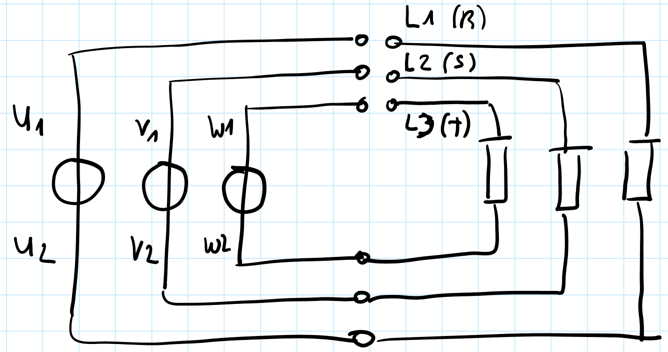
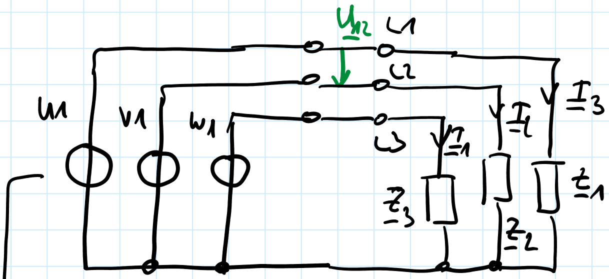




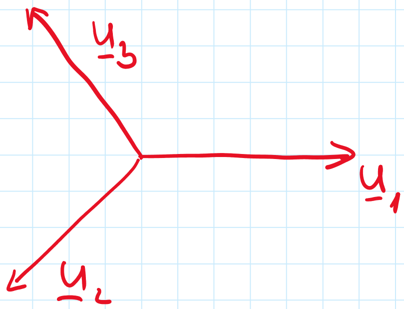
STERNSCHALTUNG ⅄

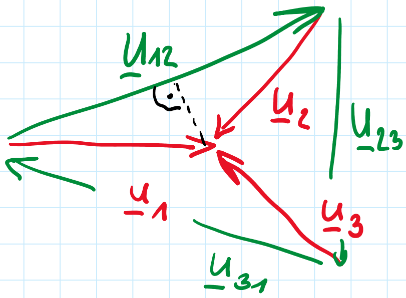
"Vierleitersystem"

Strangspannung

N … Neutralleiter

$\underline{U}_1 = U \angle 0°$ $\underline{U}_2 = U \angle -120°$ $\underline{U}_3 = U \angle -240° = U \angle +120°$



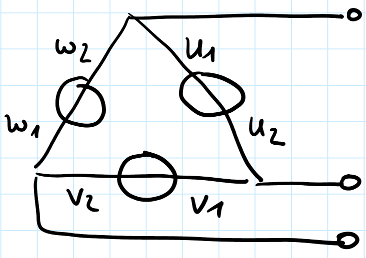


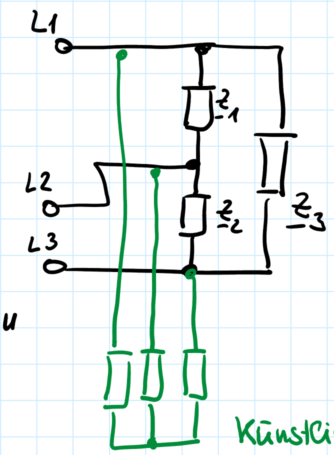
$\underline{U}_{12} = 2\, U_⅄ \cdot \cos 30° = \sqrt{3}\, U_⅄$

DREIECKSSCHALTUNG Δ

Strangspannung = Außenleiterspannung

$U_{St} = U = U_Δ$



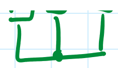


"Dreileitersystem"

