R_n}$ |

**(c) Explain about different steps for solving a network by Norton's theorem.**

**Ans.** Different steps for solving a network by Norton's Theorem.

**Step-1 :** In order to find the current in the load resistance ($R_L$), we have to short circuit (S.C.) the resistor '$R_L$'.



The current flowing through short circuit terminal = $I_{SC}$ will be found out.

$$I_{SC} = I \times \frac{R_2}{R_2 + R_3}$$

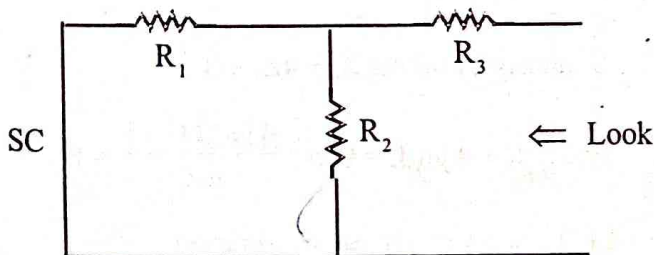$$\therefore I = \frac{V}{R_1 + (R_2 \| R_3)} = \frac{V}{R_1 + \dfrac{R_2 R_3}{R_2 + R_3}}$$

$$= \frac{V(R_2 + R_3)}{R_1 R_2 + R_2 R_3 + R_3 R_1}.$$

$$\therefore I_{SC} = I \times \frac{R_2}{R_2 + R_3}$$

$$= \frac{V(R_2 + R_3)}{R_1 R_2 + R_2 R_3 + R_3 R_1} \times \frac{R_2}{(R_2 + R_3)}$$

$$= \frac{V.R_2}{R_1 R_2 + R_2 R_3 + R_3 R_1}.$$

**Step-2 :** Norton's equivalent resistance ($R_N$) will be found out by eliminating the energy source i.e. V is to be short circuited and we have to look into the circuit.



$$\therefore R_N = R_3 + \frac{R_1 . R_2}{R_1 + R_2} = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_1 + R_2}$$

**Step-3 :** The Norton's equivalent circuit is to be drawn as follows.
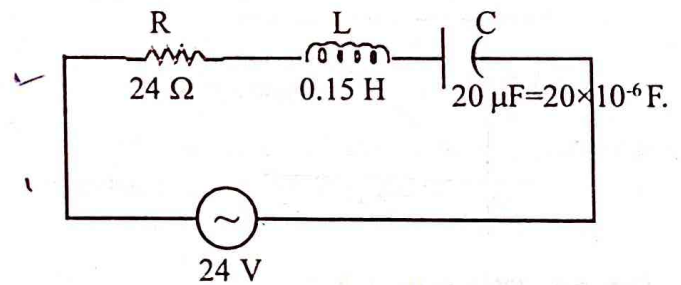


$$\therefore \text{ Current through } R_L = I_{SC} \times \frac{R_N}{R_N + R_L}$$

These are the steps to be followed for solving Norton's theorem.

(d) A circuit consisting of a coil of resistance of 24Ω and inductance of 0.15 H in series with a capacitor of 20 μF connected to a variable frequency supply which has a supply voltage of 24 V. Calculate [5

  (i) Resonant Frequency

 (ii) Current in the circuit at resonance

(iii) Voltage across the capacitor and coil at resonance.

**Ans.**



(i) $\therefore$ Resonant frequency '$f_0$' $= \dfrac{1}{2\pi\sqrt{LC}}$

$$= \frac{1}{2\pi\sqrt{0.15 \times 20 \times 10^{-6}}} = \frac{10^3}{2\pi \times \sqrt{3}}$$

$$= 91.93 \text{ Hz.}$$

(ii) Current in the circuit of resonance

$$= I_0 = \frac{V}{R} = \frac{24}{24} = 1A.$$

(iii) Voltage across the capacitor

$$= V_{C_0} = I_0 X_C = 1 \times \frac{1}{\omega_0 c}$$

$$\omega_0 c = 2\pi f_0 \times c = 2\pi \times 91.93 \times 20 \times 10^{-6}$$

$$= 0.01154$$

$$V_{C_0} = I_0 \times \frac{1}{\omega_0 c} = 1 \times \frac{1}{0.01154} = 86.65 \text{ V}$$

Voltage drop across the coil i.e. across (L)

$V_{L_0}$ = Voltage across 'L' = 86.65 V

(under resonance)

$V_R = V = 24$ V (under resonance (across 'R')

**(e) Discuss briefly the B-H curve of ferromagnetic material.**

**Ans. B-H Curve for Magnetic Materials**

The (B-H) curve (or magnetisation) curve indicates the manner in which the flux density (B) varies with magnetising force (H).

**For Non-magnetic materials :**

For non-magnetic materials (i.e. air, copper, rubber, wood etc.) The relation between B and H is given by $B = \mu_0 H$.

Since $\mu_0$ is constant equal to $4\pi \times 10^{-7}$ H/m.

$\therefore \ B \propto H$

Hence B-H curve for a non-magnetic material is a straight line passing thorugh the origin as shown in (fig.8.2).
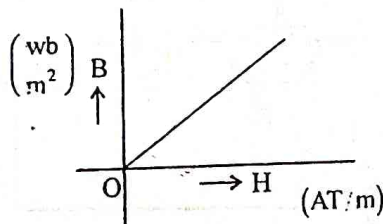


**For magnetic materials :**

For magnetic materials (i.e. iron, steel, etc.) The relation between B and H is given by

$B = \mu_0 \mu_r H$ .............. (8.7)

But $\mu_r$ is not constant but varies with the flux density. Hence the B-H curve of a magnetic material is not linear. (Fig. 8.3) shows the B-H curve of a magnetic materials.
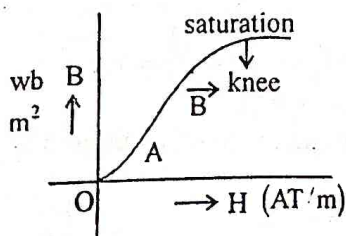


The non-linearity of the curve indicates that relative permeability '$\mu_r$' of a magnetic material is not constant. The magnetisation curve is varied according to different magnetic materials (fig. 8.4).
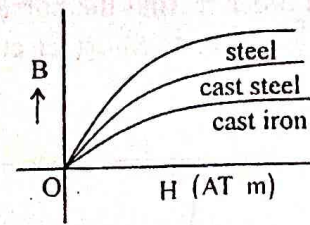


**(f) Explain constant k-high-pass filter with diagram.**

**Ans.** The circuit diagram of constant-k Hp filter in T and π network is given below :
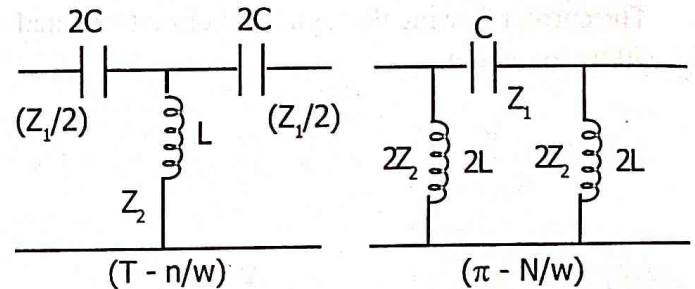


Fig. 13.5)

Here $Z_1$ = Series arm impedance

$$= \frac{1}{j\omega 2C} + \frac{1}{j\omega 2C}$$

$$= \frac{1}{j\omega C} \ \dots\dots\dots (13.26)$$

Similarly $Z_2$ = shunt arm impedance

$$= j\omega L \dots\dots\dots(13.27)$$

$$\therefore \ Z_1 Z_2 = j\omega L \cdot \frac{1}{j\omega C} = K^2 = R_0^2$$

$$\therefore \ Z_1 Z_2 = \frac{L}{C} = k^2 = R_0^2$$

$$\therefore \ R_0 = \sqrt{\frac{L}{C}} \ \dots\dots\dots (13.28)$$

**(i) Cut-off Frequency ($f_c$) :**

By putting $Z_1$ = i.e.

$\therefore \ \omega_c = \infty$ or $f_c = \infty$

Similarly by taking $Z_1 + 4Z_2 = 0$

or, $\dfrac{1}{j\omega C} + 4 j\omega_c L = 0$ or, $\dfrac{4 j\omega_c^2 LC + 1}{j\omega C} = 0$

or, $1 - j\omega_c^2 LC = 0$ or, $4 j\omega_c^2 LC = 1$

or, $\omega_c^2 = \dfrac{1}{4LC}$

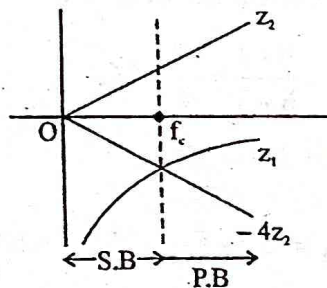$$\therefore \omega_c = \frac{1}{2\sqrt{LC}}$$

$$\therefore 2\pi f_c = \frac{1}{2\sqrt{LC}}$$

$$\therefore f_c = \frac{1}{4\pi\sqrt{LC}} \quad \cdots\cdots\cdots (8.29)$$

Thus the pass band (P.B) will lie in between

$$\frac{1}{4\pi\sqrt{LC}} \text{ to } \infty.$$

The impedance vrs frequency characteristics is given below,



(Fig. 13.6)

The cut-of frequency at the interception of the curves $Z_1$ and $-4Z_2$ is indicated as $f_c$. The filter transmits all the frequencies between $f_c$ and $\infty$.

