

$$S_{\text{Ж}} := 95 \cdot 10^{-6} \quad S_{\text{ЖN}} := 50 \cdot 10^{-6}$$

$$\rho_{\text{Ж}} := 2.8 \times 10^{-8} \quad \text{Ом*м} \quad \text{Алюминий}$$

$$r_{\text{Ж}} := \sqrt{\frac{S_{\text{Ж}}}{\pi}} = 5.499 \times 10^{-3} \quad \text{м}$$

$$r_{\text{ЖN}} := \sqrt{\frac{S_{\text{ЖN}}}{\pi}} = 3.989 \times 10^{-3} \quad \text{м}$$

$$d_{\text{ИЗ}} := 1.6 \cdot 10^{-3} \quad \text{м}$$

$$d1 := 2 \cdot (r_{\text{Ж}} + d_{\text{ИЗ}}) = 0.014 \quad \text{м}$$

$$d2 := (r_{\text{ЖN}} + d_{\text{ИЗ}}) + (r_{\text{Ж}} + d_{\text{ИЗ}}) = 0.013 \quad \text{м}$$

$$d3 := \frac{\sqrt{3}}{2} \cdot d1 + \sqrt{d2^2 - 0.25 \cdot d1^2} = 0.023 \quad \text{м}$$

$$d_{\text{П.Т.}} := \sqrt[3]{d2^2 \cdot d3} = 0.015 \quad \text{м} \quad \text{между проводами и 4м проводом (тросом)}$$

$$d_{\text{П}} := d1 \quad \text{м} \quad \text{между проводами}$$

$$R_{\text{Ж}} := \frac{\rho_{\text{Ж}}}{S_{\text{Ж}}} \cdot 1000 = 0.295 \quad R_{\text{ЖN}} := \frac{\rho_{\text{Ж}}}{S_{\text{ЖN}}} \cdot 1000 = 0.56$$

$$f := 50 \quad \text{Гц} \quad \rho_3 := 100 \quad \text{Ом*м}$$

$$R_3 := \pi^2 \cdot f \cdot 10^{-4} = 0.049 \quad D_3 := 658.86 \cdot \sqrt{\frac{\rho_3}{f}} = 931.769$$

$$\mu_{\text{Ж}} := 1 \quad \mu_{\text{ЖN}} := 1$$

$$X_{\text{ВНУТ.Ж}} := \mu_{\text{Ж}} \cdot \pi \cdot f \cdot 10^{-4} = 0.016$$

$$X_{\text{ВНУТ.ЖN}} := \mu_{\text{ЖN}} \cdot \pi \cdot f \cdot 10^{-4} = 0.016$$

$$ZL := R_{\text{Ж}} + R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{r_{\text{Ж}}}\right) + i \cdot X_{\text{ВНУТ.Ж}} = 0.344 + 0.772i$$

$$ZL_{\text{N}} := R_{\text{ЖN}} + R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{r_{\text{ЖN}}}\right) + i \cdot X_{\text{ВНУТ.ЖN}} = 0.609 + 0.793i$$

$$Z_{m1} := R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{d_{II}}\right) = 0.049 + 0.697i$$

$$Z_{m2} := R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{d_{II.T.}}\right) = 0.049 + 0.692i$$

$$Z_1 := Z_L - Z_{m1} = 0.295 + 0.075i \quad \text{Ом/км} \quad \text{сопротивление прямой последовательности}$$

$$Z_0 := Z_L + 2 \cdot Z_{m1} - 3 \cdot \frac{(Z_{m2})^2}{Z_{LN}} = 1.151 + 0.909i \quad \text{Ом/км} \quad \text{с учетом нулевого провода}$$

$$Z_0' := Z_L + 2 \cdot Z_{m1} = 0.443 + 2.166i \quad \text{Ом/км} \quad \text{без учета нулевого провода}$$

ВЛ (для контроля)

$$X_a := -2 \quad Y_a := 14.5$$

$$X_b := 2 \quad Y_b := 17.5$$

$$X_c := 3.5 \quad Y_c := 14.5$$

$$X_t := 0 \quad Y_t := 20.5$$

$$D_{AB} := \sqrt{(X_a - X_b)^2 + (Y_a - Y_b)^2} = 5$$

$$D_{BC} := \sqrt{(X_b - X_c)^2 + (Y_b - Y_c)^2} = 3.354$$

$$D_{CA} := \sqrt{(X_c - X_a)^2 + (Y_c - Y_a)^2} = 5.5$$

$$D_{At} := \sqrt{(X_a - X_t)^2 + (Y_a - Y_t)^2} = 6.325$$

$$D_{Bt} := \sqrt{(X_b - X_t)^2 + (Y_b - Y_t)^2} = 3.606$$

$$D_{Ct} := \sqrt{(X_c - X_t)^2 + (Y_c - Y_t)^2} = 6.946$$

$$r_{IIp} := 0.5 \cdot 21.6 \cdot 10^{-3} \quad \text{м} \quad \text{AC 240/39}$$

$$r_{Tp} := 0.5 \cdot 9.1 \cdot 10^{-3} \quad \text{м} \quad \text{C-50}$$

$$d_{III} := \sqrt[3]{D_{At} \cdot D_{Bt} \cdot D_{Ct}} = 5.411 \quad \text{м}$$

$$d_{IV} := \sqrt[3]{D_{AB} \cdot D_{BC} \cdot D_{CA}} = 4.518 \quad \text{м}$$

$$R_{\text{пр}} := 0.1222 \quad \text{Ом/км}$$

$$R_{\text{тр}} := 3.6 \quad \text{Ом/км}$$

$$f := 50 \quad \rho_{\text{ж}} := 100$$

$$R_3 := \pi^2 \cdot f \cdot 10^{-4} \quad D_3 := 658.86 \cdot \sqrt{\frac{\rho_3}{f}} = 931.769$$

$$\mu_{\text{пр}} := 1 \quad \mu_{\text{тр}} := 44.5$$

$$X_{\text{внут.пр}} := \mu_{\text{пр}} \cdot \pi \cdot f \cdot 10^{-4} = 0.016$$

$$X_{\text{внут.тр}} := \mu_{\text{тр}} \cdot \pi \cdot f \cdot 10^{-4} = 0.699$$

$$Z_L := R_{\text{пр}} + R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{r_{\text{пр}}}\right) + i \cdot X_{\text{внут.пр}} = 0.172 + 0.73i$$

$$Z_{L_N} := R_{\text{тр}} + R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{r_{\text{тр}}}\right) + i \cdot X_{\text{внут.тр}} = 3.649 + 1.468i$$

$$Z_{m1} := R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{d_{\text{п}}}\right) = 0.049 + 0.335i$$

$$Z_{m2} := R_3 + i \cdot 0.1447 \cdot \log\left(\frac{D_3}{d_{\text{п.т.}}}\right) = 0.049 + 0.324i$$

$$Z_1 := Z_L - Z_{m1} = 0.122 + 0.395i$$

$$Z_0 := Z_L + 2 \cdot Z_{m1} - 3 \cdot \frac{(Z_{m2})^2}{Z_{L_N}} = 0.334 + 1.348i$$

$$Z_0' := Z_L + 2 \cdot Z_{m1} = 0.27 + 1.4i$$