

SNAGA U SLOŽENOM KRUGU izmjenične struje

$$P_{UK} = \sum P \quad Q_{L_{UK}} = \sum Q_L \quad Q_{C_{UK}} = \sum Q_C \quad Q_{UK} = \sum Q_L - \sum Q_C$$

$$S_{UK} = \sqrt{P_{UK}^2 + Q_{UK}^2} \quad \cos \varphi_{UK} = \frac{P_{UK}}{S_{UK}}$$

Poboljšanje faktora snage dodavanjem radne snage

$$\Delta P = Q \left(\frac{1}{\tan \varphi_2} - \frac{1}{\tan \varphi_1} \right)$$

Kompenzacija jalove snage kondenzatorom

$$Q_L = P \cdot \tan \varphi_1$$

$$\Delta Q = Q_L - Q_C = P \cdot \tan \varphi_2$$

$$Q_C = P \cdot (\tan \varphi_1 - \tan \varphi_2)$$

$$\Delta S = S_1 - S_2 = \frac{P}{\cos \varphi_1} - \frac{P}{\cos \varphi_2}$$

$$Q_C = U_C \cdot I_C = \frac{U_C^2}{X_C} = U_C^2 \cdot \omega C$$

$$C = \frac{Q_C}{U_C^2 \cdot \omega} \quad C \approx 66 \cdot Q_C$$

Rad izmjenične struje

$$W = P \cdot t$$

Snaga u kompleksnom obliku

$$\vec{S} = \vec{U} \cdot \vec{I}^*$$

$$\vec{S} = \vec{U} \cdot \vec{I}^* = UI \cos \varphi + jUI \sin \varphi$$

$$\vec{S} = U \angle \alpha_U \cdot I \angle -\alpha_I = UI \angle \alpha_U - \alpha_I = UI \angle \varphi$$

$$\vec{S} = P + jQ$$

Rezonancija ili potpuna kompenzacija : uvjet je $\mathbf{Im}(\underline{Z})=0$ ili $\mathbf{Im}(\underline{Y})=0$!!!

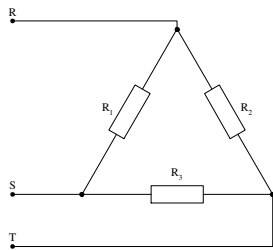
TROFAZNA STRUJA

➤ OSNOVNI POJMOVI I OZNAKE

| | |
|---------------------------|-----------------------------------|
| ➤ Faza generatora ⇒ | $U_1, U_2, U_3 \quad \{U, V, W\}$ |
| ➤ Faza trošila ⇒ | Z_1, Z_2, Z_3 |
| ➤ Fazni vodič ⇒ | $L_1, L_2, L_3 \quad \{R, S, T\}$ |
| ➤ Nulvodič ⇒ | N |
| ➤ Fazni napon ⇒ | U_f |
| ➤ Linijski napon ⇒ | U_l |
| ➤ Fazna struja ⇒ | I_f |
| ➤ Linijska struja ⇒ | I_l |
| ➤ Simetrično trošilo ⇒ | $Z_1 = Z_2 = Z_3$ |
| ➤ Ne simetrično trošilo ⇒ | $Z_1 \neq Z_2 \neq Z_3$ |
| ➤ Zvijezdište ⇒ | 0-0' |

Simetrična trošila:

Trošilo u spoju trokut



$$I_L = I_F \cdot \sqrt{3}$$

$$U_L = U_F$$

$$I_F = \frac{U_F}{R_F}$$

$$I_{12} = \frac{U_{12}}{Z}$$

$$I_{12} = I_{23} = I_{31} = \frac{U_F}{Z} = I_F$$

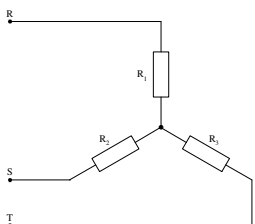
$$\vec{I}_1 = \vec{I}_{12} - \vec{I}_{31}$$

