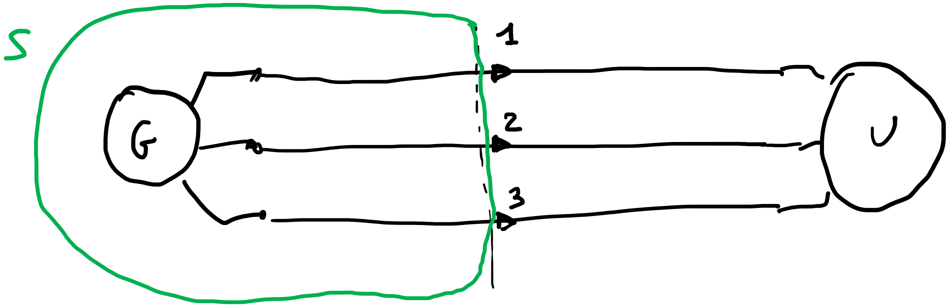
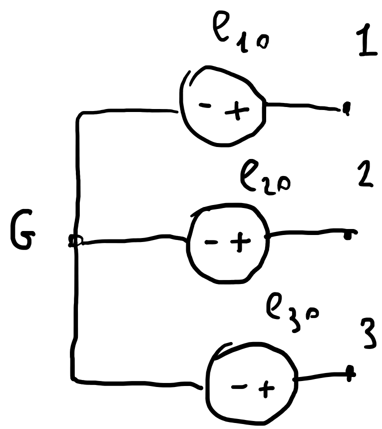


$v_{12},\ v_{23},\ v_{31}$ TEN. CONCATENATE

$i_1,\ i_2,\ i_3$ COR. LINEA

LKT 1231 $\quad v_{12}(t)+v_{23}(t)+v_{31}(t)=0 \qquad \underline{V}_{12}+\underline{V}_{23}+\underline{V}_{31}=0$

LKC S $\quad i_1(t)+i_2(t)+i_3(t)=0 \qquad \underline{I}_1+\underline{I}_2+\underline{I}_3=0$



$e_{10},\ e_{20},\ e_{30}$ TENSIONI PRINCIPALI DI FASE (STELLATE)

$$\left.\begin{aligned}\underline{V}_{12}&=\underline{E}_{10}-\underline{E}_{20}\\ \underline{V}_{23}&=\underline{E}_{20}-\underline{E}_{30}\end{aligned}\right\}+$$

$$\cancel{\underline{V}_{31}=\underline{E}_{30}-\underline{E}_{10}} \qquad \underline{E}_{10}+\underline{E}_{20}+\underline{E}_{30}=0$$

$$\underline{V}_{12}+\underline{V}_{23}=\underline{E}_{10}-\underline{E}_{30} \Rightarrow -\underline{V}_{31}=\underline{E}_{10}-\underline{E}_{30} \qquad \underline{V}_{31}=\underline{E}_{30}-\underline{E}_{10}$$

$$\underline{V}_{31}=-\underline{V}_{12}-\underline{V}_{23}$$

SISTEMA TRIFASE SIMMETRICO $V_{12,e} = V_{23,e} = V_{31,e} = V_e$

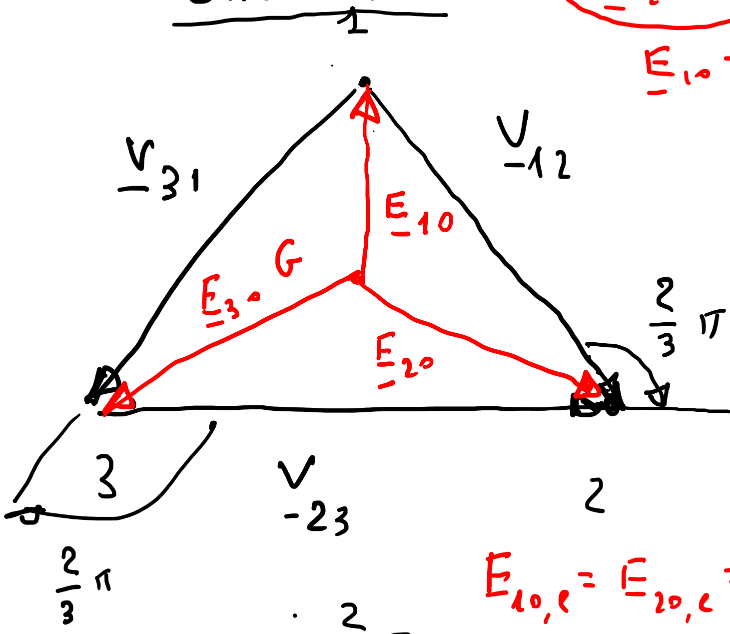
$\underline{V}_{12} + \underline{V}_{23} + \underline{V}_{31} = 0$

