NUMERO: 2204A

ANNO: 2017

A P P U N T I

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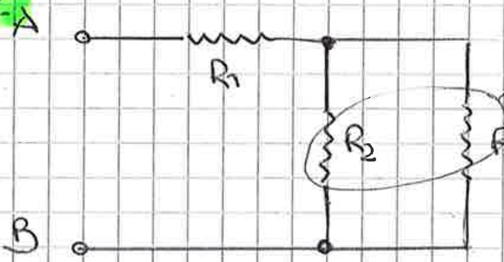
MATERIA: Esercitazioni di Elettrotecnica + Simulazione d'Esame - Prof. Repetto

10.10.16

ESERCITAZIONE 1

ES 1



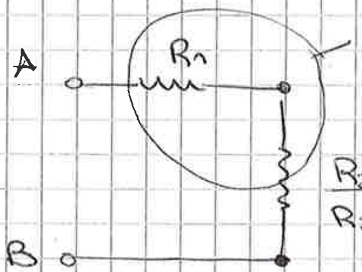
in //

$R_1 = 10\ \Omega$

$R_2 = 1\ \Omega$

$R_3 = 9\ \Omega$

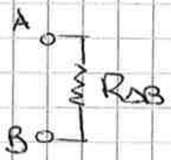
• R_{AB} ?



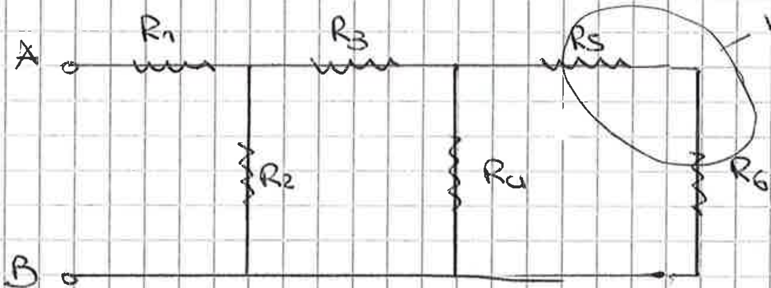
in serie

$$\frac{R_2 \cdot R_3}{R_2 + R_3} = \frac{1 \cdot 9}{1+9} = \frac{9}{10} = 0{,}9\ \Omega$$

$$R_{AB} = R_1 + 0{,}9 = 10 + 0{,}9 = 10{,}9\ \Omega$$



ES 2



in serie : $R' = R_5 + R_6 = 40\ \Omega$

• R_{AB} ?

$R_1 = 20\ \Omega$

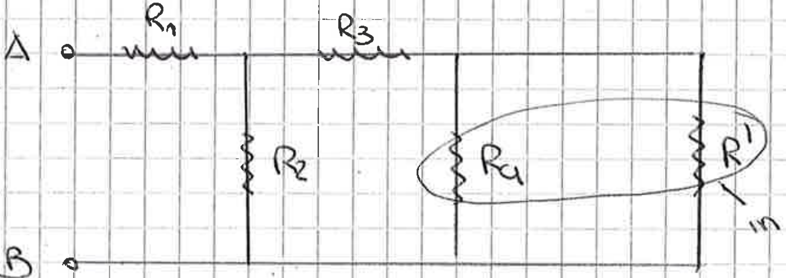
$R_2 = 40\ \Omega$

$R_3 = 20\ \Omega$

$R_4 = 40\ \Omega$

$R_5 = 20\ \Omega$

$R_6 = 20\ \Omega$



in // : $R'' = \dfrac{R_4\ R'}{R_4 + R'} = 20\ \Omega$

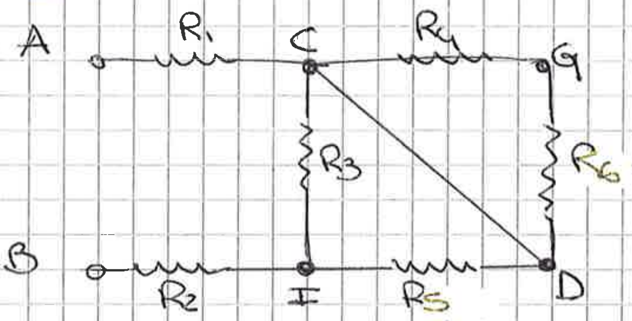
in serie : $R'' + R_3 = 20 + 20 = 40\ \Omega = R'''$

Nota

Due resistenze uguali in //
$\Rightarrow$ Req vale la metà
(se 3 uguali $\Rightarrow \frac{1}{3}$ ecc)

$$R^{IV} = (R'''\ R_2) / (R''' + R_2) = 20\ \Omega$$

ES 4



• R_{AB}?

Morsetti C-D non sono elettricamente distinti!

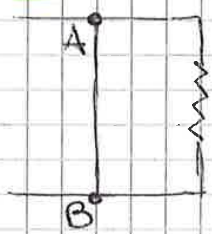
C-D corto circuito

$R_1 = 10\ \Omega$ $\quad$ $R_4 = 20\ \Omega$

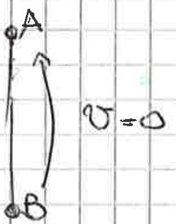
$R_2 = 10\ \Omega$ $\quad$ $R_5 = 20\ \Omega$

$R_3 = 20\ \Omega$ $\quad$ $R_6 = 20\ \Omega$

OSS

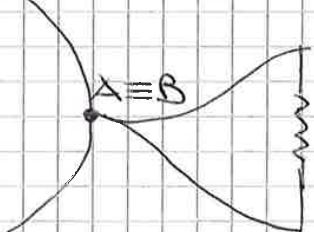


$R_{eq} = 0$

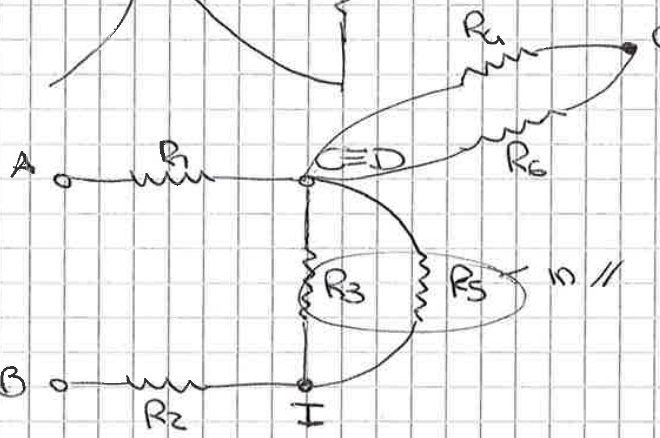


corto circuito

è equivalente disegnarli così:



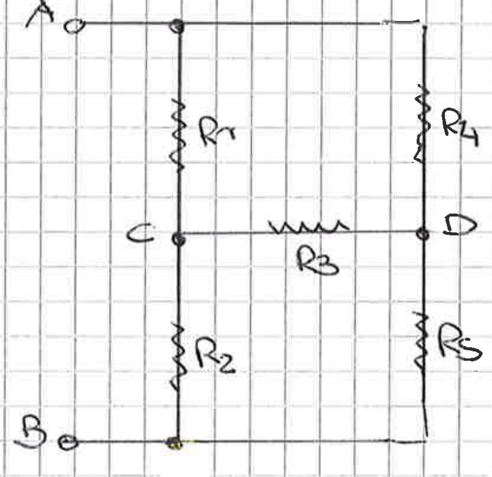
=>



in // : $\dfrac{R_3 \cdot R_5}{R_3 + R_5}$

$$R_{AB} = R_1 + R_2 + (R_3 \cdot R_5)/(R_3 + R_5) = 10 + 10 + \frac{20 \cdot 20}{20 + 20} = 30$$

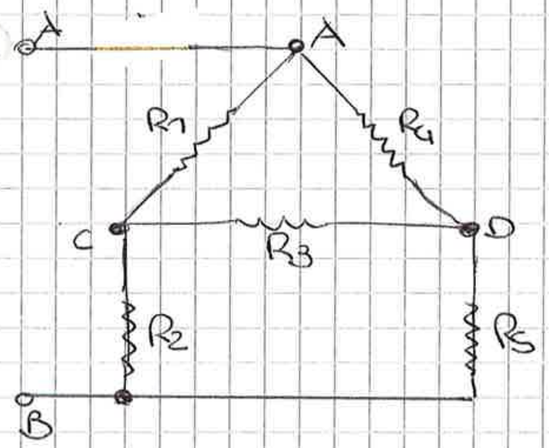
ES 6



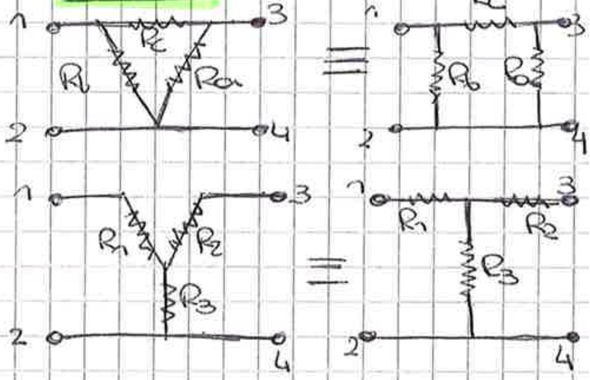
• R_{AB} ?

