POLITECNICO DI MILANO

Elettrotecnica
Parte 10: Sistemi Trifase

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Dipartimento di Elettronica, Informazione e Bioingegneria

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Indice

- Sistema Trifase
- Potenza nel sistema trifase
- Cenni di distribuzione della potenza

Terna trifase di Generatori

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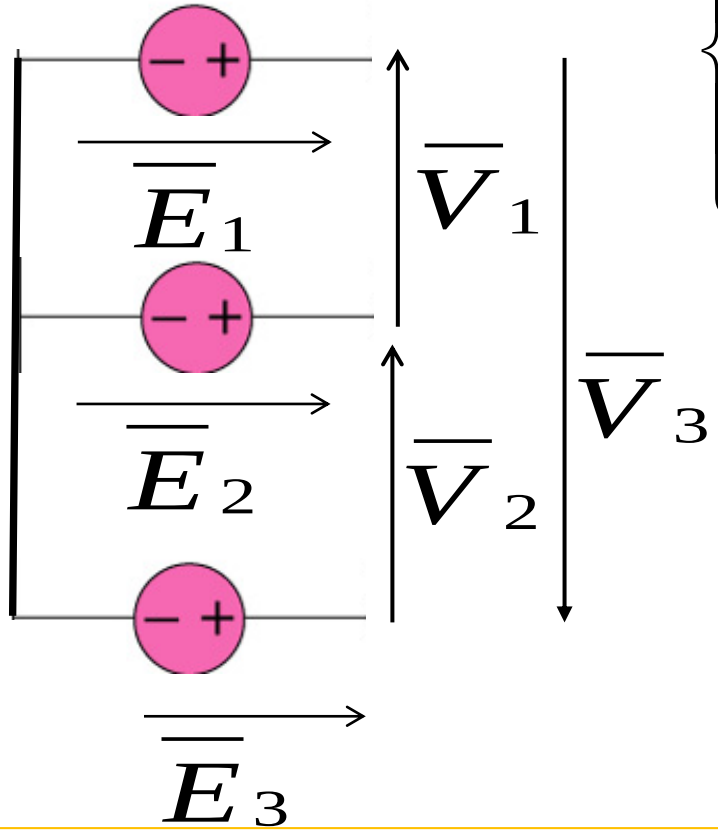
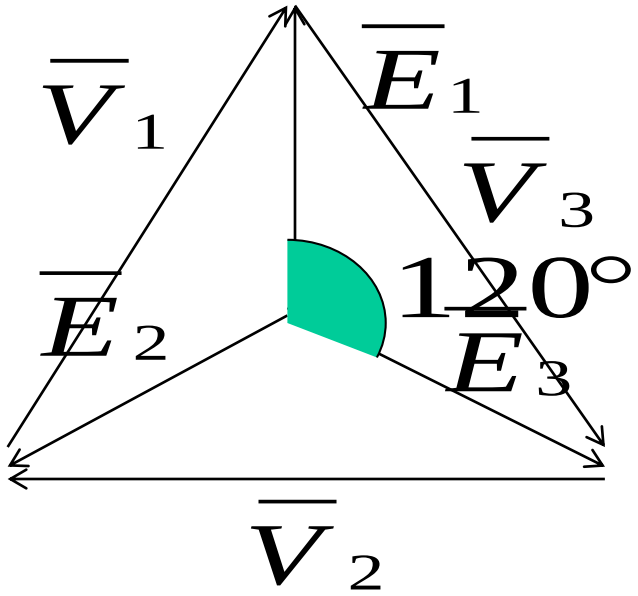
$$\begin{cases} e_1 = E_p \cos(\omega t + \phi) \\ e_2 = E_p \cos(\omega t + \phi + 120°) \\ e_3 = E_p \cos(\omega t + \phi + 240°) \end{cases}$$





$$V_p = \sqrt{3} E_p$$

$$\angle \overline{V} = \angle \overline{E} + 30°$$

Terna trifase di Generatori

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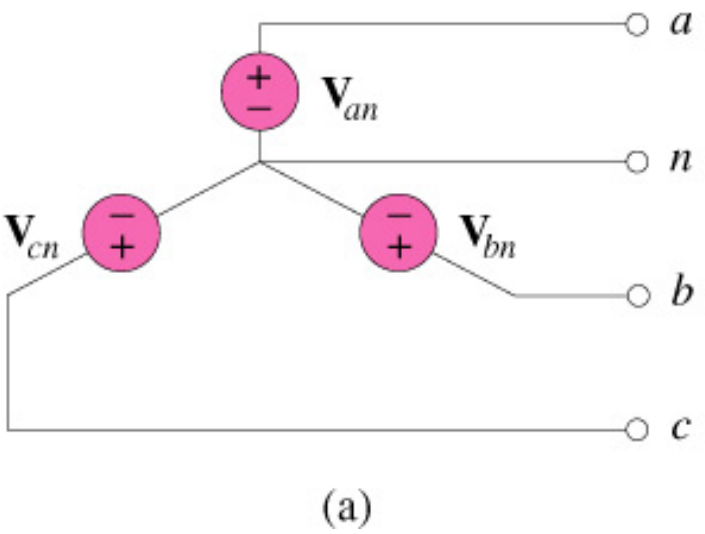
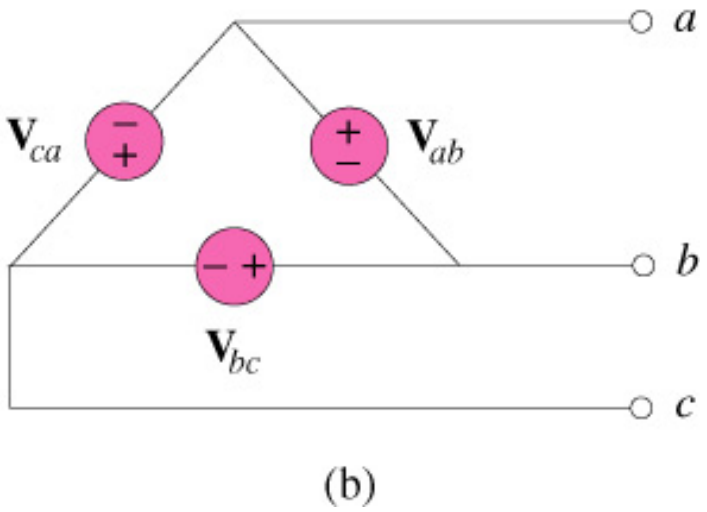


