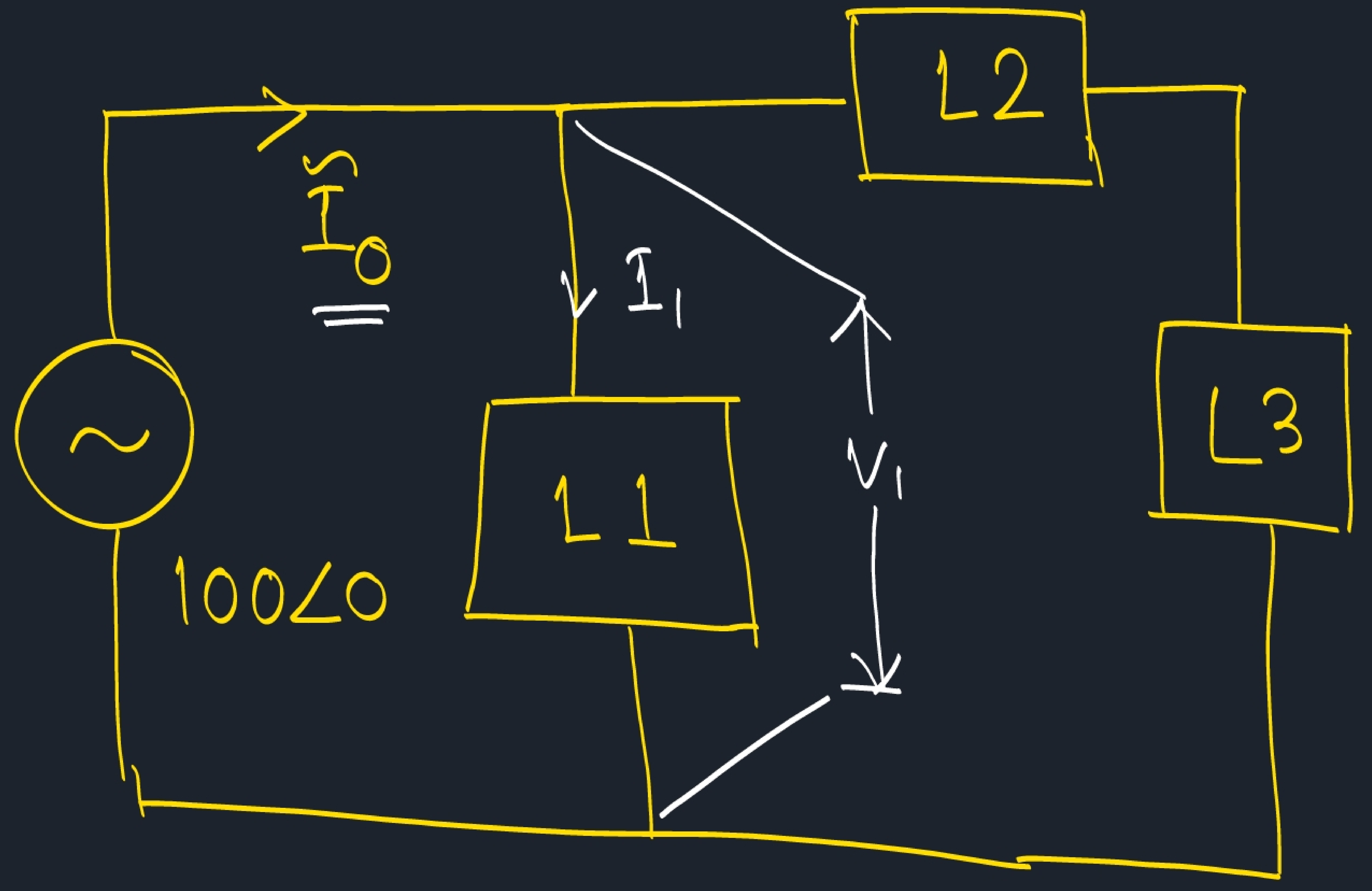
Problem :-

$$\boxed{\frac{Q}{P} = \tan\theta}$$



L_1 : 2 KVA, 0.707 pf(lead)

L_2 : 1.2 KW, 0.8 KVAR (Cap)

L_3 : 4 KW, 0.9 pf(lag)

$$P + jQ = \hat{V}\hat{I}^*$$

$$P - jQ = \hat{V}^* I$$

$\underline{L_1}$:-

$$S_1 = P_1 - jQ_1$$

$$P_1 = S_1 \cos\theta_1 = (2 \times 0.707)\ \text{KW}$$

$$Q_1 = S_1 \sin\theta_1 = 2 \times \sin\{\cos^{-1}(0.707)\}\ \text{KVAR}.$$

$\underline{L_2}$:-

$$S_2 = P_2 - jQ_2$$

$$P_2 = 1.2\ \text{KW}$$

$$Q_2 = +0.8\ \text{KVAR}$$

$\underline{L_3}$:-

$$S_3 = P_3 + jQ_3$$

$$P_3 = 4\ \text{KW}.$$

$$Q_3 = 4 \times \tan\{\cos^{-1} 0.9\}\ \text{KVAR}$$

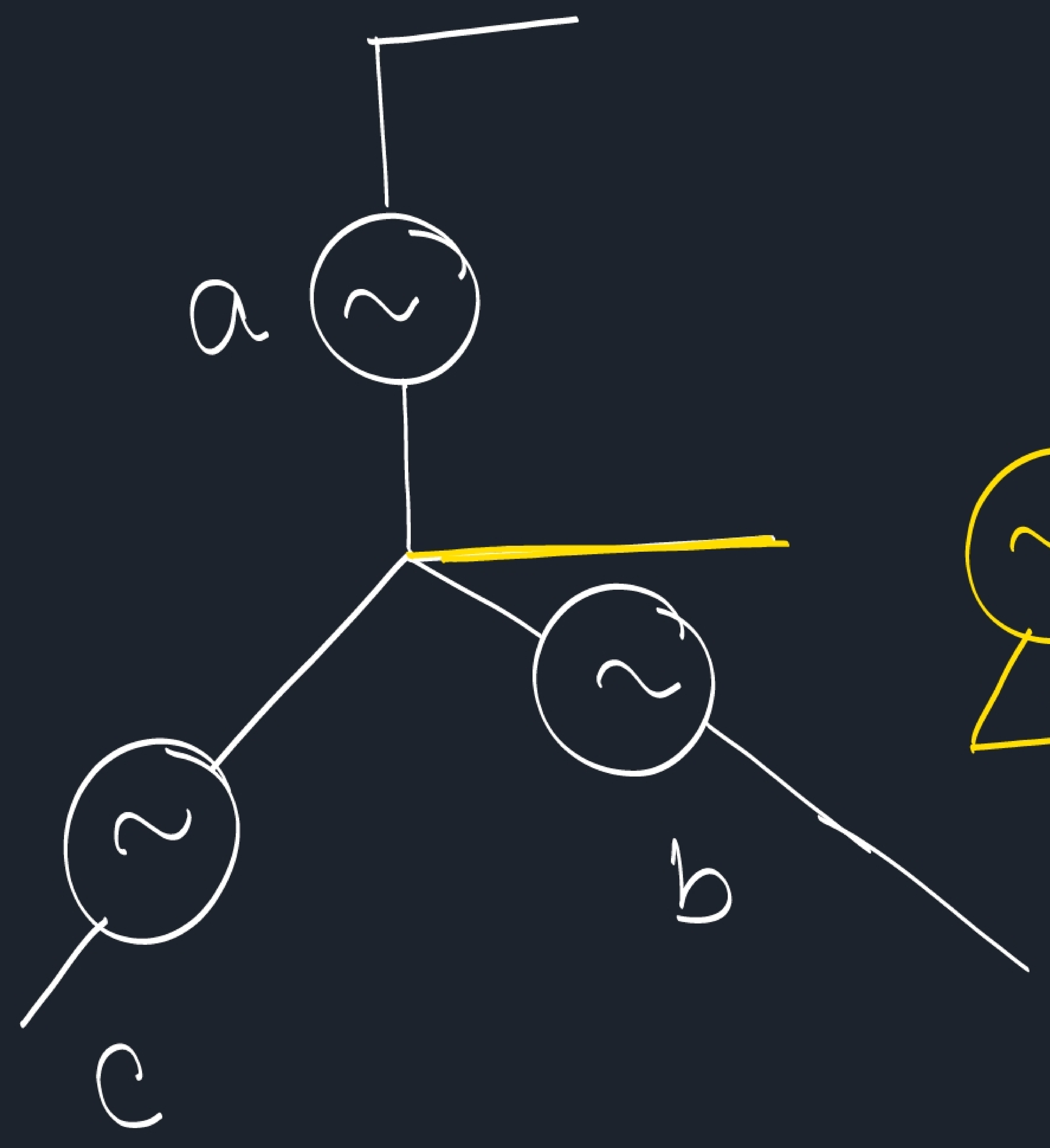
$$S = S_1 + S_2 + S_3$$

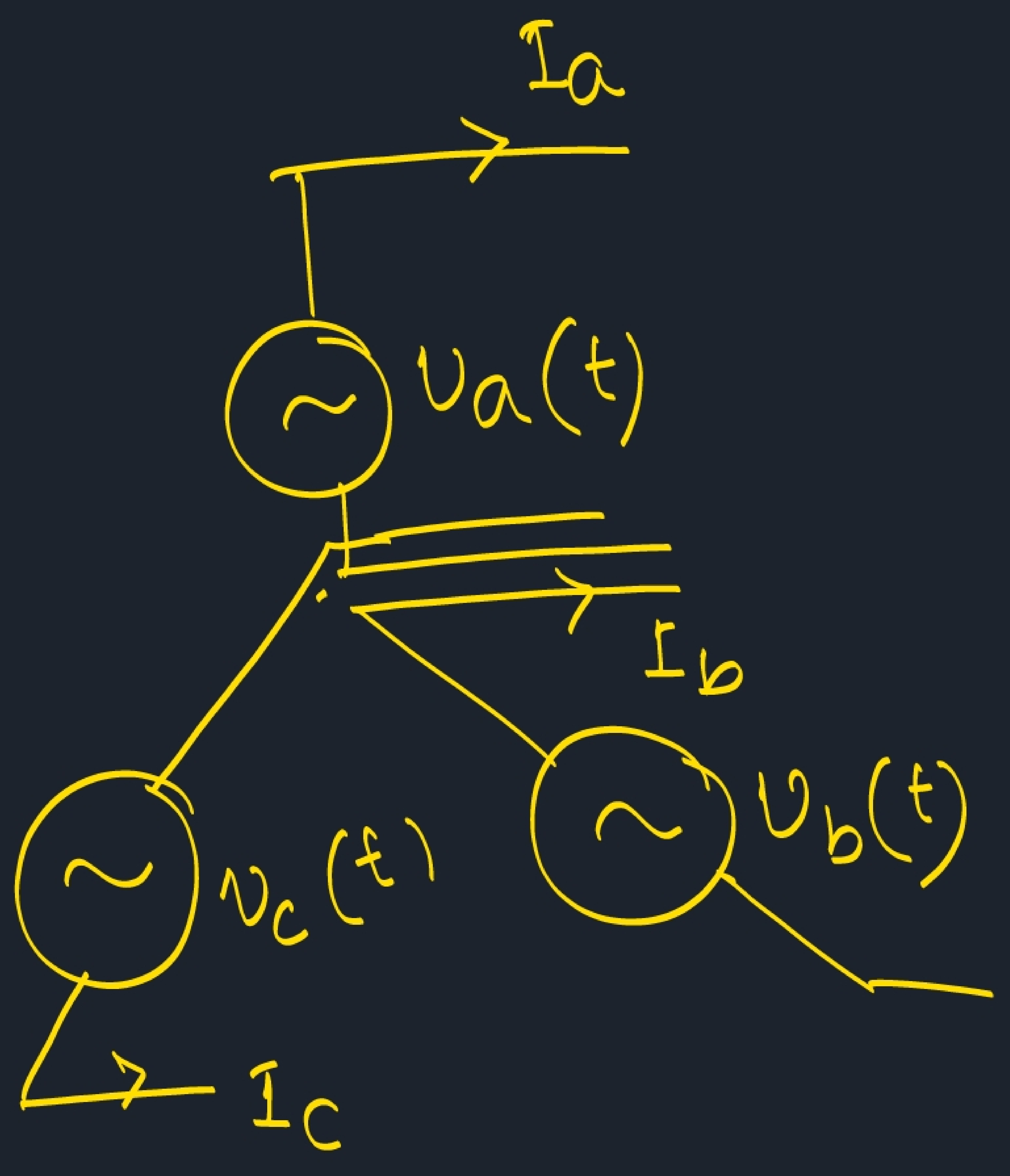
$$= \{6.614 - j0.241\}\ \text{KVA}.$$

$$= V I_0^*$$

$$\hat{I}_0 = 66.29\angle 2.4^\circ\ \text{Amps}$$

POLYPHASE CKT :-



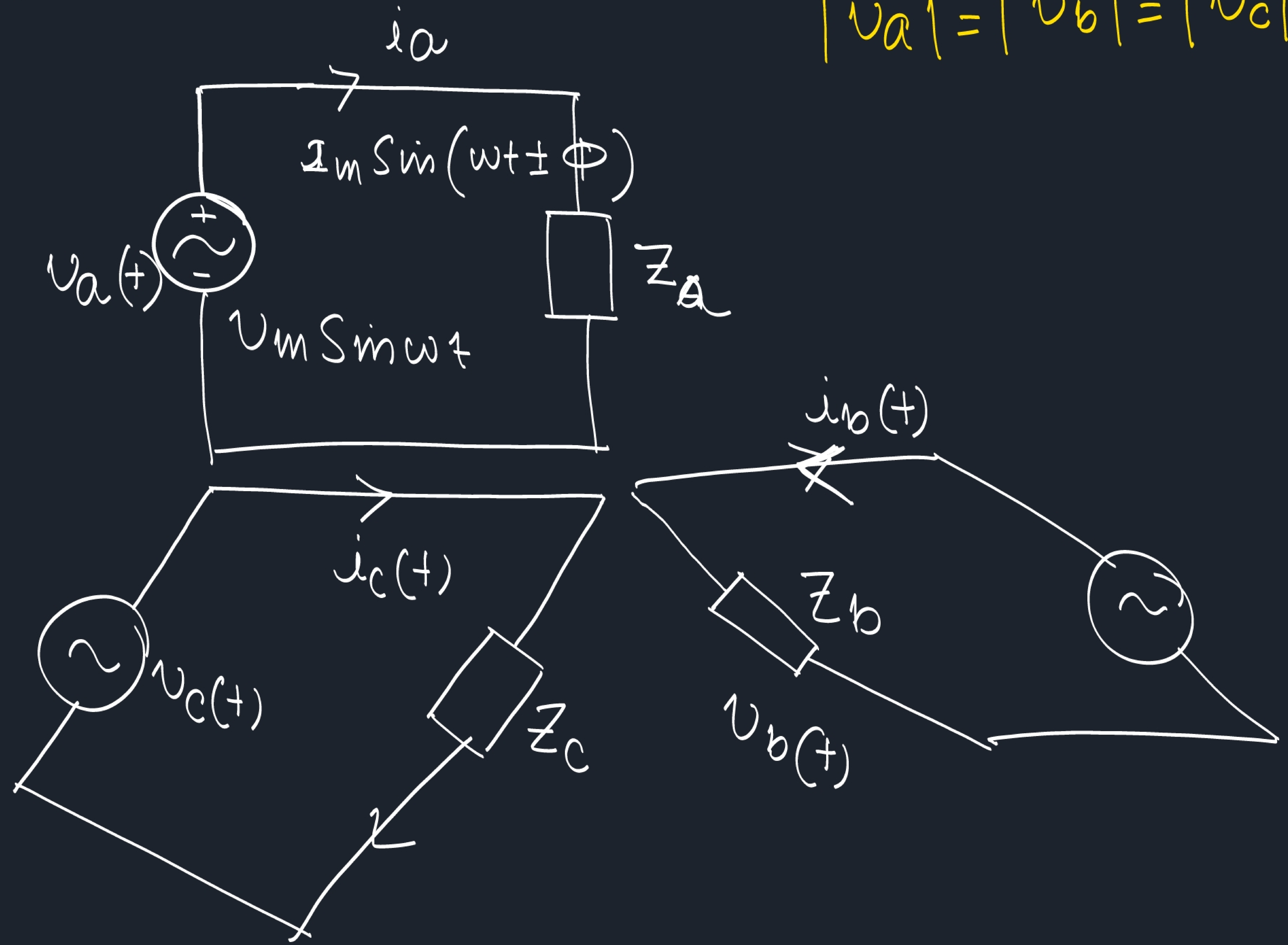


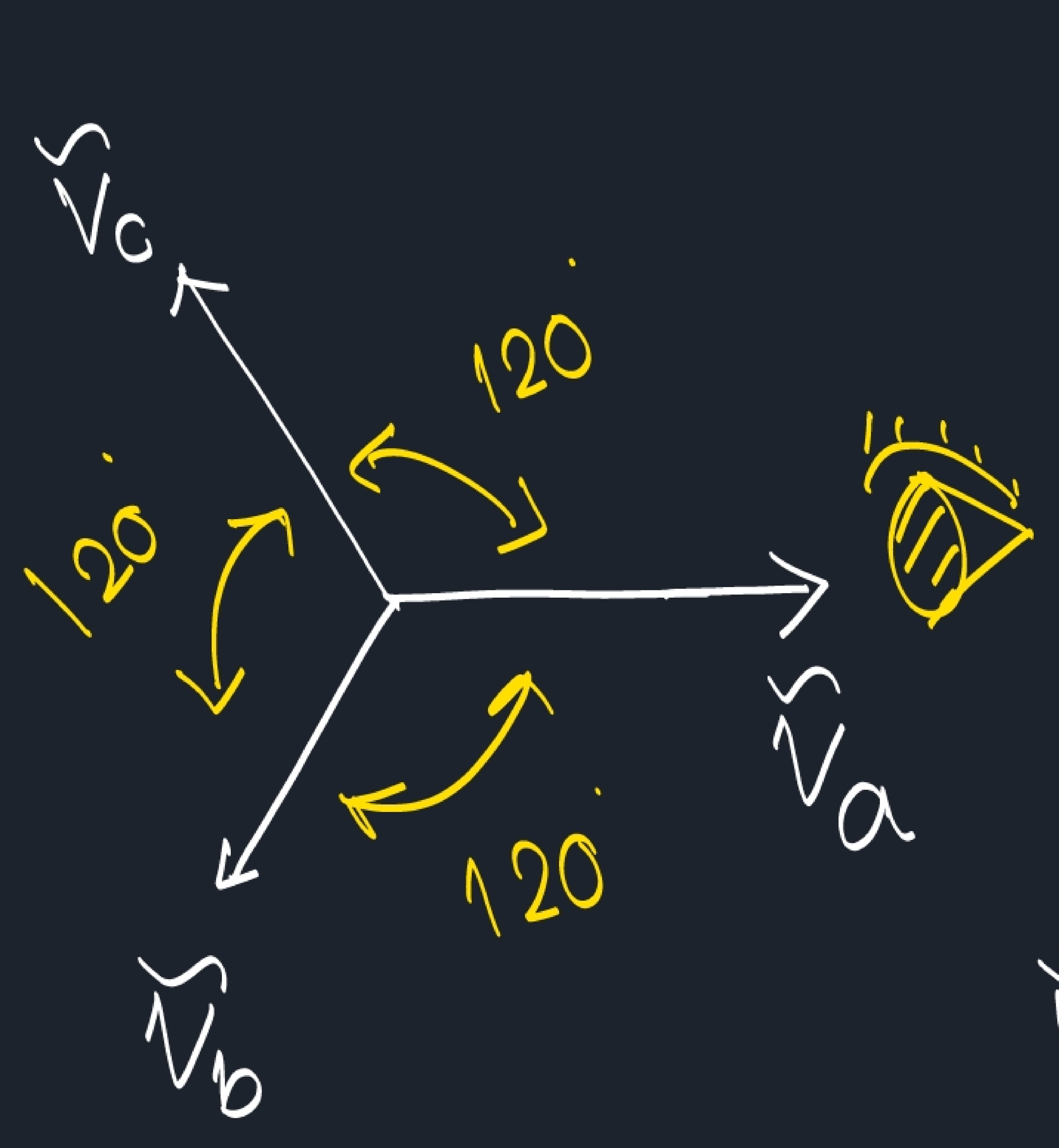
$$\boxed{v_a(t) + v_b(t) + v_c(t) = 0} \quad \forall t$$

