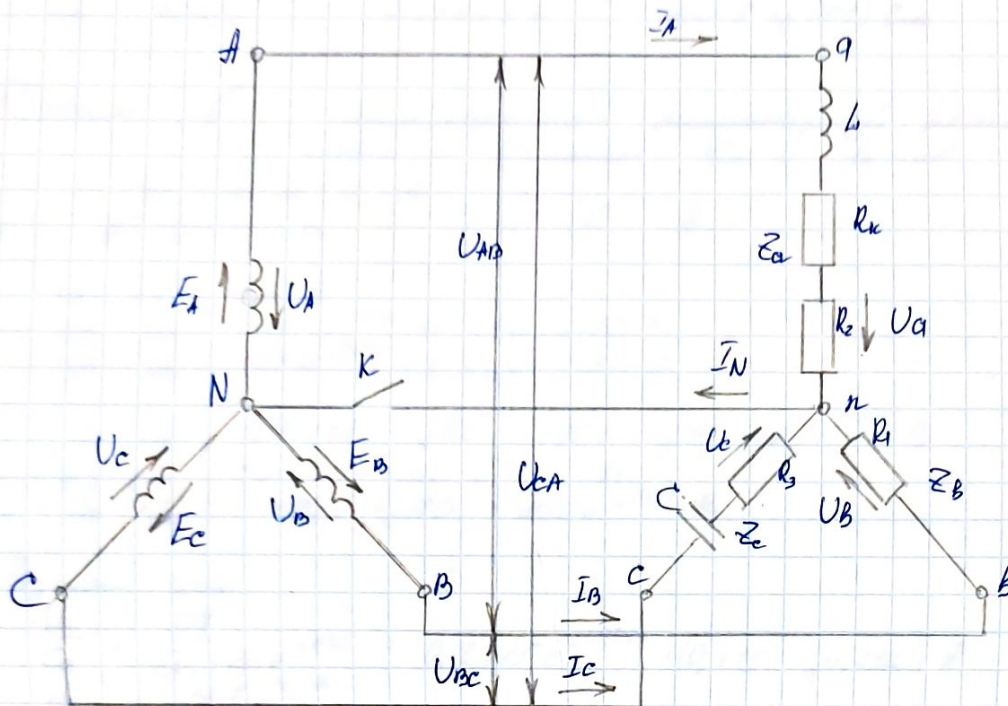


Цифровое задание 7.1.

"Расчет трехфазной э. цепи при соединении однофазных приемников звездой"

Дано: $U_n = 220 \text{ В}$; $U_p = 127 \text{ В}$;
 $f = 50 \text{ Гц}$;
 разгрузка фазы "с".

$R_{\Sigma \text{ на}}$	$L, \Gamma_{\text{н}}$	R_1, Ω	R_2, Ω	R_3, Ω	$C, \mu\text{Ф}$	в фазе приемник векторный		
		Ω	Ω	Ω		"a"	"b"	"c"
14,5	0,418	150	60	50	60	R_2, R_1, R_1	R_1	R_3, C



Определить: напряжения $U_a, U_b, U_c, U_p, U_{ab}, U_{bc}, U_{ca}$ и токи I_a, I_b, I_c, I_N . В след. случаях:

- исслед. при $Z_N = 0$, ключ к замкнут;
- исслед. при $Z_N = \infty$, ключ к разомкнут;
- разгрузка одной фазы трехф. приемника при $Z_N = 0$ к-замкнут;
- разгрузка одной фазы трехф. приемника при $Z_N = \infty$ к-разомкнут;
- короткое замыкание фазы приемника при $Z_N = \infty$, к-разомкнут;
- Опр-ть для симметричного приемника
- построить топографию, диаграммы U с векторными диаграммами I для всех случаев

Решение.

$$\begin{aligned} U_A &= 127 \text{ В} \\ U_B &= 127 e^{-j120} = (-63,5 - j110) \text{ В} \\ U_C &= 127 e^{j120} = (-63,5 + j110) \text{ В} \end{aligned}$$

Линейное напряжение генератора:

$$\begin{aligned} U_{AB} &= U_A - U_B = 127 + 63,5 + j110 = 190,5 + j110 = 220 e^{j30} \text{ В} \\ U_{BC} &= U_B - U_C = -63,5 - j110 + 63,5 - j110 = -j220 = 220 e^{-j90} \text{ В} \\ U_{CA} &= U_C - U_A = -63,5 + j110 - 127 = -190,5 + j110 = 220 e^{j150} \text{ В} \end{aligned}$$