### Design of HPF (Constant k-type)

We know that $Z_1 Z_2 = k^2 = R_0^2 = \dfrac{L}{C}$

or $k^2 = \dfrac{L}{C}$ similarly $f_c = \dfrac{1}{4\pi\sqrt{LC}}$ .....(13.35)

$$\therefore f_c^2 = \frac{1}{16\pi^2 LC}$$

$$\text{or, } LC = \frac{1}{16\pi^2 f_c^2}$$

but $R_0^2 = \dfrac{L}{C}$ or $L = CP_0^2$

$$\therefore \left(CP_0^2\right).C = \frac{1}{16\pi^2 f_c^2}$$

$$\text{or, } C^2 = \frac{1}{16\pi^2 f_c^2 R_0^2}$$

$$\therefore C = \frac{1}{4\pi f_c R_0} \quad \cdots\cdots\cdots (13.36)$$

Similarly $L = CR_0^2$

$$\therefore L = \frac{1}{4\pi f_c R_0} \cdot R_0^2 = \frac{R_0}{4\pi f_c} \text{ (Ans.)}$$

**(g) State and explain maximum power transfer theorem ?**

**Ans. Maximum Power Transfer Theorem :**

**Statement :** A Resistive load, being connected to a dc network receives maximum power when the load resistance is equal to the internal resistance of the source network as sum from the load terminals.

**Explanation :**

Let's consider a generator supplying electrical power over a transmission line a load resistor $R_L$ as shown in fig-1.
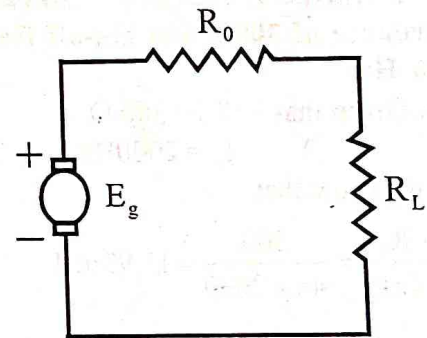


fig—1

Let $E_g$ = voltage generated inside the generator.

$R_0$= the internal resistance of generator plus the resistance of the two line conductors.

The current delivered to load resistance.

$$I = \frac{E_g}{(R_0 + R_1)}$$

Power delivered to load resistance

$$P = I^2 R_L = \frac{E_g^2}{(R_0 + R_L)^2} \times R_L$$

$$= \frac{E_g^2 R_L}{(R_0 + R_L)^2}$$

The power will be maximum when

$$\frac{dP}{dR_L} = 0$$

So

$$\frac{dP}{dR_L} = \frac{E_g^2(R_0 + R_L^2) - 2R_L(R_0 + R_L)E_g^2}{(R_0 + R_L)^4} = 0$$

$\Rightarrow E_g^2 (R_0+R_L)^2 - 2R_L(R_0+R_L) E_g^2 = 0$

$\Rightarrow E_g^2 (R_0+R_L)^2 = 2R_L (R_0+R_L) E_g^2$

$\Rightarrow (R_0+R_L) = 2R_L$

$\Rightarrow R_0 = 2R_L - R_L = R_L$

$\Rightarrow \boxed{R_0 = R_L}$

The value of the maximum power transfermed is

$$P_{max} = \frac{E_g^2 R_L}{(R_L + R_L)^2} = \frac{E_g^2 R_L}{4R_L^2} = \frac{E_g}{4R_L}.$$

$$\Rightarrow \boxed{P_{max} = \frac{E_g^2}{4R_L}}$$

**(h)** Design T-section of the high-pass filter having an infinite frequency characteristics impedance of 300Ω and cut-off frequency of 2000 Hz.

**Ans.** Given that $R_0 = 300 \ \Omega$

$f_c = 2000 Hz.$

But we know that

$$L = \frac{R_0}{4\pi f_c} = \frac{300}{4\pi \times 2000} = 11.93 \, mH$$

$$C = \frac{1}{4\pi R_0 f_c} = \frac{1}{4\pi \times 300 \times 2000} = 0.133 \, \mu F$$

The T-section of High Pass Filter (HPF) is shown as fig-1.
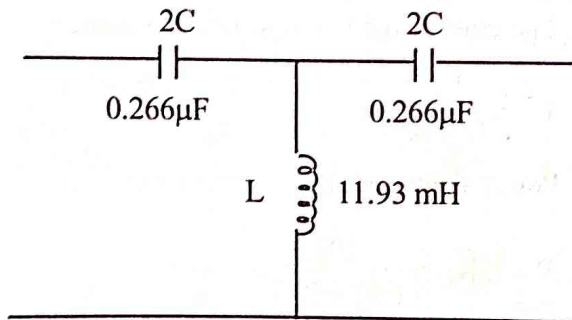


**Fig.-1**

**3.** Using superposition principle, find the current 3Ω resistance. **[10**
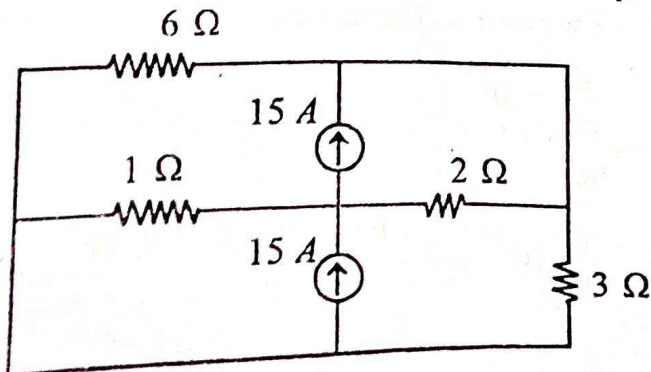


**Ans.**
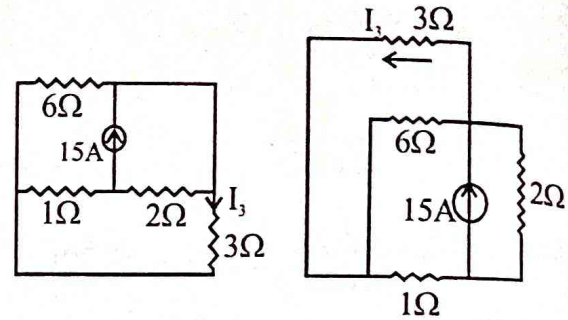


Considering upper 15A source and deactivating lower 15A source we have.

6Ω ‖′ 3Ω resistor and the combination in series with 1Ω resistor. We have to find current in 1Ω resistor by current deviding rule

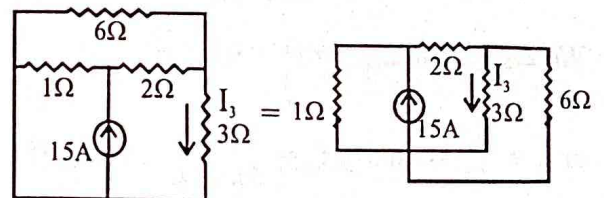$$6 \|' 3 = \frac{6 \times 3}{6+3} = \frac{18}{9} = 2\Omega$$

$$2\Omega + 1\Omega = 3\Omega$$

So $I_{1\Omega} = 15 \times \dfrac{2}{2+3} = 15 \times \dfrac{2}{3} = 6A$

Then 6A devides between 3Ω and 6 Ω resistor

So $I_{3\Omega} = 6 \times \dfrac{6}{6+3} = 6 \times \dfrac{6}{9} = 4A \, (\downarrow)$

Considering lower 15 A source nd deactivating upper 15A source the circuit is redrawn as



3Ω ‖′ 6Ω and combination is in series with

$$2\Omega \quad 6 \|' 3 = \frac{6 \times 3}{6+3} = 2\Omega$$

$$2\Omega + 2\Omega = 4\Omega$$
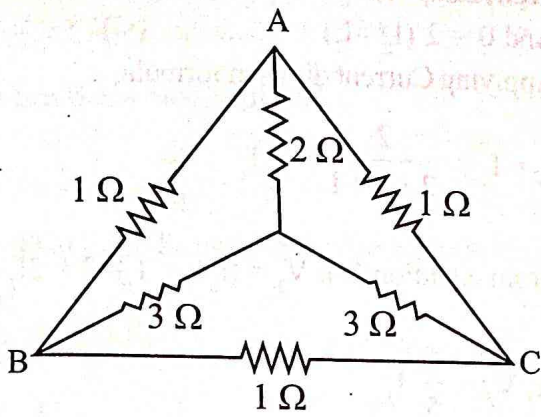
Current through 2Ω resistor $15 \times \dfrac{1}{1+4} = 3A$

Now Current through 3Ω resistor

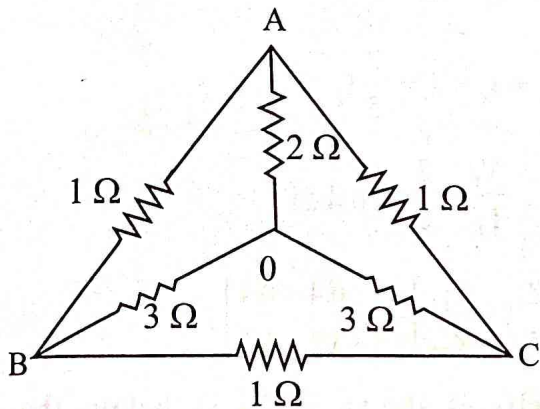$$= 3 \times \frac{6}{6+3} = 3 \times \frac{6}{9} = 2A (\downarrow)$$