Sternschaltung

Symmetrische Last: $Z = Z_1 = Z_2 = Z_3$

Sternschaltung



Künstlicher Sternpunkt

Symmetrische Last $\underline{Z} = \underline{Z}_1 = \underline{Z}_2 = \underline{Z}_3$

$$\underline{I}_1 + \underline{I}_2 + \underline{I}_3 = \underline{I}_N = \emptyset \qquad I_1 = I_2 = I_3 = \frac{U_\lambda}{Z}$$

$$p(t) = U \cdot I \cdot \cos(2\omega t + \varphi_u + \varphi_i) + U \cdot I \cdot \cos(\varphi_u - \varphi_i)$$

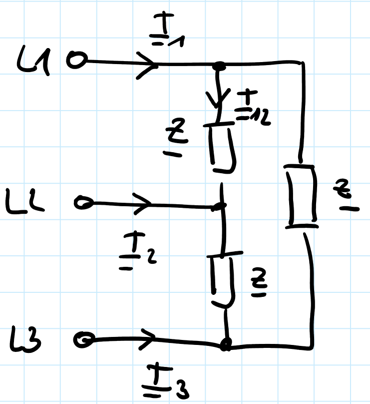
$$\varphi_u - \varphi_i = \varphi \qquad \text{(einphasige Schaltung)}$$

$$p(t) = U_\lambda I_\lambda \cdot \cos\varphi + U_\lambda I_\lambda \cos(2\omega t - \varphi) \qquad \text{(dreiphasige Schaltung)}$$
$$+ U_\lambda I_\lambda \cos\varphi + U_\lambda I_\lambda \cos(2\omega t - 240° - \varphi)$$
$$+ U_\lambda I_\lambda \cos\varphi + \underbrace{U_\lambda I_\lambda \cos(2\omega t + 240° - \varphi)}_{=0}$$

$$= 3 \cdot U_\lambda I_\lambda \cos\varphi = \underline{\text{const.}}$$

$$\underline{S} = 3\, U_\lambda I_\lambda \angle\varphi = \sqrt{3}\, U \cdot I \angle\varphi = P + jQ$$

Verbraucherschaltung Δ



$$U_\Delta = U = \sqrt{3}\, U_\lambda$$

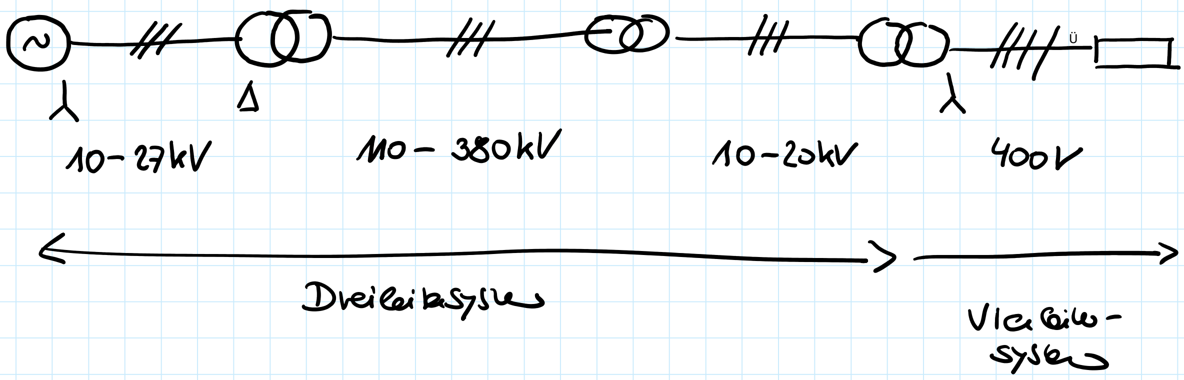
$$I_\Delta = \frac{U_\Delta}{Z} = I_{12}$$

$$I = I_1 = I_2 = I_3 = \sqrt{3}\, I_\Delta$$

$$P(t) = 3\, U_\Delta I_\Delta \cos\varphi = \text{const!}$$

$$S_\Delta = 3\, S_\lambda \quad \text{sofern } Z = \text{const.}$$

VERSORGUNGSSYSTEM



Unsymmetrische Belastung

- Starres Netz = ideale Spannungsquelle + min. Leiterspannung
- Sternpunktleiter belastet
- Wirkleistung nicht konstant