(a)



(b)

Carico Trifase

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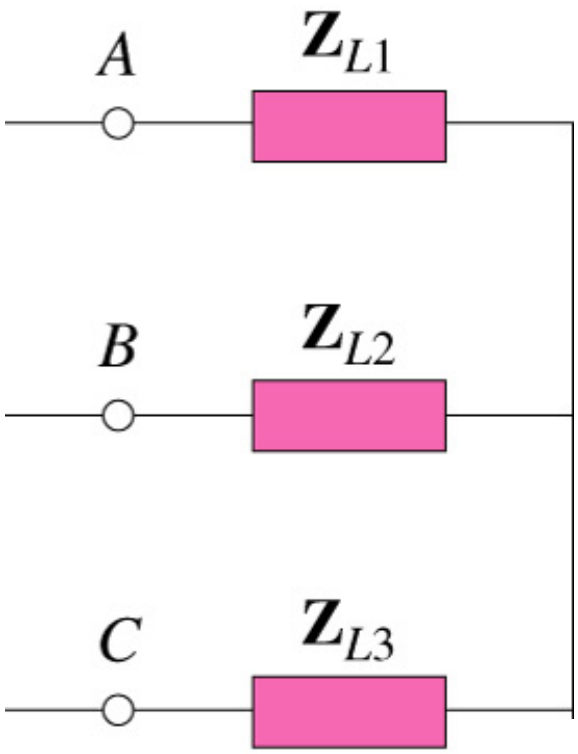

Carico Trifase bilanciato

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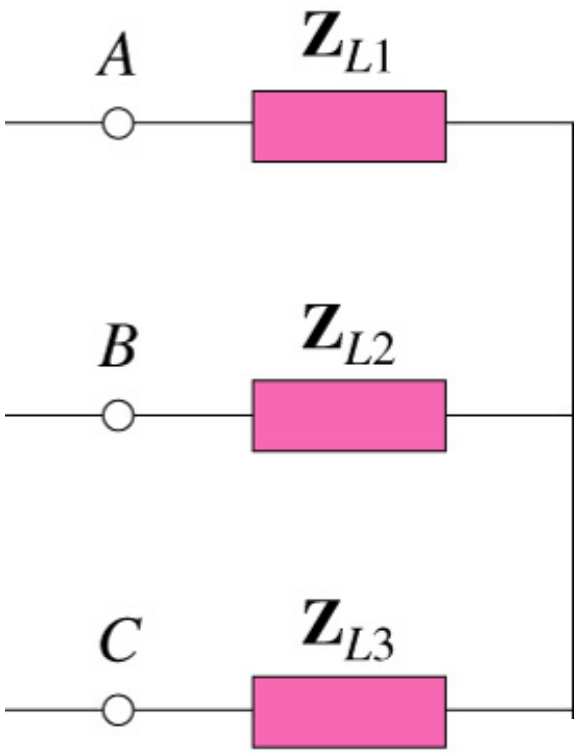

$$\overline{Z_{L1}} = \overline{Z_{L2}} = \overline{Z_{L3}}$$

Carico Trifase bilanciato

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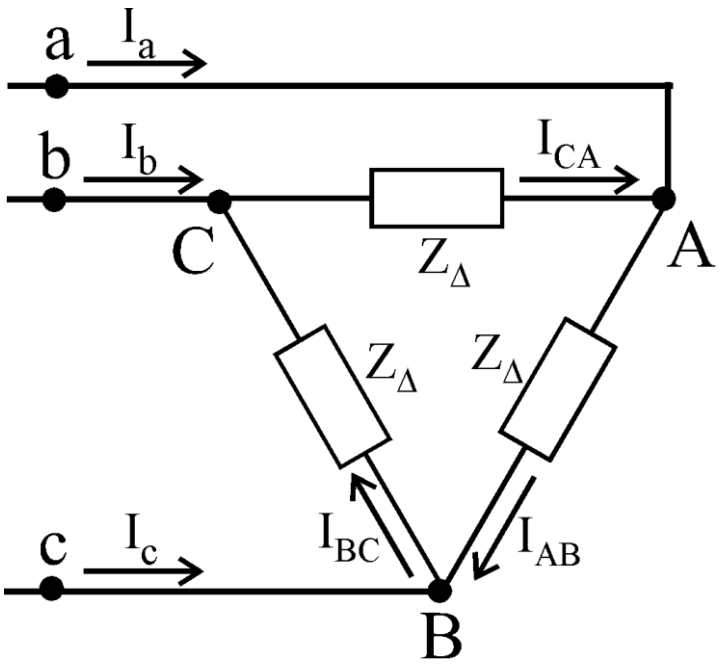

