EX

CARICO COMPOSTO DA DUE MOTORI IN PARALLELO

#1: $P_1 = 1{,}5$ kW $\cos\varphi_1 = 0{,}75$ (rit.)

#2: $P_2 = 1$ kW $Q_2 = 0{,}5$ kVAR

TENSIONE $V = 220V$ (val. eff.) ; $f = 50$ Hz

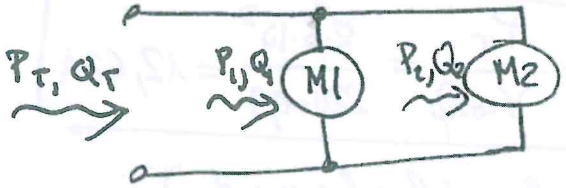
a) DETERMINARE IL FATTORE DI POTENZA DEL CARICO, E LA CORRENTE (val. eff.)

b) SE HA SENSO, RIFASARE PER OTTENERE UN FATTORE DI POTENZA 0,9 (rit.)

c) DET. LA CORRENTE IN VAL. EFF., DOPO IL RIFASAMENTO EFFETTUATO

d) DET. L'ENERGIA ASSORBITA DAL CARICO FUNZIONANTE PER 8 ORE

a) Trovo il triangolo delle potenze del carico

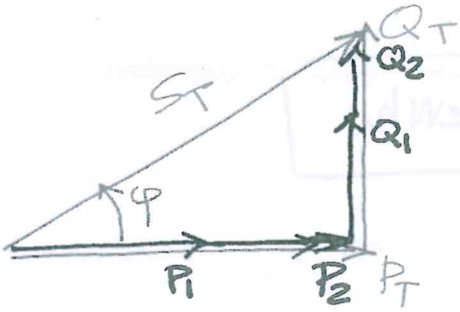


- $P_T = P_1 + P_2 = 2{,}5$ kW

$\varphi_1 = \arccos(0{,}75) = 41{,}41°$

$Q_1 = P_1 \, tg\varphi_1 = 1{,}5 \, tg(41{,}41°) = 1{,}32$ kVAR

- $Q_T = Q_1 + Q_2 = 1{,}32 + 0{,}5 = 1{,}82$ kVAR



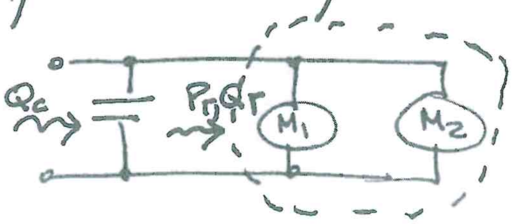
$S_T = \sqrt{P_T^2 + Q_T^2} = 3{,}09$ kVA

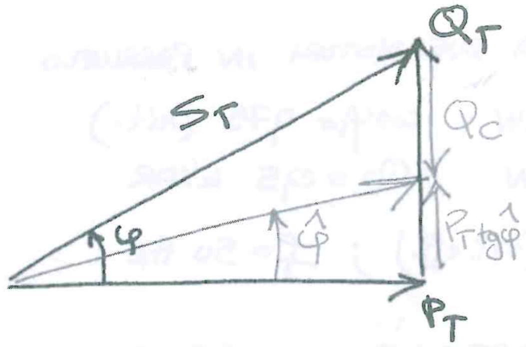
$$\boxed{\cos\varphi = \frac{P_T}{S_T} = \frac{2{,}5}{3{,}09} = 0{,}809 \text{ (rit.)}}$$

$$S_T = VI \Rightarrow \boxed{I = \frac{S_T}{V} = \frac{3{,}09 \cdot 10^3}{220} = 14\,A}$$

b) Essendo $\cos\varphi < \cos\hat{\varphi}$ ($0{,}809 < 0{,}9$)

