Compito di Elettrotecnica

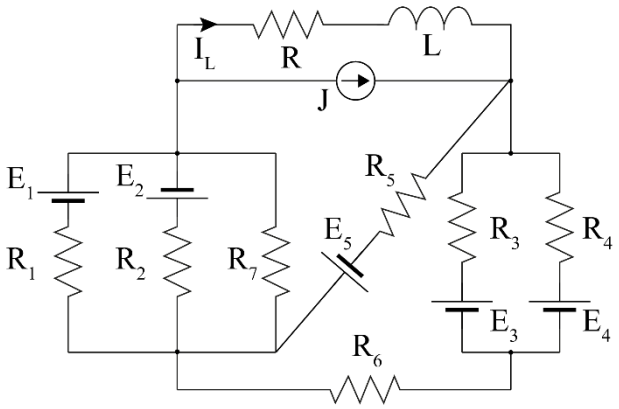
6 Maggio 2024

Nome e Cognome …… Matricola……

Corso di Laurea……

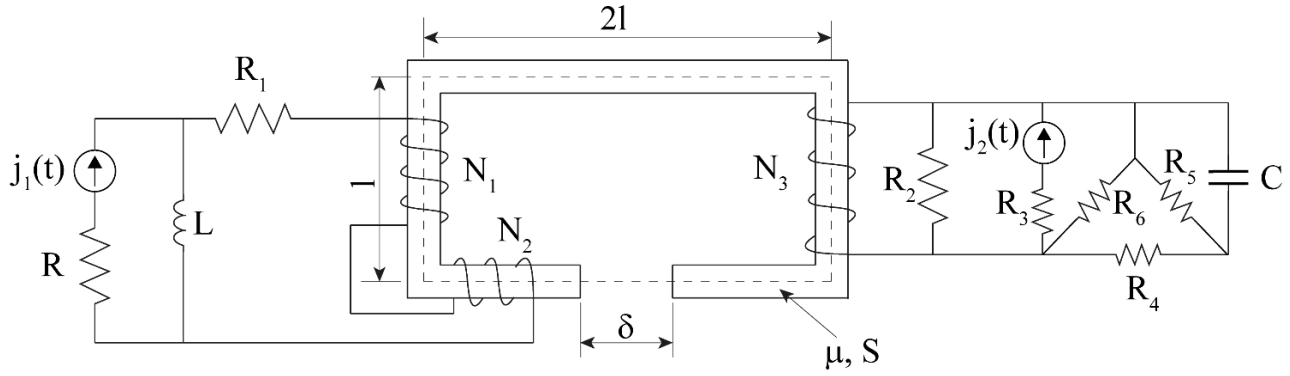
ES.1 – Dato il circuito in figura a regime, determinare il valore dell'energia immagazzinata dall'induttore L e la potenza generata ed erogata dal generatore di tensione reale (E4- R4)

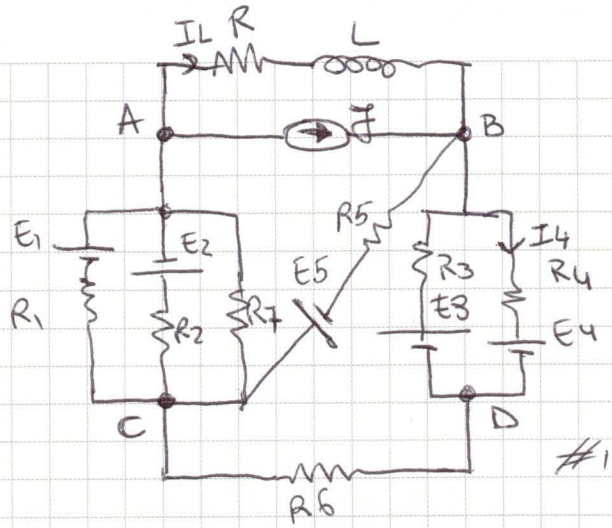
$\mathbf{E_1 = 5\ V};\ \mathbf{E_2 = 2\ V};\ \mathbf{E_3 = 4\ V};\ \mathbf{E_4 = 6\ V};\ \mathbf{E_5 = 3\ V};\ \mathbf{J = 2\ A};\ \mathbf{L = 0.5\ mH};$
$\boldsymbol{R = 2\ \Omega};\ \mathbf{R_1 = 3\ \Omega};\ \mathbf{R_2 = 7\ \Omega};\ \mathbf{R_3 = 3\ \Omega};\ \mathbf{R_4 = 7\ \Omega};\ \mathbf{R_5 = 3\ \Omega};$
$\mathbf{R_6 = 7\ \Omega};\ \mathbf{R_7 = 5\ \Omega};$



ES.2 – Dato il circuito in figura, determinare il valore della potenza generata da J2 e la potenza reattiva sul carico L.