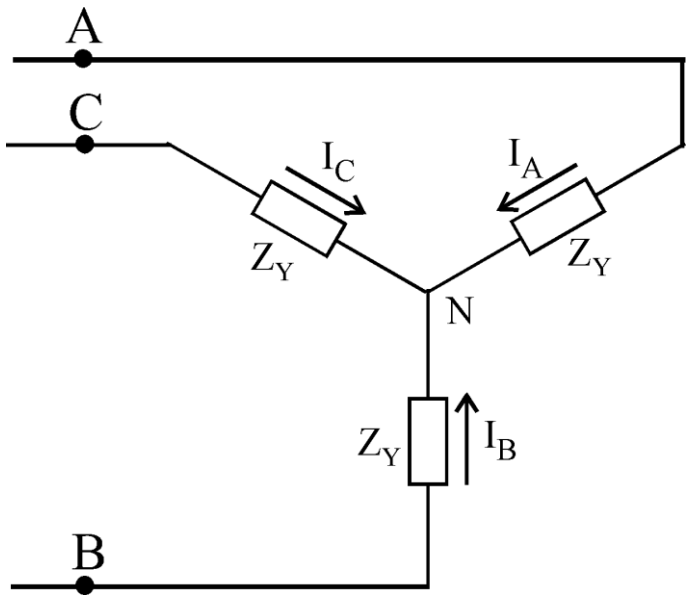

$$\overline{Z}_\Delta = 3\overline{Z}_Y$$

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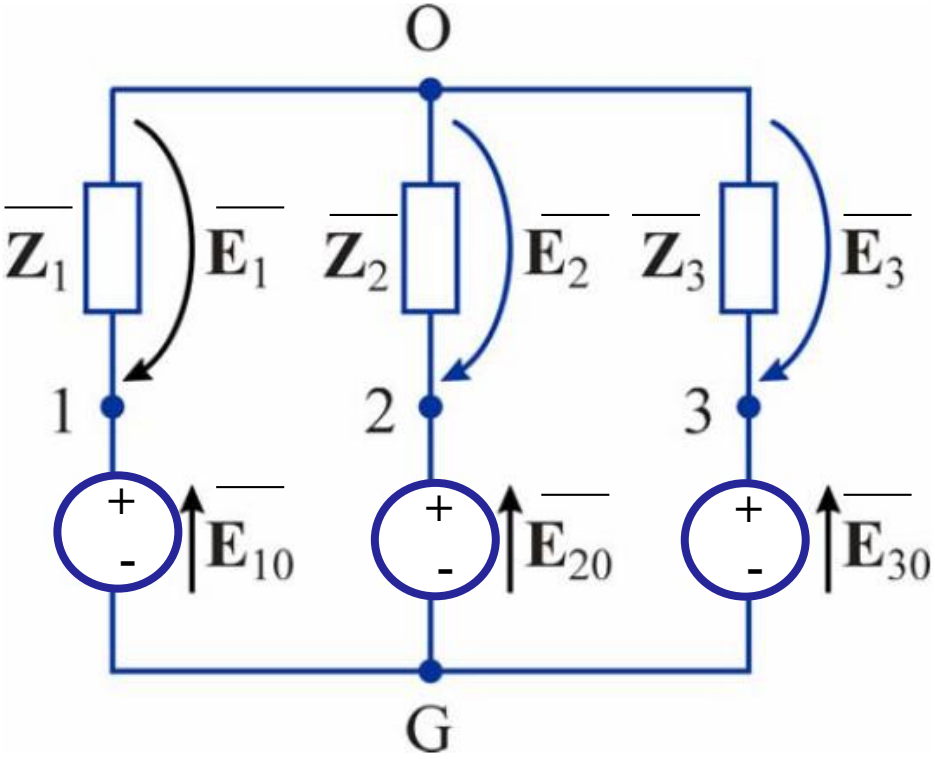
Tensione di Centro stella



$$\mathbf{V}_{OG} = \frac{\mathbf{E}_{10}\mathbf{Y}_1 + \mathbf{E}_{20}\mathbf{Y}_2 + \mathbf{E}_{30}\mathbf{Y}_3}{\mathbf{Y}_1 + \mathbf{Y}_2 + \mathbf{Y}_3}$$

$$\mathbf{V}_{OG} = \frac{\mathbf{E}_{10} + \mathbf{E}_{20} + \mathbf{E}_{30}}{3} = 0$$

Nb: Sono in grassetto quindi sono numeri complessi

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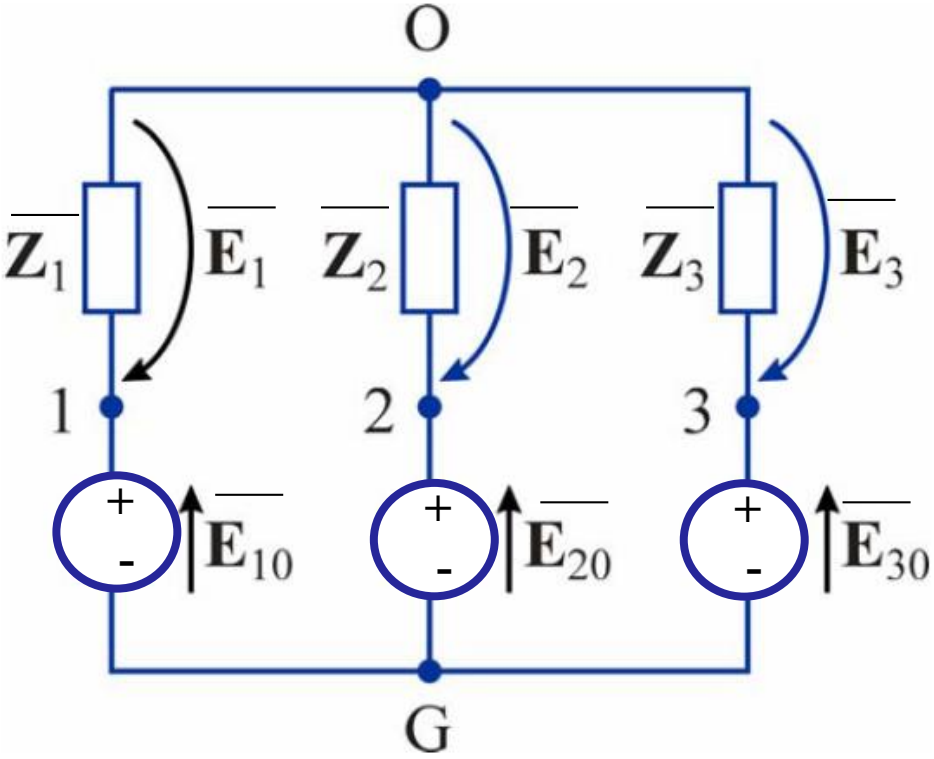
Tensione di Centro stella



