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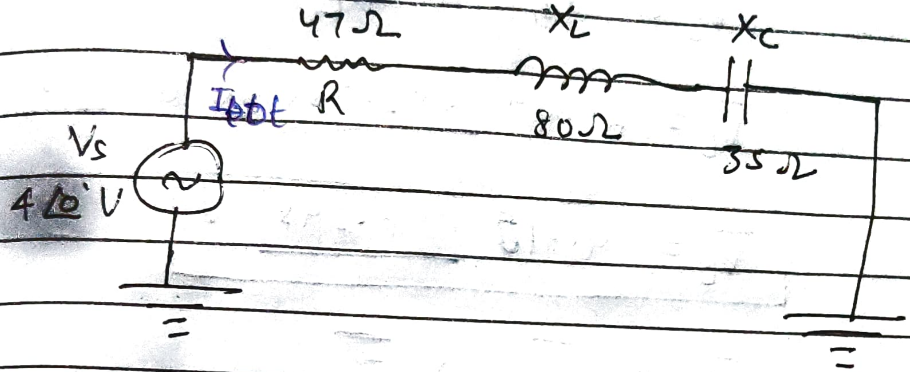
Basic Electrical Engineering (EE100)
Assignment No. 2

1 Problem from Section 17-2

5. For the circuit shown in figure, find I_{tot}, V_R, V_L and V_C in polar form.



$$Z = R + j(X_L - X_C)$$

$$Z = 47 + j(80 - 35)$$

$$Z = 47 + j45 \ \Omega$$

$$\bar{Z} = 65.069 \angle 43.755° \ \Omega$$

$$\therefore \ \bar{I}_{tot} = \frac{\bar{V}_s}{\bar{Z}}$$

$$\bar{I}_{tot} = \frac{4\angle 0°}{65.069\angle 43.755°} \ A$$

$$\boxed{I_{tot} = 61.47 \angle -43.755° \ mA}$$

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$\therefore \quad \overline{V_R} = \overline{I_{tot}} \times \overline{Z_R}$

$= 61.47\angle{-43.755^\circ} \times 47\angle{0^\circ}$ mV

$$\boxed{\overline{V_R} = 2.889\angle{-43.755^\circ}\ V}$$

and, $\overline{V_L} = \overline{I_{tot}} \times \overline{Z_{XL}}$

$\overline{V_L} = 61.47\angle{-43.755^\circ} \times 80\angle{90^\circ}$ mV

$$\boxed{\overline{V_L} = 4.918\angle{46.245^\circ}\ V}$$

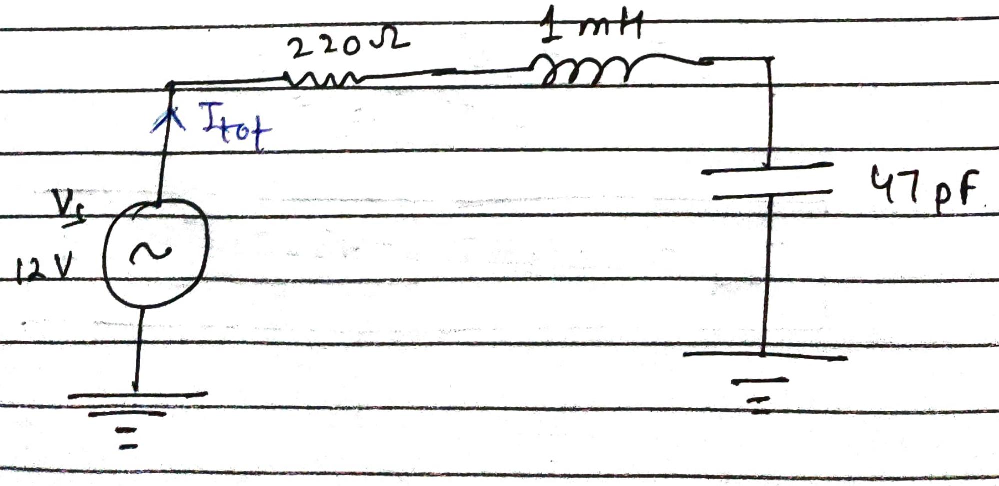
and, $\overline{V_C} = \overline{I_{tot}} \times \overrightarrow{Z_{XC}}$

$\overline{V_C} = 61.47\angle{-43.755^\circ} \times 35\angle{-90^\circ}$ mV

$$\boxed{\overline{V_C} = 2.151\angle{-133.755^\circ}\ V}$$

1 Problem from Section 17-3

10. Find X_L, X_C, Z and I_{tot} at the resonant frequency in the figure



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As we know resonance frequency is given by

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

$$f_r = \frac{1}{2\pi\sqrt{10^{-3} \times 47 \times 10^{-12}}}$$

$$f_r = \frac{1}{2\pi\sqrt{470 \times 10^{-8}}}$$

$$\boxed{f_r = 734.5 \text{ kHz}}$$

$\therefore$ $X_L = 2\pi f_r L$

$= 2 \times 3.14 \times 734.5k \times 1m$

$$\boxed{X_L = 4.613 \text{ k}\Omega}$$

and, $X_C = \frac{1}{2\pi f_r C}$

$= \frac{1}{2\pi \times 734.5k \times 47p}$

$$\boxed{X_C = 4.613 \text{ k}\Omega}$$

$\therefore$ $Z = R + j(X_L - X_C)$

$$\boxed{\begin{aligned} Z &= 220\,\Omega \\ \bar{Z} &= 220 \angle 0^\circ\ \Omega \end{aligned}}$$

$\therefore$ $\bar{I}_{tot} = \frac{\bar{V}_s}{\bar{Z}} = \frac{12 \angle 0^\circ}{220 \angle 0^\circ}$ $\Rightarrow$ $\boxed{\bar{I}_{tot} = 54.55 \angle 0^\circ \text{ mA}}$

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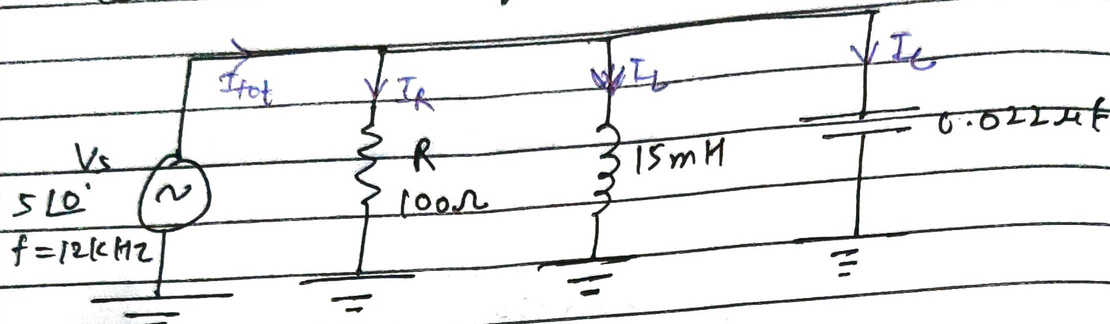
1 Problem from Section 17-5

19. For the given circuit, find all currents and voltages in polar form.



Clearly, $\boxed{\bar{V_R} = \bar{V_C} = \bar{V_L} = \bar{V_s} = 5\angle 0^\circ \text{ V}}$

$$X_L = 2\pi f L$$
$$= 2 \times 3.14 \times 12k \times 15m$$
$$X_L = 1130.4 \ \Omega$$

and $$X_C = \frac{1}{2 \times 3.14 \times 12k \times 0.022 \mu}$$

$$X_C = 603.165 \ \Omega$$

Now, $$\bar{I_R} = \frac{\bar{V_s}}{\bar{Z_R}}$$

$$= \frac{5\angle 0^\circ}{100\angle 0^\circ}$$

$$\boxed{\begin{aligned} \bar{I_R} &= 50\angle 0^\circ \text{ mA} \\ I_R &= 50 + j0 \text{ mA} \end{aligned}}$$

