általános összefüggések

$$|U_v| = \sqrt{3}\,|U_f| = |U|$$

$$|I_v| = |I_f| = I = \sqrt{3}\,|I_\Delta|$$

$$|Z^Y| = \frac{|U_f|}{|I|}$$

$$|Z^\Delta| = 3|Z^Y|$$

$$S_{3f} = S = 3|U_f||I_f| = \sqrt{3}\,U I$$

$$P_{3f} = P = \sqrt{3}\,U I \cos\varphi \qquad Q = -\sqrt{3}\,|U||I| \sin\varphi$$

transzformátor:

$$\varepsilon^{\%} = \frac{U_{rz}^N}{U_{nf}^N}100 \qquad U_{rz} = Z^N I_n^N$$

$$Z^N = \frac{\varepsilon}{100}\frac{U_n^{N\,2}}{S_n} \qquad S_{rz} = \frac{\sqrt{3}\,U_n I_n}{\varepsilon/100}$$

generátor:

$$X_g^{\Omega} = \frac{x^{\%}}{100}\frac{U_n^2}{S_n} \qquad U_k \simeq \frac{U_n}{\sqrt{3}}$$

$$\cos\varphi \Rightarrow \varphi \qquad S_n = \sqrt{3}\,U_n I_n$$

nagy hálózat:

$$S_z = \sqrt{3}\,U_n I_n$$

$$x^H = \frac{U_n^2}{S_z}$$

∞ hálózat:

$$S_z = \infty$$

$$x^H = \emptyset$$

$$U = U_n$$

távvezeték:

$$R = r l$$

$$X_L = x_L l$$

$$X_C = \frac{x_c}{l}$$

foqyasztó:

$$S_n = \sqrt{3}\, U_n I_n$$

- Z tartó:

$$Z = \frac{U_n^2}{S_n}\left(\cos\varphi \pm j \sin\varphi\right)$$

(+: ind., −: kap)

- I tartó:

$$I_f = \frac{S_n}{\sqrt{3}\, U_n}\left(\cos\varphi \mp j \sin\varphi\right)$$

(−: ind., +: kap.)

szimmetrikus összetevőkre való bontás:

$$\overline{I}_f = \overline{\overline{T}}\, \overline{I}_s \qquad \overline{I}_s = \overline{\overline{T}}^{-1} \overline{I}_f \qquad U_s = \begin{bmatrix} U_0 \\ U_1 \\ U_2 \end{bmatrix} \qquad U_f = \begin{bmatrix} U_a \\ U_b \\ U_c \end{bmatrix}$$

$$\overline{U}_f = \overline{\overline{T}}\, \overline{U}_s \qquad \overline{U}_s = \overline{\overline{T}}^{-1} \overline{U}_f$$

$$\overline{\overline{T}} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \qquad \overline{\overline{T}}^{-1} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \qquad I_s = \begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix} \qquad I_f = \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

$$I_a = I \,;\; I_b = I a^2 \,;\; I_c = I a$$

$$a = 1 e^{j120°} \qquad 1 + a + a^2 = \emptyset \qquad a^3 = 1 \qquad a^4 = a$$

$$\overline{U}_f = \overline{\overline{Z}}_f \overline{I}_f \qquad \overline{\overline{Z}}_f = \begin{bmatrix} Z_{aa} & Z_{ab} & Z_{ac} \\ Z_{ba} & Z_{bb} & Z_{cc} \\ Z_{ca} & Z_{cb} & Z_{cc} \end{bmatrix}$$

$$\overline{U}_s = \overline{\overline{Z}}_s \overline{I}_s$$

$$\overline{\overline{Z}}_s = \overline{\overline{T}}^{-1} \overline{\overline{Z}}_f \overline{\overline{T}} \qquad \overline{\overline{Z}}_s = \begin{bmatrix} Z_{00} & Z_{01} & Z_{02} \\ Z_{10} & Z_{11} & Z_{12} \\ Z_{20} & Z_{21} & Z_{22} \end{bmatrix}$$

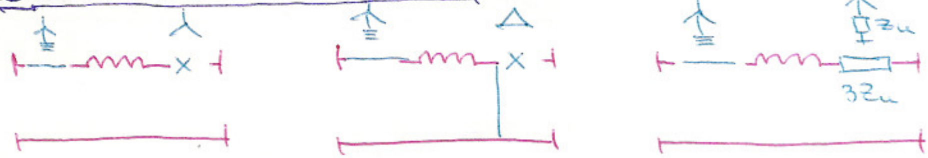
$$\overline{\overline{Z}}_f = \begin{bmatrix} Z_{\bar{o}} & Z_m & Z_n \\ Z_n & Z_{\bar{o}} & Z_m \\ Z_m & Z_n & Z_{\bar{o}} \end{bmatrix} \qquad \overline{\overline{Z}}_s = \begin{bmatrix} \underbrace{Z_{\bar{o}} + Z_m + Z_n}_{Z_0} & 0 & 0 \\ 0 & \underbrace{Z_{\bar{o}} + a^2 Z_m + a Z_n}_{Z_1} & 0 \\ 0 & 0 & \underbrace{Z_{\bar{o}} + a Z_m + a^2 Z_n}_{Z_2} \end{bmatrix}$$

