$$Z_a = Z_в = Z_c$$

$$Z_a = z_a e^{j\varphi_a}$$

$$Z_в = z_в e^{j\varphi_в}$$

$$Z_c = z_c e^{j\varphi_c}$$

$$I_л = I_ф$$

$$I_A = I_B = I_C = I_л$$

$$I_a = I_в = I_c = I_ф$$

$$U_л = \sqrt{3} U_ф; \quad U_ф = \frac{U_л}{\sqrt{3}}$$

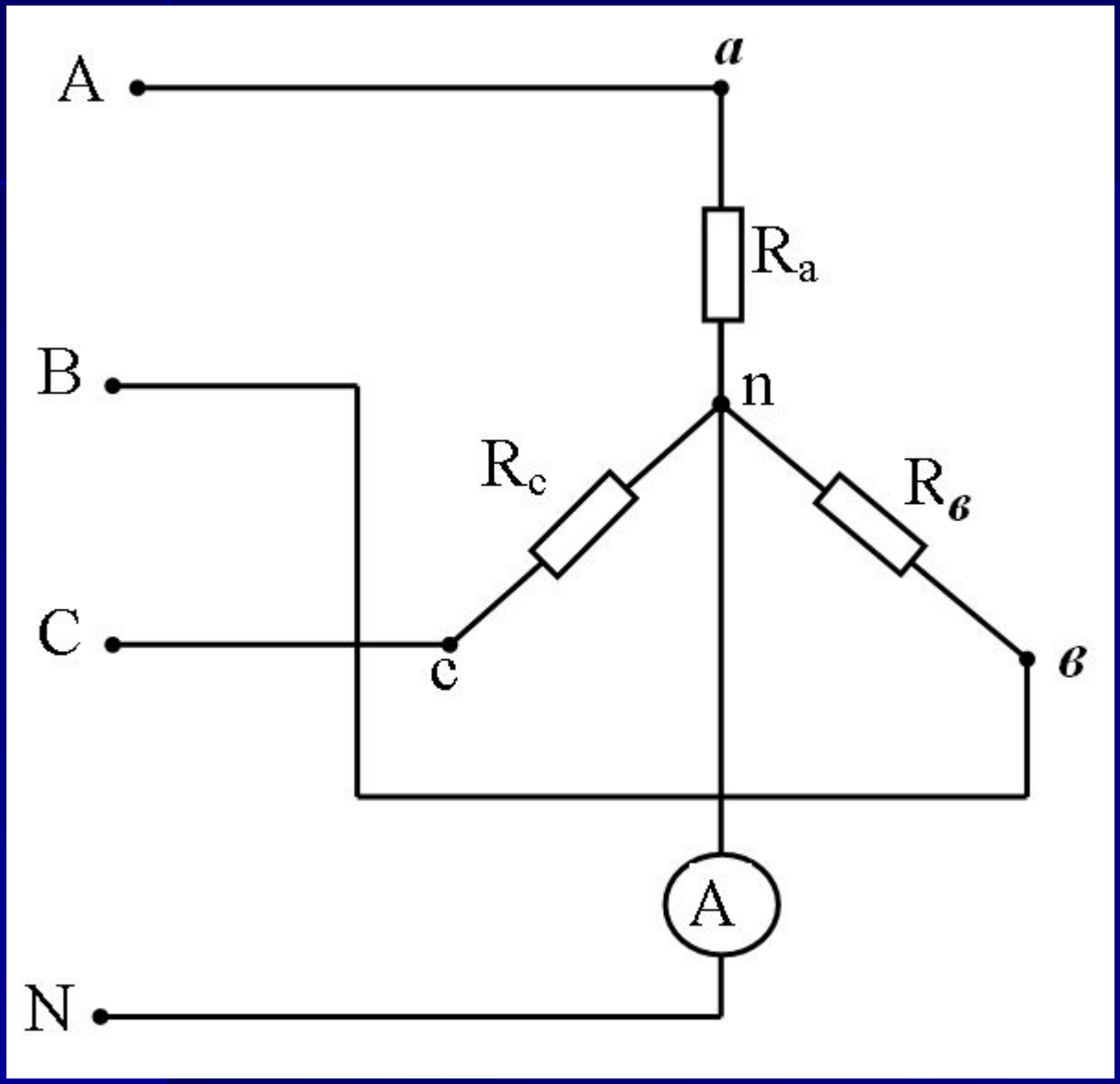
$$\dot{U}_a = U_ф e^{j0^\circ} = U_ф$$

$$\dot{U}_в = U_ф e^{-j120^\circ}$$

$$\dot{U}_c = U_ф e^{j120^\circ}$$

$U_л$	$U_ф$
660	380
380	220
220	127

problem 1



Given

$R_a = R_в = R_c = R =$
$= 20\ Ohm$

$V_L = 380\ V$

Find:

$I_a, I_в, I_c, I_N$ - ?

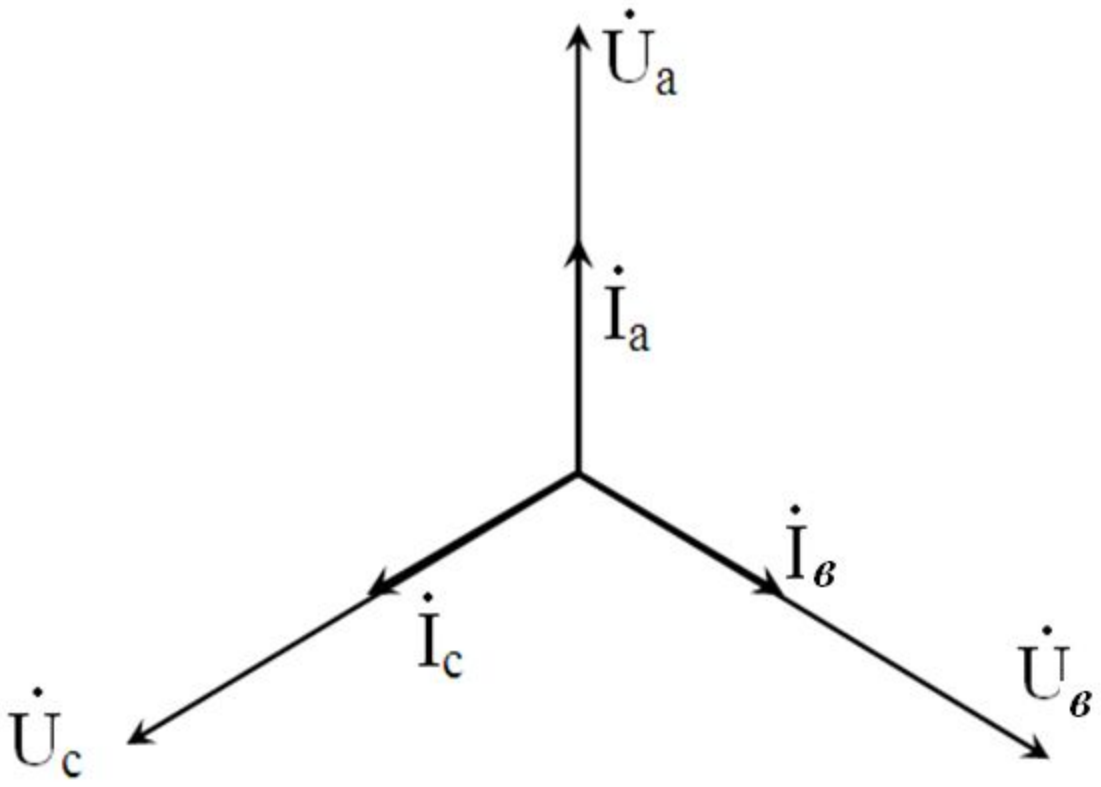
$$U_{ф} = \frac{U_{л}}{\sqrt{3}} = 220 \text{ В}$$

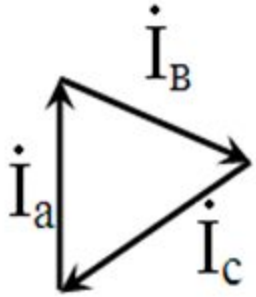
$$\dot{I}_{a} = \frac{\dot{U}_{a}}{Z_{a}} = \frac{U_{ф} e^{j0^{\circ}}}{R_{a}} = \frac{U_{ф}}{R} = I_{ф} = 11 \ A$$

$$\dot{I}_{в} = \frac{U_{ф} e^{-j120^{\circ}}}{R} = I_{ф} e^{-j120^{\circ}} = 11 e^{-j120^{\circ}} \ A$$

$$\dot{I}_{c} = \frac{U_{ф} e^{j120^{\circ}}}{R} = I_{ф} e^{j120^{\circ}} = 11 e^{j120^{\circ}} \ A$$

$$\dot{I}_{a} + \dot{I}_{в} + \dot{I}_{c} = 11 + 11 e^{-j120^{\circ}} + 11 e^{j120^{\circ}} = 0$$

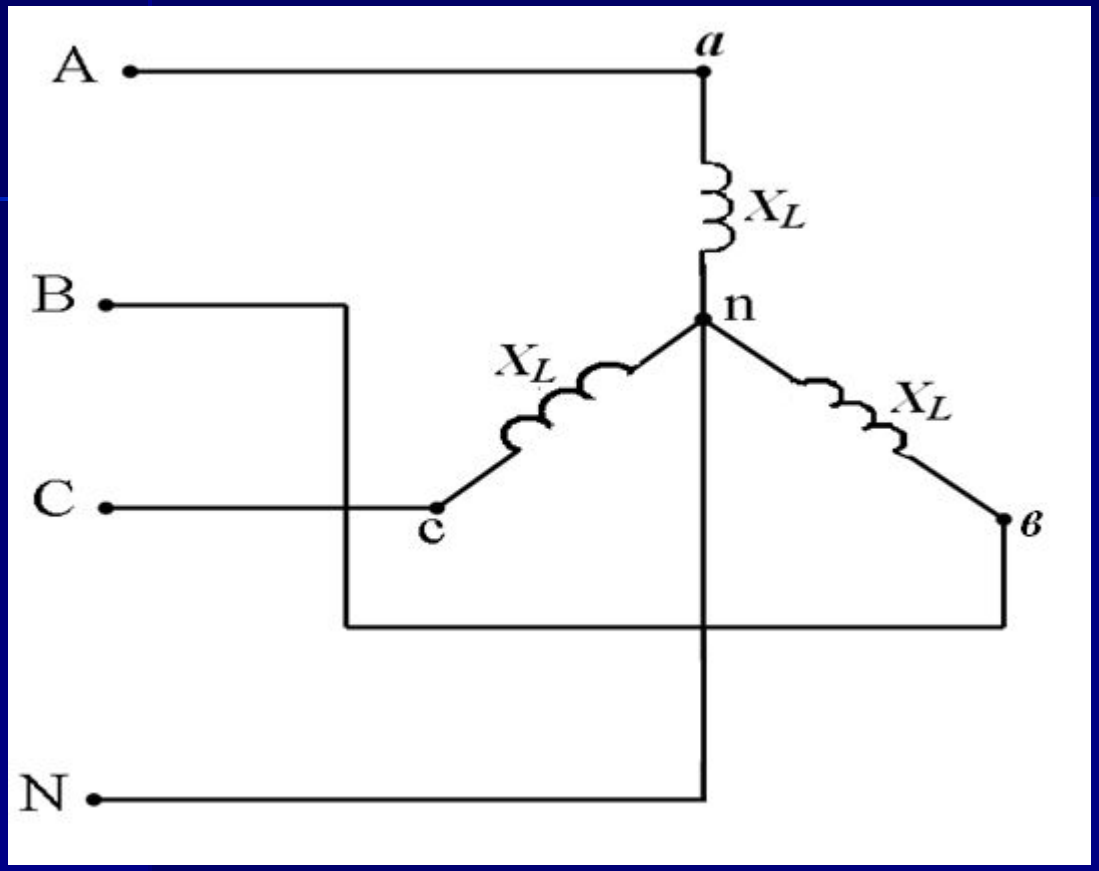




$$\dot{I}_a + \dot{I}_B + \dot{I}_c = \dot{I}_N$$

$$\dot{I}_N = 0$$

Problem 2



Given:

$V_L = 380\ V$

$X_L = 20\ Ohm$

Define:

