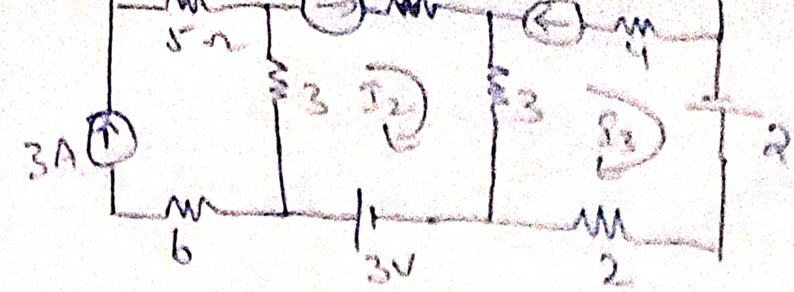
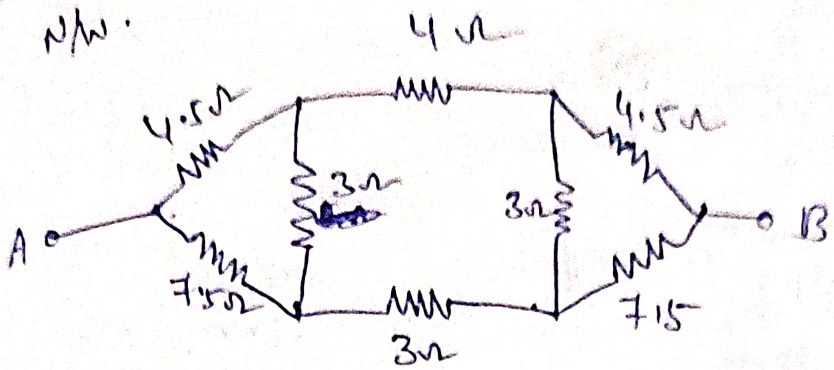
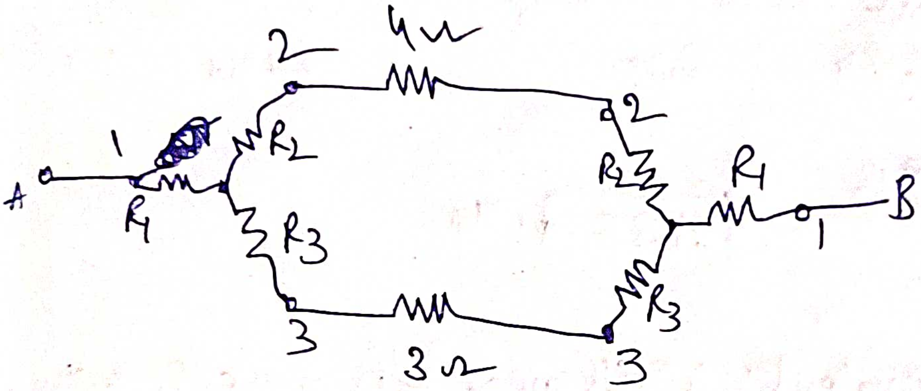
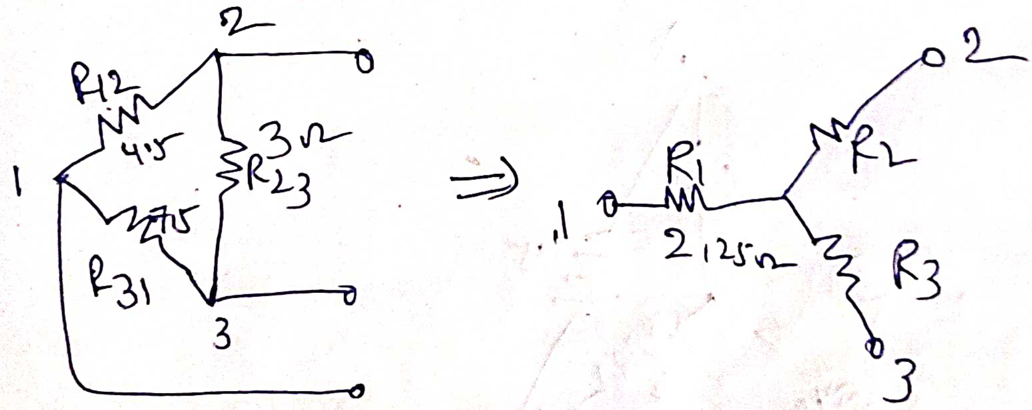


→ Find an equivalent resistance b/n A and B in the N/W.



Sol:- Step1:- Converting the two delta networks formed by resistors 4.5Ω, 3Ω, 7.5Ω into equivalent star connection.

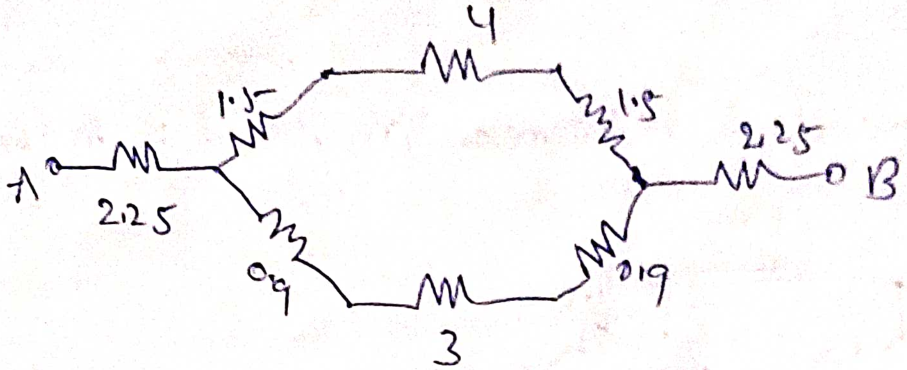




$$R_1 = \frac{R_{12} R_{31}}{R_{12}+R_{23}+R_{13}} = \frac{4.5 \times 7.5}{4.5+3+7.5} = 2.25\,\Omega$$

$$R_2 = \frac{R_{23} R_{21}}{R_{12}+R_{23}+R_{31}} = \frac{7.5 \times 3}{4.5+7.5+3} = 1.5\Omega$$

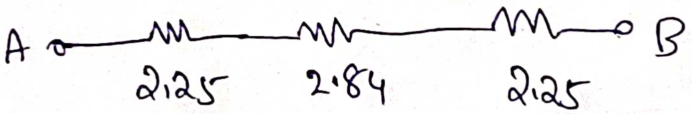
$$R_3 = \frac{R_{31} R_{23}}{R_{12}+R_{23}+R_{31}} = \frac{4.5 \times 3}{4.5+7.5+3} = 0.9\Omega$$