Сопротивление фаз приемника:

$$X_L = \omega L = 314 \cdot 0,418 = 131,252 \Omega; \quad X_C = \frac{1}{\omega C} = \frac{1}{314 \cdot 60 \cdot 10^{-6}} = 53,079 \Omega.$$

$$\begin{aligned} Z_a &= R_2 + R_L + j'X_L = 60 + 14,5 + j'131,252 = 74,5 + j'131,252 = 150,922 e^{j60,42} \Omega \\ Z_b &= R_1 = 150 \Omega \\ Z_c &= R_3 - j'X_C = 50 - j'53,079 = 72,92 e^{-j46,71} \Omega \end{aligned}$$

$$\varphi_a = 60,42^\circ; \quad \varphi_b = 0^\circ; \quad \varphi_c = -46,71^\circ$$

Проводимости:

$$\underline{Y}_a = \frac{1}{\underline{Z}_a} = \frac{1}{150,922 e^{j69,42}} = 0,006626 e^{-j69,42} = (0,003 - j0,006) \text{ См}$$

$$\underline{Y}_b = \frac{1}{\underline{Z}_b} = \frac{1}{150} = 0,006667 \text{ См}$$

$$\underline{Y}_c = \frac{1}{\underline{Z}_c} = \frac{1}{72,92 e^{j166,711}} = 0,01371 e^{-j166,711} = (0,009 + j0,01) \text{ См}$$

Решим "А": Несимметричной полноразмерной цепи. Ключ "К" замкнут; $\underline{Z}_n = 0$; $\underline{Y}_n = \infty$.

$$\underline{U}_n = \frac{\underline{U}_a \cdot \underline{Y}_a + \underline{U}_b \cdot \underline{Y}_b + \underline{U}_c \cdot \underline{Y}_c}{\underline{Y}_a + \underline{Y}_b + \underline{Y}_c + \underline{Y}_n} = \frac{1}{\infty} = 0 \text{ В}$$

$$\underline{U}_a = \underline{U}_1 - \underline{U}_n = 127 \text{ В}$$

$$\underline{U}_b = \underline{U}_2 - \underline{U}_n = 127 e^{-j120} = (-63,5 - j110) \text{ В}$$

$$\underline{U}_c = \underline{U}_3 - \underline{U}_n = 127 e^{j120} = (-63,5 + j110) \text{ В}$$

$$\underline{U}_{ab} = \underline{U}_a - \underline{U}_b = 127 + 63,5 + j110 = 190,5 + j110 = 220 e^{j30} \text{ В}$$

$$\underline{U}_{bc} = \underline{U}_b - \underline{U}_c = -j220 = 220 e^{-j90} \text{ В}$$

$$\underline{U}_{ca} = \underline{U}_c - \underline{U}_a = -190,5 + j110 = 220 e^{j150} \text{ В}$$

Разные фазы:

$$\underline{I}_a = \frac{\underline{U}_a}{\underline{Z}_a} = \frac{127}{150,922 e^{j69,42}} = 0,8415 e^{-j69,42} = (0,415 - j0,732) \text{ А}$$

$$\underline{I}_b = \frac{\underline{U}_b}{\underline{Z}_b} = \frac{127 e^{-j120}}{150} = 0,84667 e^{-j120} = (-0,423 - j0,733) \text{ А}$$

$$\underline{I}_c = \frac{\underline{U}_c}{\underline{Z}_c} = \frac{127 e^{j120}}{72,92 e^{j166,711}} = 1,74163 e^{j166,711} = (-1,695 + j0,4) \text{ А}$$

$$\underline{I}_n = \underline{I}_a + \underline{I}_b + \underline{I}_c = 0,415 - j0,732 - 0,423 - j0,733 - 1,695 + j0,4 = -1,703 - j1,065 = 2 e^{-j149}$$

Решим "Б": Несимметричной цепи. Ключ "К" разомкнут

$\underline{Z}_n = \infty$; $\underline{Y}_n = 0$

$$\begin{aligned} \underline{U}_n &= \frac{\underline{U}_a \cdot \underline{Y}_a + \underline{U}_b \cdot \underline{Y}_b + \underline{U}_c \cdot \underline{Y}_c}{\underline{Y}_a + \underline{Y}_b + \underline{Y}_c + \underline{Y}_n} = \frac{127 \cdot 0,006626 e^{-j69,42} + 127 e^{-j120} \cdot 0,006667 + 127 e^{j120} \cdot 0,01371 e^{-j166,711}}{0,003 - j0,006 + 0,006667 + 0,009 + j0,01} \\ &= \frac{0,8415 e^{-j69,42} + 0,8467 e^{-j120} + 1,7417 e^{j166,711}}{0,0187 + j0,004} = \frac{0,415 - j0,732 - 0,423 - j0,733 - 1,695 + j0,4}{0,0187 + j0,004} = \\ &= \frac{-1,703 - j1,065}{0,0187 + j0,004} = \frac{2 e^{-j149}}{0,019 e^{j12}} = 105,263 e^{-j160} = (-99 - j36) \text{ В} \end{aligned}$$