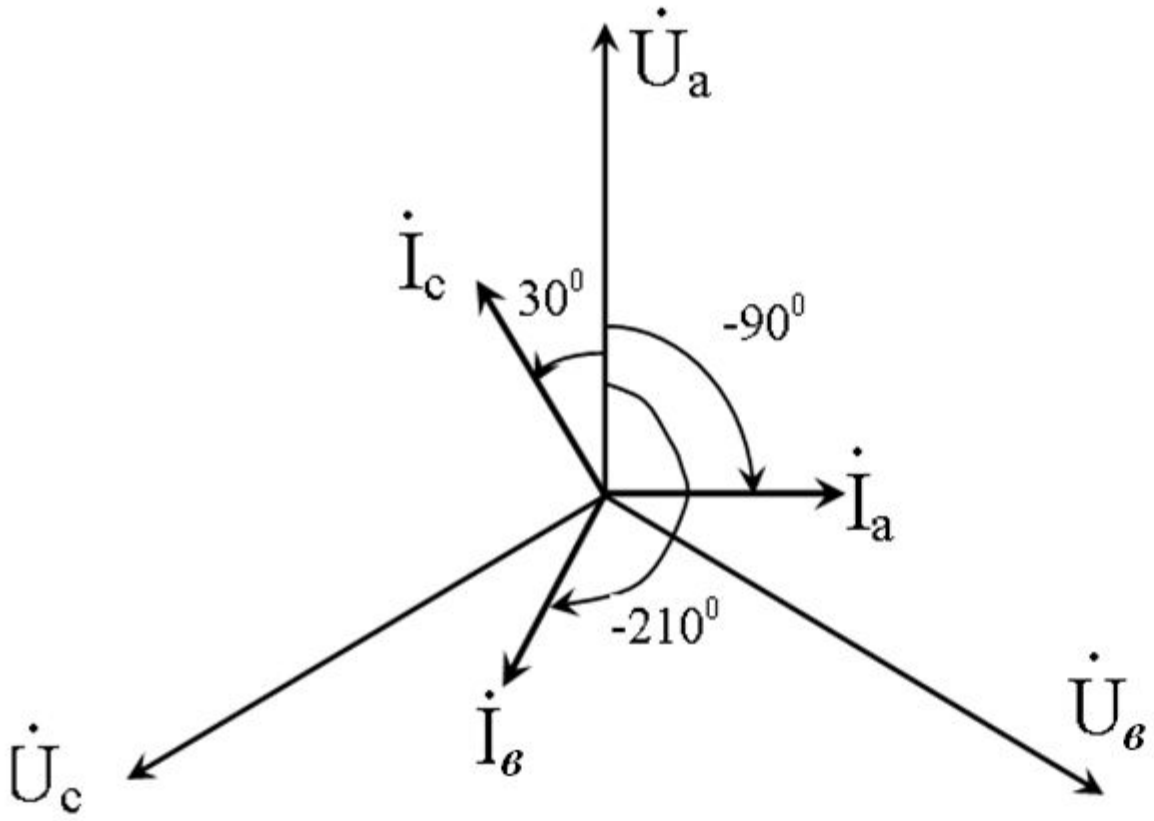
$I_a, I_в, I_c, I_N$ - ?

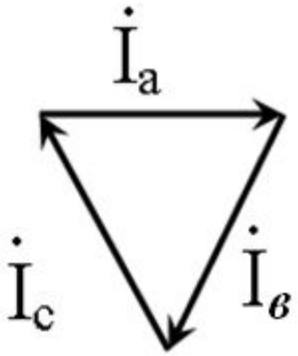
$$U_ф = \frac{U_л}{\sqrt{3}} = 220\ B$$

$$\dot{I}_a = \frac{\dot{U}_a}{jX_L} = \frac{U_\phi}{e^{j90^\circ} X_L} = \frac{220}{20e^{j90^\circ}} = 11e^{-j90^\circ}$$

$$\dot{I}_в = \frac{\dot{U}_в}{jX_L} = \frac{220e^{-j120^\circ}}{20e^{j90^\circ}} = 11e^{-j210^\circ}$$

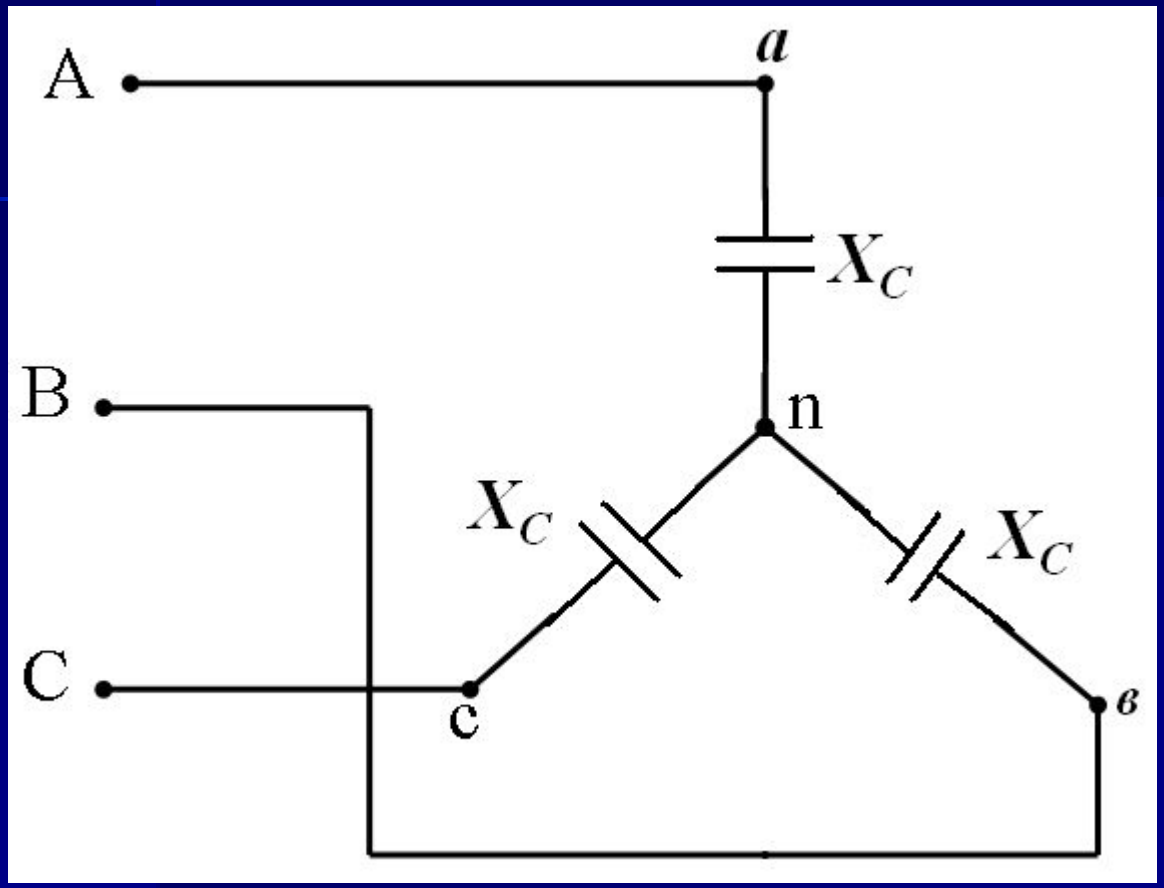
$$\dot{I}_c = \frac{\dot{U}_c}{jX_L} = \frac{220e^{j120^\circ}}{20e^{j90^\circ}} = 11e^{j30^\circ}$$


$\dot{U}_a$
$\dot{I}_c$
30^0
-90^0
$\dot{I}_a$
-210^0
$\dot{I}_в$
$\dot{U}_в$
$\dot{U}_c$


$\dot{I}_a$
$\dot{I}_c$
$\dot{I}_в$

$\dot{I}_N=0$

Problem 3



Given:

$V_L = 660\ V$

$X_C = 10\ Ohm$

Determine:

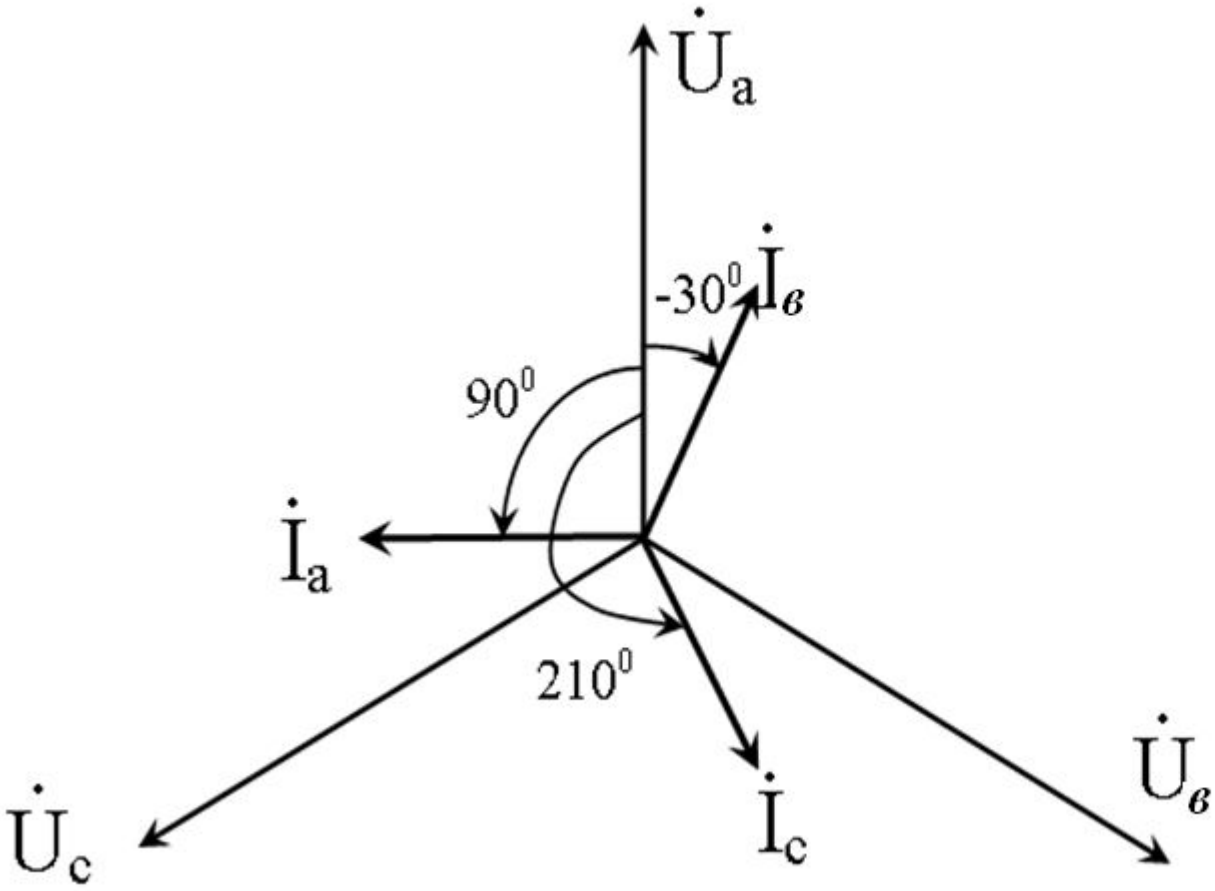
$I_a, I_в, I_c, I_N$ - ?

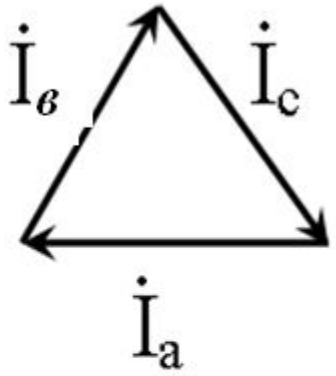
$$U_ф = \frac{U_л}{\sqrt{3}} = 380\ B$$

$$\dot{I}_a = \frac{\dot{U}_a}{-jX_C} = \frac{U_\phi}{e^{-j90^\circ}X_C} = \frac{380e^{j90^\circ}}{10} = 38e^{j90^\circ}$$

$$\dot{I}_в = \frac{\dot{U}_в}{-jX_C} = \frac{380e^{-j30^\circ}}{10} = 38e^{-j30^\circ}$$