ha senso il problema del rifasamento





$$\boxed{Q_C = P_T \, tg\hat{\varphi} - Q_T}$$

$$\hat{\varphi} = \arccos 0{,}9 = 25{,}84°$$

$$Q_C = 2{,}5 \cdot tg(25{,}84°) - 1{,}82 = -0{,}61 \text{ kVAR}$$

$$\boxed{C} = \frac{-Q_C}{\omega V^2} = \frac{0{,}61 \cdot 10^3}{2\pi \cdot 50 \cdot 220^2} = \boxed{40{,}12 \; \mu F}$$

c) Dopo il rifasamento, P_T rimane sempre la stessa, ma con $\cos\hat{\varphi}$

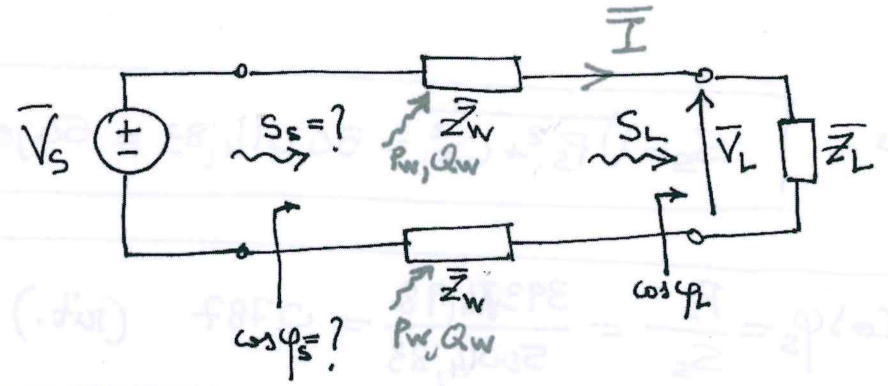
$$P_T = VI\cos\hat{\varphi} \Rightarrow \boxed{I = \frac{P_T}{V\cos\hat{\varphi}} = \frac{2{,}5 \cdot 10^3}{220 \cdot 0{,}9} = 12{,}62 A}$$

Notare che 12,62 A < 14 A (benefici del rifasamento)

d) $$\boxed{W = P\tilde{T} = 2{,}5 \cdot 8 = 20 \text{ kWh}}$$

$(1 \text{ kWh} = 3{,}6 \cdot 10^6 J)$

EX

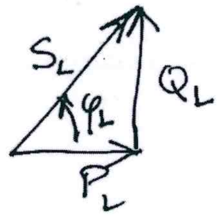


- CARICO: $\bar{Z}_L$ assorbe $S_L = 46$ kVA $\cos\varphi_L = 0{,}84$ (rit.)
- TENSIONE AL CARICO: $V_L = 2{,}4$ kV (valore efficace)
- LINEA: IMPEDENZA (per filo) $\bar{Z}_W = 1 + j8\ \Omega$

Determinare la potenza apparente S_S, il fattore di potenza $\cos\varphi_S$ e il valore efficace V_S della tensione ai morsetti della sorgente.

Metodo di calcolo basato sulla conservazione della potenza attiva e reattiva (Teorema di Boucherot)

- Potenze al carico: $S_L = V_L I \Rightarrow I = \dfrac{S_L}{V_L} = \dfrac{46 \cdot \cancel{10^3}}{2{,}4 \cdot \cancel{10^3}} = 19{,}17$ A



$$P_L = S_L \cos\varphi_L = 46 \cdot 0{,}84 = 38{,}64 \text{ kW}$$
$$Q_L = P_L \, \mathrm{tg}\,\varphi_L = 38{,}64 \; \mathrm{tg}[\arccos 0{,}84] = 24{,}96 \text{ kVAR}$$

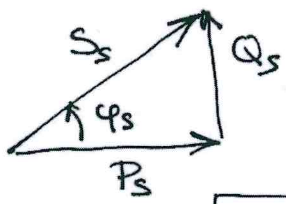
- Potenze assorbite dalla linea:

$$P_W = \mathrm{Re}\{\bar{Z}_W\} I^2 = 1 \cdot 19{,}17^2 = 367{,}49 \text{ W}$$
$$Q_W = \mathrm{Im}\{\bar{Z}_W\} I^2 = 8 \cdot 19{,}17^2 = 2939{,}91 \text{ VAR}$$