$$\begin{aligned} \underline{U}_a &= \underline{U}_1 - \underline{U}_n = 127 + 99 + j36 = 226 + j36 = 228,849 e^{j9} \text{ В} \\ \underline{U}_b &= \underline{U}_2 - \underline{U}_n = -63,5 - j110 + 99 + j36 = 35,5 - j74 = 82,075 e^{-j64,372} \text{ В} \\ \underline{U}_c &= \underline{U}_3 - \underline{U}_n = -63,5 + j110 + 99 + j36 = 35,5 + j146 = 150,254 e^{j76,334} \text{ В} \end{aligned}$$

$$\underline{U}_{ab} = \underline{U}_a - \underline{U}_b = 226 + j36 - 35,5 + j74 = 190,5 + j110 = 220 e^{j30} \text{ В}$$

$$\underline{U}_{bc} = \underline{U}_b - \underline{U}_c = 35,5 - j74 - 35,5 - j146 = -j220 = 220 e^{-j90} \text{ В}$$

$$\underline{U}_{ca} = \underline{U}_c - \underline{U}_a = 35,5 + j146 - 226 - j36 = -190,5 + j110 = 220 e^{j150} \text{ В}$$

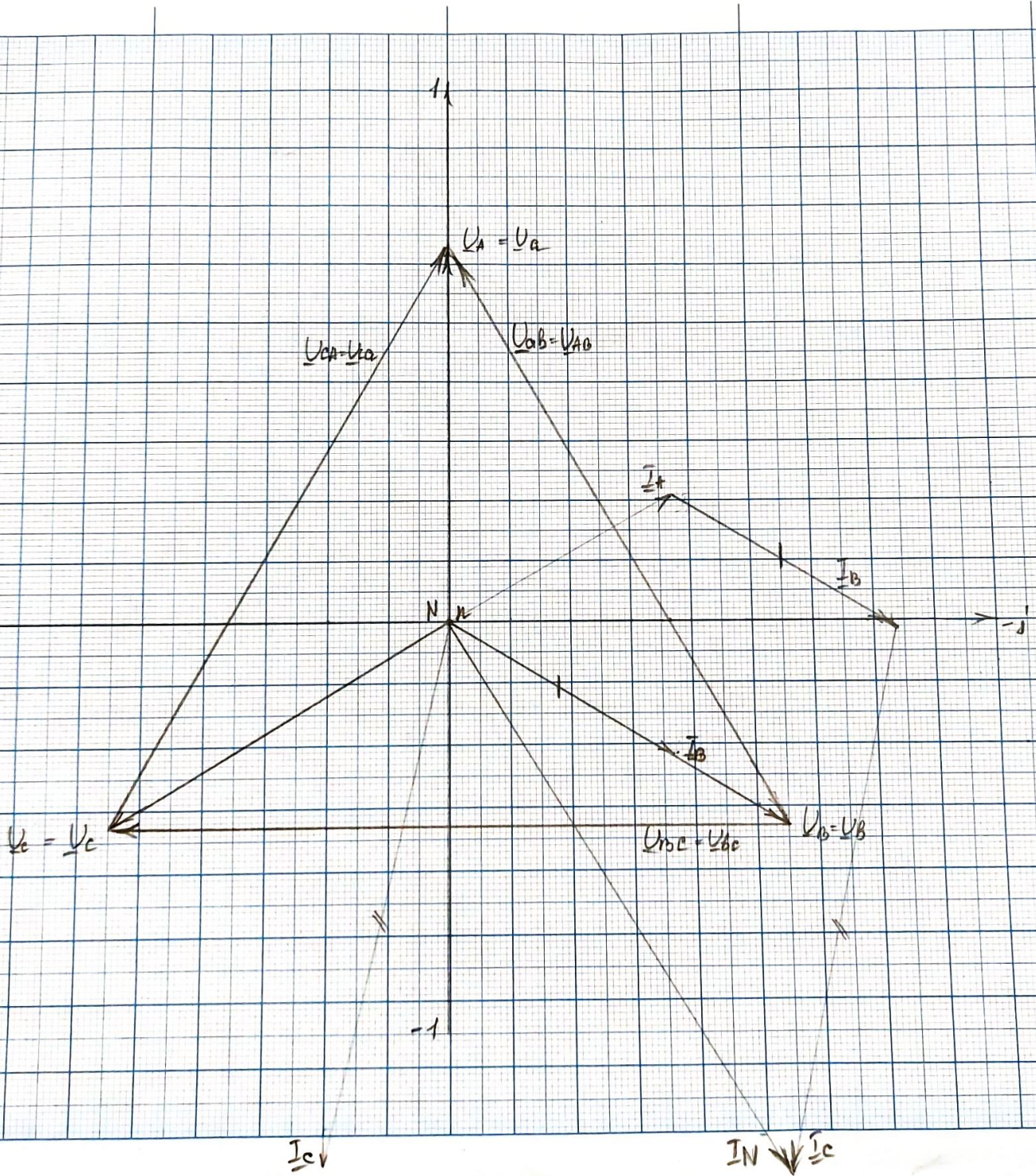
$$\underline{I}_a = \frac{\underline{U}_a}{\underline{Z}_a} = \frac{228,849 e^{j9}}{150,922 e^{j69,42}} = 1,51634 e^{-j59,42} = (0,946 - j1,185) \text{ А}$$