$R_1 = R_2 = R_3 = R_4 = R_5 = 30\ \Omega$

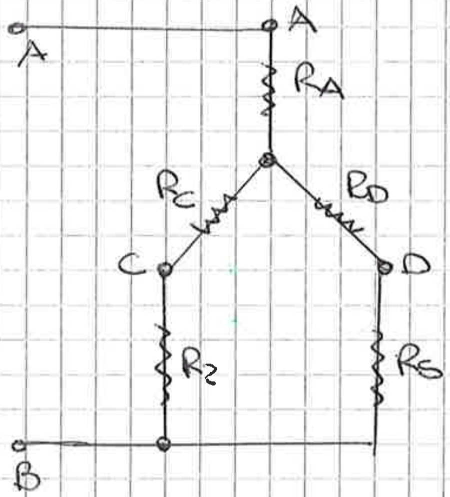
↓ equivale a



NOTA

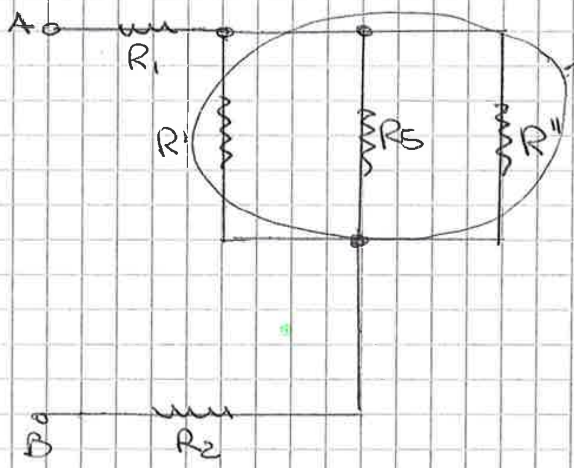


Ora posso trasformare il Δ in Y :



$\boxed{R_Y = \frac{R_\Delta}{3}} = \frac{30}{3} = 10\ \Omega$

$R_A = R_C = R_D = 10\ \Omega$



$R_{eq} = \frac{1}{3}(30) = 10\ \Omega$

$G_{eq} = G' + G_5 + G''$

$= \frac{1}{R'} + \frac{1}{R_5} + \frac{1}{R''}$

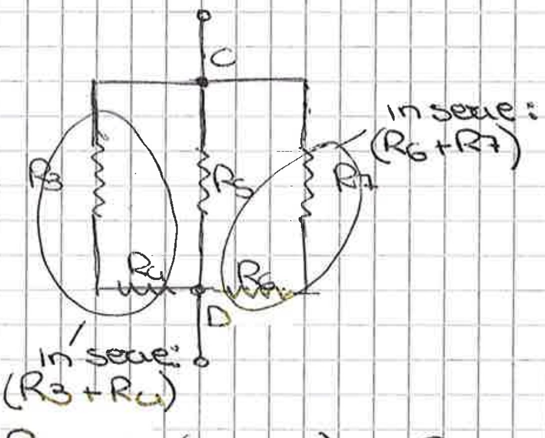
$= \frac{1}{30} + \frac{1}{30} + \frac{1}{30}$

$= \frac{3}{30} = \frac{1}{10}\ S$

$R_{eq} = \frac{1}{G_{eq}} = 10\ \Omega$

$R_{AB} = R_1 + R_2 + R_{eq} = 10 + 10 + 10 = 30\ \Omega$

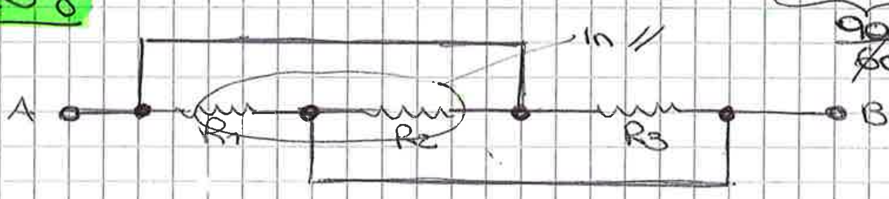
R_{CD}



(non si considerano R_1 e R_2 perché A e B aperti)

$R_{CD} = (10+20) \parallel R_5 \parallel (10+20) = \underbrace{\left(\frac{30 \cdot 30}{30+30}\right)}_{\frac{900}{60} = 15} \parallel 30 = \frac{30 \cdot 15}{30+15} = \frac{450}{45} = 10\ \Omega$

ES 8



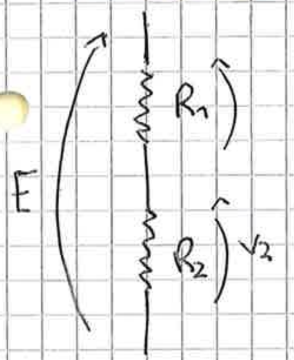
$R_1 = R_2 = R_3 = 30\ \Omega$

- R_{AB} ?

$R' = R_1 \parallel R_2 = \frac{R_1 \cdot R_2}{R_1 + R_2} = \frac{30 \cdot 30}{30+30} = 15\ \Omega$

$R_{AB} = R' \parallel R_3 = \frac{15 \cdot 30}{15+30} = 10\ \Omega$

Partitore di tensione per trovare V_2:



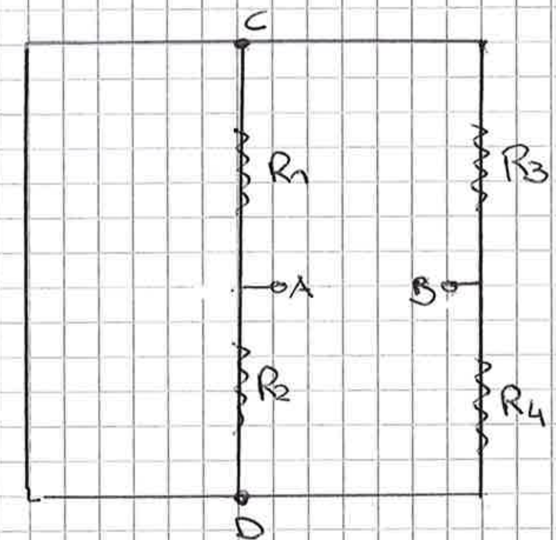
$$V_2 = E \frac{R_2}{R_1 + R_2} = 200 \cdot \frac{40}{10+40} = 200 \cdot \frac{4}{5} = 160 \text{ V}$$

Partitore di tensione per trovare V_4:

$$V_4 = E \cdot \frac{R_4}{R_3 + R_4} = 200 \cdot \frac{5}{20+5} = 200 \cdot \frac{1}{5} = 40 \text{ V}$$

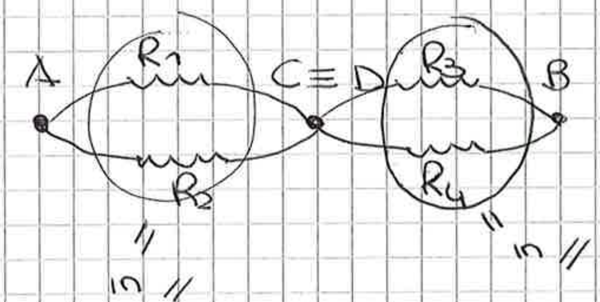
$$E_{eq} = 160 - 40 = 120 \text{ V}$$

Per trovare R_{eq}, passiviamo la rete:



Nota

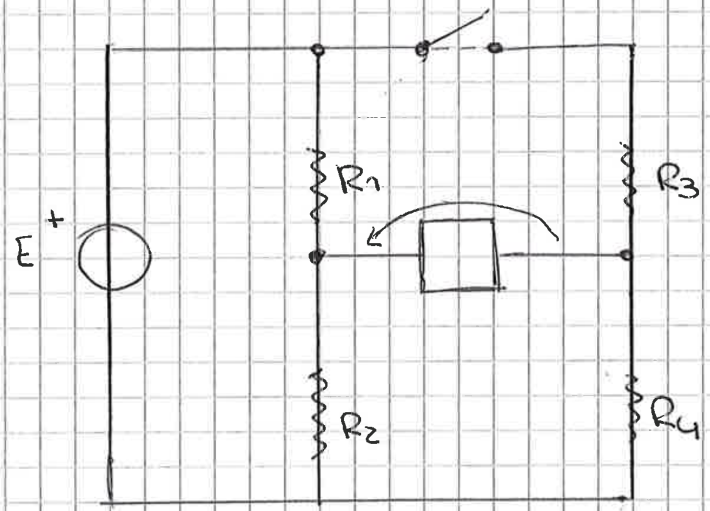
C e D non sono elettricamente distinti perché c'è un c.c. => è come se nodi coincidessero



$$R_{eq} = \frac{R_1 \cdot R_2}{R_1 + R_2} + \frac{R_3 \cdot R_4}{R_3 + R_4} = \frac{10 \cdot 40}{10+40} + \frac{20 \cdot 5}{20+5} = 8 + 4 = 12 \ \Omega$$

PONTE DI WHEATSTONE:

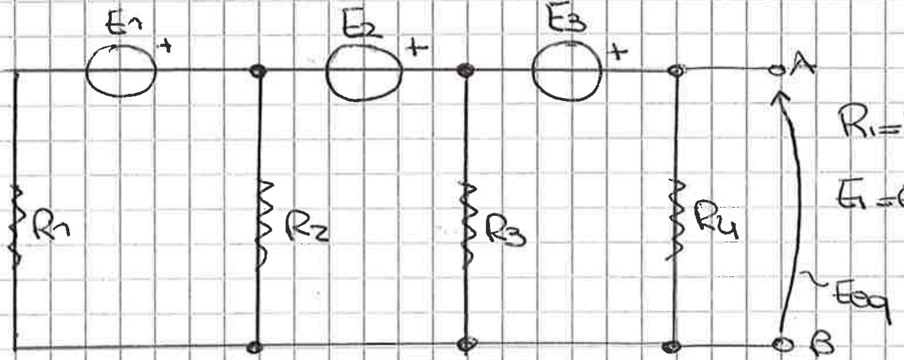
Consente di mettere in allarme qualcosa che non funziona nel sistema. LADRI XD



- Interruttore chiuso => ponte equilibrato (tensione nulla)

- Se interruttore viene aperto => il ponte non è più equilibrato

ES 2

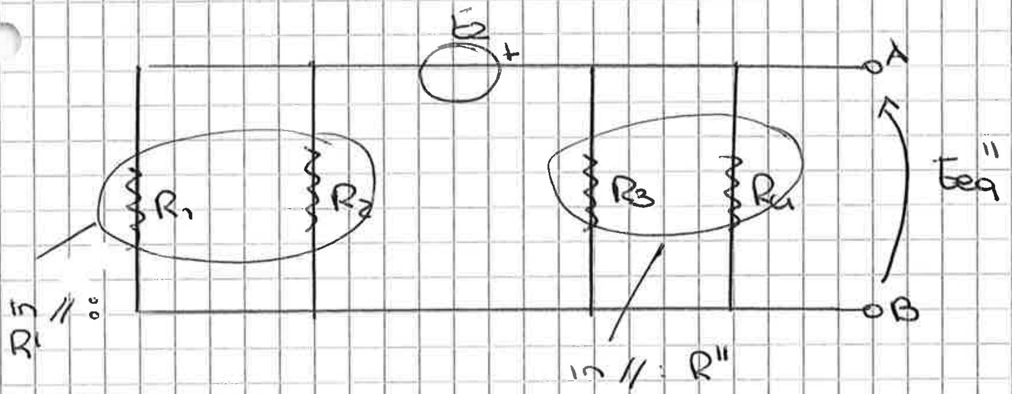


$R_1 = R_2 = R_3 = R_4 = 1\Omega$

$E_1 = E_2 = E_3 = 10V$

- Circuito equivalente ai morsetti AB?