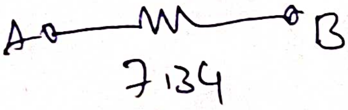
Step2:- Simplifying the N/W

4.0 + 1.5 + 1.5 = 7.0

0.9 + 0.9 + 3 = 4.8

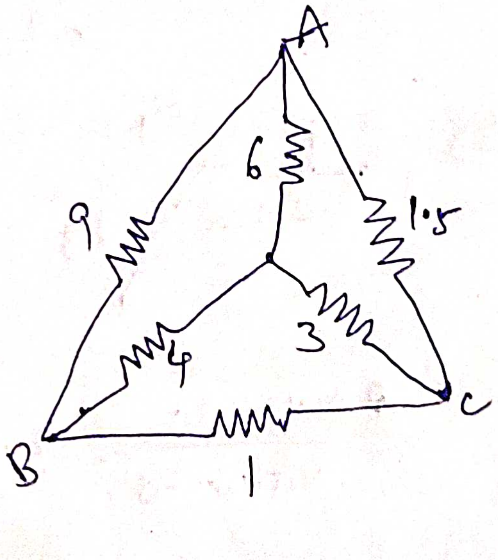


$$\frac{7 \times 4.8}{7+4.8} = \frac{33.6}{11.8} = 2.$$

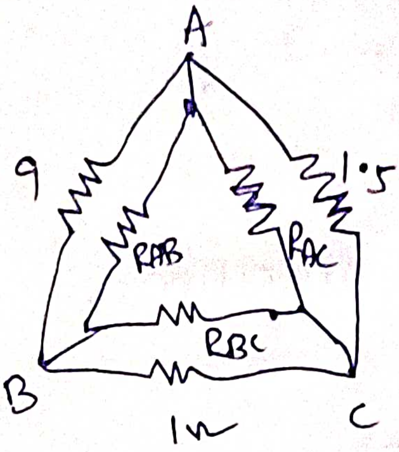


$R_{AB} = 7.34$

→ Find an equivalent resistance b/n A and B in the N/w



Step 1:- Converting the star N/W formed by resistors of 3Ω, 4Ω and 6Ω into an equivalent delta N/W



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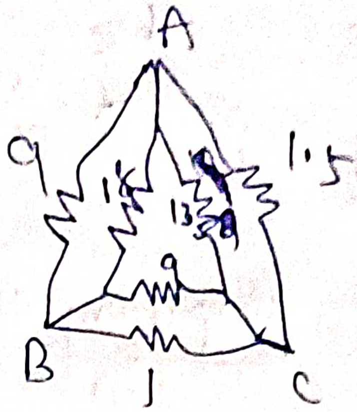
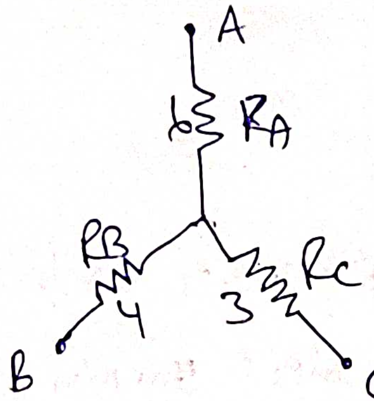




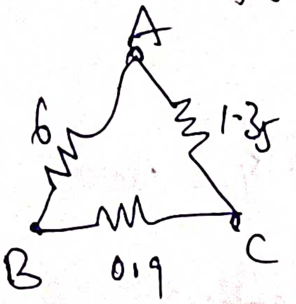
$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$= 6 + 4 + \frac{6 \times 4}{3} = 18\Omega$$

$$R_{BC} = R_B + R_C + \frac{R_B R_C}{R_A} = 9\Omega$$

$$R_{CA} = R_C + R_A + \frac{R_C R_A}{R_B} = 13.5$$

Step 2:- Simplifying the N/W.



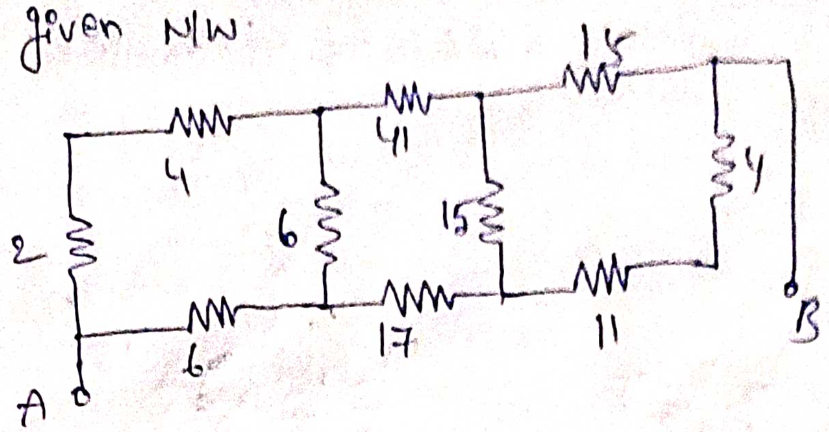
$$R_{AB} = \frac{9 \times 18}{9+18} = 6$$

$$R_{BC} = \frac{9 \times 1}{9+1} = 0.9$$

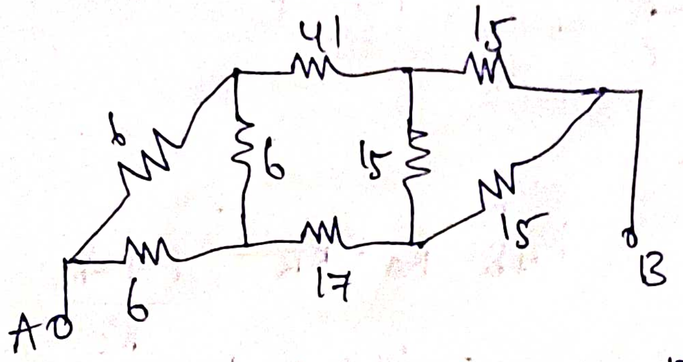
$$R_{CA} = \frac{1.5 \times 13.5}{1.5 + 13.5} = 1.35$$