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and, $\overline{I_L} = \dfrac{\overline{V_L}}{\overline{Z_L}}$

$\overline{I_L} = \dfrac{5\angle 0^\circ}{1130.4\angle 90^\circ}$ A

$$\boxed{\begin{aligned} \overline{I_L} &= 4.42\angle -90^\circ \text{ mA} \\ I_L &= 0 - j(4.42) \text{ mA} \end{aligned}}$$

and, $\overline{I_C} = \dfrac{\overline{V_C}}{\overline{Z_C}}$

$= \dfrac{5\angle 0^\circ}{603.165\angle -90^\circ}$ A

$$\boxed{\begin{aligned} \overline{I_C} &= 8.29\angle 90^\circ \text{ mA} \\ I_C &= 0 + j(8.29) \text{ mA} \end{aligned}}$$

From KCL, we have

$I_{tot} = I_R + I_L + I_C$

$$\boxed{\begin{aligned} \therefore\ I_{tot} &= 50 + j(3.87) \text{ mA} \\ \overline{I_{tot}} &= 50.149\angle 4.426^\circ \text{ mA} \end{aligned}}$$

1 Problem from Section 17-6

23. Find Z at resonance and f_r for the tank circuit in figure

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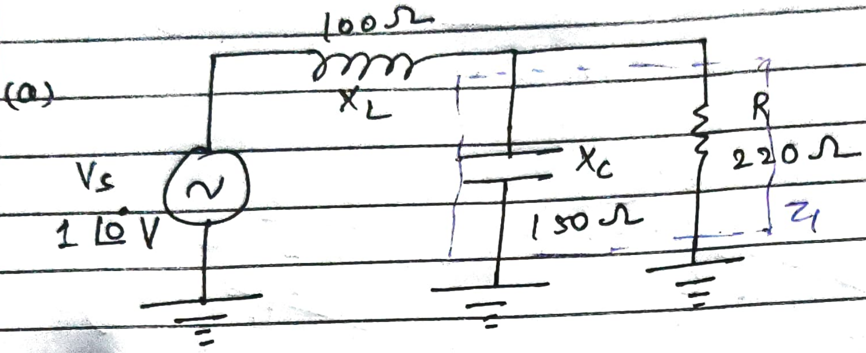
2 Problems from Section 17-7

28. Find the total impedance for each circuit.

(a)



$$Z_1 = Z_R \parallel Z_{X_C}$$

$$\bar{Z}_1 = \frac{220\angle 0^\circ \times 150\angle -90^\circ}{220 - j\,150}$$

$$\bar{Z}_1 = \frac{33000\angle -90^\circ}{266.27\angle -34.294}$$

$$\bar{Z}_1 = 123.934\angle -55.706^\circ\ \Omega$$

$$Z_1 = 69.829 - j\,(102.389)\ \Omega$$

and $Z_{X_L} = 0 + j\,(100)\ \Omega$

$\therefore$ $Z = Z_1 + Z_{XL}$

$$\boxed{\begin{aligned} Z &= 69.829 - j\,(2.389)\ \Omega \\ \bar{Z} &= 69.869\angle -1.959^\circ\ \Omega \end{aligned}}$$

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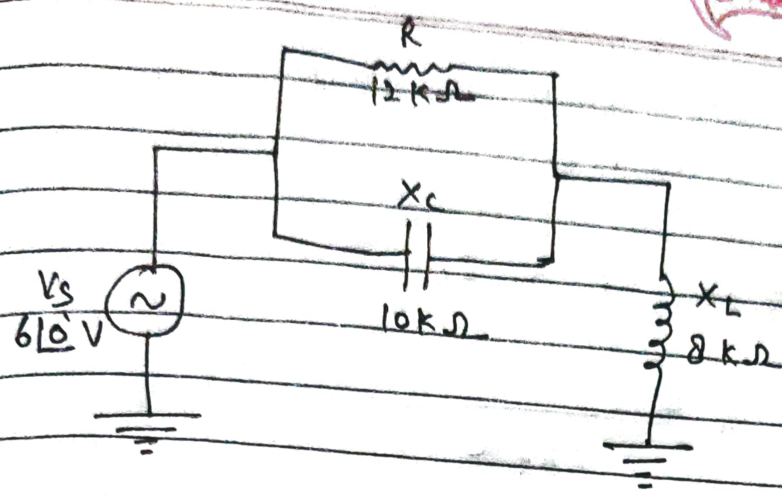
(b)



$Z_1 = Z_R \parallel Z_{X_C}$

$$\bar{Z}_1 = \frac{12K\angle 0° \times 10K\angle -90°}{12K - j10K}$$

$$\bar{Z}_1 = \frac{120 \times 10^6 \angle -90°}{15.62K \angle -39.8}$$

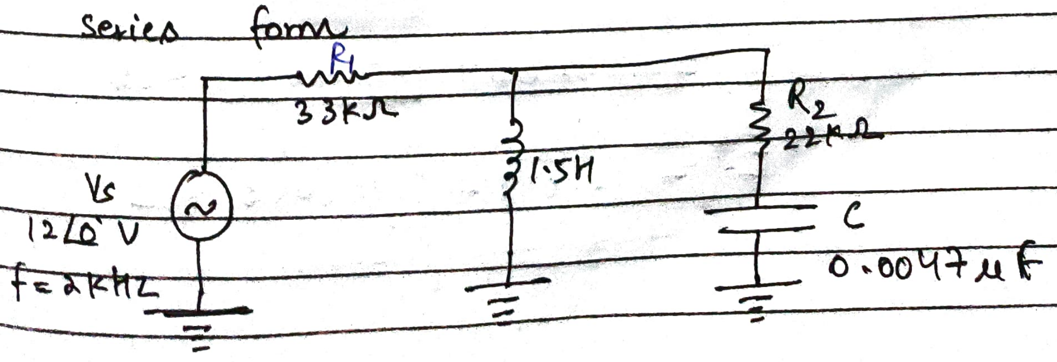
$$\bar{Z}_1 = 7.682 \angle -50.2 \text{ k}\Omega$$

$$Z_1 = 4.917 - j5.902 \text{ k}\Omega$$

and $Z_{X_L} = 0 + j8 \text{ k}\Omega$

$$\therefore \boxed{\begin{aligned} Z &= 4.917 + j2.098 \text{ k}\Omega \\ \bar{Z} &= 5.346 \angle 23.107 \text{ k}\Omega \end{aligned}}$$

29. Convert the circuit to an equivalent series form



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Let us first find the impedance of the circuit.

Let $z_1 = z_{R_2} + z_C$

Now, $X_C = \dfrac{1}{2\pi f C}$

$X_C = 16.94 \ k\Omega$

$\therefore Z_1 = 22 + j(-16.94) \ k\Omega$

$\bar{Z_1} = 27.766 \angle -37.596^\circ \ k\Omega$

Now, $X_L = 2\pi f L$
$= 6.28 \times 2000 \times 1.5$
$X_L = 18.84 \ k\Omega$

Let say $Z_2 = Z_1 \parallel Z_L$

$\therefore \bar{Z_2} = \dfrac{27.766 \angle -37.596^\circ \times 18.84 \angle 90^\circ \times 10^6}{(22 + j(-16.94) + j(18.84)) \times 10^3}$

$\bar{Z_2} = \dfrac{523.11 \angle 52.404}{22.082 \angle 4.936} \times 10^3$

$\bar{Z_2} = 23.689 \angle 47.468 \ k\Omega$

$Z_2 = 16.014 + j\,17.456 \ k\Omega$

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Now, $Z = Z_{R_1} + Z_2$

$$Z = \left(33 + j(0) + 16.014 + j(17.456)\right) k\Omega$$

$$Z = 49.014 + j(17.456)\ k\Omega$$

The impedance of the circuit is Z,

$$Z = 49.014 + j(17.456)\ k\Omega$$

As the reactance X is equal to 17.456 kΩ, the reactance is inductive.

