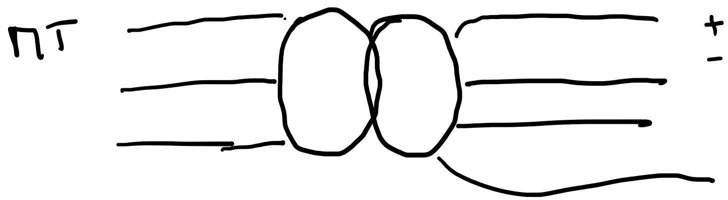
SISTEMI TRIFASE CON IL FILO NEUTRO



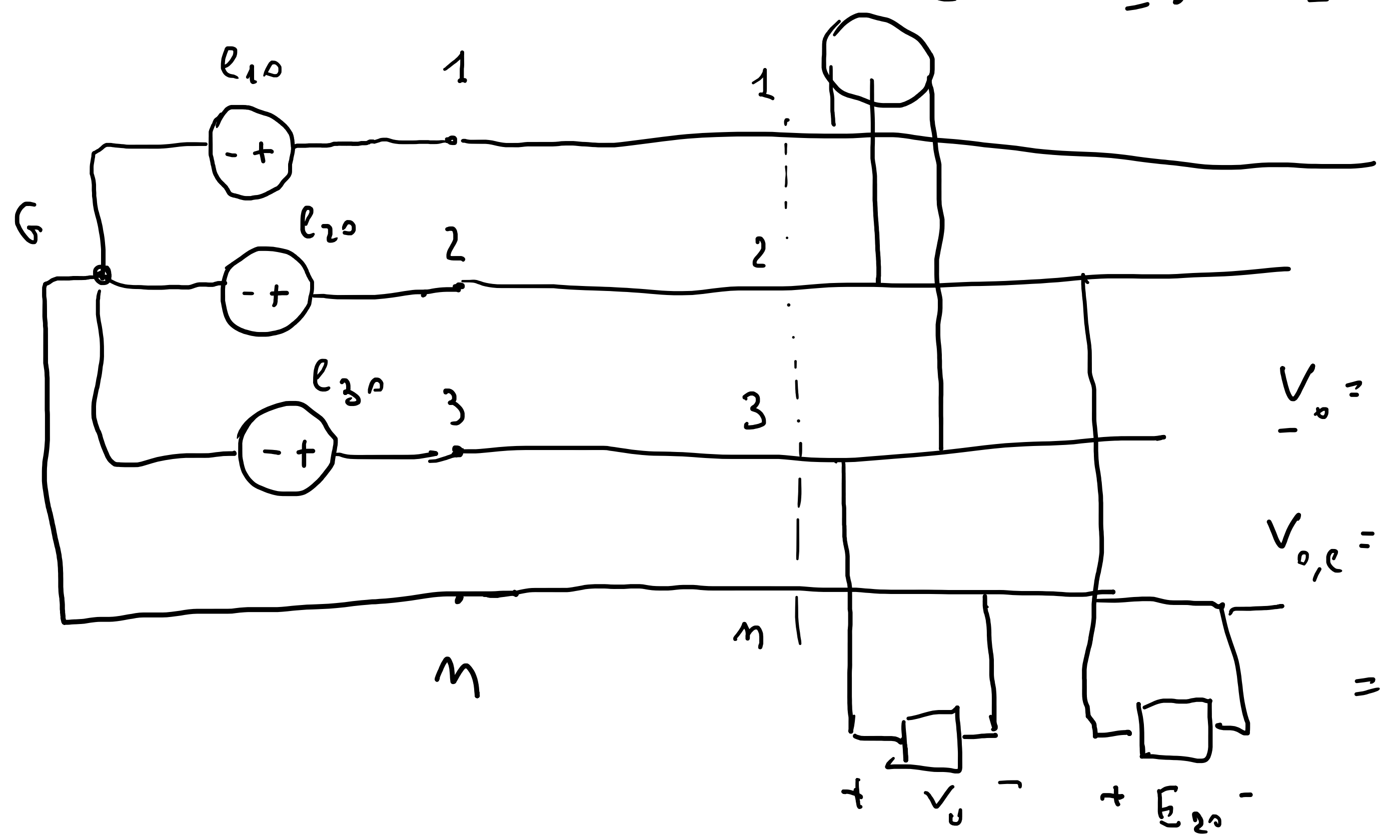
$V_e = 30$

15 kV

$V_e = 400\ V$

$$\begin{cases} \underline{V}_{12} = \underline{E}_{10} - \underline{E}_{20} \\ \underline{V}_{23} = \underline{E}_{20} - \underline{E}_{30} \\ \underline{V}_{31} = \underline{E}_{30} - \underline{E}_{10} \end{cases}$$