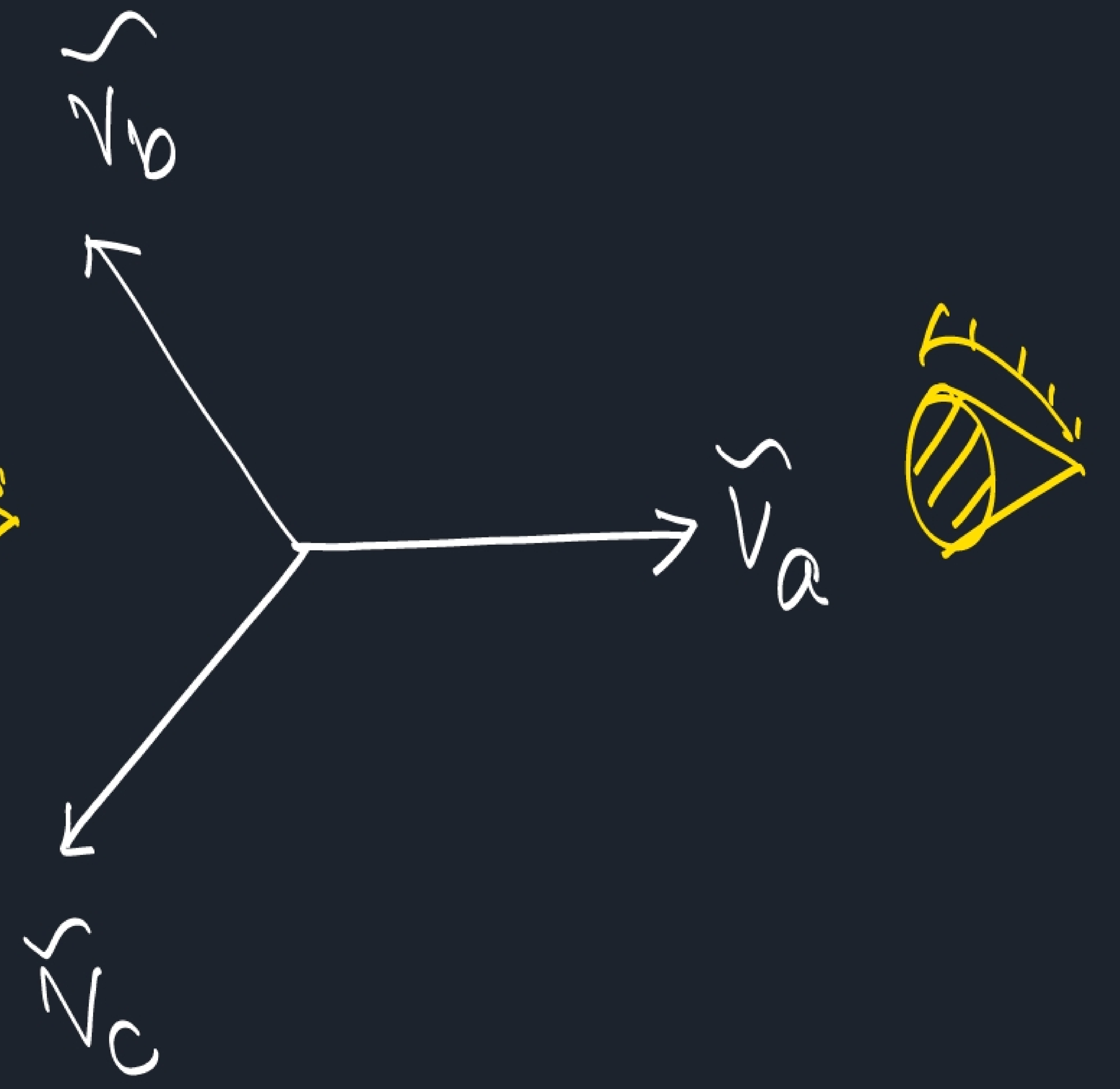
$$|v_a| = |v_b| = |v_c| = K.$$

3φ Balanced.

$$v_a(t) = V_m \sin \omega t$$







$$\underbrace{a-b-c-a-b-c}_{(+ve)\ \text{Seq}}$$

$$\underbrace{a-c-b-a-c-b}_{(-ve)\ \text{Seq.}}$$

a - b - c

$$\hat{V}_a = V_m \angle 0^\circ \qquad v_a(t) = V_m \sin(\omega t)$$

$$\hat{V}_b = V_m \angle -120^\circ \qquad v_b(t) = V_m \sin(\omega t - 120^\circ)$$

$$\hat{V}_c = V_m \angle +120^\circ \qquad v_c(t) = V_m \sin(\omega t + 120^\circ)$$

a - c - b

$$\hat{V}_a = V_m \angle 0^\circ \qquad v_a(t) = V_m \sin \omega t$$

$$\hat{V}_b = V_m \angle 120^\circ \qquad v_b(t) = V_m \sin(\omega t + 120^\circ)$$

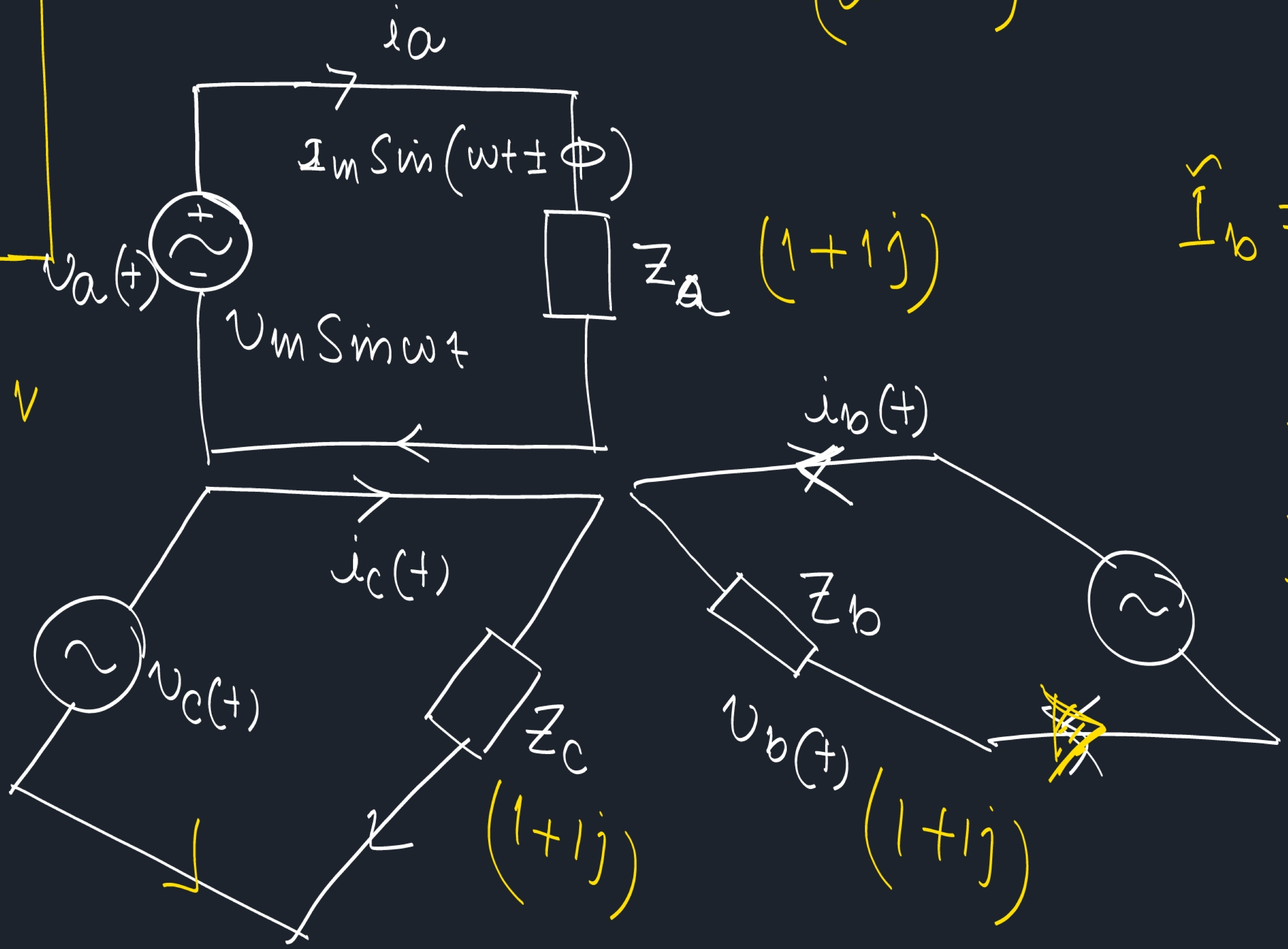
$$\hat{V}_c = V_m \angle -120^\circ \qquad v_c(t) = V_m \sin(\omega t - 120^\circ)$$

$$v_a(t)+v_b(t)+v_c(t)=0$$

$$\check{V}_a+\hat{V}_b+\hat{V}_c=0$$

$\boxed{Y \quad \Delta}$

$$|V_a|=|V_b|=|V_c|=100\,V$$



$(a\text{-}b\text{-}c)$

$$\check{I}_a=\frac{\check{V}_a}{Z_a}=\frac{100\angle 0}{1+j}$$

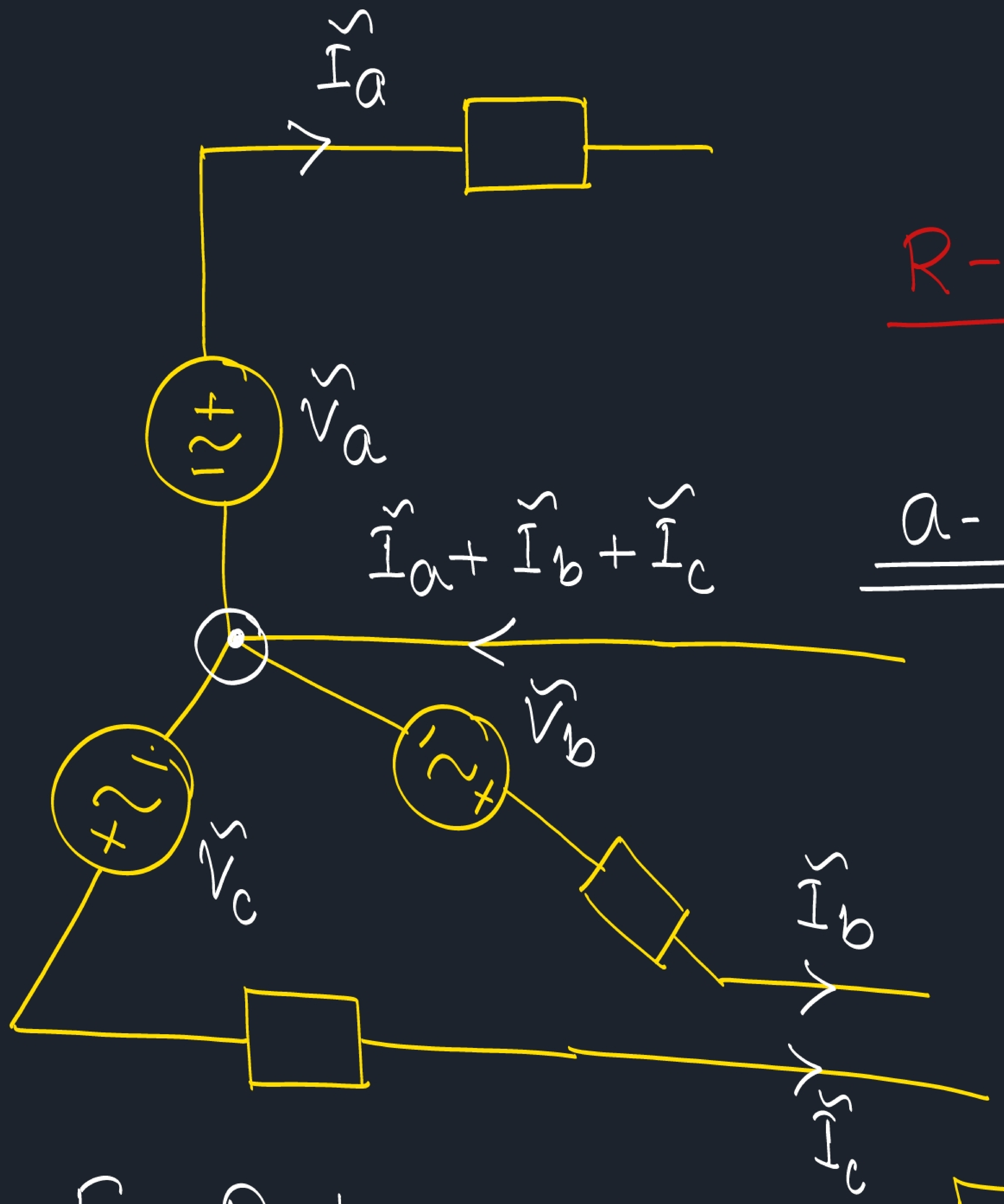
$$=70.7\angle -45$$

$$\hat{I}_b=\frac{100\angle -120}{1+1j}$$

$$=70.7\angle -120-45$$

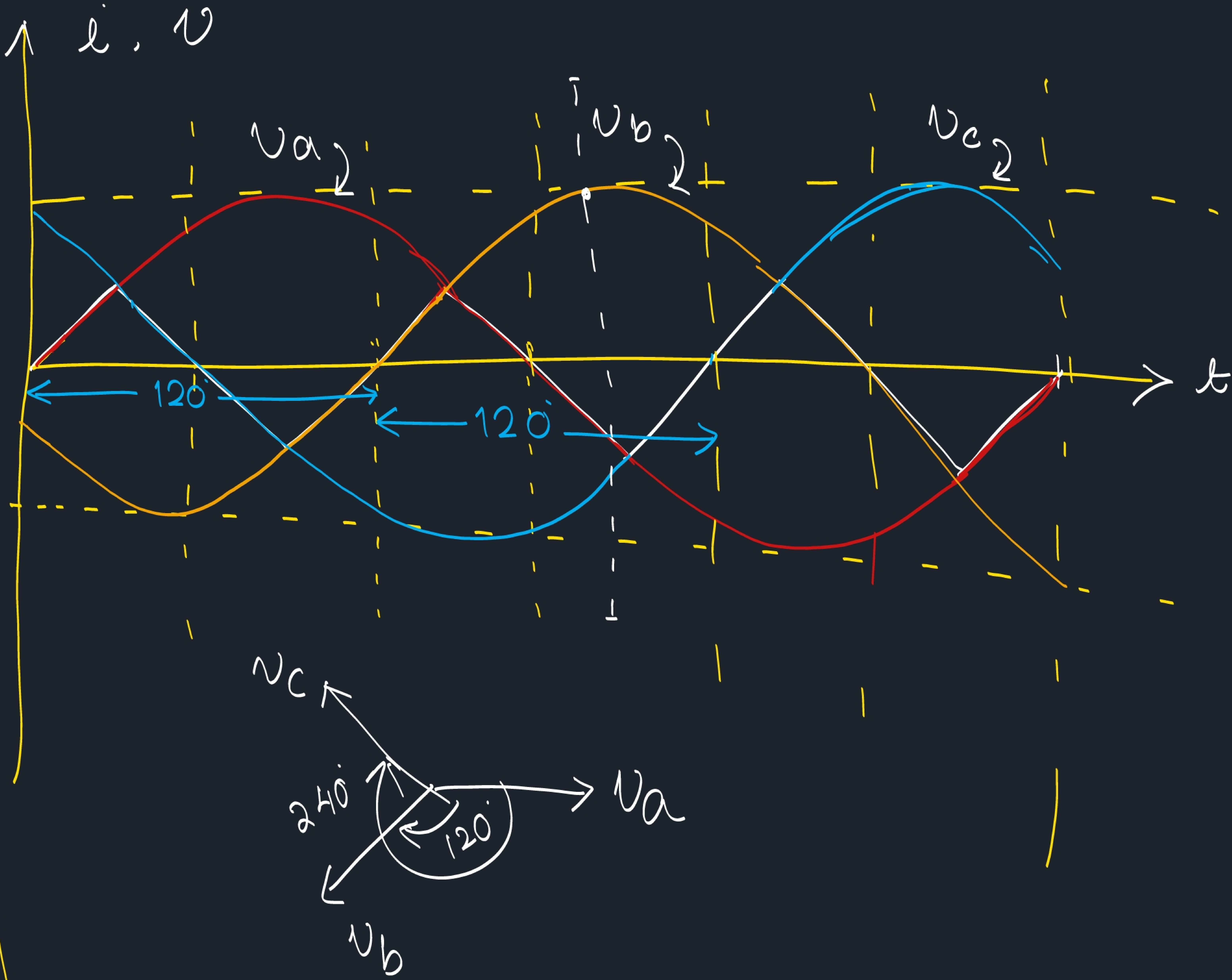
$$\check{I}_c=\frac{\check{V}_c}{Z_c}=\frac{100\angle 120}{1+1j}$$