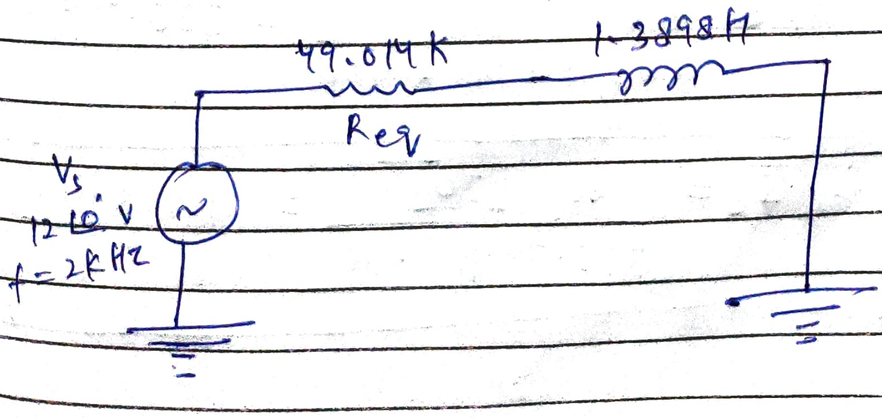
Therefore, the value of inductance at which $X_{Leq} = 17.456\ k\Omega$ is Leq,

$$X_{Leq} = 2\pi f\ L_{eq}$$

$$L_{eq} = \frac{17.456\ K}{2 \times 3.14 \times 2000}$$

$$L_{eq} = 1.3898\ H$$

Hence, the equivalent series circuit is



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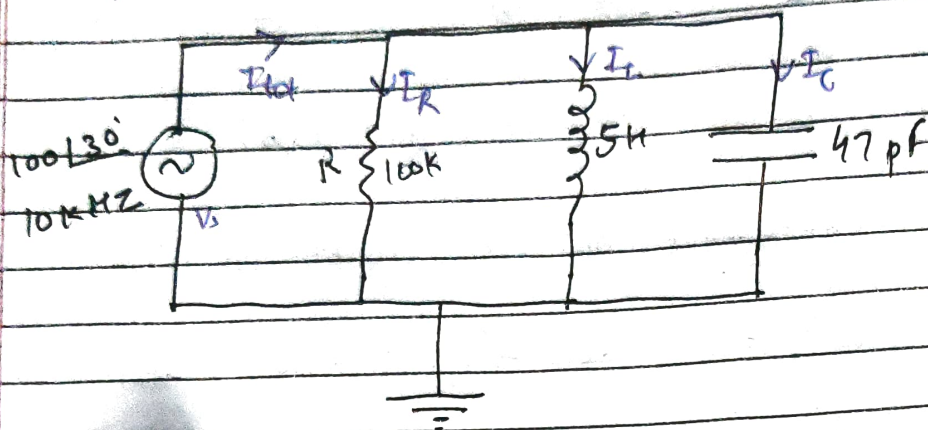
Q. Find all currents and voltages and plot the phasor diagram



Since, R, L and C are in parallel

$$\boxed{\bar{V}_R = \bar{V}_L = \bar{V}_C = \bar{V}_s = 100\angle 30^\circ \text{ V}}$$

$$\boxed{I_R = \frac{\bar{V}_s}{\bar{Z}_R} = \frac{100\angle 30^\circ}{100K} = 1\angle 30^\circ \text{ mA}}$$

$$X_L = 2 \times 3.14 \times 10K \times 5$$
$$= 314\, K\Omega$$

$$\boxed{\therefore\ \bar{I}_L = \frac{100\angle 30^\circ}{314K\angle 90^\circ} = 0.318 \text{ mA}\angle -60^\circ}$$

$$X_C = \frac{1}{2 \times 3.14 \times 10K \times 47P} = 338.799\, K\Omega$$

$$\boxed{\therefore\ I_C = \frac{100\angle 30}{338.799K\angle -90^\circ} = 0.295\angle 120^\circ \text{ mA.}}$$

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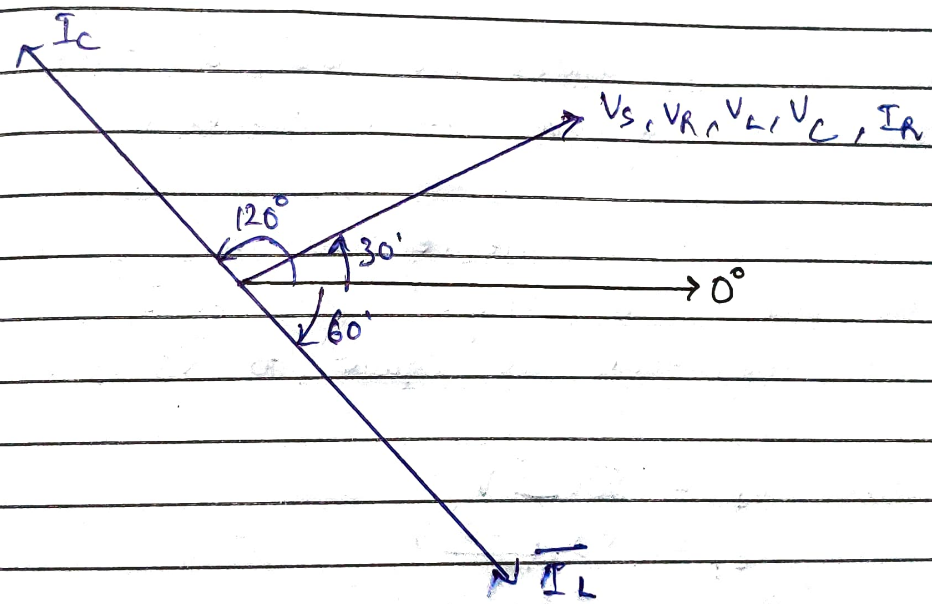
From KCL,

$$\bar{I}_{tot} = \bar{I}_R + \bar{I}_L + \bar{I}_C$$

$$\bar{I}_{tot} = (0.866 + j(0.5)) + (0.159 - j(0.275)) + (-0.1475 + j\,0.255)\ mA$$

$$\bar{I}_{tot} = 0.8775 + j(0.48)\ mA$$

$$\boxed{\bar{I}_{tot} = 1.002 \angle 28.679^\circ\ mA}$$



3 Questions from Section ~~21~~-3

7. Determine the following quantities for the Y-Y system in figure
(a) Line voltages (b) Phase currents
(c) Line currents (d) Load currents
(e) Load Voltages