$\underline{E}_{10} - \underline{E}_{20} = \underline{V}_{12}$ $\quad$ $\underline{E}_{30} - \underline{E}_{10} = \underline{V}_{31}$

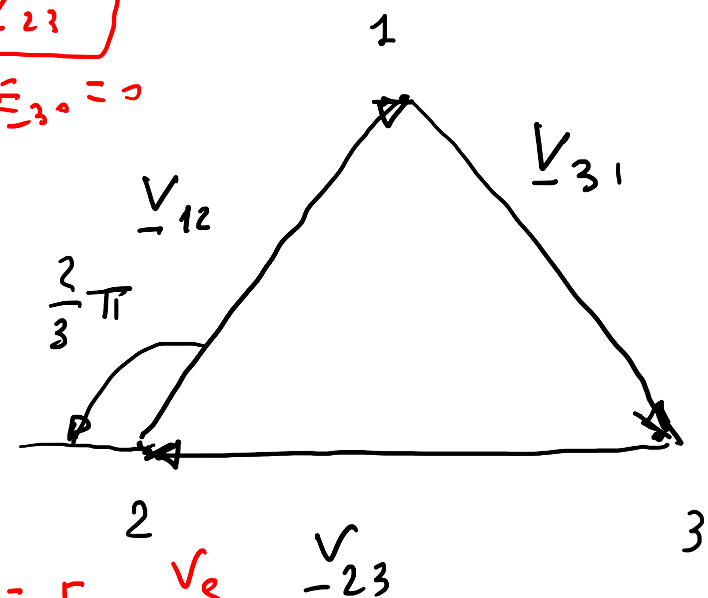
$\underline{E}_{20} - \underline{E}_{30} = \underline{V}_{23}$

$\underline{E}_{10} + \underline{E}_{20} + \underline{E}_{30} = 0$

DIRETTO



INVERSO



$$E_{10,e} = E_{20,e} = E_{30,e} = E_f = \frac{V_e}{\sqrt{3}}$$

$$\underline{V}_{23} = \underline{V}_{12}\, e^{-j\frac{2}{3}\pi}$$

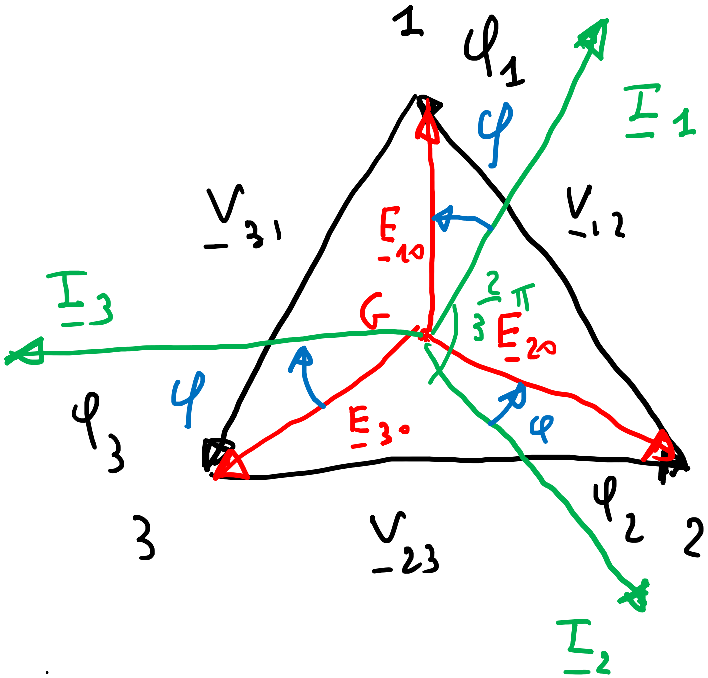
$$\underline{V}_{31} = \underline{V}_{23}\, e^{-j\frac{2}{3}\pi}$$