Effetto 2 (E_2):

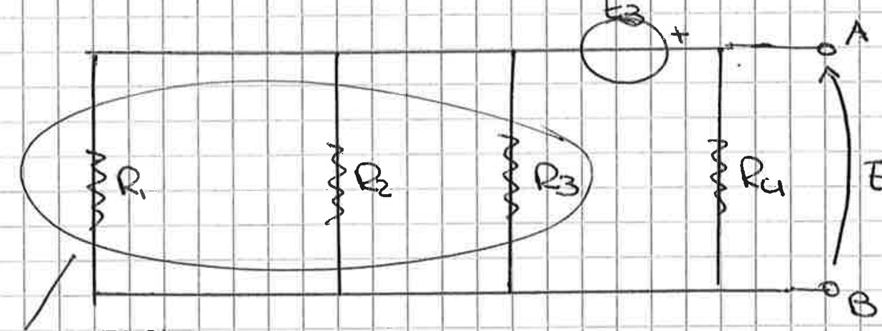


$$R' = \frac{R_1 \cdot R_2}{R_1 + R_2} = 6\ \Omega$$

$$R'' = \frac{R_3 \cdot R_4}{R_3 + R_4} = 6\ \Omega$$

$$E_{eq}'' = E_2 \cdot \frac{R''}{R' + R''} = 10 \cdot \frac{6}{6+6} = 10 \cdot \frac{6}{12} = \frac{10}{2} = 5\ V$$

Effetto 3 (E_3):



in //: $R' = \frac{12}{3} = 4\ \Omega$

$$E_{eq}''' = E_3 \frac{R_4}{R_4 + R'} = 10 \cdot \frac{12}{12+4} = 10 \cdot \frac{\cancel{12}^{3}}{\cancel{16}_{4}} = \frac{30}{4} = \frac{15}{2}\ V = 7{,}5\ V$$

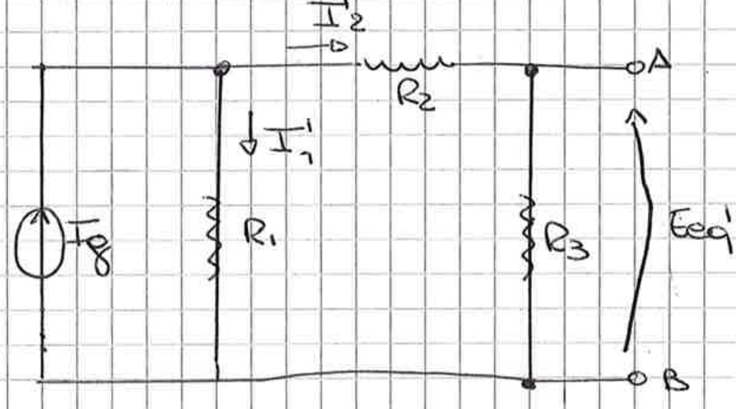
$$E_{eq} = 2{,}5 + 5 + 7{,}5 = 15\ V$$

Nb. (per casa)
Calcolo con Millman V_{CB} e poi trovo E_{eq}

Ora lo risolviamo con la sovrapposizione:

$$E_{eq} = \underset{\underset{I_g}{\uparrow}}{E'_{eq}} + \underset{\underset{E}{\uparrow}}{E''_{eq}}$$

Effetto 1 (I_g):

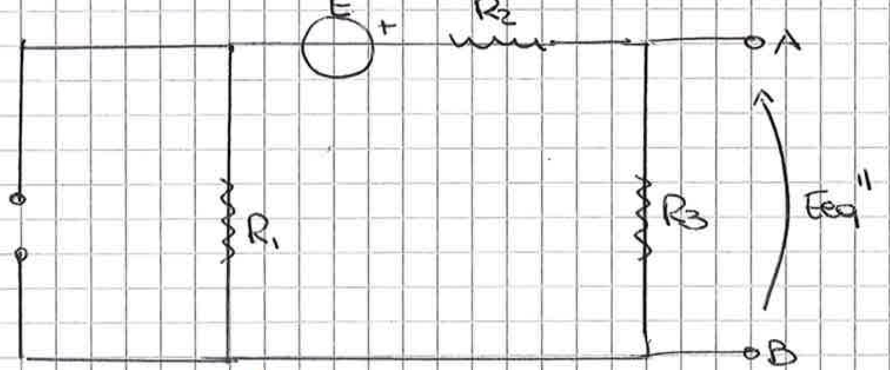


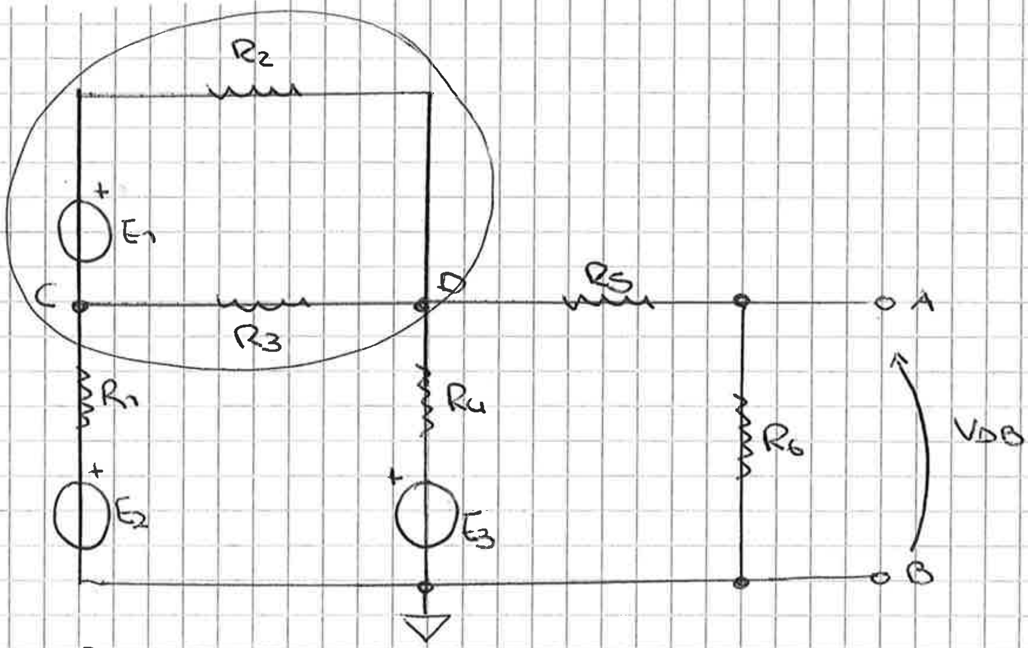
Partitore di corrente $I'_2 = I_g \dfrac{R_1}{R_1 + (R_2 + R_3)}$

$$= 10 \frac{10}{10 + 5 + 5} = 5\ A$$

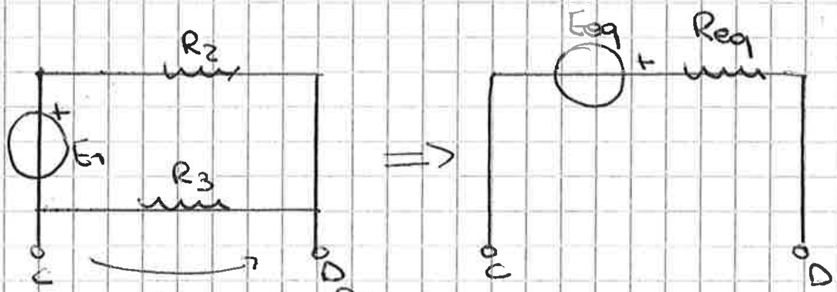
$$E'_{eq} = R_3 \cdot I'_2 = 5 \cdot 5 = 25\ V$$

Effetto 2 (E):





• V_{DB} ?