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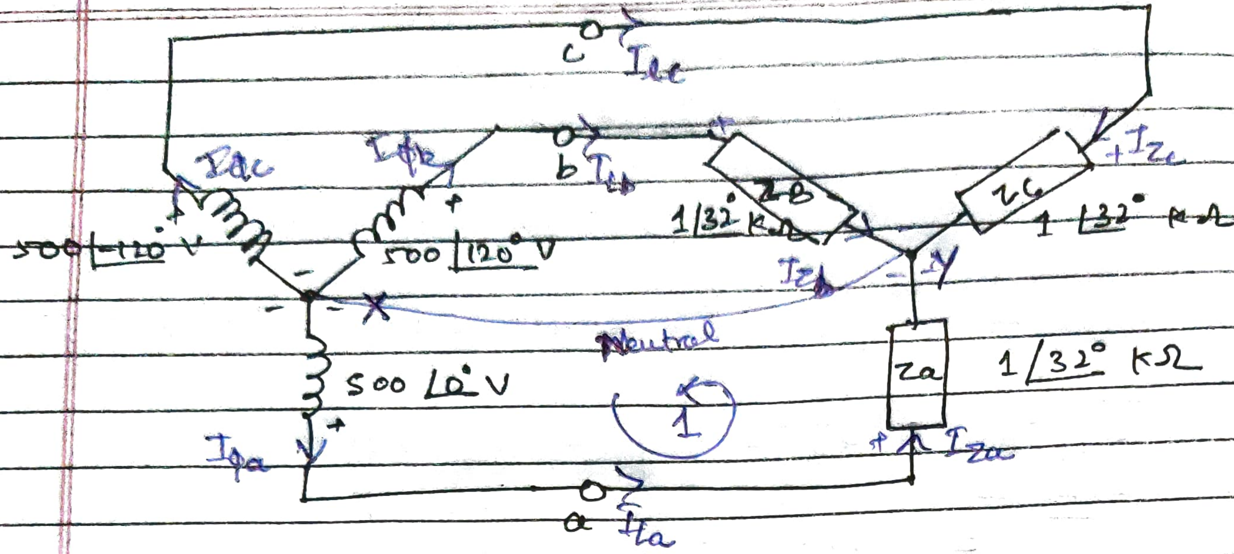

As all the loads and all the sources are equal, hence the system is balanced.

As the phase angles are 120°, 0°, -120°, this is a negative phase sequence

In negative phase sequence (balanced system) the line-to-line voltages lag by 30° and their magnitude is equal to $\sqrt{3}\,V_\phi$.

Given $V_{\phi a} = 500\angle{0^\circ}$ V
$V_{\phi b} = 500\angle{120^\circ}$ V
$V_{\phi c} = 500\angle{-120^\circ}$ V

(a) Therefore line-to-line voltages

$$\boxed{\begin{aligned} V_{L(ab)} &= \sqrt{3} \times 500 \angle{-30^\circ} \text{ V} \\ &= 866\angle{-30^\circ} \text{ V} \\ V_{L(bc)} &= 866\angle{90^\circ} \text{ V} \\ V_{L(ca)} &= 866\angle{-150^\circ} \text{ V} \end{aligned}}$$

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(b) As the system is balanced, the current through neutral wire is zero.

Applying Kirchoff's Voltage law,

$$\overline{V}_{\phi a} - \overline{I}_{Za} \cdot Z_a = 0$$

$$\overline{I}_{Za} = \frac{V_{Za}}{Z_a}$$

$$\overline{I}_{\phi a} = \frac{500 \angle 0^\circ}{1 \angle 32^\circ \, k\Omega} \quad (\text{as } I_{\phi a} = I_{Za})$$

$$\boxed{\overline{I}_{\phi a} = 500 \angle -32^\circ \text{ mA}}$$

Similarly, $\overline{I}_{\phi b} = 500 \angle 88^\circ$ mA

and, $\overline{I}_{\phi c} = 500 \angle -152^\circ$ mA

(c)(d) From the circuit is is clear that,

$$\overline{I}_{La} = \overline{I}_{Za} = \overline{I}_{\phi a} = 500 \angle -32^\circ \text{ mA}$$

$$\overline{I}_{Lb} = \overline{I}_{Zb} = \overline{I}_{\phi b} = 500 \angle 88^\circ \text{ mA}$$

$$\overline{I}_{Lc} = \overline{I}_{Zc} = \overline{I}_{\phi c} = 500 \angle -152^\circ \text{ mA}$$

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(e) Using KVL in loop 1,

$$\overline{V_{\phi a}} - \overline{V_{Za}} = 0$$

$$\therefore V_{Za} = \overline{V_{\phi a}}$$

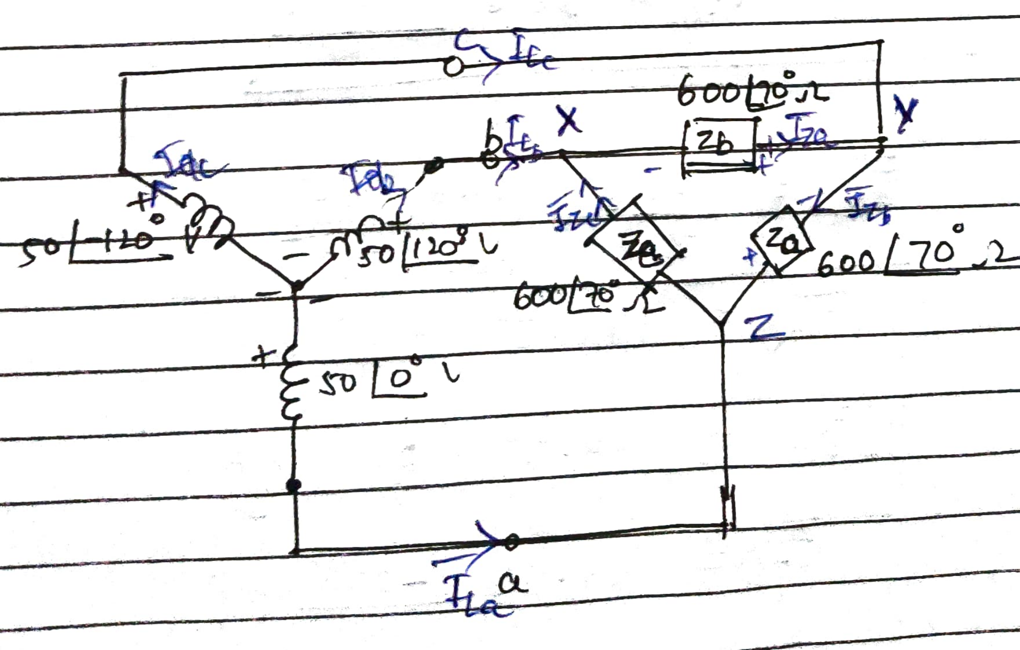
$$\overline{V_{Za}} = 500\angle 0^\circ \text{ V}$$

Similarly, $\overline{V_{Zb}} = 500\angle 120^\circ$ V

and, $V_{Zc} = 500\angle -120^\circ$ V

9. Determine the following quantities for given circuit

(a) Line Voltages (b) Load ~~currents~~ voltages
(c) Load ~~voltages~~ currents (d) Line currents
(e) Phase Currents



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(a) $\overline{V}_{L(ab)} = \overline{V}_{\phi a} - \overline{V}_{\phi b}$

$= 50 \angle 0^\circ - 50 \angle 120^\circ$

$$\boxed{\begin{aligned} \overline{V}_{L(ab)} &= 86.6 \angle -30^\circ \text{ V} \\ \overline{V}_{L(bc)} &= 86.6 \angle 90^\circ \text{ V} \\ \overline{V}_{L(ca)} &= 86.6 \angle -150^\circ \text{ V} \end{aligned}}$$

(b) from the circuit it is clear that,

$\overline{V}_{zc} = \overline{V}_{La} - \overline{V}_{Lb} = \overline{V}_{L(ab)}$

$$\boxed{\begin{aligned} \therefore\ \overline{V}_{zc} &= 86.6 \angle -30^\circ \text{ V} \\ \text{and, } \overline{V}_{zb} &= 86.6 \angle 90^\circ \text{ V} \\ \text{and, } \overline{V}_{za} &= 86.6 \angle -150^\circ \text{ V} \end{aligned}}$$

(c) $\overline{I}_{zc} = \dfrac{\overline{V}_{zc}}{Z_c} = \dfrac{86.6 \angle -30^\circ}{600 \angle 70^\circ}$

$$\boxed{\begin{aligned} \overline{I}_{zc} &= 144.33 \angle -100^\circ \text{ mA} \\ \overline{I}_{zb} &= 144.33 \angle 20^\circ \text{ mA} \\ I_{za} &= 144.33 \angle -220^\circ \text{ mA} \end{aligned}}$$