$$\underline{V}_{12} = \underline{V}_{31}\, e^{-j\frac{2}{3}\pi}$$

$$\underline{V}_{23} = \underline{V}_{12}\, e^{j\frac{2}{3}\pi}$$

$$\underline{V}_{31} = \underline{V}_{23}\, e^{j\frac{2}{3}\pi}$$

$$\underline{V}_{12} = \underline{V}_{31}\, e^{j\frac{2}{3}\pi}$$



SISTEMA EQUILIBRATO

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

$$I_{1,e} = I_{2,e} = I_{3,e} = I_e$$

$$\underline{I}_2 = \underline{I}_1 e^{-j\frac{2}{3}\pi}$$

$$\underline{I}_3 = \underline{I}_2 e^{-j\frac{2}{3}\pi}$$

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

$$\underline{V}_{12} = \underline{V}_{23} e^{j\frac{2}{3}\pi} = V_e e^{j\frac{2}{3}\pi}$$

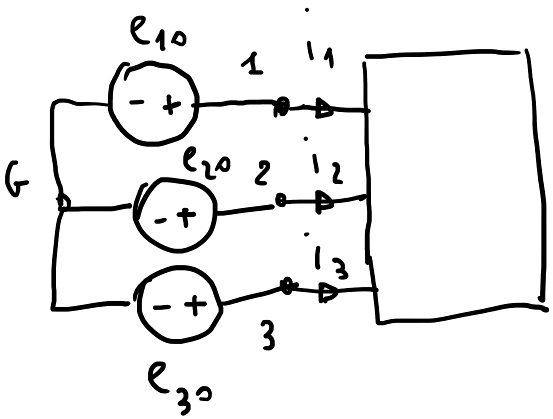
$$\underline{V}_{31} = \underline{V}_{23} e^{-j\frac{2}{3}\pi} = V_e e^{-j\frac{2}{3}\pi}$$

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

$$\underline{E}_{20} = \underline{E}_{10} e^{-j\frac{2}{3}\pi} = \frac{V_e}{\sqrt{3}} e^{j\left(\frac{\pi}{2} - \frac{2}{3}\pi\right)}$$

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

SISTEMA EQUILIBRATO $\quad I_{1,e} = I_{2,e} = I_{3,e} = I_e$



$$P(t) = \sum_{k=1}^{3} v_{k0}(t)\, i_k(t) =$$

$$0 \equiv 2 \qquad = v_{12}(t)\, i_1(t) + v_{32}(t)\, i_3(t) =$$

$$0 \equiv G \qquad = \sum_{k=1}^{3} e_{k0}(t)\, i_k(t)$$

$$P = \text{POT. ATTIVA } (W) = \frac{1}{T}\int_0^T p(t)\,dt = \frac{1}{T}\int_0^T \sum_{k=1}^{3} e_{k0}(t)\, i_k(t)\,dt =$$

$$= \sum_{k=1}^{3} \frac{1}{T}\int_0^T e_{k0}(t)\, i_k(t)\,dt = \sum_{k=1}^{3} E_{k0,e}\, I_{k,e} \cos(\varphi_k) = \sum_{k=1}^{3} \frac{V_e}{\sqrt{3}} I_e \cos\varphi$$

$$\varphi_k = \alpha_{e_{k0}} - \alpha_{i_k}$$

<u>SIMMETRICO ED EQUILIBRATO</u>

$$E_{k0,e} = E_e = \frac{V_e}{\sqrt{3}}$$

$$\varphi_k = \varphi$$

$$I_{k,e} = I_e$$

$$P = 3\,\frac{V_e}{\sqrt{3}} I_e \cos\varphi = \sqrt{3}\, V_e\, I_e \cos\varphi$$