$$\underline{I}_b = \frac{\underline{U}_b}{\underline{Z}_b} = \frac{82,075 e^{-j64,372}}{150} = 0,5472 e^{-j64,372} = (0,237 - j0,493) \text{ А}$$

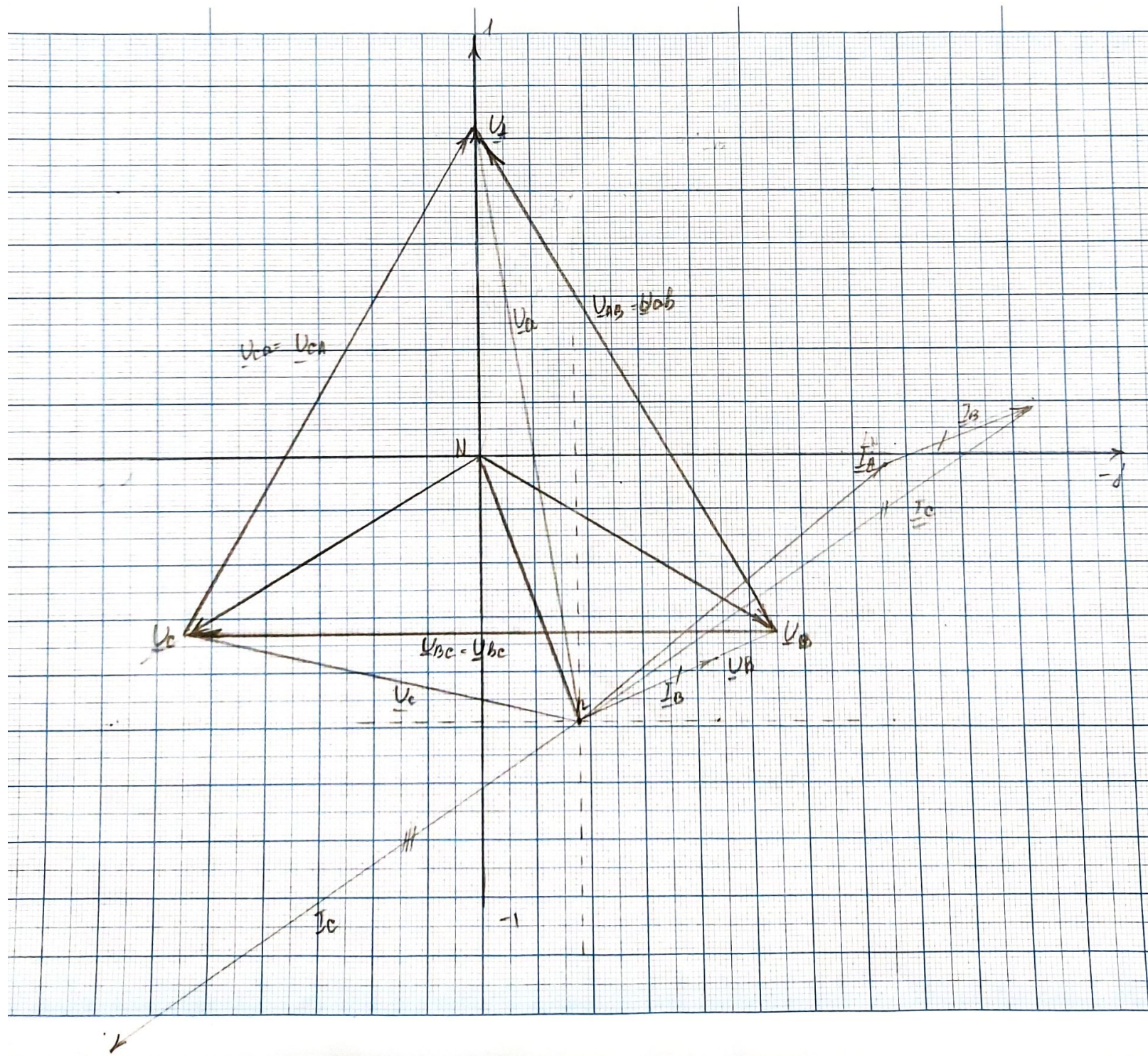
$$\underline{I}_c = \frac{\underline{U}_c}{\underline{Z}_c} = \frac{150,254 e^{j76,334}}{72,92 e^{j166,711}} = 2,061 e^{j123,045} = (1,124 + j1,728) \text{ А}$$

