EEE 1001

Digital Assignment - 1

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19BCE2105

Slot- A1 ; SJT 322

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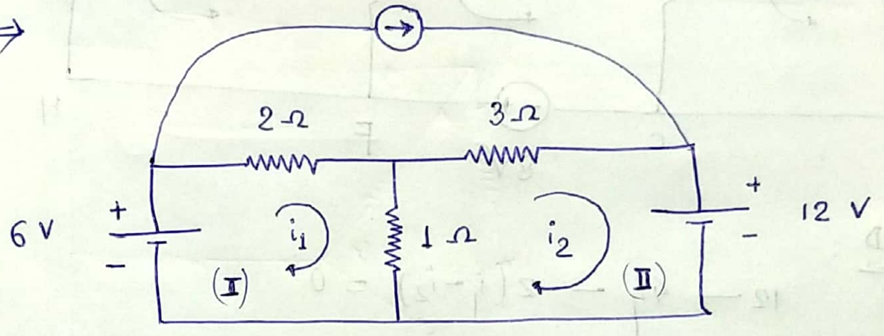
by Sharadindu Adhikari

Q1. For the circuit shown in figure, find the current in different branches of resistors.

⟹ 

We have,

$$6 - 2(i_1 - 2) - 1(i_1 - i_2) = 0$$

$$-1(i_2 - i_1) - 3(i_2 - 2) - 12 = 0$$

$\therefore\ 6 - 2i_1 + 4 - i_1 + i_2 = 0$

$\Rightarrow 6 - 3i_1 + 4 + i_2 = 0$

$\boxed{i_2 - 3i_1 = -10}$ — (i)

Ily, $-i_2 + i_1 - 3i_2 + 6 - 12 = 0$

$\Rightarrow \boxed{-4i_2 + i_1 = 6}$ — (ii)

Solving eqn (i) and (ii), we get: $i_1 = 3.090$ A

$i_2 = -0.727$ A

$\therefore\ i_{2\Omega} = -(i_1 - 2)$

$= -(3.090 - 2)$ A

$\Rightarrow \boxed{i_{2\Omega} = -1.09 \text{ A}}$

and, $i_{1\Omega}$

$= -1(i_1 - i_2)$

$= -1(3.090 + 0.727)$ A

$\therefore$ $\boxed{i_{1\Omega} = -3.817 \text{ A}}$

Ily, $i_{3\Omega} = -3(i_2 - 2)$

$= -3(-0.727 - 2)$ A

$\Rightarrow i_{3\Omega} = 2.$

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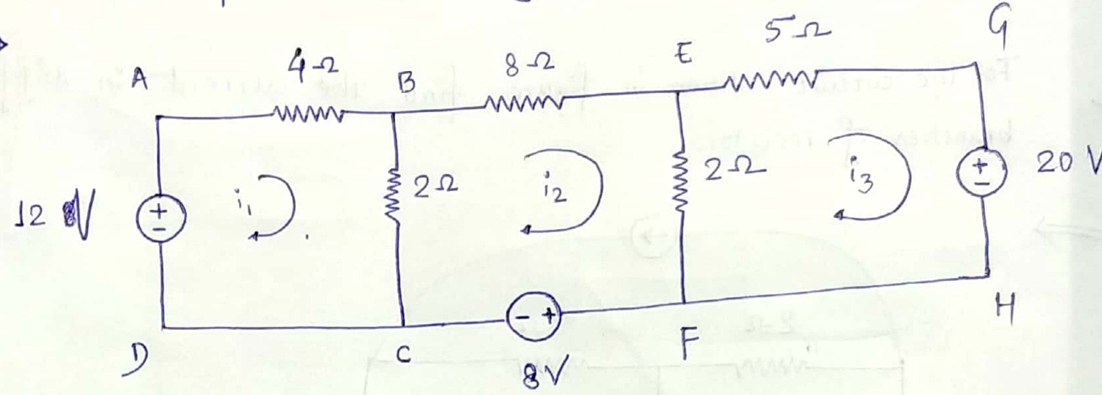
Q.2. For the circuit shown in figure, find the mesh currents and the power observed by the 8 Ω resistor.