$$\bar{I}_1 = \frac{\bar{E}_{10}}{\bar{Z}_1}$$

$$\bar{I}_2 = \frac{\bar{E}_{20}}{\bar{Z}_2}$$

$$\bar{I}_3 = \frac{\bar{E}_{30}}{\bar{Z}_3}$$

Esempio di Calcolo

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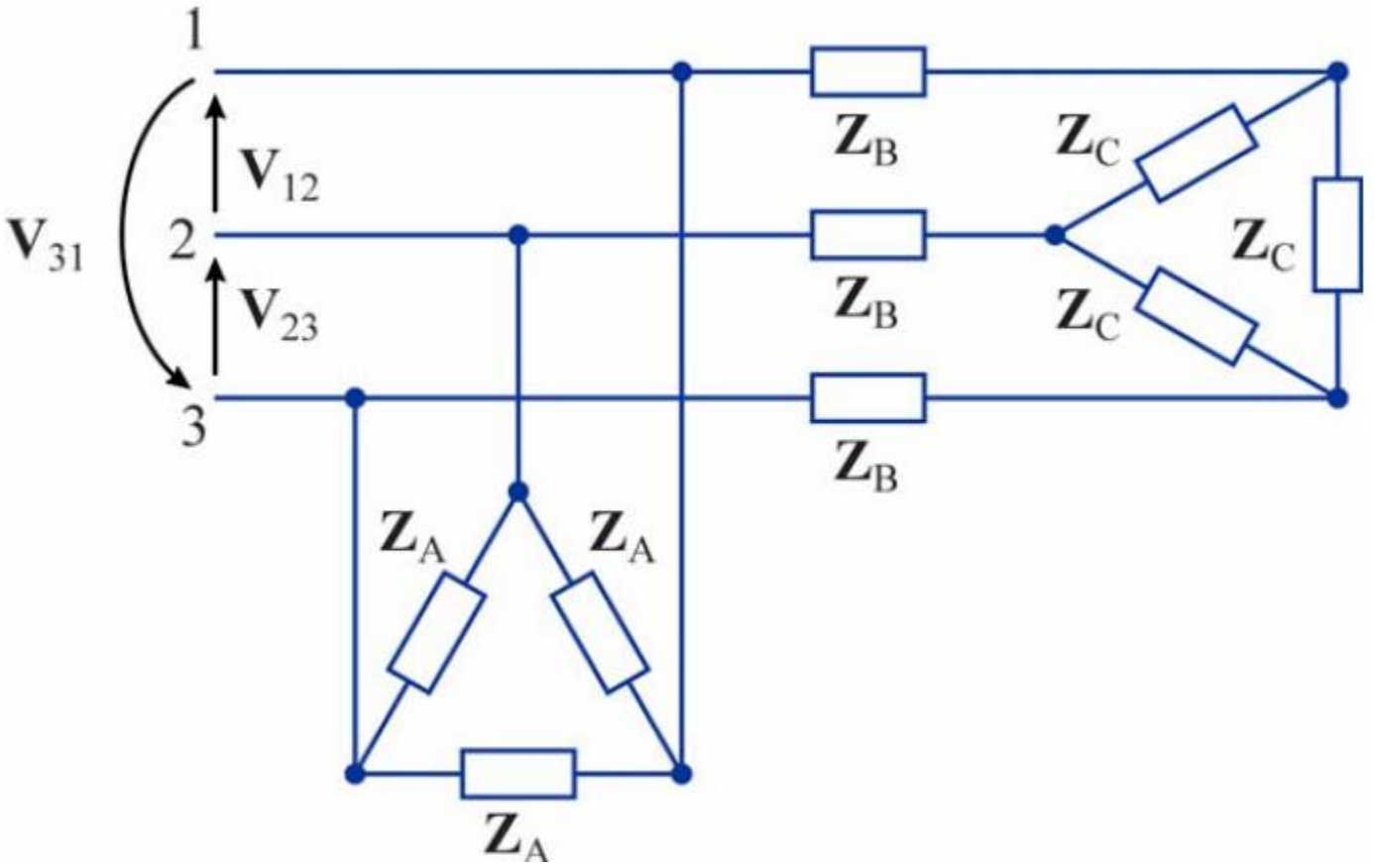

Esempio di Calcolo

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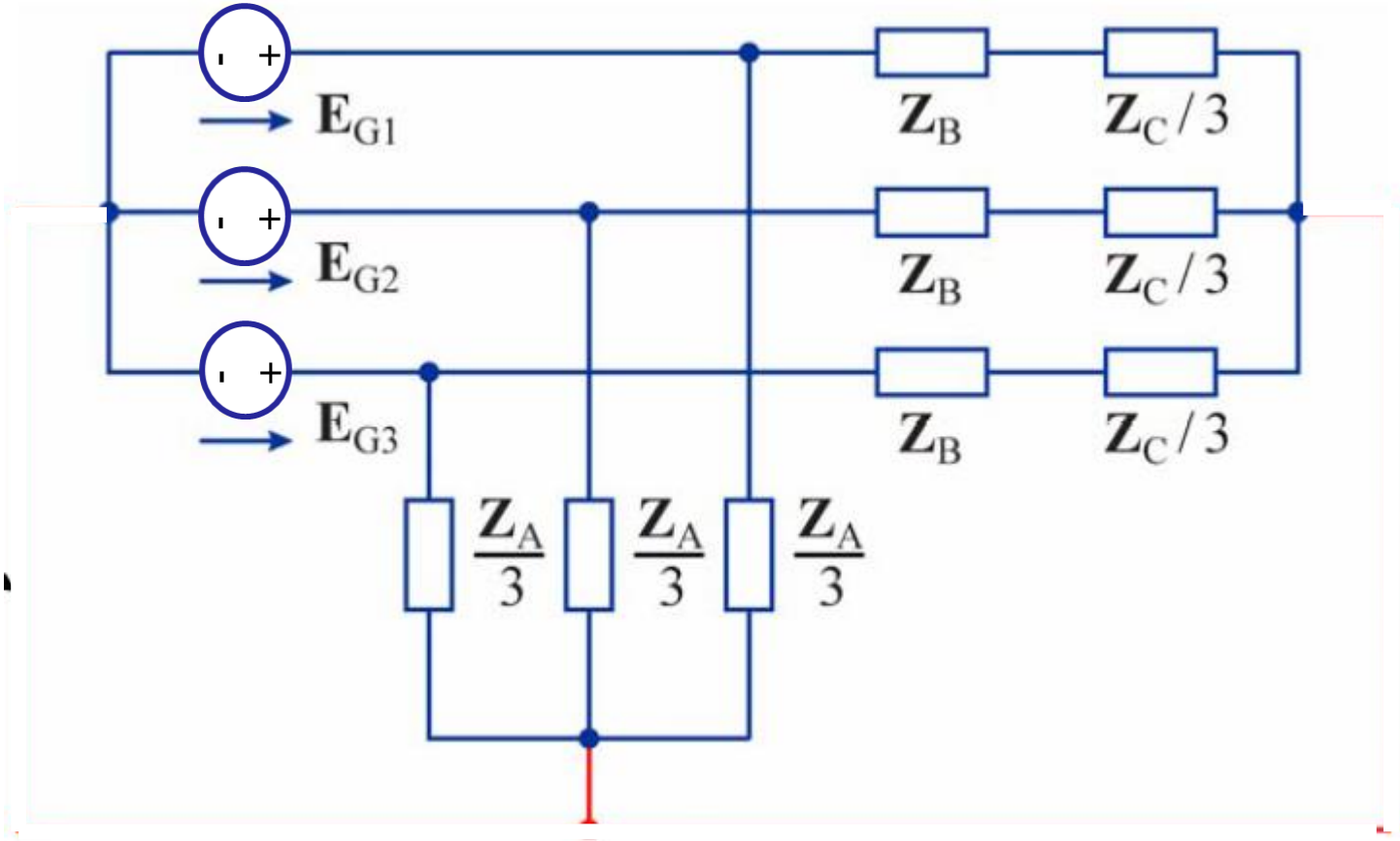