BSP Vierleiternetz ⅄

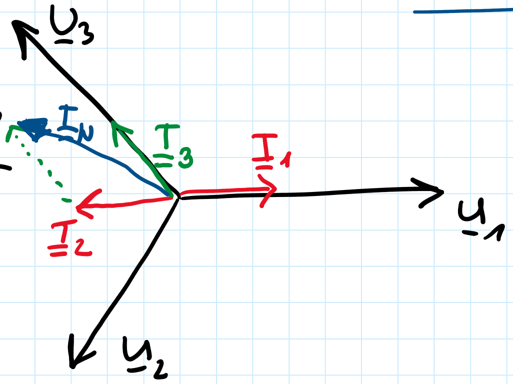
ges. $U = 400V$ L1: $R = 23\,\Omega$

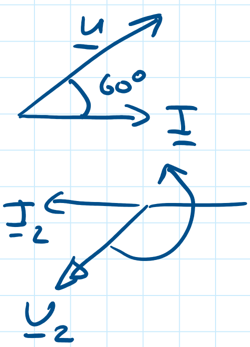
L2: $I_w = 10A$ $\cos\varphi = 0,5$ ($\varphi = 60°$)

$\underline{U}_1 = 230V\angle 0°$ $\underline{I}_1 = 10A\angle 0°$

$\underline{U}_2 = 230V\angle -120°$

$\underline{I}_2 = 10A\angle -120° - 60°$





$\underline{I}_N = \underline{I}_1 + \underline{I}_2 + \underline{I}_3 = 10A\angle 0° + 10A\angle -180° = \underline{\underline{0A}}$

Annahme R an L3 statt L1

$\underline{U}_3 = 230V\angle +120°$ $\underline{I}_3 = 10A\angle +120°$

$\underline{I}_N = \underline{I}_1 + \underline{I}_2 + \underline{I}_3 = 0 + 10A\angle -180° + 10A\angle +120° =$

$= 10A(-1 + j0) + 10A(-0,5 + j0,866) =$

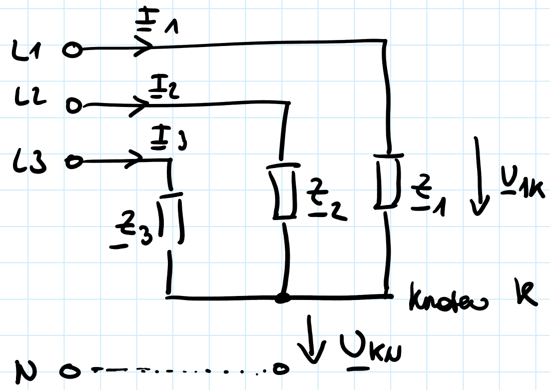
$= 10A(-1,5 + j0,866) = 17,32A\angle +150°$ (Zeiger siehe oben)

DREILEITERNETZ ⅄ UNSYMMETRISCH

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

$$\underline{U}_{1K}\underline{Y}_1 + \underline{U}_{2K}\underline{Y}_2 + \underline{U}_{3K}\underline{Y}_3 = 0$$

$$(\underline{U}_{1N}-\underline{U}_{KN})\underline{Y}_1 + (\underline{U}_{2N}-\underline{U}_{KN})\underline{Y}_2 + (\underline{U}_{3N}-\underline{U}_{KN})\underline{Y}_3 = 0$$



$$\underline{U}_{1N}\underline{Y}_1 + \underline{U}_{2N}\underline{Y}_2 + \underline{U}_{3N}\underline{Y}_3 = \underline{U}_{KN}(\underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3)$$

$$\underline{U}_{KN} = \frac{\underline{U}_{1N}\underline{Y}_1 + \underline{U}_{2N}\underline{Y}_2 + \underline{U}_{3N}\underline{Y}_3}{\underline{Y}_1 + \underline{Y}_2 + \underline{Y}_3}$$ STERNPUNKTSPANNUNG