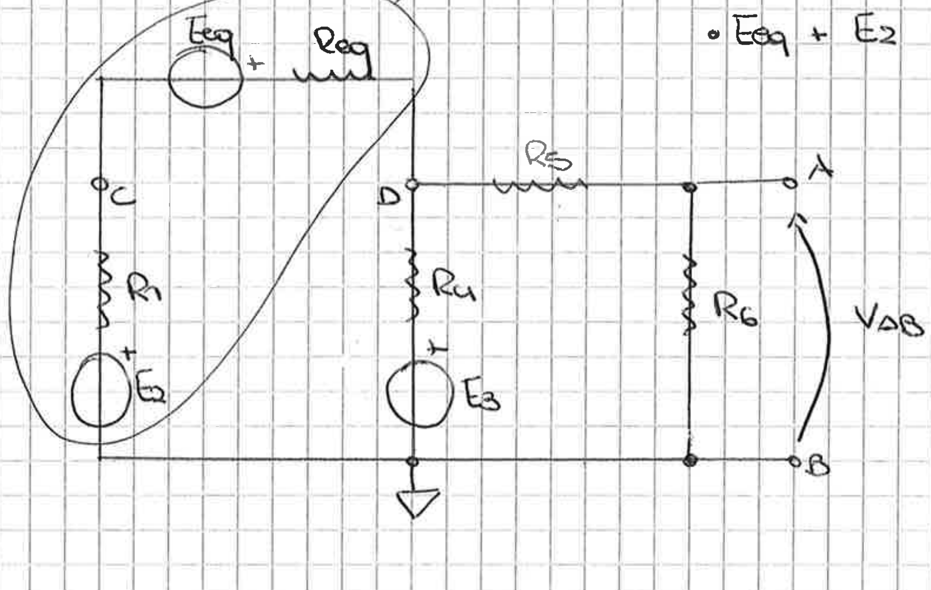


$$E_{eq} = E_1 \frac{R_3}{R_2 + R_3}$$

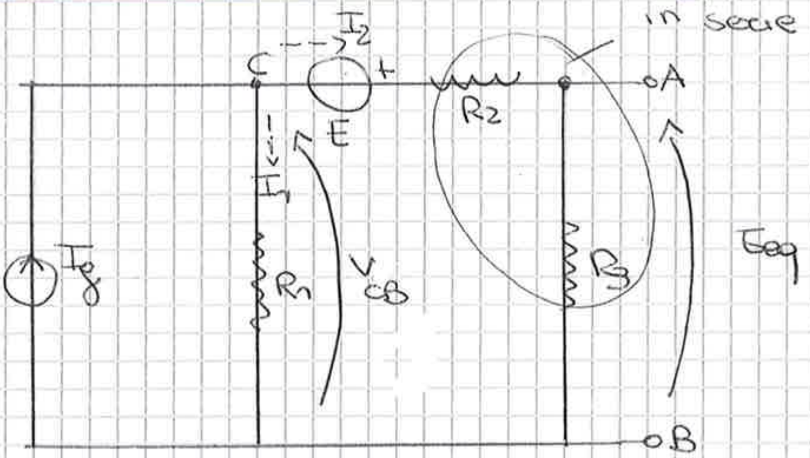
$$R_{eq} = \frac{R_2 R_3}{R_2 + R_3}$$

In serie => • $R_{eq} + R_1 = R'$

• $E_{eq} + E_2 = E'$



ESERCITAZIONE 2 - ES. 3 CON MILLMAN



$$V_{CB} = \frac{I_g + (-E)/R_2+R_3}{\frac{1}{R_1} + \frac{1}{R_2+R_3}}$$

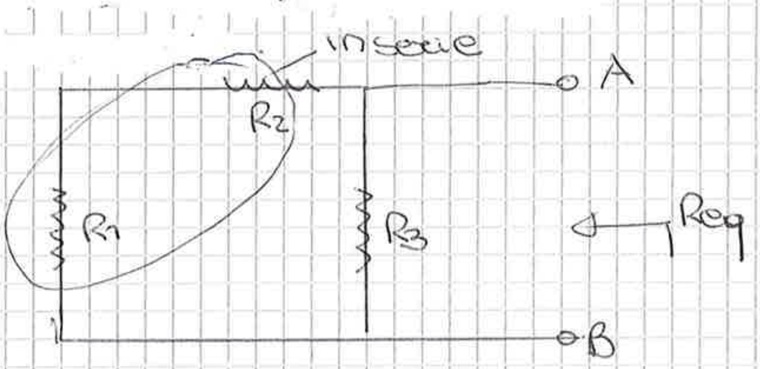
$$= \frac{10 - 40/10}{\frac{1}{10} + \frac{1}{10}} = \frac{10-4}{\frac{2}{10}} = \frac{6}{\frac{1}{5}} = 30\ V$$

$$I_1 = \frac{V_{CB}}{R_1}$$

$$= 30/10 = 3\ A$$

$I_2 = I_g - I_1 = 10 - 3 = 7A \implies V_{R3} = E_{eq} = R_3\ I_2$
$= 5 \cdot 7$
$= 35\ V$

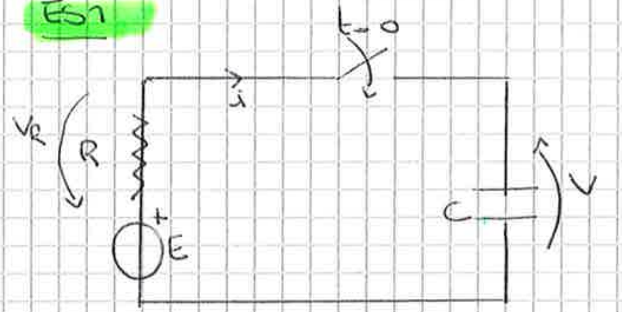
R_{eq} (sempre passivando la rete)



$$R_{eq} = (R_1 + R_2) // R_3 = \frac{15 \cdot 5}{15+5} = \frac{\cancel{75}}{\cancel{20}} = \frac{15}{4}\ \Omega$$

ESERCITAZIONE 3

ES1



$R = 100\,\Omega$

$C = 100\,\mu F$

$E = 10\,V$

$Q = CV$

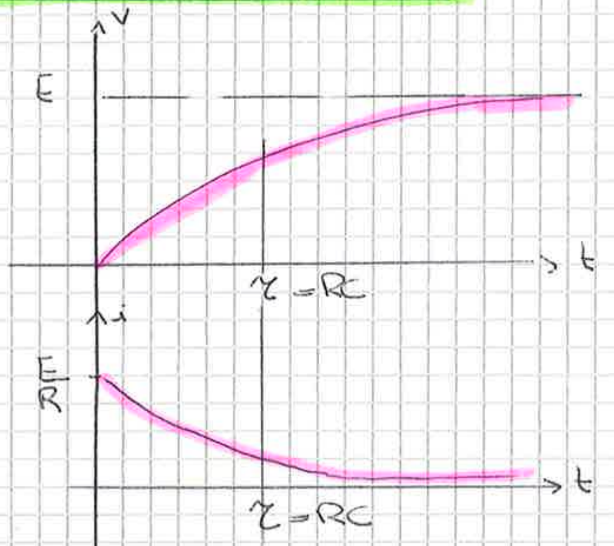
LKT: $E - V_R - V = 0$

Eq. COSTITUTIVA: $V_R = R \cdot i$ $\Rightarrow i = \frac{E-V}{R}$

Derivando si ottiene: $\frac{dQ}{dt} = C\frac{dv}{dt}$

$$\boxed{i = C\frac{dv}{dt}}$$

Andamento di $V(t)$ e $i(t)$



$V(0) = 0$

$V(\infty) = E$

$i(0) = \frac{E - V(0)}{R}$

$i(\infty) = 0$

$E - V - R \cdot i = 0$

$E - V - R \cdot C\frac{dv}{dt} = 0$ → eq. differenziale di I ordine (*)

$\frac{dv}{dt} = \frac{(E-V)}{RC}$

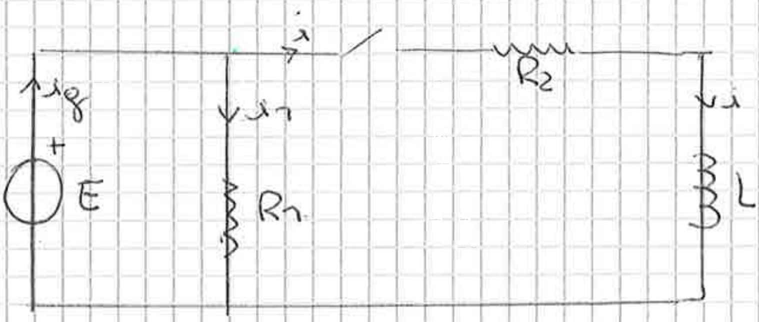
(*)

- omogenea associata

$E = 0$

$V + RC\frac{dv}{dt} = 0$

ES 2



$E = 12\,V$
$R_1 = R_2 = 10\,\Omega$
$L = 0{,}5\,H$

Tasto aperto: $i_g = i_1 = \frac{E}{R_1} = 1{,}2\,A$

NOTA: appena chiudo il tasto non ci può essere corrente sull'induttore perché la variabile i è continua $\boxed{W_L = \frac{1}{2} L i^2}$

$\Rightarrow \boxed{i(0^-) = i(0^+) = 0}$

Anche la tensione è nulla di conseguenza.

A regime: $\boxed{\frac{di}{dt} = 0}$ corrente stazionaria

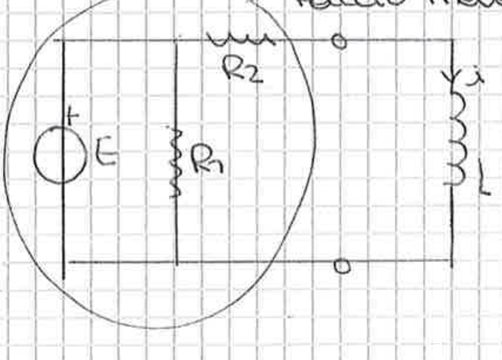
$\Rightarrow V_L = L \frac{di}{dt} = 0$

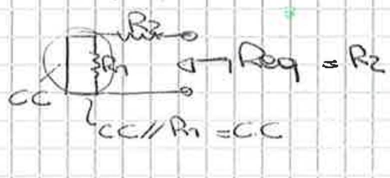
$i = \frac{E}{R_2} = 1{,}2\,A$

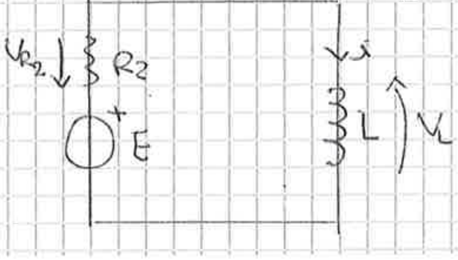
$i_{g\infty} = i_1 + i_\infty = 2{,}4\,A$

$\boxed{P_G(t) = E \cdot i_g} = E(i_1 + i)$

Faccio thevenin: $E_{eq} = E$







$$\begin{cases} E - R_2 i - V_L = 0 \\ V_L = L \frac{di}{dt} \end{cases}$$

$$i_g = i_1 + i = \frac{E}{R_1} + \left[-\frac{E}{R_2} e^{-t/L/R_2} + \frac{E}{R_2} \right]$$

$$\boxed{P_g = E \cdot i_g} = E \cdot i_1 + E \cdot i = \frac{E^2}{R_1} + \left[-\frac{E^2}{R_2} e^{-t/L/R_2} + \frac{E^2}{R_2} \right]$$

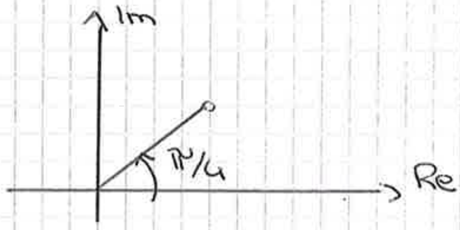
ES 2

$$\bar{Y} = \frac{1}{\underbrace{(10 + j10)}_{=\bar{d}}} \qquad f = 100\ Hz$$

- $y(t)$?

$$|10 + j10| = \sqrt{10^2 + 10^2} = \sqrt{200} = 10\sqrt{2}$$

$$\angle \bar{d} = \text{arctg}\ \frac{10}{10} = \frac{\pi}{4}$$



$$\bar{Y} = \frac{1}{10\sqrt{2}\, e^{j\pi/4}} = \frac{\sqrt{2}}{20}\, e^{-j\pi/4}$$

$$\omega = 2\pi f = 628\ \frac{rad}{s}$$

$$y(t) = \sqrt{2} \cdot \frac{\sqrt{2}}{20} \sin\left(628t - \frac{\pi}{4}\right)$$

ES 3

$$\bar{Z} = \frac{10\, e^{j\pi/4}}{\underbrace{(10 + j10)}_{=\,10\sqrt{2}\, e^{j\pi/4}}}\ \Omega$$