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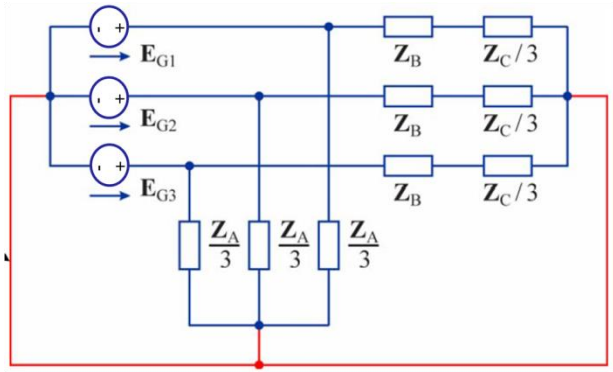
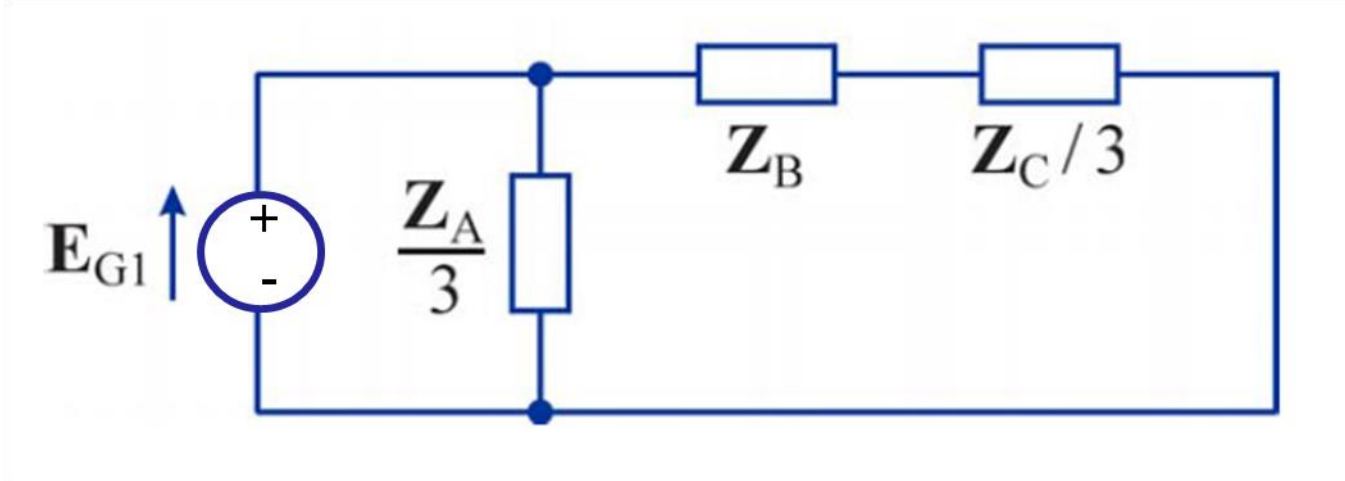
Esempio di Calcolo: rete ridotta al monofase





Calcolo della potenza

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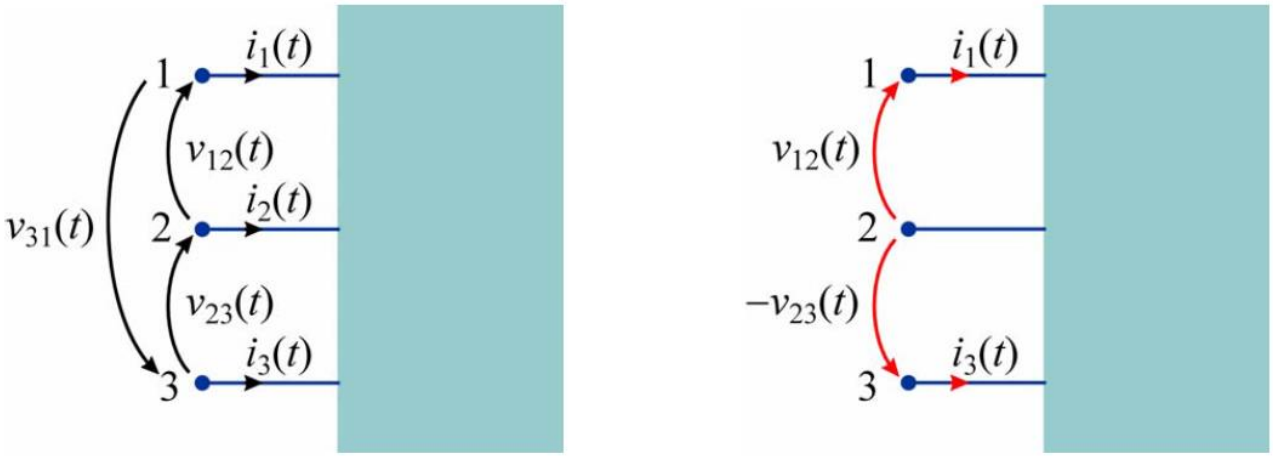