- Potenze alla sorgente: applico il teorema di Boucherot

$$P_S = P_L + 2P_W = 38640 + 2 \cdot 367{,}49 = 39\,374{,}98 \text{ W}$$
$$Q_S = Q_L + 2Q_W = 24960 + 2 \cdot 2939{,}91 = 30\,839{,}82 \text{ VAR}$$

$$\boxed{P_S = 39{,}37 \text{ kW} \qquad Q_S = 30{,}84 \text{ kVAR}}$$



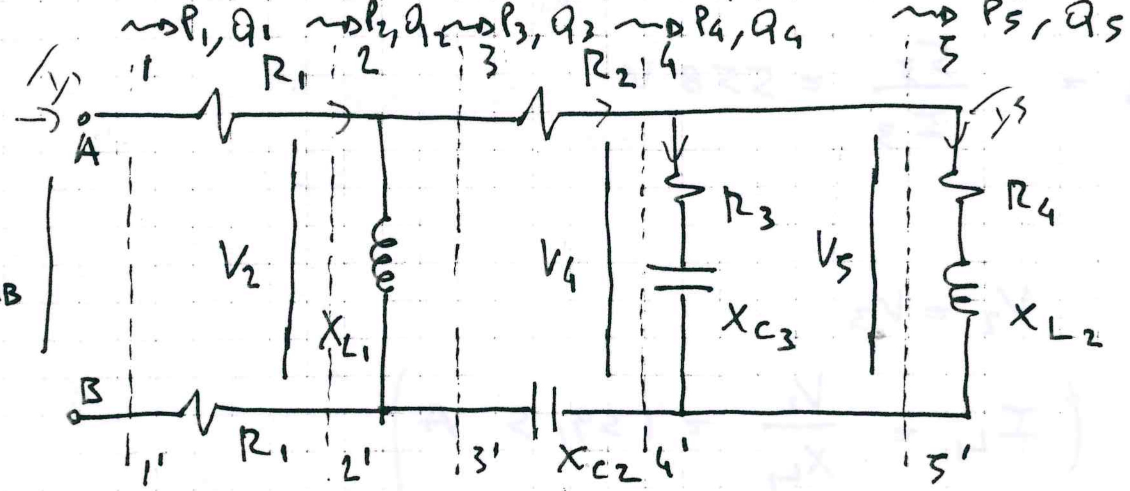
$$\boxed{S_s = \sqrt{P_s^2 + Q_s^2} = 50\,014{,}83 = 50{,}014 \text{ kVA}}$$

$$\boxed{\cos\varphi_s = \frac{P_s}{S_s} = \frac{39374{,}98}{50014{,}83} = 0{,}787 \quad (\text{rit.})}$$

$$\boxed{V_s = \frac{S_s}{I} = \frac{50014{,}83}{19{,}17} = 2609{,}01 \text{ V} = 2{,}61 \text{ kV}}$$

X ESERCIZIO (METODO DI BOUCHEROT)

Dato il valore efficace della corrente I_5, calcolare il valore efficace della tensione V_{AB} e della corrente I_1