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(d) Applying KCL at node Z,

$$\bar{I}_{La} = \bar{I}_{Zc} - \bar{I}_{Za}$$

$$\bar{I}_{La} = 144.33\angle{-100^\circ} - 144.33\angle{-220^\circ}$$

$$\bar{I}_{La} = -25.06 - j\,142.13 - (-110.56 + j\,92.90)$$

$$\bar{I}_{La} = 85.5 - j\,(235.03)$$

$$\boxed{\bar{I}_{La} = 250\angle{-70.009}\ mA}$$

similarly $\bar{I}_{Lb} = 250\angle{50^\circ}\ mA$

and, $\bar{I}_{Lc} = 250\angle{170^\circ}\ mA$

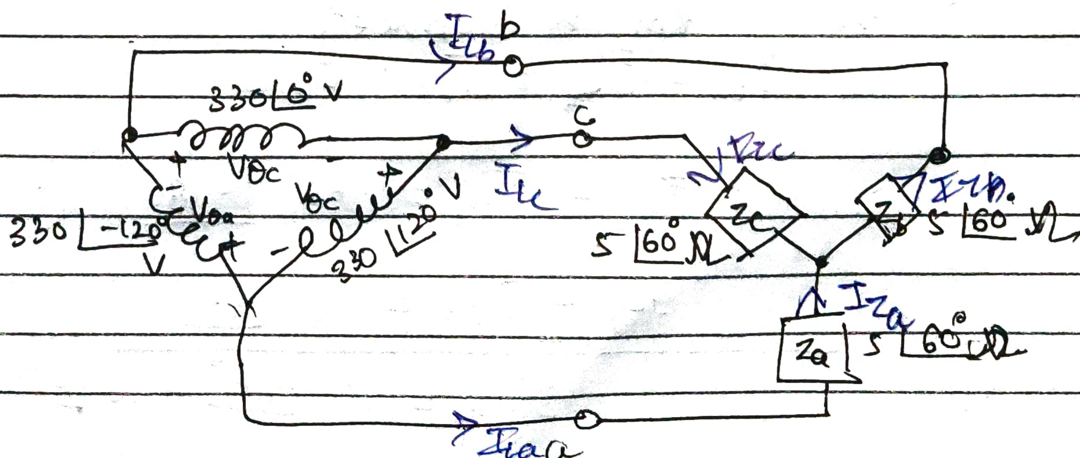
(e)

$$\bar{I}_{\phi a} = \bar{I}_{La} = 250\angle{-70.009}\ mA$$

$$\bar{I}_{\phi b} = \bar{I}_{Lb} = 250\angle{50^\circ}\ mA$$

$$\bar{I}_{\phi c} = \bar{I}_{Lc} = 250\angle{170^\circ}\ mA$$

Q.11 Determine the line voltages and load currents for the system.



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Line to line voltages

$$V_{L(ab)} = 330 \angle -120^\circ \text{ V}$$

$$V_{L(bc)} = 330 \angle 0^\circ \text{ V}$$

$$V_{L(ca)} = 330 \angle 120^\circ \text{ V}$$

Now,

$$V_{L(ca)} = (\bar{I}_{zc} - \bar{I}_{za}) Z_a \quad \text{— (I)}$$

$$V_{L(bc)} = (\bar{I}_{zb} - \bar{I}_{zc}) Z_b \quad \text{— (II)}$$

$$V_{L(ab)} = (\bar{I}_{za} - \bar{I}_{zb}) Z_c \quad \text{— (III)}$$

$$\frac{330 \angle 120^\circ}{5 \angle 60^\circ} = \bar{I}_{zc} - \bar{I}_{za}$$

$$66 \angle 60^\circ = \bar{I}_{zc} - \bar{I}_{za} \quad \text{— (IV)}$$

$$66 \angle -60^\circ = \bar{I}_{zb} - \bar{I}_{zc} \quad \text{— (V)}$$

$$66 \angle -180^\circ = \bar{I}_{za} - \bar{I}_{zb} \quad \text{— (VI)}$$

$\because$ the system is balanced,

$$\bar{I}_{za} + \bar{I}_{zb} + \bar{I}_{zc} = 0$$

$$\therefore \quad 2\bar{I}_{za} + \bar{I}_{zc} = 66 \angle -180^\circ \quad (\text{from (VI)})$$

$$\bar{I}_{zc} - \bar{I}_{za} = 66 \angle 60^\circ$$

$$3\bar{I}_{za} = 66 \angle -180^\circ - 66 \angle 60^\circ$$

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$\bar{I}_{Za} = 22 \angle -180^\circ - 22 \angle 60^\circ$

$\bar{I}_{Za} = -33 - j\, 11\sqrt{3}$

$$\boxed{\begin{aligned} \bar{I}_{Za} &= 38.2 \angle 30^\circ \text{ A} \\ \text{similarly} \quad \bar{I}_{Zb} &= 38.2 \angle 150^\circ \text{ A} \\ \bar{I}_{Zc} &= 38.2 \angle -90^\circ \text{ A} \end{aligned}}$$

2 Problems from Section 27-4

Q. In a certain Δ - connected balanced load, the line voltages are 250V and the impedance are $50 \angle 30^\circ\ \Omega$. Determine the load power.

For Δ - connected system

$V_Z = V_L$ and $I_L = \sqrt{3} I_Z$

$I_Z = \frac{V_Z}{Z} = \frac{250\text{ V}}{50} = 5\text{ A}$

$I_L = \sqrt{3}\, I_Z = 8.66\text{ A}$

∴ Power factor, $\cos\theta = \cos 30^\circ = \frac{\sqrt{3}}{2} = 0.866$.

∴ $P_{L(tot)} = \sqrt{3}\, V_L\, I_L \cos\theta$

$= \sqrt{3}\,(250)(8.66\text{ A}) \times 0.866$

$$\boxed{P_{tot} = 3.247\text{ KW}}$$

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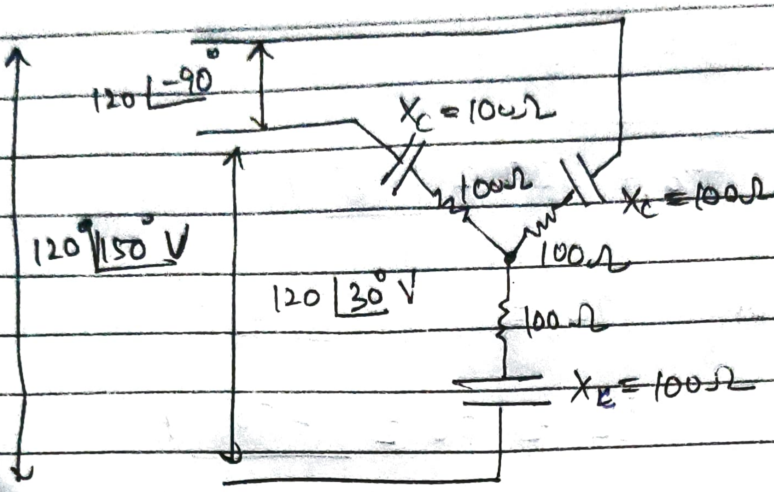
Q.18. Find total load power in circuit



$$Z = 100 - j(100)\ \Omega$$

$$V_L = 120$$

$$V_\phi = \frac{V_L}{\sqrt{3}} = \frac{120}{\sqrt{3}} = 40\sqrt{3}\ V$$

$$\bar{Z}_\phi = 100\sqrt{2}\angle -45^\circ\ \Omega$$

$$\bar{I}_\phi = \frac{\bar{V}_\phi}{\bar{Z}_\phi} = \frac{69.28}{100\sqrt{2}}\ VA$$