So total current through 3Ω resistance
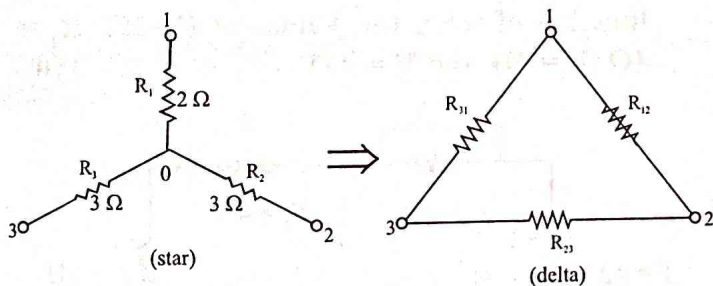
$$= 4 + 2 = 6A \, (\downarrow)$$

**4.** Compute the network resistance between terminals B and C in the given figure. **[10**

**Ans.**



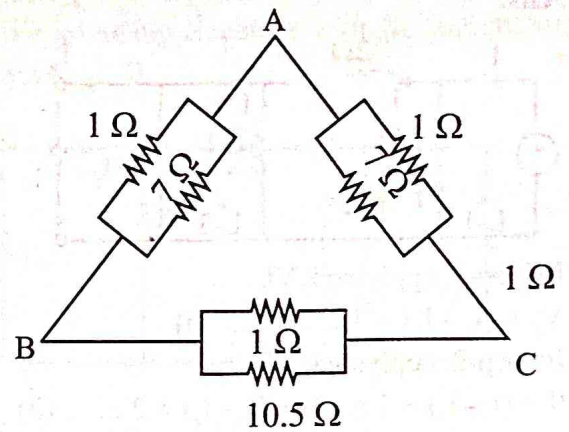The inner star side is now connected into delta (Δ) as shown below :



Here $R_{12} = \dfrac{R_1 R_2 + R_2 R_3 + R_3 R_4}{R_3}$

$= \dfrac{2 \times 3 + 3 \times 3 + 3 \times 2}{2} = \dfrac{21}{3} = 7\Omega$

$R_{23} = \dfrac{21}{R_1} = \dfrac{21}{2} = 10.5\ \Omega$
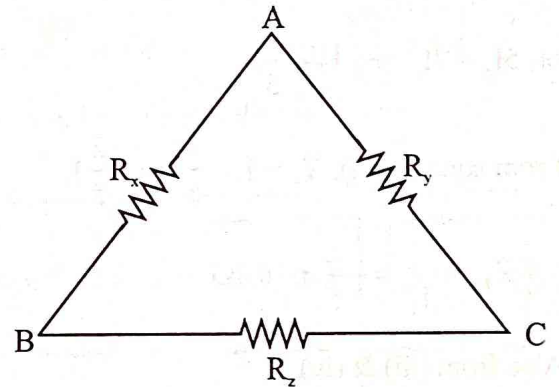
$R_{31} = \dfrac{21}{R_2} = \dfrac{21}{3} = 7\ \Omega$

The circuit is again drawn below.



And finally we got, $R_x = \dfrac{1 \times 7}{1+7} = \dfrac{7}{8}\Omega$

$R_y = \dfrac{7}{8}\Omega,\ R_z = \dfrac{10.5 \times 1}{10.5 + 1}$
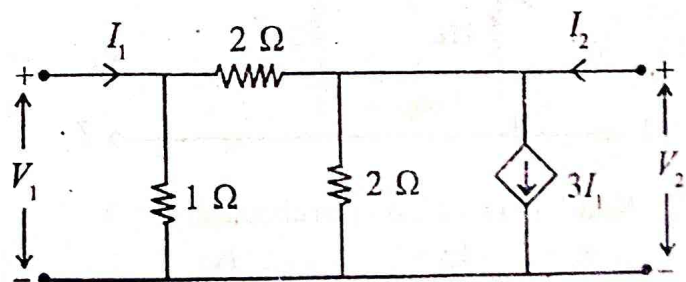
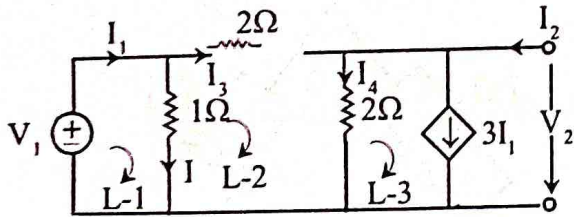$= \dfrac{10.5}{11.5} = 0.913\ \Omega$



∴ The resistance between B, C is

$(R_x + R_y) \| (R_z) = \left(\dfrac{7}{8} + \dfrac{7}{8}\right) \| (0.913)$

$= \dfrac{\dfrac{7}{4} \times 0.913}{\dfrac{7}{4} + 0.913} = 0.6\Omega.$  (Ans)

**5.**  Find z parameters for the giving network. [10

**Ans.**



In loop-1, applying KVL,
$$V_1 = (I_1 - I_3) \times 1 \quad \text{......} \quad \text{(i)}$$
In loop-2, applying KVL,
$$0 = (I_3 - I_1) \times 1 + 2I_3 + (I_3 - I_4) \times 2 \quad \text{.......} \quad \text{(ii)}$$
In loop-3,
$$V_2 = 2(I_3 - I_4) \quad \text{...........} \quad \text{(iii)}$$
And $I_4 = 3I_1 \quad \text{.............} \quad \text{(iv)}$

From equation (ii) by putting the value of $I_4$ in equation (iv) we have,
$$0 = (I_3 - I_4) + 2I_3 + 2I_3 - 2 \times (3I_1)$$
$$= (I_3 - I_1) + 2I_3 + 2I_3 - 6I_1$$
$$= 5I_3 - 7I_1$$

or, $5I_3 = 7I_1 \implies I_3 = \dfrac{7}{5}I_1$

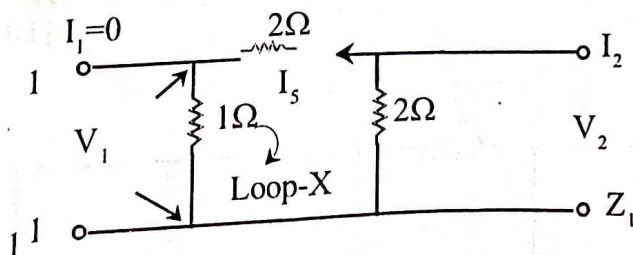From equation (i), $V_1 = I_1 - \dfrac{7}{5}I_1 = -\dfrac{2}{5}I_1$

$$\therefore \quad Z_{11} = \frac{V_1}{I_1} = -\frac{2}{5} = -0.4\,\Omega$$

Also from (iii) & (iv),

$$V_2 = 2(I_3 - I_4) = 2(I_3 - 3I_1) = 2\left(\frac{7}{5}I_1 - 3I_1\right)$$

$$= 2\left(-\frac{8}{5}I_1\right) = -\frac{16}{5}I_1$$

$$\implies Z_{21} = \frac{V_2}{I_1} = -\frac{16}{5} = 3.2\,\Omega \quad \text{(Ans.)}$$



Next Port $(1 - 1')$ is open circuited, $I_1 = 0$
$$\therefore \quad V_2 = (I_2 - I_5) \times 2 \quad \text{...............} \quad \text{(v)}$$

**From Loop -X**
And $0 = 2(I_5 - I_2) + 2I_5 \quad \text{..........} \quad \text{(vi)}$
Applying Current division formula,

$$I_5 = I_2 \times \frac{2}{2+2+1} = \frac{2}{5}I_2$$

From equation (v), $V_2 = (I_2 - \dfrac{2}{5}I_2) \times 2 = 2I_2 - \dfrac{4}{5}I_2$

or, $V_2 = \dfrac{6}{5}I_2$

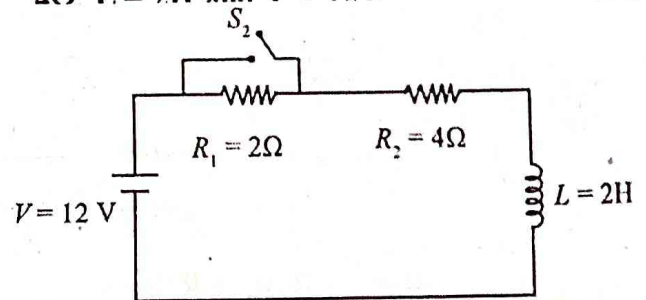$$\implies Z_{22} = \frac{V_2}{I_2} = \frac{6}{5} = 1.2\,\Omega$$