$\Rightarrow$



Loop ABCD:

$$12 - 4i_1 - 2(i_1 - i_2) = 0$$

$$\Rightarrow 12 - 6i_1 + 2i_2 = 0$$

$$\Rightarrow 3i_1 - i_2 = 6 \quad \text{——— [1]}$$

Loop BEFC:

$$-2(i_2 - i_1) - 8i_2 - (i_2 - i_3)\cdot 2 - 8 = 0$$

$$\Rightarrow -12i_2 + 2i_1 + 2i_3 = 8$$

$$\Rightarrow i_1 - 6i_2 + i_3 = 4 \quad \text{——— [2]}$$

Loop EGHF:

$$-(i_3 - i_2)\cdot 2 - 5i_3 - 20 = 0$$

$$\Rightarrow 2i_2 - 7i_3 = 20 \quad \text{——— [3]}$$

Solving eqn's [1], [2], & [3], we get:

$i_1 = 1.699$ A ; $i_2 = -0.902$ A

$i_3 = -3.115$ A.

$\therefore$ power across 8 Ω resistor,

$$P_{8\Omega} = i_2^2 \cdot R$$

$$= (-0.902)^2 \times 8 \text{ W}$$

$$\boxed{P = 6.508 \text{ W}}$$

ans.

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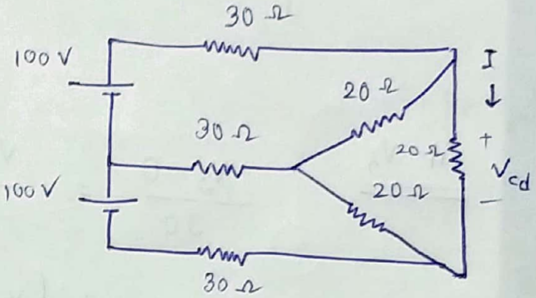
Q3.

Source transform the voltage sources and find the nodal voltages using nodal analysis for the circuit in the figure. Also, find V_{cd} and I.



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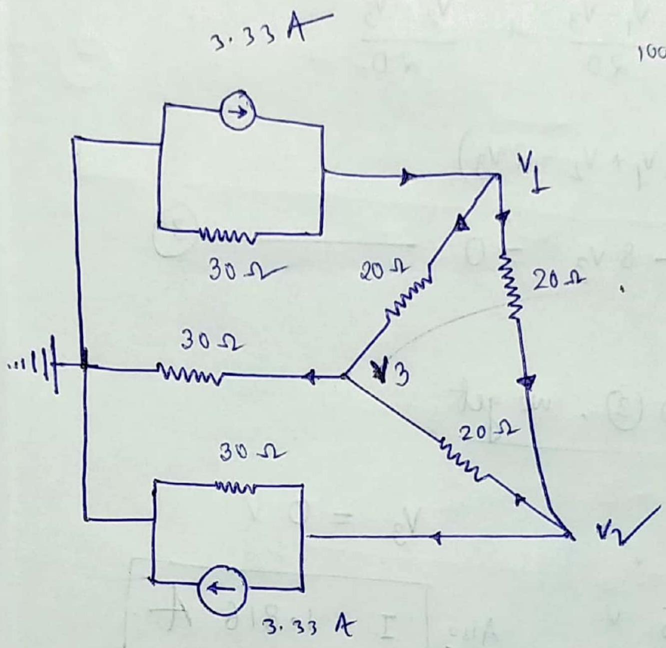

At V_1:

$$3.33 + \left(\frac{0-V_1}{30}\right) = \left(\frac{V_1-V_3}{20}\right) + \left(\frac{V_1-V_2}{20}\right)$$

$$\Rightarrow 33.3 - \frac{V_1}{3} = \frac{2V_1 - V_3 - V_2}{2}$$

$$\Rightarrow (99.9 - V_1)\,2 = 3(2V_1 - V_3 - V_2)$$

$$\Rightarrow 199.8 - 2V_1 = 6V_1 - 3V_3 - 3V_2$$

$$\Rightarrow 8V_1 - 3V_2 - 3V_3 = 199.8 \quad \text{——— (1)}$$

At V_2:

$$\frac{V_1-V_2}{20} = \frac{V_2-V_3}{20} + 3.33 + \frac{V_2-0}{30}$$

$$\Rightarrow \frac{V_1-V_2}{2} = \frac{V_2-V_3}{2} + 33.3 + \frac{V_2}{3}$$

$$\Rightarrow \frac{V_1-V_2}{\cancel{2}} = \frac{3V_2 - 3V_3 + 199.8 + 2V_2}{3\,\cancel{6}}$$

