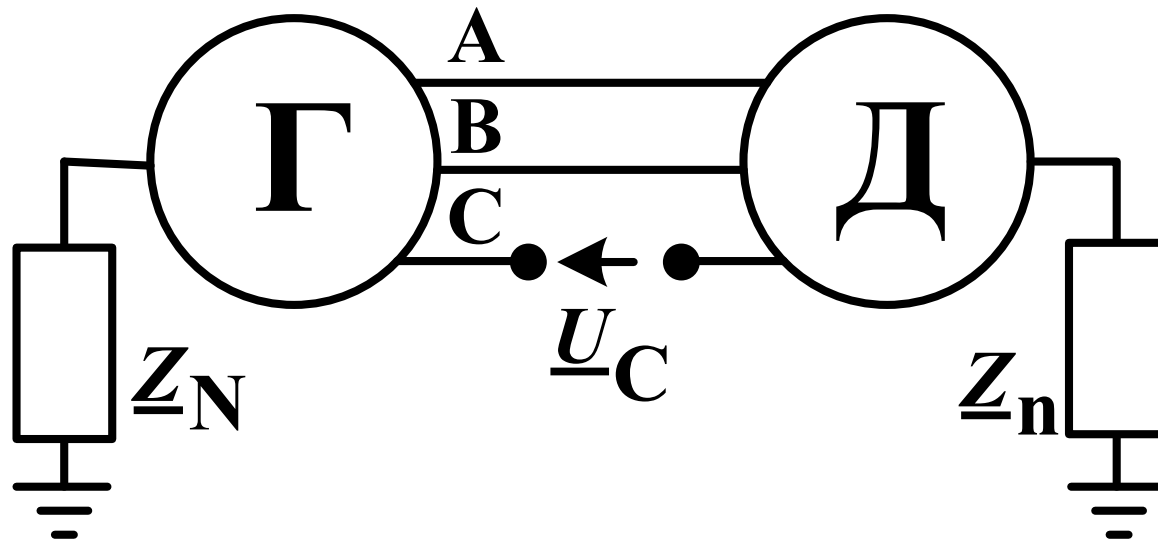
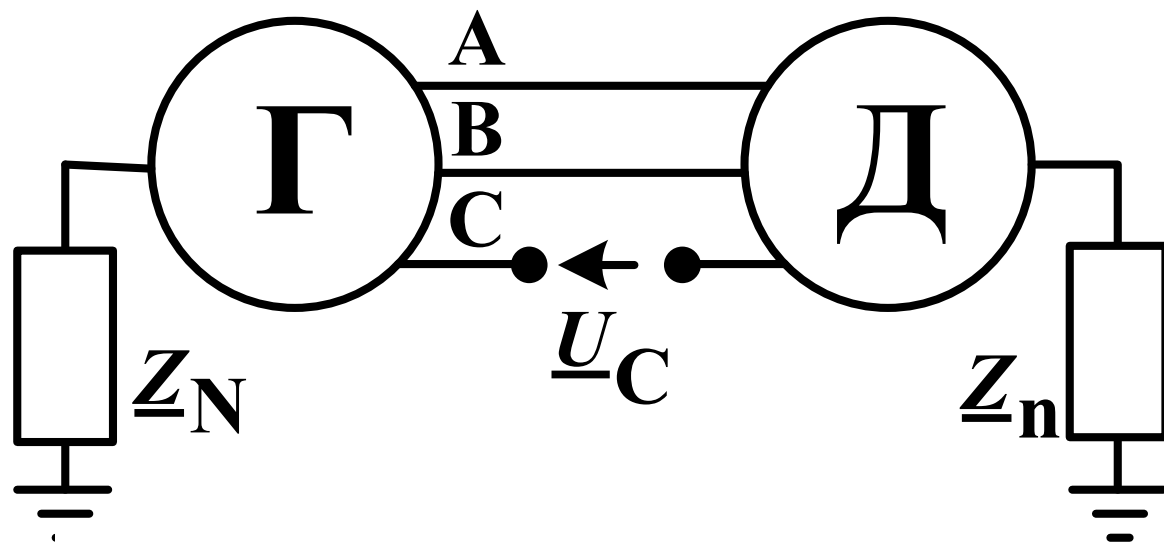


# Продольная несимметрия





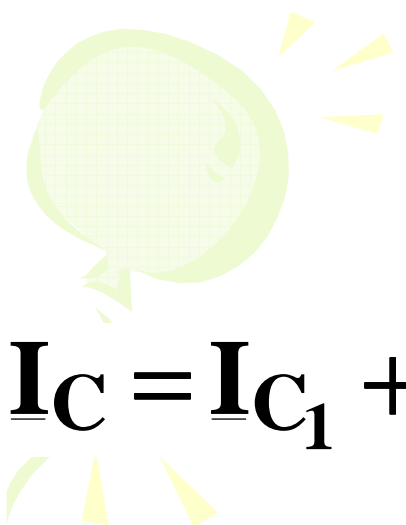
Условие:

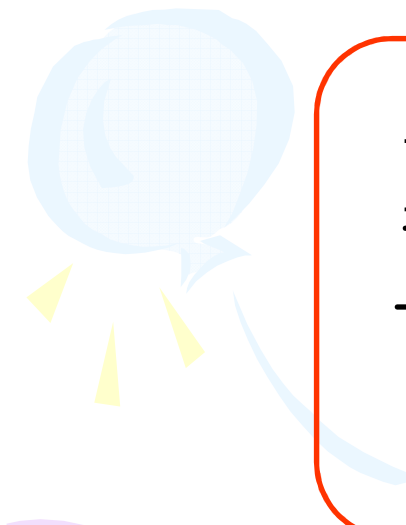
$$\underline{U}_A = 0; \quad \underline{U}_B = 0; \quad \underline{I}_C = 0$$