Also, $V_1 = I_5 \times 1 = \dfrac{2}{5}I_2$

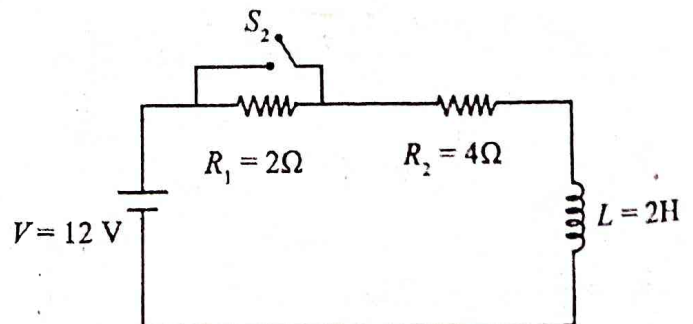$$\implies Z_{12} = \frac{V_1}{I_2} = \frac{2}{5} = 0.4\,\Omega$$

Thus $\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} -0.4 & 0.4 \\ -3.2 & 1.2 \end{bmatrix}$

6. **In the circuit shown in figure below, the battery has remained switched on for a long time. Suddenly the switch is closed. Find an expression for current in the circuit as a function of time, the Values of $R_1 = 2\Omega$, $R_2 = 4\Omega$, $L = 2H$ and $V = 12V$.**



**Ans.**



The steady state has reched after opening the switch at $t = 0^-$

$$i\,(0^-) = \frac{V}{R_1 + R_2} = \frac{12}{2+4} = 2A$$

When the switch is closed,

$$V = i.R_2 + L\,\frac{di}{dt}$$

Taking Laplace transformation on both sides,

$$\frac{V}{S} = I(S).R_2' + L\,[SI(S) - i(0^-)]$$

$$\Rightarrow \frac{12}{S} = 4I(S) + 2\,[SI(S) - 2]$$

or, $$\frac{12}{S} = 4I\,(S) + 2SI(S) - 4$$

or, $$\left(\frac{12}{S} + 4\right) = I\,(S)\,[2S + 4]$$

$$\therefore\; I(S) = \frac{\left(\dfrac{4S + 12}{S}\right)}{(2S + 4)} = \frac{\left(\dfrac{4S+12}{S}\right)}{(2S+4)} = \frac{(4S+12)}{S(2S+4)}$$

or $$I(S) = \frac{(2S+6)}{S(S+2)} = \frac{6}{S(S+2)} + \frac{2S}{S(S+2)}$$

$$= \frac{6}{S(S+2)} + \frac{2}{(S+2)}$$

Taking Inverse Laplace transformation on both sides,

$$i(t) = 2e^{-2t} + L^{-1}\left[\frac{6}{S(S+2)}\right]$$

$$\frac{6}{S(S+2)} = \frac{A}{S} + \frac{B}{S+2}$$

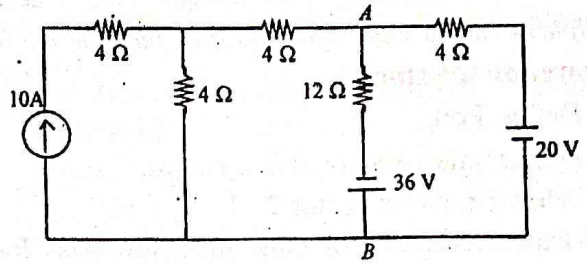$$A = \left.\frac{6}{S+2}\right|_{S=0} = 3 \text{ and } \left.\frac{6}{S}\right|_{S=-2} = \frac{6}{-2} = -3$$

$$\therefore\; \frac{6}{S(S+2)} = \frac{3}{S} - \frac{3}{S+2}$$

$$\therefore\; L^{-1}\left[\frac{S}{S(S+2)}\right] = 3 - 3e^{-2t} = 3(1 - e^{-2t})$$

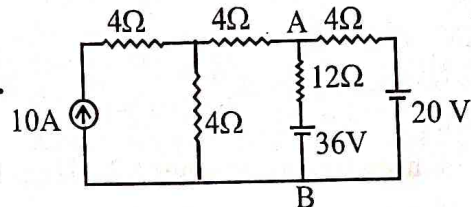$$\therefore\; i(t) = 2 - e^{-2t} = 3\,(1 - e^{-2t})$$

$$= 2e^{-2t} + 3 - 3e^{-2t} = 3 - e^{-2t} \;\;(\text{Ans.})$$

7. **Using source conversion technique reduce the following circuit to a single current source across AB.** [10
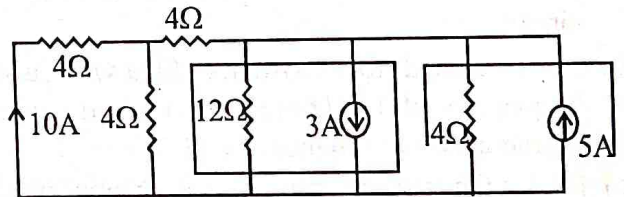


**Ans.**



Using source conversion technique, in the two branches of voltage sources, the current source values are

(i) $$\frac{36V}{12} = 3A$$    (ii) $$\frac{20V}{4\Omega} = 5A$$
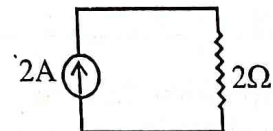
Again the circuit is drawn,



$$\therefore\; R_{eq} = \{(4 \parallel 4) + 4\} \parallel (12 \parallel 4)$$

$$= (2 + 4) \parallel \left(\frac{12 \times 4}{12 + 4}\right) = 6 \parallel 3 = \frac{6 \times 3}{6 + 3} = 2\Omega$$

Net current in AB $= 5 - 3 = 2A$

The circuit is redrawn



□◆□

**Full Marks : 80**    (Code - EET-301)  **Time : 3 Hours**

Answer any **five** questions including Q.Nos. **1** & **2**

*The figures in the right-hand margin indicate marks.*

**1. Answer *all* questions :**                          [2×10

(a) Define Port.

(b) Define time-constant in *R-L* circuit.

(c) What is a power factor ?

(d) Draw the circuit of constant-k low-pass R-C circuit.

(e) State KVL and KCL.

(f) What is two port network ?

(g) What is transient ?

(h) What is non-linear element ? Give two examples.

(i) Define Resistance and state its unit. What is Conductance ?

(j) Define temperature coefficient of resistance and state its effect on conductor and insulator.

**2. Answer *any six* questions :**                          [5×6

(a) Derive the expression for lower and upper half power frequencies of a resonant series R-L-C circuit.

(b) Design a band stop, constant K-filter with cut-off frequencies of 4 kHz and 10 KHz and nominal characteristic impedance 500 Ω.

(c) Derive the transient current in R-C series circuit assuming initial charge on capacitor is zero.
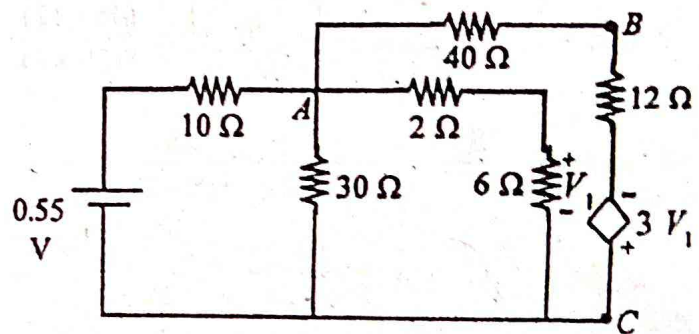
(d) Find z-parameter of the following circuit.
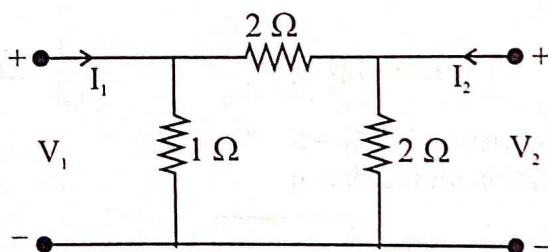


(e) Using superposition theorem, find the current flowing through 10 Ω resistor.
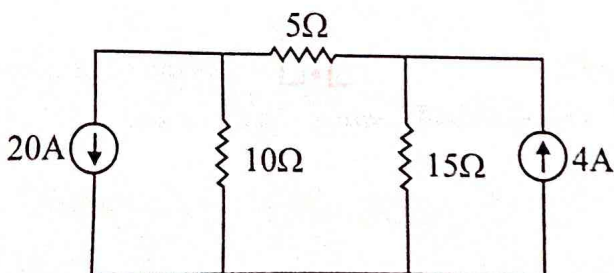


(f) Discuss biefly about B-H cuve of ferro-magnetic material.

(g) Draw the power triangle for R-L series circuit. State the expression for active, reactive and apparent power.

(h) Design a high pass filter having a cut-off frequency of 1 kHz with a load resistance of 600 Ω.