$$\underline{I}_n = \underline{I}_a + \underline{I}_b + \underline{I}_c = 0,946 - j1,185 + 0,237 - j0,493 - 1,124 + j1,728 \approx 0 \text{ А}$$

U 1:2
I 20:1



1.2
20.1



Результат В.
 Разрывная точка "с".
 $\underline{Z}_N = 0$; $\underline{Y}_N = \infty$
 $\underline{Z}_C = \infty$; $\underline{Y}_C = 0$.

$$\underline{U}_N = 0 \quad B$$

$$\underline{U}_A = \underline{U}_B = 127 \quad B$$

$$\underline{U}_B = \underline{U}_B = 127 e^{-j120} = (-63,5 - j110) B$$

$$\underline{U}_C = \underline{U}_C = 127 e^{j120} = (-63,5 + j110) B.$$

$$\underline{U}_{AB} = \underline{U}_A - \underline{U}_B = 127 + 63,5 + j110 = (190,5 + j110) = 220 e^{j30} B$$

$$\underline{U}_{BC} = \underline{U}_B - \underline{U}_C = -63,5 - j110 + 63,5 - j110 = -j220 = 220 e^{-j90} B$$

$$\underline{U}_{CA} = \underline{U}_C - \underline{U}_A = -63,5 + j110 - 127 = -190,5 + j110 = 220 e^{j150} B$$

$$\underline{I}_A = \underline{U}_A \cdot \underline{Y}_A = 127 \cdot 0,006626 e^{-j60,42} = 0,8415 e^{-j60,42} = (0,415 - j0,732) A$$

$$\underline{I}_B = \underline{U}_B \cdot \underline{Y}_B = 127 e^{-j120} \cdot 0,006667 = 0,846667 e^{-j120} = (-0,423 - j0,733) A$$

$$\underline{I}_C = \underline{U}_C \cdot \underline{Y}_C = 0 \quad A.$$

$$\underline{I}_N = \underline{I}_A + \underline{I}_B + \underline{I}_C = 0,415 - j0,732 - 0,423 - j0,733 + 0 = (-0,008 - j1,465) = 1,465 e^{-j90,3}$$

Результат Г.
 Разрывная точка "с".
 $\underline{Z}_N = \infty$; $\underline{Y}_N = 0$
 $\underline{Z}_C = \infty$; $\underline{Y}_C = 0$

$$\underline{U}_N = \frac{\underline{U}_A \cdot \underline{Y}_A + \underline{U}_B \cdot \underline{Y}_B}{\underline{Y}_A + \underline{Y}_B} =$$

$$= \frac{127 \cdot 0,006626 e^{-j60,42} + 127 e^{-j120} \cdot 0,006667}{0,003 - j0,006 + 0,006667} = \frac{0,8415 e^{-j60,42} + 0,8467 e^{-j120}}{0,009667 - j0,006} =$$

$$= \frac{0,415 - j0,732 - 0,423 - j0,733}{0,009667 - j0,006} = \frac{-0,008 - j1,465}{0,009667 - j0,006} = \frac{1,465 e^{-j90,313}}{0,011 e^{-j37,227}} = 133,18 e^{-j53,486} = (69,614 - j113,538) B.$$