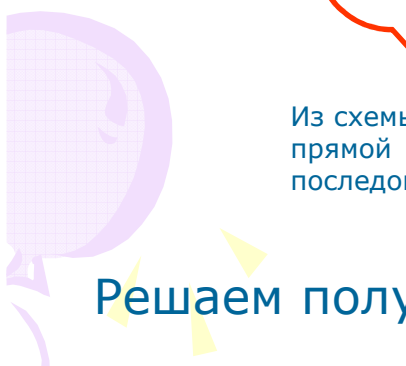
$$\underline{U}_{C1} = \frac{\cancel{a\underline{U}_A^0} + \cancel{a^2\underline{U}_B^0} + \underline{U}_C}{3} = \frac{\underline{U}_C}{3} = \underline{U}_{C2} = \underline{U}_{C0}$$

$$\underline{U}_{C2} = \frac{\cancel{a^2\underline{U}_A^0} + \cancel{a\underline{U}_B^0} + \underline{U}_C}{3} = \frac{\underline{U}_C}{3}$$

$$\underline{U}_{C0} = \frac{\cancel{\underline{U}_A^0} + \cancel{\underline{U}_B^0} + \underline{U}_C}{3} = \frac{\underline{U}_C}{3}$$


$$\underline{I}_C = \underline{I}_{C_1} + \underline{I}_{C_2} + \underline{I}_{C_0} = \frac{\underline{E}_C - \underline{U}_C}{\underline{Z}_1} - \frac{\underline{U}_C}{\underline{Z}_2} - \frac{\underline{U}_C}{\underline{Z}_0} = 0$$


$$\frac{\underline{E}_C - \frac{\underline{U}_C}{3}}{\underline{Z}_1} - \frac{\frac{\underline{U}_C}{3}}{\underline{Z}_2} - \frac{\frac{\underline{U}_C}{3}}{\underline{Z}_0} = 0$$