3. Using Thevein's theorem find the current through the load resistance $R_1$.                          [10
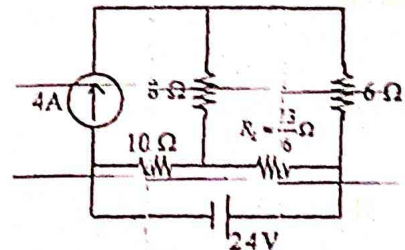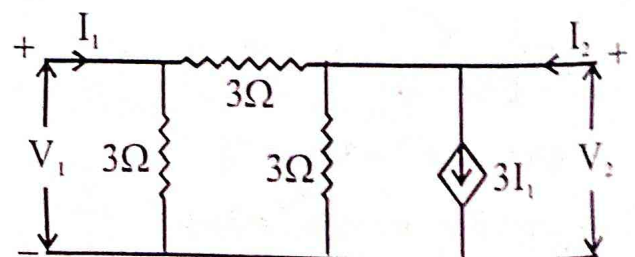


4. Using nodal analysis find the potential difference between points *B* and *C* of the following cirucit :                          [10



5. Using Norton's theorem find the current in 3Ω resistance in teh following circuit :                          [10
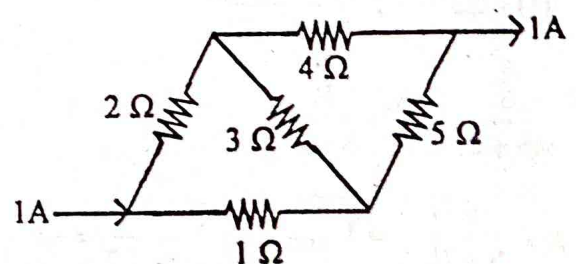


6. Find the Y parameters of the two port network as shown below :                          [10

7. Two impedance $z_1 = 10 + j 1.5 \Omega$ and $z_2 = 8 + j 6\Omega$ are connected in parallel. If total current taken is 20A. Find the current taken by each branch and different power consumed by the circuit.[10

# ANSWERS TO SET-3

1. Answer *all* questions : [2×10

(a) Define Port.

Ans. A port is defined as any pair of terminals in to which energy is supplied or from which energy is with drawn in a network is termed as port.

(b) Define time-constant in *R-L* circuit.

Ans. The time constant of a series R-L circuit is L/R second.

(c) What is a power factor ?
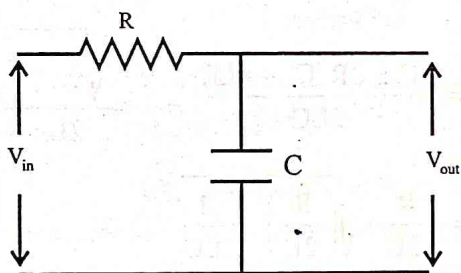
Ans. Power factor may be defined

(a) Cosine of the phase angle between voltage and current.

(b) the ratio of the resistance to impedance.

(c) the ratio of the active power to apparent power.

(d) Draw the circuit of constant-k low-pass R-C circuit.

Ans. The circuit diagram for a low-pass R–C filter is shown as fig-1.



(e) State KVL and KCL.

Ans. Kirchhoff's Mesh Law :- (KVL) :

In any closed circuit or mesh the algebraic sum of emfs acting in that circuit or mesh is equal to the algebraic sum of the products of the current and resistances of each part of the circuit.

Kirchhoff's Current Law (KCL) :

In any network of wires carrying currents, the algebraic sum of all currents meeting at a point is zero.

(f) What is two port network ?

Ans. Two port network consists of '4' terminals and two ports. Each port contains two terminals.
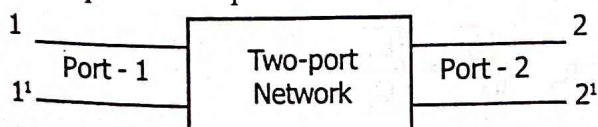


(g) What is transient ?

Ans. Transient : It is a condition at which the process is very quick and generally during sudden opening or closing of a switch transient state occurs. During this period (transient) there will be sudden rise or fall in voltage or current.

(h) What is non-linear element ? Give two examples.

Ans. Non-linear element is nothing but an element in which ohm's law will not hold good and the (p.d. and current) do not vary propertionally and the graph will not be linear. Examples of non-linear element (two) are :

(i) Inductor  (ii) Capacitor

(i) Define Resistance and state its unit. What is Conductance ?

Ans. Resistance is a property of conductor which opposes the flow of current. It is also the ratio between voltage applied and current carrying in a conductor at a particular temperature. It's unit is ohm or $\Omega$. Conductance is the reciprocal of resistance.

(j) Define temperature coefficient of resistance and state its effect on conductor and insulator.

Ans. The temperature coefficient of resistance may be defined as the ratio of increase in resistance per degree rise of temperature to the original resistances. It may be represented as '$\alpha_0$'.

$$\alpha_0 = \frac{\Delta R}{R_0 t}$$

The effect of temperature coefficient of resistance of conductor is positive i.e. the resistance of all pure conductors increase with the increase in termperature. But the effect of temperature coefficient of resistance of insulator is negative. i.e. the resistance of insulator decreases with increase in temperature.

2. Answer *any six* questions : [5×6

(a) Derive the expression for lower and upper half power frequencies of a resonant series R-L-C circuit.

Ans. At half power frequency the net reactance of the series resonant circuit.
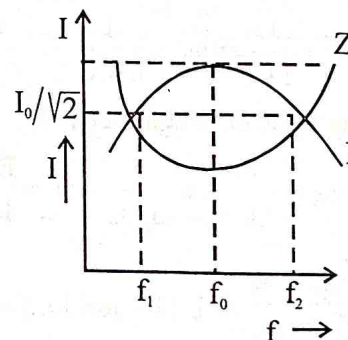
$$X = f(X_L - X_C) = R$$

Let $f_1$ = the frequency when the net circuit reactance be $-ve$

$f_2$ = the frequency whemn the net circuit reactance is $+ve$

So $R = \pm\left(\omega L - \dfrac{1}{\omega C}\right) = \pm X$

Thus $\omega_2 L - \dfrac{1}{\omega_2 C} = R$    ...(1)

$\omega_1 L - \dfrac{1}{\omega_1 C} = R$    ...(2)

Adding equation (1) and (2)

$$\left(\omega_2 L - \dfrac{1}{\omega_2 C}\right) + \left(\omega_1 L - \dfrac{1}{\omega_1 C}\right) = R - R$$

$$\Rightarrow (\omega_1 + \omega_2)L - \dfrac{1}{C}\left(\dfrac{1}{\omega_1} + \dfrac{1}{\omega_2}\right) = 0$$

$$\Rightarrow L(\omega_1 + \omega_2) - \dfrac{1}{C}\left(\dfrac{\omega_1 + \omega_2}{\omega_1 \omega_2}\right) = 0$$

$$\Rightarrow L(\omega_1 + \omega_2) = \dfrac{1}{C}\left(\dfrac{\omega_1 + \omega_2}{\omega_1 \omega_2}\right)$$

$$\Rightarrow L = \dfrac{1}{C}\left(\dfrac{\omega_1 + \omega_2}{\omega_1 \omega_2}\right) \times \left(\dfrac{1}{\omega_1 + \omega_2}\right) = \dfrac{1}{C} \times \dfrac{1}{\omega_1 \omega_2}$$

$$\Rightarrow \omega_1 \omega_2 = \dfrac{1}{LC}$$    ...(3)

At resonance $\omega_0 = \dfrac{1}{\sqrt{LC}}$    ...(4)

Comparing equation (3) and (4) we have

$$\omega_0^2 = \omega_1 \omega_2 \Rightarrow \omega_0 = \sqrt{\omega_1 \omega_2}$$

But we know $\omega_2 - \omega_1 = \dfrac{R}{L}$    ...(5)

As $\omega_1 - \omega_2 = \dfrac{1}{LC} \Rightarrow \omega_2 = \dfrac{1}{\omega_1 LC}$

putting this value $\omega_1$ is equation (5)

$$\omega_2 - \omega_1 = \dfrac{1}{LC} \Rightarrow \dfrac{1}{\omega_1 LC} - \omega_1 = \dfrac{R}{L}$$

$$\Rightarrow \dfrac{1 - \omega_1^2 LC}{\omega_1 LC} = \dfrac{R}{L} \Rightarrow L(1 - \omega_1^2 LC) = \omega_1 LCR$$

$$\Rightarrow 1 - \omega_1^2 LC = \omega_1 CR$$
$$\Rightarrow \omega_1^2 LC + \omega_1 RC - 1 = 0$$

$$\Rightarrow \omega_1 = \dfrac{-RC \pm \sqrt{R^2 C^2 - 4LC}}{2LC} = \dfrac{-R \pm \sqrt{R^2 - 4\dfrac{L}{C}}}{2L}$$

$$= \dfrac{-R + \sqrt{R^2 - \dfrac{L}{C}}}{2L} = \dfrac{R}{2L} + \sqrt{\left(\dfrac{R}{2C}\right)^2 - \dfrac{1}{LC}}$$

Again    $\omega_1 \omega_2 = \dfrac{1}{LC}$

$$\Rightarrow \omega_1 = \dfrac{1}{\omega_2 LC}$$

$$\therefore \omega_2 - \omega_1 = \dfrac{R}{L} \Rightarrow \omega_2 - \dfrac{1}{\omega_2 LC} = \dfrac{R}{L}$$

$$\Rightarrow \dfrac{\omega_2^2 LC - L}{\omega_2 LC} = \dfrac{R}{L}$$

$$\Rightarrow L(\omega_2^2 LC - 1) = RLC\omega_2$$
$$\Rightarrow \omega_2^2 LC - \omega_2 RC - 1 = 0$$

$$\therefore \omega_2 = \dfrac{RC \pm \sqrt{R^2 C^2 - 4LC}}{2LC} = \dfrac{R \pm \sqrt{R^2 - 4\dfrac{L}{C}}}{2L}$$

$$\therefore \omega_1 = -\dfrac{R}{2L} + \sqrt{\left(\dfrac{R}{2L}\right)^2 - \dfrac{1}{LC}}$$

$$\omega_2 = \dfrac{R}{2L} + \sqrt{\left(\dfrac{R}{2C}\right)^2 - \dfrac{1}{LC}}$$

**(b) Design a band stop, constant K-filter with cut-off frequencies of 4 kHz and 10 KHz and nominal characteristic impedance 500 Ω.**

**Ans.** Given

$f_1$ = 4KHZ

$f_2$ = 10KHZ

$R_0$ = 500 Ω

$$R_0 = \sqrt{\dfrac{L_1}{C_2}} = \sqrt{\dfrac{L_2}{C_1}}$$

$$C_1 = \frac{1}{4\pi R_0 (f_2 - f_1)}$$

$$= 26.52 \times 10^{-9}\,F$$

$$C_2 = \frac{f_2 - f_1}{\pi f_1 f_2 R_0} = 95.49 \times 10^{-9}\,F$$

$$L_1 = C_2 R_0^2$$

$$= 23.87\,mH$$

$$L_2 = C_1 R_0^2$$

$$= 6.63\,mH$$

Here $C_1 = 0.02652 \times 10^{-6}\,F = 0.02652\,\mu F$.
$\quad C_2 = 0.09549 \times 10^{-6}\,F = 0.09549\,\mu F$.