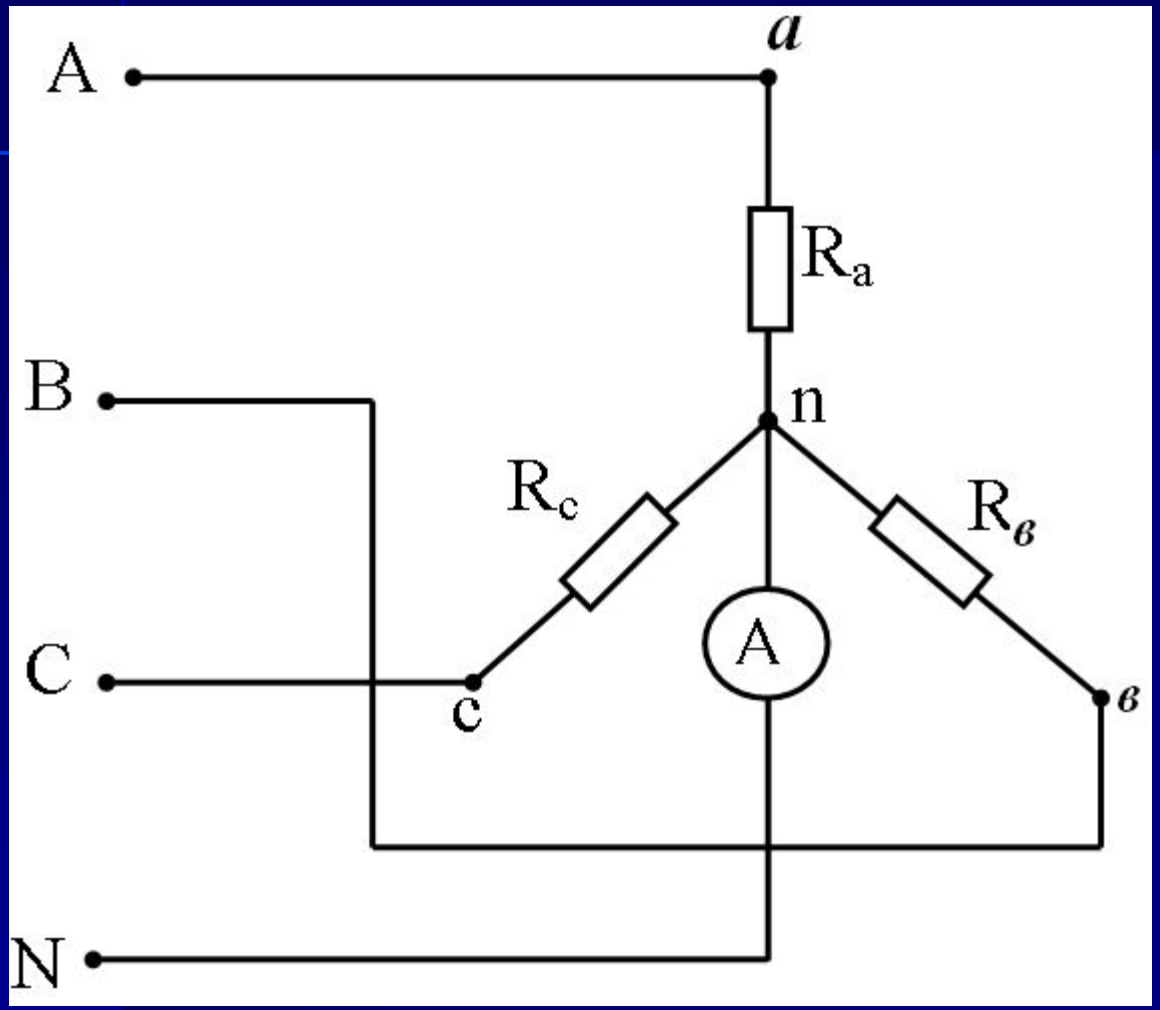
$$\dot{I}_c = \frac{\dot{U}_c}{-jX_C} = \frac{380e^{j210^\circ}}{10} = 38e^{j210^\circ}$$


$\dot{U}_a$
$\dot{I}_в$
-30^0
90^0
$\dot{I}_a$
210^0
$\dot{U}_c$
$\dot{I}_c$
$\dot{U}_в$


$\dot{I}_в$
$\dot{I}_c$
$\dot{I}_a$

$\dot{I}_N=0$

Problem 4



Given:

$U_л = 220\ В$

$R_а = R_в = 10\ Ом$

$R_с = 20\ Ом$

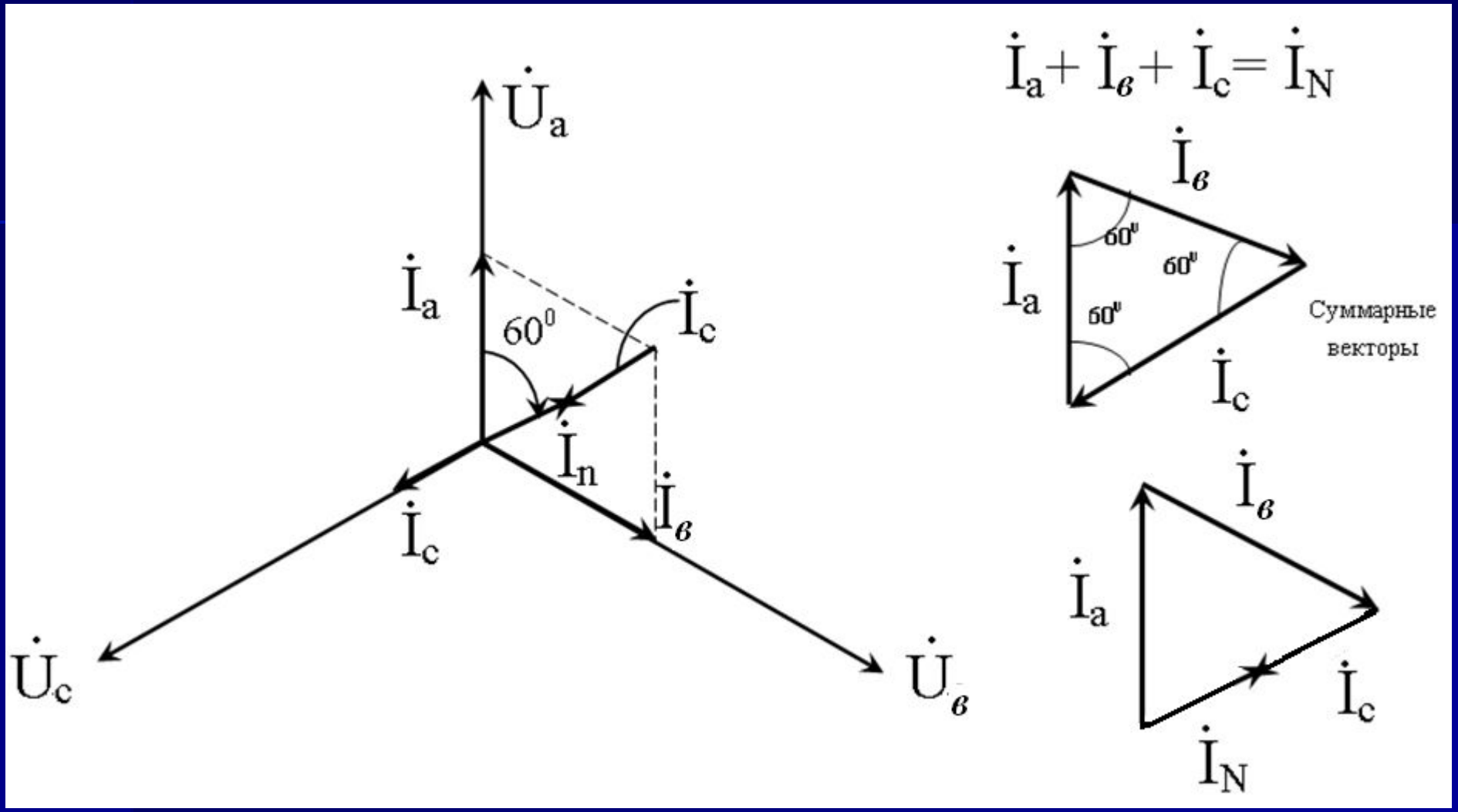
Define:

I_N - ?

$$U_{ф} = \frac{U_{л}}{\sqrt{3}} = 127\ B$$

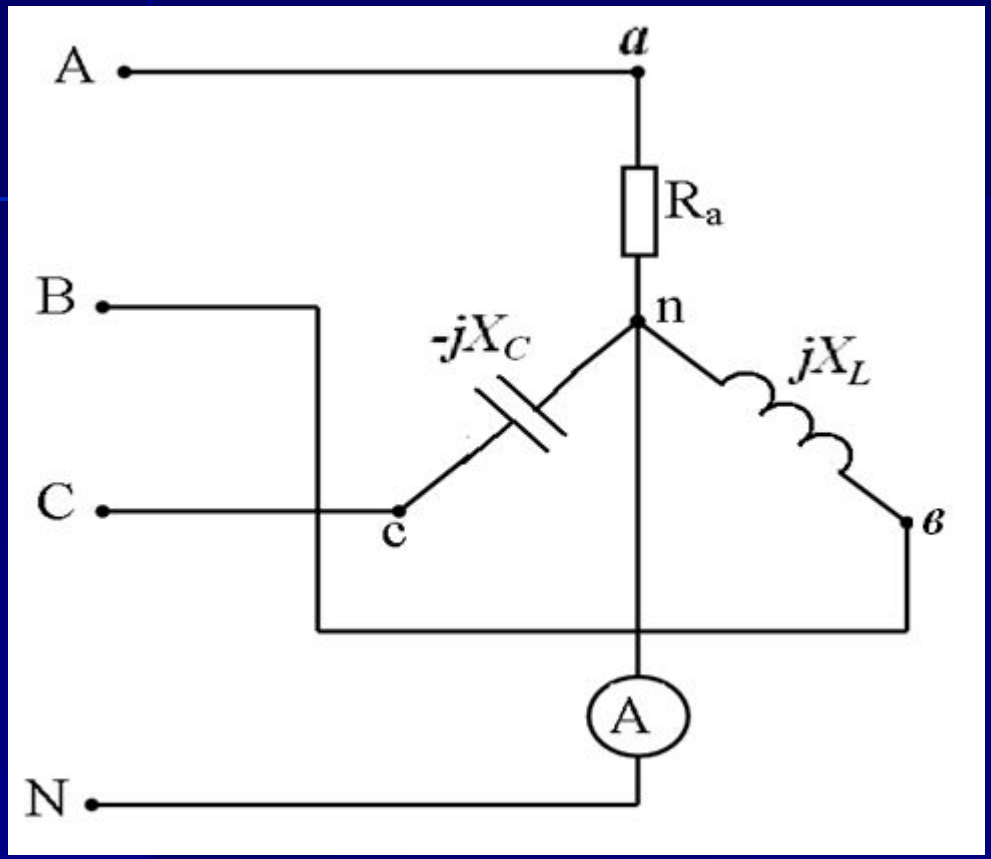
$$I_{a} = I_{в} = \frac{U_{ф}}{R_{a}} = \frac{127}{10} = 12{,}7\,A$$

$$I_{c} = \frac{U_{ф}}{R_{c}} = \frac{127}{20} = 6\,A$$



$$\dot{I}_N = 6{,}7e^{-j60^\circ}$$

Problem 5



Given:

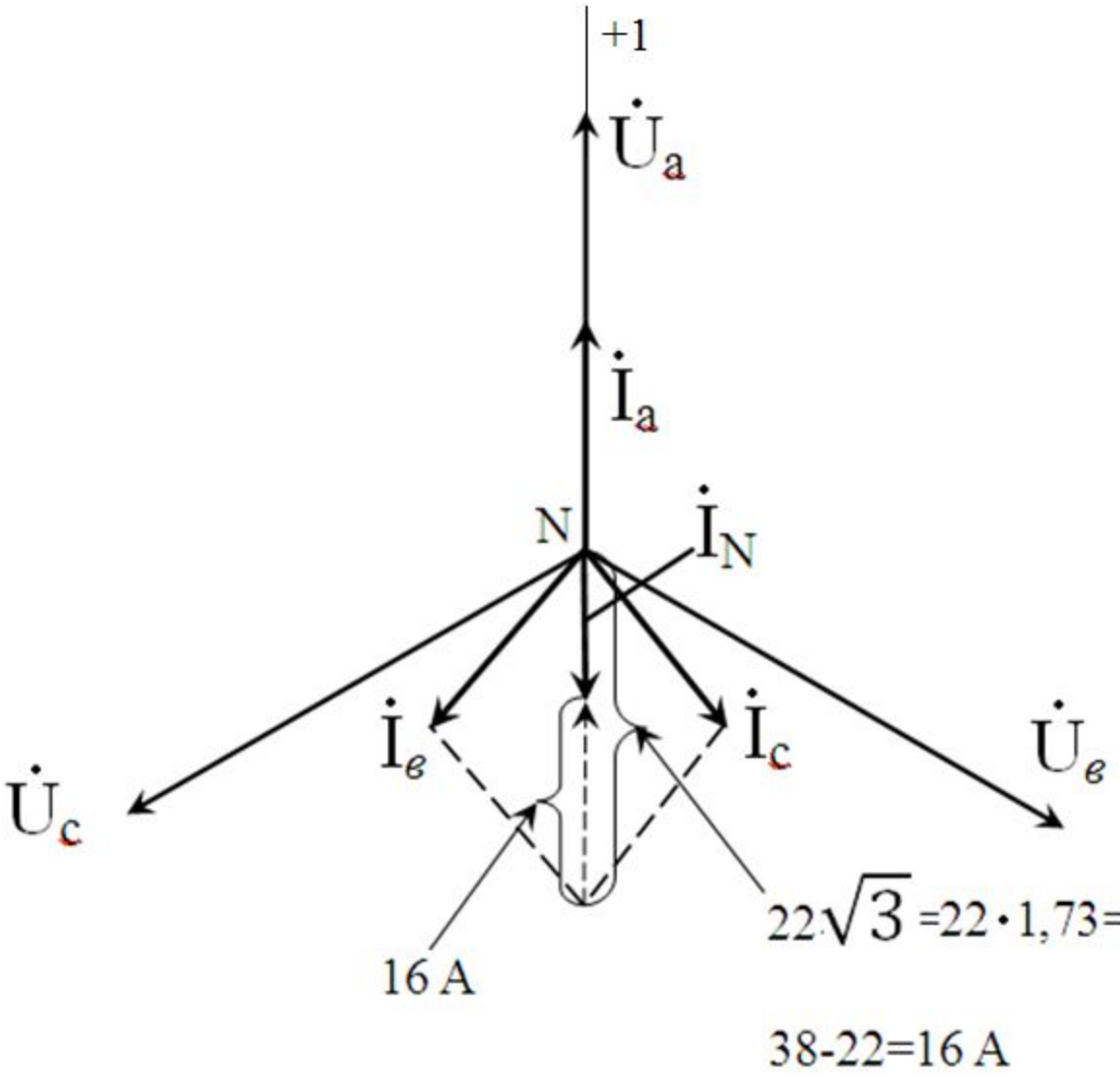
$V_L = 380\ V$

$R_a = X_в = X_c = 10\ ohm$

Define:

$I_a, I_в, I_c, I_N - ?$

$$I_a = I_в = I_c = \frac{U_ф}{Z_ф} = \frac{220}{10} = 22\ A$$

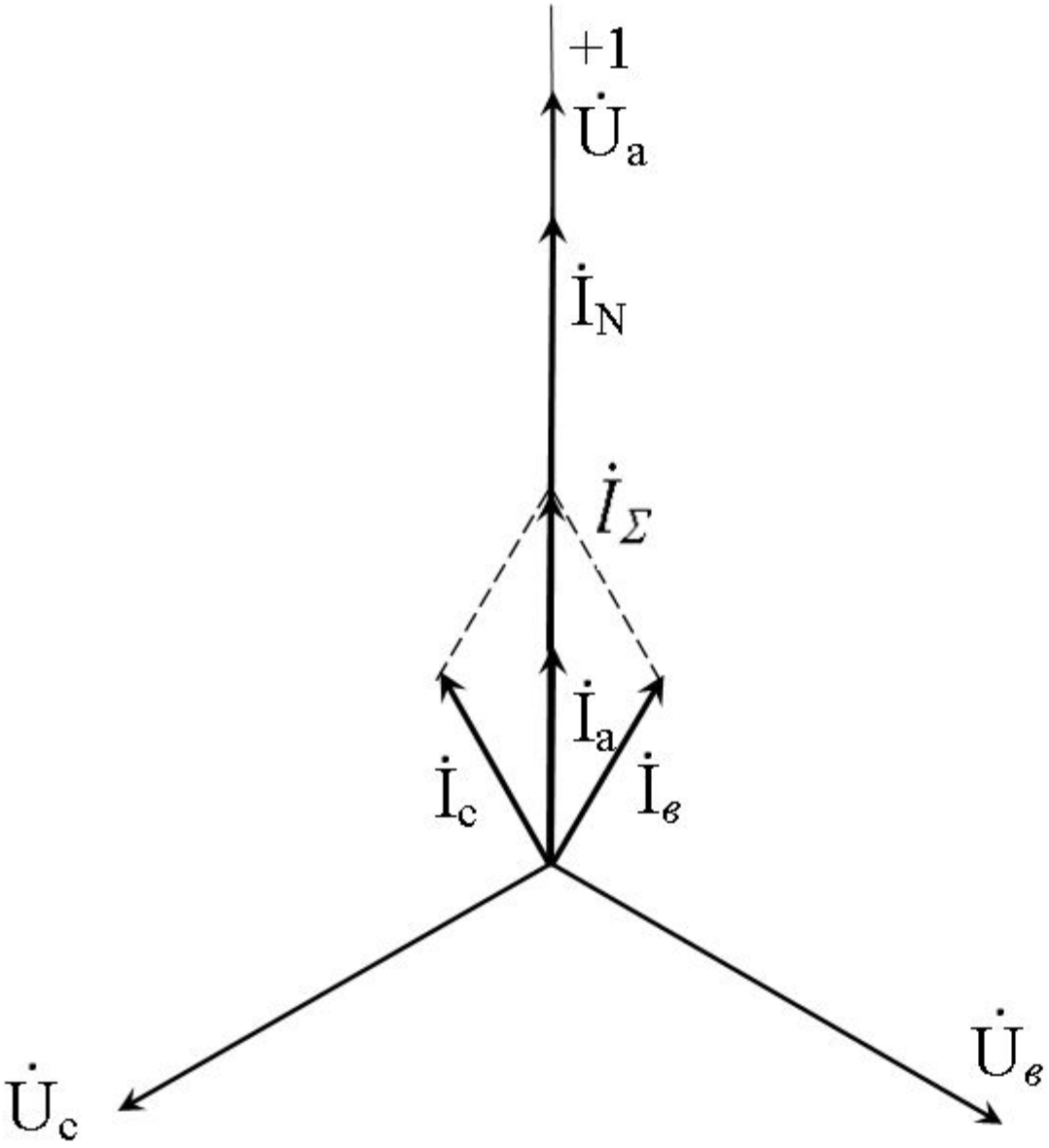


$$\dot{I}_N=\dot{I}_a+\dot{I}_в+\dot{I}_c=$$

$$=16e^{j180^\circ}$$

$$I_N=16\ A$$

Если поменять с местами $X_в$ и $X_с$



$\dot{I}_a = \dot{I}_в = \dot{I}_c = 22\ A$

Сумма $\dot{I}_в + \dot{I}_c = \dot{I}_\Sigma e^{j0} = 38\ A$

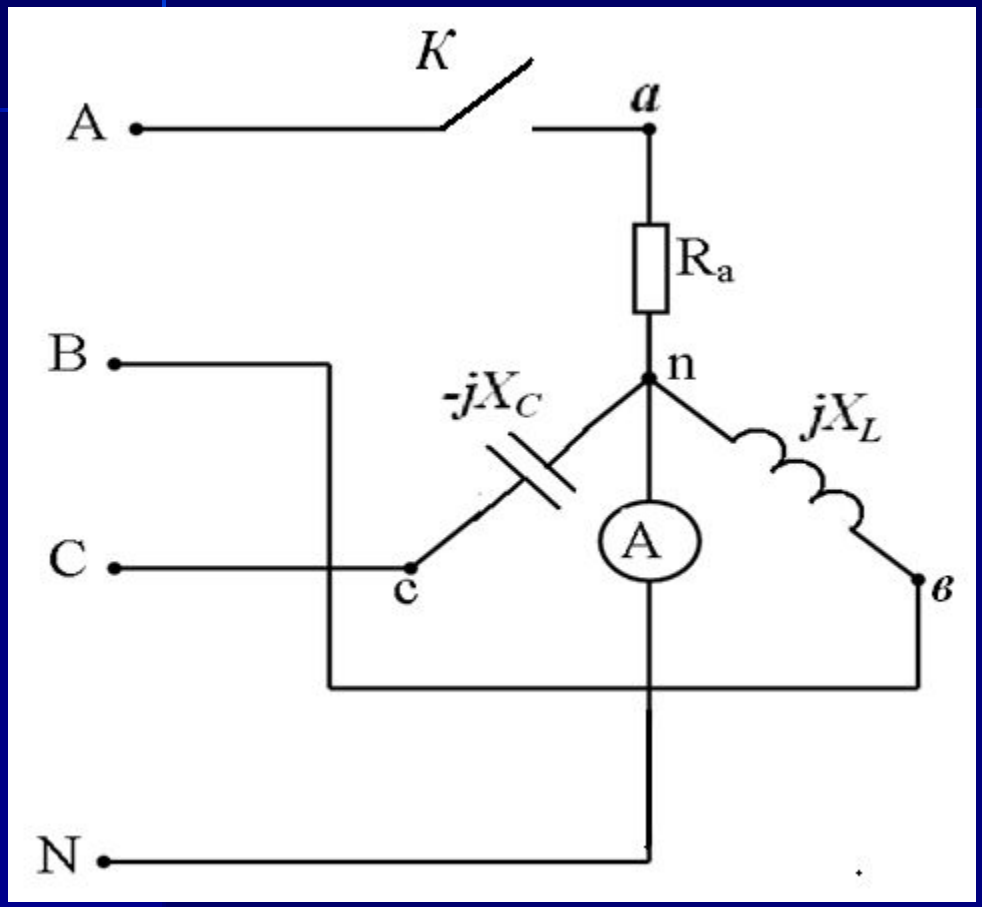
$\dot{I}_N = 38 + 22 = 60\ A$

$\dot{I}_N = \dot{I}_a + \dot{I}_в + \dot{I}_c =$

$= 60 e^{j0} = 60\ A$

$\dot{I}_N = 60\ A$

Problem 6



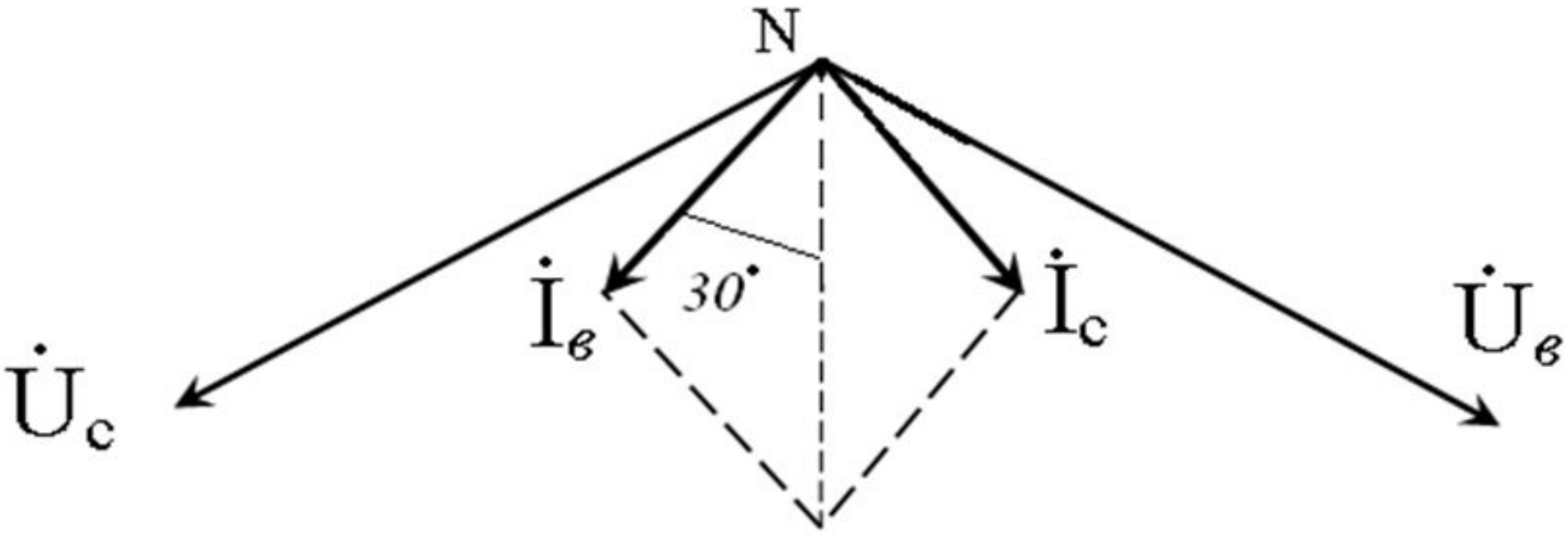
Given:

$V_л = 380\ V$

$R_a = X_в = X_c = 10Ohm$

Define:

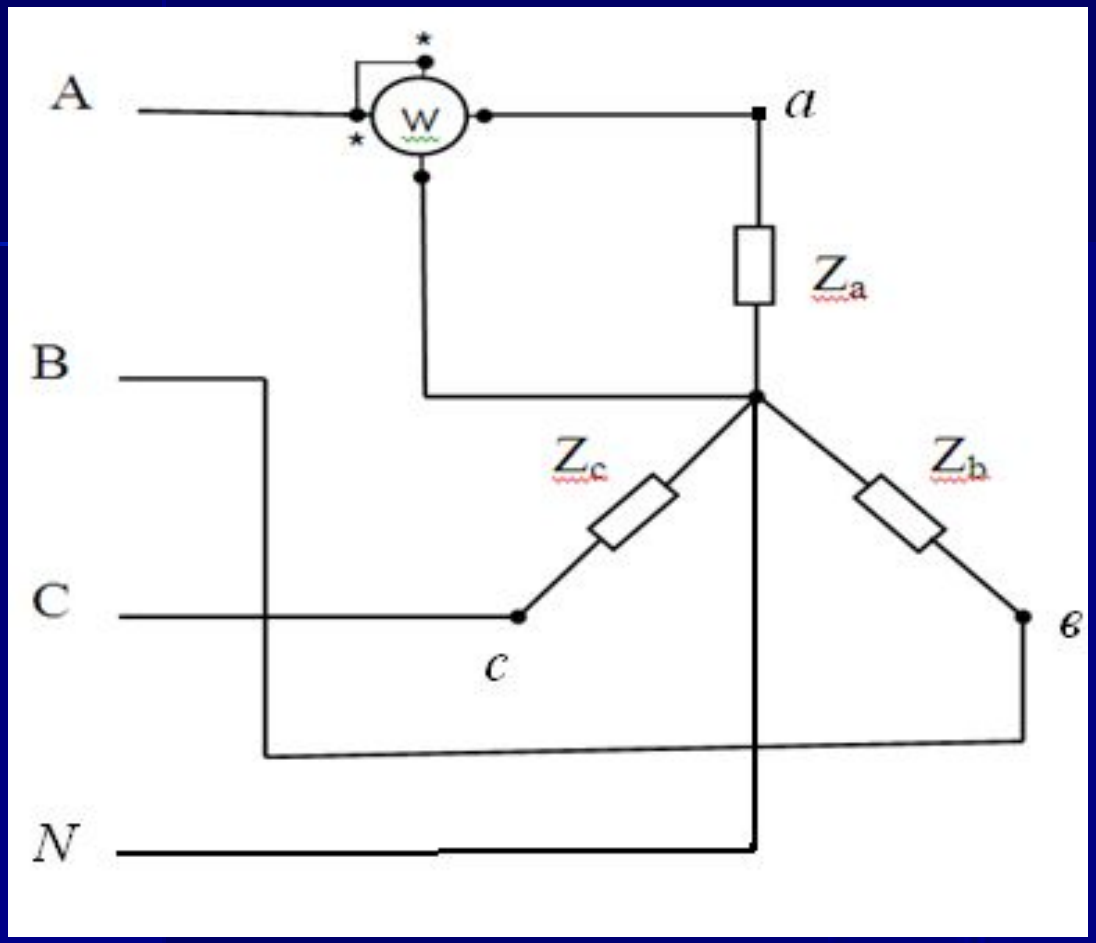
I_N - ?