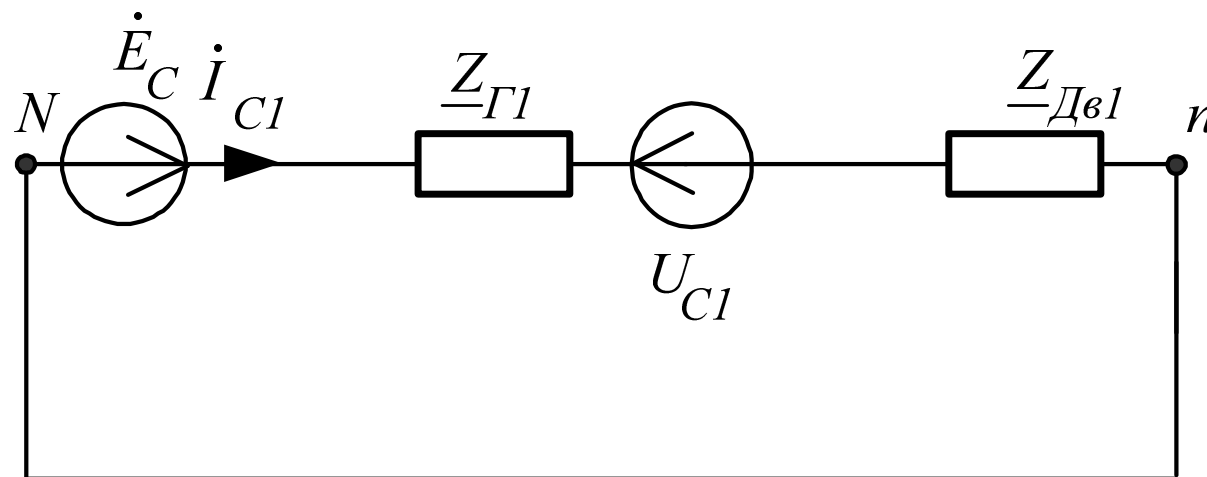
Из схемы  
прямой  
последовательности

Из схемы  
обратной  
последовательности

Из схемы  
нулевой  
последовательности

Решаем полученное уравнение относительно одной неизвестной **U<sub>C</sub>**

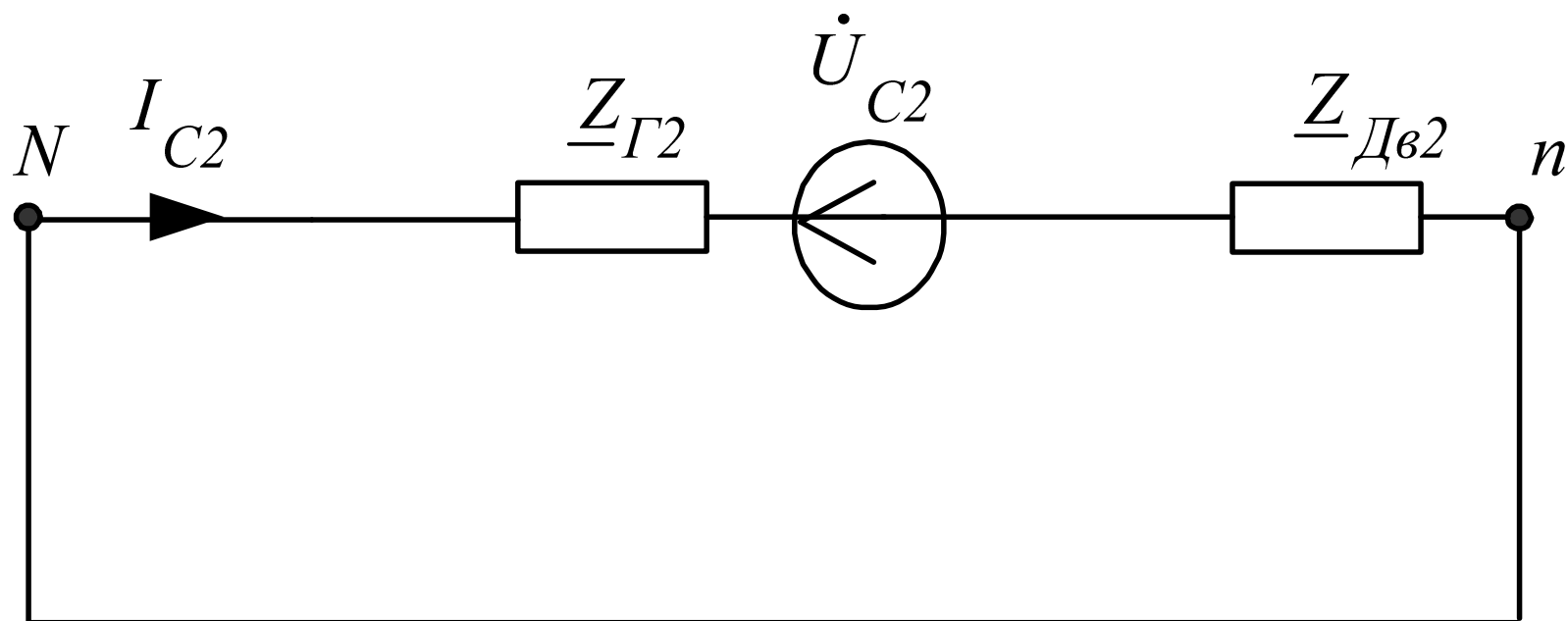
# Схема прямой последовательности



$$\dot{i}_{C1} = \frac{\dot{E}_C - \dot{U}_{C1}}{\underline{Z}_1};$$

$$\underline{Z}_1 = \underline{Z}_{\Gamma 1} + \underline{Z}_{Дв1}$$

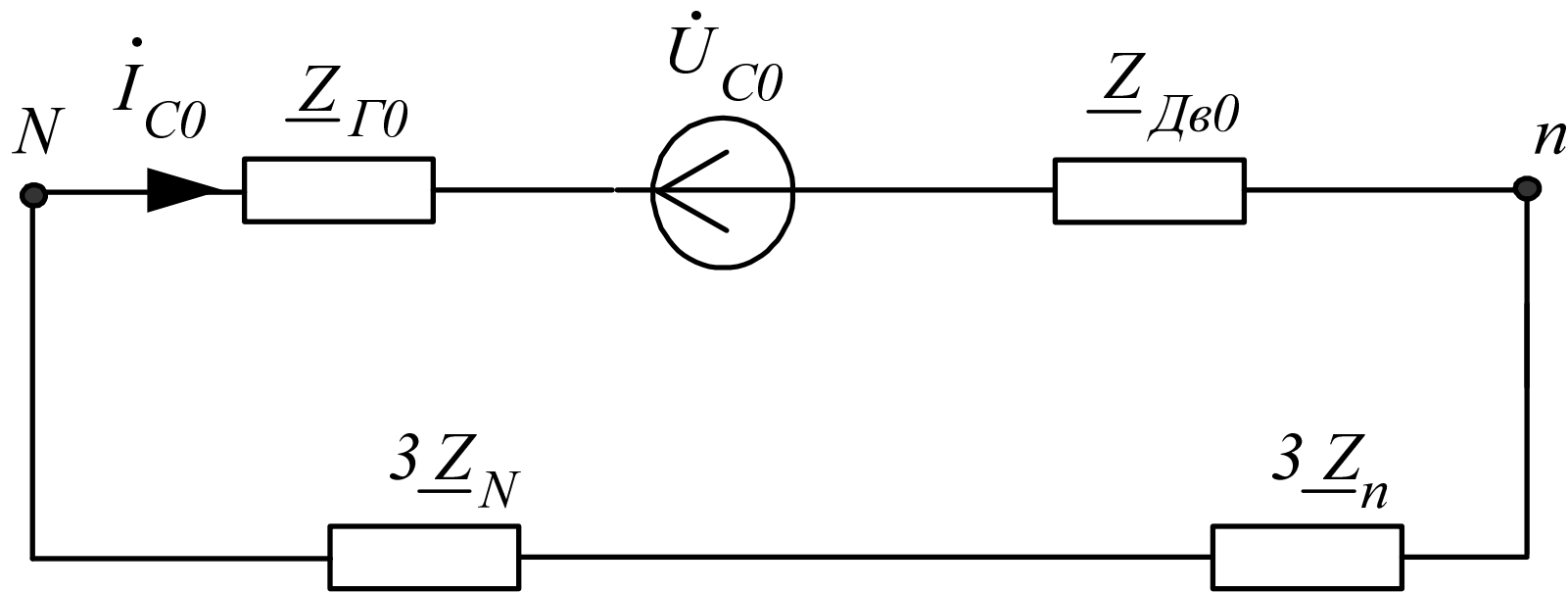
# Схема обратной последовательности



$$\dot{i}_{c2} = \frac{-\dot{U}_{c2}}{\underline{Z}_2};$$

$$\underline{Z}_2 = \underline{Z}_{Г2} + \underline{Z}_{Дв2}$$