$$\underline{U}_A = \underline{U}_A - \underline{U}_N = 127 - 69,614 + j113,538 = 57,386 + j113,538 = 124,216 e^{j63,186} B$$

$$\underline{U}_B = \underline{U}_B - \underline{U}_N = -63,5 - j110 - 69,614 + j113,538 = -133,114 + j3,538 = 133,161 e^{j178,478} B$$

$$\underline{U}_C = \underline{U}_C - \underline{U}_N = -63,5 + j110 - 69,614 + j113,538 = -133,114 + j223,538 = 260,17 e^{j120,773} B$$

$$\underline{U}_{AB} = \underline{U}_A - \underline{U}_B = 57,386 + j113,538 + 133,114 - j3,538 = 190,5 + j110 = 220 e^{j30} B$$

$$\underline{U}_{BC} = \underline{U}_B - \underline{U}_C = -133,114 + j3,538 + 133,114 - j223,538 = -j220 = 220 e^{-j90} B$$

$$\underline{U}_{CA} = \underline{U}_C - \underline{U}_A = -133,114 + j223,538 - 57,386 - j113,538 = -190,5 + j110 = 220 e^{j150} B$$

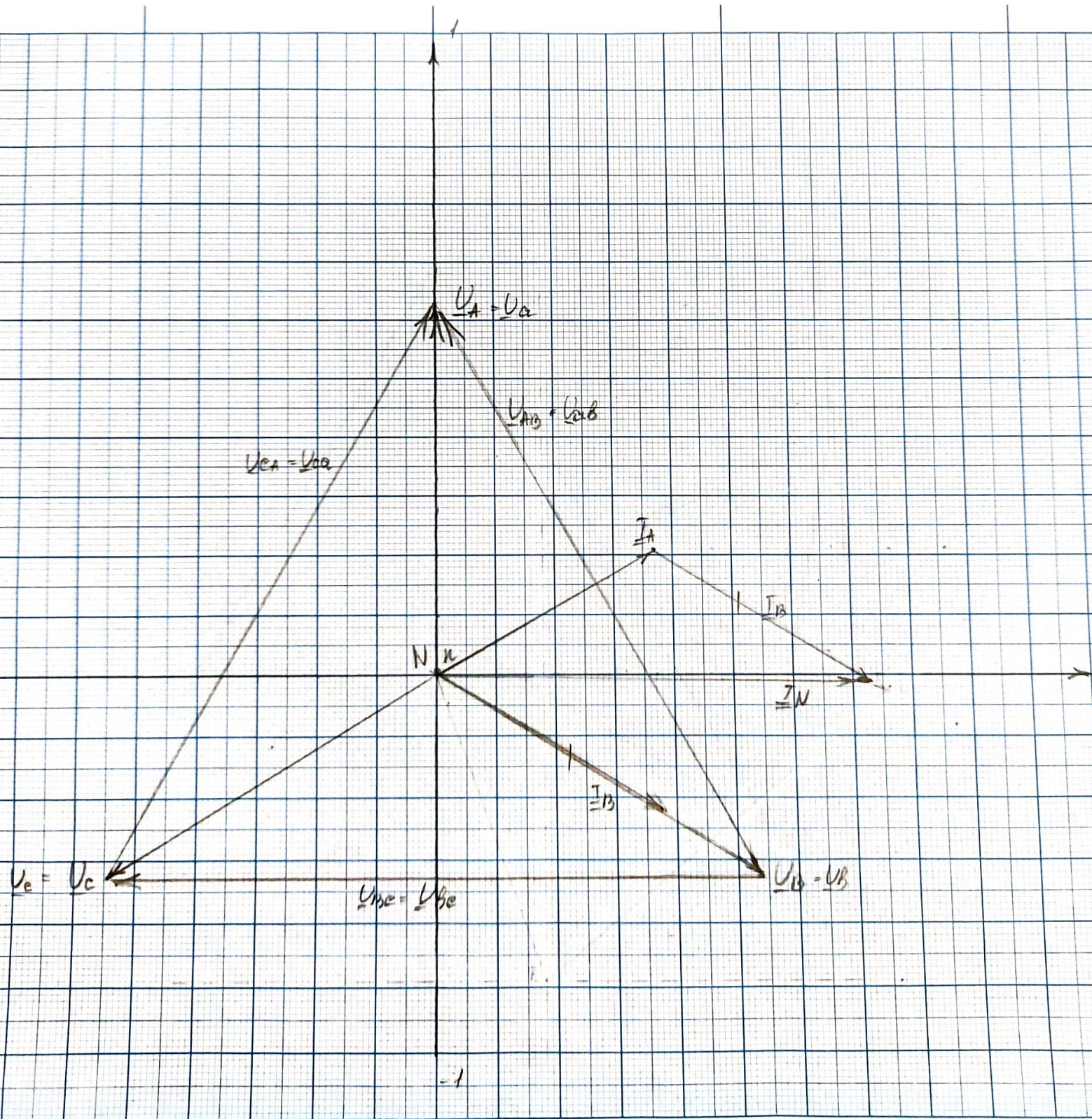
$$\underline{I}_A = \underline{U}_A \cdot \underline{Y}_A = 124,216 e^{j63,186} \cdot 0,006626 e^{-j60,42} = 0,8429 e^{j2,77} = (0,842 + j0,041) A$$