$$\dot{I}_N = \dot{I}_в + \dot{I}_c;$$

$$I_N = 38\ A$$

Problem 7



Given

$\dot{V}_L = 380\ B$

$I_a = 2\ A;\ \cos\phi_\phi = 0{,}8$

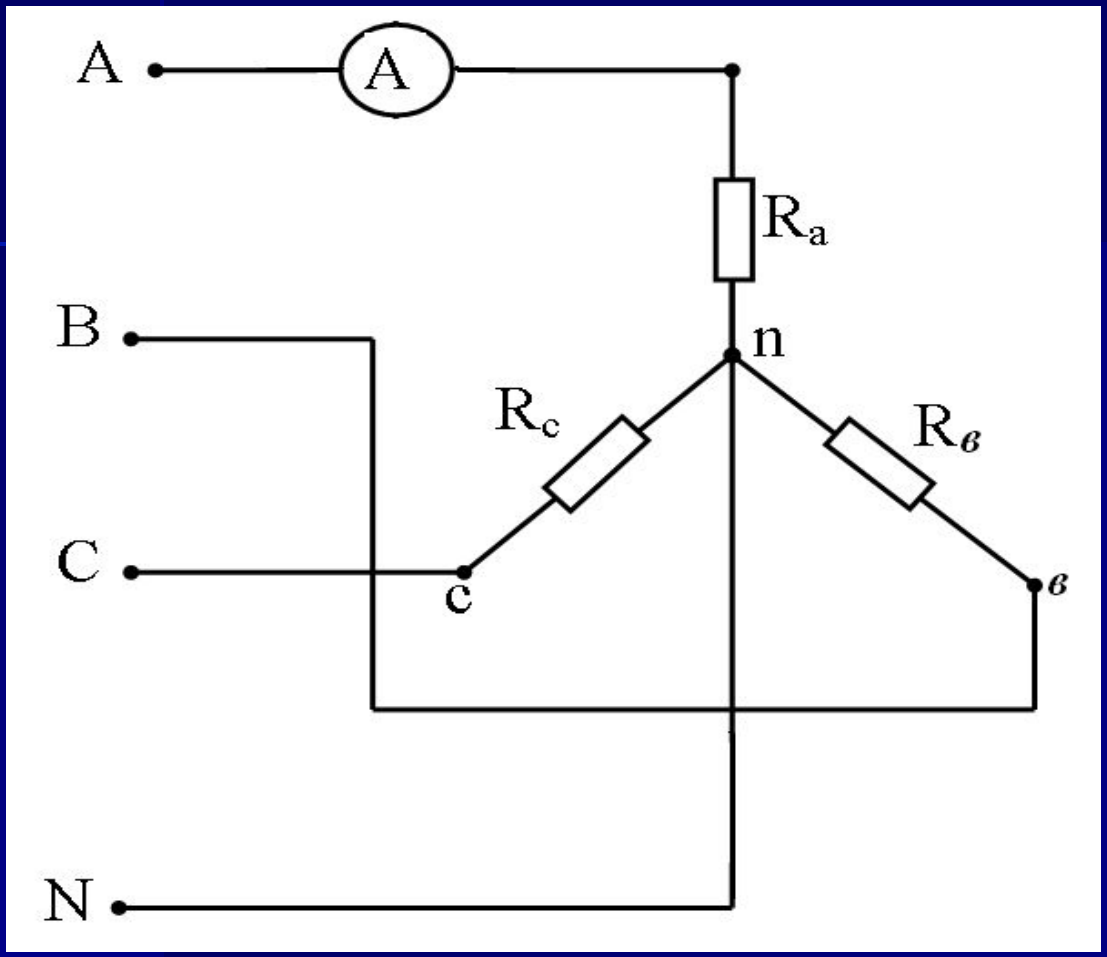
Define:

P_w-?

$$P_w = U_a I_a \cos(\dot{U}_a, \dot{I}_a) = 220 \cdot 2 \cdot 0{,}8 =$$

$$= 352\ Bm$$

Problem 8



Given

$\underline{U}_л = 380\ В$

$R_a = 10\ Ом;$

$R_в = 20\ Ом;$

$R_c = 30\ Ом.$

Define instrument readings - ?

$$I_a = \frac{U_a}{R_a} = \frac{220}{10} = 22\ A$$

Problem 9

Given:

S=1000 VA

P=600 Wt.

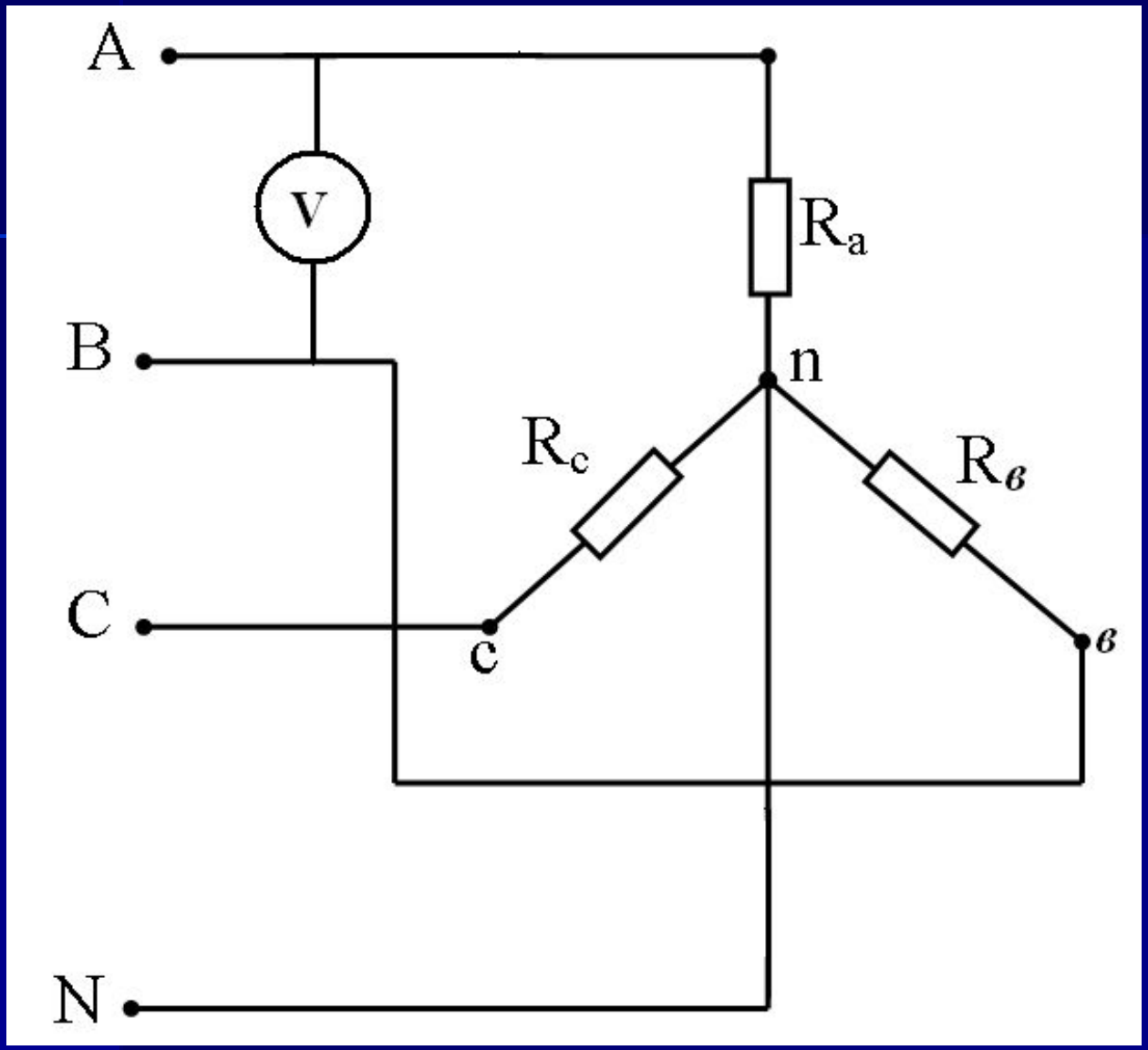
Define:

Power factor - ?

$$P = UI\cos\varphi = S\cos\varphi$$

$$\cos\varphi = \frac{P}{S} = 0{,}6$$

Problem 10



Given:

R_a =10 *Ом*,

$R_в$ =20 *Ом*,

R_c =30 *Ом*,

$I_л$ =22 А.

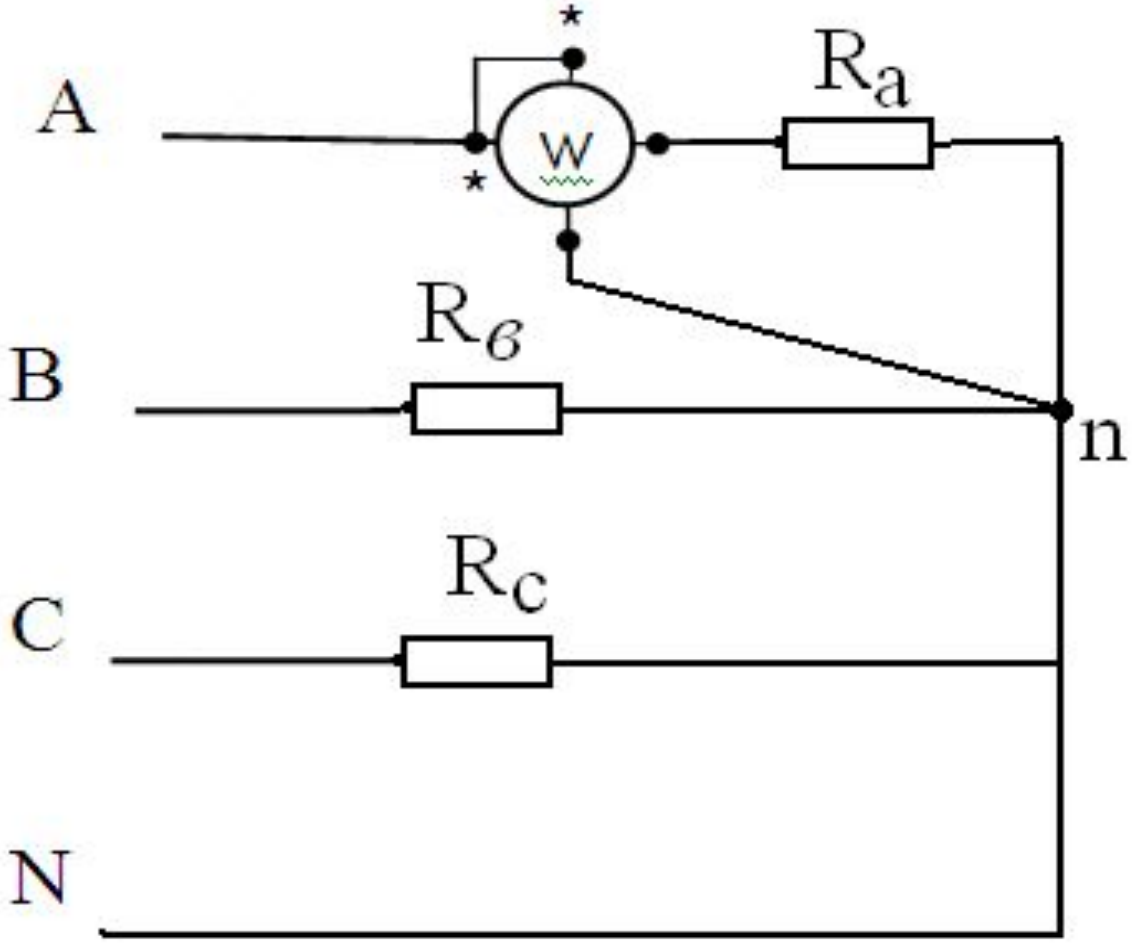
Define instrument readings - ?

$$I_a = I_л = 22\ A$$

$$U_ф = R_a \cdot I_a = 10 \cdot 22 = 220\ B$$

$$U_л = \sqrt{3} \cdot U_ф = 1{,}73 \cdot 220 = 380\ B$$

Problem 11



Given:

$R_a = 10$ *Ом*,

$R_в = 20$ *Ом*,

$R_c = 30$ *Ом*,

$I_a = 22$ A.