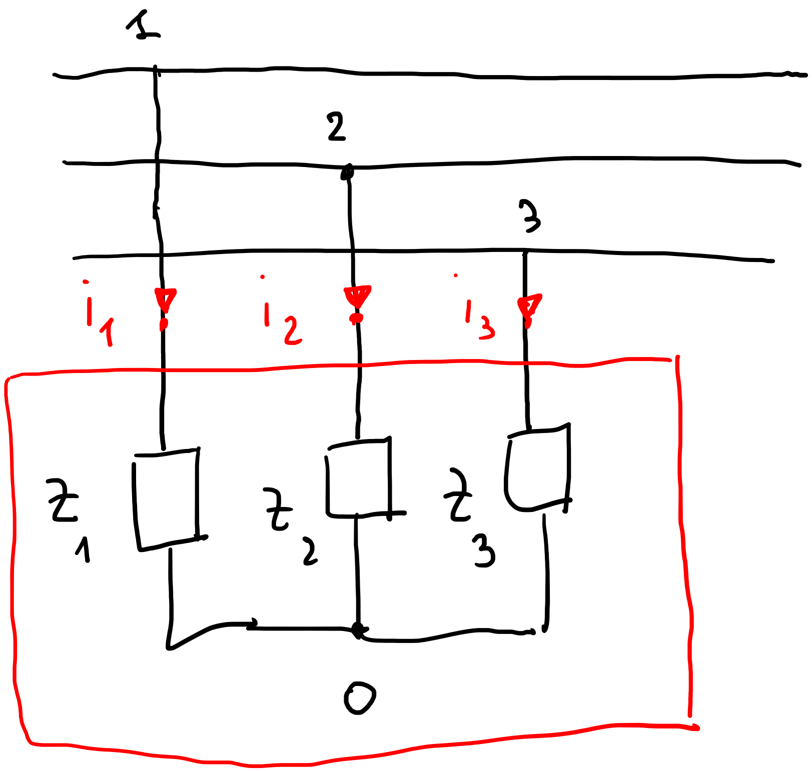
$V_e = 400\ V$



$\underline{V}_u = \underline{V}_{3G} = \underline{E}_{30}$

$V_{o,e} = E_e = \dfrac{V_e}{\sqrt{3}} =$

$= \dfrac{400}{\sqrt{3}} = 230\ V$



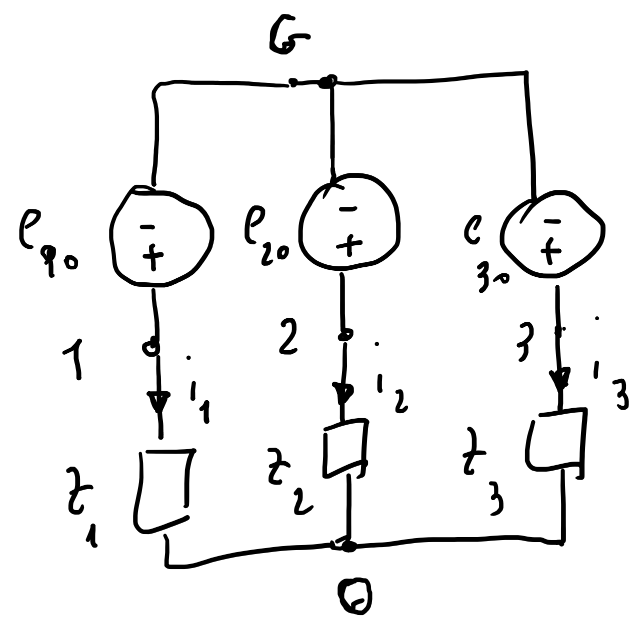
1 SIMMETRICO E

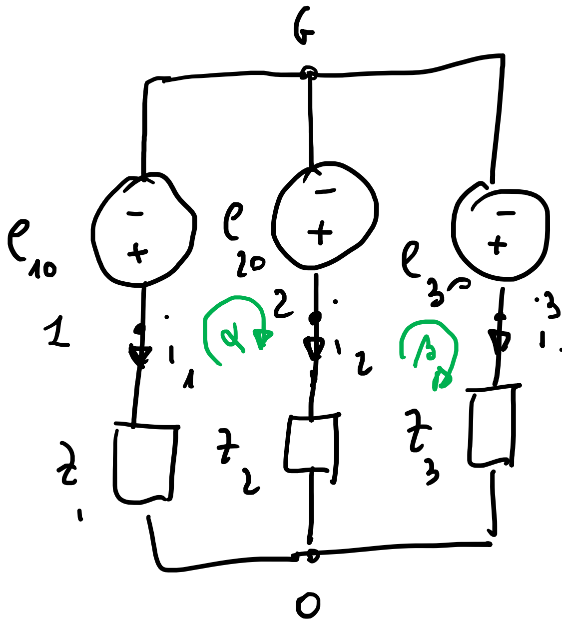
2 DIRETTO

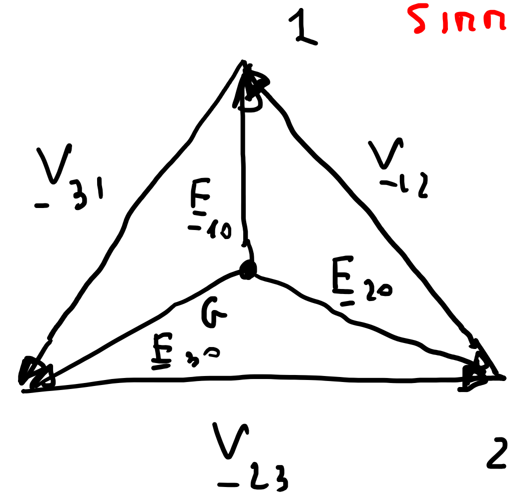
3 V_e

3 IMPEDENZE COLLEGATE A STELLA

DATI: Z_1, Z_2, Z_3







SIMMETRICO DIRETTO

$$\underline{V}_{23} = V_e$$

$$\underline{E}_e = \frac{V_e}{\sqrt{3}}$$

$$\underline{E}_{10} = E_e e^{j\frac{\pi}{2}}$$

RIFERIMENTO ANGOLI DI FASE

$$\underline{E}_{20} = \underline{E}_{10} e^{-j\frac{2}{3}\pi}$$

$$\underline{E}_{20} = E_e e^{j\frac{\pi}{2}} e^{-j\frac{2}{3}\pi} = E_e e^{j\left(\frac{\pi}{2}-\frac{2}{3}\pi\right)}$$

$$\underline{E}_{30} = \underline{E}_{10} e^{j\frac{2}{3}\pi} = E_e e^{j\frac{\pi}{2}} e^{j\frac{2}{3}\pi} = E_e e^{j\left(\frac{\pi}{2}+\frac{2}{3}\pi\right)}$$

$$\begin{cases} G) & \underline{I}_1 + \underline{I}_2 + \underline{I}_3 = 0 \\ \alpha) & -z_1\underline{I}_1 + \underline{E}_{10} - \underline{E}_{20} + z_2\underline{I}_2 = 0 \\ \beta) & -z_2\underline{I}_2 + \underline{E}_{20} - \underline{E}_{30} + z_3\underline{I}_3 = 0 \end{cases}$$