$\mathbf{j_1(t) = \frac{\sqrt{2}}{2}\ \sin\left(\omega t + \frac{\pi}{2}\right) A};\ \mathbf{j_2(t) = \frac{\sqrt{2}}{4}\ \sin\left(\omega t + \frac{\pi}{3}\right) A};\ \mathbf{L = 1 mH};$
$\mathbf{C = 3.5\ mF};\ \boldsymbol{\omega = 100\ \frac{rad}{s}};\ \boldsymbol{N_1 = 300};\ \boldsymbol{N_2 = 100};\ \boldsymbol{N_3 = 200};$
$\mathbf{R_1 = 6\ \Omega};\ \mathbf{R_2 = 2\ \Omega};\ \mathbf{R_3 = 10\ \Omega};\ \mathbf{R_4 = 10\ \Omega};\ \mathbf{R_5 = 5\ \Omega};\ \mathbf{R_6 = 3\ \Omega};\ \mathbf{R = 10\ \Omega};$
$\mathbf{l = 2.5\ cm};\ \mathbf{S = 25\ cm^2};\ \boldsymbol{\delta = 0.5 cm};\ \boldsymbol{\mu_r = 1000};$

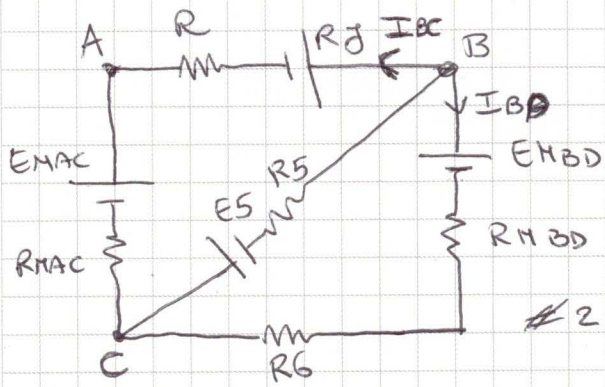




$E_1 = 5V \quad E_2 = 2V \quad E_3 = 4V \quad E_4 = 6V$

$E_5 = 3V \quad R = 2\Omega \quad R_1 = R_3 = R_5 = 3\Omega$

$R_2 = R_4 = R_6 = R_7 = 7\Omega$

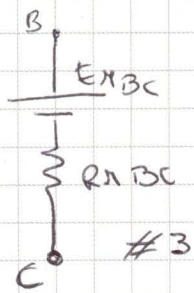


$$E_{MAC} = \frac{\frac{E_1}{R_1} - \frac{E_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_7}}$$

$$R_{MAC} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_7}}$$

$$E_{MBD} = \frac{\frac{E_3}{R_3} + \frac{E_4}{R_4}}{\frac{1}{R_3} + \frac{1}{R_4}}$$

$$R_{MBD} = \frac{1}{\frac{1}{R_3} + \frac{1}{R_4}}$$



$$E_{MBC} = \frac{\frac{(R_J + E_{MAC})}{R + R_{MAC}} - \frac{E_5}{R_5} + \frac{E_{MBD}}{(R_{MBD} + R_6)}}{\frac{1}{(R + R_{MAC})} + \frac{1}{R_5} + \frac{1}{(R_{MBD} + R_6)}}$$