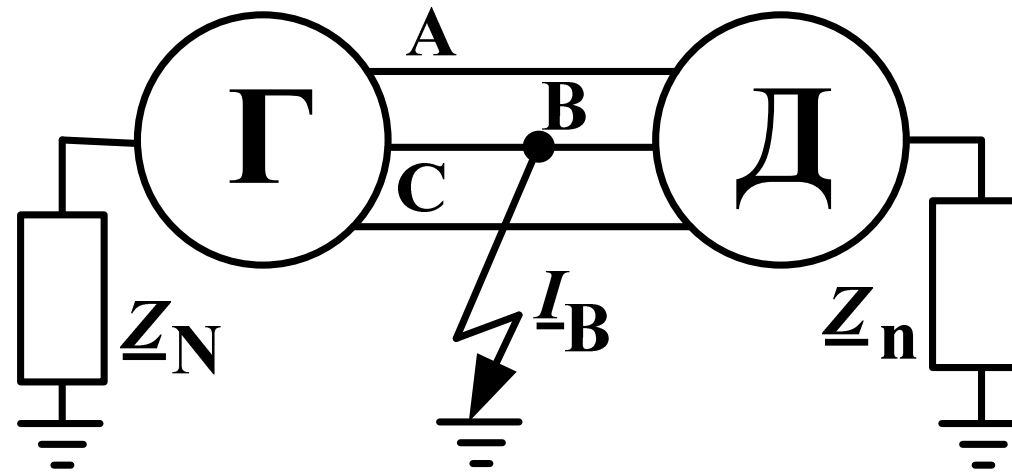
# Схема нулевой последовательности



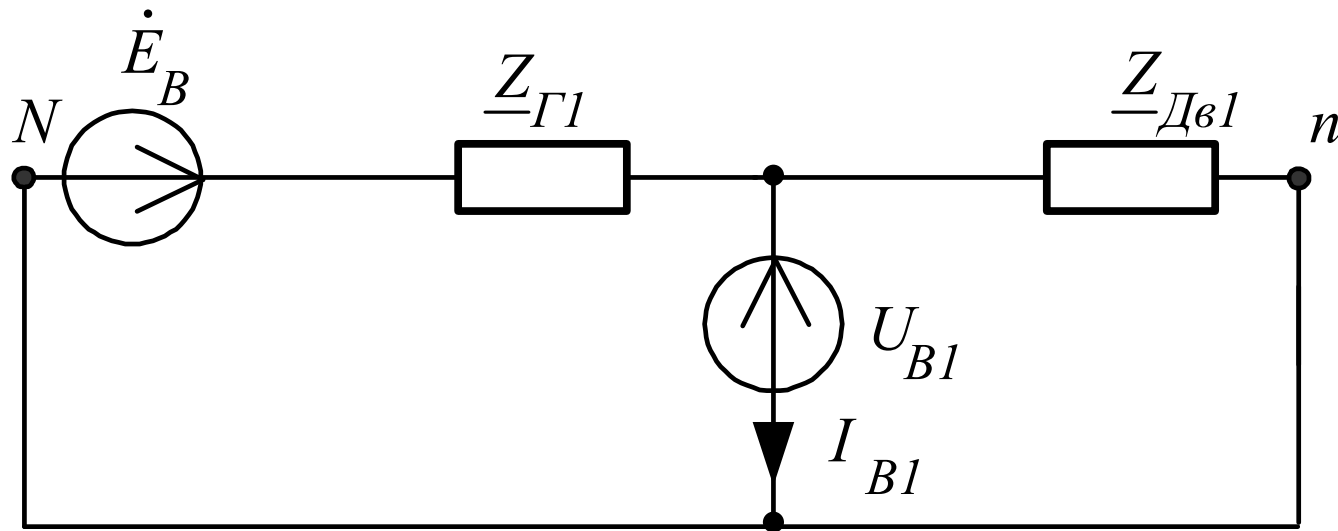
$$\dot{i}_{c0} = \frac{-\dot{U}_{c0}}{\underline{Z}_0};$$

$$\underline{Z}_0 = \underline{Z}_{\Gamma 0} + \underline{Z}_{Дв0} + 3\underline{Z}_N + 3\underline{Z}_n$$

# Поперечная несимметрия

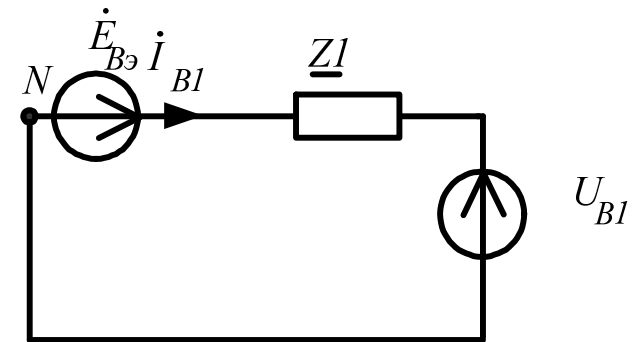


# Схема прямой последовательности



$$\dot{E}_{BЭ} = \frac{\dot{E}_B}{\underline{Z}_{\Gamma 1}} \underline{Z}_1;$$

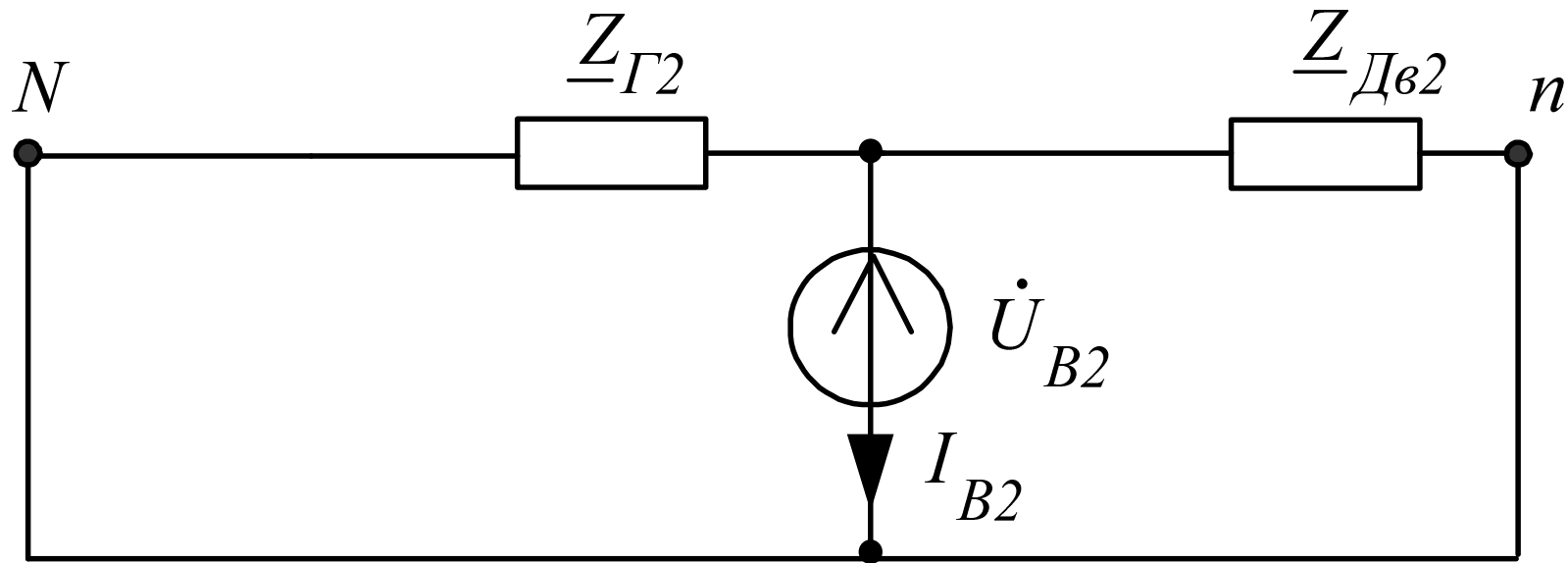
$$\underline{Z}_1 = \frac{\underline{Z}_{\Gamma 1} \cdot \underline{Z}_{Дв1}}{\underline{Z}_{\Gamma 1} + \underline{Z}_{Дв1}}$$



