**Jednačine telegrafičara za idealan vod**

$$\underline{U}_2 = \underline{U}_1 \cos\beta L - jZ_c \underline{I}_1 \sin\beta L \qquad \underline{I}_2 = \underline{I}_1 \cos\beta L - j\frac{\underline{U}_1}{Z_c}\sin\beta L$$

**Parametri pojedinačnih namotaja tronamotajnog transformatora**

$$R_1 = \frac{1}{2}\left(R_{12} + R_{13} - R_{23}\right) \qquad R_2 = \frac{1}{2}\left(R_{12} + R_{23} - R_{13}\right),$$

$$R_3 = \frac{1}{2}\left(R_{13} + R_{23} - R_{12}\right)$$

**Parametri nesimetrične π šeme regulacionog transformatora**

$$\underline{Z}_1 = \frac{t^2 \underline{Z}_T}{1-t} \qquad \underline{Z}_2 = t\underline{Z}_T \qquad \underline{Z}_3 = \frac{t\underline{Z}_T}{t-1}.$$

**Formule za padove napona**

$$\underline{U}_1 = U_2 + \frac{P_2 R + Q_2 X}{U_2} + j\frac{P_2 X - Q_2 R}{U_2}$$

$$\underline{U}_2 = U_1 - \frac{P_1 R + Q_1 X}{U_1} - j\frac{P_1 X - Q_1 R}{U_1}$$

$$\underline{U}_2 = \frac{U_1}{2} + \sqrt{\left(\frac{U_1}{2}\right)^2 - P_2 R - Q_2 X - \left(\frac{P_2 X - Q_2 R}{U_1}\right)^2} - j\frac{P_2 X - Q_2 R}{U_1}$$

$$\underline{U}_1 = \frac{U_2}{2} + \sqrt{\left(\frac{U_2}{2}\right)^2 + P_1 R + Q_1 X - \left(\frac{P_1 X - Q_1 R}{U_2}\right)^2} + j\frac{P_1 X - Q_1 R}{U_2}$$

**Statički koeficijenti promene snage sa promenom napona**

$$P_p = C_{PU} U^{k_{PU}} \qquad Q_p = C_{QU} U^{k_{QU}}$$

$$P_p = P_{po} + P_{po} k_{PU} \frac{U - U_o}{U_o} \qquad Q_p = Q_{po} + Q_{po} k_{QU} \frac{U - U_o}{U_o}$$

**Elementi matrice admintansi nezavisnih čvorova ($[\underline{Y}_{čv}]$)**

$$\underline{Y}_{ii} = \sum_{\substack{j=0 \\ j\neq i}}^{N} Y_{ij}^{gr} \text{ (na glavnoj dijagonali)} \qquad \underline{Y}_{ij} = -\underline{Y}_{ij}^{gr} \text{ (van dijagonale)}$$

**Jednačine za formiranje matrice impedansi nezavisnih čvorova ($[\underline{Z}_{čv}]$)**

a) Novi čvor (k) - referentni čvor (o) - grana $\underline{Z}_{ko}^{gr}$

$$[\underline{Z}_{čv}]^{post} = \left[\begin{array}{ccc|c} & [\underline{Z}_{čv}]^{pre} & & \begin{matrix}0\\ \vdots \\ 0\end{matrix} \\ \hline 0 & \cdots & 0 & \underline{Z}_{ko}^{gr} \end{array}\right]$$

b) Novi čvor (k) - stari čvor (j) - grana $\underline{Z}_{kj}^{gr}$

$$[\underline{Z}_{čv}]^{post} = \left[\begin{array}{ccc|c} & [\underline{Z}_{čv}]^{pre} & & \begin{matrix}\underline{Z}_{1j}\\ \vdots \\ \underline{Z}_{n^o j}\end{matrix} \\ \hline \underline{Z}_{j1} & \cdots & \underline{Z}_{jn^o} & \underline{Z}_{jj} + \underline{Z}_{kj}^{gr} \end{array}\right], \; n^o \text{ je dimenzija } [\underline{Z}_{čv}]^{pre}$$