$V_{BC} = E_{MBC}$

Del #2 $\Rightarrow V_{BC} = R_J + E_{MAC} + I_{BC}(R + R_{MAC}) \Rightarrow$

$\Rightarrow I_{BC} = \frac{V_{BC} - R_J - E_{MAC}}{R + R_{MAC}}$

Del #2 $\Rightarrow V_{AB} = -R_J - R \cdot I_{BC}$

Del #2 $\Rightarrow V_{AC} = E_{MAC} + R_{MAC} \cdot I_{BC}$

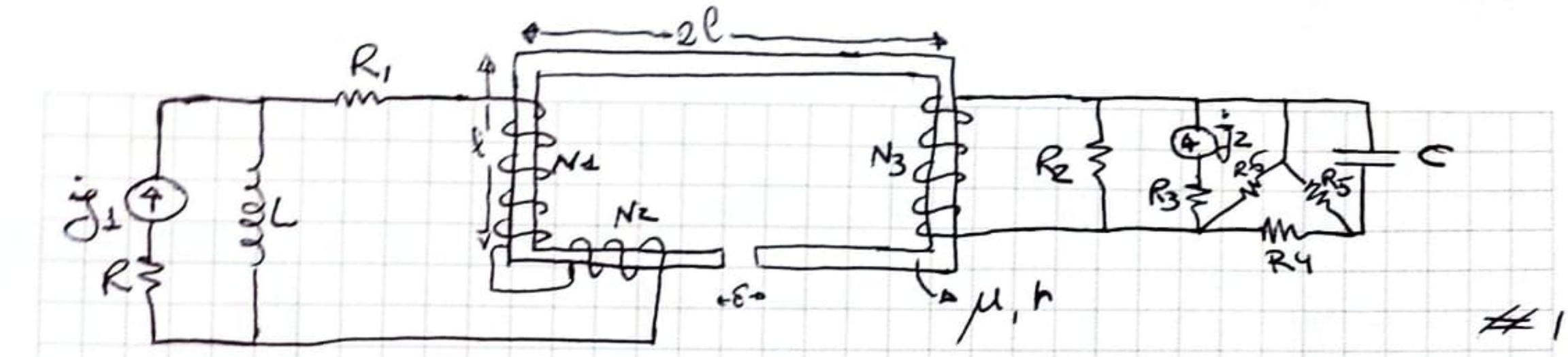
Del #1 $\Rightarrow I_L = \frac{V_{AB}}{R} \Rightarrow W_L = \frac{1}{2} L I_L^2$

Del #2 $\Rightarrow V_{BC} = E_{MBD} + I_{BD}(R_{MBD} + R_6) \Rightarrow I_{BD} = \frac{V_{BC} - E_{MBD}}{R_{MBD} + R_6}$

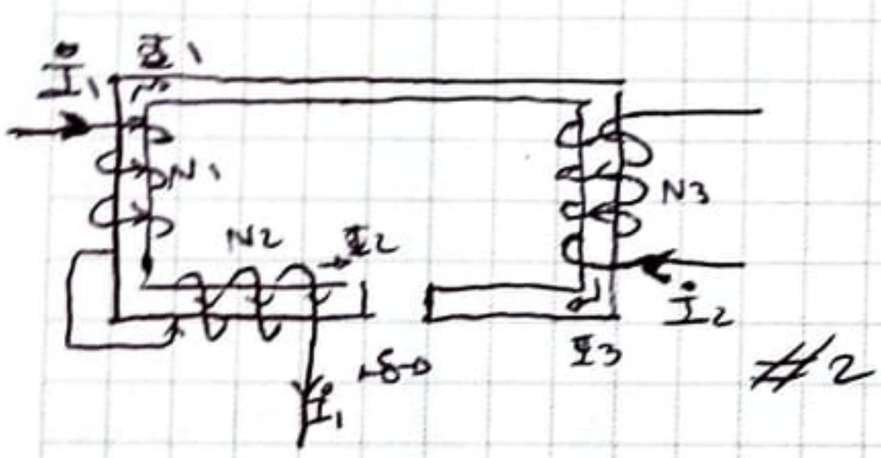
Del #2 $\Rightarrow V_{BD} = E_{MBD} + R_{MBD} \cdot I_{BD}$

Del #4 $\Rightarrow V_{BD} = E_4 + R_4 \cdot I_4 \Rightarrow I_4 = \frac{V_{BD} - E_4}{R_4}$