(Design Circuit)

Fig. *Design Circuit.*

(c) **Derive the transient current in R-C series circuit assuming initial charge on capacitor is zero.**

**Ans.**
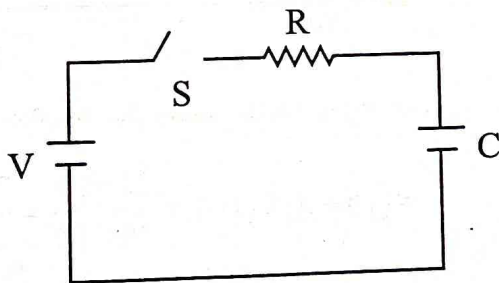


When the switch is closed at $t = 0$ and initial stored charge $= 0$.

$$\therefore\ iR + \frac{1}{c}\int i\,dt = V$$

$$\Rightarrow R\frac{di}{dt} + \frac{1}{c}i = 0$$

$$\Rightarrow \frac{di}{dt} + \frac{1}{RC}i = 0$$

$$\Rightarrow \frac{di}{dt} = -\frac{1}{RC}i$$

$$\Rightarrow \frac{di}{dt} = -\frac{1}{RC}\,dt$$

or, Integrating both the sides,

$$\ell n\,i = -\frac{1}{RC}.t + constant\,(k)$$

At $t = 0$, $i = I_0$

$$\therefore\ \ell n\,I_0 = -\frac{1}{RC}.0 + k$$

$$\therefore\ \boxed{k = \ell n\,I_0}$$
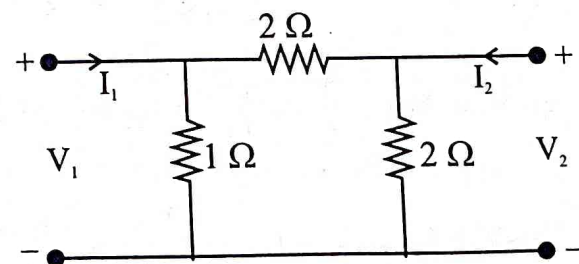
$$\therefore\ \ell n\,i = -\frac{1}{RC}t + \ell n\,I_0$$

or, $\ell n\,i - \ell n\,I_0 = -\frac{1}{RC}.t$

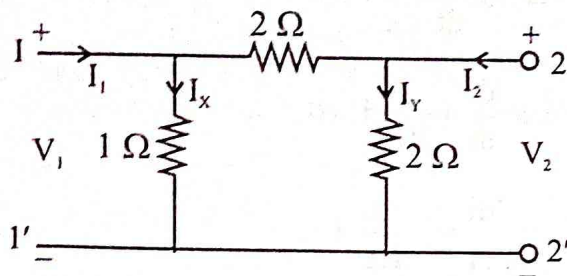$$\Rightarrow \ell n\left(\frac{i}{I_0}\right) = -\frac{1}{RC}.t$$

or $\dfrac{i}{I_0} = e^{-t/RC}$

or $\boxed{i = I_0\,e^{-t/RC}}$

(d) **Find z-parameter of the following circuit.**

**Ans.**



**Step-1 :** First we have to find $Z_{11}$ and $Z_{21}$

i.e., $Z_{11} = \dfrac{V_1}{I_1}\Big]_{I_2=0}$ and $Z_{21} = \dfrac{V_2}{I_2}\Big]_{I_2=0}$

i.e., 2 - 2' port is open circuited (o.c.)

$\therefore$ From figure-1, $I_2 = 0$

$\therefore V_1 = I_x \cdot (1\,\Omega)$

But $I_x = I_1 \times \dfrac{(2\times 2)}{2+2+1} = \dfrac{4I_1}{5}$

$\therefore V_1 = \dfrac{4}{5}I_1 \times 1 \Rightarrow \boxed{\dfrac{V_1}{I_1} = z_{11} = \dfrac{4}{5} = 0.8\ \Omega}$

Also $V_2 = 2.I_y$

$\Rightarrow I_y = I_1 \times \dfrac{1}{1+2+2} = \dfrac{I_1}{5}$

$\therefore V_2 = 2 \times \dfrac{I_1}{5} \Rightarrow \boxed{\dfrac{V_1}{I_1} = z_{21} = \dfrac{2}{5} = 0.4\ \Omega}$

**Step-2 :** Next we have to find $Z_{12}$ and $Z_{22}$

i.e., $Z_{12} = \dfrac{V_1}{I_2}\Big]_{I_1=0}$ and $\dfrac{V_2}{I_2}\Big]_{I_1=0}$

Here port $(1 - 1')$ is open circuited (o.c.),
from figure-1, putting $I_1 = 0$.

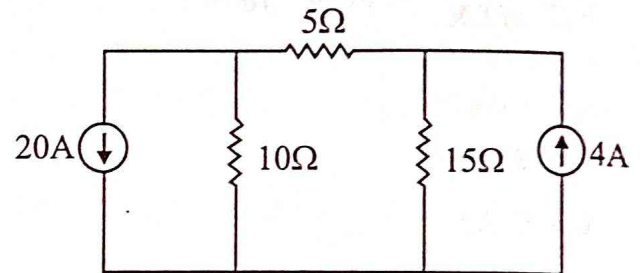$V_2 = 2.I_y$ but $I_y = I_2 \times \dfrac{(2+1)}{2+1+2} = I_2 \times \dfrac{3}{5}$

$\Rightarrow V_2 = 2 \times I_2 \times \dfrac{3}{5} \Rightarrow \boxed{\dfrac{V_2}{I_2} = z_{22} = \dfrac{6}{5} = 1.2\ \Omega}$

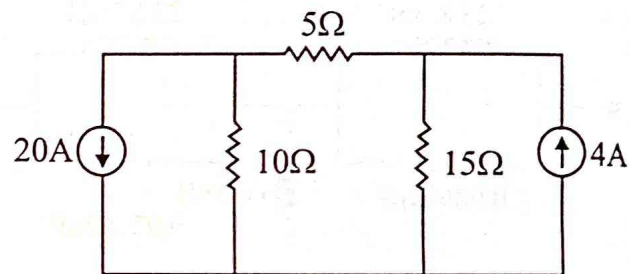Also $V_1 = I_x \cdot 1$, $I_x = I_2 \times \dfrac{2}{2+2+1} = \dfrac{2I_2}{5}$

$\therefore V_1 = \dfrac{2I_2}{5} \times 1$

$\therefore \boxed{\dfrac{V_2}{I_2} = z_{12} = \dfrac{2}{5}\Omega = 0.4\ \Omega}$. **(Ans)**
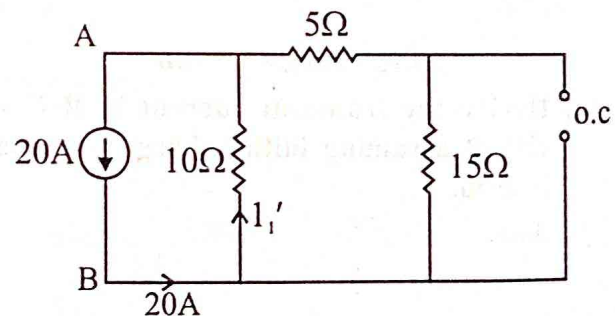
**(e) Using superposition theorem, find the current flowing through 10 Ω resistor.**



**Ans.**



**Step-1 :** The 20A source is considered and 4A source is deactivated i.e., open circuited (o.c.).
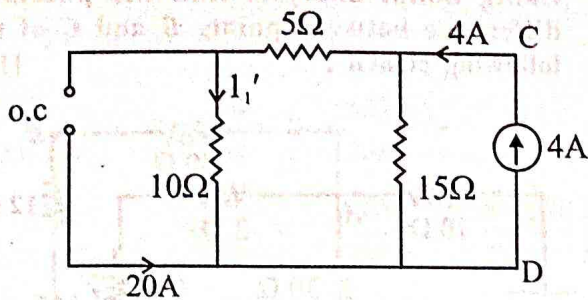


$\therefore$ The equivalent resistance across AB

$= (15+5)\,\|\,(10) = \dfrac{22\times 10}{20+10} = \dfrac{200}{30} = \dfrac{20}{3}\,\Omega$

$\therefore I_1{}' = $ current in 10 Ω resistor

$= 20\text{A} \times \dfrac{(15+5)}{(15+5+10)} = \dfrac{40}{3}\text{A}(\uparrow)$

**Step-2 :** 4A source is considered and 20A is o/c.

Equivalent resistance across CD.