$$\dot{U}_{B1} = \dot{E}_{CЭ} - \dot{I}_{B1} \underline{Z}_1;$$

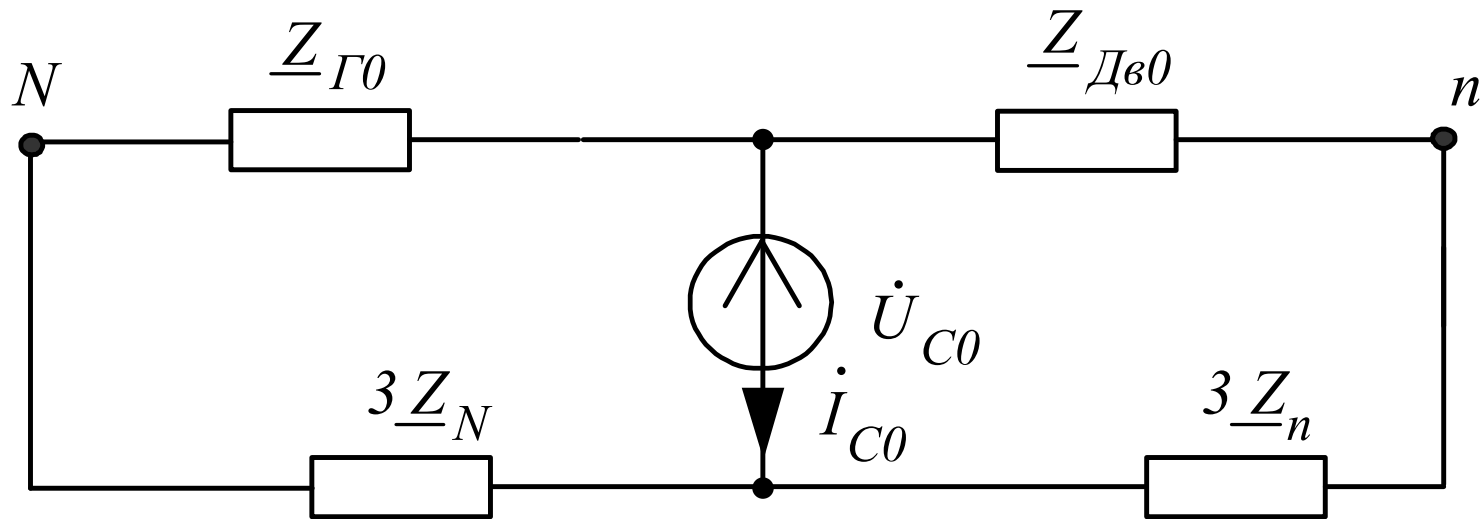


# Схема обратной последовательности



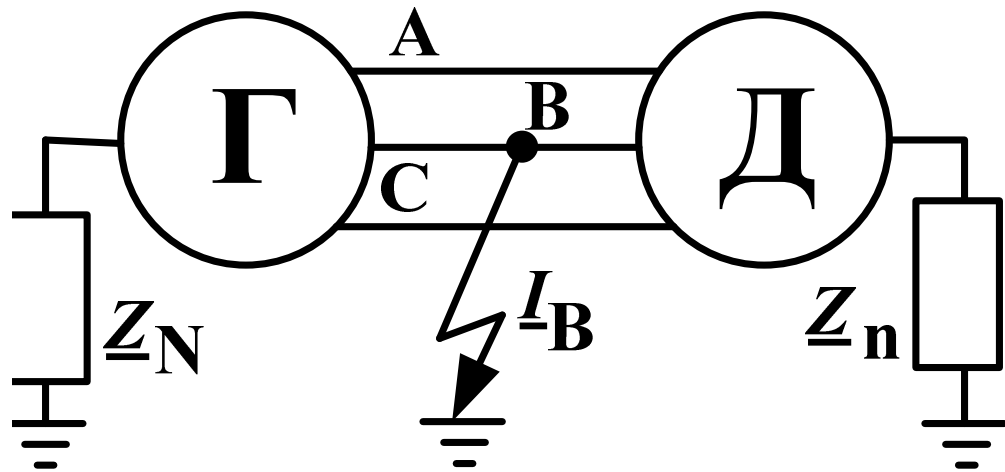
$$\dot{U}_{B2} = -\dot{I}_{B2} \underline{Z}_2; \quad \underline{Z}_2 = \frac{\underline{Z}_{Г2} \cdot \underline{Z}_{Дв2}}{\underline{Z}_{Г2} + \underline{Z}_{Дв2}}$$

# Схема нулевой последовательности



$$\dot{U}_{B0} = -\dot{I}_{B0} \underline{Z}_0;$$

$$\underline{Z}_0 = \frac{(\underline{Z}_{\Gamma 0} + 3\underline{Z}_N)(\underline{Z}_{Дв0} + 3\underline{Z}_n)}{\underline{Z}_{\Gamma 0} + \underline{Z}_{Дв0} + 3\underline{Z}_N + 3\underline{Z}_n}$$