$R_1 = 2\Omega$

$R_2 = 3\Omega$

$R_3 = 4\Omega$

$R_4 = 6\Omega$

$X_{L_1} = 4\Omega$

$X_{L_2} = 8\Omega$

$X_{C_2} = -3\Omega$

$X_{C_3} = -3\Omega$

$I_5 = 30\,A$

5-5'

$$P_5 = R_4 I_5^2 = 5400\,W$$

$$Q_5 = X_{L_2} I_5^2 = 7200\,VAR$$

$$S_5 = \sqrt{P_5^2 + Q_5^2} = 9000\,VA \Rightarrow$$

$$V_5 = \frac{S_5}{I_5} = 300\,V$$

$$V_4 = V_5$$

4-5'

$$I_{R_3} = \frac{V_4}{\sqrt{R_3^2 + X_{C_3}^2}} = 60\,A$$

4-4'

$$P_4 = R_3 I_{R_3}^2 + P_5 = 19800\,W$$

$$Q_4 = X_{C_3} I_{R_3}^2 + Q_5 = -3600\,VAR$$

$$S_4 = \sqrt{P_4^2 + Q_4^2} = 20{,}12\,KVA$$

$$I_4 = \frac{S_4}{V_4} = 67{,}08\,A$$

3 - 3'

$I_3 = I_4$

$$P_3 = P_4 + R_2 I_3^2 = 33299 \ W$$

$$Q_3 = Q_4 + X_{c2} I_3^2 = -17099 \ VAR$$

$$S_3 = \sqrt{P_3^2 + Q_3^2} = 37433 \ VA$$

$$V_3 = \frac{S_3}{I_3} = 558 \ V$$

2 - 2'

$$V_2 = V_3$$

$$\left(I_{L_1} = \frac{V_2}{X_{L_1}} = 139{,}5 \ A \right)$$

$$P_2 = P_3 \qquad Q_2 = Q_3 + \frac{V_2^2}{X_4} =$$

$$\cancel{Q_2} = \cancel{Q_3} \cancel{+} X_{L_1} \cancel{I_{L_1}^2} = 60742 \ VAR$$

$$S_2 = \sqrt{P_2^2 + Q_2^2} = 69271 \ VA$$

$$I_2 = \frac{S_2}{V_2} = 124 \ A$$

1 - 1'

$$P_1 = P_2 + 2R_1 I_1^2 = 94803 \ W \qquad I_1 = I_2$$

$$Q_1 = Q_2$$

$$S_1 = \sqrt{P_1^2 + Q_1^2} = 112593 \ VA$$

$$V_{AB} = V_1 = \frac{S_1}{I_1} = 908 \ V$$

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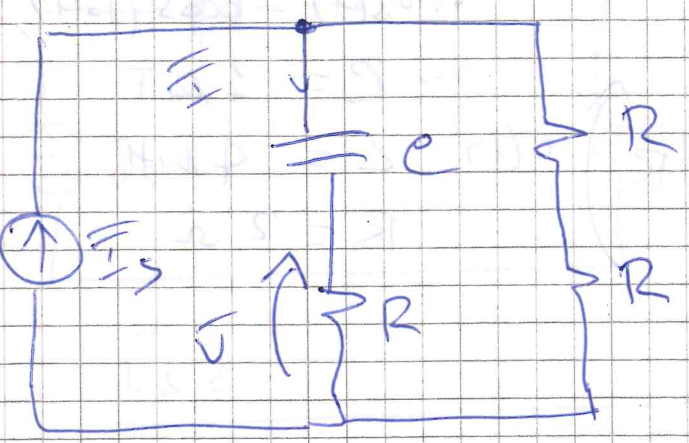


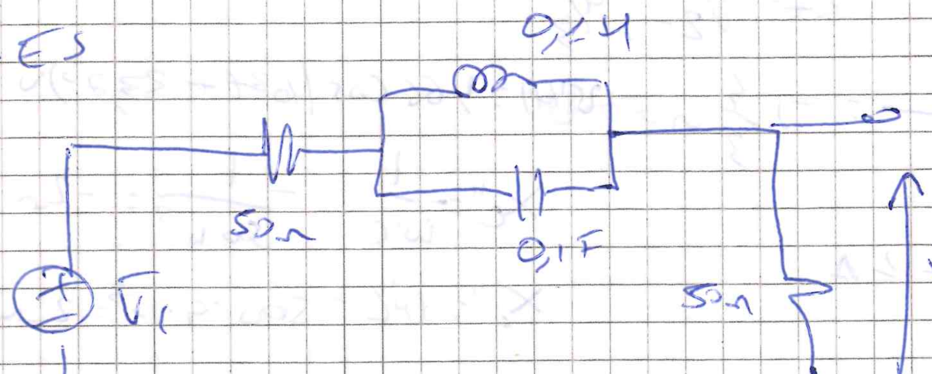
$$\bar Z(j\omega) = \frac{\bar V}{\bar I_s}$$