0 1 G 0 $\quad \underline{V}_{01} + \underline{V}_{1G} + \underline{V}_{G0} = 0$

$$-z_1\underline{I}_1 + \underline{E}_{10} + \underline{V}_{G0} = 0$$

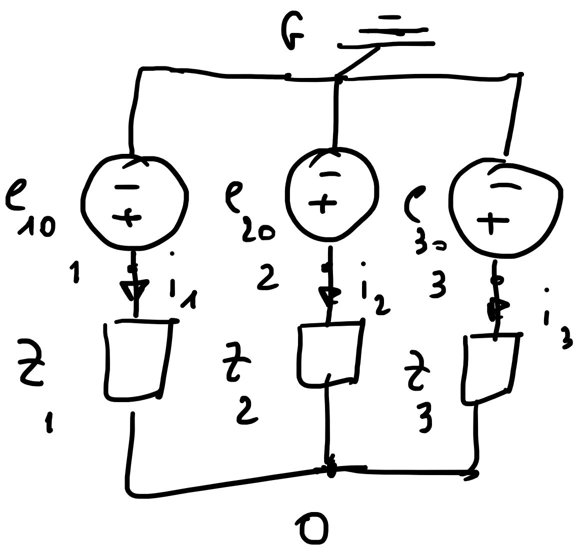
$$\underline{I}_1 = \frac{\underline{E}_{10} - \underline{V}_{0G}}{z_1} \qquad \underline{I}_k = \frac{\underline{E}_{k0} - \underline{V}_{0G}}{z_k}$$

$k = 1, 2, 3$

TENSIONI DI NODO : LE TENSIONI DEI NODI DEL CIRCUITO RISPETTO AD UN NODO PRESO COME RIFERIMENTO

$(N-1)$

N = NUMERO DI NODI



$$\underline{I}_1 = \frac{\underline{E}_{10} - \underline{V}_{0G}}{\underline{Z}_1}, \quad \underline{I}_2 = \frac{\underline{E}_{20} - \underline{V}_{0G}}{\underline{Z}_2}, \quad \underline{I}_3 = \frac{\underline{E}_{30} - \underline{V}_{0G}}{\underline{Z}_3}$$

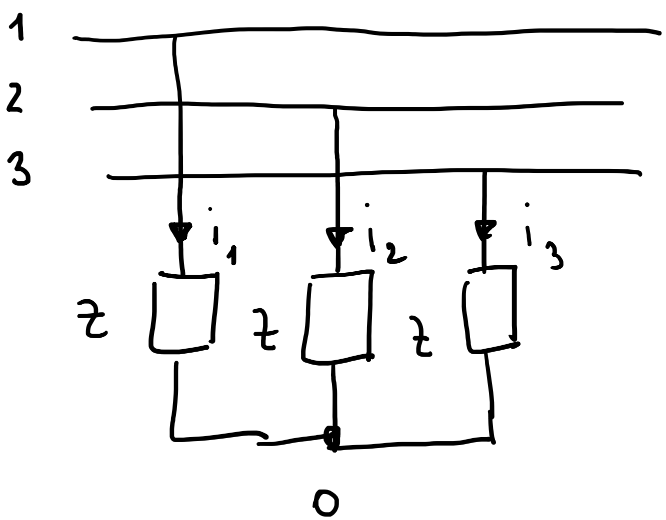
$$\underline{I}_1 + \underline{I}_2 + \underline{I}_3 = 0$$

$$\frac{\underline{E}_{10} - \underline{V}_{0G}}{\underline{Z}_1} + \frac{\underline{E}_{20} - \underline{V}_{0G}}{\underline{Z}_2} + \frac{\underline{E}_{30} - \underline{V}_{0G}}{\underline{Z}_3} = 0$$

$\underline{V}_{0G}$

$$\boxed{\underline{V}_{0G} = \frac{\dfrac{\underline{E}_{10}}{\underline{Z}_1} + \dfrac{\underline{E}_{20}}{\underline{Z}_2} + \dfrac{\underline{E}_{30}}{\underline{Z}_3}}{\dfrac{1}{\underline{Z}_1} + \dfrac{1}{\underline{Z}_2} + \dfrac{1}{\underline{Z}_3}}}$$