$$I_\phi = 0.4898\ A$$

$$I_L = I_\phi = 0.4898\ A$$

$$\cos\phi = \cos 45^\circ = \sqrt{2}$$

$$P_{L(tot)} = \sqrt{3}\ V_L I_L \cos\phi$$

$$= \sqrt{3} \times 120 \times 0.4898 \times \sqrt{2}$$

$$\boxed{P_{L(tot)} = 71.97\ W}$$

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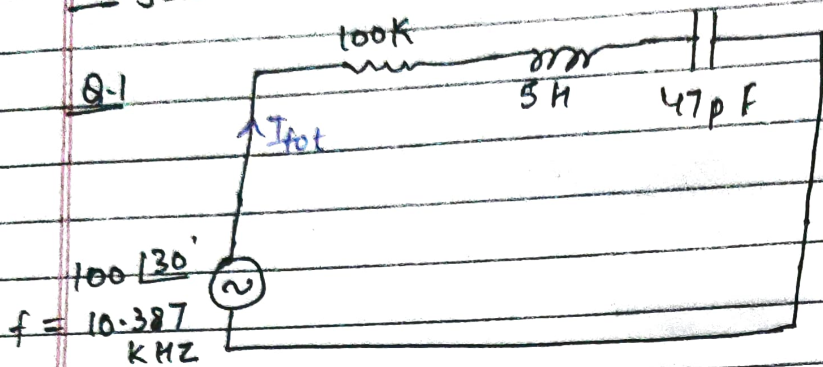
Any 5 Questions from Homework

Q.1



Find all currents and voltages. Draw the phasor diagram. Find true power P, reactive power Q, apparent power S.

$$X_C = \frac{1}{2 \times 3.14 \times 10.387K \times 47p}$$

$$X_C = 326.176 \ K\Omega$$

and $X_L = 2 \times 3.14 \times 10.387K \times 5$

$X_L = 326.1518 \ K\Omega$

as $X_C \approx X_L$,

$$\bar{Z} = \bar{Z}_R = 100\angle 0^\circ \ K\Omega$$

$$\therefore \bar{I}_{tot} = \frac{100\angle 30^\circ \ V}{100\angle 0^\circ \ K\Omega}$$

$$\boxed{\bar{I}_{tot} = 1\angle 30^\circ \ mA}$$

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As all components are in series,

$$\boxed{\overline{I_R} = \overline{I_L} = \overline{I_C} = \overline{I_{tot}} = 1\angle 30^\circ \text{ mA}}$$

Now, $\overline{V_R} = \overline{I_{tot}} \times \overline{Z_R}$

$$= 1m\angle 30^\circ \times 100K\angle 0^\circ$$

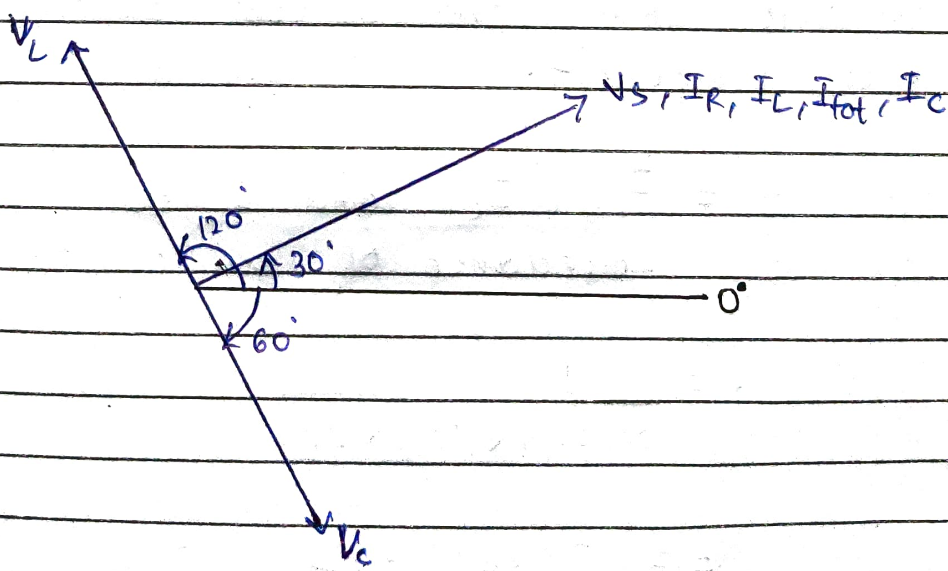
$$\boxed{\overline{V_R} = 100\angle 30^\circ \text{ V}}$$

and $\overline{V_L} = 1m\angle 30^\circ \times 326.152K\angle 90^\circ$

$$\boxed{\overline{V_L} = 326.152\angle 120^\circ \text{ V}}$$

and $\overline{V_C} = 1m\angle 30^\circ \times 326.176K\angle -90^\circ$

$$\boxed{\overline{V_C} = 326.176\angle -60^\circ \text{ V}}$$



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true power, $P = I^2 R$

$P = (1mA)^2 \times 100K$

$\boxed{P = 100\,mW}$

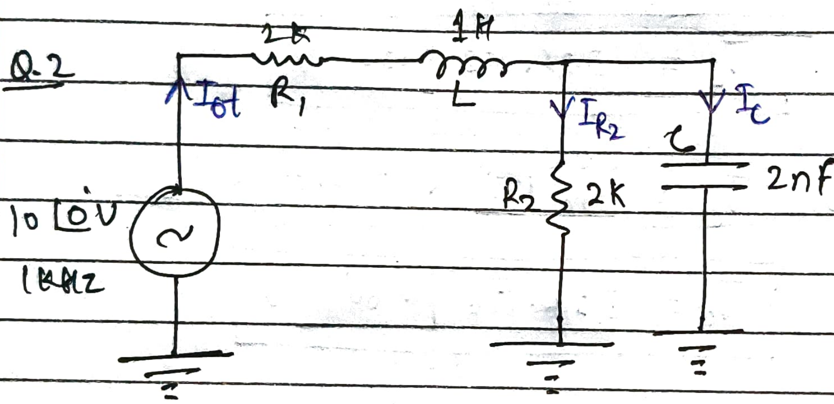
reactive power, $Q = I^2 X$

$\boxed{Q = 0\ VAR}$ (as $X = 0$)

Apparent power, $S = \sqrt{P^2 + Q^2}$

$\boxed{S = P = 100\,mVA}$

Q.2



Calaltate voltage and current across each component.

Let $Z_1 = Z_{R_2} \parallel Z_C$ and Z be the net impedance of the circuit.

$$X_C = \frac{1}{2 \times 3.14 \times 1000 \times 2n}$$

$$X_C = 79.618\ k\Omega$$

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and $X_L = 2 \times 3.14 \times 1000 \times 1$

$X_L = 6.28\,k$

Now, $Z_1 = Z_{R_2} \parallel Z_C$

$$= \frac{2k\angle 0^\circ \times 79.618k\angle -90^\circ}{2k - j(79.618k)}$$

$$Z_1 = \frac{2k\angle 0^\circ \times 79.618k\angle -90^\circ}{79.643k\angle -88.56^\circ}$$

$$Z_1 = 1.999\angle -1.44^\circ\ k\Omega$$

$$Z_1 \approx 2\angle -1.44^\circ\ k\Omega$$

$$Z_1 = 1.9994k - j(0.050k)\ \Omega$$

Now, $Z = Z_1 + Z_{R_1} + Z_L$

$$Z = 1.9994k - j(0.050k) + 2k + j(6.28k)$$

$$Z = 3.9994k + j(6.23k)\ \Omega$$

$$\boxed{\bar{Z} = 7.403k\angle 57.3^\circ\ \Omega}$$

$$\therefore \bar{I}_{tot} = \frac{V_s}{\bar{Z}}$$

$$\bar{I}_{tot} = \frac{10\angle 0^\circ}{7.403k\angle 57.3^\circ}\ A$$

$$\boxed{\bar{I}_{tot} = 1.351\angle -57.3\ mA}$$

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$$\boxed{\overline{I_{R_1}} = \overline{I_t} = \overline{I_{tot}} = 1.351 \angle -57.3^\circ \text{ mA}}$$