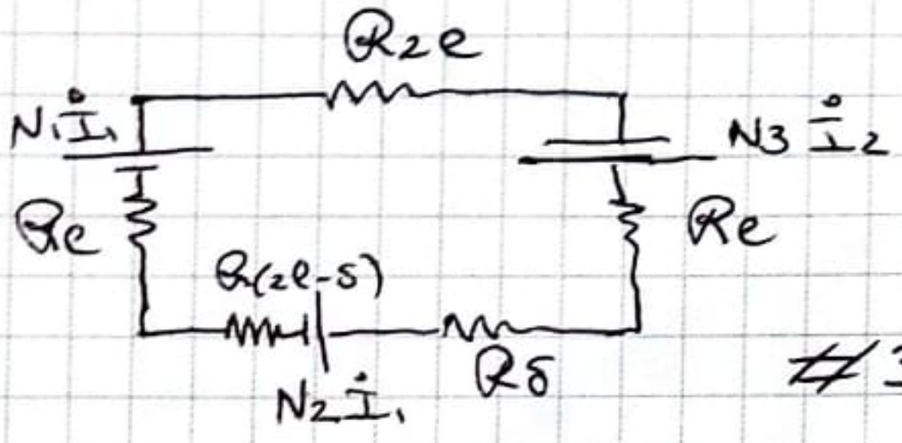
$P_{J-R} = V_{BD} \cdot I_4 = (E_4 + R_4 \cdot I_4) I_4 = E_4 I_4 + R_4 \cdot I_4^2$



#1



#2



#3

$$R_e = \frac{l}{\mu_0 \mu_n S} \qquad R_{2e} = \frac{2l}{\mu_0 \mu_n S} \qquad R_{(2e-\delta)} = \frac{(2l-\delta)}{\mu_0 \mu_n S} \qquad R_\delta = \frac{\delta}{\mu_0 S}$$

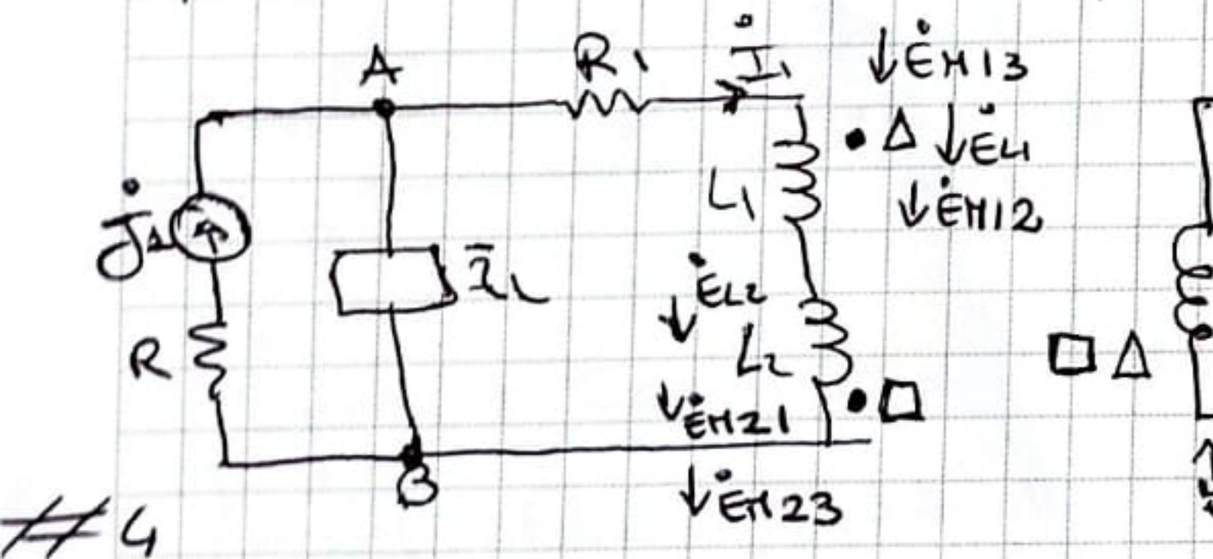
$$Req_1 = Req_2 = Req_3 = Req = 2R_e + R_{2e} + R_{(2e-\delta)} + R_\delta$$

$$L_1 = \frac{N_1^2}{Req} \qquad L_2 = \frac{N_2^2}{Req} \qquad L_3 = \frac{N_3^2}{Req}$$