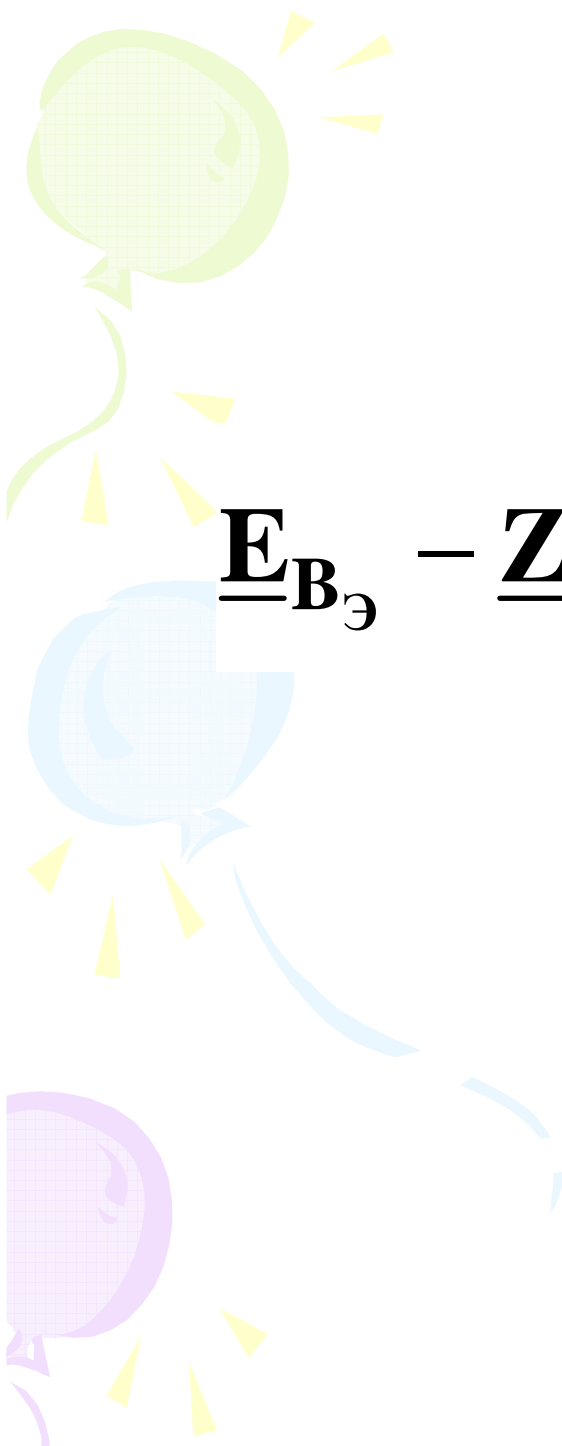


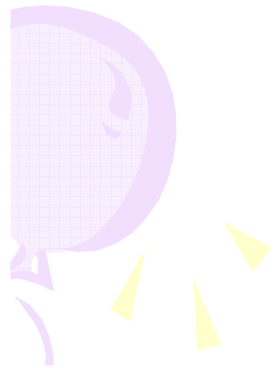
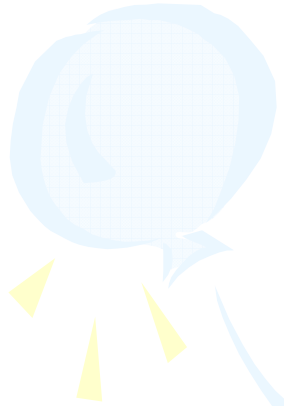
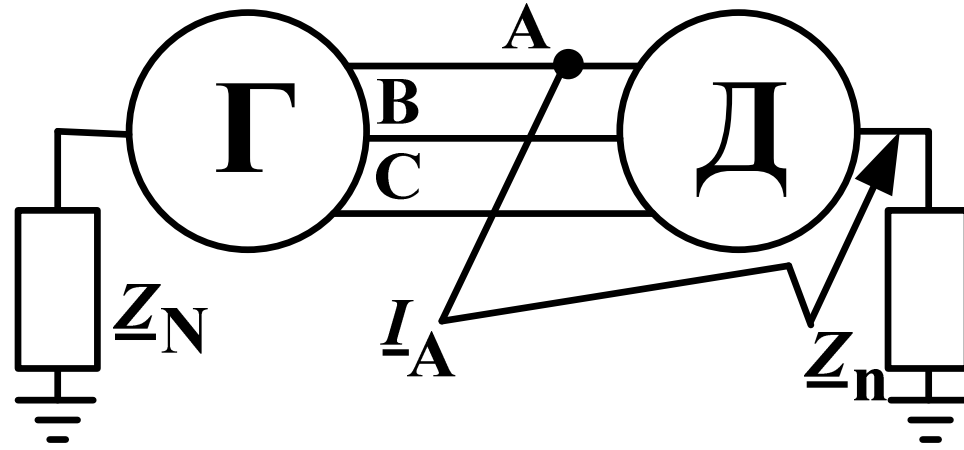
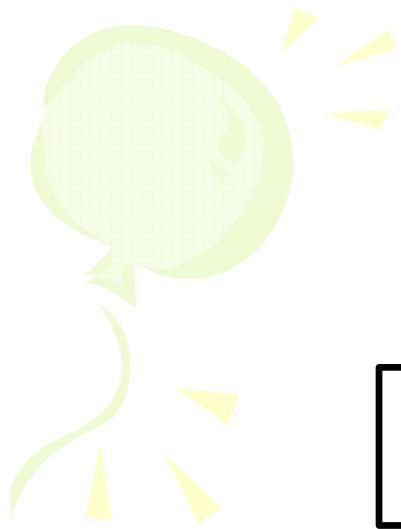
Условие:

$$\underline{I}_A = 0; \quad \underline{I}_C = 0; \quad \underline{U}_B = 0$$

$$\underline{I}_{B1} = \frac{\cancel{a^2 \underline{I}_A^0} + \underline{I}_B + \cancel{a \underline{I}_C^0}}{3} = \frac{\underline{I}_B}{3} = \underline{I}_{B2} = \underline{I}_{B0}$$

$$\underline{U}_B = \left( \underline{E}_{B_3} - \underline{Z}_1 \underline{I}_{B1} \right) - \underline{Z}_2 \underline{I}_{B2} - \underline{Z}_0 \underline{I}_{B0} = 0$$