$$\vec{I}_2 = \vec{I}_{23} - \vec{I}_{12}$$

$$\vec{I}_3 = \vec{I}_{31} - \vec{I}_{23}$$

$$\vec{I}_1 + \vec{I}_2 + \vec{I}_3 = 0$$

Trošilo u spoju zvijezda



$$I_L = I_F$$

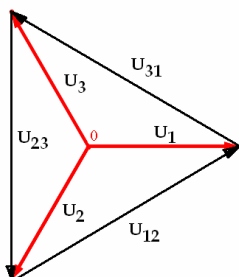
$$U_L = U_F \cdot \sqrt{3}$$

$$I_F = \frac{U_F}{R_F}$$

$$\vec{I}_1 + \vec{I}_2 + \vec{I}_3 = 0$$

$$\vec{I}_1 + \vec{I}_2 + \vec{I}_3 = \vec{I}_N$$

Trofazni naponi u kompleksnom obliku



$$\vec{U}_1 = U_F \angle 0^\circ = U_F$$

$$\vec{U}_2 = U_F \angle -120^\circ = \frac{-U_F}{2} - j \frac{\sqrt{3}U_F}{2}$$

$$\vec{U}_3 = U_F \angle 120^\circ = \frac{-U_F}{2} + j \frac{\sqrt{3}U_F}{2}$$

$$\vec{U}_1 + \vec{U}_2 + \vec{U}_3 = 0$$

$$\vec{U}_{12} = \vec{U}_1 - \vec{U}_2 = U_l \angle 30^\circ$$

$$\vec{U}_{23} = \vec{U}_2 - \vec{U}_3 = U_l \angle -90^\circ$$

$$\vec{U}_{31} = \vec{U}_3 - \vec{U}_1 = U_l \angle 150^\circ$$

$$\vec{U}_{12} + \vec{U}_{23} + \vec{U}_{31} = 0$$

Nesimetrično trošilo u spoju trokuta

$$\bar{I}_{12} = \frac{\bar{U}_{12}}{\bar{Z}_{12}} \quad \bar{I}_{23} = \frac{\bar{U}_{23}}{\bar{Z}_{23}} \quad \bar{I}_{31} = \frac{\bar{U}_{31}}{\bar{Z}_{31}}$$

$$\bar{I}_1 = \bar{I}_{12} - \bar{I}_{31} \quad \bar{I}_2 = \bar{I}_{23} - \bar{I}_{12} \quad \bar{I}_3 = \bar{I}_{31} - \bar{I}_{23}$$

Nesimetrično trošilo u spoju zvijezda s nulvodičem

$$\bar{I}_1 = \frac{\bar{U}_1}{\bar{Z}_1} \quad \bar{I}_2 = \frac{\bar{U}_2}{\bar{Z}_2} \quad \bar{I}_3 = \frac{\bar{U}_3}{\bar{Z}_3} \quad \bar{I}_1 + \bar{I}_2 + \bar{I}_3 = \bar{I}_N \quad \bar{I}_L = \bar{I}_F$$

Nesimetrično trošilo u spoju zvijezda bez nulvodičem

$$\bar{I}_1 = \frac{\bar{U}'_1}{\bar{Z}_1} \quad \bar{I}_2 = \frac{\bar{U}'_2}{\bar{Z}_2} \quad \bar{I}_3 = \frac{\bar{U}'_3}{\bar{Z}_3} \quad \bar{U}_{000} = \frac{\frac{\bar{U}_1}{\bar{Z}_1} + \frac{\bar{U}_2}{\bar{Z}_2} + \frac{\bar{U}_3}{\bar{Z}_3}}{\frac{1}{\bar{Z}_1} + \frac{1}{\bar{Z}_2} + \frac{1}{\bar{Z}_3}}$$

$$\bar{U}'_1 = \bar{U}_1 - \bar{U}_{000} \quad \bar{U}'_2 = \bar{U}_2 - \bar{U}_{000} \quad \bar{U}'_3 = \bar{U}_3 - \bar{U}_{000}$$

Snaga nesimetričnog trošila

$$P_{UK} = P = \sum P_f \quad Q_{UK} = Q = \sum Q_{Lf} - \sum Q_{Cf} \quad S_{UK} = S = \sqrt{P^2 + Q^2} \quad \cos \varphi_{UK} = \cos \varphi = \frac{P_{UK}}{S_{UK}} = \frac{P}{S}$$