Scegliamo il 2 come nodo di riferimento

$$p(t) = v_{12}(t)i_1(t) + v_{32}(t)i_3(t) = v_{12}(t)i_1(t) - v_{23}(t)i_3(t)$$

Calcolo della potenza

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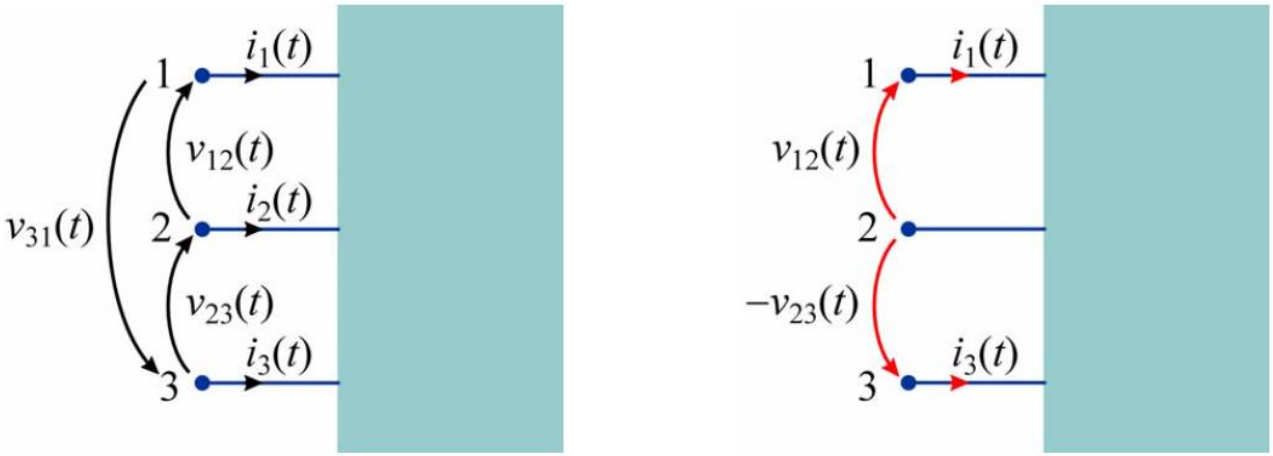

$$
\begin{aligned}
p(t) &= v_{12}(t)i_1(t) - v_{23}(t)i_3(t) = \\
&= \left[e_1(t) - e_2(t)\right]i_1(t) - \left[e_2(t) - e_3(t)\right]i_3(t) = \\
&= e_1(t)i_1(t) - e_2(t)\left[i_1(t) + i_3(t)\right] + e_3(t)i_3(t) = \\
&= e_1(t)i_1(t) + e_2(t)i_2(t) + e_3(t)i_3(t)
\end{aligned}
$$

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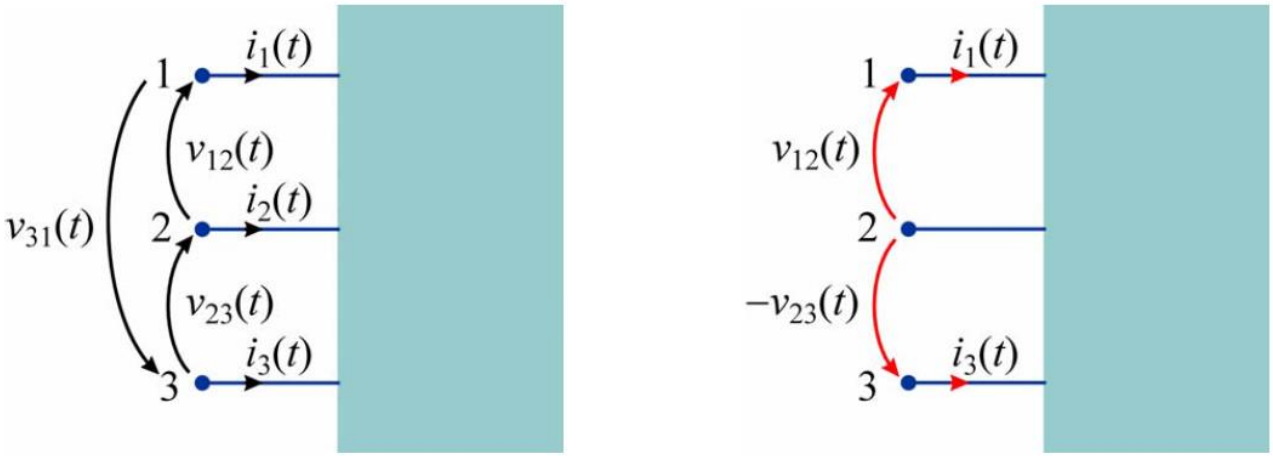
Calcolo della potenza



$$p(t) = e_{10}(t)\,i_1(t) + e_{20}(t)\,i_2(t) + e_{30}(t)\,i_3(t) =$$

$$= E_0 I \cos\varphi + E_0 I \cos(2\omega t + \varphi_V + \varphi_I) +$$

$$+ E_0 I \cos\varphi + E_0 I \cos\left(2\omega t + \varphi_V + \varphi_I + \tfrac{2}{3}\pi\right) +$$

$$+ E_0 I \cos\varphi + E_0 I \cos\left(2\omega t + \varphi_V + \varphi_I - \tfrac{2}{3}\pi\right) =$$