$$R_{AB} = (1.35 + 0.9) \,//\, 6 = 1.64\Omega$$

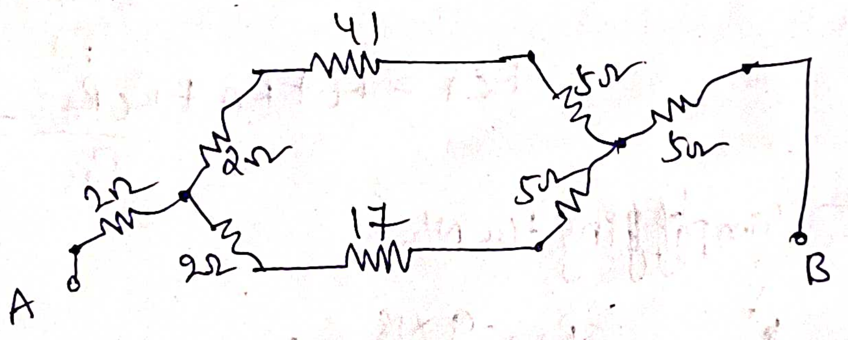
→ Find an equivalent resistance b/n A and B for the given N/W:



Step1:- simplifying the series connection

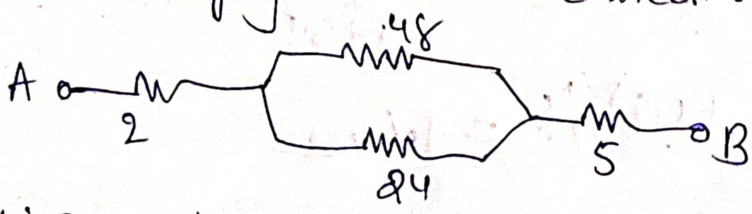


Step2:- Convert the Delta N/W forming of 6Ω, 6Ω and 6Ω and 15Ω, 15Ω and 15Ω into equivalent star N/W

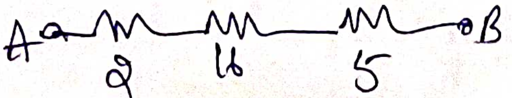


$R_1 = R_2 = R_3 = R/3 = 6/3 = 2\Omega$; $R_{\Delta 3} = 15/3 = 5\Omega$

Step3:- Simplifying the series connection

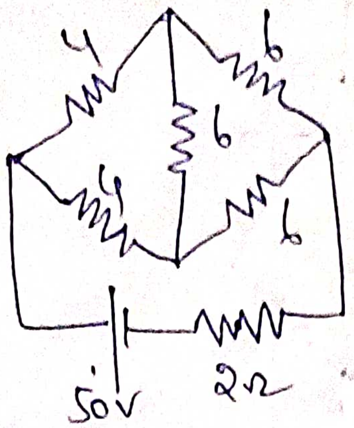


Step4:- simplifying the N/W.

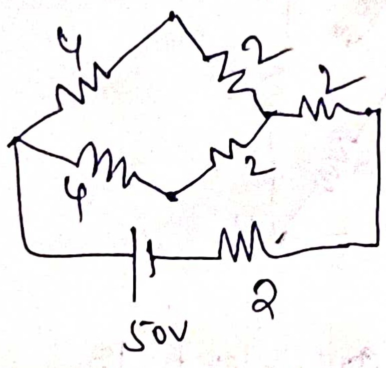


$R_{AB} = 23\Omega$

→ Determine the current supplied by the battery in the N/W.

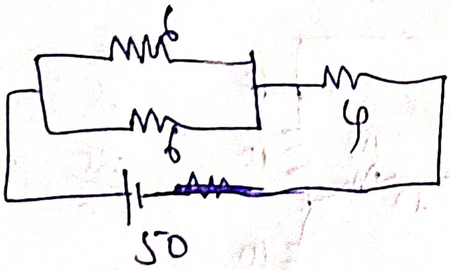


Step1:- Converting the Delta N/W formed by 6Ω resistors in to equivalent Star N/W.



$R_1 = R_2 = R_3 = R/3 = 6/3 = 2\Omega$

Step2:- Simplifying the N/W



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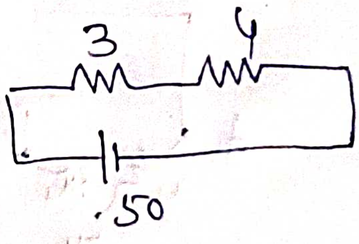
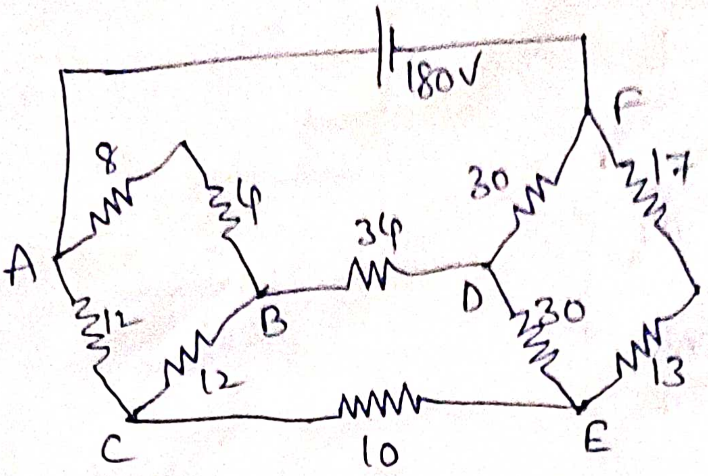
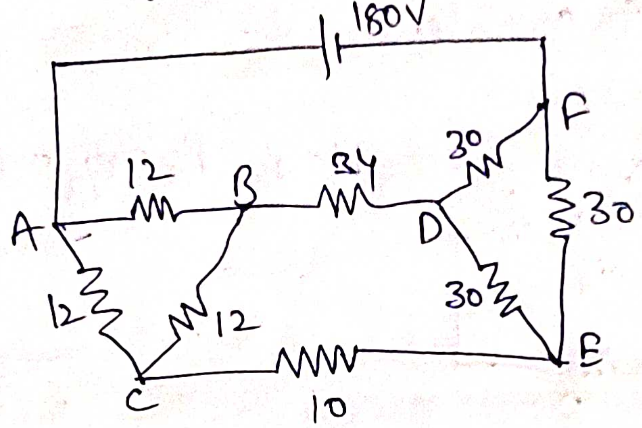


$$I = \frac{V}{R_{eq}} = \frac{50}{7} = 7.14A$$

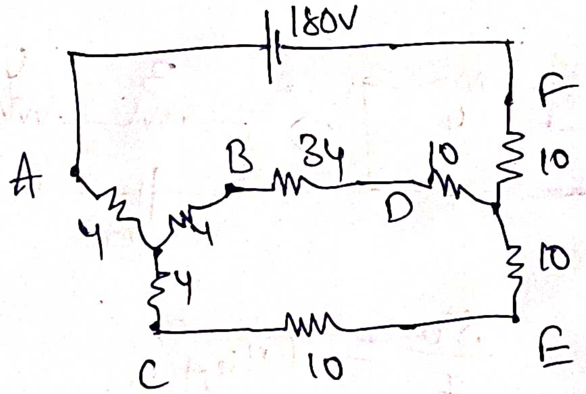
→ Calculate the current through the 10Ω resistor in given N/w:



Step1:- Simplifying the series connection



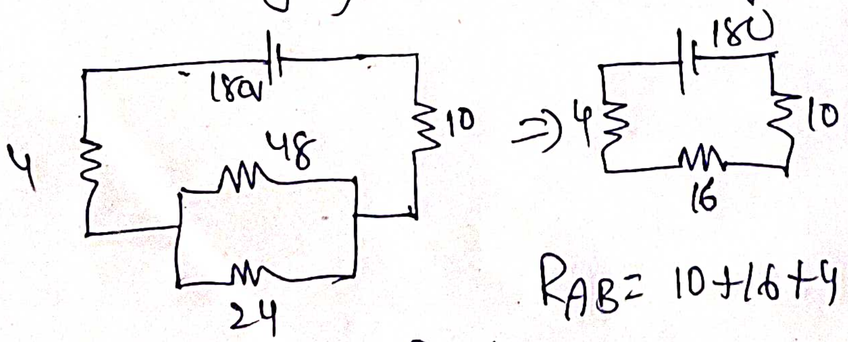
Step2:- converting the Delta equivalent formed by 12Ω resistors and 30Ω resistors into star N/w



$\frac{12}{3} = 4\Omega$

$\frac{30}{3} = 10\Omega$

Step3:- Simplifying the series and parallel connections



$R_{AB} = 10 + 16 + 4 = 30\Omega$

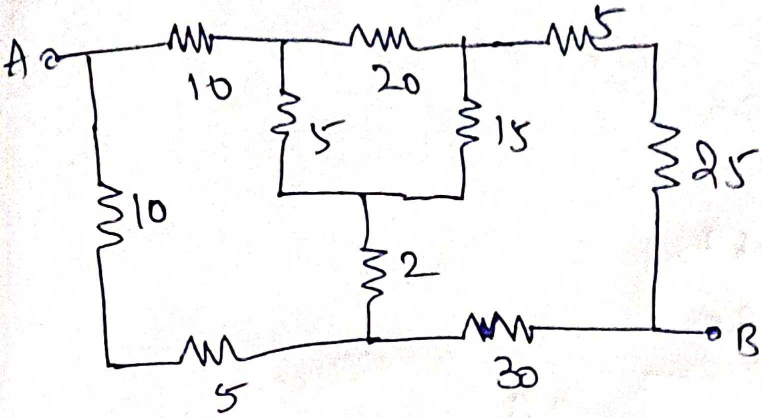
$I = \frac{180}{30} = 6A$

$I_{10\Omega} = I_{24\Omega}$

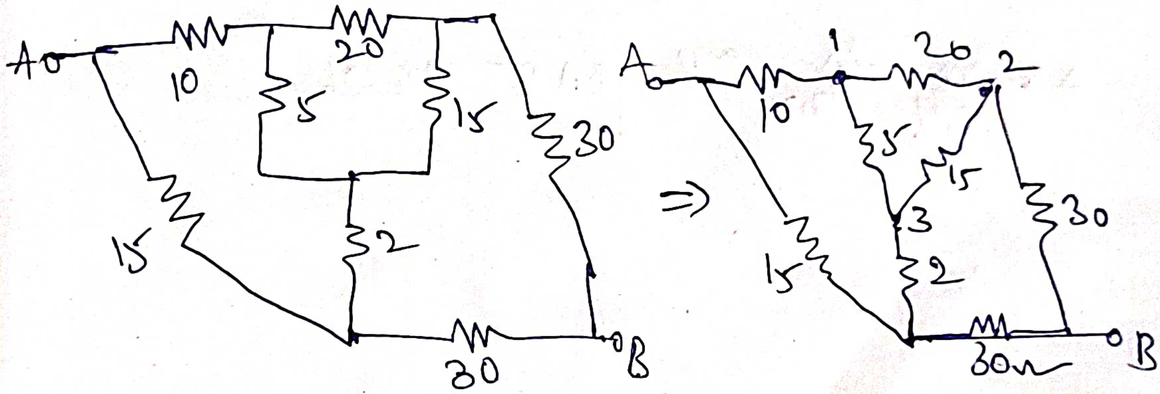
By current Division Rule

$$I_{24} = I_{10\Omega} = 6 \times \frac{48}{24+48} = 4A$$

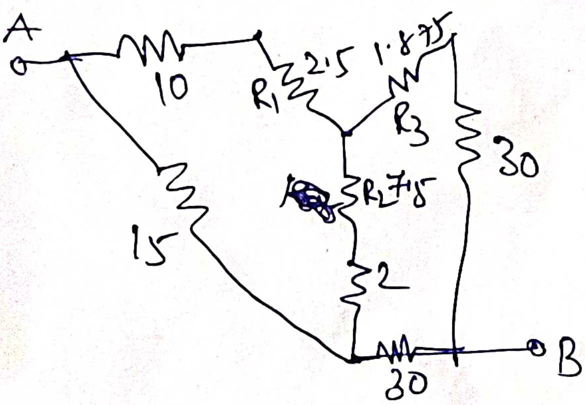
→ Find an equivalent resistance b/n A & B in the N/w.



Step1:- Simplify the series connection.