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$$\Rightarrow 3V_1 - 3V_2 = 5V_2 - 3V_3 + 199.8$$

$$\Rightarrow 3V_1 - 8V_2 + 3V_3 = 199.8 \quad \text{——— (2)}$$

At V_3 :

$$\frac{V_3 - 0}{30} = \frac{V_1 - V_3}{20} + \frac{V_2 - V_3}{20}$$

$$\Rightarrow 2V_3 = 3(V_1 + V_2 - 2V_3)$$

$$\Rightarrow 3V_1 + 3V_2 - 8V_3 = 0 \quad \text{——— (3)}$$

Solving eq^{n}s (1), (2), and (3), we get

$V_1 = 18.16$ ✓ $\qquad V_3 = 0$ V

$V_2 = -18.16$ V $\qquad$ Also $\boxed{I = 1.816\ A.}$

$$V_{cd} = V_1 - V_2$$

$$= 18.16 - (-18.16)$$ ✓

$$\boxed{\therefore V_{cd} = 36.32 \text{ V}}$$

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Q4. Apply mesh analysis to find i in the circuit shown in the figure.

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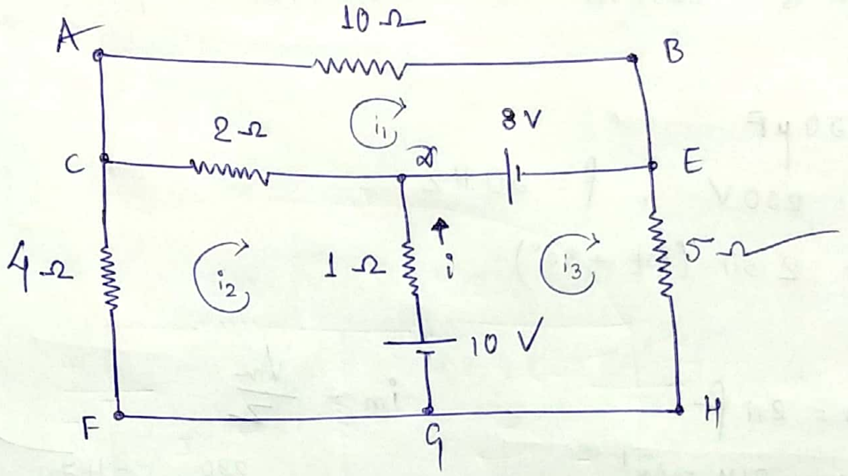

In Loop ABEC,

$$-10 i_1 + 8 - 2(i_1 - i_2) = 0$$

$$\Rightarrow 6 i_1 - i_2 = 4 \quad \text{—— (1)}$$

In Loop FCDG,

$$-4 i_2 - (i_2 - i_1)2 - (i_2 - i_3) - 10 = 0$$

$$\Rightarrow 2 i_1 - 7 i_2 + i_3 = 10 \quad \text{—— (2)}$$

In Loop GDEM,

$$10 - (i_3 - i_2) - 8 - 5 i_3 = 0$$

$$\Rightarrow i_2 - 6 i_3 = -2 \quad \text{—— (3)}$$

Solving (1), (2), & (3), we've

$i_1 = 0.453$ A

$i_2 = -1.282$ A

$i_3 = 0.119$

$\therefore i = i_3 - i_2$

$$\boxed{i = 1.401 \text{ A}}$$ ans.

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Q5. A coil of resistance $R\ \Omega$ and inductance L henrys is connected in series with a $50\ \mu F$ capacitor. If the supply voltage is $230\ V$ at $50\ Hz$ and the current flowing in the circuit is $2\angle 30°A$, determine the different parameters :—