FORMULA DI MILLMAN



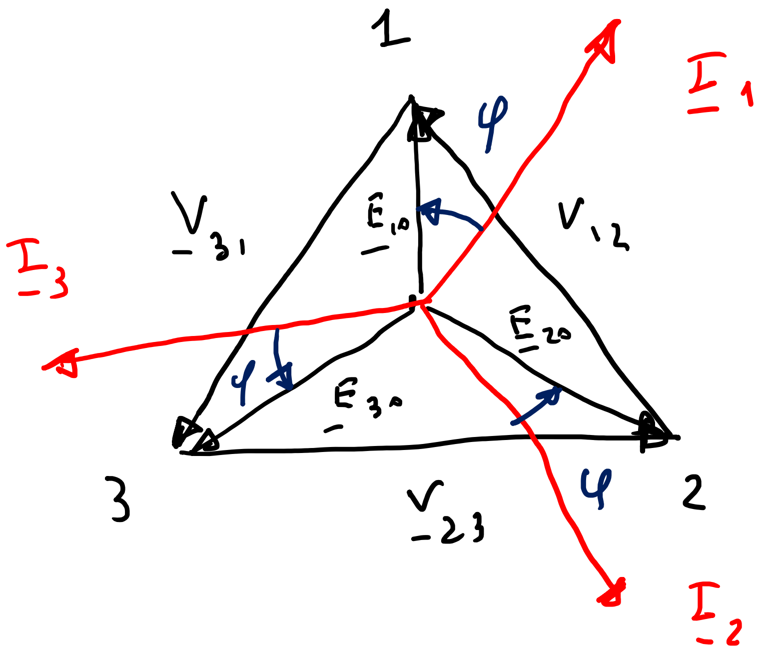
$$\underline{V}_{0G} = \frac{\dfrac{\underline{E}_{10}}{\underline{Z}} + \dfrac{\underline{E}_{20}}{\underline{Z}} + \dfrac{\underline{E}_{30}}{\underline{Z}}}{\dfrac{1}{\underline{Z}} + \dfrac{1}{\underline{Z}} + \dfrac{1}{\underline{Z}}} = \frac{\dfrac{1}{\underline{Z}} \left(\overbrace{\underline{E}_{10} + \underline{E}_{20} + \underline{E}_{30}}^{=0} \right)}{\dfrac{3}{\underline{Z}}} = 0$$

$$\underline{Z}_1 = \underline{Z} \quad \underline{Z}_2 = \underline{Z} \quad , \quad \underline{Z}_3 = \underline{Z}$$

$$\underline{I}_1 = \frac{\underline{E}_{10} - \underline{V}_{0G}}{\underline{Z}} = \frac{\underline{E}_{10}}{\underline{Z}} \quad , \quad \underline{I}_2 = \frac{\underline{E}_{20}}{\underline{Z}} \quad , \quad \underline{I}_3 = \frac{\underline{E}_{30}}{\underline{Z}}$$

$$I_{1e} = \left| \frac{\underline{E}_{10}}{\underline{Z}} \right| = \frac{|\underline{E}_{10}|}{|\underline{Z}|} = \frac{E_e}{|\underline{Z}|} = \frac{V_e}{\sqrt{3}\,|\underline{Z}|} = I_e = I_{2,e} = I_{3,e}$$

$$\underline{I}_2 = \frac{\underline{E}_{20}}{\underline{Z}} = \frac{\underline{E}_{10}\, e^{-j\frac{2}{3}\pi}}{\underline{Z}} = \frac{\underline{E}_{10}}{\underline{Z}}\, e^{-j\frac{2}{3}\pi} = \underline{I}_1\, e^{-j\frac{2}{3}\pi}$$



$$\underline{I}_1 = \frac{\underline{E}_{10}}{\underline{Z}} = \frac{E_e\, e^{j\alpha_{10}}}{|Z|\, e^{j\vartheta}} =$$

$$\underline{E}_{10} = E_e\, e^{j\alpha_{10}}$$

$$\underline{Z} = |Z|\, e^{j\vartheta}$$

$$\underline{I}_1 = \frac{E_e}{|Z|}\, e^{j(\alpha_{10}-\vartheta)}$$

$$Z = R + jX \qquad |Z| = \sqrt{R^2 + X^2}$$

$$\cos\vartheta = \frac{R}{\sqrt{R^2+X^2}}$$

$$\vartheta = \tan^{-1}\left(\frac{X}{R}\right)$$

$$\sin\vartheta = \frac{X}{\sqrt{R^2+X^2}}$$

$$I_e = \frac{E_e}{|Z|} \qquad \alpha_{i1} = \alpha_{10} - \vartheta$$

$$\varphi = \alpha_{10} - \alpha_{i1} = \vartheta$$

$$P = R_1 I_{1,e}^2 + R_2 I_{2,e}^2 + R_3 I_{3,e}^2$$

$$Q = X_1 I_{1,e}^2 + X_2 I_{2,e}^2 + X_3 I_{3,e}^2$$

$$Z_1 = R_1 + j X_1$$
$$Z_2 = R_2 + j X_2$$
$$Z_3 = R_3 + j X_3$$

$$Z_1 = Z_2 = Z_3 = Z$$

$$I_{1e} = I_{2,e} = I_{3,e} = I_e = \frac{V_e}{\sqrt{3}\,|Z|} = \frac{V_e}{\sqrt{3}\sqrt{R^2 + X^2}}$$