c) Stari čvor (j) - referentni čvor (o) - grana $\underline{Z}_{jo}^{gr}$

$$[\underline{Z}_{čv}]^{post} = [\underline{Z}_{čv}]^{pre} - [\Delta \underline{Z}_{čv}]$$

$$[\Delta \underline{Z}_{čv}] = \frac{1}{\underline{Z}_{jj} + \underline{Z}_{jo}^{gr}} \begin{bmatrix} \underline{Z}_{1j} \\ \vdots \\ \underline{Z}_{n^o j} \end{bmatrix} \begin{bmatrix} \underline{Z}_{j1} & \cdots & \underline{Z}_{jn^o} \end{bmatrix}, \; n^o \text{ je dimenzija } [\underline{Z}_{čv}]^{pre}$$

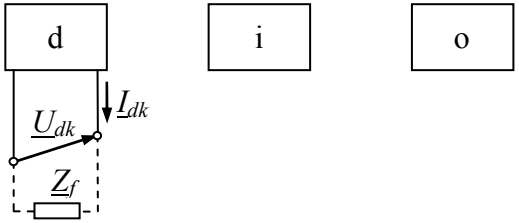
d) Stari čvor (i) - stari čvor (j) - grana $\underline{Z}_{ij}^{gr}$

$$[\underline{Z}_{čv}]^{post} = [\underline{Z}_{čv}]^{pre} - [\Delta \underline{Z}_{čv}]$$

$$[\Delta \underline{Z}_{čv}] = \frac{1}{\underline{Z}_{ii} + \underline{Z}_{jj} - 2\underline{Z}_{ij} + \underline{Z}_{ij}^{gr}} \begin{bmatrix} \underline{Z}_{1i} - \underline{Z}_{1j} \\ \vdots \\ \underline{Z}_{n^o i} - \underline{Z}_{n^o j} \end{bmatrix} \begin{bmatrix} (\underline{Z}_{i1} - \underline{Z}_{j1}) & \cdots & (\underline{Z}_{in^o} - \underline{Z}_{jn^o}) \end{bmatrix}$$

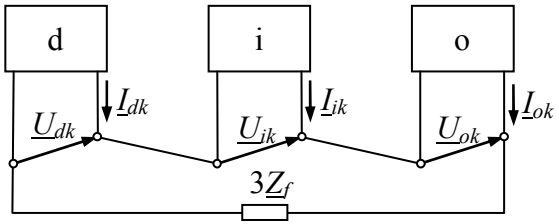
**Proračun kratkih spojeva matričnom metodom**

a) Trofazni kratki spoj (3kz)




$$\underline{I}_{dk} = \frac{\underline{E}}{\underline{Z}^d_{(k,k)} + \underline{Z}_f},\ \underline{U}_{dl} = \underline{E} - \underline{Z}^d_{(l,k)}\underline{I}_{dk},\ l = 1,...,n$$

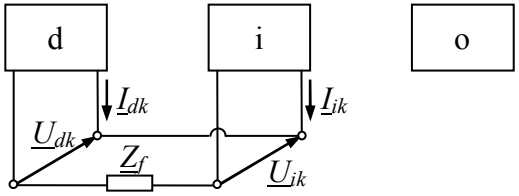
b) Jednofazni kratki spoj (1kz)




$$\underline{I}_{dk} = \underline{I}_{ik} = \underline{I}_{ok} = \frac{\underline{E}}{\underline{Z}^d_{(k,k)} + \underline{Z}^i_{(k,k)} + \underline{Z}^o_{(k,k)} + 3\underline{Z}_f}$$

$$\underline{U}_{dl} = \underline{E} - \underline{Z}^d_{(l,k)}\underline{I}_{dk},\ \underline{U}_{il} = -\underline{Z}^i_{(l,k)}\underline{I}_{ik},\ \underline{U}_{ol} = -\underline{Z}^o_{(l,k)}\underline{I}_{ok},\ l = 1,...,n$$