$$M_{12} = M_{21} = \sqrt{L_1 L_2} \quad (<0)$$

$$M_{13} = M_{31} = \sqrt{L_1 L_3} \quad (>0)$$

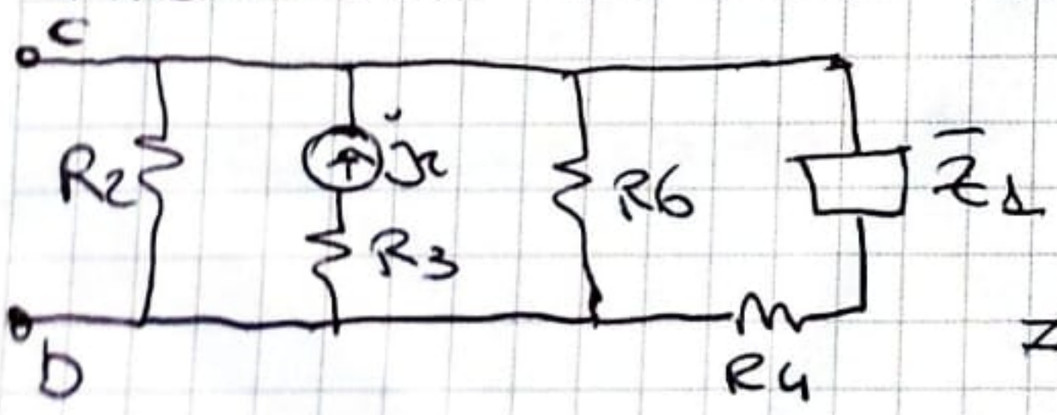
$$M_{23} = M_{32} = \sqrt{L_2 L_3} \quad (<0)$$



#4

Riduciamo il circuito retrogrado e iniziamo a semplificarlo:

$$\bar{Z}_1 = \frac{R_5 \cdot \left(-\frac{j}{\omega C}\right)}{R_5 - \frac{j}{\omega C}}$$



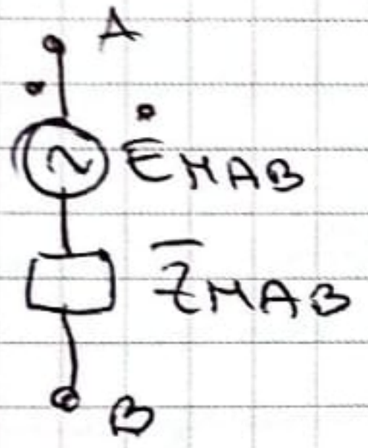
#5

Applico Millman tra i pali C-D:

$$\dot{E}_M = \frac{\dot{J}_2}{\frac{1}{R_2} + \frac{1}{R_6} + \frac{1}{\bar{Z}_1}}$$

$$\bar{Z}_M = \frac{1}{\frac{1}{R_2} + \frac{1}{R_6} + \frac{1}{\bar{Z}_1}}$$

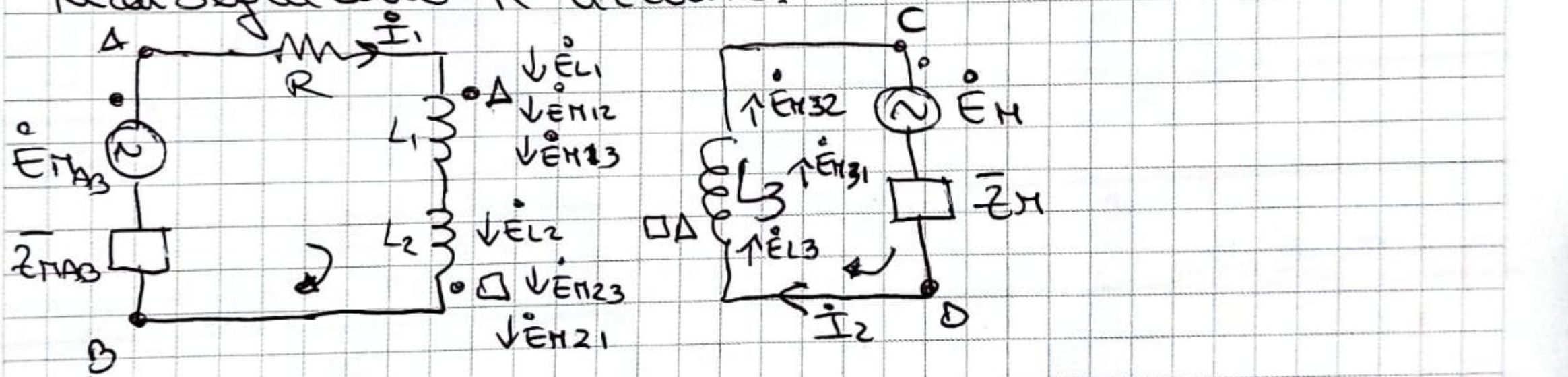
Dal #4 : Applico Millman tra A-B:



$$\dot{E}_{MAB} = \frac{\dot{J}_1}{\frac{1}{\bar{Z}_1}}$$

$$\bar{Z}_{MAB} = \bar{Z}_1$$

Ridisegniamo il circuito:



$$\begin{cases} \dot{E}_{MAB} + \dot{E}_{L1} + \dot{E}_{M12} + \dot{E}_{M13} + \dot{E}_{L2} + \dot{E}_{M23} + \dot{E}_{M21} = \dot{I}_1 (R + \bar{Z}_{MAB}) \\ -\dot{E}_M + \dot{E}_{L3} + \dot{E}_{M32} + \dot{E}_{M31} = \dot{I}_2 \bar{Z}_M \end{cases}$$

$$\dot{E}_{MAB} - j\omega L_1 \dot{I}_1 + j\omega M_{12} \dot{I}_2 - j\omega M_{13} \dot{I}_3 - j\omega L_2 \dot{I}_2 + j\omega M_{23} \dot{I}_3 + \dots$$

$$\dots + j\omega M_{21} \dot{I}_1 = \dot{I}_1 (R + \bar{Z}_{MAB})$$

$$-\dot{E}_M - j\omega L_3 \dot{I}_2 + j\omega M_{32} \dot{I}_2 - j\omega M_{31} \dot{I}_1 = \dot{I}_2 \bar{Z}_M$$

$$\begin{cases} \dot{E}_{MAB} - \dot{I}_1 \underbrace{\left(j\omega L_1 - j\omega M_{12} + j\omega L_2 - j\omega M_{21} + R + \bar{Z}_{MAB}\right)}_{A} + \\ + \dot{I}_2 \left(-j\omega M_{13} + j\omega M_{23}\right) = 0 \\ -\dot{E}_M + \dot{I}_1 \left(+j\omega M_{32} - j\omega M_{31}\right) = \dot{I}_2 \left(\bar{Z}_M + j\omega L_3\right) \end{cases}$$

$$\dot{I}_2 = \frac{\dot{I}_1 \underbrace{\left(j\omega M_{32} - j\omega M_{31}\right) - \dot{E}_M}_{C}}{\bar{Z}_M + j\omega L_3}$$

$$\dot{E}_{MAB} - \dot{I}_1 \cdot A + \dot{I}_1 \underbrace{\left(\left(j\omega M_{32} - j\omega M_{31}\right) - \dot{E}_M\right)}_{C} \cdot \underbrace{\frac{-j\omega M_{13} + j\omega M_{23}}{\bar{Z}_M + j\omega L_3}}_{B}$$

$$\dot{I}_1 \left(A - BC\right) = \dot{E}_{MAB} \Rightarrow \dot{I}_1 = \frac{\dot{E}_{MAB}}{A - BC}$$

$$\dot{I}_2 = \cancel{\dot{I}_1 C} \; \frac{\dot{E}_{MAB}}{A - BC} \cdot \frac{C}{\bar{Z}_M + j\omega L_3}$$

$$\dot{V}_{CA} = \dot{V}_{CH} + \dot{V}_{HD} \Rightarrow \dot{V}_{CH} = \dot{V}_{CD} - \dot{V}_{HD}$$

$$P_{generj2} = \dot{V}_{HC} \cdot \dot{J}_2 = \left(-\dot{V}_{CH}\right) \cdot \dot{J}_2$$

$$\bar{S}_{AB} = \dot{V}_{AB} \cdot \left(\overset{\vee}{I}_{AB}\right) = P_{AB} + jQ_{AB}$$

$$\dot{V}_{AB} = \dot{Z}_L \cdot \dot{I}_{AB} \cdot \overset{\vee}{I}_{AB}$$