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Potenza trifase in regime fasoriale

- Potenza attiva

$$P = 3E_0 I \cos\varphi = \sqrt{3} V I \cos\varphi$$

- Potenza reattiva

$$Q = 3E_0 I \operatorname{sen}\varphi = \sqrt{3} V I \operatorname{sen}\varphi$$

- Potenza apparente

$$S = 3E_0 I = \sqrt{3} V I$$

- Fattore di potenza

$$\cos\Phi = \cos\varphi$$

Che fine fa il fattore ½ ?
Tradizionalmente in regime trifase si usano i valori efficaci

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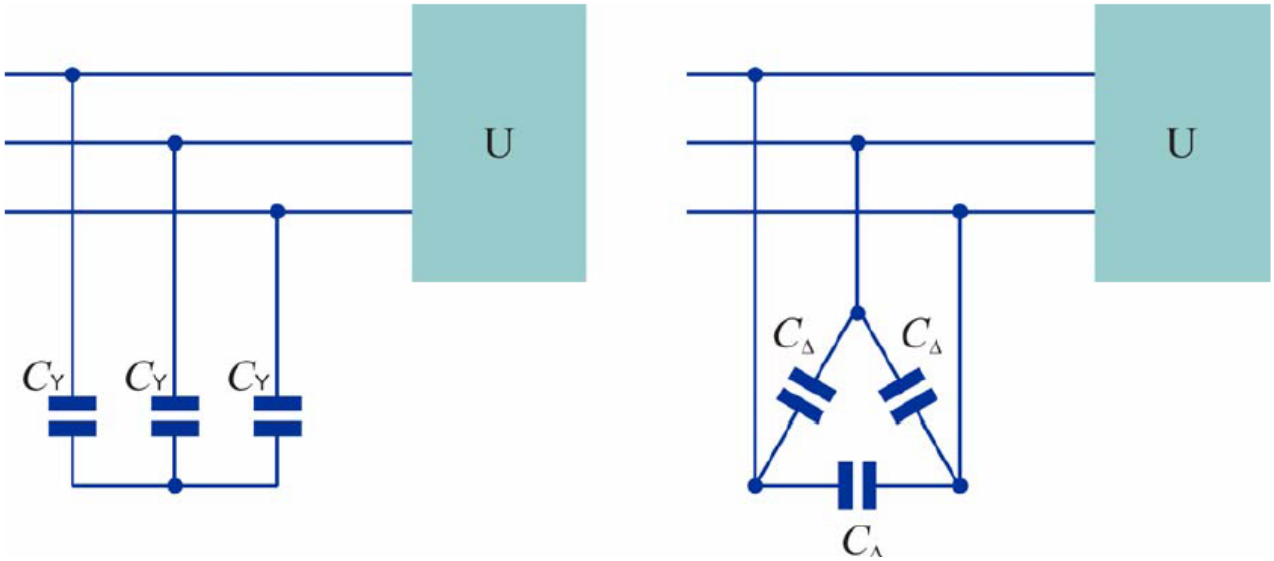
Rifasamento in regime trifase



$$Q_R = P(tg\varphi' - tg\varphi)$$

$$Q_R = -3\omega C V_{Ce}^2 = -\omega C_Y V_e^2 = -3\omega C_\Delta V_e^2$$

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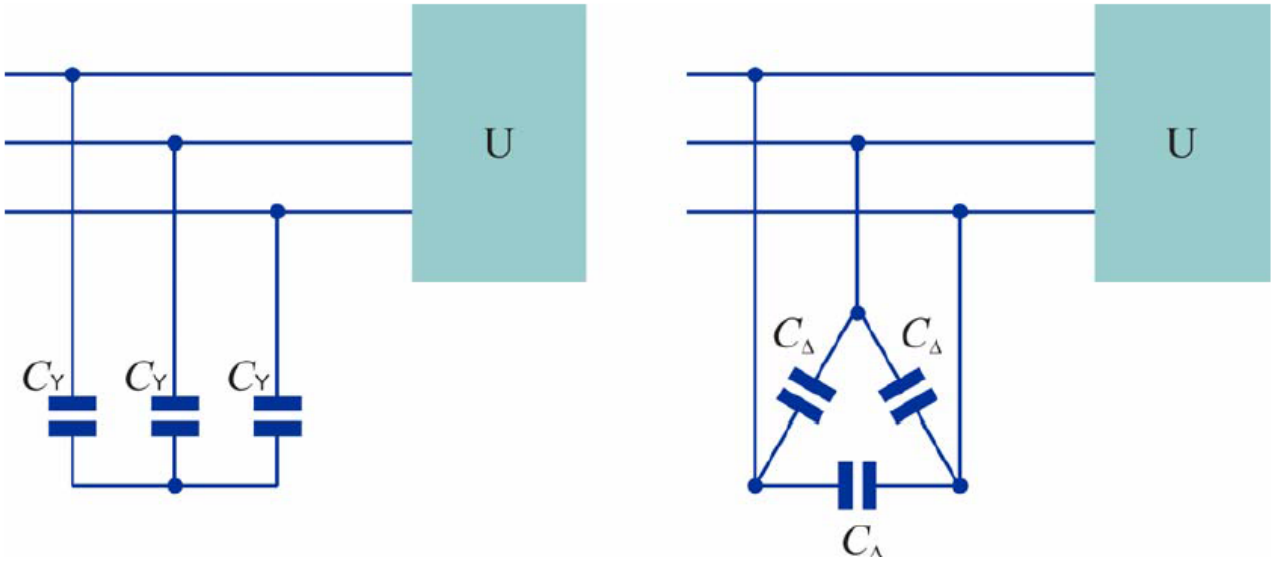
Rifasamento in regime trifase