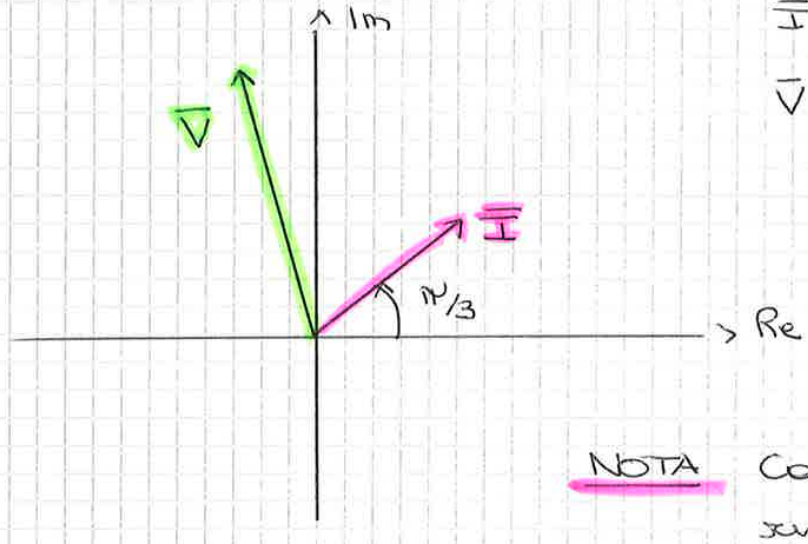
- Riduco l'espressione

$$\bar{Z} = \frac{\cancel{10}\, \cancel{e^{j\pi/4}}}{\cancel{10}\sqrt{2}\, \cancel{e^{j\pi/4}}} = \underbrace{\frac{1}{\sqrt{2}}}\ \Omega$$

Modulo $= \frac{1}{\sqrt{2}} = 0{,}7$

Fase $= 0$

L'impedenza è un RESISTORE perché ha solo parte reale



$\overline{I} = 6\, e^{j\frac{\pi}{3}}$ A

$\overline{V} = 10\sqrt{2}\; e^{j\frac{7}{12}\pi}$ V

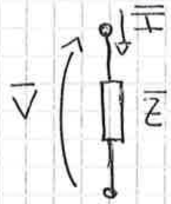
NOTA Corrente in ritardo rispetto $\overline{V}$

ES 5

$\overline{Z} = (1 - j)\ \Omega$ → Impedenza di tipo **OHMICO – CAPACITIVA**

$\overline{V} = 100\,V = 100 \cdot e^{j0}\ V$

- $\overline{I}$?



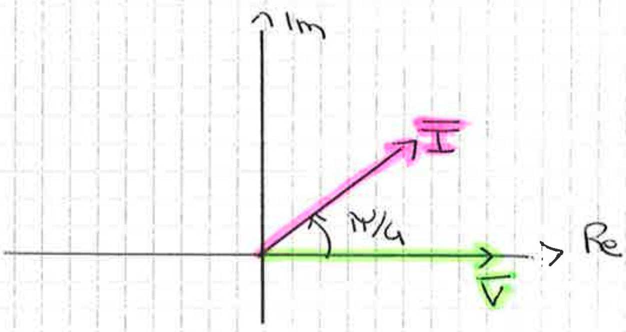
$$\begin{cases} |\overline{Z}| = \sqrt{2} \\ \angle \overline{Z} = -45° = -\frac{\pi}{4} \end{cases}$$

$\Rightarrow$

$\overline{Z} = \sqrt{2}\; e^{-j\frac{\pi}{4}}$

$\overline{V} = \overline{Z} \cdot \overline{I} \Rightarrow \overline{I} = \frac{\overline{V}}{\overline{Z}} = \frac{100}{\sqrt{2}\, e^{-j\frac{\pi}{4}}} = \frac{100}{\sqrt{2}}\, e^{j\frac{\pi}{4}}$

$= \left(70{,}7\ e^{j\frac{\pi}{4}}\right)$ A

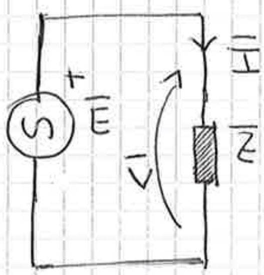


NOTA Corrente in anticipo rispetto tensione

ESERCITAZIONE 5

31.10.16

ES 1



$\bar{Z} = (1 + j)\ \Omega$

$\bar{I} = 10\, e^{j\pi/3}$

$e(t)$?

$v(t) = e(t)$

$\bar{I} \longrightarrow i(t)$

$i(t) = \sqrt{2}\, |\bar{I}| \sin(\omega t + \arg \bar{I})$

$|\bar{I}| = 10\ A \qquad \arg(\bar{I}) = \frac{\pi}{3}$

$i(t) = \sqrt{2} \cdot 10 \sin\left(\omega t + \frac{\pi}{3}\right)$

$\bar{Z} \overset{\Delta}{=} \bar{V}/\bar{I}$
per definizione

$|\bar{Z}| = \frac{V}{I} \quad ; \quad \arg(\bar{Z}) = \arg(\bar{V}) - \arg(\bar{I})$

$V = |\bar{Z}| \cdot I = \sqrt{2} \cdot 10 = (10\sqrt{2})\ V$

$\arg(\bar{Z}) = \operatorname{arctg} \frac{\operatorname{Im}(\bar{Z})}{\operatorname{Re}(\bar{Z})} = \operatorname{arctg} 1 = \frac{\pi}{4}$

$\arg(\bar{V}) = \arg(\bar{Z}) + \arg(\bar{I}) = \frac{\pi}{4} + \frac{\pi}{3} = \frac{7}{12}\pi$

$\bar{V} = \bar{Z} \cdot \bar{I} = (1+j)\, 10\, e^{j\pi/3} = \sqrt{2} \cdot e^{j\pi/4} \cdot 10\, e^{j\pi/3}$

$= \underbrace{10\sqrt{2}}_{V} \cdot e^{j\frac{7}{12}\pi}$

$v(t) = \sqrt{2} \cdot V \sin(\omega t + \arg \bar{V})$

$= 20 \sin\left(\omega t + \underbrace{\frac{7}{12}\pi}_{\theta_v}\right)$

$$\overline{Z} = 10 \frac{(2\pi)^2}{100+(2\pi)^2} + j\, 2\pi \cdot \frac{100}{100+(2\pi)^2}$$

$$= (2.83 + j\, 4{,}50)\ \Omega$$

$f = 5\ KHz$

$X_L = 2\pi \cdot 100\ \Omega$

$$\overline{Z} = 10 \frac{(2\pi \cdot 100)^2}{100+(2\pi\cdot 100)^2} + j\, 2\pi \cdot 100 \cdot \frac{100}{100+(2\pi\cdot 100)^2}$$

$$\overline{Z} = 10 + j\, 0{,}16$$

NOTA

f piccola →
- Se R e L in serie, prevale la resistenza (prevale quello più grande)
- Se R e L in parallelo, prevale il comportamento induttivo

$\overline{I}_L = \dfrac{\overline{U}}{j\omega L}$ più ω è piccola ⇒ più $\overline{I}_L$ aumenta, mentre $\overline{I}_R$ è sempre la stessa
⇒ Se ω molto piccola
$\overline{I} = \overline{I}_L$
segue che R la faccio diventare c.a essendo trascurabile

(Due elementi in parallelo prevale quello più piccolo)

$$I_1 = |27.6 - j\,36.8| = 46\ A$$

$$\overline{Z_{eq_2}} = \frac{R \cdot 4j}{R + 4j} = \frac{3 \cdot 4j}{3 + 4j} = \frac{12j}{3+4j} \cdot \frac{(3-4j)}{(3-4j)} =$$

$$= (1,92 + 1,44j)\ \Omega$$

$$\overline{I_2} = \frac{230}{1,92 + 1,44j} = (76,67 - j\,57,5)\ A$$

$$I_2 = |76,67 - j\,57,5| = 96\ A$$

d)

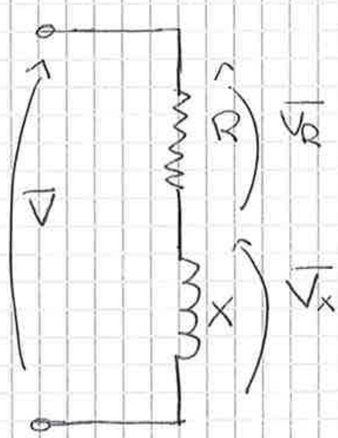
$$\overline{S} = P + jQ = (2101 + j\,4202)\ VA$$

$$|\overline{S}| = S = \sqrt{2101^2 + 4202^2} = 4700\ VA$$ POTENZA APPARENTE

OPPURE

$$S = \sqrt{P^2 + Q^2} = \sqrt{(VI\cos\theta)^2 + (VI\sin\theta)^2} = VI$$
$$= 230 \cdot 20{,}5$$
$$= 4715\ VA$$

OPPURE



$$P = \frac{V_R^2}{R} = \frac{102{,}5^2}{5} = 2101\ W$$

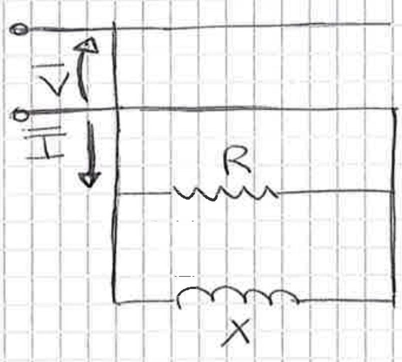
$$Q = \frac{V_X^2}{X} = \frac{205^2}{10} = 4202\ VAR$$

OPPURE

$$P = \frac{V^2}{Z}\cos\theta = \frac{230^2}{11{,}2}\cdot\cos(63{,}4°) = 2115\ W$$

$$Q = \frac{V^2}{Z}\sin\theta = \frac{230^2}{11{,}2}\sin(63{,}4°) = 4223\ VAR$$

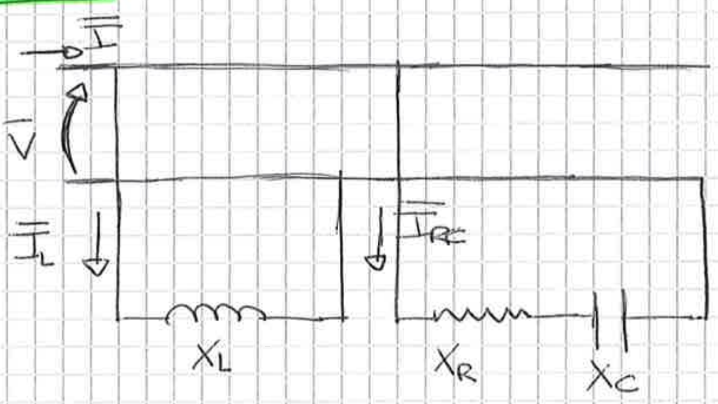
ES 2



$V = 230\ V$
$R = 5\ \Omega$
$X = 6\ \Omega$

1° $\overline{I}$?
2° $\overline{S}$?