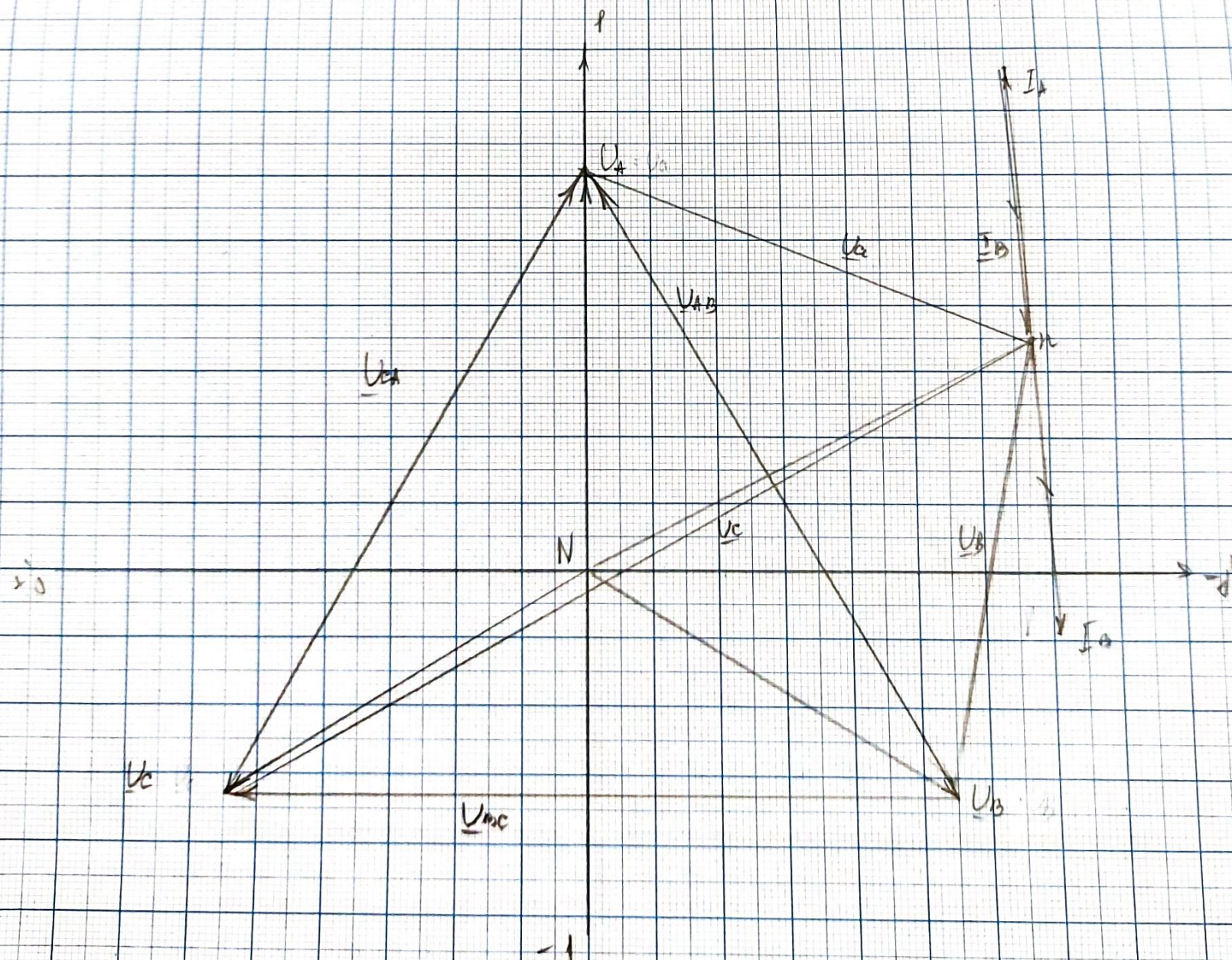
$$\underline{I}_B = \underline{U}_B \cdot \underline{Y}_B = 133,161 e^{j178,478} \cdot 0,006667 = 0,8878 e^{j178,478} = (-0,887 + j0,024) A$$