$$\varphi = \alpha_{e_{k0}} - \alpha_{i_k}$$

$$N = \sum_{k=1}^{3} \underline{E}_{k0} \, \underline{I}_k^{*} = P + jQ$$

SIMMETRICO ED EQUILIBRATO

$$\underline{E}_{k0} = \frac{V_e}{\sqrt{3}} e^{j\alpha_{e_{k0}}}$$

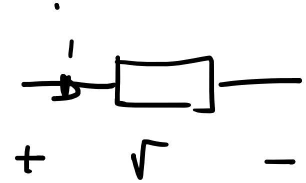
$$\alpha_{e_{k0}} - \alpha_{i_k} = \varphi$$

$$\underline{I}_k = I_e \, e^{j\alpha_{i_k}}$$

$$N = \sum_{k=1}^{3} \frac{V_e}{\sqrt{3}} e^{j\alpha_{e_{k0}}} I_e \, e^{-j\alpha_{i_k}} =$$

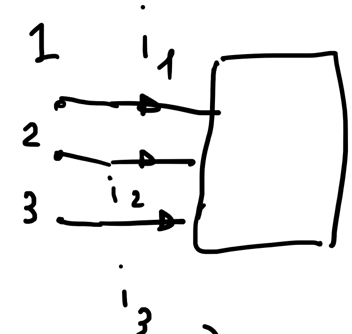
$$= \sum_{k=1}^{3} \frac{V_e I_e}{\sqrt{3}} e^{j\varphi} = \overset{\sqrt{3}}{\cancel{3}} \frac{V_e I_e}{\cancel{\sqrt{3}}} e^{j\varphi}$$

$$= \underbrace{\sqrt{3} V_e I_e \cos\varphi}_{P\ (W)} + j \underbrace{\sqrt{3} V_e I_e \sin\varphi}_{Q\ (VAR)}$$



$$p(t) = v(t)\, i(t)$$

$$N = \underline{V}\, \underline{I}^{*}$$



$$p(t) = \sum_{k=1}^{3} e_{k0}(t)\, i_k(t)$$

$$p(t) = v_{12}(t)\, i_1(t) + v_{32}(t)\, i_3(t)$$

$$N = \underline{V}_{12} \underline{I}_1^{*} + \underline{V}_{32} \underline{I}_3^{*}$$

$$A = |N| = |P + jQ| = \sqrt{P^2 + Q^2} = \sqrt{3}\, V_e I_e$$

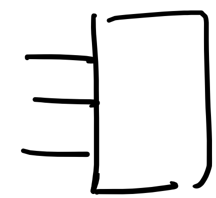
(VA)

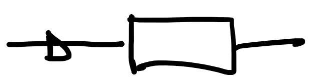
$$P = \sqrt{3}\, V_e I_e \cos\varphi = A \cos\varphi$$