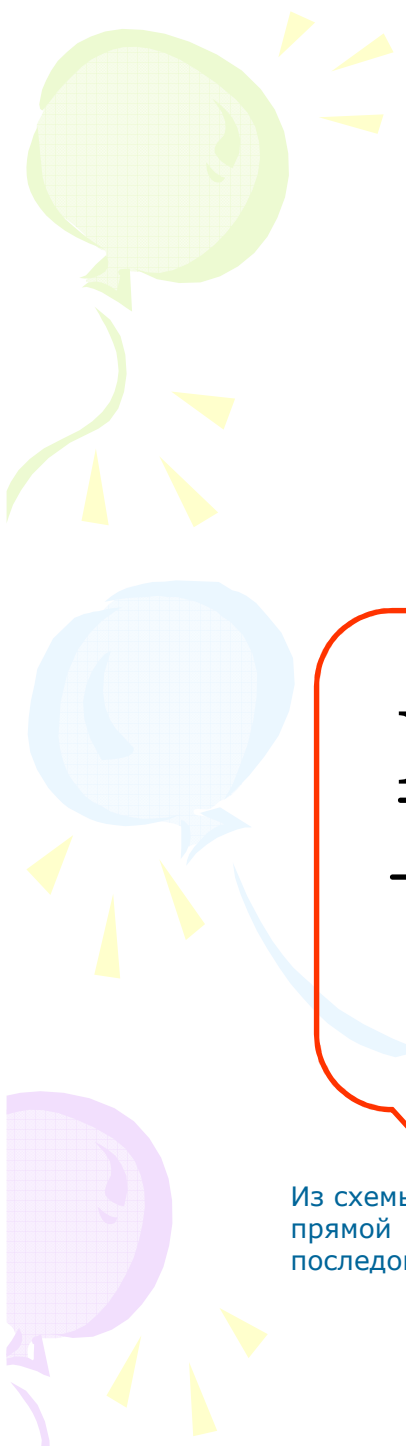

$$\underline{\mathbf{E}}_{\mathbf{B}_3} - \underline{\mathbf{Z}}_1 \frac{\underline{\mathbf{I}}_{\mathbf{B}}}{3} - \underline{\mathbf{Z}}_2 \frac{\underline{\mathbf{I}}_{\mathbf{B}}}{3} - \underline{\mathbf{Z}}_0 \frac{\underline{\mathbf{I}}_{\mathbf{B}}}{3} = \mathbf{0}$$





Так как

$$\begin{aligned} \underline{I}_A &= \underline{I}_{A_1} + \underline{I}_{A_2} + \underline{I}_{A_0} = \\ &= \frac{\underline{E}_{A_3} - \underline{U}_{A1}}{\underline{Z}_1} + \left(-\frac{\underline{U}_{A2}}{\underline{Z}_2}\right) + \left(-\frac{\underline{U}_{A0}}{\underline{Z}_0}\right) = 0 \end{aligned}$$


$$\frac{\underline{E}_A - \frac{\underline{U}_A}{3}}{\underline{Z}_1} - \frac{\underline{U}_A}{3} - \frac{\underline{U}_A}{3} = 0$$

Из схемы  
прямой  
последовательности

Из схемы  
обратной  
последовательности

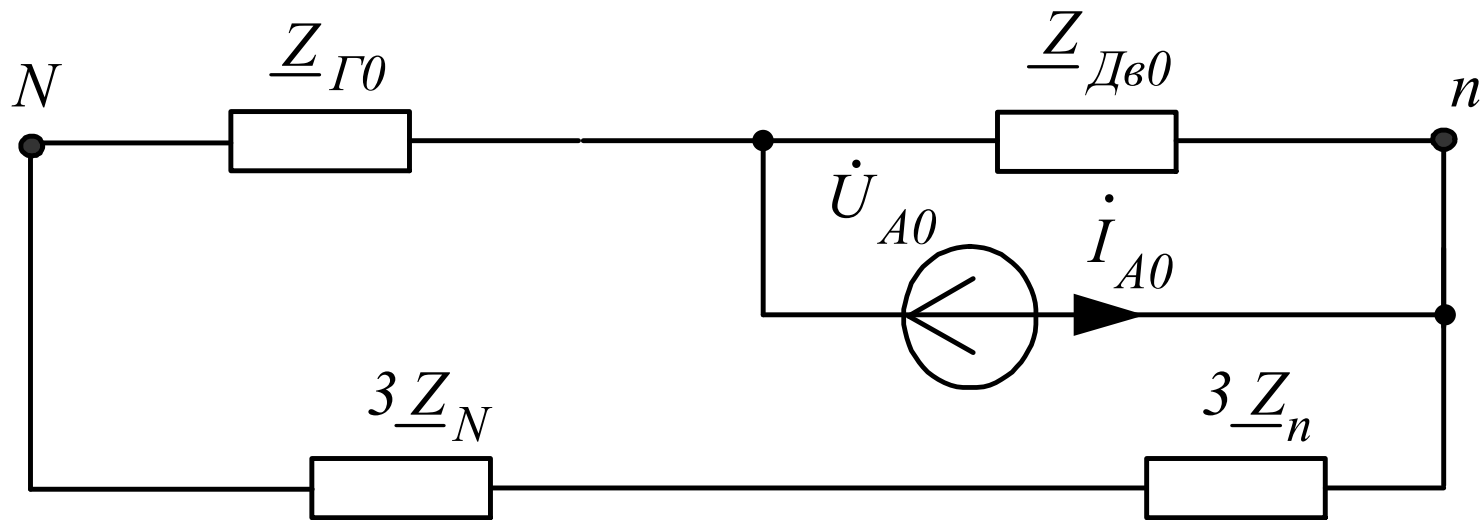
Из схемы  
нулевой  
последовательности



Схема прямой и  
обратной последовательности  
такие же как и при КЗ на землю



# Схема нулевой последовательности



$$\dot{I}_{a0} = \frac{-\dot{U}_{a0}}{\underline{Z}_0};$$

$$\underline{Z}_0 = \frac{(\underline{Z}_{\Gamma 0} + 3\underline{Z}_N + 3\underline{Z}_n) \underline{Z}_{Дв0}}{\underline{Z}_{\Gamma 0} + \underline{Z}_{Дв0} + 3\underline{Z}_N + 3\underline{Z}_n}$$