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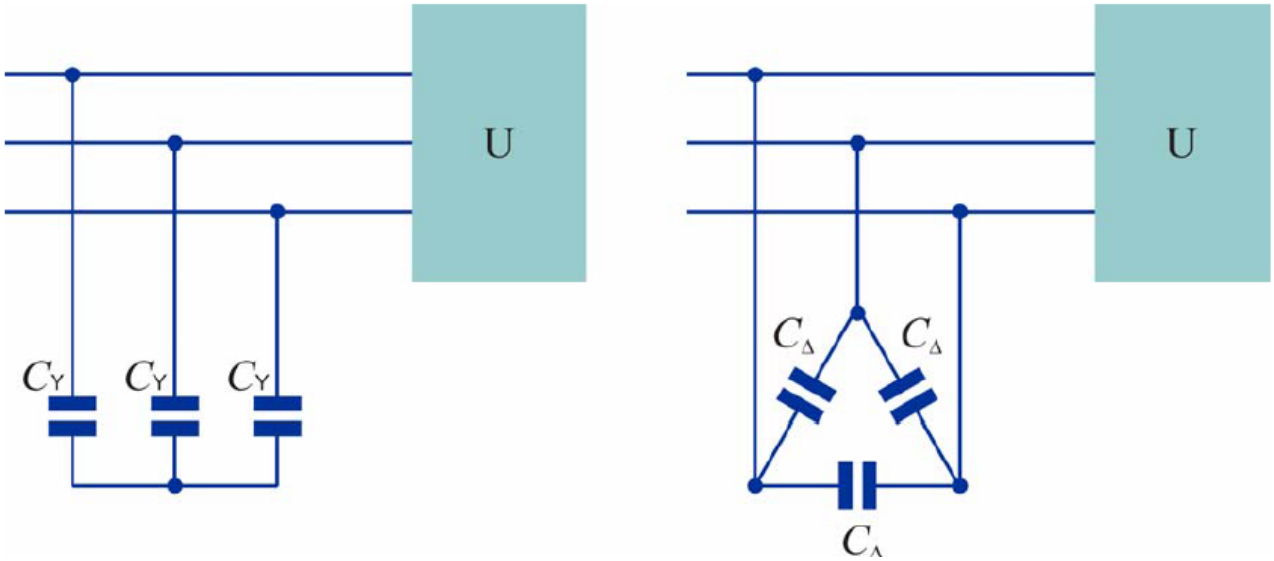
Rifasamento in regime trifase



- collegamento a stella

$$C_Y = \frac{P(tg\varphi - tg\varphi')}{\omega V_e^2}$$

- collegamento a triangolo

$$C_\Delta = \frac{P(tg\varphi - tg\varphi')}{3\omega V_e^2} = \frac{C_Y}{3}$$

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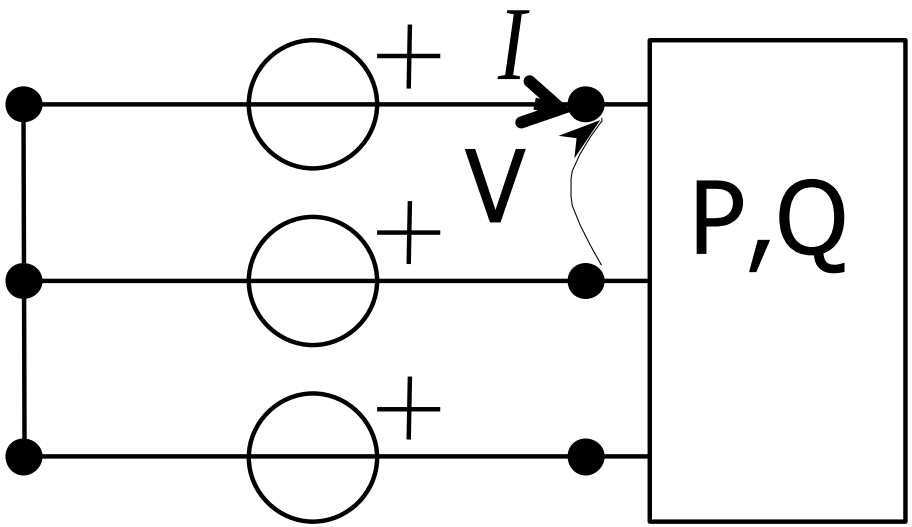
Carico Trifase: determinazione dei parametri



$$\tan\varphi = \frac{Q}{P}$$ Determino lo sfasamento

$$I = \frac{P}{\sqrt{3}\cdot V\cdot\cos\varphi}$$ Determino la corrente di linea

Carico Trifase: determinazione dei parametri

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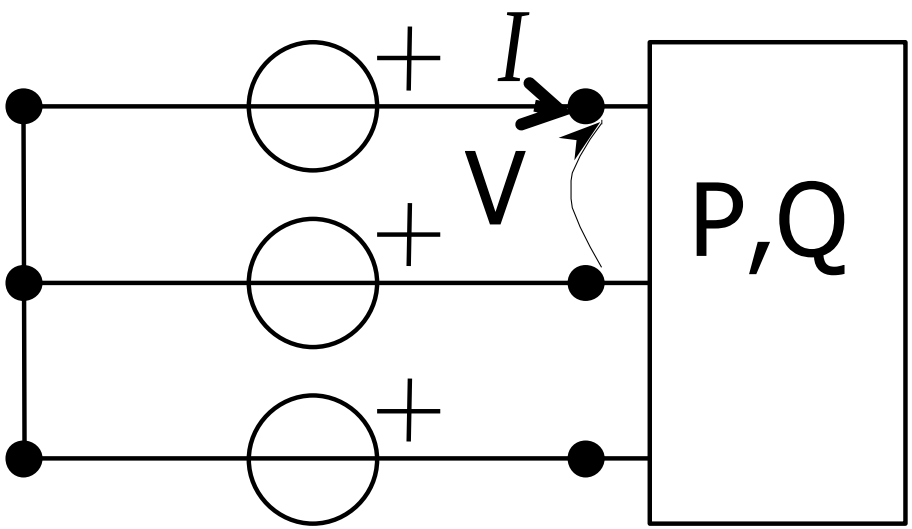

$$R_y = \frac{P}{3I^2}$$

$$X_y = \frac{Q}{3I^2}$$

$$\bar{Z}_y = R_y + jX_y$$

Applicazioni

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