$$=70.7\angle 120-45$$



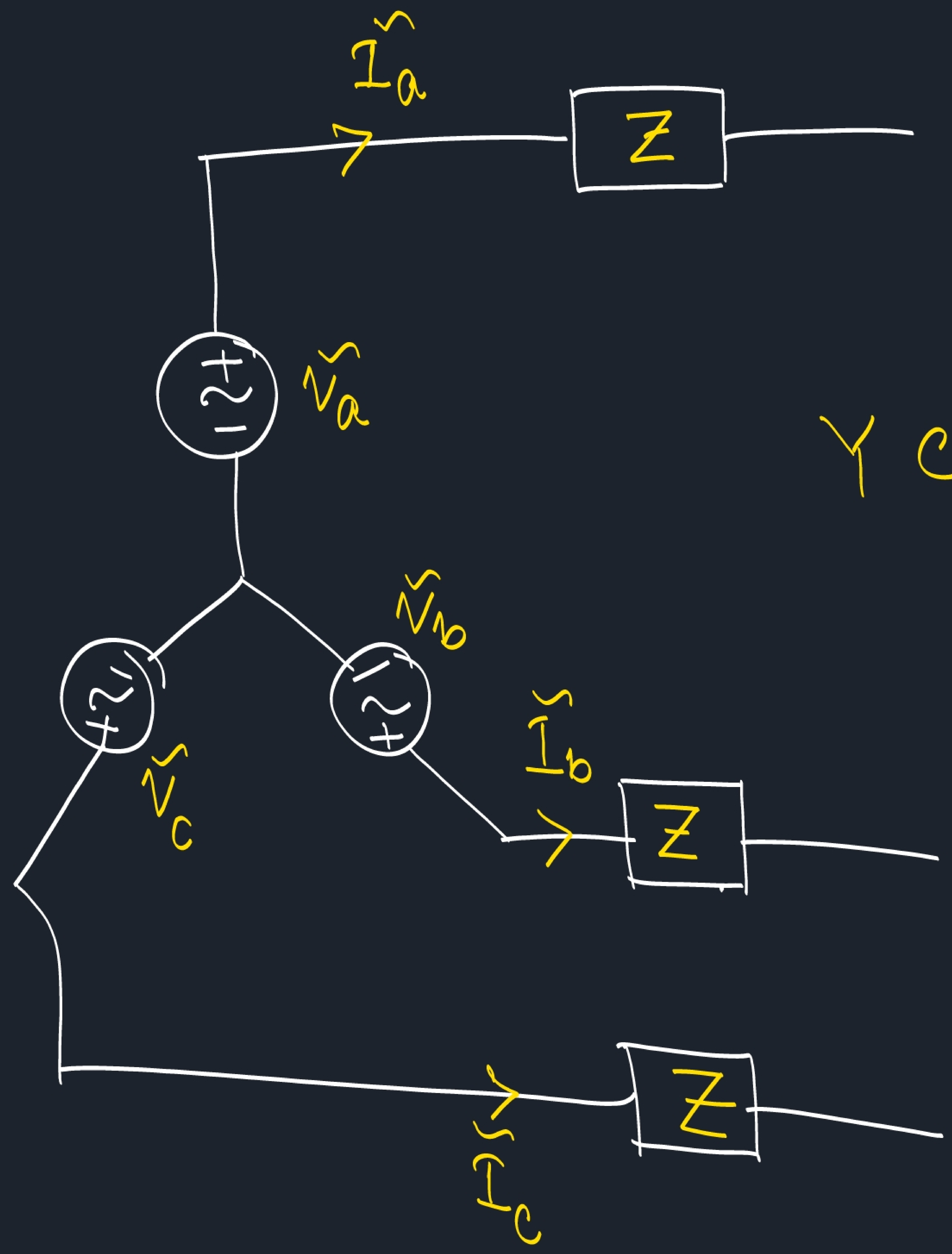
R-Y-B

a-b-c

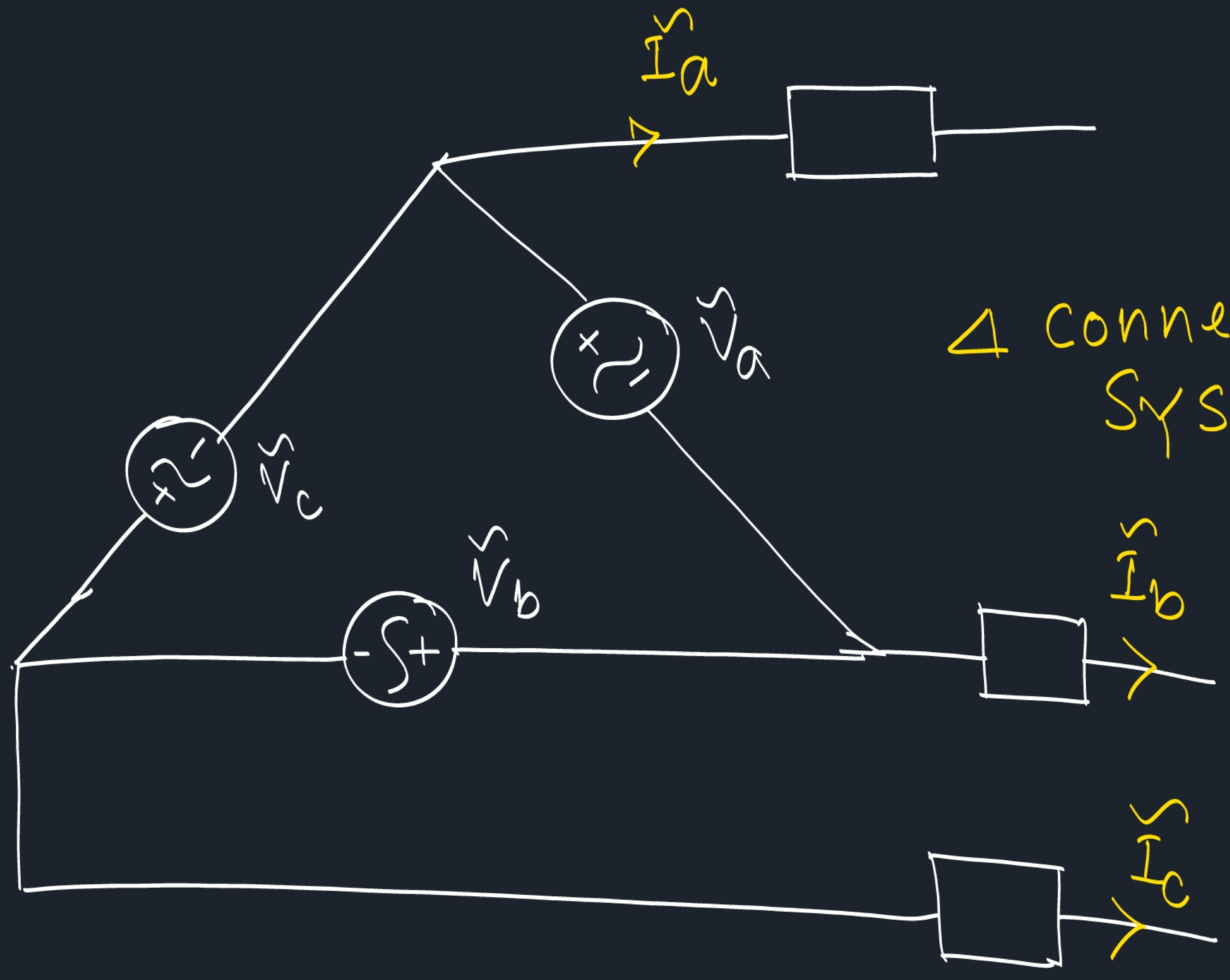


For Balanced System

$$\boxed{\check{I}_a+\check{I}_b+\check{I}_c=0}$$



Y connected System.

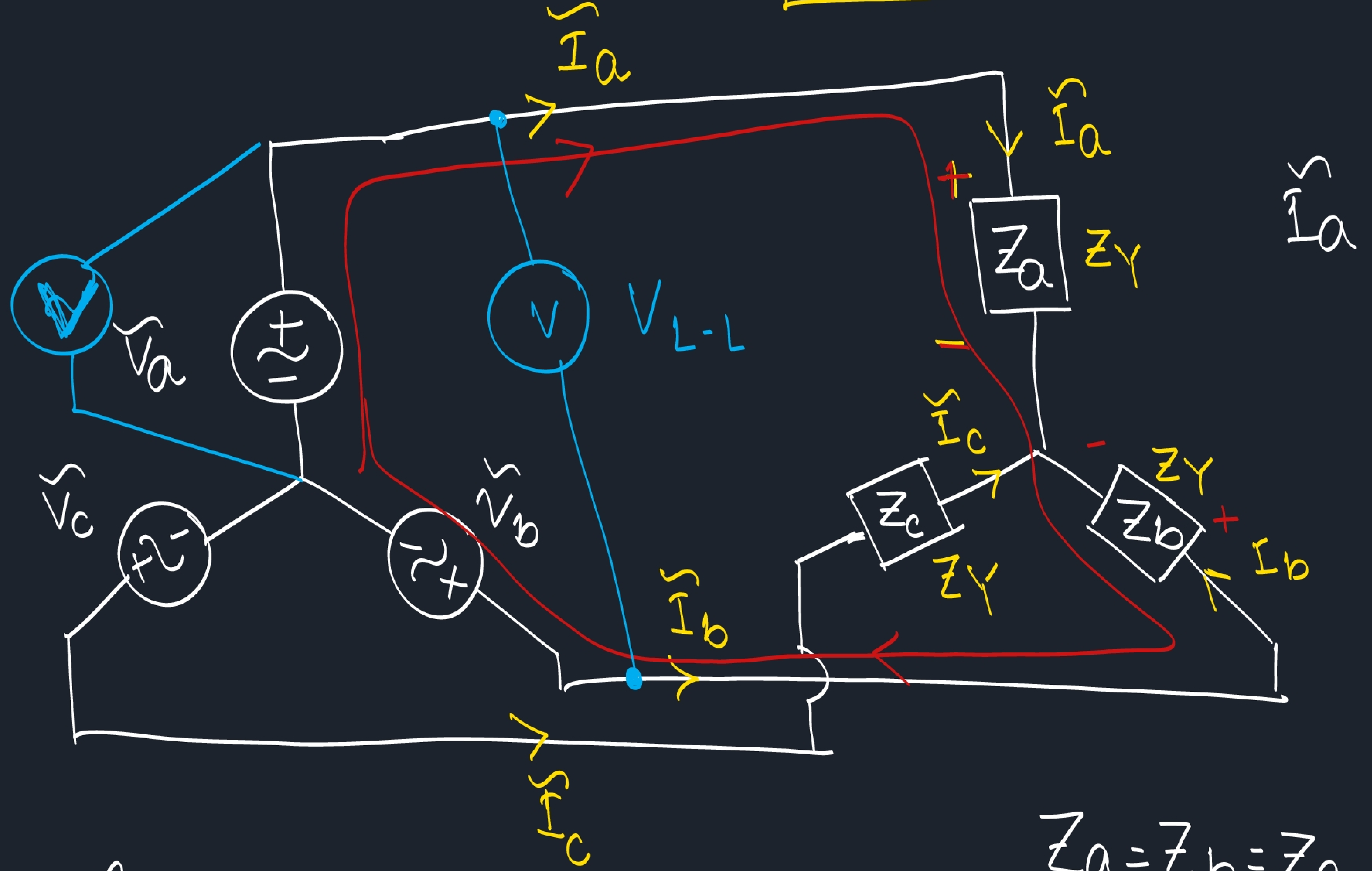


Δ connected System.

	Source	Load.
1.	Y	Y
2.	Y	Δ
3.	Δ	Y
4.	Δ	Δ

Y – Y :

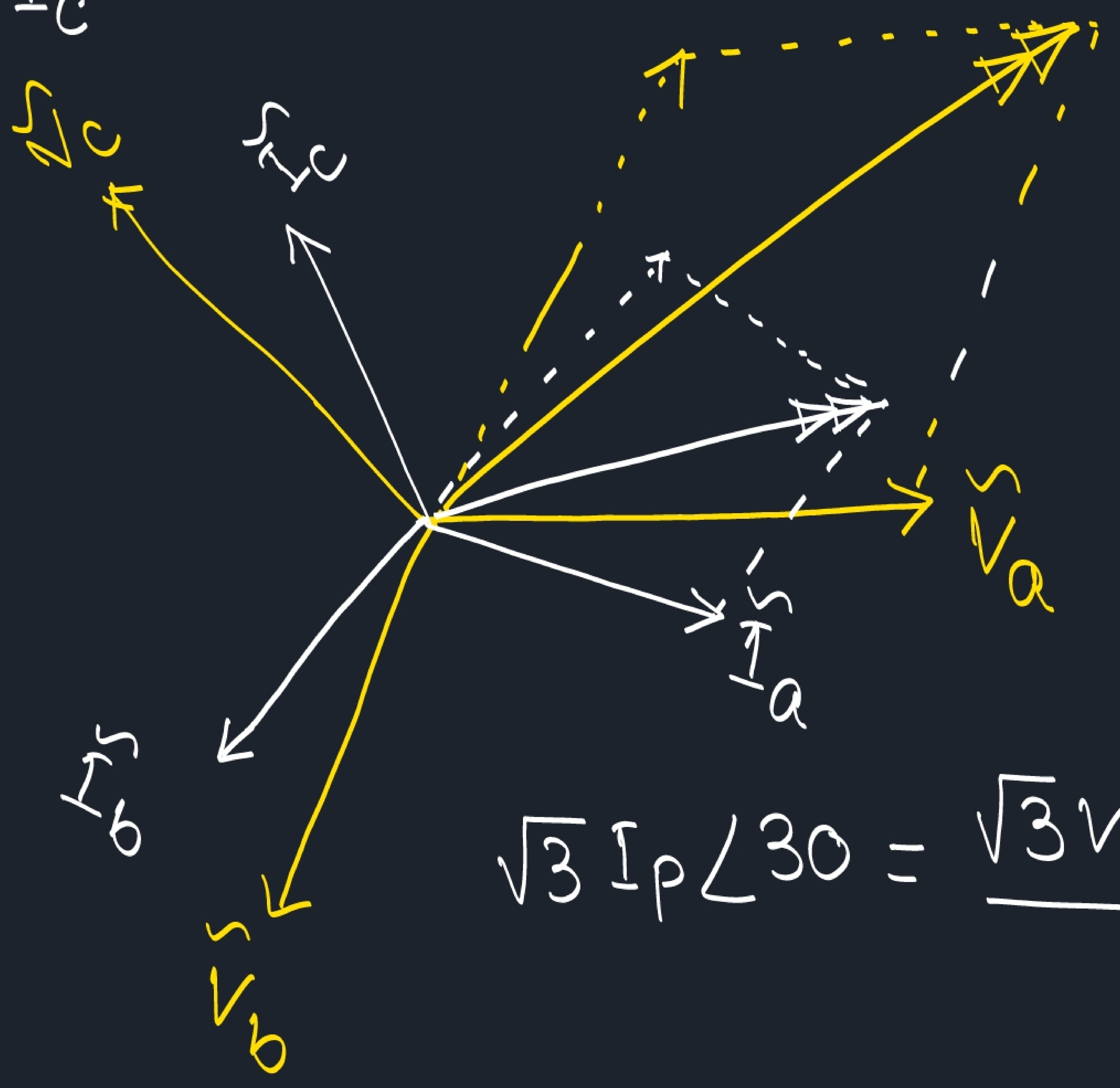
$$\boxed{I_p = \frac{V_p}{Z_Y}}$$



$$\hat{V}_a - \hat{I}_a Z_Y + \hat{I}_b Z_Y - \hat{V}_b = 0$$

$$\Rightarrow (\hat{I}_a - \hat{I}_b) = \frac{\hat{V}_a - \hat{V}_b}{Z_Y} = \frac{\sqrt{3}V_p \angle 30}{Z_Y}$$

$\hat{I}_a, \hat{I}_b, \hat{I}_c$



$\hat{V}_a = V_p \angle 0$

$\hat{V}_b = V_p \angle -120^\circ$

$\hat{V}_c = V_p \angle +120^\circ$

$|I_a| = |I_b| = |I_c|$

$= I_p$

$$\sqrt{3} I_p \angle 30 = \frac{\sqrt{3} V_p \angle 30}{Z_Y}$$

$\hat{V}_a + \hat{V}_b + \hat{V}_c = 0$ $\quad |\hat{V}_a| = |\hat{V}_b| = |\hat{V}_c|$