$$Z = R + jX$$

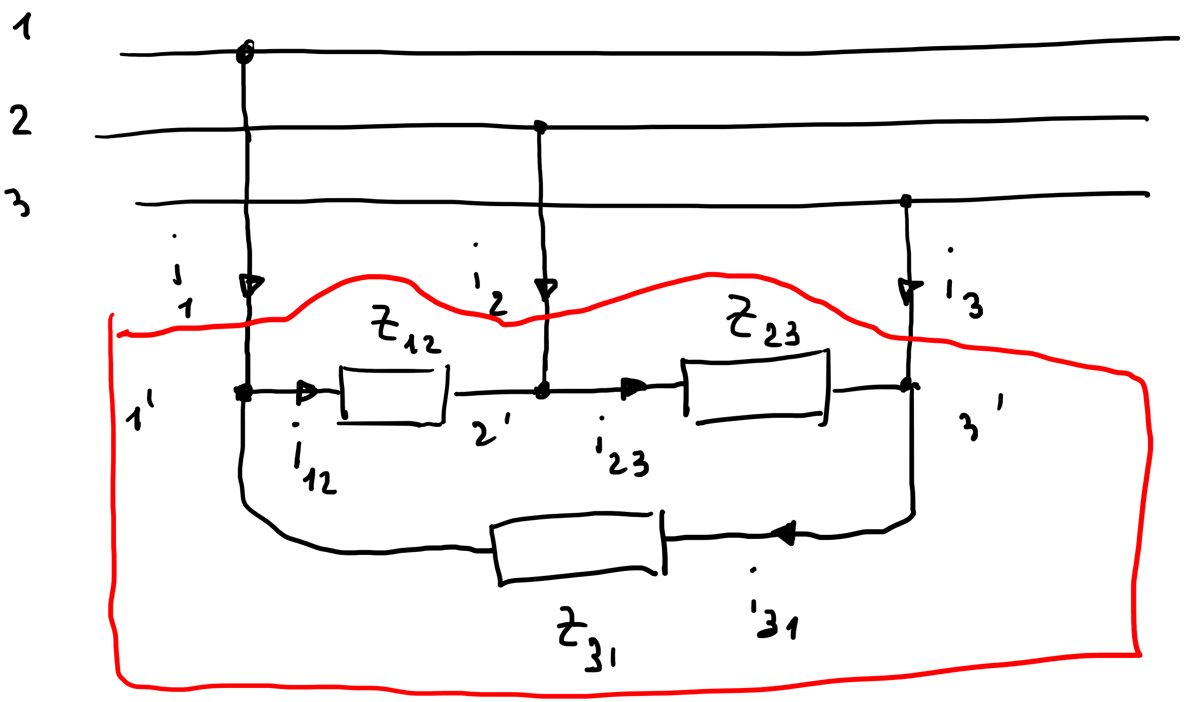
$$P = 3 R I_e^2 \quad , \quad Q = 3 X I_e^2$$

COLLEGAMENTO A TRIANGOLO

SISTEMA SIMMETRICO DIRETTO V_e

Z_{12}, Z_{23}, Z_{31}

i_1, i_2, i_3



$$\underline{I}_{12} = \frac{\underline{V}_{12}}{Z_{12}} \qquad \underline{I}_{31} = \frac{\underline{V}_{31}}{Z_{31}}$$