Define instrument readings - ?

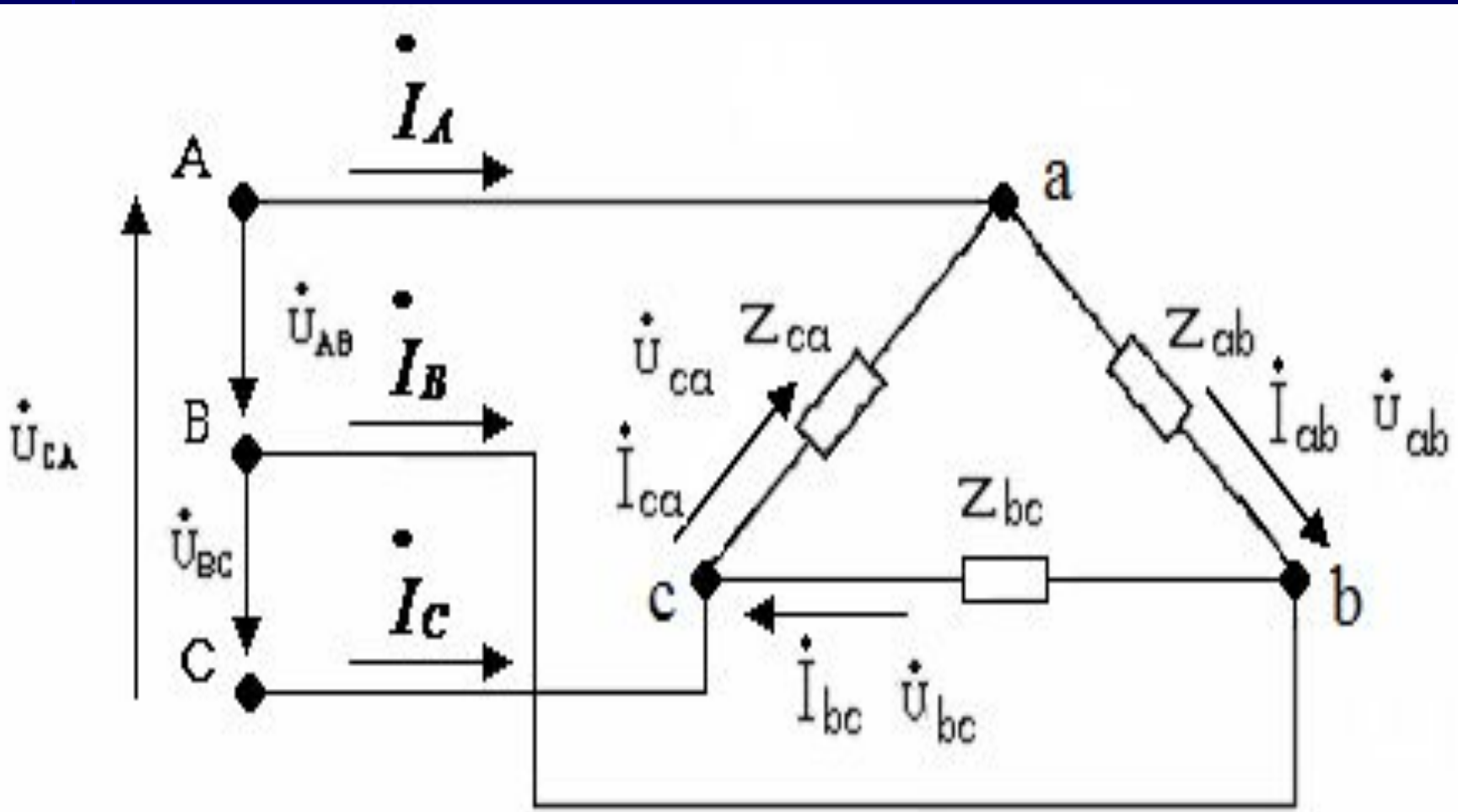
$$P_w = I_a^2 R_a = 484 \cdot 10 = 4840 \ Bm$$

Three-wire three-phase chain (practical training)

For symmetrical receiver phase connections, a three-wire three-phase circuit is used by the star.

Symmetrical receiver - three-phase electric motors, electric furnaces.

A three-wire three-phase circuit can be used under an unsymmetrical load, but the load is connected by a triangle.


A
B
C
a
b
c
$\dot{I}_A$
$\dot{I}_B$
$\dot{I}_C$
$\dot{U}_{AB}$
$\dot{U}_{BC}$
$\dot{U}_{CA}$
$\dot{U}_{ca}$
Z_{ca}
$\dot{I}_{ca}$
Z_{ab}
$\dot{I}_{ab}$
$\dot{U}_{ab}$
Z_{bc}
$\dot{I}_{bc}$
$\dot{U}_{bc}$

$$\dot{U}_{ab} = \dot{U}_{AB} = U_{л} e^{j30^\circ}$$

$$\dot{U}_{bc} = \dot{U}_{BC} = U_{л} e^{-j90^\circ}$$

$$\dot{U}_{ca} = \dot{U}_{CA} = U_{л} e^{j150^\circ}$$

$$U_{ф} = U_{л}; \quad I_{л} = \sqrt{3}\, I_{ф}.$$

At symmetrical loading

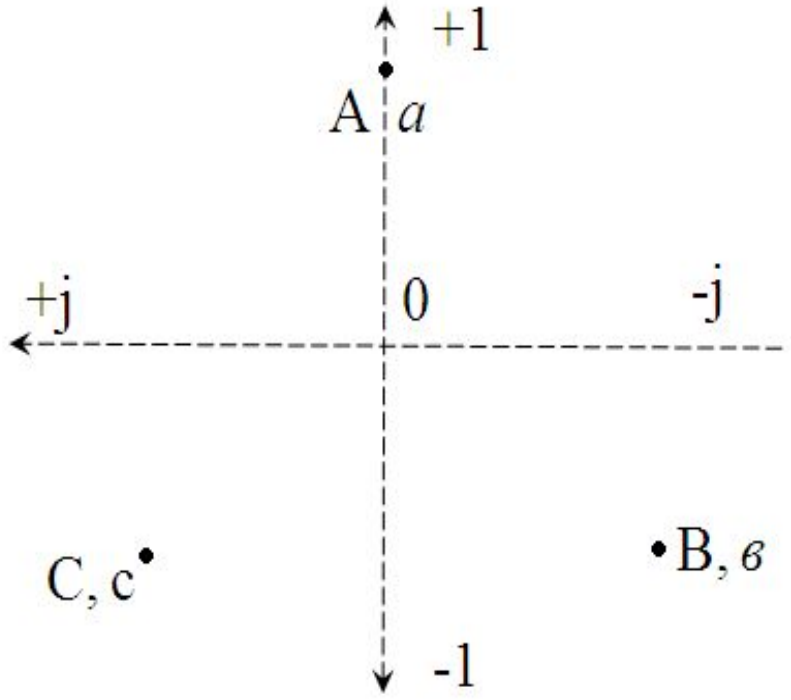
$$\dot{I}_A = \dot{I}_{ab} - \dot{I}_{ca};$$

$$\dot{I}_B = \dot{I}_{bc} - \dot{I}_{ab};$$

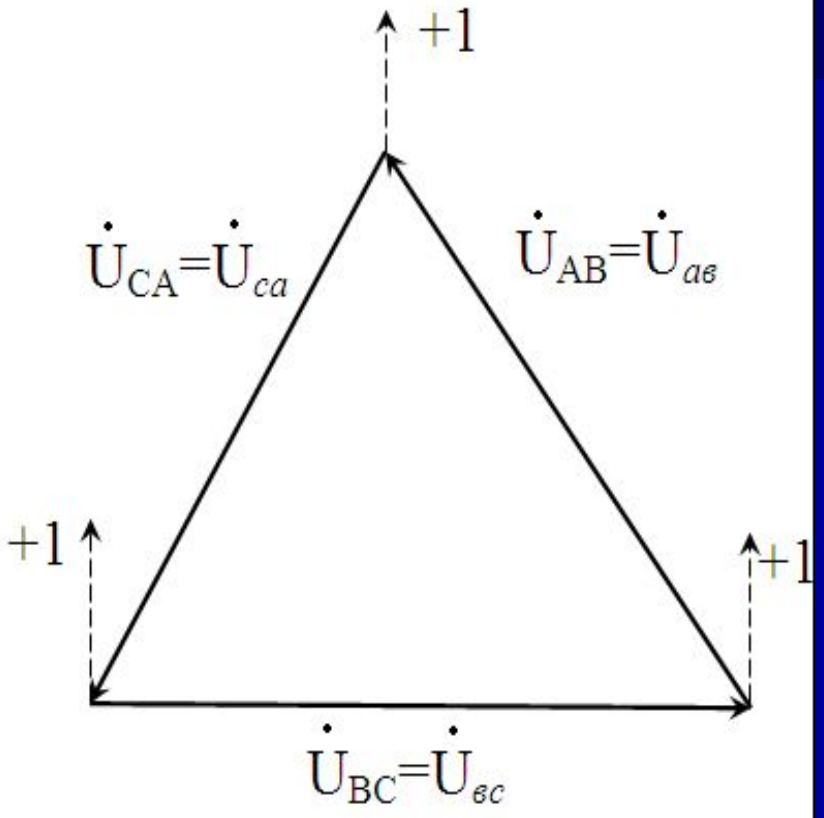
$$\dot{I}_C = \dot{I}_{ca} - \dot{I}_{bc};$$

$$\dot{I}_A + \dot{I}_B + \dot{I}_C = 0;$$

At any loading



Потенциальная диаграмма



Векторная диаграмма

Problem 1

Given:

$V_L = 380\ В,\quad R_{ав} = R_{вс} = R_{са} = R = 10\ Ом$

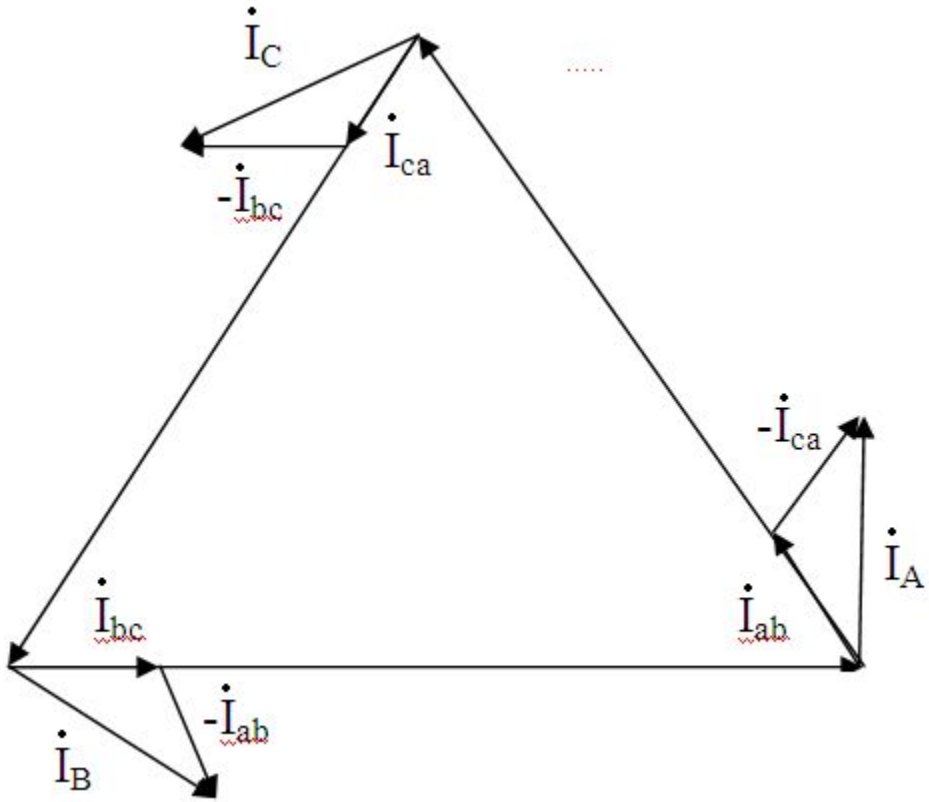
Define: $I_ф,\ I_л - ?$

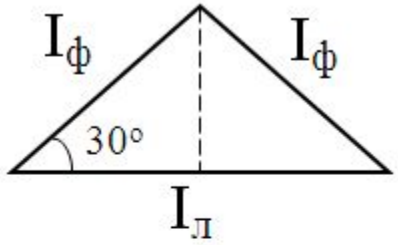
Solution:

$U_ф = U_л = 380\ V$

$I_ф = I_{ав} = I_{вс} = I_{са} = U_ф / R = 380/10 = 38\ A$

$\dot{I}_A = \dot{I}_{ав} - \dot{I}_{са};\quad \dot{I}_B = \dot{I}_{вс} - \dot{I}_{ав};\quad \dot{I}_C = \dot{I}_{са} - \dot{I}_{вс}.$