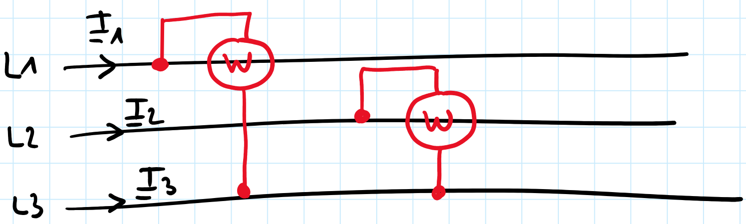
$$\underline{S} = \underline{U}_{1K}\underline{I}_1^* + \underline{U}_{2K}\cdot\underline{I}_2^* + \underline{U}_{3K}\underline{I}_3^* =$$

$$= \underline{U}_{1N}\underline{I}_1^* + \underline{U}_{2N}\underline{I}_2^* + \underline{U}_{3N}\underline{I}_3^* - \underline{U}_{KN}\underbrace{(\underline{I}_1^* + \underline{I}_2^* + \underline{I}_3^*)}_{=0}$$

$$\underline{I}_3^* = -\underline{I}_1^* - \underline{I}_2^*$$

$$\underline{S} = (\underline{U}_{1N} - \underline{U}_{3N})\underline{I}_1^* + (\underline{U}_{2N} - \underline{U}_{3N})\underline{I}_2^* =$$

$$= \underline{U}_{13}\underline{I}_1^* + \underline{U}_{23}\underline{I}_2^*$$

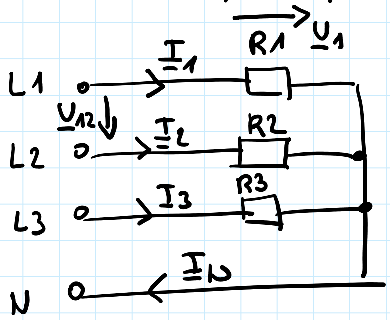


ARON – SCHALTUNG

DREILEITERSYSTEM Δ ASSYMETRISCH

- Summe Außenleiterströme = 0
- Außenleiterströme nicht symmetrisch
- $\underline{S} = \underline{U}_{1N}\underline{I}_1^* + \underline{U}_{2N}\underline{I}_2^* + \underline{U}_{3N}\underline{I}_3^*$ (→ Aron - Schaltung)

DREHSTROMSYSTEM



Vierleiter – Drehstromsystem

$U = 400V$ (verkettete Spannung U_Δ)

$\underline{U}_1 = 230V \angle 0^\circ$ (Annahme)

$R_1 = 80\Omega \quad R_2 = 20\Omega \quad R_3 = 50\Omega$

a) Spannung zwischen L1 und N ?

$$U_\lambda = \frac{U_\Delta}{\sqrt{3}} = \frac{400V}{\sqrt{3}} = 230,9V$$

b) Größen der Ströme $\underline{I}_1, \underline{I}_2, \underline{I}_3, \underline{I}_N$?

$$\underline{I}_1 = \underline{U}_1 \cdot \underline{Y}_1 = 230V \angle 0^\circ \cdot \frac{1}{80} \angle 0^\circ = 2,88A \angle 0^\circ$$

$$\underline{I}_2 = \underline{U}_2 \, \underline{Y}_2 = 230V \angle -120^\circ \, \frac{1}{20} \angle 0^\circ = 11,5A \angle -120^\circ$$

$$\underline{I}_3 = \underline{U}_3 \, \underline{Y}_3 = 230V \angle 120^\circ \, \frac{1}{50} \angle 0^\circ = 4,6A \angle +120^\circ$$

$$\underline{I}_N = \underline{I}_1 + \underline{I}_2 + \underline{I}_3 = 2,88 \angle 0^\circ + 11,5 \angle -120^\circ + 4,6 \angle +120^\circ =$$

$$= 7,9A \angle -130,9^\circ$$