Step2:- Converting Delta connection formed by 20, 5, 15 Resistors into Star connection

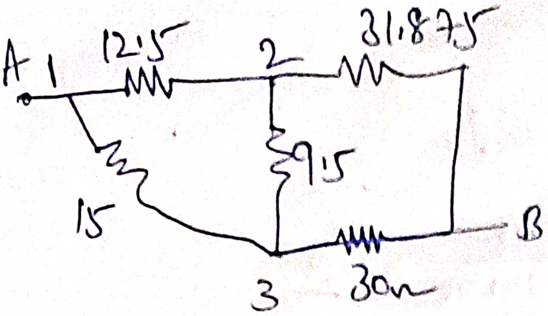


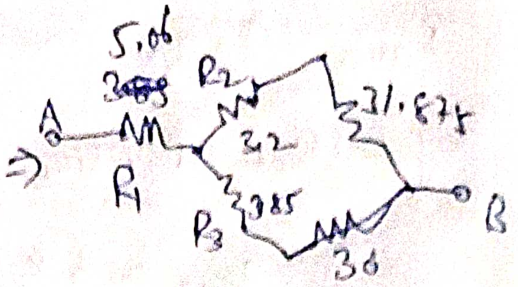
$$R_1 = \frac{R_{12} \times R_{31}}{R_{12}+R_{23}+R_{31}} = 2.5\Omega$$

$$R_2 = \frac{R_{23} \times R_{12}}{R_{12}+R_{23}+R_{31}} = \frac{15 \times 20}{15+20+5} = 7.5$$

$$R_3 = \frac{R_{31} \times R_{23}}{R_{12}+R_{23}+R_{31}} = 1.875$$

Step3:- Simplifying the ckt



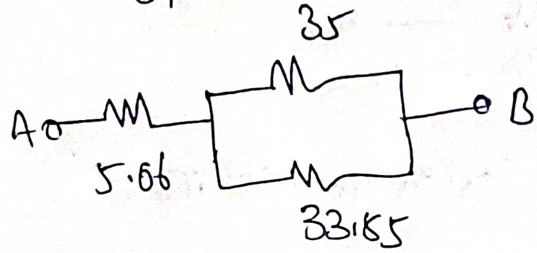


31.875
3.2
35.075

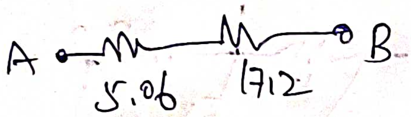
$$R_1 = \frac{12.5 \times 15}{12.5+15+9.5} = 5.06$$

$$R_2 = \frac{12.5 \times 9.5}{37} = 3.2$$

$$R_3 = \frac{15 \times 9.5}{37} = 3.87$$



$$\frac{35 \times 33.85}{35+33.85} = 17.2$$



$R_{AB} = 22.26\,\Omega$

Hence, power consumed by a purely capacitive circuit is zero.

Fig. 4.53 Power waveform

Example 4.49 *An ac circuit consists of a pure resistance of 10 ohms and is connected across an ac supply of 230 V, 50 Hz. Calculate (a) current, (b) power consumed, (c) power factor, and (d) write down the equations for voltage and current.*

Solution

$$R = 10\ \Omega,\quad V = 230\ \text{V},\quad f = 50\ \text{Hz}$$

(a) Current

$$I = \frac{V}{R} = \frac{230}{10} = 23\ \text{A}$$

(b) Power consumed

$$P = VI = 230 \times 23 = 5290\ \text{W}$$

(c) Power factor

Since the voltage and current are in phase with each other, $\phi = 0°$

$$\text{pf} = \cos\phi = \cos(0°) = 1$$

(d) Voltage and current equations

$$V_m = \sqrt{2}\,V = \sqrt{2} \times 230 = 325.27\ \text{V}$$

$$I_m = \sqrt{2}\,I = \sqrt{2} \times 23 = 32.53\ \text{A}$$

$$\omega = 2\pi f = 2\pi \times 50 = 314.16\ \text{rad/s}$$

$$v = V_m \sin\omega t = 325.27 \sin 314.16\,t$$

$$i = I_m \sin\omega t = 32.53 \sin 314.16\,t$$

Example 4.50 *An inductive coil having negligible resistance and 0.1 henry inductance is connected across a 200 V, 50 Hz supply. Find (a) inductive reactance, (b) rms value of current, (c) power, (d) power factor, and (e) equations for voltage and current.*

Solution

$$L = 0.1\text{ H},\quad V = 200\text{ V},\quad f = 50\text{ Hz}$$

(a) Inductive reactance

$$X_L = 2\pi f L = 2\pi \times 50 \times 0.1 = 31.42\ \Omega$$

(b) rms value of current

$$I = \frac{V}{X_L} = \frac{200}{31.42} = 6.37\text{ A}$$

(c) Power

Since the current lags behind the voltage by 90° in purely inductive circuit, $\phi = 90°$

$$P = VI\cos\phi = 200 \times 6.37 \times \cos(90°) = 0$$

(d) Power factor

$$\text{pf} = \cos\phi = \cos(90°) = 0$$

(e) Equations for voltage and current

$$V_m = \sqrt{2}\,V = \sqrt{2} \times 200 = 282.84\text{ V}$$

$$I_m = \sqrt{2}\,I = \sqrt{2} \times 6.37 = 9\text{ A}$$

$$\omega = 2\pi f = 2\pi \times 50 = 314.16\text{ rad/s}$$

$$v = V_m \sin\omega t = 282.84 \sin 314.16\,t$$

$$i = I_m \sin\left(\omega t - \frac{\pi}{2}\right) = 9\sin\left(314.16\,t - \frac{\pi}{2}\right)$$

Example 4.52 *A capacitor has a capacitance of 30 microfarads which is connected across a 230 V, 50 Hz supply. Find (a) capacitive reactance, (b) rms value of current, (c) power, (d) power factor, and (e) equations for voltage and current.*

Solution

$$C = 30\ \mu\text{F}, \quad V = 230\ \text{V}, \quad f = 50\ \text{Hz}$$

(a) Capacitive reactance

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 30 \times 10^{-6}} = 106.1\ \Omega$$

(b) rms value of current

$$I = \frac{V}{X_C} = \frac{230}{106.1} = 2.17\ \text{A}$$

(c) Power

Since the current leads the voltage by 90° in purely capacitive circuit, $\phi = 90°$

$$P = VI \cos \phi = 230 \times 2.17 \times \cos (90°) = 0$$

(d) Power factor

$$\text{pf} = \cos \phi = \cos (90°) = 0$$

(e) Equations for voltage and current

$$V_m = \sqrt{2}\ V = \sqrt{2} \times 230 = 325.27\ \text{V}$$

$$I_m = \sqrt{2}\ I = \sqrt{2} \times 2.17 = 3.07\ \text{A}$$

$$\omega = 2\pi f = 2\pi \times 50 = 314.16\ \text{rad/s}$$

$$v = V_m \sin \omega t = 325.27 \sin 314.16\, t$$

$$i = I_m \sin\left(\omega t + \frac{\pi}{2}\right) = 3.07 \sin\left(314.16\, t + \frac{\pi}{2}\right)$$

From power triangle, $\text{pf} = \dfrac{P}{S}$

In case of series *RL* circuit, the power factor is lagging in nature.