→

$C = 50\ \mu F$

$V_m = 230V$, $f = 50\ Hz$

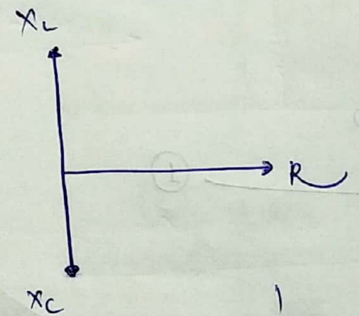
$i = 2 \sin(\omega t + 30°)$

(i) $\omega = 2\pi f$

$\Rightarrow \omega = 314\ rad s^{-1}$

$i_m = \frac{V_m}{Z}$

$\Rightarrow Z = \frac{230}{2} = 115$



$\phi = 30°$

$\tan \phi = \frac{X_L - X_C}{R}$

$\Rightarrow X_L - X_C = R/\sqrt{3}$

$X_C = \frac{1}{\omega C} = 63.7$

$Z^2 = R^2 + (X_L - X_C)^2$

$\Rightarrow Z^2 = R^2 + (R/\sqrt{3})^2$

$\Rightarrow (115)^2 = R^2 + \frac{R^2}{3}$

$\Rightarrow R^2 = (115)^2 \times 3/4$

$\Rightarrow \boxed{R = 99.6\ \Omega}$

$X_L = X_C + \frac{R}{\sqrt{3}} = 121.20$

$\Rightarrow \omega L = 121.20$

$\Rightarrow L = \frac{121.20}{314}$

$\boxed{\therefore\ L = 0.386\ H}$

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(ii) $v_L = i X_L$

$= 2 \times 121.2 \times \sin(314t + 30^\circ)$

$= 242.2 \sin(314t + 30^\circ)$

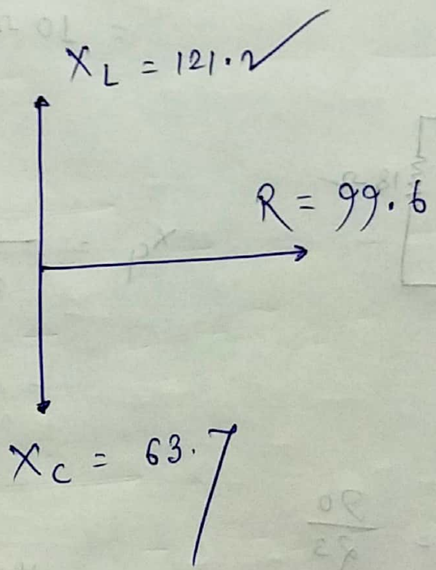
(iii) $V_c = i X_c$

$= 63.7 \times 2 \times \sin(314t + 30^\circ)$

$= 127.4 \sin(314t + 30^\circ)$

(iv) $\phi = 30^\circ$

(v)



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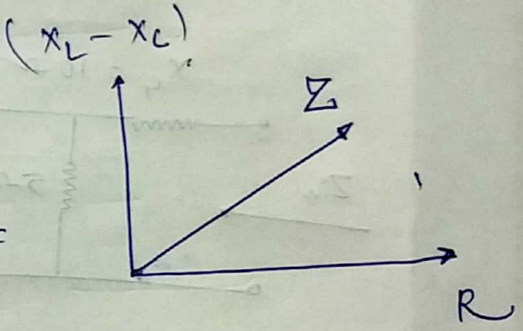

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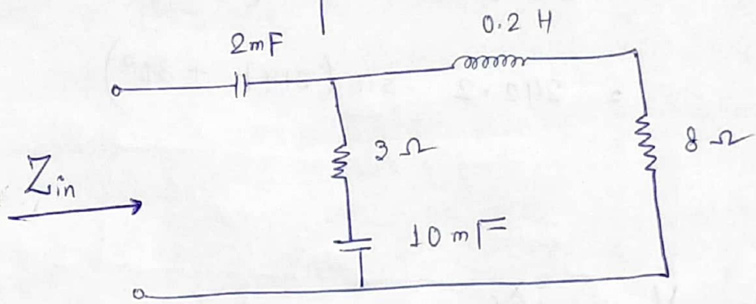
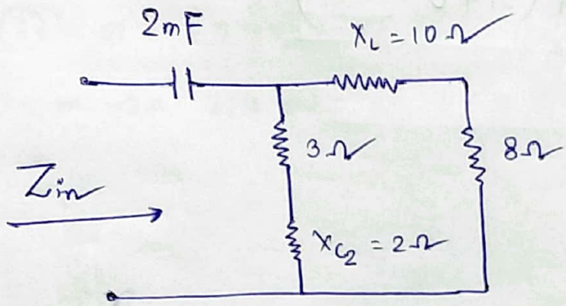
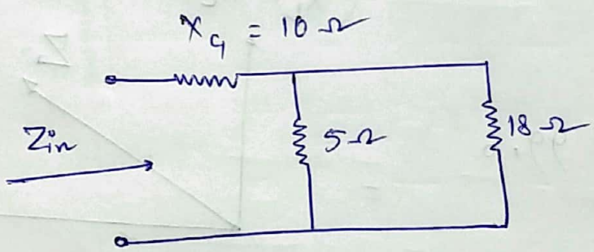
Q6. Find the input impedance of the circuit shown in figure. Assume that the circuit operates at $\omega = 50 \text{ rad } s^{-1}$.