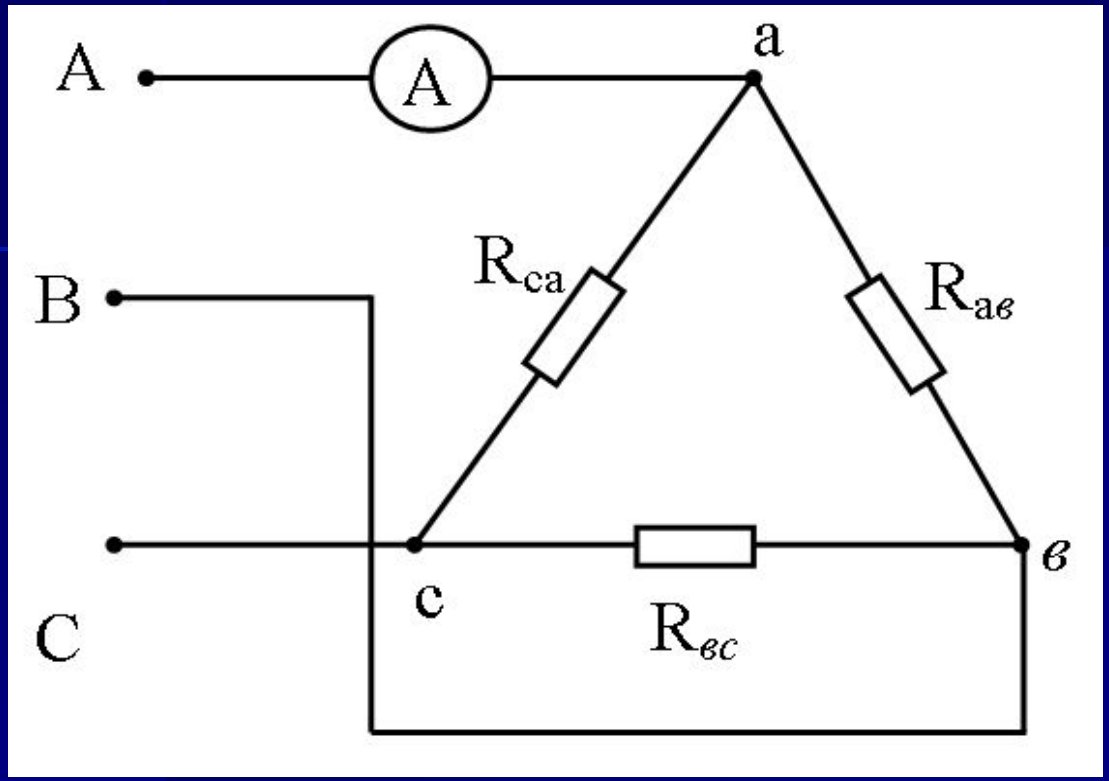




$$\frac{I_л}{2} = I_ф \cos 30° = I_ф \frac{\sqrt{3}}{2}$$

$$I_л = \sqrt{3} I_ф = \sqrt{3} \cdot 38 = 66\ A$$

Problem 2



Given:

$V_L = 220\ V$

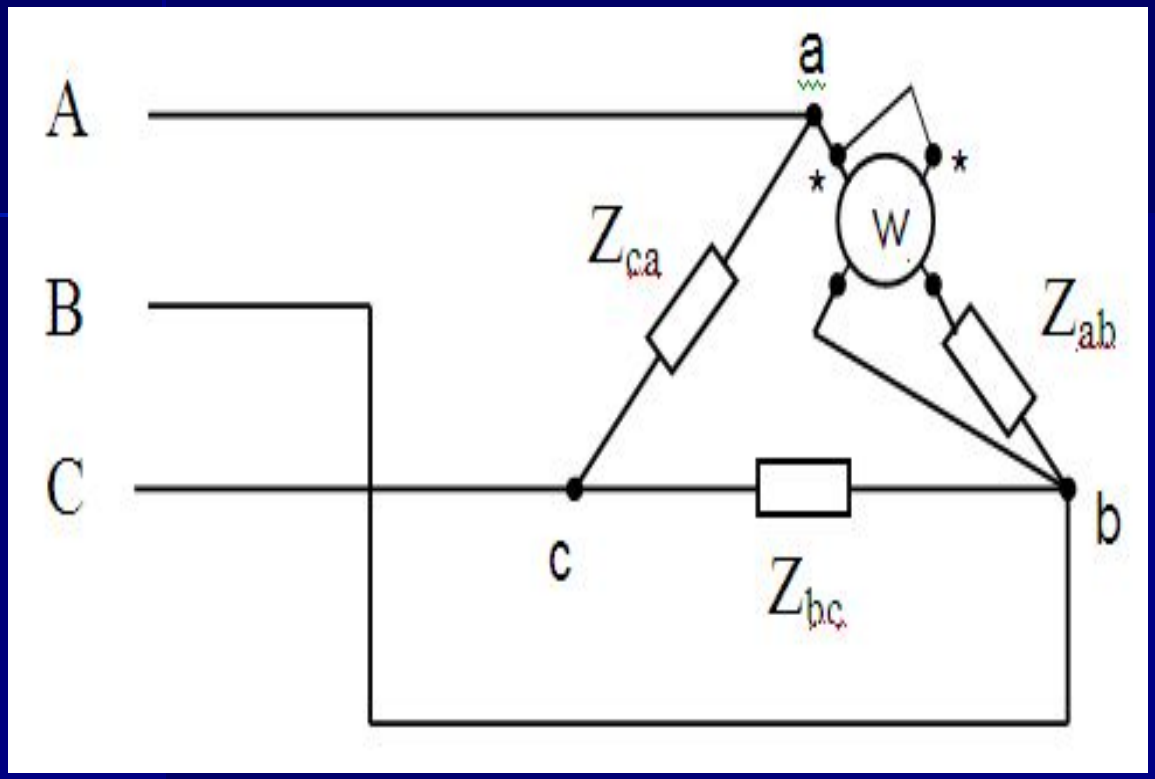
$R_{ав} = R_{са} = R_{вс} = 10\ Ohm.$

Determine of reading ammeter I_L - ?

$$I_л = \sqrt{3} I_ф \qquad I_ф = \frac{U_л}{R_ф} = \frac{U_ф}{R_ф} = \frac{220}{10} = 22\ A$$

$$I_л = 1{,}73 \cdot 22 = 38\ A$$

Problem 3



Given

$V_L = 220\ B$

$I_L = 17{,}3\ A$

$\cos\phi = 0.6$

$Z_{ab} = Z_{bc} = Z_{ca} = Z$

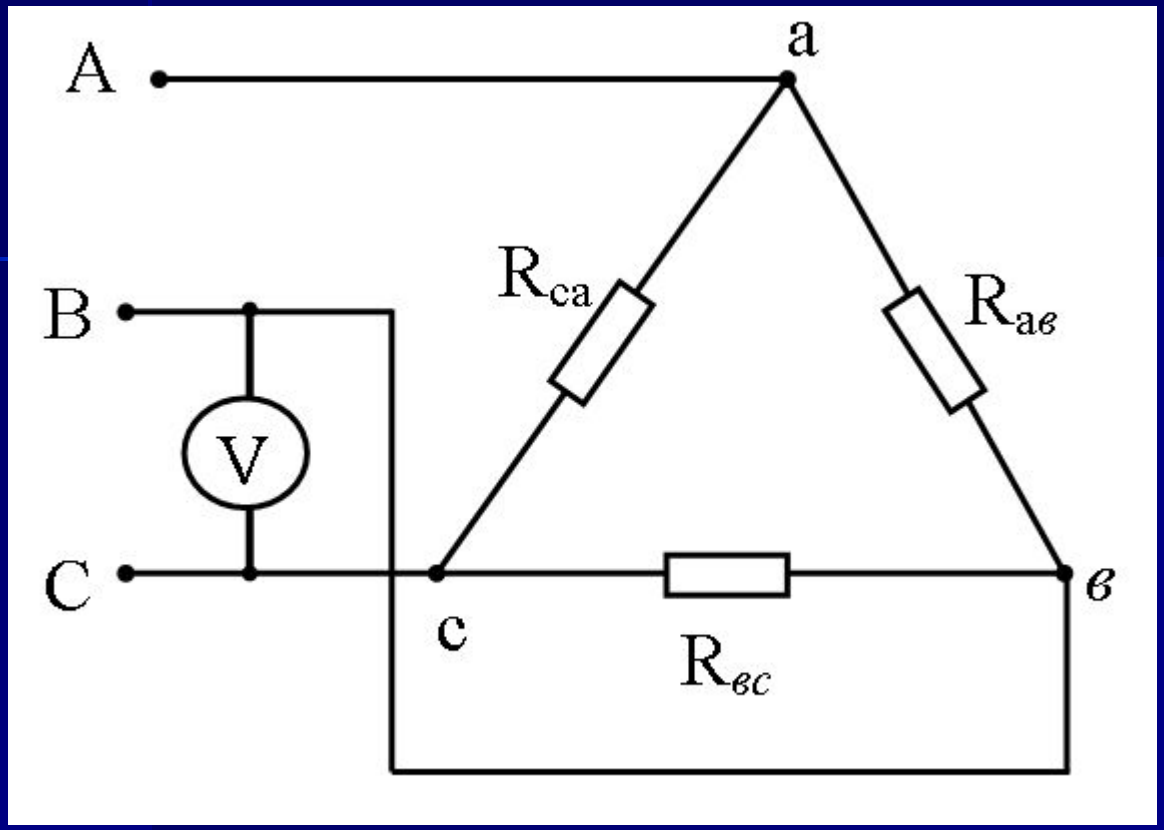
Determine of reading wattmeter- ?

$$I_\phi = \frac{I_л}{\sqrt{3}} = \frac{17{,}3}{\sqrt{3}} = 10\ A$$

$$P_w = U_\phi I_\phi \cos(\hat{\dot{U}_\phi, \dot{I}_\phi}) = U_{ab} I_{ab} \cos\varphi_\phi =$$

$$= 220 \cdot \frac{17{,}3}{1{,}73} \cdot 0{,}6 = 1320\ Bm$$

Problem 4



Given

$I_{ав}$ =22 A,

$R_{ав}$ =10 *Ом*,

$R_{вс}$ =20 *Ом*,

R_{ca} =30 *Ом*.

Determine of reading voltmeter- ?

$$U_{BC} = U_{л} = U_{ф} = I_{ав} \cdot R_{ав} =$$

$$= 22 \cdot 10 = 220 \ B$$

Problem 5

Given: $V_L = 220\ V$

$R_{ав} = 10\ Ом, \quad R_{вс} = 4\ Ом, \quad R_{са} = 5\ Ом$

$\dot{U}_{AB} = 220\, e^{j30^\circ} \qquad \phi_{ав} = \phi_{вс} = \phi_{са} = \phi = 0$

Define:

$I_{ав}, I_{вс}, I_{са}, I_A, I_B, I_C$ - ?

Solution:

$$\dot{I}_{ав} = \frac{\dot{U}_{ав}}{R_{ав}} = \frac{U_л e^{j30^\circ}}{R_{ав}} = 22\, e^{j30^\circ}$$

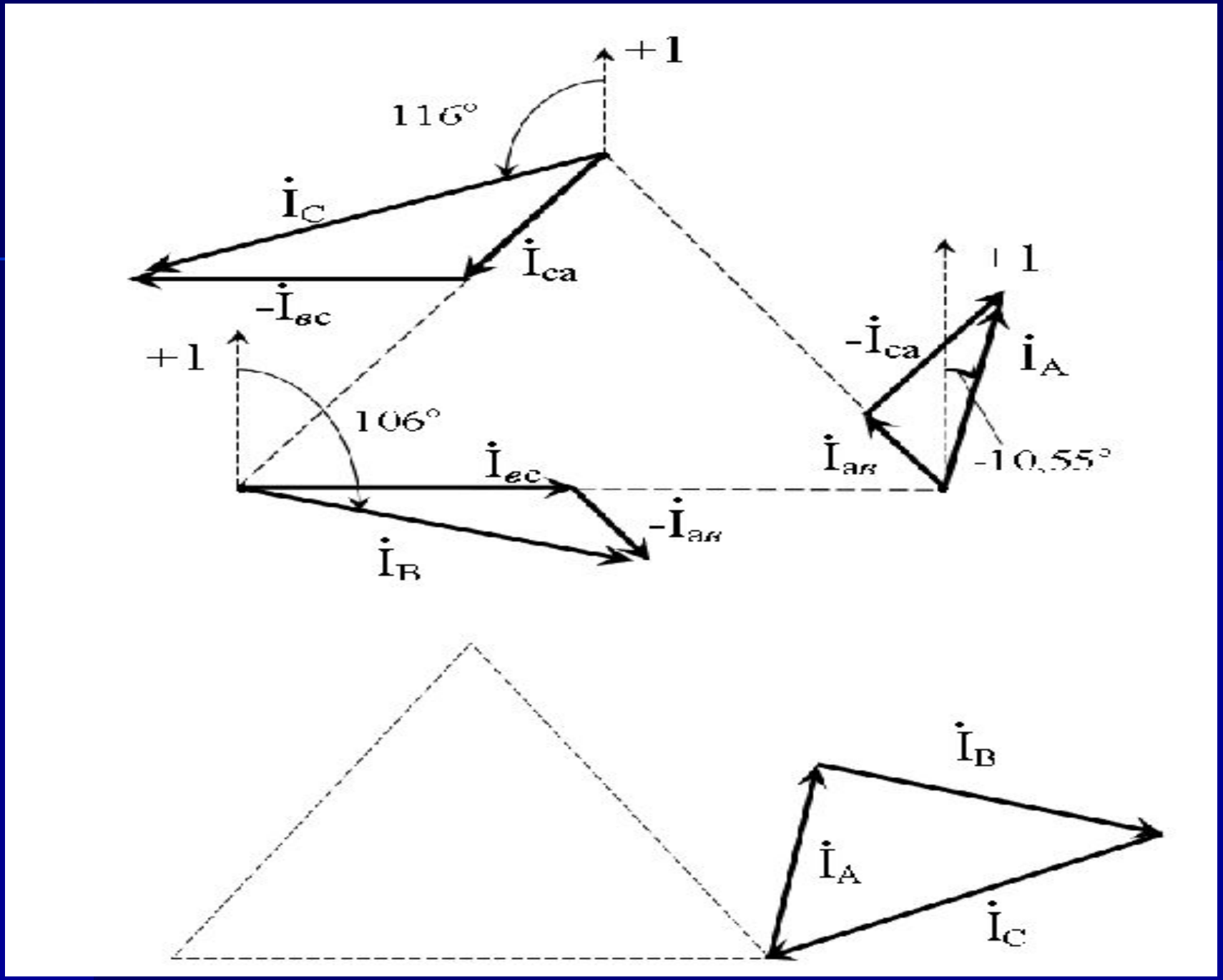
$$\dot{I}_{вс} = \frac{\dot{U}_{вс}}{R_{вс}} = \frac{220\, e^{-j90^\circ}}{4} = 55\, e^{-j90^\circ}$$