Snaga simetričnog trošila

$$P_{UK} = P = 3 \cdot P_f \quad Q_{UK} = Q = 3 \cdot Q_f \quad S_{UK} = S = \sqrt{(3 \cdot P_f)^2 + (3 \cdot Q_f)^2} = 3 \cdot S_f$$

$$\cos \varphi_{UK} = \cos \varphi = \frac{P}{S} = \frac{3 \cdot P_f}{3 \cdot S_f} = \frac{P_f}{S_f} = \cos \varphi_f$$

Snaga trošila u spoju trokut

$$U_L = U_F \quad I_L = I_F \cdot \sqrt{3} \quad I_F = \frac{U_F}{Z_F} = \frac{U_L}{Z_F}$$

$$P = S \cdot \cos \varphi = 3 \cdot \frac{U_L^2}{Z} \cdot \cos \varphi$$

$$Q = S \cdot \sin \varphi = 3 \cdot \frac{U_L^2}{Z} \cdot \sin \varphi$$

$$S = 3 \cdot S_f = 3 \cdot U_F I_F = 3 \cdot U_L I_F = 3 \cdot \frac{U_L^2}{Z}$$

$$S = 3 \cdot S_f = 3 \cdot U_F I_F = 3 \cdot U_L I_F = 3 \cdot U_L \frac{I_L}{\sqrt{3}} =$$

$$S = \sqrt{3} \cdot U_L I_L$$

$$P = \sqrt{3} \cdot U_L I_L \cdot \cos \varphi$$

$$Q = \sqrt{3} \cdot U_L I_L \cdot \sin \varphi$$

Snaga trošila u spoju zvijezda

$$U_L = \sqrt{3} \cdot U_F \quad I_L = I_F \quad I_F = \frac{U_F}{Z_F}$$

$$P = S \cdot \cos \varphi = 3 \cdot \frac{U_F^2}{Z} \cdot \cos \varphi$$

$$Q = S \cdot \sin \varphi = 3 \cdot \frac{U_F^2}{Z} \cdot \sin \varphi$$

$$S = 3 \cdot S_f = 3 \cdot U_F I_F = 3 \cdot U_F I_L = 3 \cdot \frac{U_F^2}{Z}$$

$$S = 3 \cdot S_f = 3 \cdot U_F I_F = 3 \cdot U_F I_L = 3 \cdot \frac{U_L}{\sqrt{3}} I_L =$$

$$S = \sqrt{3} \cdot U_L I_L$$

$$P = \sqrt{3} \cdot U_L I_L \cdot \cos \varphi$$

$$Q = \sqrt{3} \cdot U_L I_L \cdot \sin \varphi$$

Snaga u slučaju prekida jednog faznog vodiča:

Prekid kod spoja simetričnog trošila u **zvijezdu- četverovodni priključak**

$$S' = \frac{2}{3} \cdot S$$

Prekid kod spoja simetričnog trošila u **zvijezdu- trovodni priključak**

$$S' = \frac{S}{2}$$

Prekid kod spoja simetričnog trošila u **trokut**

$$S' = \frac{S}{2}$$

Rad i energija trofaznog trošila

Radna energija W (rad)

$$W = P \cdot t$$

Jalova energija W_Q

$$W_Q = Q \cdot t$$

potrebna kapacitivna snaga

$$Q_C = P \cdot (\tan \varphi_1 - \tan \varphi_2)$$

$$C = \frac{Q_C}{3 \cdot U_C^2 \cdot \omega}$$

Spoj u zvijezdu

$$C_Y = \frac{Q_C}{3 \cdot U_f^2 \cdot 2\pi \cdot f} = \frac{Q_C}{6 \cdot \pi \cdot f \cdot U_f^2}$$

$$U = 220V, f = 50Hz$$

$$C_Y \approx 22 \cdot Q_C$$

Spoj u trokut

$$C_\Delta = \frac{Q_C}{3 \cdot U_L^2 \cdot 2\pi \cdot f} = \frac{Q_C}{18 \cdot \pi \cdot f \cdot U_f^2}$$

$$U = 220V, f = 50Hz$$

$$C_\Delta \approx \frac{22}{3} \cdot Q_C = \frac{1}{3} \cdot C_Y$$