ES 3



$V = 230\ V$

$X_L = 10\ \Omega$

$X_R = R = 10\ \Omega$

$X_C = 7{,}5\ \Omega$

a) $\bar{I}_L$? b) $\bar{I}_{RC}$?

c) Q_L ? d) $\bar{S}_{TOT}$?

e) I ?

a) $\bar{I}_L = \dfrac{\bar{V}}{\bar{Z}_L} = \dfrac{230\ e^{j0}}{10\ e^{j\pi/2}} = 23\ e^{-j\pi/2}\ A = 23\ e^{-j90°}\ A$

b) $\bar{I}_{RC} = \dfrac{\bar{V}}{\bar{Z}_{RC}} = \dfrac{\bar{V}}{\underbrace{R - jX_C}} = \dfrac{230}{12{,}5 \cdot e^{-j37°}} = 18{,}4\ e^{j37°}\ A$

modulo $= 12{,}5\ \Omega$

fase $= -37°$

c) $Q_L = X_L\ I_L^2 = 10 \cdot 23^2 = 5290\ VAR$

d) $\bar{S}_{TOT} = \sum_K \bar{S}_K$

$\bar{S}_L = j\ Q_L\ VA$

$\bar{S}_{RC} = \bar{Z}_{RC} \cdot I_{RC}^2 = (10 - j7{,}5) \cdot 18{,}4^2 = 3385 - j2539\ VA$

$\bar{S}_{TOT} = \bar{S}_{RC} + jQ_L = 3385 - j2539 + j5290$

$= (3385 + j2751)\ VA$

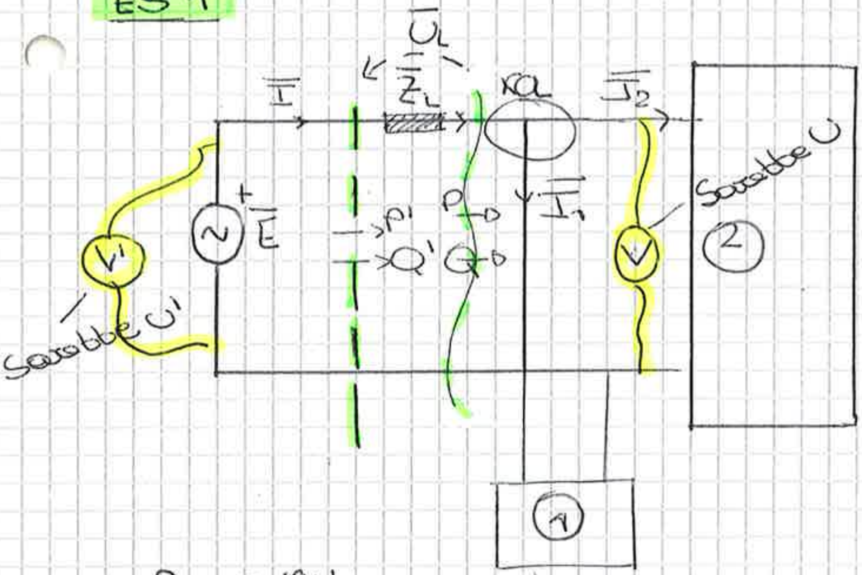
$S_{TOT} = \sqrt{P^2 + Q^2} = 4362\ VA$

e) $S_{TOT} = V\ I \Rightarrow I = \dfrac{S_{TOT}}{V} = 4362/230 = 18{,}9\ A$

ESERCITAZIONE 7

16.11.16

ES 1



$P_1 = 10\ KW$

$Q_1 = 7{,}5\ KVAR$

$P_2 = 20\ KW$

$Q_2 = 7{,}5\ KVAR$

$\overline{Z_L} = 50 + j100 \quad (m\Omega)$

$U = 230\ V$ Nota: è un valore efficace!

$$\begin{cases} \overline{S_1} = P_1 + jQ_1 \\ \overline{S_1} = \overline{U} \cdot \overline{I_1}^* = \overline{U}\left(\dfrac{\overline{U}}{\overline{Z_1}}\right)^* = \overline{U} \cdot \dfrac{\overline{U}^*}{\overline{Z_1}^*} = \dfrac{U^2}{\overline{Z_1}^*} \Rightarrow \\ \overline{Z_1} = \dfrac{U^2}{\overline{S_1}^*} = \dfrac{230^2}{P_1 - jQ_1} \end{cases}$$

$S = U \cdot I$ potenza apparente (per questa non vale il teo. di conservazione di Boucherot)

$= |\overline{S}| = \sqrt{P^2 + Q^2} = 15\sqrt{5} = 33{,}54\ KVA$

$P = P_1 + P_2 \qquad Q = Q_1 + Q_2$

$I = \dfrac{S}{U} = 33{,}54 \cdot 10^3 / 230 = 145{,}82\ A$

$S' = U' \cdot I$ (*) potenza apparente del generatore

$\sqrt{P'^2 + Q'^2} \qquad P' = P_L + P \qquad Q' = Q_L + Q$

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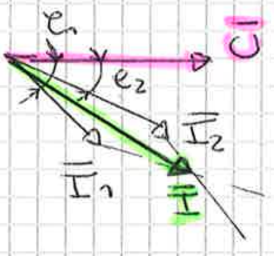


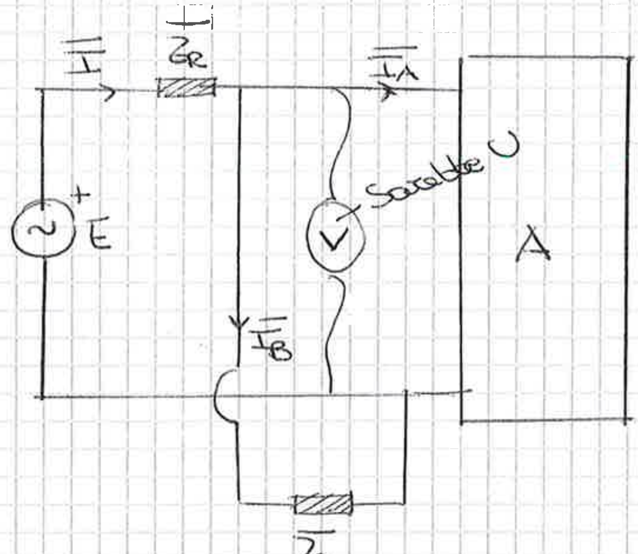
$$\overline{I} = (86{,}95 + 43{,}47) - j\,(32{,}60 + 32{,}60)$$
$$= 130{,}42 - j\,65{,}2 \text{ A}$$

Facendo il modulo di $\overline{I}$ dovrei ottenere di nuovo 145,82 A

$I = |\overline{I}| = 145{,}82 \text{ A}$

$\overline{E} = \overline{Z}_L \cdot \overline{I} + \overline{U} = (50 + j100) \cdot 10^{-3} \; (130{,}42 - j65{,}2) + 230$

ES 2



$P_A = 20 \text{ kW}$

$Q_A = 20 \text{ kVAR}$ $\Big\}\; \overline{S}_A = \overline{U} \cdot \overline{I}_A^*$

$Z_B = 10 + j5 \;\Omega$

$Z_R = 75 + j100 \;(\text{m}\Omega)$

$V = 230 \text{ V}$

- $\overline{I}$?
- $\overline{E}$?

$$\overline{I}_A = \frac{\overline{S}_A^*}{\overline{U}^*} = 86{,}95 - j\,86{,}95 \text{ A}$$

$\overline{S}_A^* = (20 - j20) \cdot 10^3$, $\overline{U}^* = 230$

$$\overline{I}_B = \frac{\overline{U}}{\overline{Z}_B} = \frac{230}{10 + j5} = 18{,}4 - j9{,}2 \text{ A}$$

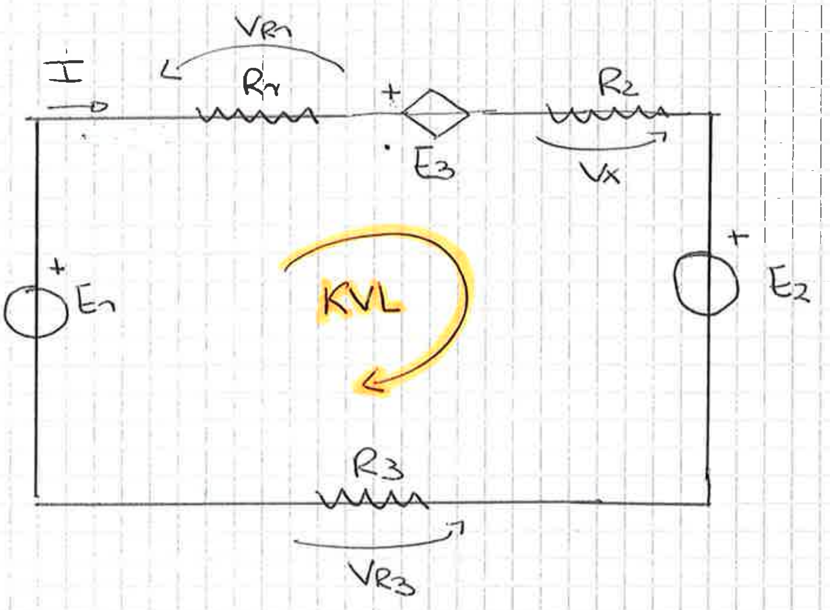
$\overline{I} = \overline{I}_A + \overline{I}_B = 105{,}35 - j\,96{,}15 \text{ A}$

$I = |\overline{I}|$ $\qquad \overline{E} = \overline{Z}_R \, \overline{I} + \overline{U}$

ESERCITAZIONE 8

16.11.16

ES 1



• I ?

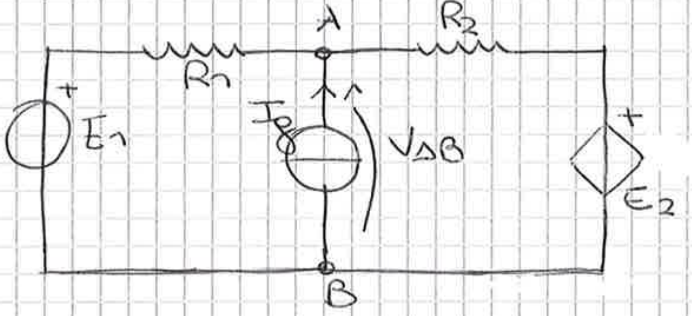
$R_1 = 4\,\Omega$
$R_2 = 2\,\Omega$
$E_2 = 120\,V$
$E_3 = \alpha V_x$ $\quad\quad \alpha = 3$
$R_3 = 6\,\Omega$
$E_1 = 12\,V$

KVL

$$E_1 - V_{R1} - E_3 + V_x - E_2 - V_{R3} = 0$$
$$E_1 - R_1 I - \alpha V_x + V_x - E_2 - V_{R3} = 0$$
$$E_1 - \underline{\underline{R_1 I}} - \alpha\underline{\underline{(-R_2 I)}} + \underline{\underline{(-R_2 I)}} - E_2 - \underline{\underline{R_3 I}} = 0$$
$$I(-R_1 + \alpha R_2 - R_2 - R_3) = E_2 - E_1$$
$$I = \frac{E_2 - E_1}{-R_1 + \alpha R_2 - R_2 - R_3} = \frac{120 - 12}{-4 + 3 \cdot 2 - 2 - 6} = \frac{108}{-6} = -18\,A$$

$$I_2 = \frac{V_{AB}}{R_2} = \frac{48}{7} \cdot \frac{1}{8} = \frac{6}{7} \text{ A}$$

ES 3



$R_1 = 2\,\Omega$
$R_2 = 4\,\Omega$
$E_1 = 2\,V$
$I_g = 1\,A$
$E_2 = \alpha V_{AB}$
$\alpha = 2$

- V_{AB}?