$Z_a = Z_b = Z_c$

$= Z_Y$

$$\hat{I}_a = I_p \angle 0$$

$$= \frac{V_p}{Z_Y} \angle 0 = \frac{V_p}{|Z|} \angle -\theta$$

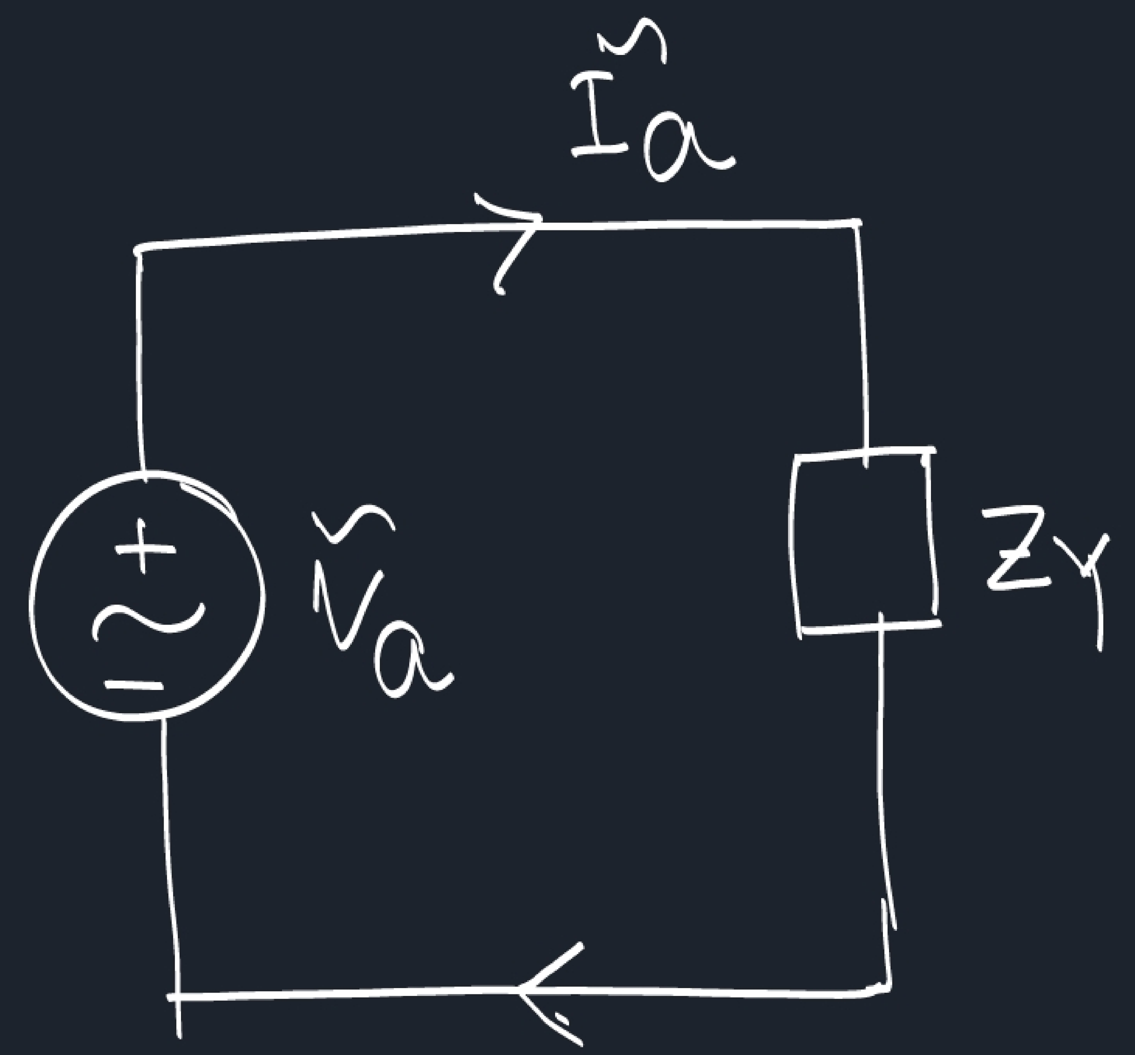
$$Z_Y = |Z_Y| \angle \theta$$

$1 + 1j$

$$\hat{I}_b = \frac{V_p}{|Z_Y|} \angle -\theta - 120^\circ$$

$$\hat{I}_c = \frac{V_p}{|Z_Y|} \angle -\theta + 120^\circ$$

$$Y \begin{cases} |V_{L-L}| = \sqrt{3}\,|V_{ph}| \\ |I_L| = |I_{ph}| \end{cases}$$



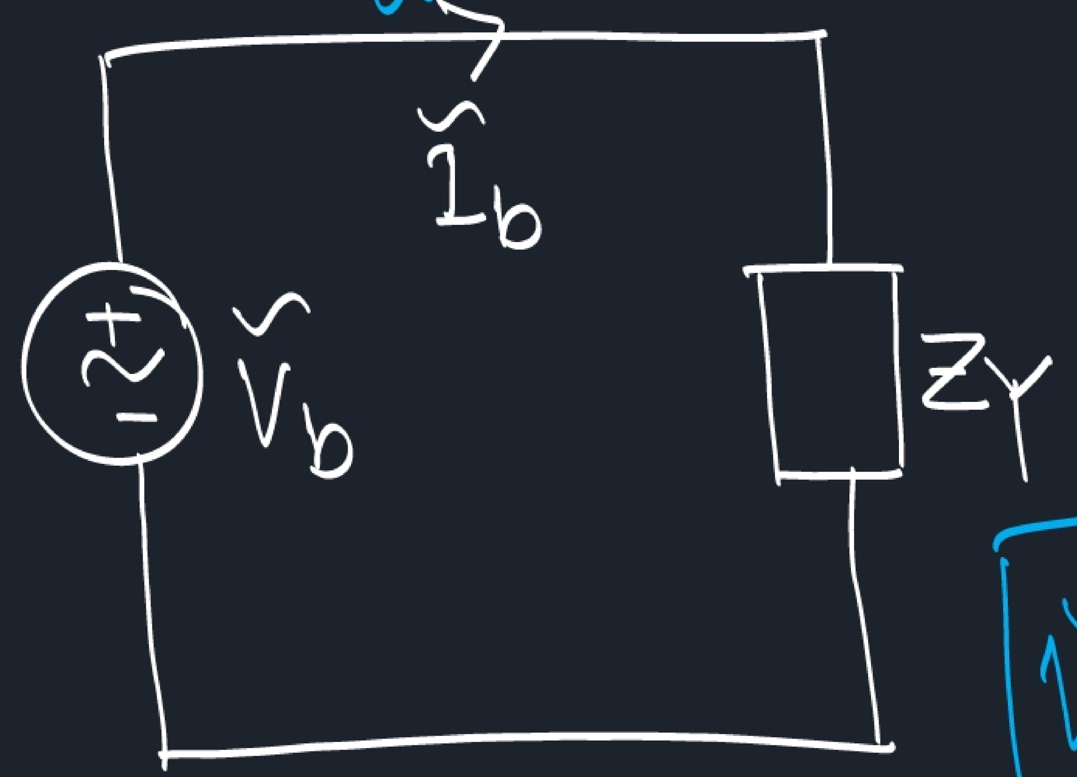
$$\hat{V}_a = V_p \angle 0$$

$$V_{L-L} = \hat{V}_a - \hat{V}_b \qquad V_{ph} = \hat{V}_a$$

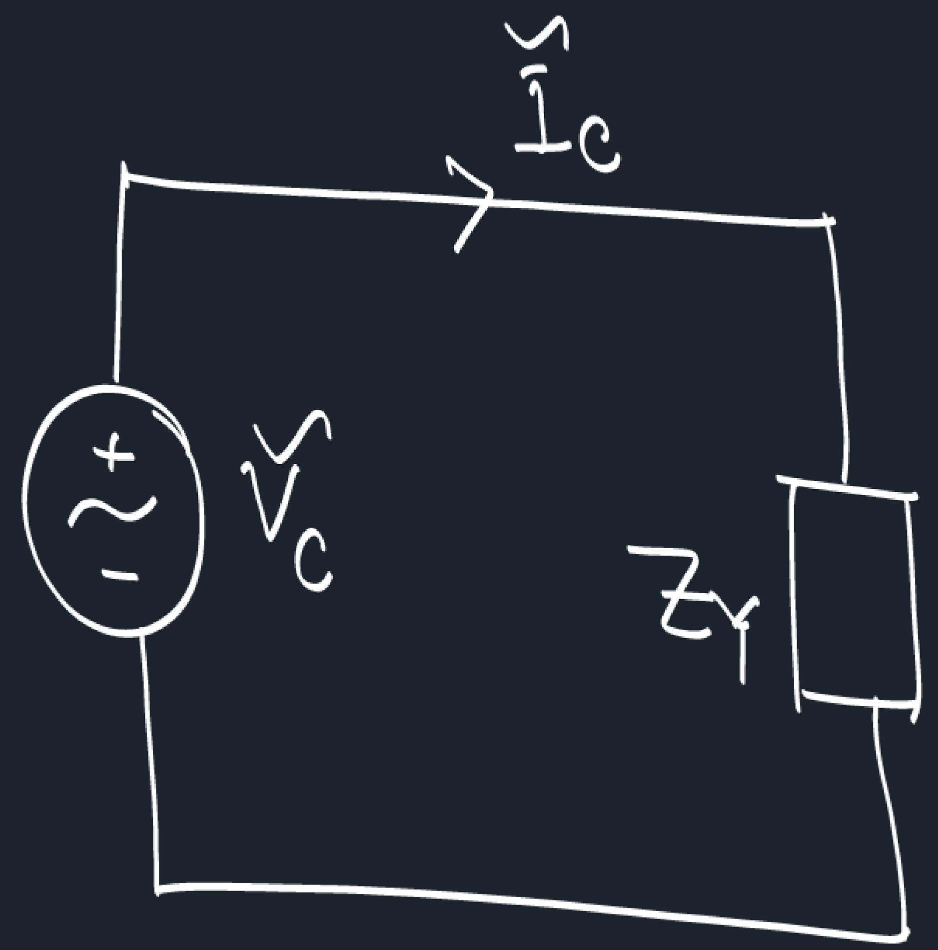
$$= \hat{V}_{ab}$$

$$\hat{V}_a - \hat{V}_b = \sqrt{3}\, V_p \angle 30^\circ$$

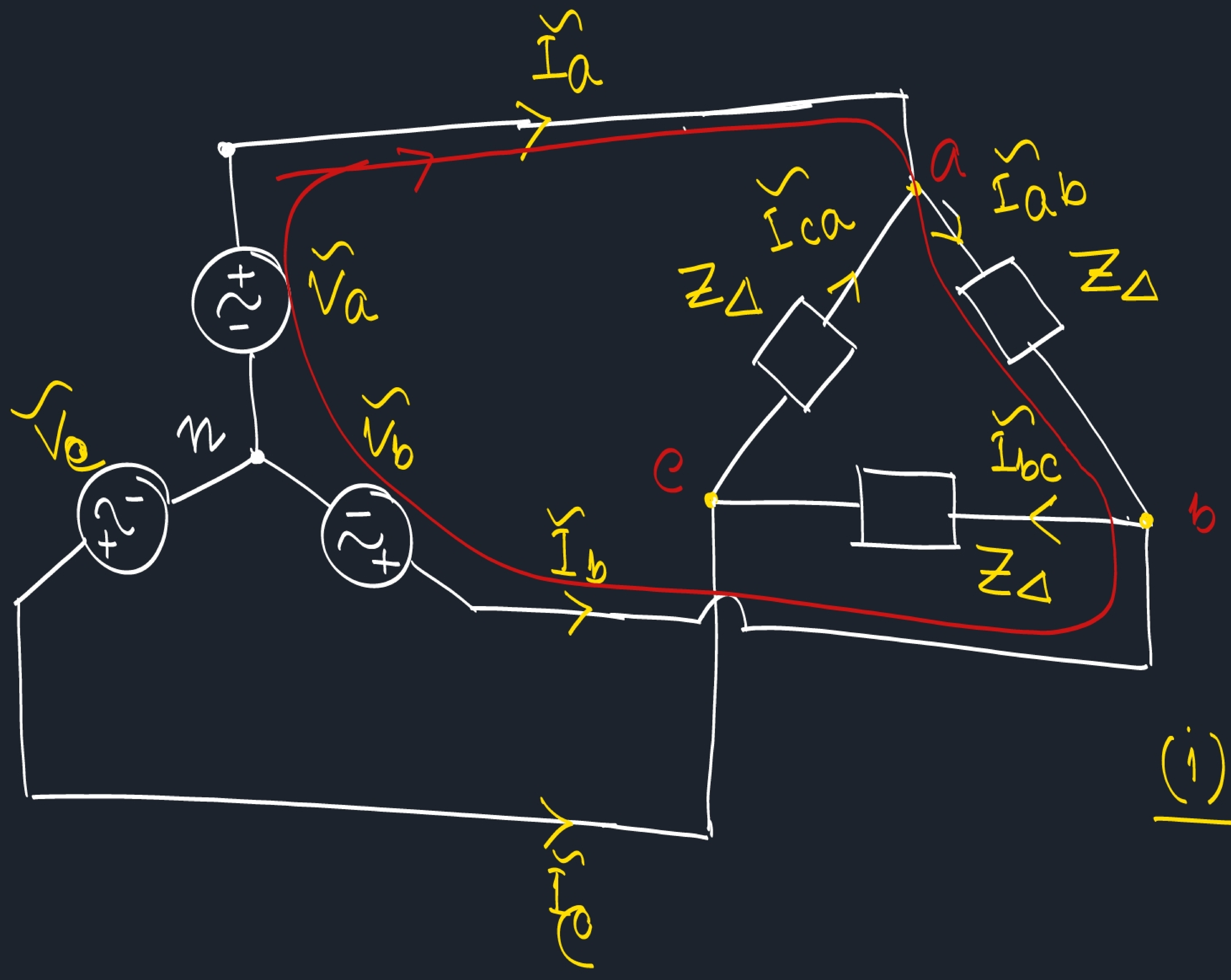
$$= \underbrace{(V_p \angle 0)}_{\hat{V}_a} \cdot \sqrt{3} \angle 30^\circ$$



$$\boxed{\hat{V}_a - \hat{V}_b = \hat{V}_a \left(\sqrt{3} \angle 30\right)}$$



$Y-\Delta$:-



KVL

$$\hat{V}_a - \hat{I}_{ab} Z_\Delta - \hat{V}_b = 0$$

$$\Rightarrow \hat{I}_{ab} = \frac{\hat{V}_a - \hat{V}_b}{Z_\Delta}$$

$$\hat{V}_a - \hat{V}_b = V_p \sqrt{3} \angle +30^\circ$$

$$\hat{I}_a = \hat{I}_{ab} - \hat{I}_{ca} \quad \ldots (i)$$

$$\hat{I}_b = \hat{I}_{bc} - \hat{I}_{ab} \quad \ldots (ii)$$

$$\hat{I}_c = \hat{I}_{ca} - \hat{I}_{bc} \quad \ldots (iii)$$

$$\hat{I}_{ab} + \hat{I}_{bc} + \hat{I}_{ca} = 0$$

as the S/S is balanced.

(i) - (ii)

$$\hat{I}_a - \hat{I}_b = 2\hat{I}_{ab} - (\hat{I}_{bc} + \hat{I}_{ca})$$

$$= 3\hat{I}_{ab}$$

$$\boxed{\hat{I}_{ab} = \frac{\hat{I}_a - \hat{I}_b}{3}}$$

1850.

$$\hat{I}_{ab} = \frac{\hat{V}_a - \hat{V}_b}{Z_\Delta}$$

$$\hat{I}_{ab} = \frac{\hat{I}_a - \hat{I}_b}{3}$$

$$\hat{V}_a - \hat{V}_b = \sqrt{3}\, V_p \angle 30^\circ$$

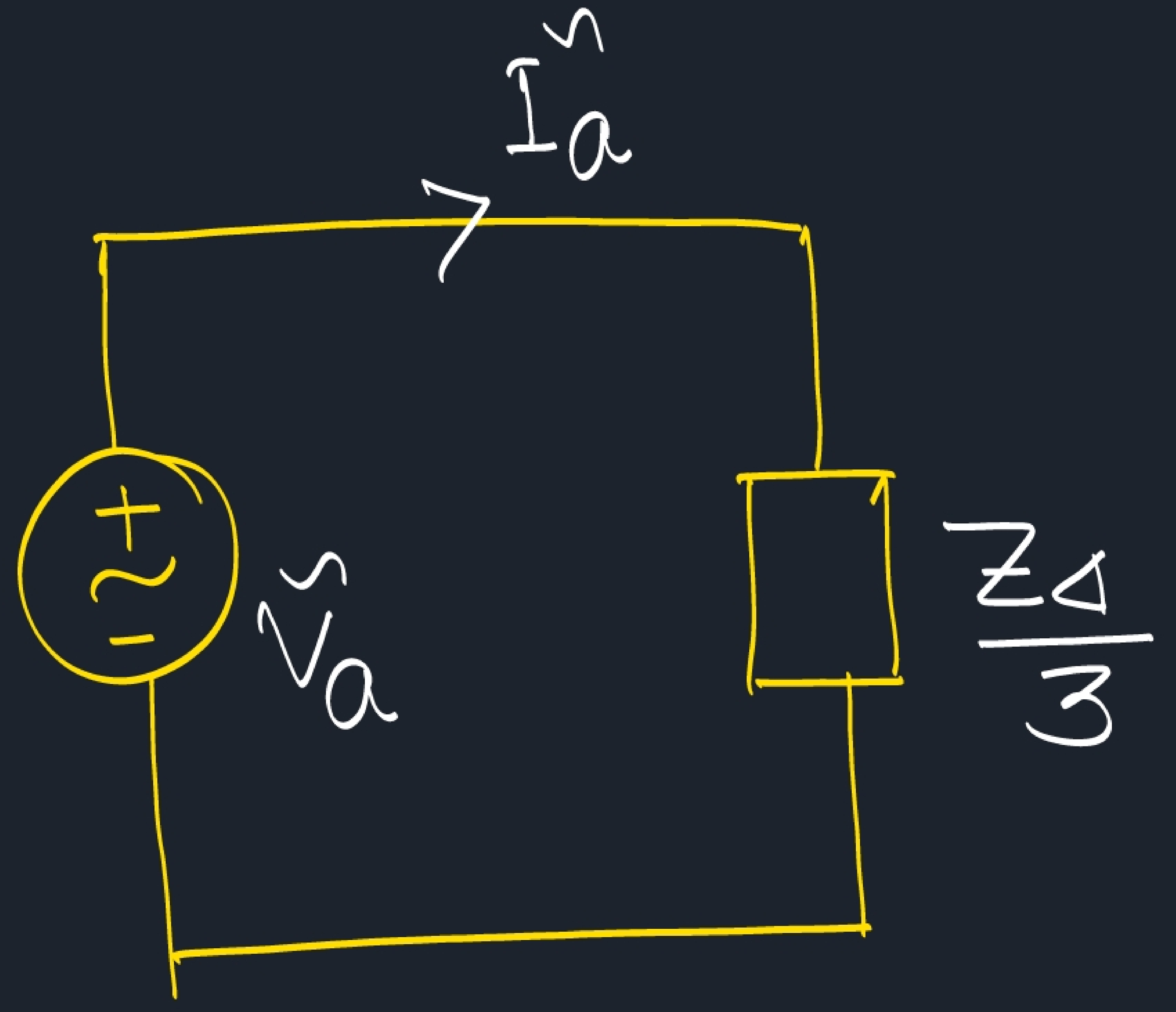
$$\hat{I}_a - \hat{I}_b = \sqrt{3}\, I_p \angle 30^\circ$$