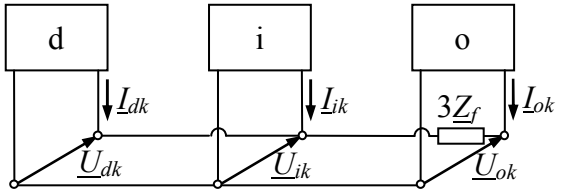
c) Dvofazni kratki spoj bez zemlje (2k)




$$\underline{I}_{dk} = -\underline{I}_{ik} = \frac{\underline{E}}{\underline{Z}^d_{(k,k)} + \underline{Z}^i_{(k,k)} + \underline{Z}_f} \qquad \underline{I}_{ok} = 0$$

$$\underline{U}_{dl} = \underline{E} - \underline{Z}^d_{(l,k)}\underline{I}_{dk},\ \underline{U}_{il} = -\underline{Z}^i_{(l,k)}\underline{I}_{ik},\ \underline{U}_{ol} = 0,\ l = 1,...,n$$

d) Dvofazni kratki spoj sa zemljom (2kz)




$$\Delta = \underline{Z}^d_{(k,k)}\left(\underline{Z}^i_{(k,k)} + \underline{Z}^o_{(k,k)} + 3\underline{Z}_f\right) + \underline{Z}^i_{(k,k)}\left(\underline{Z}^o_{(k,k)} + 3\underline{Z}_f\right)$$

$$\underline{I}_{dk} = \frac{\underline{E}\left(\underline{Z}^i_{(k,k)} + \underline{Z}^o_{(k,k)} + 3\underline{Z}_f\right)}{\Delta}$$

$$\underline{I}_{ik} = -\frac{\underline{E}\left(\underline{Z}^o_{(k,k)} + 3\underline{Z}_f\right)}{\Delta} \qquad \underline{I}_{ok} = -\frac{\underline{E}\underline{Z}^i_{(k,k)}}{\Delta}$$

$$\underline{U}_{dl} = \underline{E} - \underline{Z}^d_{(l,k)}\underline{I}_{dk},\ \underline{U}_{il} = -\underline{Z}^i_{(l,k)}\underline{I}_{ik},\ \underline{U}_{ol} = -\underline{Z}^o_{(l,k)}\underline{I}_{ok},\ l = 1,...,n$$

Simetrične komponente struje po grani k-l

$$\underline{I}^{(d,i,o)}_{kl} = \frac{\underline{U}^{(d,i,o)}_k - \underline{U}^{(d,i,o)}_l}{\underline{Z}^{gr(d,i,o)}_{kl}}$$

**Transformacija simetričnih komponenata u fazne i obratno**

$$\begin{bmatrix}\underline{I}_a\\ \underline{I}_b\\ \underline{I}_c\end{bmatrix} = \begin{bmatrix}1 & 1 & 1\\ 1 & \underline{a}^2 & \underline{a}\\ 1 & \underline{a} & \underline{a}^2\end{bmatrix}\begin{bmatrix}\underline{I}_o\\ \underline{I}_d\\ \underline{I}_i\end{bmatrix} \qquad \begin{bmatrix}\underline{I}_o\\ \underline{I}_d\\ \underline{I}_i\end{bmatrix} = \frac{1}{3}\begin{bmatrix}1 & 1 & 1\\ 1 & \underline{a} & \underline{a}^2\\ 1 & \underline{a}^2 & \underline{a}\end{bmatrix}\begin{bmatrix}\underline{I}_a\\ \underline{I}_b\\ \underline{I}_c\end{bmatrix}$$

**Uticaj na TK vod**

$$E = 3\left|\underline{I}_o\right| \cdot 2\pi f \cdot L_p \cdot k_z \frac{4}{\sqrt{a}}$$

U slučaju kose deonice TK voda, rastojanje $a$ se računa kao geometrijska sredina dva krajnja rastojanja $a_1$ i $a_2$, odnosno $a = \sqrt{a_1 a_2}$ .