$$\bar I = \frac{\bar I_s 2R}{2R + R + \frac{1}{j\omega C}} = \frac{\bar I_s 2R j\omega C}{3Rj\omega C + 1}$$

$$\bar V = R\bar I = \frac{\bar I_s 2R^2 j\omega C}{3Rj\omega C + 1}$$

$$Z(j\omega) = \frac{\bar V}{\bar I_s} = \frac{2R^2 j\omega C}{3j\omega CR + 1}$$

- ES



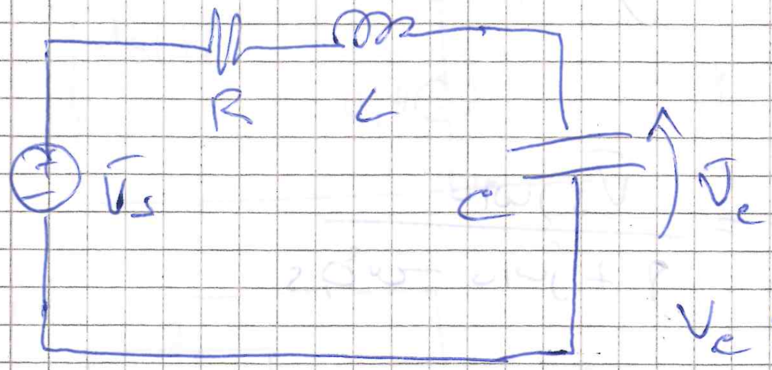
$$H(j\omega) = \frac{\bar V_2}{\bar V_1}$$

$$\bar Z_p = \frac{j0{,}1\omega / j0{,}1\omega}{j0{,}1\omega + \frac{1}{j\omega 0{,}1}} = \frac{j0{,}1\omega}{1 - 0{,}1^2\omega^2}$$

$$\bar V_2 = \frac{\bar V_1 50}{50 + 50 + \frac{j0{,}1\omega}{1 - 0{,}1^2\omega^2}} = \frac{50\bar V_1 (1 - 0{,}1^2\omega^2)}{100(1 - 0{,}1^2\omega^2) + j0{,}1\omega} =$$

$$H(j\omega) = \frac{\bar{V}_2}{\bar{V}_1} = \frac{50 - 0,5\,\omega^2}{100 - \omega^2 + j\,0,1\,\omega}$$

-E-



$L = 0,1\ mH$

$C = 1\ \mu F$

$R = 10\ \Omega$

$V_c\ ?,\quad \omega = \frac{1}{\sqrt{LC}}$

$$\bar{V}_c = \frac{\bar{V}_s \frac{1}{j\omega C}}{R + j\omega L + \frac{1}{j\omega C}} = \frac{\bar{V}_s}{Rj\omega C + 1 - \omega^2 LC} = \frac{\bar{V}_s}{Rj\frac{1}{\sqrt{LC}}C + 1 - 1}$$

$$= \frac{\bar{V}_s}{j\frac{RC}{\sqrt{LC}}} = -j\,\bar{V}_s$$

$$\bar{I} = \frac{\bar{V}_s}{R}$$

$$\bar{V}_c = \cancel{\ \ }\ \frac{1}{j\omega C}\,\bar{I} = \frac{1}{j\omega C}\,\frac{\bar{V}_s}{R} = \frac{\bar{V}_s}{j\frac{RC}{\sqrt{LC}}} = -j\,\bar{V}_s$$