$$\underline{I}_C = \underline{U}_C \cdot \underline{Y}_C = 0$$

$$\underline{I}_N = \underline{I}_A + \underline{I}_B + \underline{I}_C = 0,842 + j0,041 - 0,887 + j0,024 \approx 0 \quad A$$

1.2
20.1





Решим D.

Короткое замыкание фазы "с"; кинетический.

$$\underline{Z}_N = \infty, \quad \underline{Y}_N = 0$$

$$\underline{Z}_c = 0, \quad \underline{Y}_c = \infty$$

$$\underline{U}_N = \underline{U}_c = 127 e^{j120} = (-63,5 + j110) \text{ В}$$

$$\underline{U}_a = \underline{U}_A - \underline{U}_N = 127 + 63,5 - j110 = 190,5 - j110 = 220 e^{-j30} \text{ В}$$

$$\underline{U}_B = \underline{U}_B - \underline{U}_N = -63,5 - j110 + 63,5 - j110 = -j220 = 220 e^{-j90} \text{ В}$$

$$\underline{U}_c = \underline{U}_c - \underline{U}_N = 0$$

$$\underline{U}_{ab} = \underline{U}_a - \underline{U}_B = 190,5 - j110 + j220 = 190,5 + j110 = 220 e^{j30} \text{ В}$$

$$\underline{U}_{bc} = \underline{U}_B - \underline{U}_c = 220 e^{-j90} = (-j220) \text{ В}$$

$$\underline{U}_{ca} = \underline{U}_c - \underline{U}_a = -190,5 + j110 = 220 e^{j150} \text{ В}$$

$$\underline{I}_A = \underline{U}_a \cdot \underline{Y}_a = 220 e^{-j30} \cdot 0,006626 e^{-j60,42} = 1,456 e^{-j90,42} = (-0,011 - j1,456) \text{ А}$$

$$\underline{I}_B = \underline{U}_B \cdot \underline{Y}_B = 220 e^{-j90} \cdot 0,006667 = 1,4667 e^{-j90} = -j1,467 \text{ А}$$

$$\underline{I}_c = -(\underline{I}_A + \underline{I}_B) = -\underline{I}_A - \underline{I}_B = 0,011 + j1,456 + j1,467 = 0,011 + j2,923 = 2,923 e^{j90} \text{ А}$$

Симметричный прием.

$$\underline{Z}_A = 100 \text{ Ом}$$

$$\underline{Z}_a = \underline{Z}_c = \underline{Z}_B = 100 \text{ Ом}$$

$$\underline{U}_N = 0 \text{ В}$$

$$\underline{U}_a = \underline{U}_A = 127 \text{ В}$$

$$\underline{U}_B = \underline{U}_B = 127 e^{-j120} = (-63,5 - j110) \text{ В}$$

$$\underline{U}_c = \underline{U}_c = 127 e^{j120} = (-63,5 + j110) \text{ В}$$

$$\underline{U}_{ab} = \underline{U}_{AB} = 220 e^{j30} = (190,5 + j110) \text{ В}$$

$$\underline{U}_{bc} = \underline{U}_{BC} = 220 e^{-j90} = (-j220) \text{ В}$$

$$\underline{U}_{ca} = \underline{U}_{CA} = 220 e^{j150} = (-190,5 + j110) \text{ В}$$

$$\underline{I}_A = \frac{\underline{U}_A}{\underline{Z}_a} = \frac{127}{100} = 1,27 \text{ А}$$

$$\underline{I}_B = \frac{\underline{U}_B}{\underline{Z}_B} = \frac{127 e^{-j120}}{100} = 1,27 e^{-j120} = (-0,635 - j1,1) \text{ А}$$

$$\underline{I}_c = \frac{\underline{U}_c}{\underline{Z}_c} = \frac{127 e^{j120}}{100} = 1,27 e^{j120} = (-0,635 + j1,1) \text{ А}$$

$$\underline{I}_N = \underline{I}_A + \underline{I}_B + \underline{I}_c = 1,27 - 0,635 + j1,1 - 0,635 + j1,1 = 0 \text{ А}$$