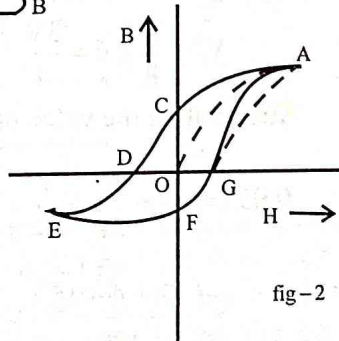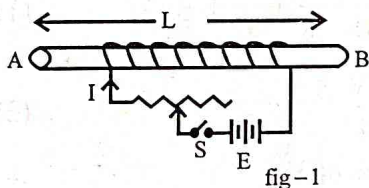$$= (10+5) \| (15) = \frac{15 \times 15}{15+15} = \frac{15}{2} = \frac{15}{2} \Omega$$

$$\therefore I_1^{11} = 4A \times \frac{15}{10+5+15} = \frac{4 \times 15}{30} = 2A(\downarrow)$$

**Step-3 :** Net current in 10 Ω resistor

$$= I_1^1 - I_1^{11} = \frac{40}{3} - 2 = \frac{34}{3} = 11.33A. \, (Ans)$$

**(f) Discuss biefly about B-H curve of ferro-magnetic material.**

**Ans.** The phenomenon of lagging of magnetisation or induction flux density behind the magnetising force is called as magnetic hystersis.
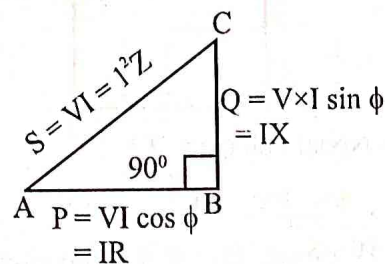


fig–1

fig–2

Let's consider a core of specimen of iron be would with a number of turns of wire and current be passed thrugh the solenoid. A magnetic field of intensity 'H' proportional to the current folowing through the solenoid is produced. Let the magnetising force 'H' is increased from zero to maximum value and then gradually reduced to zero. If the value of flux density 'B' in the come to various values of magnetising force 'H' are determined, then we have found B-H curve.

If the direction of flow of current is reversed the magnetising force 'H' is reversed. Let the current be increased in the negative direction until the induction density 'B' becomes zero. At B=0, the demagnetising force H=OD which is required to neutralize the residual magnetism. If the demagnetising force 'H' is further increased to previous maximum value and again gradually decreased to zero further increased in origional or positive direction to the maximum value, there is a closed loop ACDEF is formed. This loop is called hystersis loop as shown is fig-2.

**(g) Draw the power triangle for R-L series circuit. State the expression for active, reactive and apparent power.**

**Ans.** Power triangle for R – L series circuit.



In triangle ABC

AB = P = VI cos ɸ = Active power

BC = Q = VI sin ɸ = Reactive power

AC = S = VI = Appanent power.

Active power $P = I^2 R = VI \cos \phi$ watt OR KW.

Reactive power $Q = P_{X_L} = VI \sin \phi$ VAR OR KVAR

Appanent power $S = V.I = I^2_R$ VA OR KVA

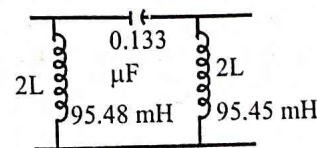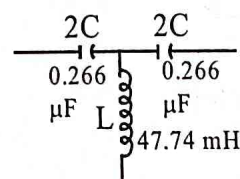**(h) Design a high pass filter having a cut-off frequency of 1 kHz with a load resistance of 600 Ω.**

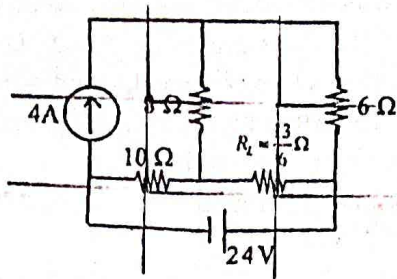**Ans.** Cut off frequency $f_c$ = 1 KHZ = 1000 HZ

$R_L = K = 600\Omega$

$$L = \frac{RL}{4\pi f_c} = \frac{600}{4\pi \times 1000} = 47.74mH$$

$$C = \frac{1}{4\pi R_L f_c} = \frac{1}{4\pi \times 600 \times 1000} = 0.133\mu F$$

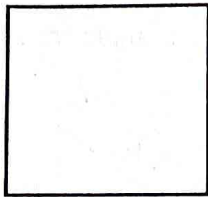The T section and 8π section is shown as

**3.** Using Thevein's theorem find the current through the load resistance R$_L$.  [10



**Ans.** Alternate to find V$_{th}$



Let V = Nodal voltage at 1.

So $4 = \dfrac{V}{10+8} + \dfrac{V-24}{6}$

$\Rightarrow 4 = \dfrac{V}{18} + \dfrac{V}{6} - 4$

$\Rightarrow 8 = \dfrac{V+3V}{18} = \dfrac{4V}{18}$
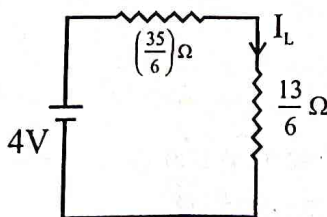
$\Rightarrow V = \dfrac{18 \times 8}{4} = 36$

So $I_8 = \dfrac{V}{18} = \dfrac{36}{18} = 2A$

$\Rightarrow I_8 = 2A$

$I_6 = \dfrac{V-24}{6} = \dfrac{36-24}{6} = \dfrac{12}{6} = 2A$

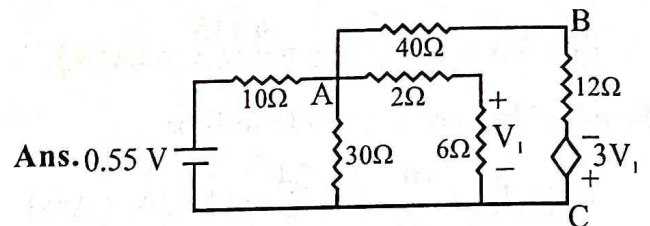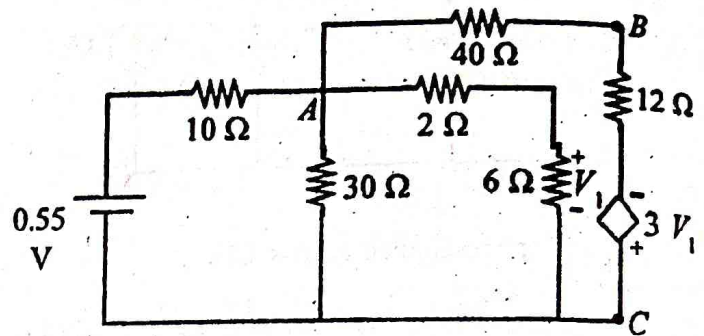Hence $V_{th} = V_8 - V_6 = 8 \times 2 - 6 \times 2$

$= 16 - 12 = 4$volt

So thevenin equivalent circuit is



$I_L = \dfrac{4}{\dfrac{35}{6} + \dfrac{13}{6}} = \dfrac{4}{\left(\dfrac{48}{6}\right)} = \dfrac{4}{8} = 0.5A$

**4.** Using nodal analysis find the potential difference between points $B$ and $C$ of the following cirucit :  [10



**Ans.** 0.55 V



Let V = node voltage at junction A
Nodal equation in written as

$\dfrac{0.55-V}{10} = \dfrac{V}{30} + \dfrac{V}{(2+6)} + \dfrac{V+3V_1}{40+12}$

or $0.055 - \dfrac{V}{10} = \dfrac{V}{30} + \dfrac{V}{8} + \dfrac{V}{52} + \dfrac{3}{52}V_1$ ...(1)

$V_1 = \dfrac{V}{8} \times 6 = \dfrac{3V}{4}$ ...(2)

Substituting the value of V$_1$

$0.055 = \dfrac{V}{10} + \dfrac{V}{30} + \dfrac{V}{8} + \dfrac{V}{52} + \dfrac{3}{52} + \dfrac{3}{4}$

$= \left(\dfrac{12+4+15}{120}\right)V + \left(\dfrac{4+9}{208}\right)V$

$= \dfrac{31}{120}V + \dfrac{13V}{208} = 0.3208V$

or $V = \dfrac{0.055}{0.3208} = 0.1714$ volt

$V_{AC} = 0.1714$ volt.