Using current division,

$$\overline{I_{R_2}} = \frac{Z_C}{Z_{R_2} + Z_C} \overline{I_{tot}}$$

$$\overline{I_{R_2}} = \frac{79.618K \angle -90}{2K - j\,79.618K} \times 1.351 \angle -57.3^\circ \text{ mA}$$

$$\overline{I_{R_2}} = \frac{107.564K \angle -\cancel{147}.3^\circ \text{ mA}}{79.643K \angle -\cancel{80}.56^\circ}$$

$$\boxed{\overline{I_{R_2}} = 1.35 \angle -58.74^\circ \text{ mA}}$$

and $$\overline{I_C} = \frac{Z_{R_2}}{Z_{R_2} + Z_C} \overline{I_{tot}}$$

$$\overline{I_C} = \frac{2K \angle 0^\circ \times 1.351 \angle -57.3^\circ \text{ mA}}{79.643K \angle -88.56^\circ}$$

$$\boxed{\overline{I_C} = 33.9 \angle 31.26^\circ \ \mu A}$$

Now, $$\overline{V_{R_1}} = \overline{I_{tot}} \times \overline{Z_{R_1}}$$

$$\overline{V_{R_1}} = 1.351 \angle -57.3^\circ \times 2K \angle 0^\circ \text{ mV}$$

$$\boxed{V_{R_1} = 2.702 \angle -57.3^\circ \text{ V}}$$

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and $\overline{V}_L = \overline{I}_{tot} \times \overline{Z}_L$

$\overline{V}_L = 1.351 \angle -57.3^\circ \times 6.28K \angle 90^\circ$ mV

$$\boxed{\overline{V}_L = 8.484 \angle 32.7^\circ \ V}$$

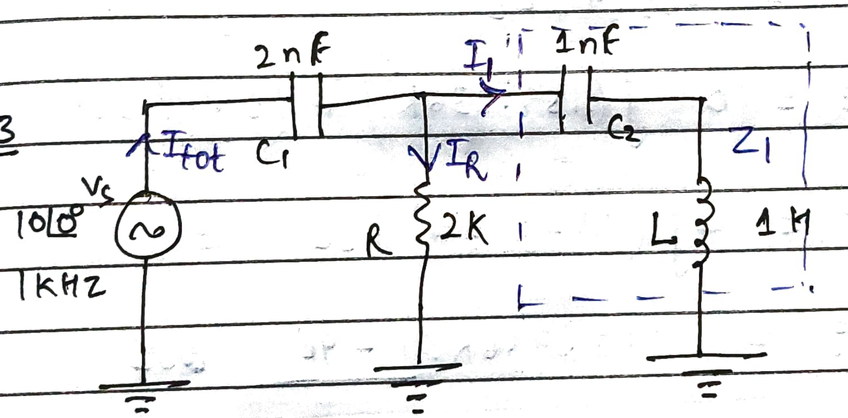
and, $\overline{V}_{R_2} = \overline{I}_{R_2} \times \overline{Z}_{R_2}$

$\overline{V}_{R_2} = 1.35 \angle -58.74^\circ \times 2K \angle 0^\circ$ mV

$$\boxed{\overline{V}_{R2} = 2.7 \angle -58.74^\circ \ V}$$

and, $\boxed{\overline{V}_C = \overline{V}_{R_2} = 2.7 \angle -58.74^\circ \ V}$

Q.3



Find ~~all~~ current and voltage across each component.

Let us assume,

$Z_1 = Z_{C_2} + Z_L$

$Z_2 = Z_R \parallel Z_1$

$\therefore$ net impedance $Z = Z_{C_1} + Z_2$

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$X_L = 2 \times 3.14 \times 1000 \times 1$

$X_L = 6.28 \, K\Omega$

$X_{C_1} = \dfrac{1}{2 \times 3.14 \times 1000 \times 2n}$

$X_{C_1} = 79.618 K\Omega$

and $X_{C_2} = \dfrac{1}{2 \times 3.14 \times 1000 \times 1n}$

$X_{C_2} = 159.236 K\Omega$

Now,

$Z_1 = Z_{C_2} + Z_L$

$Z_1 = (0 - j(159.236K)) + (0 + j6.28K)$

$Z_1 = -j(152.956) \, K\Omega$

$\overline{Z_1} = 152.956K \angle -90^\circ \; \Omega$

$\therefore \; \overline{Z_2} = \dfrac{\overline{Z_R} \times \overline{Z_1}}{Z_R + Z_1}$

$\overline{Z_2} = \dfrac{2K \angle 0^\circ \times 152.956K \angle -90^\circ}{(2K + j0) + (0 - j(152.956K))}$

$\overline{Z_2} = \dfrac{305.912 \times 10^6 \angle -90^\circ}{152.969K \angle -89.25^\circ}$

$\overline{Z_2} = 1.9998K \angle -0.75^\circ \; \Omega$

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$$\bar{Z}_2 \approx 2K\angle{-0.75^\circ}\ \Omega$$

$$Z_2 = 1.9998K - j(0.026K)\ \Omega$$

$$\therefore Z = Z_{C_1} + Z_2$$

$$Z = \left(0 - j(79.618K)\right) + \left(1.998K - j(0.026K)\right)$$

$$Z = \left(1.998K - j(79.644)K\right)\ \Omega$$

$$\boxed{Z = 79.67K\angle{-88.563^\circ}\ \Omega}$$

Now,

$$\bar{I}_{tot} = \frac{\bar{V_s}}{\bar{Z}}$$

$$\bar{I}_{tot} = \frac{10\angle{0^\circ}}{79.67K\angle{-88.563^\circ}}$$

$$\boxed{\bar{I}_{tot} = 125.52\angle{88.563^\circ}\ \mu A}$$

$$\boxed{I_{C_1} = I_{tot} = 125.52\angle{88.563^\circ}\ \mu A}$$

From current division, we have,

$$\bar{I}_R = \frac{Z_1}{Z_R + Z_1} \times \bar{I}_{tot}$$

$$\bar{I}_R = \frac{152.956K\angle{-90^\circ}}{152.969K\angle{-89.25^\circ}} \times 125.52\angle{88.563^\circ}\ \mu A$$

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$$\boxed{\overline{I_R} = 125.51 \angle 87.813 \ \mu A}$$

Now $\quad I_1 = \dfrac{Z_R}{Z_R + Z_1} \times I_{tot}$

$$I_1 = \frac{2K \angle 0^\circ}{152.969K \angle -89.25^\circ} \times 125.52 \angle 88.563^\circ \ \mu A$$

$$\boxed{\overline{I_1} = 1.64 \angle 177.813^\circ \ \mu A}$$

Since, L and C_2 are in series.

$$\therefore \boxed{\overline{I_L} = \overline{I_{C_2}} = \overline{I_1} = 1.64 \angle 177.813^\circ \ \mu A}$$