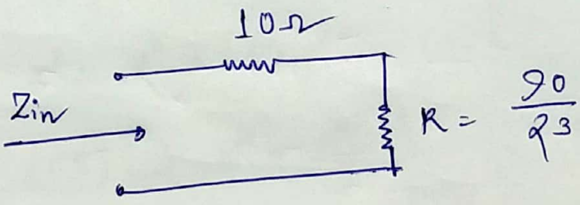


$$X_{c_2} = \frac{10^3}{10 \times 50} \ \Omega = 2 \ \Omega$$

$$X_L = 0.2 \times 50 \ \Omega = 10 \ \Omega$$



$$X_{c_1} = \frac{10^3}{2 \times 50} \ \Omega = 10 \ \Omega$$

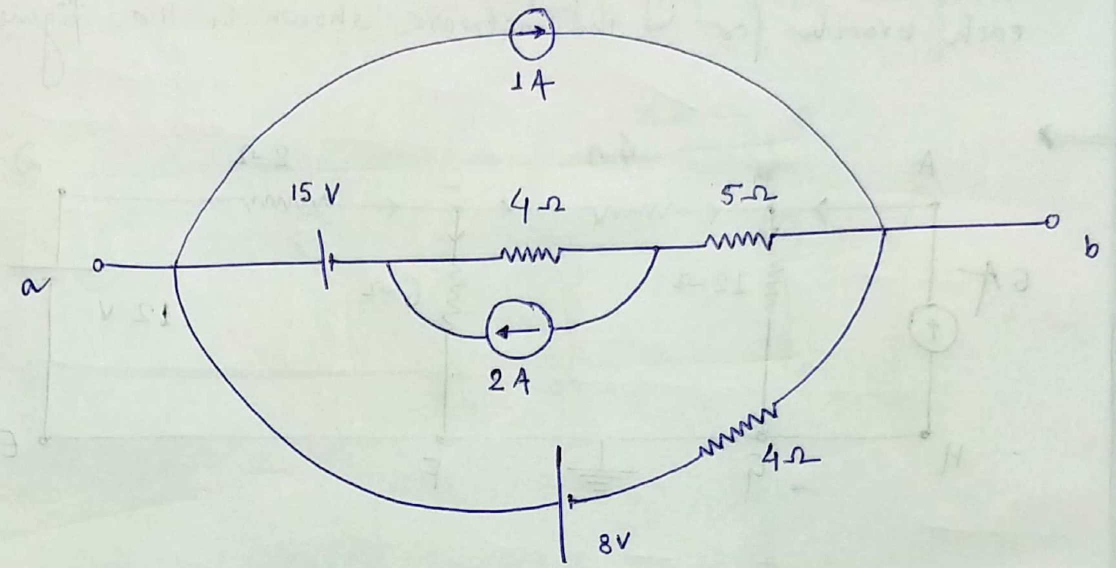


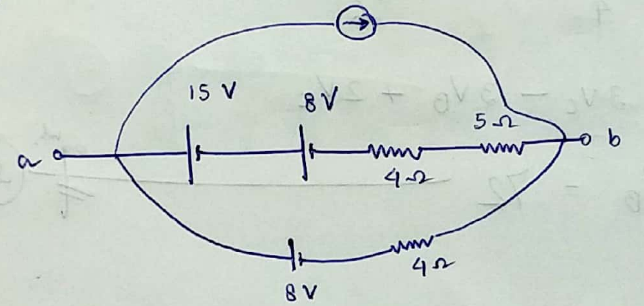
$$R = \frac{18 \times 5}{18 + 5} \ \Omega = \frac{90}{23} \ \Omega$$

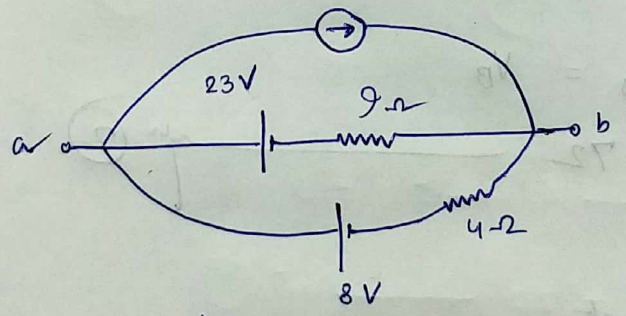
$$\therefore Z_{in} = 10 + \frac{90}{23} \ \Omega$$