Example 4.53 *An alternating voltage of 80 + j60 V is applied to a circuit and the current flowing 4 − j2 A. Find the (a) impedance, (b) phase angle, (c) power factor, and (d) power consumed.*

Solution $\mathbf{V} = 80 + j\,60\text{ V}, \quad \mathbf{I} = 4 - j\,2\text{ A}$

(a) Impedance

$$\mathbf{Z} = \frac{\mathbf{V}}{\mathbf{I}} = \frac{80 + j60}{4 - j2} = \frac{100\angle 36.87°}{4.47\angle -26.56°} = 22.37\angle 63.43°\ \Omega$$

$$Z = 22.37\ \Omega$$

(b) Phase angle

$$\phi = 63.43°$$

(c) Power factor

$$\text{pf} = \cos\phi = \cos(63.43°) = 0.447 \text{ (lagging)}$$

(d) Power consumed

$$P = VI\cos\phi = 100 \times 4.47 \times 0.447 = 199.81\text{ W}$$

Example 4.54 *The voltage and current in a circuit are given by V = 150 ∠30° V and **I** = 2 ∠−15° A. If the circuit works on a 50 Hz supply, determine impedance, resistance, reactance, power factor and power loss considering the circuit as a simple series circuit.*

Solution $\mathbf{V} = 150\angle 30°\text{ V}, \quad \mathbf{I} = 2\angle -15°\text{ A}, \quad f = 50\text{ Hz}$

(a) Impedance

$$\mathbf{Z} = \frac{\mathbf{V}}{\mathbf{I}} = \frac{150\angle 30°}{2\angle -15°} = 75\angle 45°\ \Omega = 53.03 + j53.03\ \Omega$$

$$Z = 75\ \Omega$$

(b) Resistance

$$R = 53.03\ \Omega$$

(c) Reactance

$$X = 53.03\ \Omega$$

(d) Power factor

$$\phi = 45°$$

$$\text{pf} = \cos\phi = \cos(45°) = 0.707 \text{ (lagging)}$$

(e) Power loss

$$P = VI\cos\phi = 150 \times 2 \times 0.707 = 212.1\text{ W}$$

Example 4.55 *An rms voltage of 100 ∠0° V is applied to a series combination of Z_1 and Z_2 when $\mathbf{Z}_1 = 20\angle 30°\ \Omega$. The effective voltage drop across $\mathbf{Z}_1$ is known to be 40 ∠−30° V. Find the reactive component of $\mathbf{Z}_2$.*

In case of series RC circuit, the power factor is leading in nature.

Example 4.77 *The voltage applied to a circuit is $e = 100 \sin(\omega t + 30°)$ and the current flowing in the circuit is $i = 15 \sin(\omega t + 60°)$. Determine impedance, resistance, reactance, power factor and power.*

Solution

$$e = 100 \sin(\omega t + 30°), \quad i = 15 \sin(\omega t + 60°)$$

(a) Impedance

$$\mathbf{E} = \frac{100}{\sqrt{2}} \angle 30° \text{ V}$$

$$\mathbf{I} = \frac{15}{\sqrt{2}} \angle 60° \text{ A}$$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{I}} = \frac{\frac{100}{\sqrt{2}}\angle 30^\circ}{\frac{15}{\sqrt{2}}\angle 60^\circ} = 6.67\angle -30^\circ = 5.77 - j3.33 = R - jX_C$$

$$Z = 6.67\ \Omega$$

(b) Resistance

$$R = 5.77\ \Omega$$

(c) Reactance

$$X_C = 3.33\ \Omega$$

(d) Power factor

$$\text{pf} = \cos\phi = \cos(30)^\circ = 0.866\ (\text{leading})$$

(e) Power

$$P = EI\cos\phi = \frac{100}{\sqrt{2}} \times \frac{15}{\sqrt{2}} \times 0.866 = 649.5\ \text{W}$$

Example 4.78 *A series circuit consumes 2000 W at 0.5 leading power factor, when connected to 230 V, 50 Hz ac supply. Calculate (a) current, (b) kVA, and (c) kVAR.*

Solution

$$P = 2000\ \text{W}, \quad \text{pf} = 0.5\ (\text{leading}), \quad V = 230\ \text{V}$$

(a) Current

$$P = VI\cos\phi$$

$$2000 = 230 \times I \times 0.5$$

$$I = 17.39\ \text{A}$$

(b) Apparent power

$$S = VI = \frac{P}{\cos\phi} = \frac{2000}{0.5} = 4\text{kVA}$$

(c) Reactive power

$$\phi = \cos^{-1}(0.5) = 60^\circ$$

$$Q = VI\sin\phi = 230 \times 17.39 \times \sin(60^\circ) = 3.464\ \text{kVAR}$$

$$pf = \frac{\quad}{V} = \frac{\quad}{Z} = \frac{\quad}{S}$$

Example 4.83 *A resistor of 20 Ω, inductor of 0.05 H and a capacitor of 50 μF are connected in series as shown in Fig. 4.81. A supply voltage 230 V, 50 Hz is connected across the series combination. Calculate the following: (a) impedance, (b) current drawn by the circuit, (c) phase difference and power factor and (d) active and reactive power consumed by the circuit.*

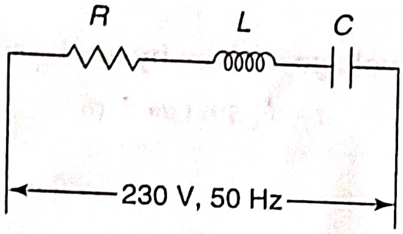


Fig. 4.81

Solution

$$R = 20\ \Omega,\quad L = 0.05\ \text{H},\quad C = 50\ \mu\text{F},\quad V = 230\ \text{V},\quad f = 50\ \text{Hz}$$