$$\boxed{I_p = \frac{V_p}{\left(\frac{Z_\Delta}{3}\right)}}$$

$$|I_p| = \frac{|V_p|}{\left|\frac{Z_\Delta}{3}\right|}$$

$$\hat{I}_a = I_p \angle \theta$$

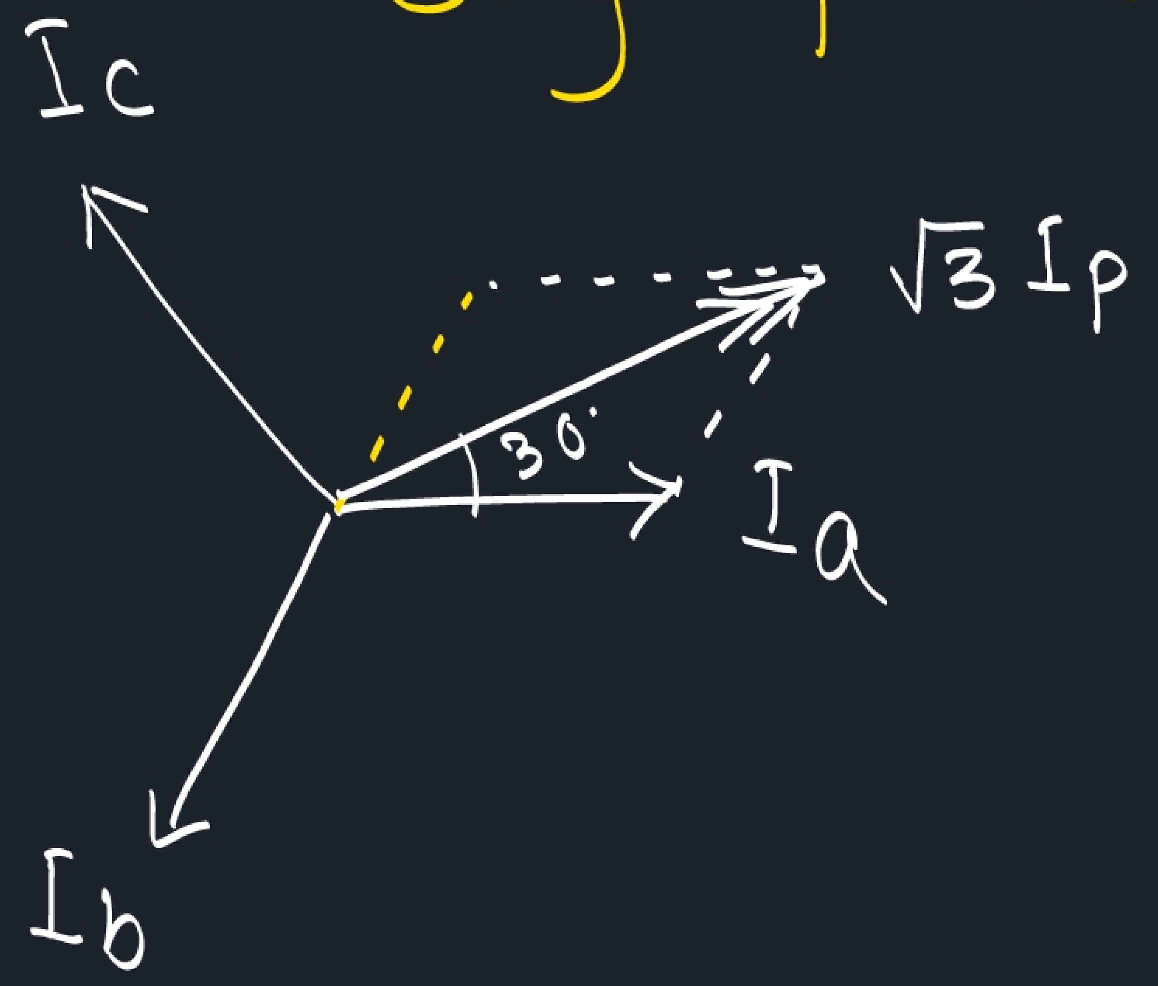
$$= \left|\frac{V_p}{\frac{Z_\Delta}{3}}\right| \angle \theta$$



$$\hat{I}_{ab} = \frac{\hat{I}_a - \hat{I}_b}{3}$$

$$\boxed{I_{L\text{-}L} = \sqrt{3}\, I_p}$$

Single phase equivalent ckt.