MILLMAN

$$V_{AB} = \frac{\frac{E_1}{R_1} + I_g + \frac{E_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}$$

$$= \frac{\frac{R_2 E_1 + R_1 R_2 I_g + R_1 E_2}{\cancel{R_1 R_2}}}{\frac{R_1 + R_2}{\cancel{R_1 R_2}}}$$

$$V_{AB} = \frac{R_2 E_1 + R_1 R_2 I_g + \alpha V_{AB} R_1}{R_1 + R_2}$$

$$V_{AB}\left((1-\alpha) R_1 + R_2 \right) = R_2 E_1 + R_1 R_2 I_g$$

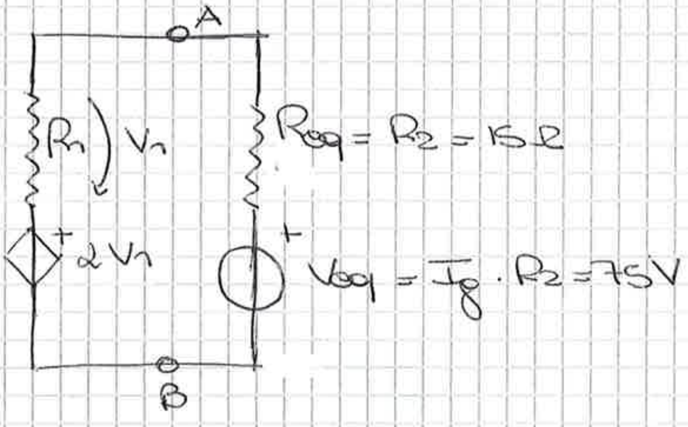
$$V_{AB} = 8\,V$$

Quindi:

$V_{AB} = 6\,V_1 + 30 = 6 \cdot 10 + 30 = 90\,V$

* NOTA

Posso anche fare:



$$V_{AB} = \frac{\frac{\alpha V_1}{R_1} + \frac{V_{eq}}{R_{eq}}}{\frac{1}{R_1} + \frac{1}{R_{eq}}} = \frac{V_1 + 5}{\frac{1}{6}} = 6V_1 + 30$$

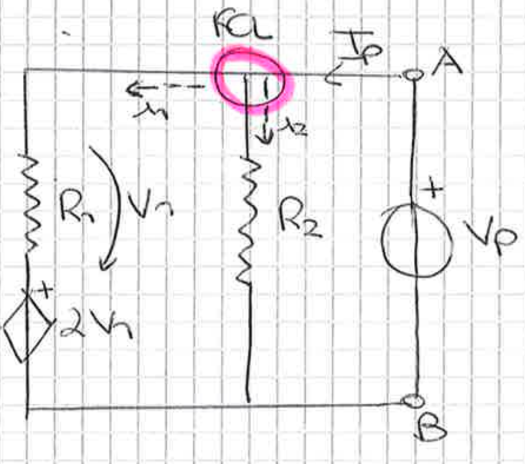
Inoltre:

$V_{AB} = \alpha V_1 - V_1 = 9V_1$

Uguagliando: $9V_1 = 6V_1 + 30 \Rightarrow V_1 = 10\,V$

$\Rightarrow V_{AB} = 90\,V$

R_{TH}



$$R_{TH} = \frac{V_p}{I_p}$$

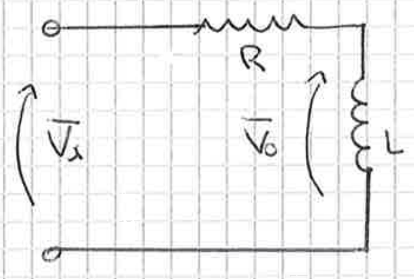
$I_p = i_1 + i_2$

$$\begin{cases} i_2 = \frac{V_p}{R_2} \\ i_1 = -\frac{V_1}{R_1} = -\frac{V_p}{9R_1} \\ V_p = \alpha V_1 - V_1 = 9V_1 \end{cases}$$

ESERCITAZIONE 9

17.11.16

ES 1



$R = 10\ K\Omega \quad L = 1\ H$

- Disegnare Bode modulo semplificato

$$H(\omega) = \frac{\overline{V_o}}{\overline{V_i}} = \frac{\cancel{\overline{V_i}} \cdot \frac{j\omega L}{R + j\omega L}}{\cancel{\overline{V_i}}}$$

~ partitore di tens.

$$\overline{H}(\omega) = \frac{j\omega L}{R\left(1 + j\omega \frac{L}{R}\right)} \qquad [L/R] = s$$

$$= \frac{j\omega\, L/R}{1 + j\omega\, L/R}$$

$$\frac{L}{R} = \tau \qquad \omega_0 = \frac{1}{L/R} = \frac{R}{L} = 10^4\ rad/s$$

$$\overline{H}(\omega) = \frac{j\frac{\omega}{R/L}}{1 + j\frac{\omega}{R/L}} = \boxed{\frac{j\,\omega/\omega_0}{1 + j\,\omega/\omega_0}} = \frac{N(\omega)}{D(\omega)}$$

N(ω)
- ha uno 0 nell'origine (pendenza + 20 dB per decade)
- per $\omega = \omega_0 \Rightarrow 0$ dB

D(ω)
- per $\omega \to 0 \Rightarrow 1$ ovvero 0 dB
- $\omega = \omega_0 \Rightarrow \frac{1}{\sqrt{2}}$ ovvero -3 dB
- $\omega \to \infty \Rightarrow$ -20 dB/dec

$$\left|1 + j\,\omega/\omega_0\right|_{\omega=\omega_0}$$

$$|1 + j| = \frac{1}{\sqrt{2}} \Rightarrow -3dB$$

$$\overline{H} = \frac{\frac{R}{1+j\omega RC}}{j\omega L + \frac{R}{1+j\omega RC}} = \frac{\cancel{\frac{R}{1+j\omega RC}}}{\frac{j\omega L - \omega^2 RLC + R}{\cancel{1+j\omega RC}}}$$

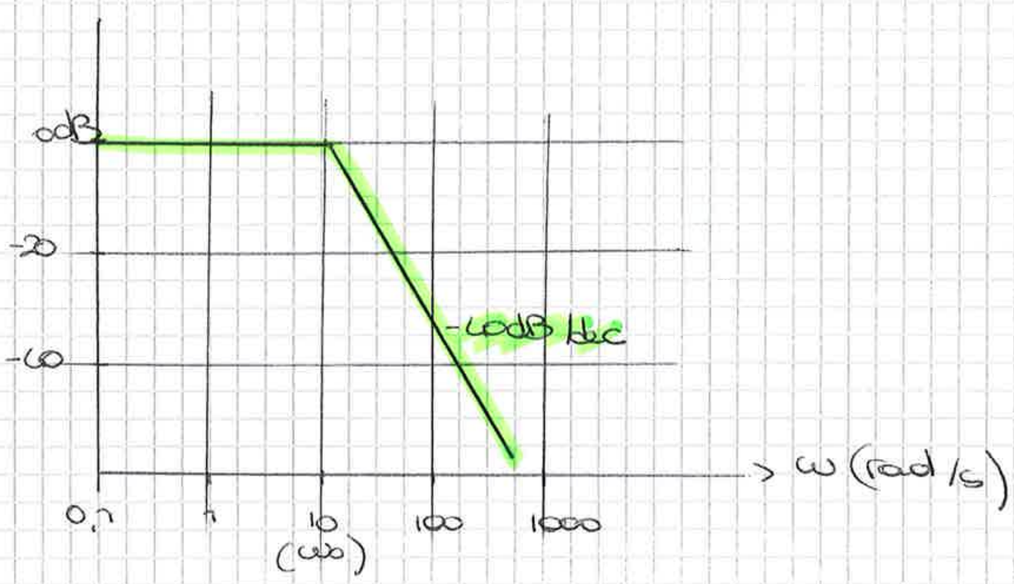
$$= \frac{R}{j\omega L - \omega^2 RLC + R}$$

$$\overline{H}(\omega) = \frac{1}{1 + j\omega\frac{L}{R} - \omega^2 LC}$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-1}\cdot 10^{-1}}} = 10 \text{ rad/s}$$

Denominatore : $\omega \to 0$ => 1 cioè 0 dB

$\omega \to \infty$ => -40 dB/dec



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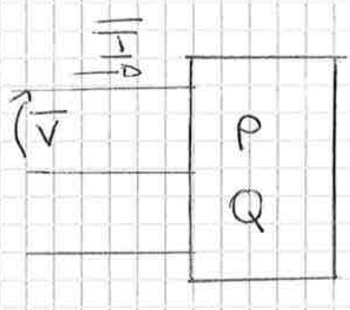
ES 4: TRIFASE



$V = 400\ V$

$P = 10\ KW$

$Q = 5\ KVAR$

- $\cos\varphi$?
- I ?