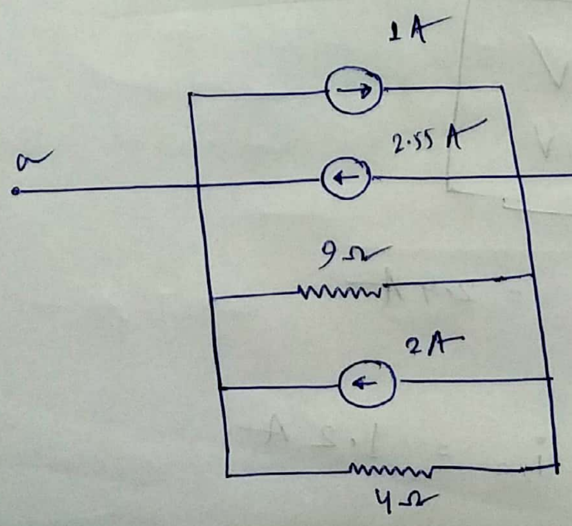
$$= 13.91 \ \Omega \quad \text{ans}$$

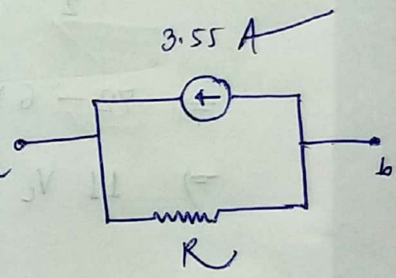
Q7. Find the Thevenin's equivalent circuit for the circuit :—











$$R = \frac{9 \times 4}{9 + 4} = \frac{36}{13}\,\Omega$$

$$R = 2.77\,\Omega$$

$$V_{Th} = 3.55 \times 2.77$$

$$\therefore \boxed{V_{Th} = 9.8335\ V}$$

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Q.9. Write the node voltage equations and determine the currents in each branch for the network shown in the figure.

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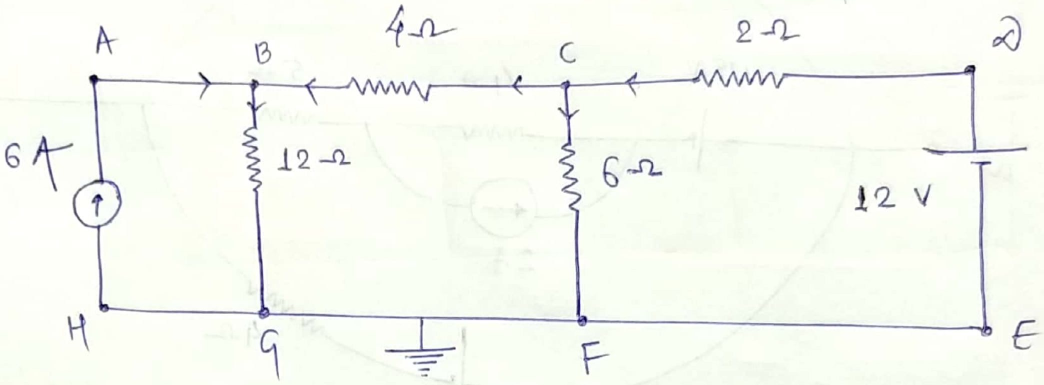

At C

$$\frac{12 - V_C}{2} = \frac{V_C - V_B}{4} = \frac{V_C - 0}{6}$$

$\Rightarrow 72 - 6V_C = 3V_C - 3V_B + 2V_C$

$\Rightarrow 11V_C - 3V_B = 72$ ——— eq^ns. (1)

At B.

$$6 + \frac{V_C - V_B}{4} = \frac{V_B - 0}{12}$$

$\Rightarrow 72 + 3V_C - 3V_B = V_B$

$\Rightarrow 4V_B - 3V_C = 72$ ——— eq^n (2)

Solving eq^ns. (1) and (2), we get,

$$\boxed{\begin{aligned} V_B &= 28.8 \text{ V} \\ V_C &= 14.4 \text{ V} \end{aligned}}$$

$i_{12\Omega} = \frac{V_B - 0}{12} = \frac{28.8}{12} = 2.4$ A

$i_{4\Omega} = 3.6$ A

$i_{6\Omega} = 2.4$ A and $i_{2\Omega} = 1.2$ A

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Q.10. Verify the Kirchoff's Law both (KCL and KVL) for the circuit shown in figure by mesh and nodal analysis.