$$|\hat{I}_{ab}| = \frac{I_p}{\sqrt{3}}$$

Y

Voltage

Line voltage

= $\sqrt{3}$ x Phase Voltage

$$\boxed{V_{L-L} = \sqrt{3} V_{ph}}$$

Current

$$\boxed{I_L = I_{ph}}$$

$\triangle$

Voltage

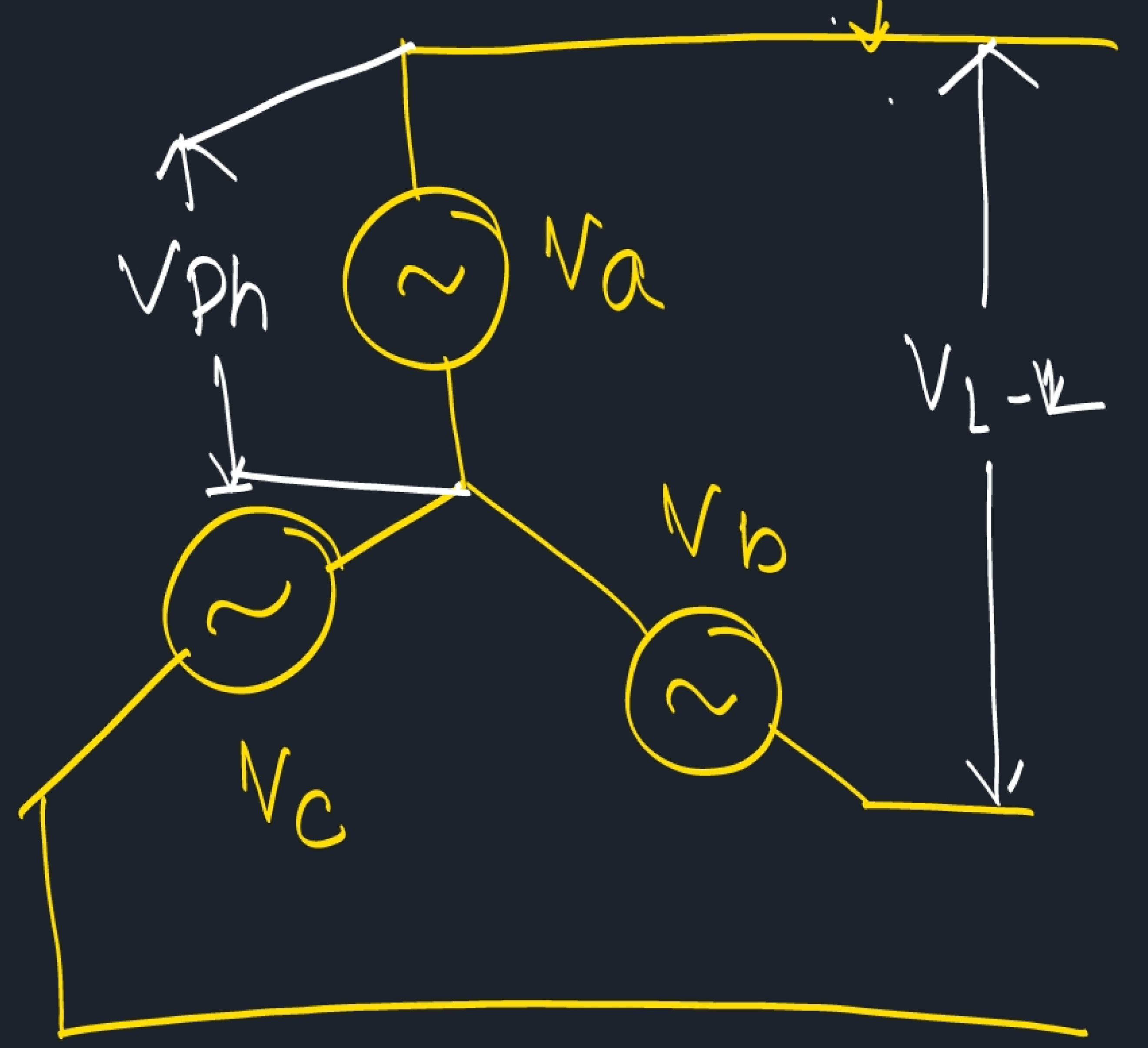
Line voltage

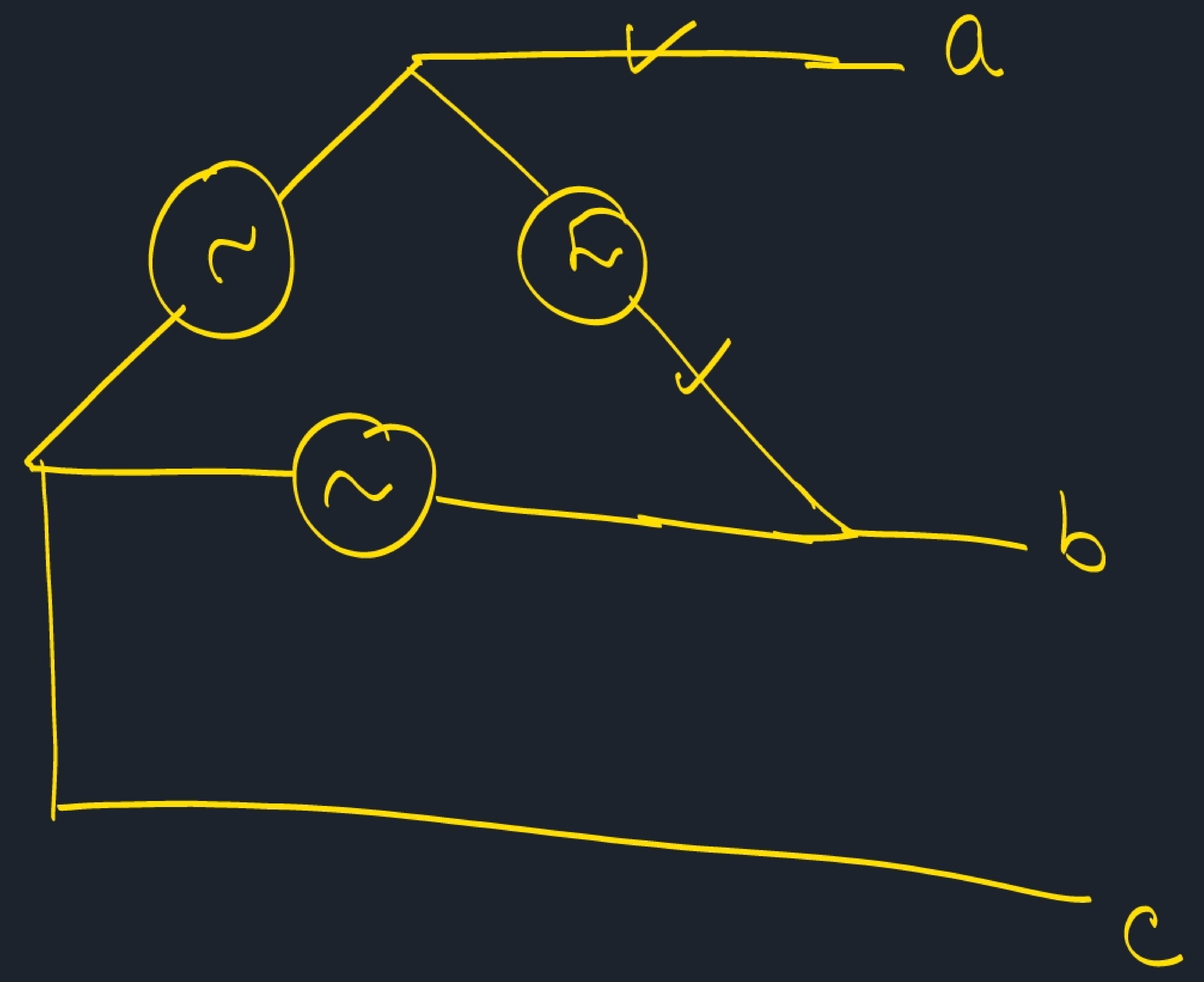
= Phase Voltage

$$\boxed{V_{L-L} = V_{ph}}$$

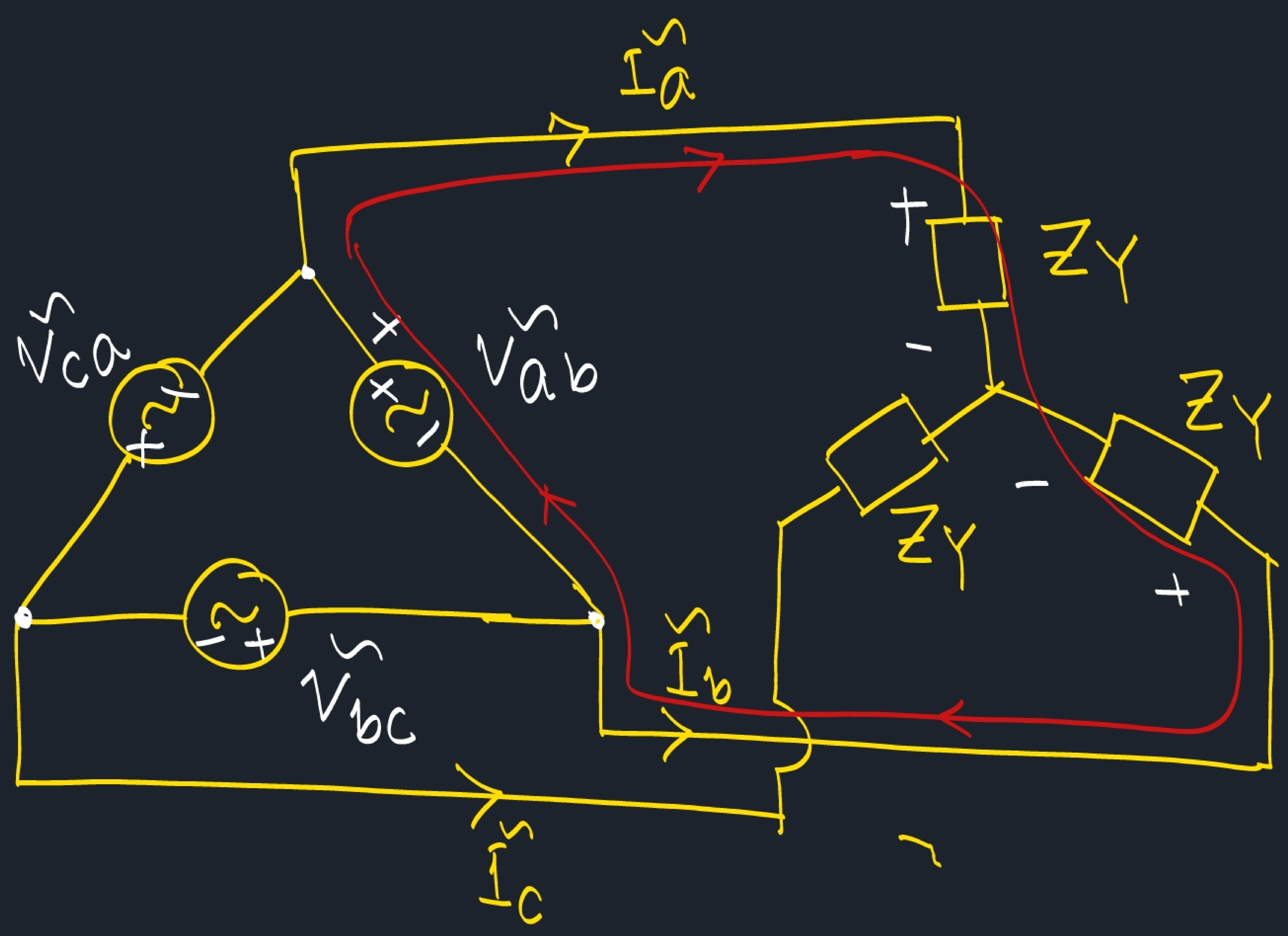
Current

$$\boxed{I_L = \sqrt{3} I_{ph}}$$





$\Delta - Y$



$$\hat{V}_{ab} - \hat{I}_a Z_Y + \hat{I}_b Z_Y = 0$$

$$\Rightarrow \hat{I}_a - \hat{I}_b = \frac{\hat{V}_{ab}}{Z_Y}$$

$$\Rightarrow \sqrt{3}\, I_p \angle 30^\circ = \frac{V_p \angle 0}{Z_Y}$$

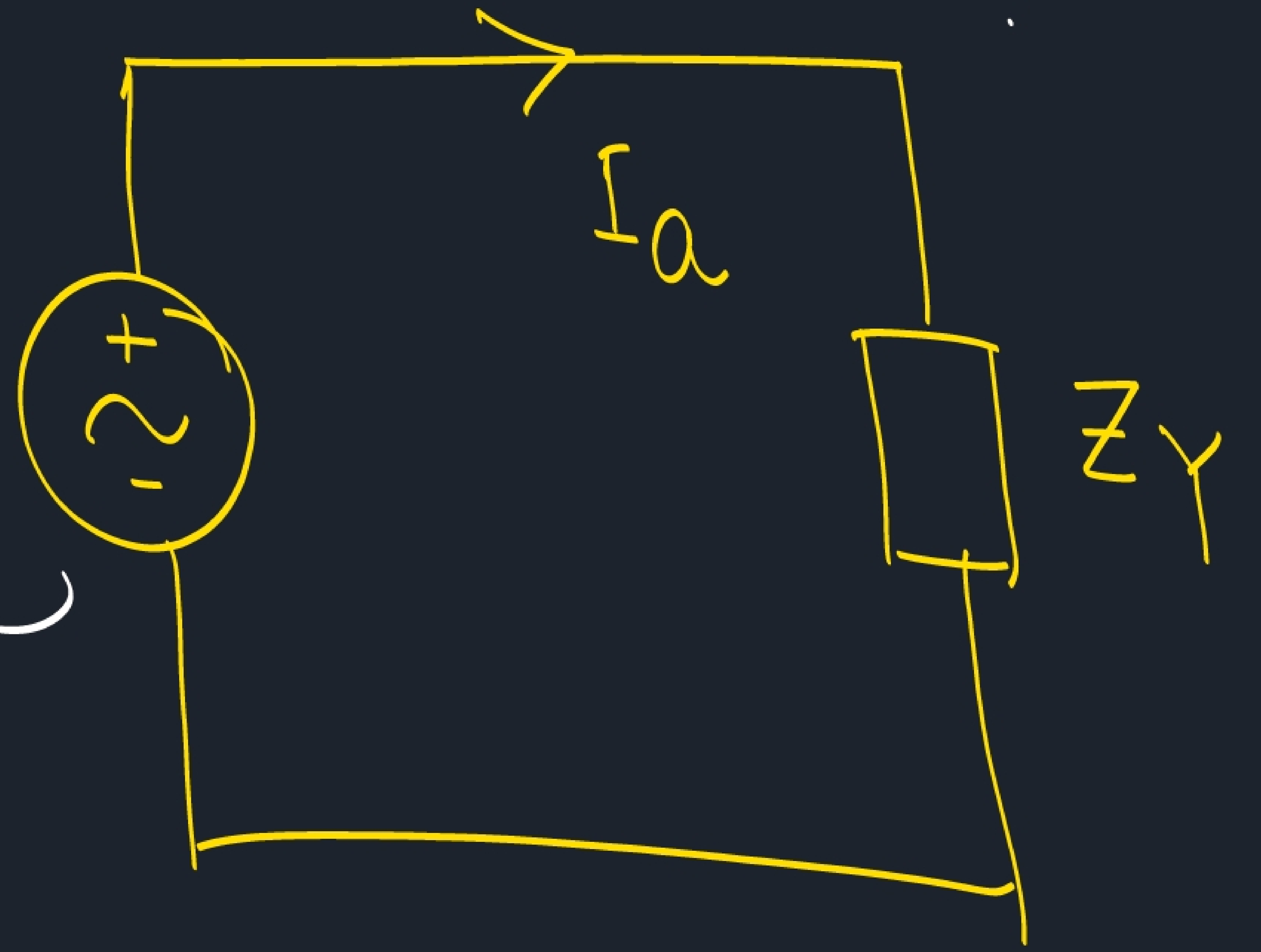
$$\Rightarrow I_p = \left(\frac{V_p}{\sqrt{3}} \angle -30\right) \cdot \frac{1}{Z_Y}$$

$$\hat{V}_{ab} = V_p \angle 0$$

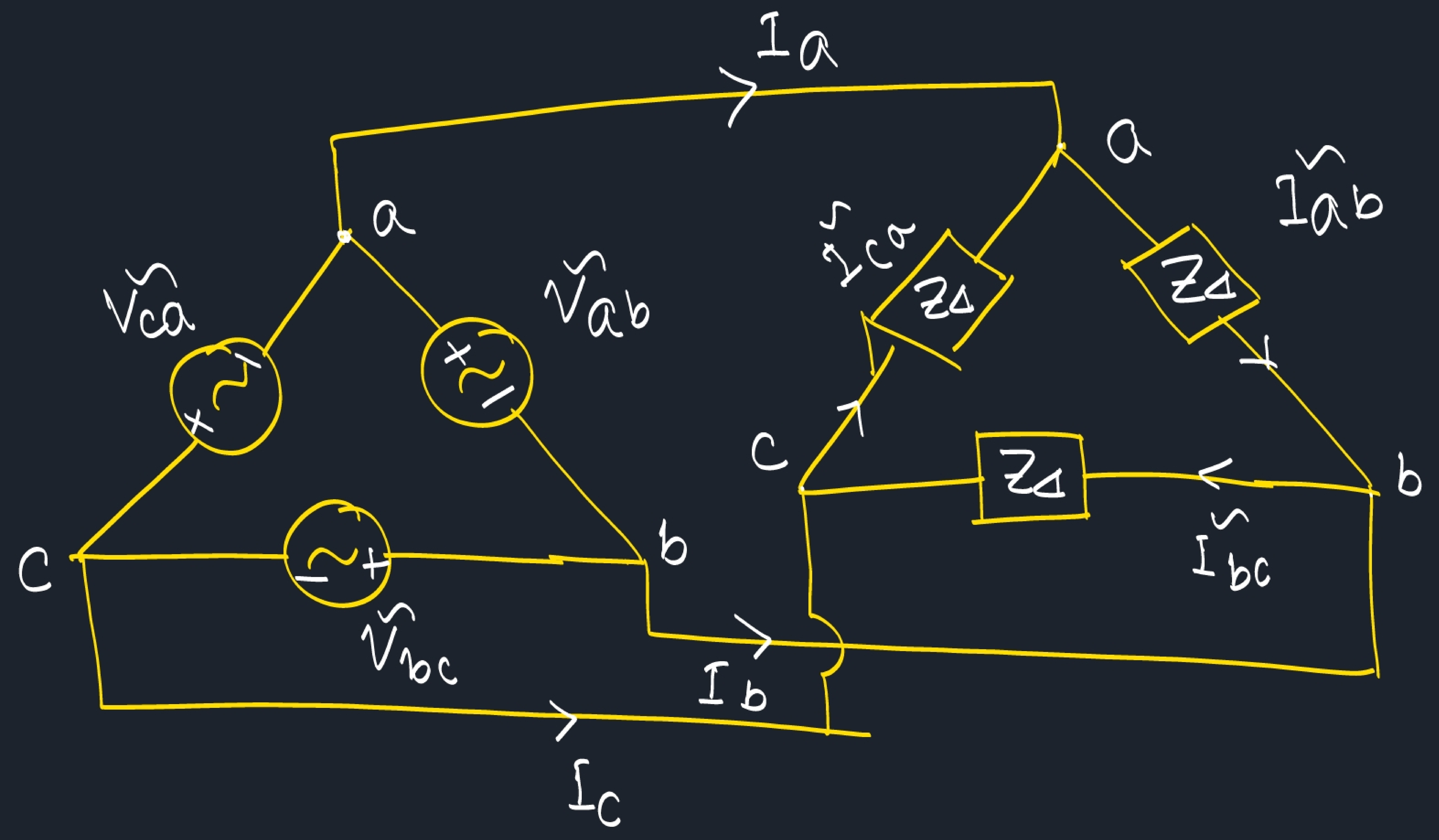
$$\hat{V}_{bc} = V_p \angle -120^\circ$$

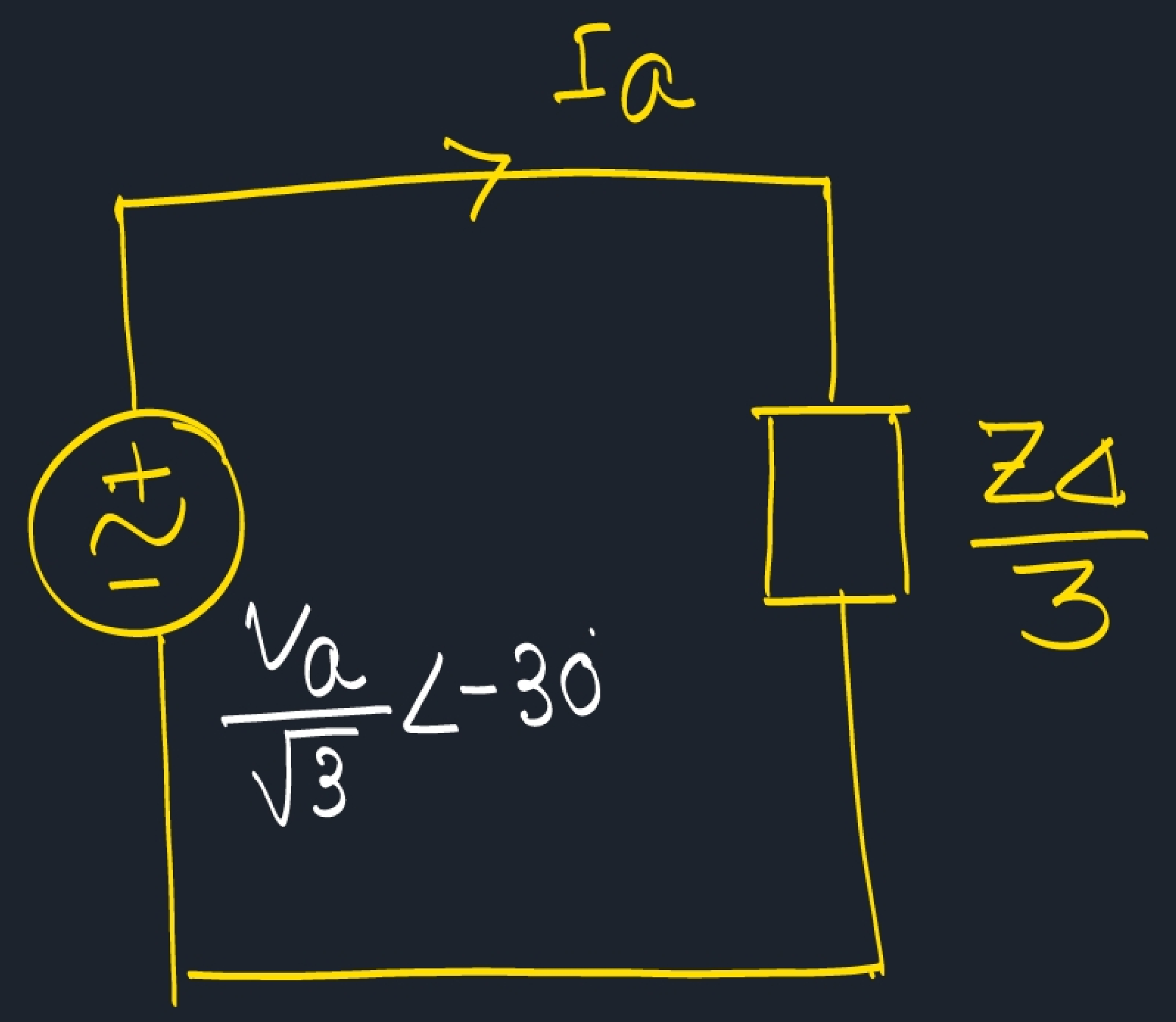
$$\hat{V}_{ca} = V_p \angle +120^\circ$$

$$\underbrace{\frac{V_p}{\sqrt{3}} \angle -30^\circ}_{\frac{V_a}{\sqrt{3}} \angle -30^\circ}$$

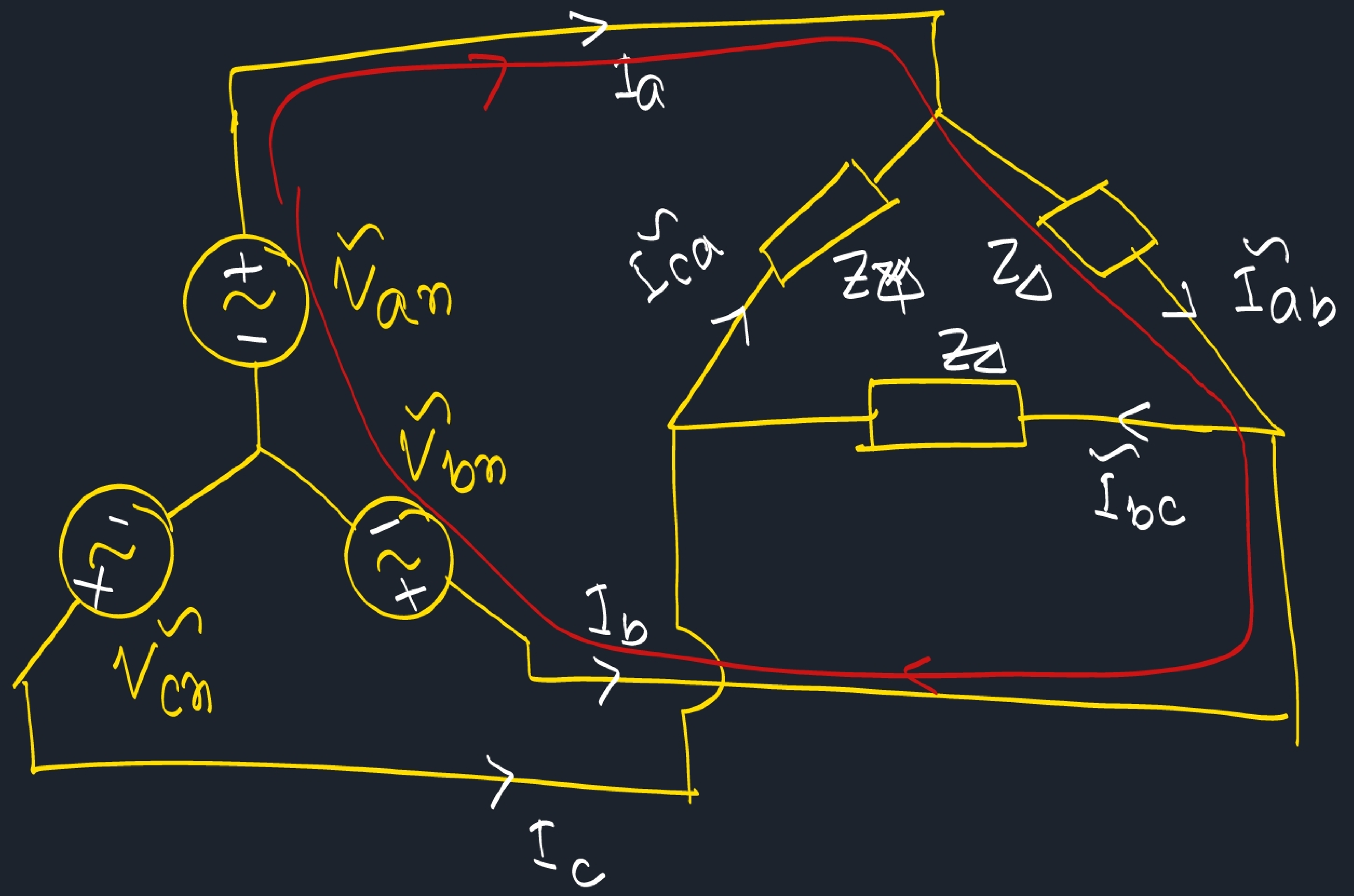


$\Delta - \Delta$





Problem:-



$$Z_\Delta = 8+j4$$

$$\hat{V}_{an} - \hat{I}_{ab} Z_\Delta - \hat{V}_{bn} = 0$$

$$\hat{I}_{ab} = \frac{\hat{V}_{an} - \hat{V}_{bn}}{Z_\Delta}$$

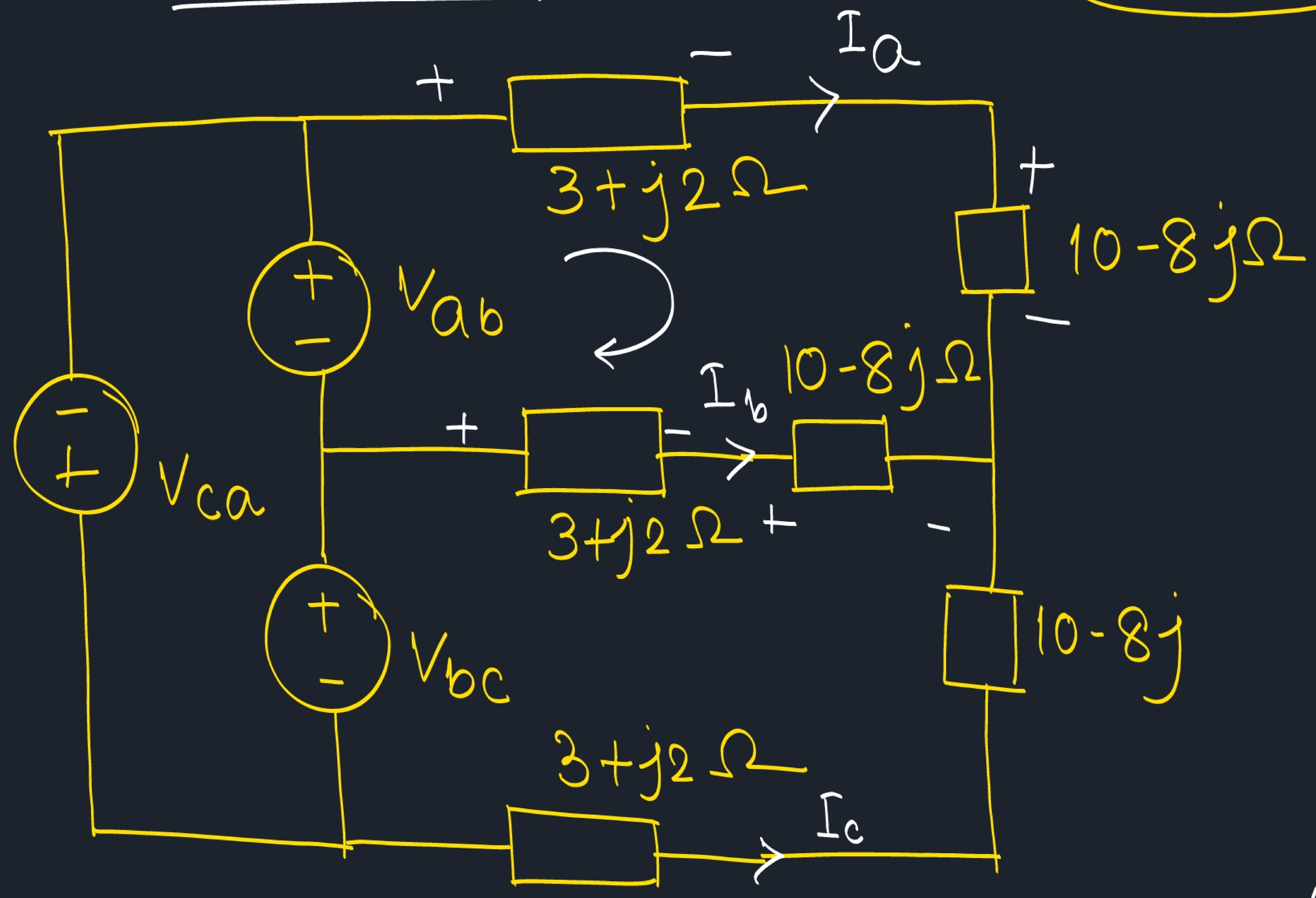
$$= \frac{100\angle 0 - 100\angle -120}{8+j4}$$

$$= 19.365\angle 3.4349$$

$\hat{V}_{an} = 100\angle 0$ v

$\hat{V}_{bn} = 100\angle -120$ v

Problem:-



$V_{ab} = 440\angle 10$

Draw phasor Diagram.