$$\underline{I}_{23} = \frac{\underline{V}_{23}}{Z_{23}}$$

CORRENTI DI FASE

1') $\underline{I}_1 = \underline{I}_{12} - \underline{I}_{31}$

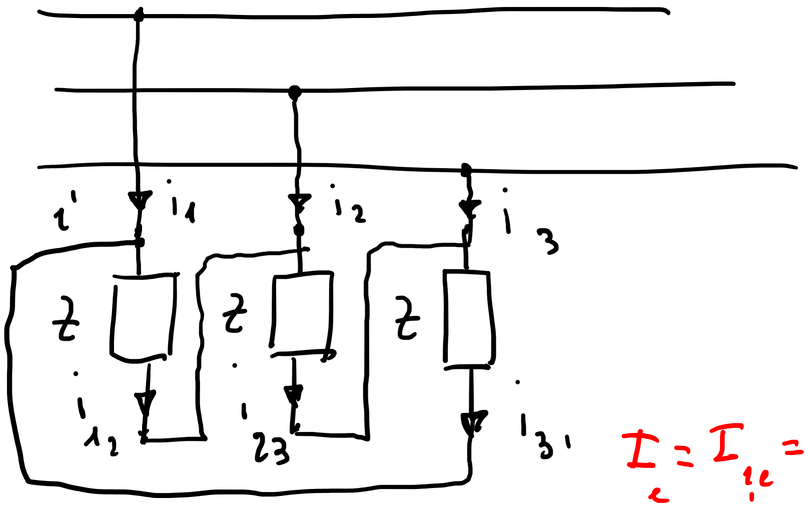
2') $\underline{I}_2 = \underline{I}_{23} - \underline{I}_{12}$

3') $\underline{I}_3 = \underline{I}_{31} - \underline{I}_{23}$

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

$$I_{12,e} = I_{23,e} = I_{31,e} = \frac{V_e}{|z|} = I_{z,e}$$

$$z_{12} = z_{23} = z_{31} = z \qquad I_e = \sqrt{3}\, I_{z,e}$$



$$\underline{I}_{12} = \frac{\underline{V}_{12}}{z}, \quad \underline{I}_{23} = \frac{\underline{V}_{23}}{z}$$

$$\underline{I}_{31} = \frac{\underline{V}_{31}}{z}$$

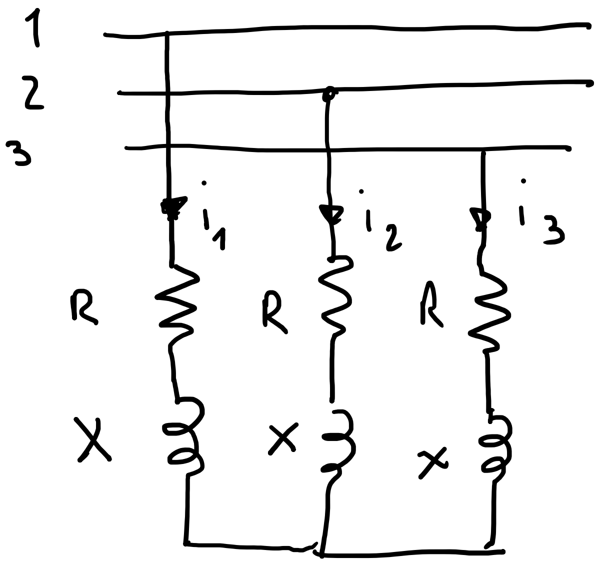
$$I_e = I_{1e} = I_{2e} = I_{3,e} = \frac{3\, E_e}{|z|} = \frac{3\,\frac{V_e}{\sqrt{3}}}{|z|} = \frac{\sqrt{3}\, V_e}{|z|}$$

$$\underline{I}_1 = \underline{I}_{12} - \underline{I}_{31} = \frac{\underline{V}_{12}}{z} - \frac{\underline{V}_{31}}{z} = \frac{1}{z}\left(\underline{V}_{12} - \underline{V}_{31}\right) =$$

$$= \frac{1}{z}\left(\underline{E}_{10} - \underline{E}_{20} - \underline{E}_{30} + \underline{E}_{10}\right) = \frac{1}{z}\Big(3\,\underline{E}_{10} \underbrace{- \underline{E}_{10} - \underline{E}_{20} - \underline{E}_{30}}_{=0}\Big)$$

$$\underline{I}_1 = \frac{3\,\underline{E}_{10}}{z}, \quad \underline{I}_2 = \frac{3\,\underline{E}_{20}}{z}, \quad \underline{I}_3 = \frac{3\,\underline{E}_{30}}{z}$$

$$\begin{cases} \underline{V}_{12} = \underline{E}_{10} - \underline{E}_{20} \\ \underline{V}_{23} = \underline{E}_{20} - \underline{E}_{30} \\ \underline{V}_{31} = \underline{E}_{30} - \underline{E}_{10} \end{cases} \qquad \underline{E}_{10} + \underline{E}_{20} + \underline{E}_{30} = 0$$