Now,

$$\overline{V_{C_1}} = \overline{I_{C_1}} \times \overline{Z_{C_1}}$$

$$\overline{V_{C_1}} = 125.52 \angle 88.563^\circ \times 79.618K \angle -90^\circ \ \mu V$$

$$\boxed{\overline{V_{C_1}} = 9.993 \angle -1.437 \ V}$$

and, $\quad \overline{V_R} = \overline{I_R} \times \overline{Z_R}$

$$= 125.51 \angle 87.813^\circ \times 2K \angle 0^\circ \ \mu V$$

$$\boxed{\overline{V_R} = 0.251 \angle 87.813^\circ \ V}$$

and, $\quad \overline{V_{C_2}} = 1.64 \angle 177.813^\circ \times 159.236K \angle -90^\circ \ \mu V$

$$\boxed{\overline{V_{C_2}} = 0.261 \angle 87.813^\circ \ V}$$

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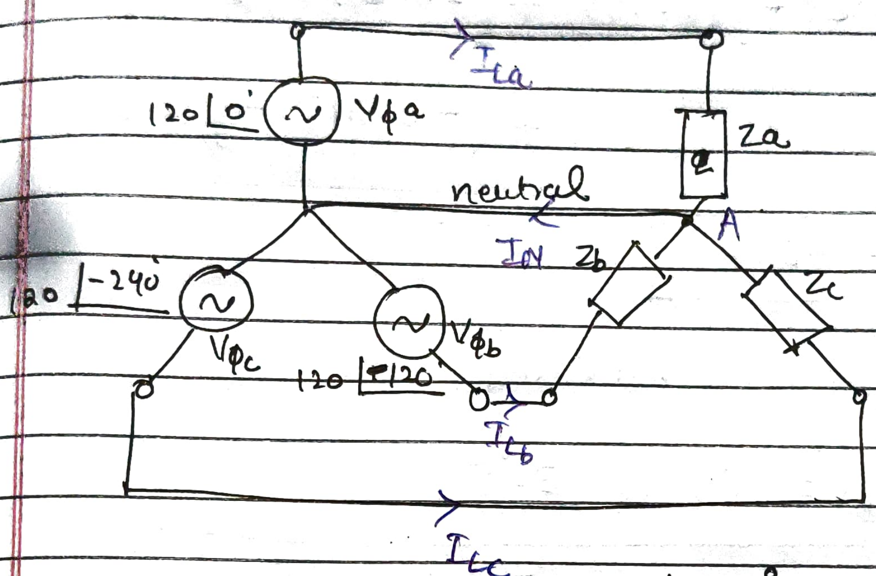
and $\overline{V_L} = 1.64 \angle 177.813^\circ \times 6.28K \angle 90^\circ \; \mu V$

$$\boxed{\overline{V_L} = 10.3 \angle 267.813^\circ \; mV}$$

4. Calculate all parameters for the circuit.



$Z_a = Z_b = Z_c = 22.4 \angle 26.6^\circ$.

$$\overline{I_{La}} = \frac{\overline{V_{\phi a}}}{\overline{Z_a}} = \frac{120 \angle 0^\circ}{22.4 \angle 26.6^\circ}$$

$$\boxed{\overline{I_{Za}} = \overline{I_{\phi a}} = \overline{I_{La}} = 5.35 \angle -26.6^\circ \; A}$$

$$\boxed{\overline{I_{Zb}} = I_{\phi b} = \overline{I_{Lb}} = 5.35 \angle -146.6^\circ \; A}$$

$$\boxed{\overline{I_{Zc}} = I_{\phi c} = \overline{I_{Lc}} = 5.35 \angle -266.6^\circ \; A}$$

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Using KCL at node A,

$$\overline{I_N} = \overline{I_{Za}} + \overline{I_{Zb}} + \overline{I_{Zc}}$$

$$I_N = 5.35 \angle -26.6^\circ + 5.35 \angle -146.6^\circ + 5.35 \angle -266.6^\circ \text{ A}$$

$$I_N = (4.784 - j(2.395)) + (-4.466 - j\,2.945) + (-0.317 + j\,5.34) \text{ A}$$

$$\boxed{I_N = 0 \text{ A}}$$

As the system is balanced,

$$\overline{V_{L(a,b)}} = \sqrt{3}\, V_\phi \angle 30^\circ$$

$$\overline{V_{L(a,b)}} = 207.84 \angle 30^\circ \text{ V}$$

and, $\overline{V_{L(b,c)}} = 207.84 \angle -90^\circ \text{ V}$

and, $\overline{V_{L(c,a)}} = 207.84 \angle -210^\circ \text{ V}$

and, load voltages

$$\overline{V_{Za}} = \overline{V_{\phi a}} = 120 \angle 0^\circ \text{ V}$$

$$\overline{V_{Zb}} = \overline{V_{\phi b}} = 120 \angle -120^\circ \text{ V}$$

$$\overline{V_{Zc}} = \overline{V_{\phi c}} = 120 \angle -240^\circ \text{ V}$$

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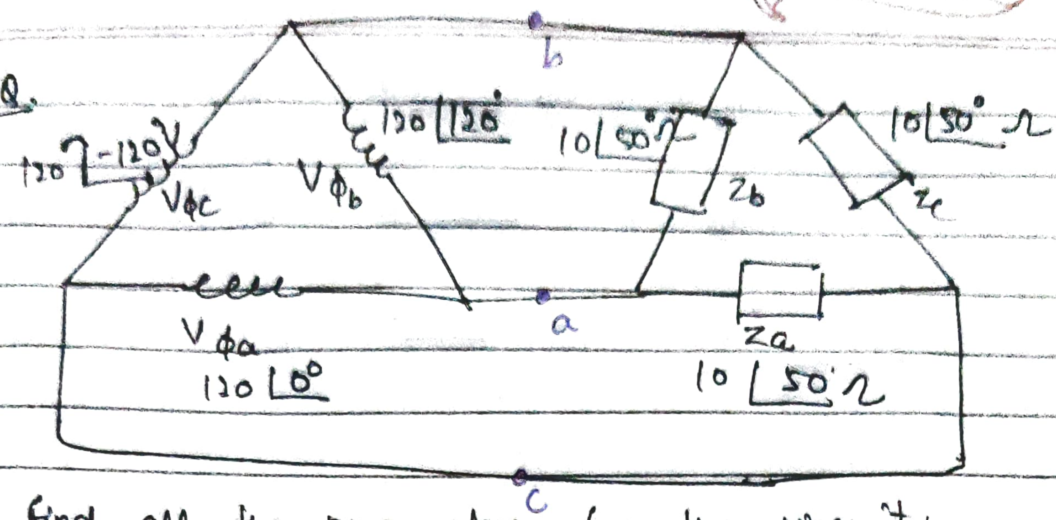
Q.



Find all the parameters for the circuit.

The system is balanced.

$$\boxed{\begin{aligned} V_{\phi b} &= V_{L(ab)} = \overline{V}_{Z_b} = 120\angle 120^\circ \text{ V} \\ V_{\phi a} &= V_{L(ca)} = \overline{V}_{Za} = 120\angle 0^\circ \text{ V} \\ V_{\phi c} &= V_{L(bc)} = \overline{V}_{Z_c} = 120\angle -120^\circ \text{ V} \end{aligned}}$$

and, $I_Z = I_{Za} = I_{Z_b} = I_{Z_c} = \dfrac{\overline{V}_{Za}}{Z_a}$

$$I_Z = \frac{120}{10} = 12 \text{ A}$$

$$\boxed{\begin{aligned} \overline{I}_{Za} &= 12\angle -50^\circ \text{ A} \\ \overline{I}_{Z_b} &= 12\angle 70^\circ \text{ A} \\ \overline{I}_{Z_c} &= 12\angle -170^\circ \text{ A} \end{aligned}}$$

For $\Delta - \Delta$ connection

$$I_L = \sqrt{2}\, I_Z$$

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$$\boxed{\begin{aligned} \therefore\ I_{La} &= 12\sqrt{3}\ \angle -50^\circ\ A \\ I_{Lb} &= 12\sqrt{3}\ \angle 70^\circ\ A \\ I_{Lc} &= 12\sqrt{3}\ \angle -170^\circ\ A \end{aligned}}$$