7867

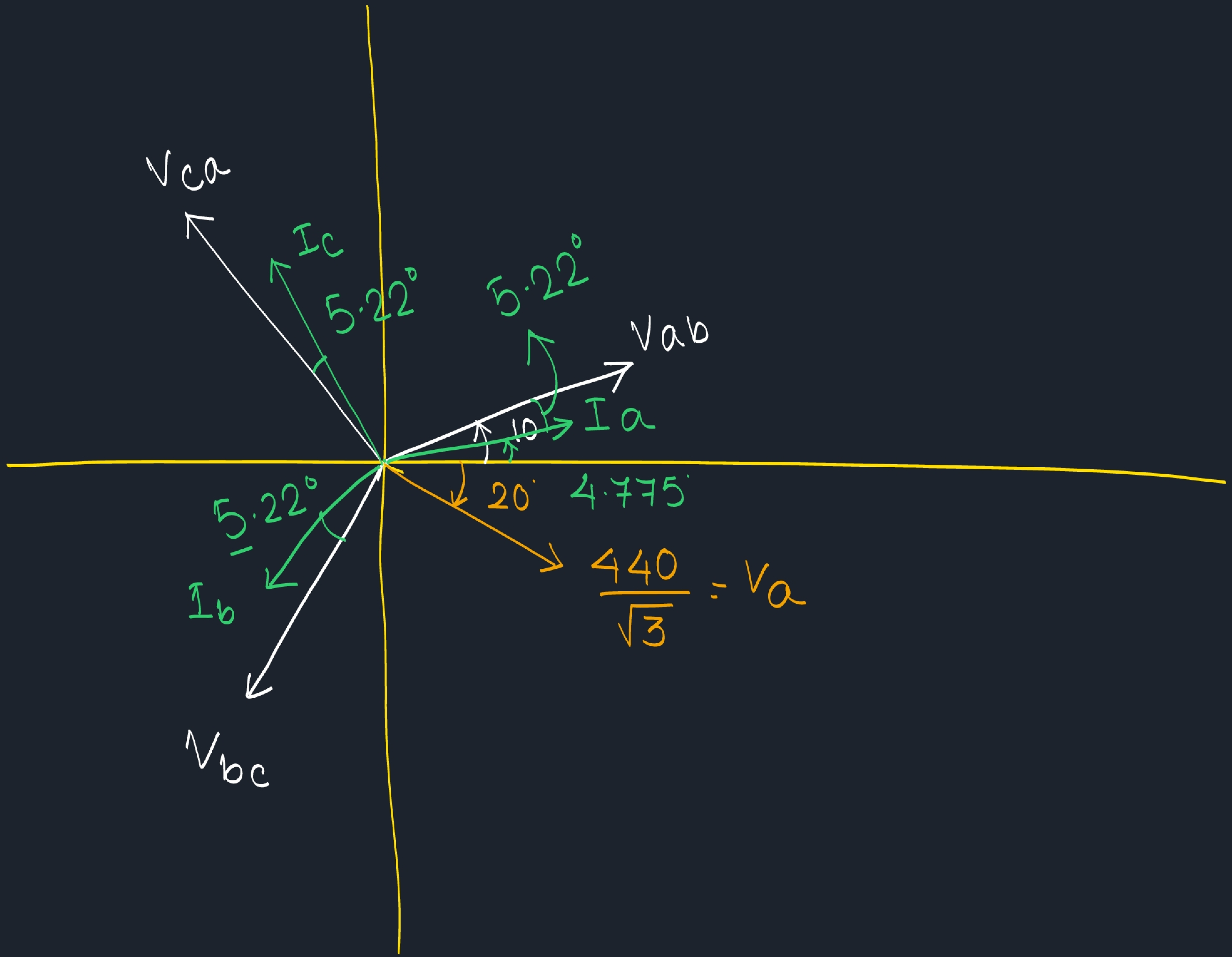
$$V_{ab} = (3+j2+10-8j)(I_a - I_b)$$

$$\underbrace{I_a - I_b}_{I_{ab}} = \frac{\overbrace{440\angle 10}^{}}{13-j6.0} \quad V_{ab}$$

$$\Rightarrow \sqrt{3}\, I_p \angle 30^\circ = \frac{440\angle 10}{13-j6}$$

$$\Rightarrow I_p = \frac{440\angle 10}{(13-j6)\times\sqrt{3}\angle 30^\circ} = (17.7425\angle 4.7751^\circ) \text{ Amp.}$$

$$I_a = (17.7425\angle 4.7751) \text{ Amp.}$$



$$\hat{V}_{ab} = \hat{V}_a - \hat{V}_b$$

$$= \sqrt{3}\, V_p \angle 30^\circ$$

$$I_a = \frac{V_a}{13 - j6} = \frac{V_a}{|Z|\angle\theta}$$

$$\theta = -24.775$$

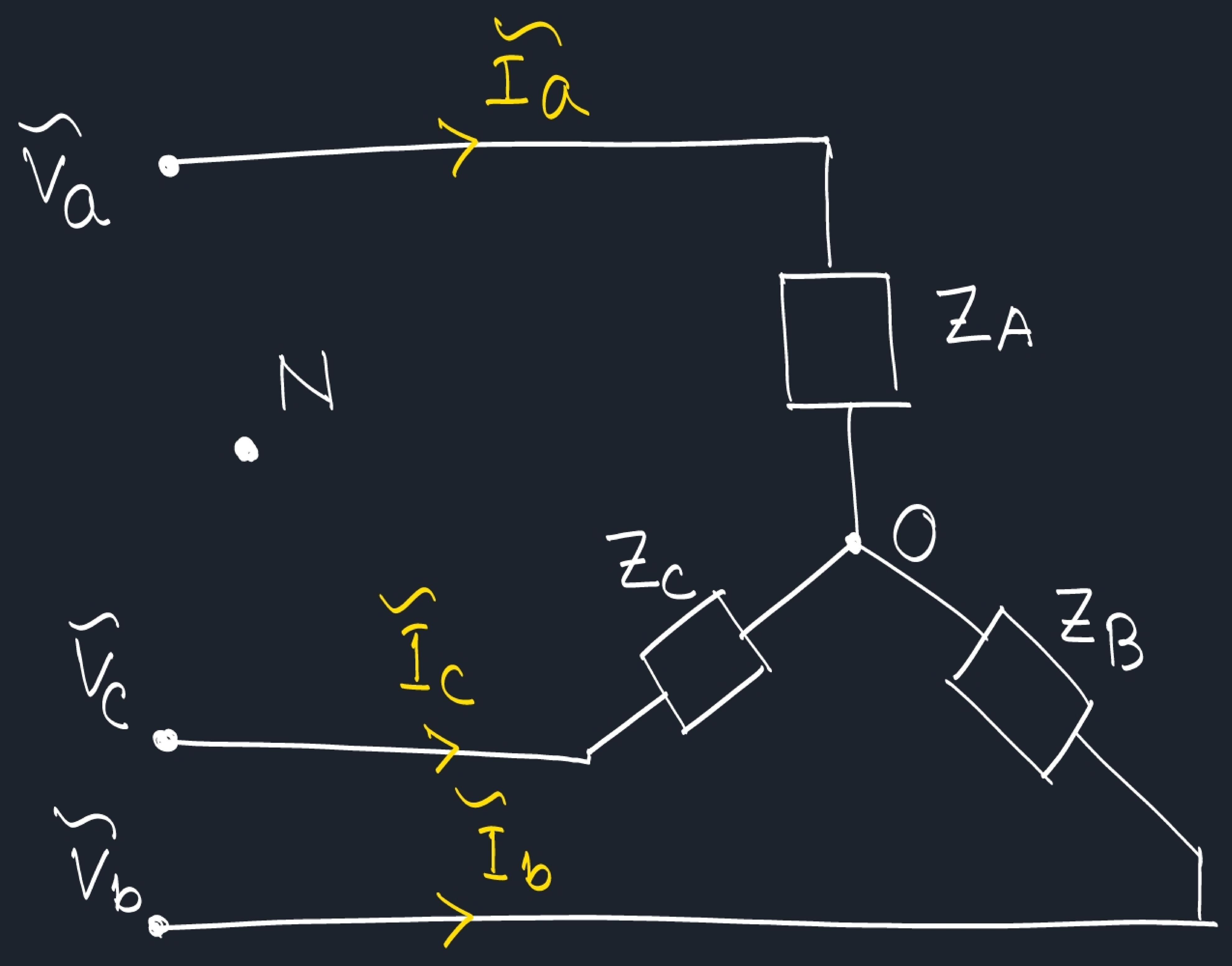
$$Z \rightarrow 14.31$$

$$\frac{440}{\sqrt{3} \times |Z|}$$

$$= ?$$

$$= \frac{V_a}{|Z|}\angle 24.775$$

Unbalanced 3φ System:-



$$\hat{I}_a + \hat{I}_b + \hat{I}_c = 0$$

$$\hat{I}_a = \frac{\hat{V}_{ao}}{Z_A}$$

$$\hat{I}_b = \frac{\hat{V}_{bo}}{Z_B}$$

$$\hat{I}_c = \frac{\hat{V}_{co}}{Z_C}$$

$$\hat{V}_{aN} + \hat{V}_{bN} + \hat{V}_{cN} = 0$$

$$\hat{V}_{ao} = \hat{V}_{aN} - \hat{V}_{oN} \quad ; \quad \hat{V}_{bo} = \hat{V}_{bN} - \hat{V}_{oN}$$

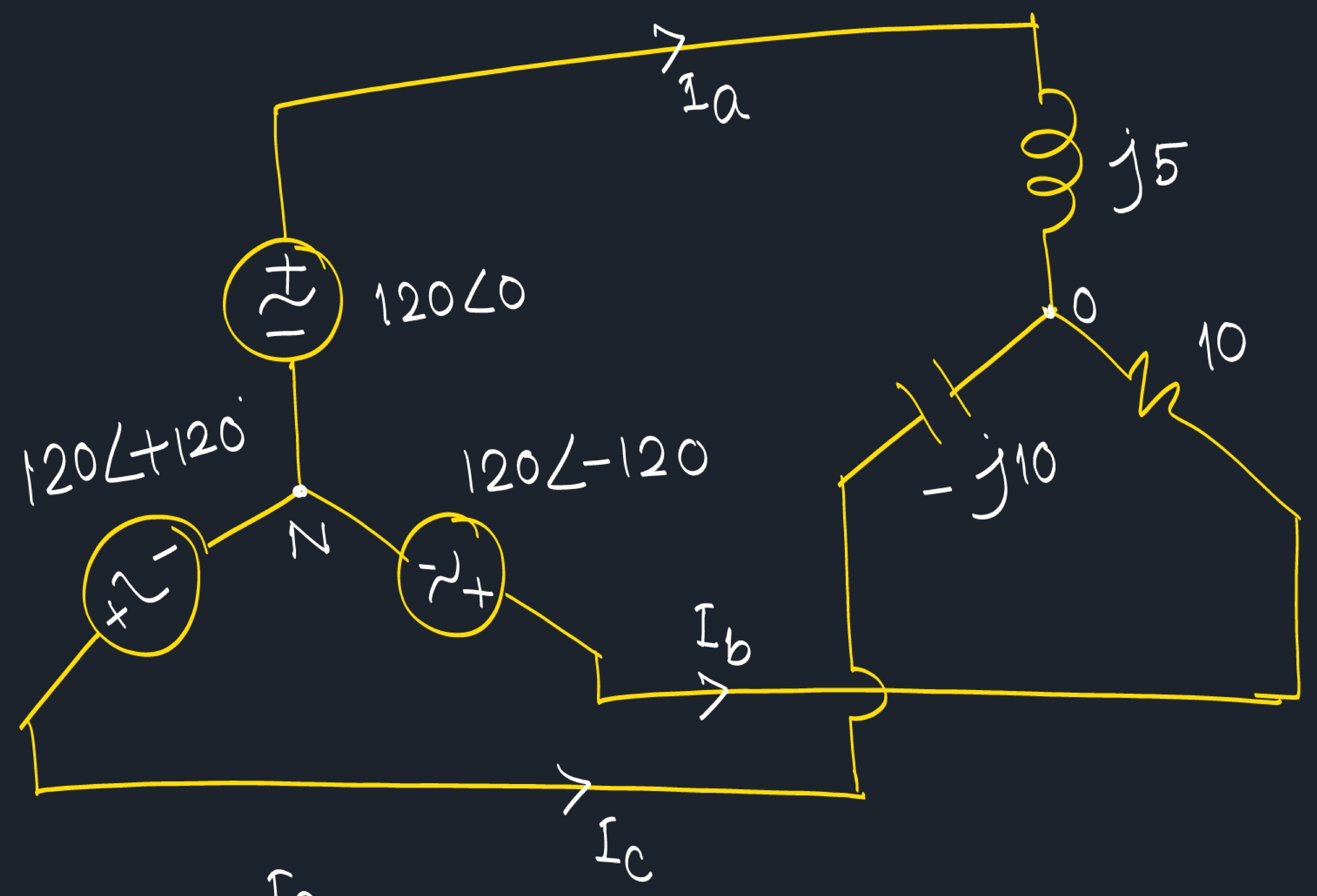
$$\hat{V}_{co} = \hat{V}_{cN} - \hat{V}_{oN}$$

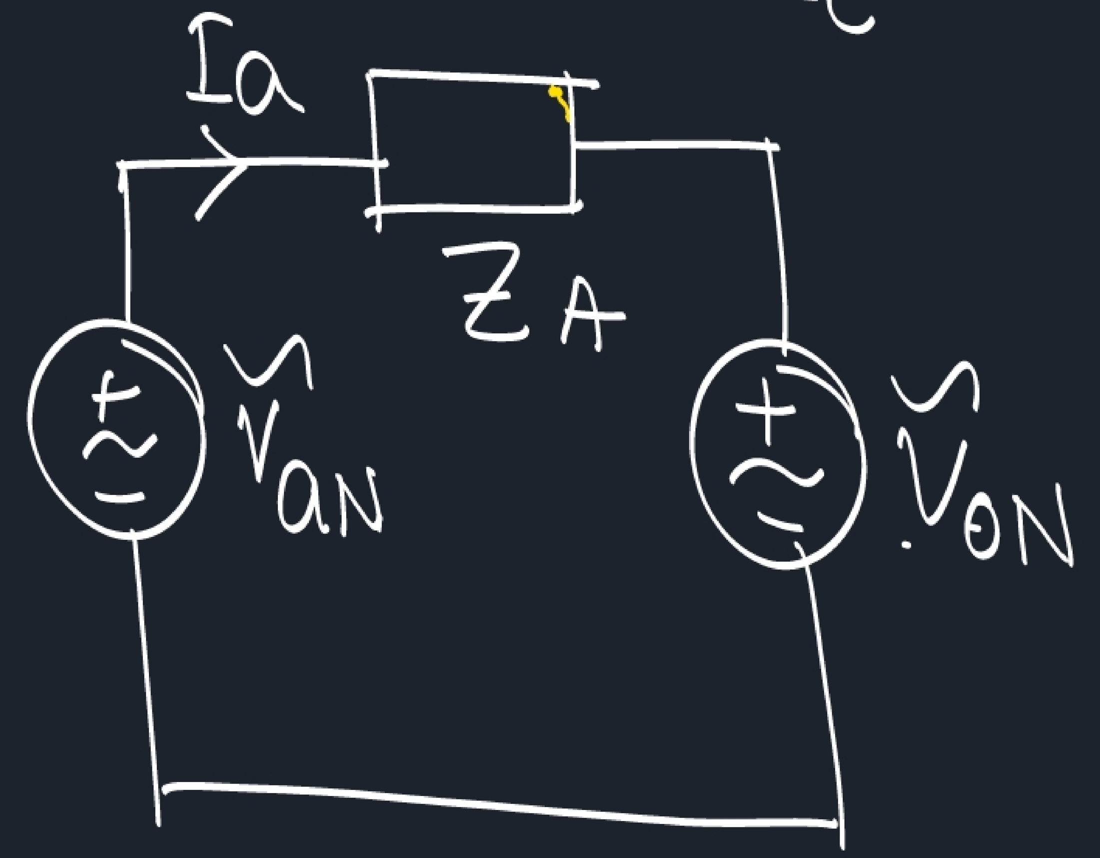
$$\frac{\hat{V}_{ao}}{Z_A} + \frac{\hat{V}_{bo}}{Z_B} + \frac{\hat{V}_{co}}{Z_C} = 0$$

$$\Rightarrow \frac{\hat{V}_{aN}}{Z_A} + \frac{\hat{V}_{bN}}{Z_B} + \frac{\hat{V}_{cN}}{Z_C} = \hat{V}_{oN}\left(\frac{1}{Z_A} + \frac{1}{Z_B} + \frac{1}{Z_C}\right)$$

$$\hat{V}_{oN} = \frac{\frac{\hat{V}_{aN}}{Z_A} + \frac{\hat{V}_{bN}}{Z_B} + \frac{\hat{V}_{cN}}{Z_C}}{\frac{1}{Z_A} + \frac{1}{Z_B} + \frac{1}{Z_C}}$$