$$\dot{I}_{са} = \frac{\dot{U}_{са}}{R_{са}} = \frac{220\, e^{j150^\circ}}{5} = 44\, e^{j150^\circ}$$

$$\dot{I}_A = \dot{I}_{ав} - \dot{I}_{са} = 58{,}1e^{-j10{,}55^\circ}$$

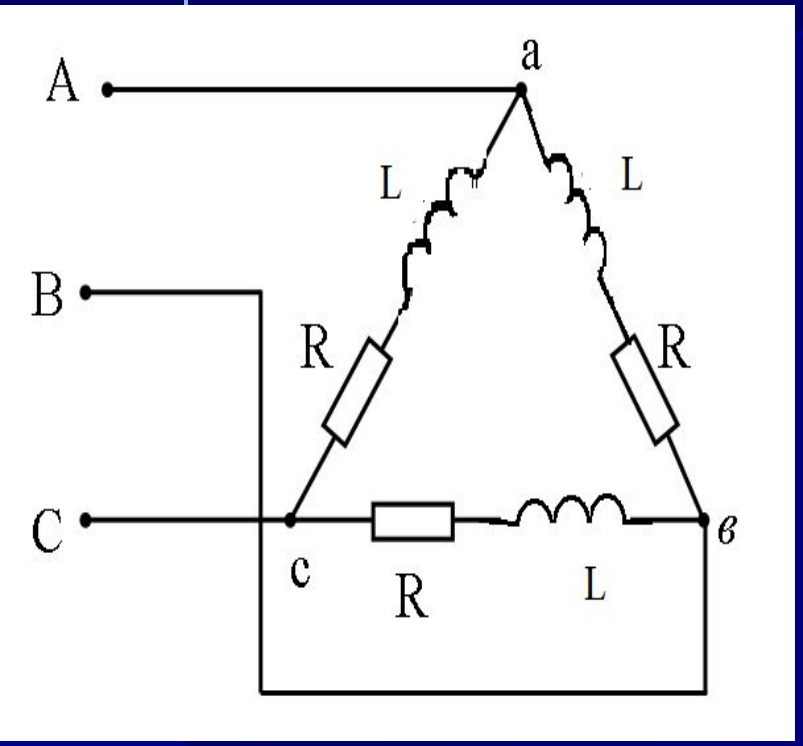
$$\dot{I}_B = \dot{I}_{вс} - \dot{I}_{ав} = 68{,}6e^{-j106^\circ}$$

$$\dot{I}_C = \dot{I}_{са} - \dot{I}_{вс} = 86e^{j116^\circ}$$


+1
116°
$\dot{I}_C$
$\dot{I}_{ca}$
$-\dot{I}_{вс}$
+1
106°
$\dot{I}_{вс}$
$-\dot{I}_{ав}$
$\dot{I}_B$
+1
$-\dot{I}_{ca}$
$\dot{I}_A$
$\dot{I}_{ав}$
-10,55°
$\dot{I}_B$
$\dot{I}_A$
$\dot{I}_C$

Problem 6

Симметричная нагрузка, включенная треугольником.



$R = X_L = 50\ Ом;\ U_л = 380\ В.$

Решение:

Полное сопротивление фазы

$$Z_ф = \sqrt{R^2 + X_L^2} = 70.7\ Ом$$

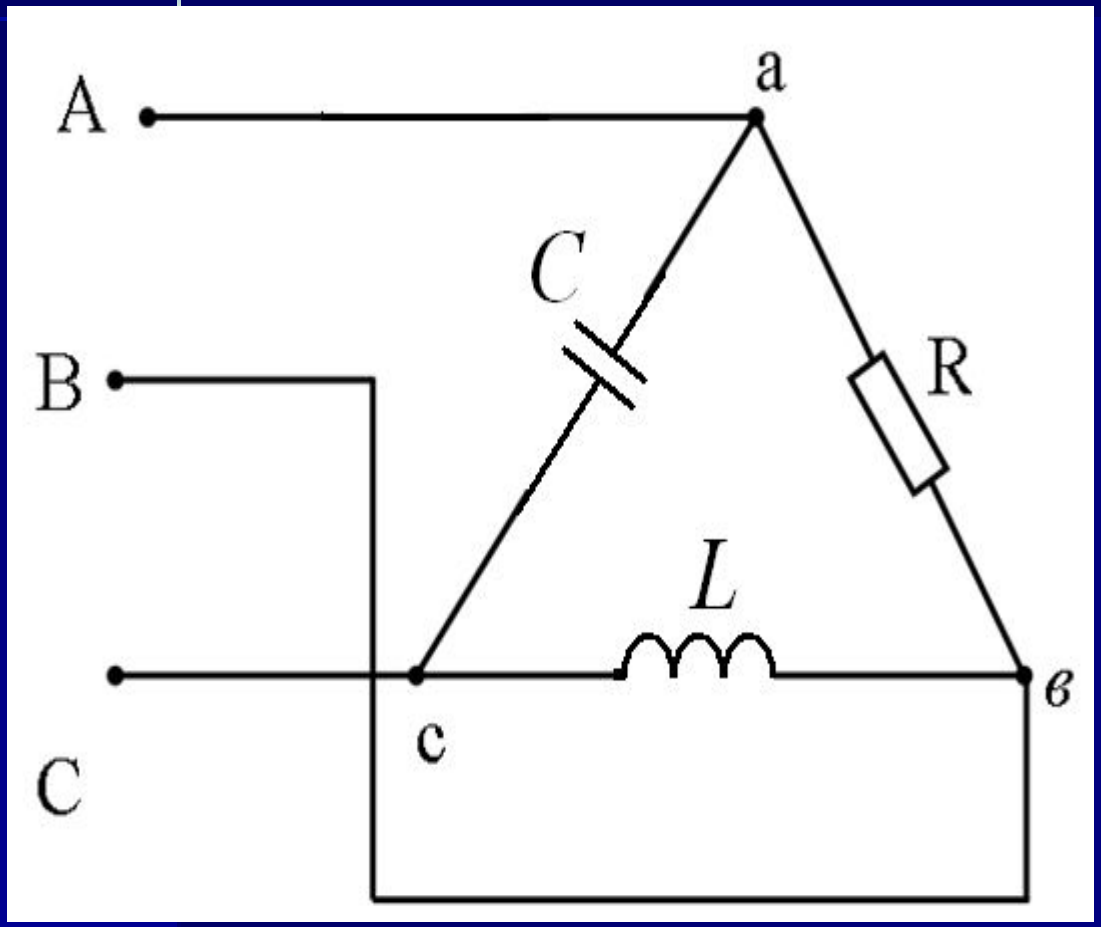
$$U_ф = U_л = 380\ В$$

Фазный ток $$I_ф = U_ф / Z_ф = 5{,}37\ А$$

Линейный ток $$I_л = \sqrt{3} \cdot I_ф = 9{,}3\ А$$

Problem 7

The asymmetric load included by the triangle.



Given:

$R=X_L=X_C=10$ Ом

$V_L=220$ В

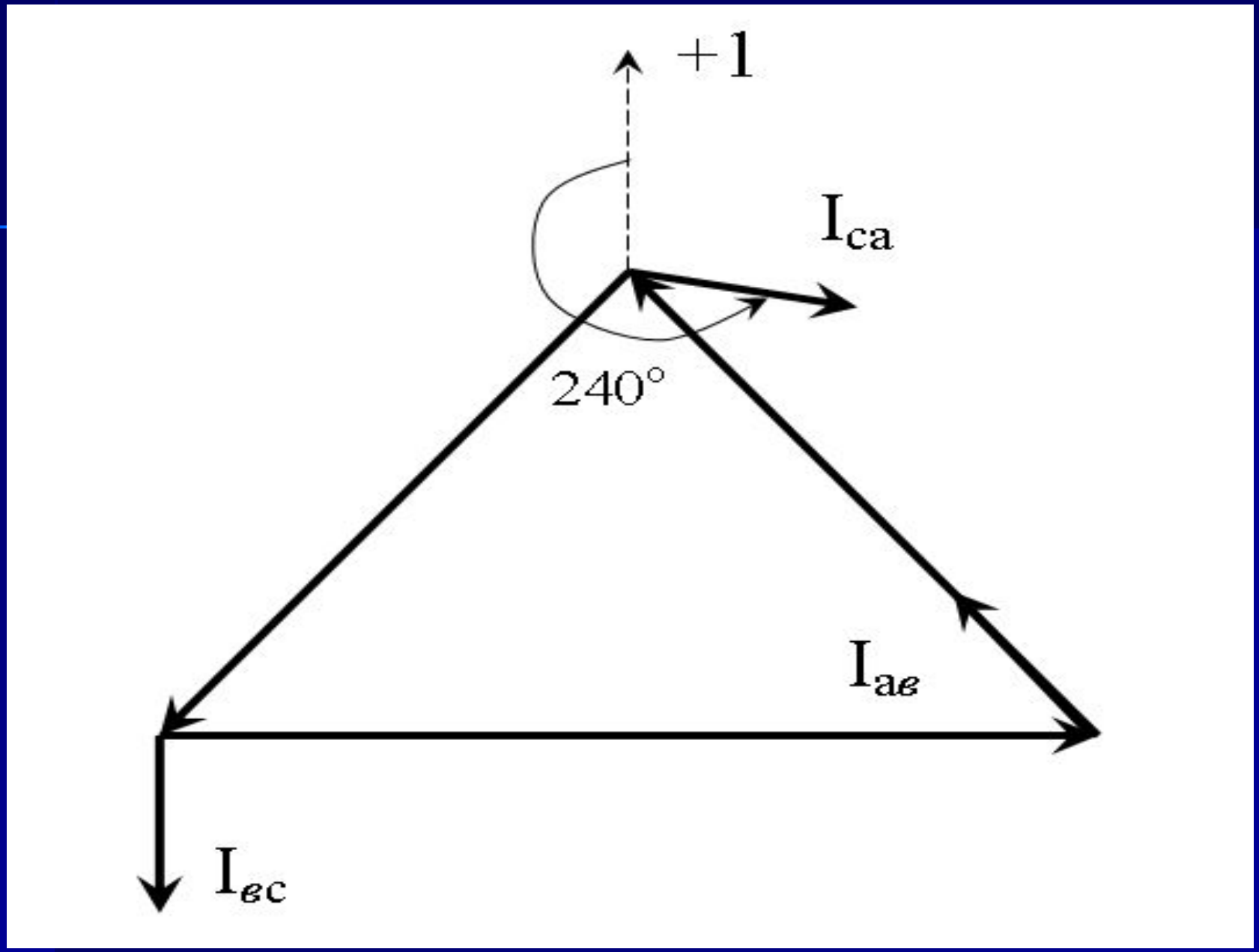
Define:

$I_ф$ - ?

$$\dot{I}_{ав} = \frac{\dot{U}_{ав}}{Z_{ав}} = \frac{\dot{U}_{л}}{R} = \frac{220\, e^{j30^\circ}}{10} = 22\, e^{j30^\circ}\, A$$

$$\dot{I}_{вс} = \frac{\dot{U}_{вс}}{Z_{вс}} = \frac{220\, e^{-j90^\circ}}{j10} = 22\, e^{-j180^\circ}\, A$$

$$\dot{I}_{са} = \frac{\dot{U}_{са}}{Z_{са}} = \frac{220\, e^{j150^\circ}}{-\, j10} = 22\, e^{j240^\circ}\, A$$


+1
I_{ca}
240°
$I_{ав}$
$I_{вс}$