**Пример:**

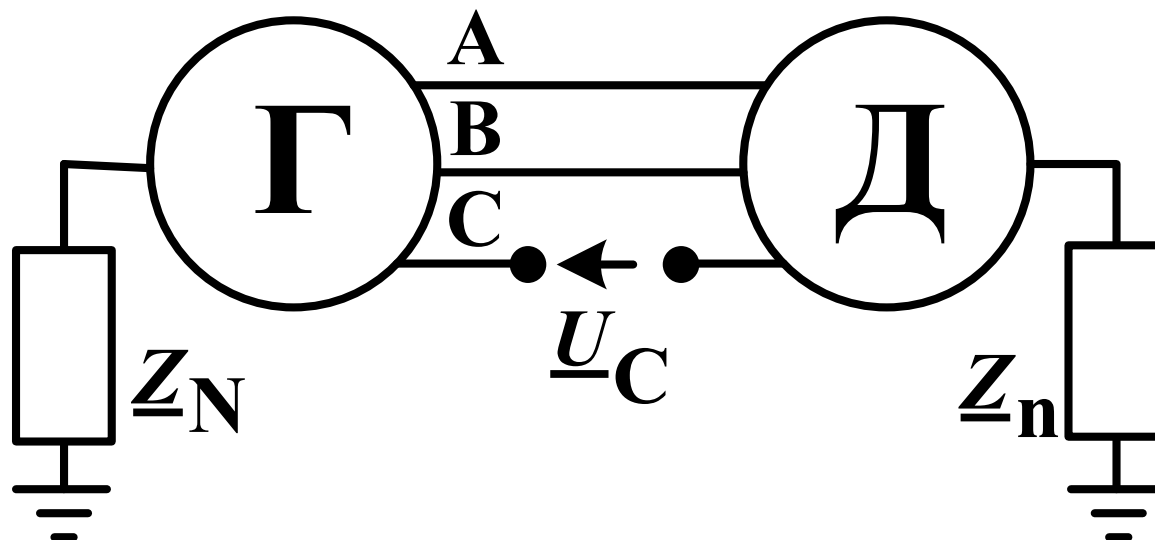
ЭДС генератора симметричны и

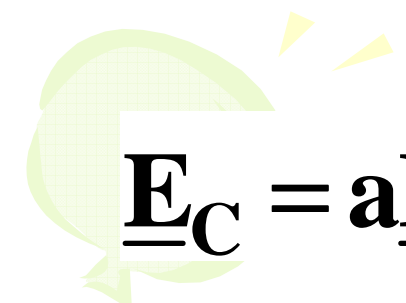
$$\underline{E}_A = 500 \text{ (В)}.$$


Определить в показательной форме напряжение

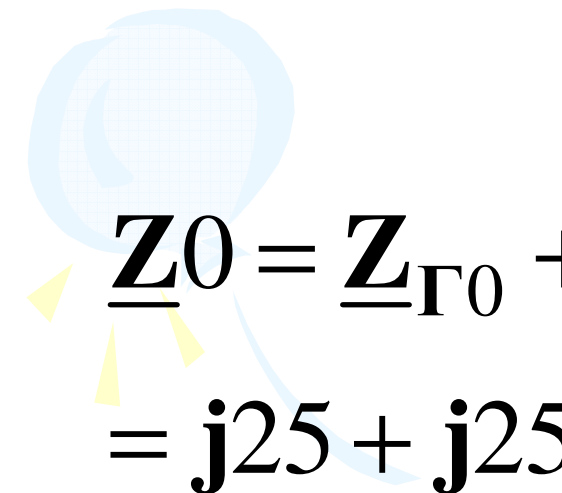
$$\underline{U}_C, \text{ если } \underline{Z}_{\Gamma 1,2,0} = \underline{Z}_{\text{Д} 1,2,0} = j25 \text{ (Ом)},$$

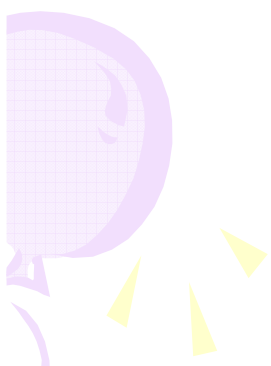
$$\underline{Z}_N = \underline{Z}_n = -j10 \text{ (Ом)}.$$

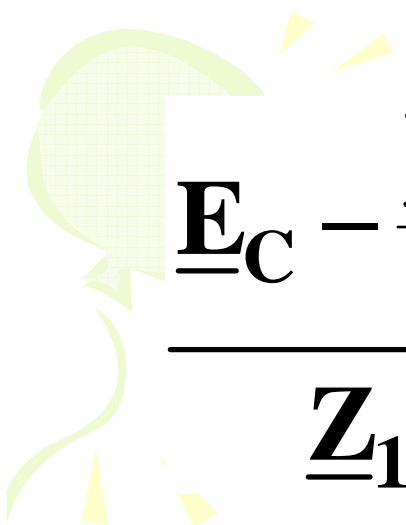


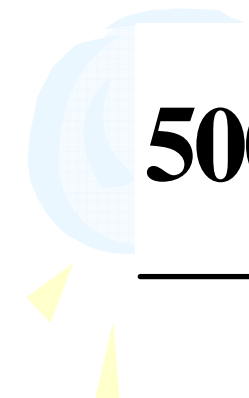

$$\underline{\mathbf{E}}_C = a\underline{\mathbf{E}}_A = 500e^{j120} \text{ В}$$


$$\underline{\mathbf{Z}}_1 = \underline{\mathbf{Z}}_2 = \underline{\mathbf{Z}}_{\Gamma 1} + \underline{\mathbf{Z}}_{\text{ДВ}1} = j50 \text{ Ом}$$


$$\begin{aligned} \underline{\mathbf{Z}}_0 &= \underline{\mathbf{Z}}_{\Gamma 0} + \underline{\mathbf{Z}}_{\text{ДВ}0} + 3(\underline{\mathbf{Z}}_N + \underline{\mathbf{Z}}_n) = \\ &= j25 + j25 + 3(-j10 - j10) = -j10 \text{ Ом} \end{aligned}$$




$$\frac{\underline{E}_C - \frac{\underline{U}_C}{3}}{\underline{Z}_1} - \frac{\underline{U}_C}{3} - \frac{\underline{U}_C}{3} = 0$$


$$\frac{500e^{j120} - \frac{\underline{U}_C}{3}}{j50} - \frac{\underline{U}_C}{j50} - \frac{\underline{U}_C}{-j10} = 0$$


$$\underline{U}_C = 500e^{j60} \text{ B}$$

$$a := e^{120i \cdot \text{deg}}$$

$$E_a := 500 \quad E_b := a^2 \cdot E_a \quad E_c := E_a \cdot a$$

$$Z_g := 25i \quad Z_d := Z_g \quad Z_N := -10i \quad Z_n := Z_N$$

$$E_{\text{D}} := E_b$$

$$Z_1 := Z_g + Z_d \quad Z_2 := Z_1 \quad Z_1 = 50i$$

$$Z_0 := Z_g + 3 \cdot Z_N + Z_d + 3 \cdot Z_n \quad Z_0 = -10i$$

$$U_c := \frac{E_{\text{D}} - \frac{U_c}{3}}{Z_1} - \frac{U_c}{Z_2} - \frac{U_c}{Z_0} \quad \text{solve, } U_c \rightarrow -500 \cdot e^{240i \cdot \text{deg}}$$

$$|U_c| = 500$$

$$\frac{\arg(U_c)}{\text{deg}} = 60$$