Problem:-





$$\hat{V}_{ON} = \frac{\frac{V_{AN}}{Z_A} + \frac{V_{BN}}{Z_B} + \frac{V_{CN}}{Z_C}}{\frac{1}{Z_A} + \frac{1}{Z_B} + \frac{1}{Z_C}}$$

$$= 308.2406 \angle -67.088^\circ \text{ V}$$

$$I_a = \frac{\hat{V}_{aN} - \hat{V}_{ON}}{Z_A}$$

$$= \frac{120\angle 0 - 308.2406 \angle -67.088}{j5}$$

$$= 56.784 \angle 0.000569^\circ \text{ Amp.}$$

Power in 3ϕ Balanced S/S :-

$$v_a(t) = v_{aN}(t) = V_m \cos(\omega t)$$

$$v_b(t) = V_m \cos(\omega t - 120)$$

$$v_c(t) = V_m \cos(\omega t + 120)$$

$$i_a(t) = I_m \cos(\omega t - \theta)$$

$$i_b(t) = I_m \cos(\omega t - \theta - 120)$$

$$i_c(t) = I_m \cos(\omega t - \theta + 120)$$

$$p(t) = v_{aN}(t)\, i_a(t) + v_{bN}(t)\, i_b(t) + v_{cN}(t)\, i_c(t)$$

$$= \underbrace{V_m I_m \cos(\omega t) \cos(\omega t - \theta)} + V_m I_m \cos(\omega t - 120) \cos(\omega t - \theta - 120) + V_m I_m \cos(\omega t + 120) \cos(\omega t + \theta + 120)$$

$$\frac{V_m I_m}{2} \left\{ \cos \omega t \cos(\omega t - \theta) \right\}$$

$$= \frac{V_m I_m}{2} \left[\cos\theta + \cos(2\omega t - \theta) \right]$$

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$$p(t) = \frac{3}{2} V_m I_m \cos\theta$$

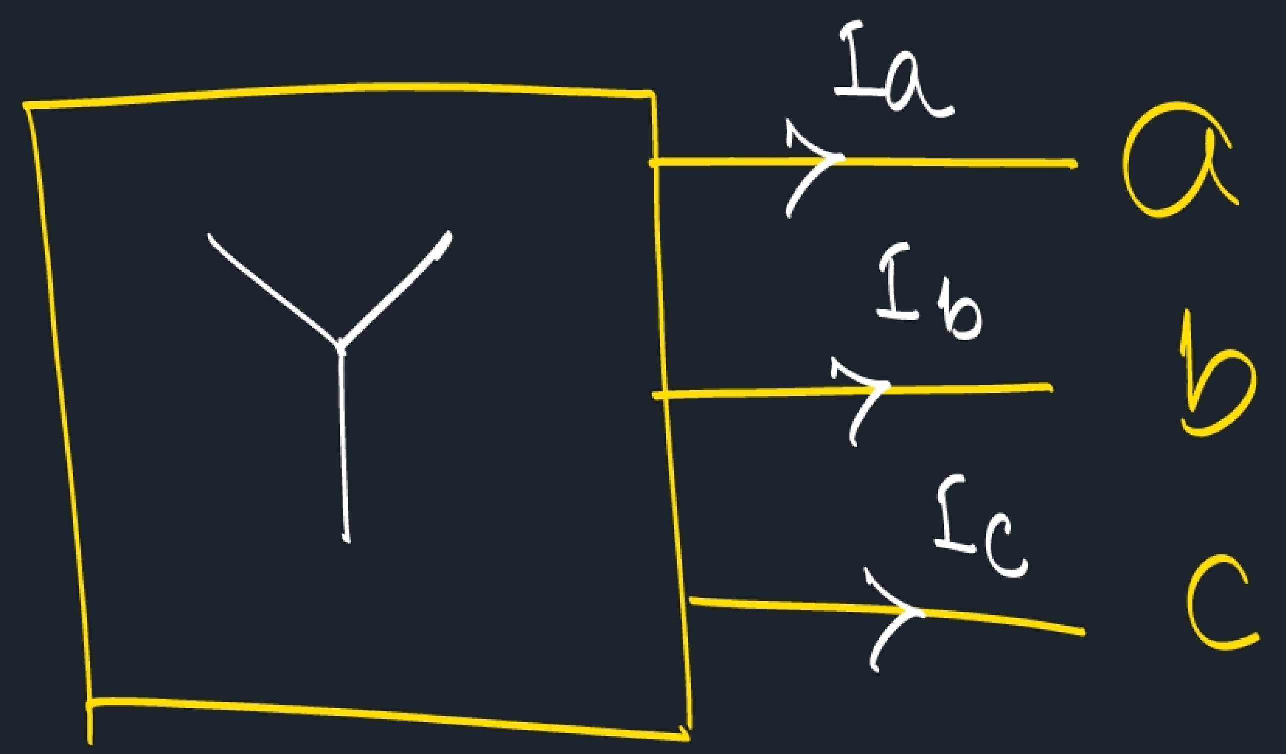
$$\boxed{P_{3\phi} = 3 V_{rms} I_{rms} \cos\theta}$$

$$Q_{3\phi} = 3 V_{rms} I_{rms} \sin\theta .$$

$$P_{3\phi} = \sqrt{3}\, V_{rms}^{L-L} I_{rms}^{L-L} \cos\theta$$

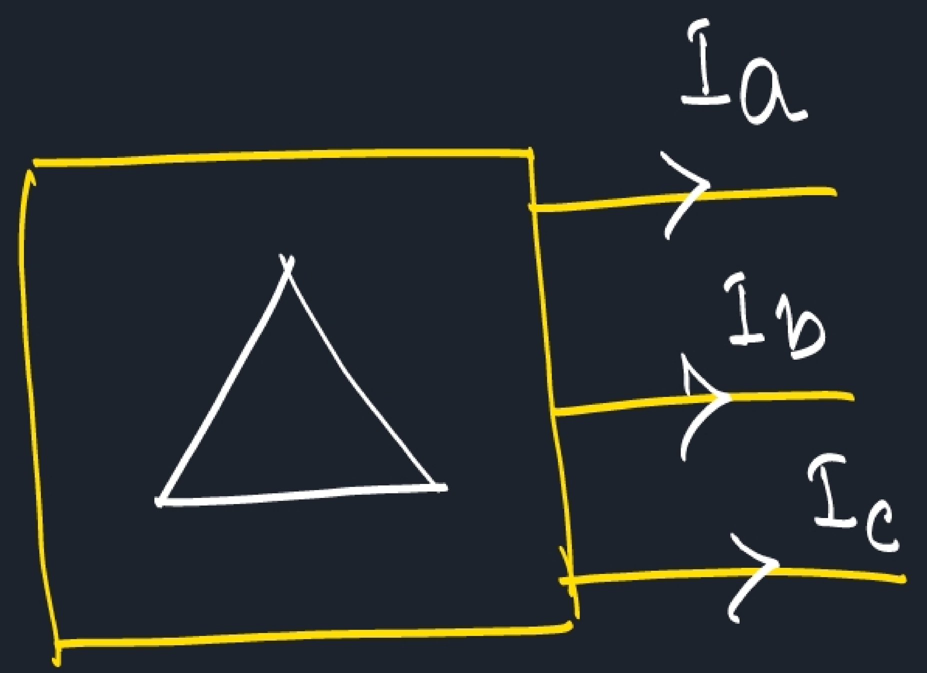
$$Q_{3\phi} = \sqrt{3}\, V_{rms}^{L-L} I_{rms}^{L-L} \sin\theta$$

$$P_{3\phi} = 3 V_{rms}^{Ph} I_{rms}^{Ph} \cos\theta$$



$$V_{rms}^{L-L} = \sqrt{3}\, V_{rms}^{Ph}$$

$$I_{rms}^{L-L} = I_{rms}^{Ph}$$



$$V_{rms}^{L-L} = V_{rms}^{Ph}$$

$$I_{rms}^{L-L} = \sqrt{3}\, I_{rms}^{Ph}$$

$$P_{3\phi}^{Y} = \sqrt{3}\, V_{rms}^{L-L} I_{rms}^{L-L} \cos\theta$$

$$P_{3\phi}^{\Delta} = \sqrt{3}\, V_{rms}^{L-L} I_{rms}^{L-L} \cos\theta$$

$$S_{3\phi} = P_{3\phi} + j\,Q_{3\phi}$$

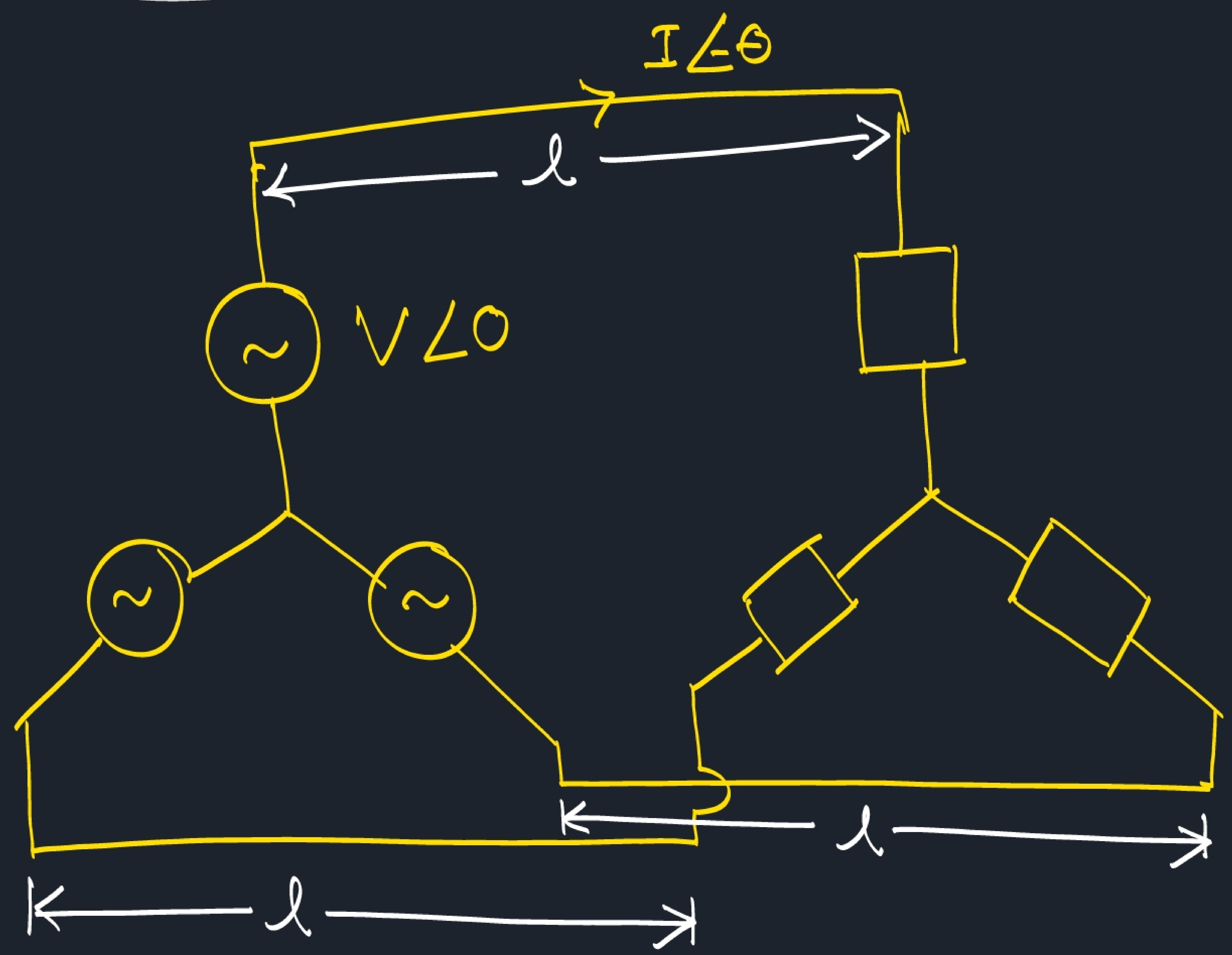
$$= \sqrt{3}\, V_{rms}^{L-L}\, I_{rms}^{L-L} \left(\cos\theta + j\sin\theta\right).$$

$$S_{1\phi} = \hat{V}\,\hat{I}^{*}$$

$$S_{3\phi} = 3\,\hat{V}_{ph}\,\hat{I}_{ph}^{*}$$

$$= \sqrt{3}\,\hat{V}_{L-L}\,\hat{I}_{L-L}^{*}$$

3ϕ 3 wire balanced.



$$P = 3VI\cos\theta$$

$$W_{3\phi} = 3I^2R_1$$

$$R_1 = \frac{\rho l}{A_1}$$

$$I = \frac{P}{3V\cos\theta}.$$

$$W_{3\phi} = 3\cdot\left(\frac{P}{3V\cos\theta}\right)^2\cdot\frac{\rho l}{A_1}$$

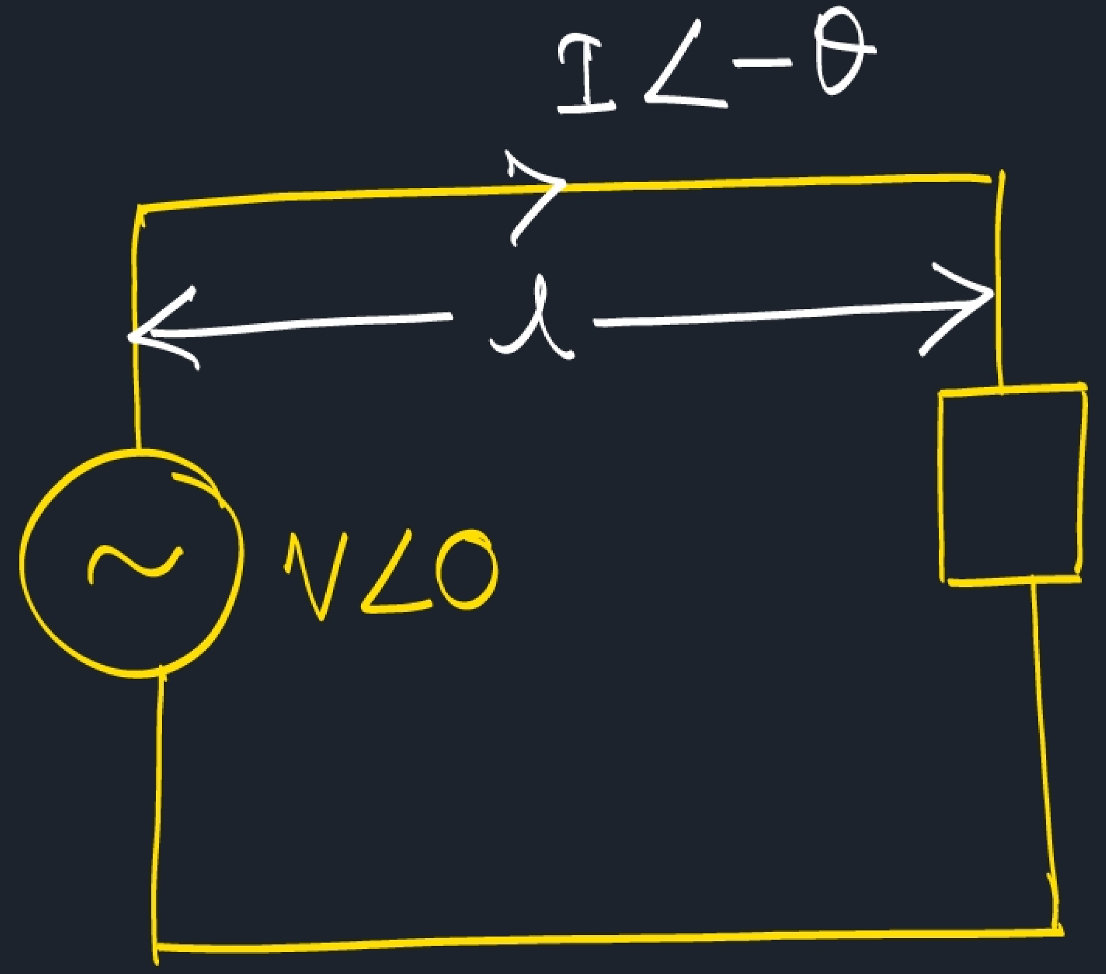
$$A_1 = \frac{P^2\rho l}{3V^2\cos^2\theta\, W_{3\phi}}$$

$$(Vol)_{3\phi} = 3A_1 l$$

$$= 3\cdot\frac{P^2\rho l^2}{3V^2\cos^2\theta\, W_{3\phi}}$$

$$\boxed{(Vol)_{3\phi} = \frac{P^2\rho l^2}{V^2\cos^2\theta\, W_{3\phi}}.}$$

1ϕ S/S:-



$$P = V I \cos\theta$$

$$\boxed{I = \frac{P}{V\cos\theta}}$$

$$W_{1\phi} = I^2 R_2$$

$$= \frac{P^2}{V^2\cos^2\theta} \cdot \frac{\rho(2l)}{A_2}$$

$$A_2 = \frac{2P^2 l \rho}{V^2\cos^2\theta\, W_{1\phi}}$$

$$(Vol)_{1\phi} = 2 l A_2$$

$$= \frac{4P^2 l^2 \rho}{V^2\cos^2\theta\, W_{1\phi}}$$

$$\boxed{W_{1\phi} = W_{3\phi}}$$

$$\frac{(Vol)_{1\phi}}{4} = (Vol)_{3\phi}$$

$$\boxed{(Vol)_{1\phi} > (Vol)_{3\phi}}$$