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

$Q = \sqrt{3}\ V I \sin\varphi$

$$\boxed{\frac{Q}{P} = tg\ \varphi} = \frac{\sqrt{3}\ V I \sin\varphi}{\sqrt{3}\ V I \cos\varphi}$$

$\overline{S} = P + jQ$

$$|\overline{S}| = \sqrt{P^2 + Q^2} = \sqrt{(\sqrt{3}\ V I \cos\varphi)^2 + (\sqrt{3}\ V I \sin\varphi)^2}$$

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

$$tg\varphi = \frac{Q}{P} = \frac{5}{10} = 0{,}5 \rightsquigarrow \cos\varphi \simeq 0{,}9$$

$$tg\ \varphi = 0{,}484 \iff \cos\varphi = 0{,}9$$

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

I: incognita

$$\boxed{I = \frac{P}{\sqrt{3}\ V \cos\varphi}} = \frac{10^4\ W}{\sqrt{3} \cdot 400 \cdot 0{,}9} = 16\ A$$

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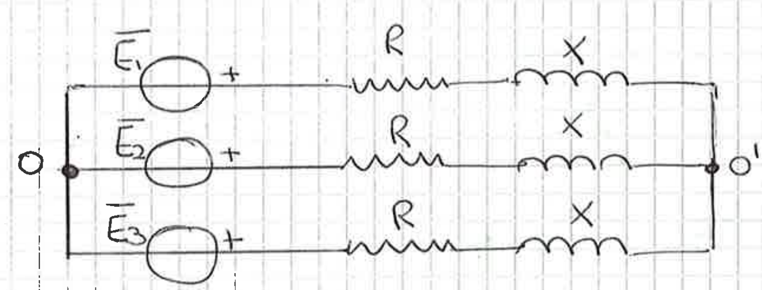
Esempio:

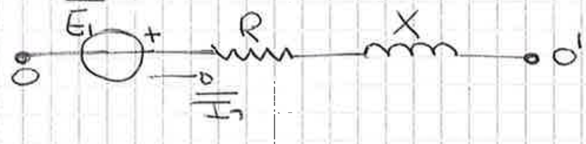


$|\overline{E}_1| = |\overline{E}_2| = |\overline{E}_3| = 230V$

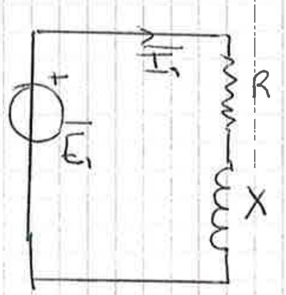
$R = 1\Omega$

$X = 1\Omega$

Se $V_{O'O} = 0V \Rightarrow$



Ovvero



Tensione di linea $= V = \sqrt{3} \cdot E = 400V$

$\overline{E}_1 = \overline{Z} \cdot \overline{I}_1 \Rightarrow \boxed{\overline{I}_1 = \frac{\overline{E}_1}{\overline{Z}}}$

$\overline{Z} = R + jX$

$|\overline{Z}| = \sqrt{R^2 + X^2} = \sqrt{2}\ \Omega$

$\angle \overline{Z} = tg^{-1} \frac{X}{R} = \frac{\pi}{4}$

$\overline{I}_1 = \frac{E \cdot e^{j0}}{Z \cdot e^{j\theta}} = \frac{230\ e^{j0}}{\sqrt{2} \cdot e^{j\pi/4}} = 162,6\ e^{-j\frac{\pi}{4}}\ A$

$\overline{E}_2 = \overline{Z} \cdot \overline{I}_2 \Rightarrow \overline{I}_2 = \frac{\overline{E}_2}{\overline{Z}}$

$\overline{I}_2 = \frac{230\ e^{-j\frac{2}{3}\pi}}{\sqrt{2} \cdot e^{j\pi/4}} = 162,6\ e^{j(-\frac{2}{3}\pi - \frac{\pi}{4})} = 162,6\ e^{-j\frac{11}{12}\pi}\ A$

ESAME ELETTROTECNICA

18.11.16

4 esercizi (ognuno 4 quesiti)

1) DC (analisi nodale può essere usata qui ma non è molto implementata)
2) transitorio
3) AC
4) risposta in frequenza

\+

domande aperte, risposta multipla

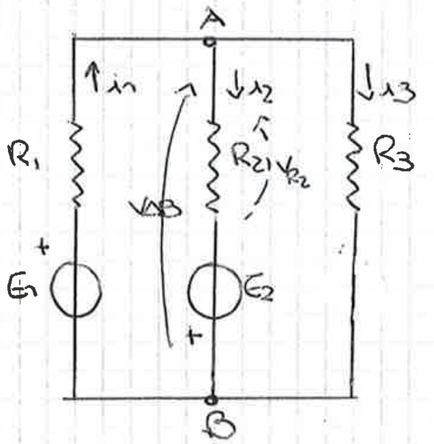
NOTA

Unità di misura SEMPRE!

2 R

SIMULAZIONE ESAME

ES 1



$E_1 = 100\ V$

$E_2 = 400\ V$

$R_1 = R_2 = R_3 = 1\ \Omega$

a) i_1 ?

b) i_2 ?

c) i_3 ?

d) potenza generatori ?

Millman (potevo usare anche sovrapposizione effetti)

$$V_{AB} = \frac{\frac{E_1}{R_1} - \frac{E_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$= \frac{100 - 400}{1 + 1 + 1} = -\frac{300}{3} = -100\ V$$

$V_{R_2} = V_{AB} + E_2 = -100 + 400 = 300 \Rightarrow V_{R_2} = R_2 \cdot i_2$

$i_2 = \frac{V_{R_2}}{R_2} = 300\ A$

$V_{AB} + R_1 I_1 - E_1 = 0 \Rightarrow i_1 = \frac{E_1 - V_{AB}}{R_1}$

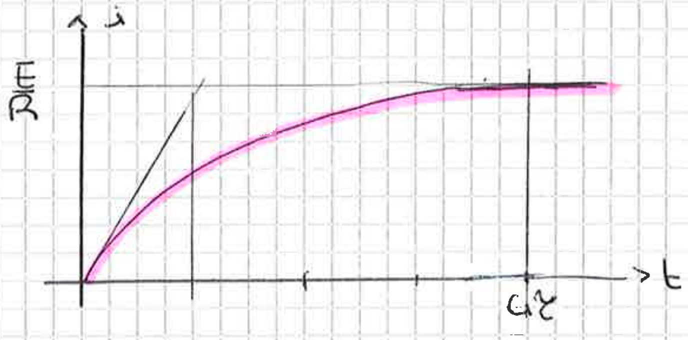
$= \frac{100 - (-100)}{1}$

$= 200\ A$

$$i(0)=0 \Rightarrow K e^{-0/\tau} + \frac{E}{R} = 0$$

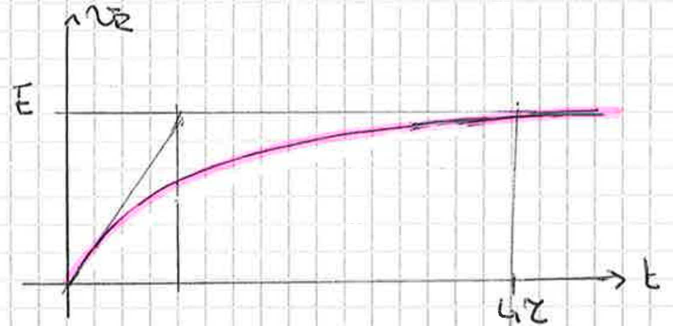
$$K = -\frac{E}{R}$$

$$i(t) = \frac{E}{R}\left(1 - e^{-t/\tau}\right)$$



b)

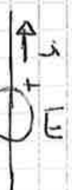
$$v_R(t) = R\,i(t) = \cancel{R}\cdot\frac{E}{\cancel{R}}\left(1 - e^{-t/\tau}\right) = E\left(1 - e^{-t/\tau}\right)$$



c) Energia in L per $t \to \infty$

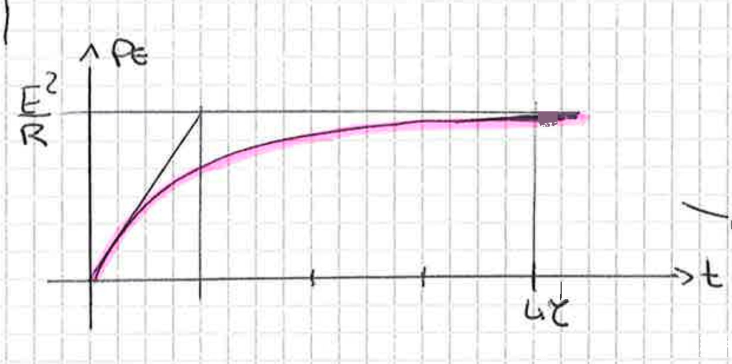
$$W_L = \frac{1}{2} L I_\infty^2 = \frac{1}{2} L \left(\frac{E}{R}\right)^2 = \frac{1}{2}\cdot 10^{-3}\cdot\left(\frac{12}{1}\right)^2 = 72 \text{ mJ}$$

d)



$$P_E(t) = E\cdot i(t) = E\cdot\frac{E}{R}\left(1 - e^{-t/\tau}\right) = \frac{E^2}{R}\left(1 - e^{-t/\tau}\right)$$

Lo stesso andamento corrente



→ Potenza max: all'infinito (> 4τ)

dipolo ohmico-induttivo.

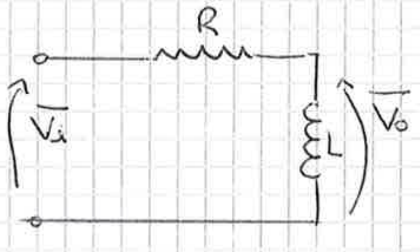
$$|\overline{S}_{TOT}| = \sqrt{4{,}2^2 + 1{,}4^2} = 4{,}4 \text{ KVA}$$

$$|\overline{S}_{TOT}| = \underbrace{V \cdot I}_{\text{valori efficaci}} \Rightarrow I = \frac{|\overline{S}_{TOT}|}{V} = \frac{4{,}4 \cdot 10^3}{230} = 19{,}1 \text{ A}$$

è minore della somma dei moduli di $\overline{I}_{RC}$ ed $\overline{I}_L$!!!

$$I \neq I_{RC} + I_L$$

ES4



$R = 10 \text{ K}\Omega$

$L = 1 \text{ H} \Rightarrow X_L = \omega L$

a) $\overline{Z}_{eq}(\omega)$

b) $\overline{H} = \frac{\overline{V}_o}{\overline{V}_i}$

c) ω_0

d) Bode modulo (semplificato)

a)

$$\overline{Z}_{eq}(\omega) = R + jX_L = R + j\omega L = (10^4 + j\omega)\ \Omega$$

b)

$$\overline{H}(\omega) = \frac{\overline{Z}_L}{\overline{Z}_{eq}} = \frac{j\omega L}{R + j\omega L} = \frac{j\omega L}{R(1 + j\omega \frac{L}{R})} = \frac{j\omega \frac{L}{R}}{1 + j\omega \frac{L}{R}}$$

c)

$$\omega_0 = \frac{1}{L/R} = \frac{R}{L} = \frac{10^4}{1} = 10^4 \text{ rad/s}$$

$$\overline{H}(\omega) = \frac{j\frac{\omega}{\omega_0}}{1 + j\frac{\omega}{\omega_0}}$$