Current through the 40Ω Resistor

$I_{40Ω} = \dfrac{V+3V_1}{52} = \dfrac{V + \dfrac{3 \times 3V}{4}}{52} = \dfrac{4V+9V}{4 \times 52} = \dfrac{13V}{208}A$

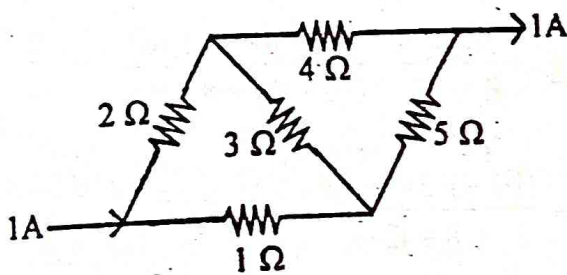PD Across $40\Omega$ Resistance $= \dfrac{V}{40\Omega} = 40 \times I_{40\Omega}$

$= 40 \times \dfrac{13V}{208}$ volt $= \dfrac{520}{208}$ volt

$V_{BC} = V - V_{40\Omega} = V - \dfrac{520V}{208} = \left(\dfrac{208-520}{208}\right)V$

$= \dfrac{312}{208} \times 0.1714$ volt

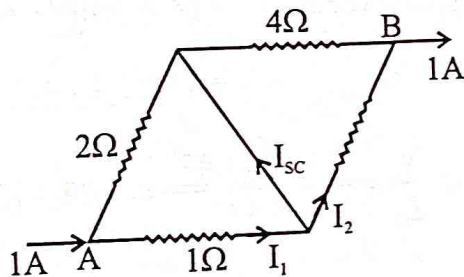$= -1.5 \times 0.1714 = -0.2571$ volt.

5. **Using Norton's theorem find the current in $3\Omega$ resistance in teh following circuit : [10**



**Ans.** The $3\Omega$ resistor is removed and short circuit is drawn about the terminals.

**To find $I_{sc}$**



$2\Omega$ resistor parallel with $1\Omega$ resistor and $4\Omega$ resistor parallel with $5\Omega$ resistor. A current after leaving at 'A' devides between $2\Omega$ and $1\Omega$ similarly 14 current before leaving at 'B' devides between $4\Omega$ and $5\Omega$.

Now $I_{sc} = I_1 - I_2$

$I_1 = 1 \times \dfrac{2}{2+1} = \dfrac{2}{3}$ A

$I_2 = 1 \times \dfrac{4}{4+5} = \dfrac{4}{9}$ A

So $I_{sc} = \dfrac{2}{3} - \dfrac{4}{9} = \dfrac{6-4}{9} = \dfrac{2}{9}$ A

To find internal resistance are the $3\Omega$ resistance the circuit is redrawn with deactiviting current source.
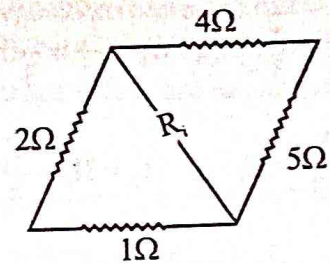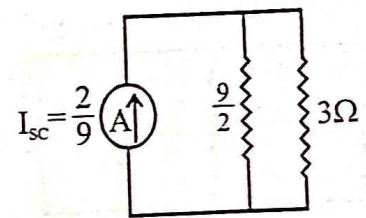


$4\Omega$ in series with $5\Omega$ & $2\Omega$ in series with $1\Omega$ the combination is parallel

$R_N = (4+5)\Omega \parallel (1+2)\Omega = 9\Omega \parallel (1+2)\Omega$

$= \dfrac{9 \times 3}{9+3} = \dfrac{27}{12} = \dfrac{9}{4}\Omega$

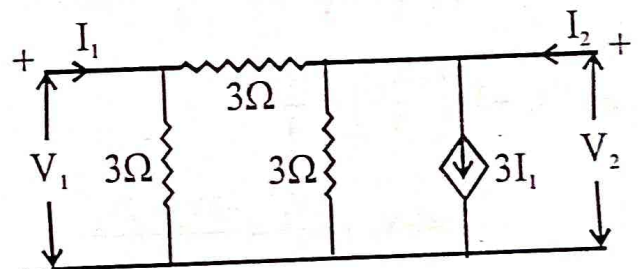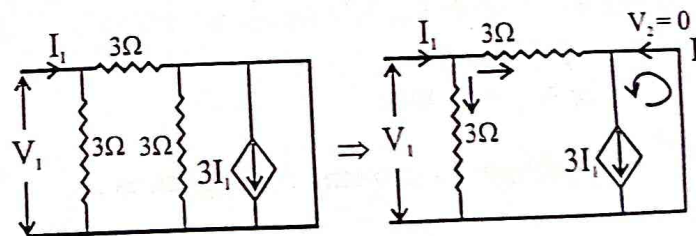Nortons equivalent circuit redrawn as



Current through $3\Omega$ resistance

$I_{3\Omega} = \dfrac{\dfrac{2}{9} \times \dfrac{9}{4}}{\dfrac{9}{4}+3} = \dfrac{0.5}{\dfrac{9+12}{4}} = \dfrac{0.5 \times 4}{21} = \dfrac{2}{21}$ A

6. **Find the Y parameters of the two port network as shown below :** [10



**Ans.**



Port – 2 is short circuited

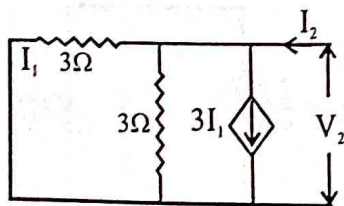Nodal equation at node $I_1 = \dfrac{V_1}{3} + \dfrac{V_1}{3} = \dfrac{2V_1}{3}$

or $\dfrac{I_1}{V_1} = \dfrac{2}{3}\ \mho$ or $Y_{11} = \dfrac{I_1}{V_1} = \dfrac{2}{3}\ \mho$

$I_2 + \dfrac{V_1}{3} = 3I_1$ or $I_2 = 3I_1 - \dfrac{V_1}{3}$

$Y_{21} = \dfrac{I_2}{V_1} = \dfrac{3I_2 - \dfrac{V_1}{3}}{V_1} = 3\left(\dfrac{I_1}{V_1}\right) = \dfrac{1}{3}$

or $Y_{21} = 3 \times \dfrac{2}{3} - \dfrac{1}{3} = 2 - \dfrac{1}{3} = \dfrac{5}{3}\ \mho$

when port 1 is short circuited



$I_1 = -\dfrac{V_2}{3}$

$V_{12} = \dfrac{I_1}{V_2} = \dfrac{-V_2/3}{V_2} = -\dfrac{1}{3}$ mho

Nodal equation is given as

$I_2 = 3I_1 + \dfrac{V_2}{3} + \dfrac{V_2}{3} = 3I_1 + \dfrac{2V_2}{3}$

or $I_2 = 3 \times \left(\dfrac{-V_2}{3}\right) + \dfrac{2V_2}{3}$

$\qquad = -V_2 + \dfrac{2V_2}{3} = \dfrac{-3V_2 + 2V_2}{3}$

or $I_2 = \dfrac{-V_2}{3}$ or $\dfrac{I_2}{V_2} = -\dfrac{1}{3}$

or $y_{22} = \dfrac{-1}{3}$ mho

y parameters in metrix for is given as :

$$[y] = \begin{bmatrix} \dfrac{2}{3} & -\dfrac{1}{3} \\[2mm] \dfrac{5}{3} & \dfrac{-1}{3} \end{bmatrix}$$

7. Two impedance $z_1 = 10 + j\,1.5\ \Omega$ and $z_2 = 8 + j\,6\Omega$ are connected in parallel. If total current taken is 20A. Find the current taken by each branch and different power consumed by the circuit. [10

Ans. Given $Z_1 = (10 + j15)\Omega = 18\underline{|57^0}$

$\qquad Z_2 = (8 + j6)\Omega$

$\qquad = 10\underline{|36.87^0}$

Total current I = 20 A

$\qquad \Rightarrow I = 20\underline{|0^0}$ A

Total impedance

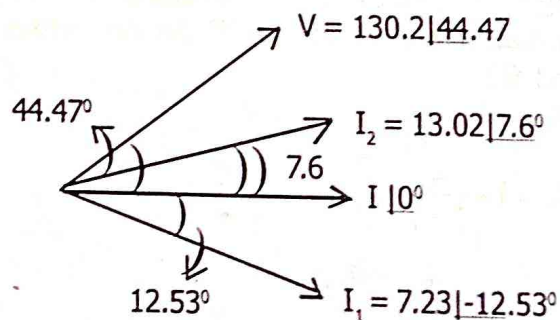$Z = \dfrac{Z_1 Z_2}{Z_1 + Z_2} = \dfrac{(10 + j15)(8 + j6)}{(10 + j15 + 8 + j6)}$

$= \dfrac{(10 + j15)(8 + j6)}{(18 + j21)} = \dfrac{(18\underline{|57^0}) \times (10\underline{|36.87^0})}{27.66\underline{|49.4^0}}$

$Z = \dfrac{180\underline{|93.87^0}}{27.66\underline{|49.4^0}} = 6.51\underline{|44.47^0}$

Applied voltage V = IZ = $20\underline{|0^0} \times 6.51\underline{|44.47^0}$

$\qquad = 130.2\underline{|44.47^0}$

$I_1 = \dfrac{V}{Z_1} = \dfrac{130.2\underline{|44.47^0}}{18\underline{|57^0}} = 7.23\underline{|-12.53^0}$

$I_2 = \dfrac{V}{Z_2} = \dfrac{130.2\underline{|44.47^0}}{10\underline{|36.87^0}} = 13.02\underline{|7.6^0}$



Power consumed

P = V I cos θ

$\quad = 130.2 \times 20 \times \cos 44.47^0$

$\quad = 11858.26$ watt