- ha $Z_m = Z_n = Z_k$:

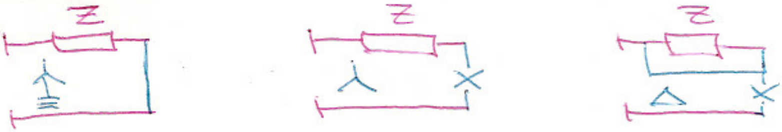
$$Z_0 = Z_{\bar{o}} + 2 Z_k$$

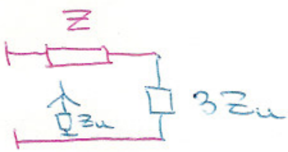
$$Z_1 = Z_2 = Z_{\bar{o}} - Z_k$$

Trafó zérussorrendű helyettesítése:

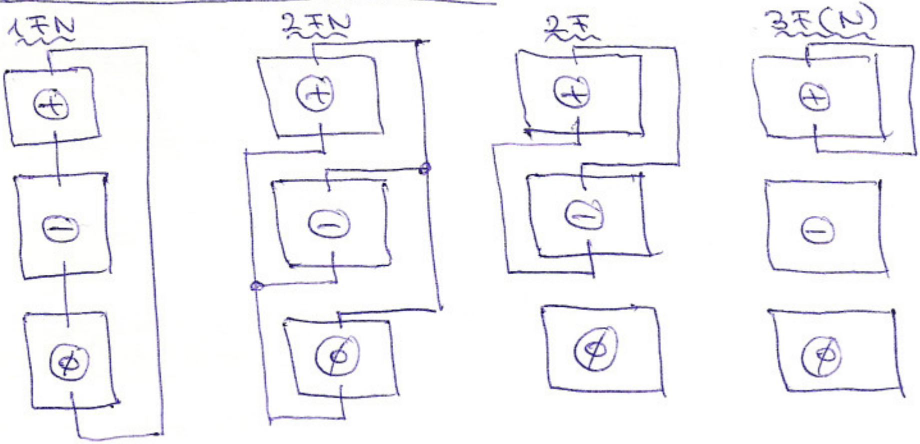


Fogyasztó / Generátor zérus sorrendű h.k.-e:





Zárlatok modellezése



Rövid vezetékek (feszültségesés)

$$I = \frac{S_n}{\sqrt{3}\,U_n}(\cos\varphi \overset{\text{ind.}}{\underset{\text{kap.}}{\mp}} j\sin\varphi) = I_w + j I_m$$

$$\Delta U = |U_s| - |U_e| \approx \Delta U_h = I_w R_v - I_m X_v$$

$$Z_v = R_v + jX_v \qquad \Delta U_k = I_w X_v + I_m R_v$$

nagyfesz. ($R_v \approx 0$)

$$\Delta U_h = -I_m X_v$$

$$\Delta U_k = I_w X_v$$

$$\Delta U\% = \frac{\Delta U\,[kV]}{U_n^F} \cdot 100$$

Rövid vezeték (terhelési szög, teljesítmény)

$$S_{s1f} = U_s I^* = P_s + jQ_s$$

$$S_{R1f} = U_R I^* = P_R + jQ_R$$

$$P_s = P_R = \frac{|U_s| \cdot |U_R|}{X} \sin\delta$$

$$Q_s = \frac{|U_s|(|U_s| - |U_R| \cos\delta)}{X}$$

$$Q_R = \frac{|U_R|(|U_s| \cos\delta - |U_R|)}{X}$$

hosszú, nagyfeszt. vezetékek (teljesítmény kördiagram)

$$U_s = A U_R + B I_R$$

$$I_s = C U_R + D I_R$$

$$S_s = K_s e^{j(\beta-\delta)} - g e^{j(\beta+\Theta)}$$

$$S_R = K_R e^{j(\beta-\alpha)} + g e^{j(\beta-\Theta)}$$

$$K_s = |U_s|^2 \left|\frac{D}{B}\right| e^{j(\beta-\delta)}$$

$$K_R = -|U_R|^2 \left|\frac{A}{B}\right| e^{j(\beta-\delta)}$$

$$g = \frac{|U_s| \cdot |U_R|}{|B|}$$

rövid vezetékre:

$|U_s| = |U_R|$; $|A| = 1$; $\alpha = \phi$; $|B| = X_v$; $\beta = 90°$; $|D| = 1$; $\delta = \phi$

fogyasztó érzékenységi tényezők

$$P = P_0 + P_0 \left(k_{pf} \frac{\Delta f}{f_0} + k_{pu} \frac{\Delta U}{U_0}\right)$$

$$Q = Q_0 + Q_0 \left(k_{qf} \frac{\Delta f}{f_0} + k_{qu} \frac{\Delta U}{U_0}\right)$$