$V_e = 400$ V SIMMETRICO E DIRETTO

$R = 3\ \Omega$ $x = \omega L = 2\ \Omega$

$\dot{Z} = 3 + j2$

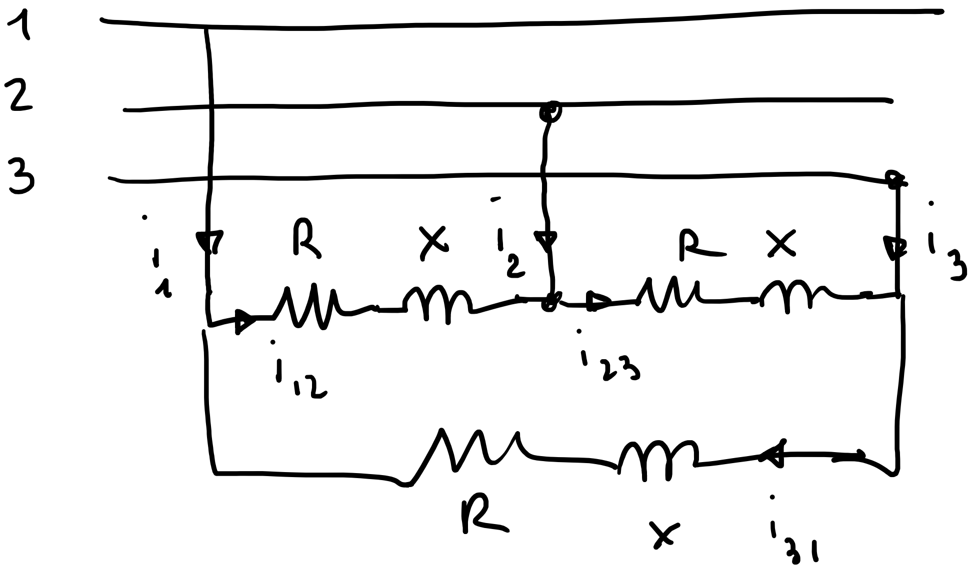
$$I_{1,e} = I_{2,e} = I_{3,e} = I_e = \frac{\frac{V_e}{\sqrt{3}}}{\sqrt{R^2 + X^2}} = \frac{\frac{400}{\sqrt{3}}}{\sqrt{9+4}} =$$

$$I_e = \frac{230.9}{3.606} = 64.03 \text{ A}$$

$$P = 3 R I_e^2 = 3 \times 3 \times 64.03^2 = 36'899 \text{ W}$$

$$Q = 3 X I_e^2 = 3 \times 2 \times 64.03^2 = 24'599 \text{ VAR}$$

$$\tan\varphi = \frac{Q}{P} = \frac{24'599}{36'899} = 0.6667 \Rightarrow \varphi = 0.588 \text{ rad}$$



$V_\ell = 400 \ V$

$R = 9 \ \Omega$

$X = 6 \ \Omega$

$$I_{12,\ell} = I_{23,\ell} = I_{31,\ell} = I_{z,\ell} = \frac{V_\ell}{|Z|}$$

$$\dot{Z} = R + jX = 9 + j6$$

$$|Z| = \sqrt{9^2 + X^2} = 10.82 \ \Omega$$

$$I_{z,\ell} = \frac{400}{10.82} = 36.97 \ A$$

$$P = 3 \ R \ I_{z,\ell}^2 = 3 \times 9 \times 36.97^2 = 36\,903 \ W$$

$$Q = 3 \ X \ I_{z,\ell}^2 = 3 \times 6 \times 36.97^2 = 24\,602 \ VAR$$

$$I_{1,\ell} = I_{2,\ell} = I_{3,\ell} = \sqrt{3} \ I_{z,\ell} = \sqrt{3} \times 36.97 = 64.03 \ A$$