(a) Impedance

$$X_L = 2\pi fL = 2\pi \times 50 \times 0.05 = 15.71\ \Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 50 \times 10^{-6}} = 63.66\ \Omega$$

$$\mathbf{Z} = R + jX_L - jX_C = 20 + j15.71 - j63.66 = 51.95\ \angle -67.36°\ \Omega$$

$$Z = 51.95\ \Omega$$

(b) Phase difference

$$\phi = 67.36°$$

(c) Current

$$I = \frac{V}{Z} = \frac{230}{51.95} = 4.43\ \text{A}$$

(d) Power factor

$$\text{pf} = \cos\phi = \cos(67.36°) = 0.385\ \text{(leading)}$$

(e) Active power

$$P = VI\cos\phi = 230 \times 4.43 \times 0.385 = 392.28\ \text{W}$$

(f) Reactive power

$$Q = VI\sin\phi = 230 \times 4.43 \times \sin(67.36°) = 940.39\ \text{VAR}$$

Example 4.84 *A circuit consists of a pure resistor, a pure inductor, and a capacitor connected in series as shown in Fig. 4.82. When the circuit is supplied with 100 V, 50 Hz supply, the voltages across inductor and resistor are 240 V and 90 V respectively. If the circuit takes a 10 A leading current, calculate (a) value of inductance, resistance and capacitance, (b) power factor of the circuit, and (c) voltage across the capacitor.*

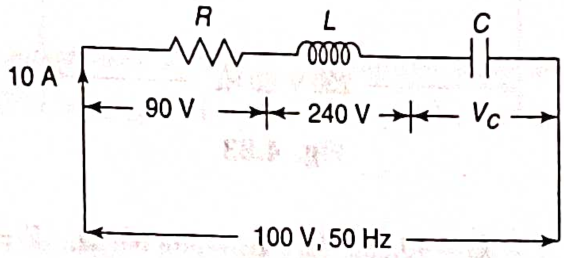


Fig. 4.82

Solution $V = 100$ V, $f = 50$ Hz, $V_L = 240$ V, $V_R = 90$ V, $I = 10$ A

(a) Value of inductance, resistance and capacitance

$$R = \frac{V_R}{I} = \frac{90}{10} = 9\ \Omega$$

$$X_L = \frac{V_L}{I} = \frac{240}{10} = 24\ \Omega$$

$$Z = \frac{V}{I} = \frac{100}{10} = 10\ \Omega$$

$$\mathbf{Z} = R + jX_L - jX_C = R - j(X_C - X_L)$$

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

$$10 = \sqrt{(9)^2 + (X_C - 24)^2}$$

$$X_C = 28.36\ \Omega$$

$$X_L = 2\pi fL$$

$$24 = 2\pi \times 50 \times L$$

$$L = 0.076\ H$$

$$X_C = \frac{1}{2\pi fC}$$

$$28.36 = \frac{1}{2\pi \times 50 \times C}$$

$$C = 112.24\ \mu\text{F}$$

(b) Power factor of the circuit

$$\text{pf} = \frac{R}{Z} = \frac{9}{10} = 0.9\ \text{(leading)}$$

(c) Voltage across the capacitor

$$V_C = X_C I = 28.36 \times 10 = 283.6\ \text{V}$$

Example 7.1 *The combined inductance of two coils connected in series is 0.6 H or 0.1 H depending on relative directions of currents in the two coils. If one of the coils has a self-inductance of 0.2 H, find (a) mutual inductance, and (b) coefficient of coupling.*

Solution

$$L_1 = 0.2\,\text{H}, \quad L_{diff} = 0.1\,\text{H}, \quad L_{cum} = 0.6\,\text{H}$$

(a) Mutual inductance

$$L_{cum} = L_1 + L_2 + 2M = 0.6 \quad \text{...(i)}$$

$$L_{diff} = L_1 + L_2 - 2M = 0.1 \quad \text{...(ii)}$$

Adding Eqs (i) and (ii),

$$2(L_1 + L_2) = 0.7$$

$$L_1 + L_2 = 0.35$$

$$L_2 = 0.35 - 0.2 = 0.15\,\text{H}$$

Subtracting Eqs (ii) from Eqs (i),

$$4M = 0.5$$
$$M = 0.125 \text{ H}$$

(b) Coefficient of coupling

$$k = \frac{M}{\sqrt{L_1 L_2}} = \frac{0.125}{\sqrt{0.2 \times 0.15}} = 0.72$$

Example 7.2 *Two coils with a coefficient of coupling of 0.6 between them are connected in series so as to magnetise in (a) same direction, and (b) opposite direction. The total inductance in the same direction is 1.5 H and in the opposite direction is 0.5 H. Find the self-inductance of the coils.*

Solution

$$k = 0.6, \quad L_{\text{diff}} = 0.5 \text{ H}, \quad L_{\text{cum}} = 1.5 \text{ H}$$

$$L_{\text{diff}} = L_1 + L_2 - 2M = 0.5 \qquad \text{...(i)}$$
$$L_{\text{cum}} = L_1 + L_2 + 2M = 1.5 \qquad \text{...(ii)}$$

Subtracting Eq. (i) from Eq. (ii),

$$4M = 1$$
$$M = 0.25 \text{ H}$$

Adding Eq. (i) and (ii),

$$2(L_1 + L_2) = 2$$
$$L_1 + L_2 = 1 \qquad \text{...(iii)}$$
$$k = \frac{M}{\sqrt{L_1 L_2}}$$
$$0.6 = \frac{0.25}{\sqrt{L_1 L_2}}$$
$$L_1 L_2 = 0.1736 \qquad \text{...(iv)}$$

Solving Eqs (iii) and (iv),

$$L_1 = 0.22 \text{ H}$$
$$L_2 = 0.78 \text{ H}$$

Example 7.9 *Find the equivalent inductance of the network shown in Fig. 7.20.*

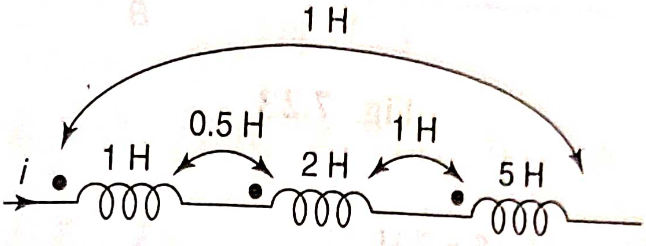


Fig. 7.20

ion

$$L = (L_1 + M_{12} + M_{13}) + (L_2 + M_{23} + M_{21}) + (L_3 + M_{31} + M_{32})$$
$$= (1 + 0.5 + 1) + (2 + 1 + 0.5) + (5 + 1 + 1)$$
$$= 13\text{ H}$$

mple 7.10 *Find the equivalent inductance of the network shown in Fig. 7.21.*

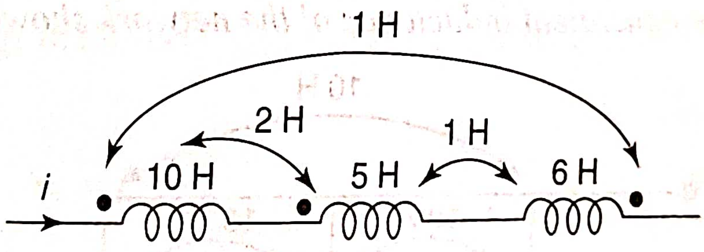


Fig. 7.21

$$L = (L_1 + M_{12} - M_{13}) + (L_2 - M_{23} + M_{21}) + (L_3 - M_{31} - M_{23})$$
$$= (10 + 2 - 1) + (5 - 1 + 2) + (6 - 1 - 1) = 21\text{ H}$$