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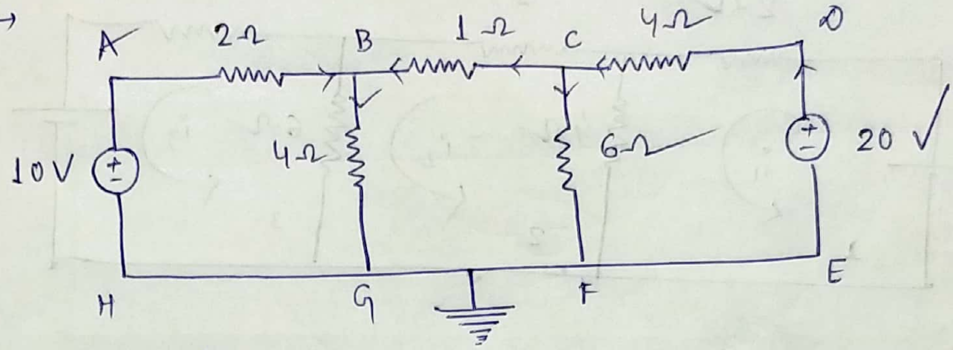

Nodal analysis :-

At B :

$$\frac{10 - V_B}{2} + \frac{V_C - V_B}{1} = \frac{V_B - 0}{4}$$

$$\Rightarrow 20 - 2V_B + 4V_C - 4V_B = V_B$$

$$\Rightarrow 7V_B - 4V_C = 20 \qquad \text{eq}^n \ (1)$$

At C :-

$$\frac{20 - V_C}{4} = \frac{V_C - V_B}{1} + \frac{V_C - 0}{6}$$

$$\Rightarrow 60 - 3V_C = 12V_C - 12V_B + 2V_C$$

$$\Rightarrow -12V_B + 17V_C = 60 \qquad \text{eq}^n \ (2)$$

Solving eq$^{n^s}$ (1) & (2),

$$\boxed{\begin{aligned} V_B &= 8.17\ V \\ V_C &= 9.29\ V \end{aligned}}$$

$i_{2\Omega} = 0.91\ A$

$i_{1\Omega} = 1.12\ A$

$i_{4\Omega} = 2.67\ A$

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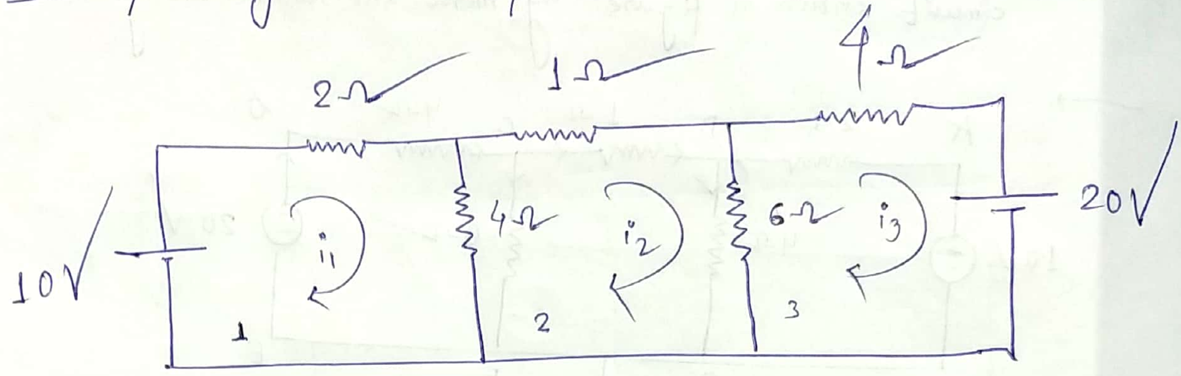
Similarly, by mesh analysis :—



Loop-1 :

$$10 - 2i_1 - (i_1 - i_2)\cdot 4 = 0$$

$$\Rightarrow 10 - 6i_1 + 4i_2 = 0$$

$$\Rightarrow 3i_1 - 2i_2 = 5 \quad \text{—— eq}^n \ (1)$$

Loop-2 :

$$-4(i_2 - i_1) - i_2 - (i_2 - i_3)\cdot 6 = 0$$

$$\Rightarrow 4i_1 - 11i_2 + 6i_3 = 0 \quad \text{—— eq}^n \ (2)$$

Loop-3 :

$$-(i_3 - i_2)6 - 4i_3 - 20 = 0$$

$$\Rightarrow 6i_2 - 10i_3 = 20 \quad \text{—— eq}^n \ (3)$$

Solving eq^{ns} (1), (2), (3), we get :—

$$\boxed{\begin{aligned} i_1 &= 0.91\ A \\ i_2 &= -1.12\ A \\ i_3 &= -2.67\ A \end{aligned}}$$

Comparing the values of current in 2 processes :—

$i_{2\Omega} = i_1 = 0.91\ A$ $\qquad$ $i_{4\Omega} = i_3 = 2.67\ A$

$i_{1\Omega} = i_2 = 1.12\ A$

∴ We can compare more, but from these 3 values, we can say that KCL & KVL are verified by the nodal and mesh - analysis methods.