$$Q = \sqrt{3}\, V_e I_e \sin\varphi = A \sin\varphi$$

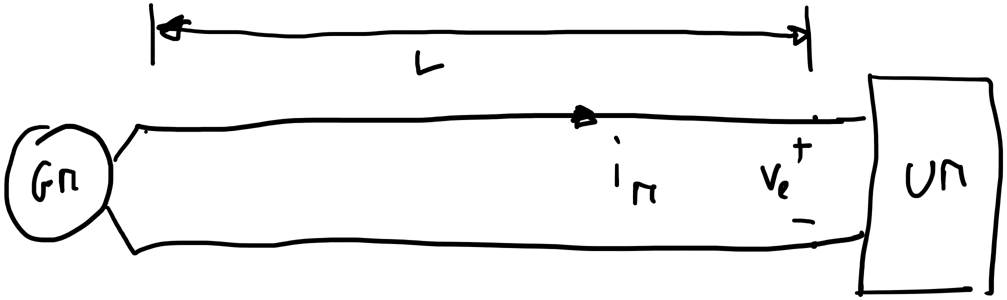
$$\frac{Q}{P} = \tan\varphi$$

$$I_e = \frac{P}{\sqrt{3}\, V_e \cos\varphi}$$





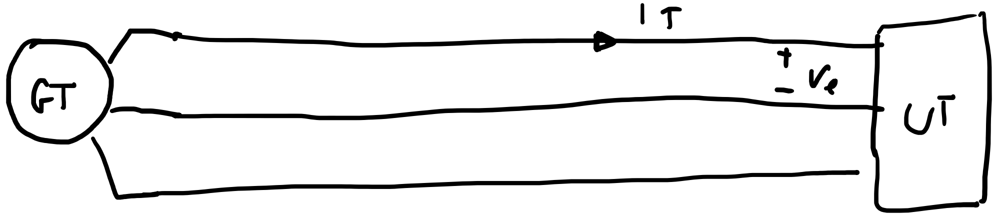
$$I_e = \frac{P}{V_e \cos\varphi}$$



P, $\cos\varphi$, V_e, ρ

VOL = VOLUME DI CONDUTTORE UTILIZZATO

UGUALE COSTO DELLE DUE LINEE. , UGUALE MATERIALE CONDUTTORE



P, $\cos\varphi$, V_e, ρ

VOL

$$\mathcal{P}_M = 2\left(\rho\frac{L}{S_M}\right)\left(\frac{P}{V_e\cos\varphi}\right)^2$$

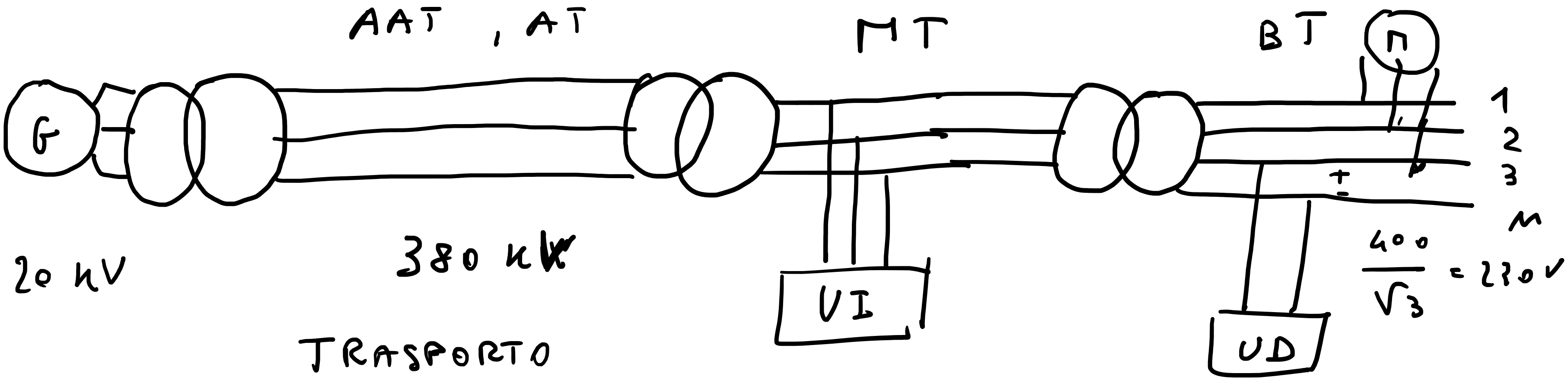
$$= 2\,\cancel{\rho}\,\frac{\cancel{L^2}\times 2}{\cancel{VOL}}\,\frac{\cancel{P^2}}{\cancel{V_e^2}\,\cancel{\cos^2\varphi}}$$

$$VOL = 2\,S_M\,L \qquad S_M = \frac{VOL}{2\times L}$$

$$VOL = 3\,S_T\,L \qquad S_T = \frac{VOL}{3\times L}$$

$$\frac{\mathcal{P}_T}{\mathcal{P}_M} = \frac{3}{4} = 0.75$$

$$\mathcal{P}_T = 3\left(\rho\frac{L}{S_T}\right)\left(\frac{P}{\sqrt{3}\,V_e\cos\varphi}\right)^2 = 3\,\cancel{\rho}\,\frac{\cancel{L^2}\times\cancel{3}}{\cancel{VOL}}\,\frac{\cancel{P^2}}{\cancel{3}\,\cancel{V_e^2}\,\cancel{\cos^2\varphi}}$$



TRASPORTO

(E INTERCONNESSIONE)

$$I_e = \frac{P}{\sqrt{3}\, V_e \cos\varphi}$$

AAT 380 kV

AT 130 kV

MT = 15 kV

BT $V_e = 400\,V$