Example 7.11 *Find the equivalent inductance of the network shown in Fig. 7.22.*

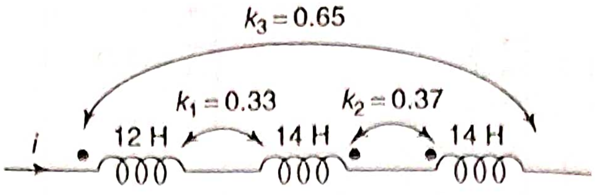


Fig. 7.22

Solution

$$M_{12} = M_{21} = k_1\sqrt{L_1L_2} = 0.33\sqrt{(12)(14)} = 4.28\text{ H}$$

$$M_{23} = M_{32} = k_2\sqrt{L_2L_3} = 0.37\sqrt{(14)(14)} = 5.18\text{ H}$$

$$M_{31} = M_{13} = k_3\sqrt{L_3L_1} = 0.65\sqrt{(12)(14)} = 8.42\text{ H}$$

$$L = (L_1 - M_{12} + M_{13}) + (L_2 - M_{23} - M_{21}) + (L_3 + M_{31} - M_{32})$$

$$= (12 - 4.28 + 8.42) + (14 - 5.18 - 4.28) + (14 + 8.42 - 5.18)$$

$$= 37.92\text{ H}$$

Example 7.12 *Find the equivalent inductance of the network shown in Fig. 7.23.*

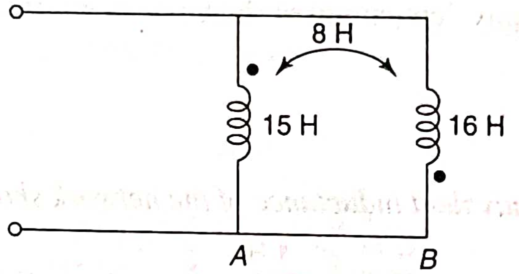


Fig. 7.23

Solution For Coil A,

$$L_A = L_1 - M_{12} = 15 - 8 = 7\text{ H}$$

For Coil B,

$$L_B = L_2 - M_{12} = 16 - 8 = 8\text{ H}$$

$$\frac{1}{L} = \frac{1}{L_A} + \frac{1}{L_B} = \frac{1}{7} + \frac{1}{8} = \frac{15}{56}$$

$$L = \frac{56}{15} = 3.73\text{ H}$$

Example 7.13 *Find the equivalent inductance of the network shown in Fig. 7.24.*

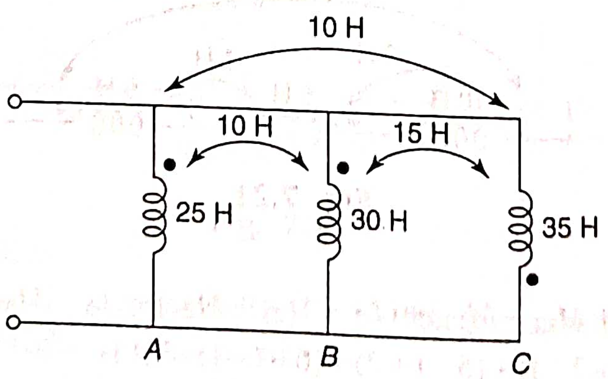


Fig. 7.24

Solution For Coil A,

$$L_A = L_1 + M_{12} - M_{13} = 25 + 10 - 10 = 25\text{ H}$$

For Coil B,

$$L_B = L_2 - M_{23} + M_{21} = 35 - 15 + 10 = 25\text{ H}$$

For Coil C,

$$L_C = L_3 - M_{32} - M_{31} = 35 - 15 - 10 = 10\text{ H}$$

$$\frac{1}{L} = \frac{1}{L_A} + \frac{1}{L_B} + \frac{1}{L_C} = \frac{1}{25} + \frac{1}{25} + \frac{1}{10} = \frac{9}{50}$$

$$L = \frac{50}{9} = 5.55\text{ H}$$

Example 7.14 *Find the equivalent impedance across the terminals A and B in Fig. 7.25.*

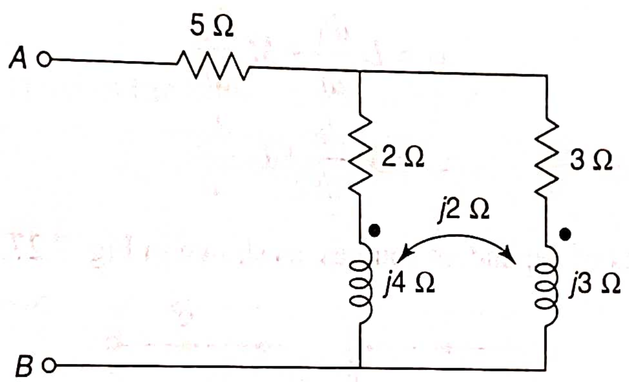


Fig. 7.25

Solution

$$\mathbf{Z}_1 = 5\,\Omega,\quad \mathbf{Z}_2 = (2 + j4)\,\Omega,\quad \mathbf{Z}_3 = (3 + j3)\,\Omega,\quad \mathbf{Z}_M = j2\,\Omega$$

$$\mathbf{Z} = \mathbf{Z}_1 + \frac{\mathbf{Z}_2\mathbf{Z}_3 - \mathbf{Z}_M^2}{\mathbf{Z}_2 + \mathbf{Z}_3 - 2\mathbf{Z}_M} = 5 + \frac{(2 + j4)(3 + j3) - (j2)^2}{2 + j4 + 3 + j3 - 2(j2)} = 6.9\angle 24.16^\circ\,\Omega$$