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Q. 11. A series RLC circuit consists of $R = 1000\ \Omega$, $L = 100\ mH$ and $C = 10$ pico farads. The applied voltage across the circuit is 100 V.

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$R = 1000\ \Omega$; $L = 100 \times 10^{-3}\ H$; $C = 10 \times 10^{-12}\ F$; $V = 100\ V$

(i) Condition for resonance, $X_L = X_C$

$X_L = L\omega$
$= 10^{-1} \times 10^{6}$
$\therefore X_L = 10^5$

$\therefore L\omega = \frac{1}{\omega C}$

$\Rightarrow \omega^2 = \frac{1}{LC}$

$\Rightarrow \omega = \sqrt{\frac{1}{LC}} = \frac{1}{\sqrt{10^{-1} \times 10^{-11}}} = \frac{1}{10^{-6}}$

$\therefore \boxed{\omega = 10^6\ rad\ s^{-1}}$

(ii) Quality factor $= \frac{\text{Power stored}}{\text{power displayed}} = \frac{i^2 X_L}{i^2 R} = \frac{i^2 X_C}{i^2 R}$ $\left[\because X_L = X_C\right]$

$= \frac{X_L}{R} = \frac{X_C}{R} = \frac{10^5}{10^3}$ Hz

$\therefore$ Q. factor $= 100$ Hz

(iii) Angular frequency at half power points:

• Lower cut-off frequency :-

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

$= \frac{-10^3}{2 \times 10^{-1}} + \sqrt{\left(\frac{10^3}{2 \times 10^{-1}}\right)^2 + \frac{1}{10^{-12}}}$

$\therefore \omega L = \frac{-10^4}{2} + 10^4 \sqrt{\frac{1}{4} + 10^4}$

• Higher cut-off frequency :-

$\omega_C = +\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$

$\therefore \omega_c = \frac{10^4}{2} + 10^4 \sqrt{\frac{1}{4} + 10^4}$

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(iv) Bandwidth $= \frac{f_r}{Q}$

$$= \frac{\omega}{2\pi Q} = \frac{10^6}{2\pi \times 10^2}$$

$$= \frac{10^4}{2\pi}$$

Q. 12. A voltage, $V = 100 \sin 314t$ is applied to a circuit consisting of a 25 Ω resistor and an 80 micro farad capacitor in series. Determine the following :-

→

$V = 100 \sin(314t)$

$R = 25\,\Omega$; $C = 80 \times 10^{-6}$ F

(i) $Z = \sqrt{625 + 6400 \times 10^{-12}}\ \Omega$

$\approx \sqrt{625}\ \Omega$

$\approx 25\ \Omega$

Also, $i_m = \frac{V_m}{Z}$

$= \frac{100}{25}$ A

$i_m = 4$ A

~~$\therefore i = 4 \sin(314t + 57.8°)$~~

Also, $\tan\phi = \frac{X_c}{R} = \frac{1}{\omega RC}$

$$= \frac{1}{314 \times 80 \times 10^{-6} \times 25}$$

$$= 1.592$$

$$\therefore \phi = \tan^{-1}(1.592)$$

$$\therefore \boxed{\phi = 57.8°}$$

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∴ Reqd. expression :—

$$i = 4 \sin(314t + 57.8^c) \quad \text{ans.}$$

(ii) Power consumed $= \frac{Vi}{2} \cdot \cos\phi$

$= \frac{100 \times \cancel{4}^2}{\cancel{2}} \cos(57.8^o)$ W

$= 200 \times (0.532)$ W

$= 106.4$ W ans.

(iii) $V = i \cdot X_C$ $\qquad i = \frac{i_m}{Z} = 2A$

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

$= \cancel{2} \times \frac{1}{314 \times \cancel{80}^{40} \times 10^{-6}}$ V

$= 79.6$ V ans.

End