versione provvisoria SOLUZIONE INCOMPLETA

Corso di Laurea in Ingegneria Informatica

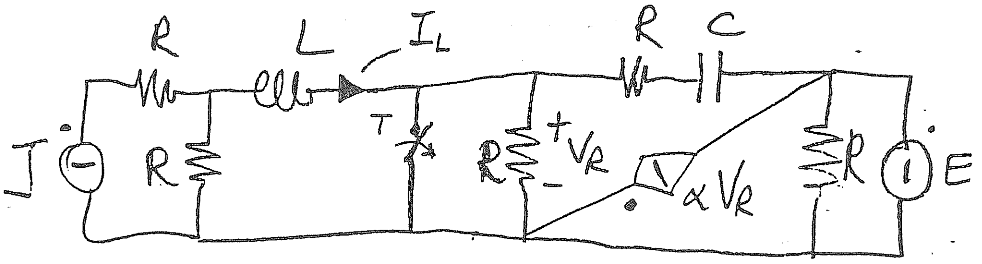
Prova Scritta di Elettrotecnica

(12 cred.: 1, 3, 4, 5; 9 cred.: 1, 2 or 5, 3, 6; 6 cred.: 2, 5, 6)

Pisa, ~~12 luglio 2002~~ 23/05/04

Allievo ....

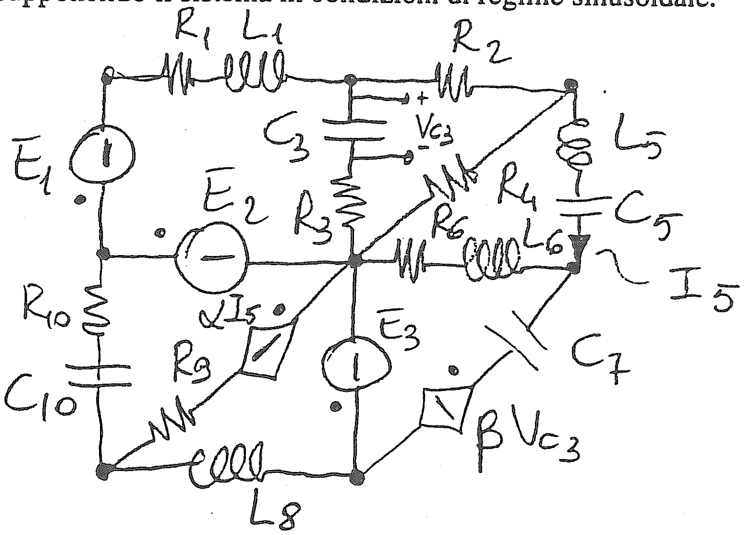
1. Il circuito di figura è in condizione di regime per t<0. Determinare l'evoluzione temporale della corrente $I_L(t)$ per t>=0.



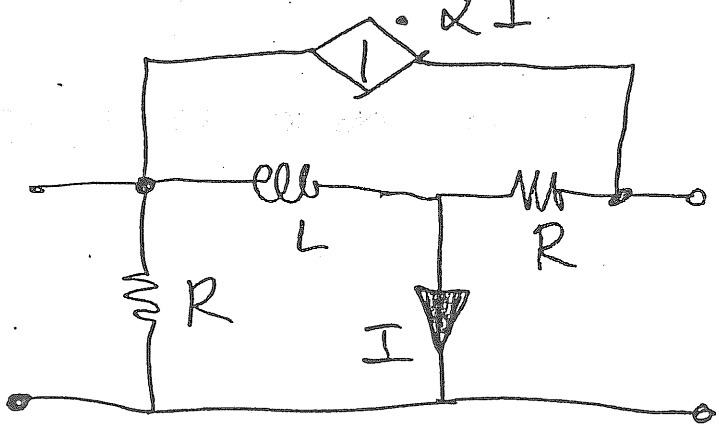
Il tasto T si apre all'istante t=0.

R = 10 Ω;
L = 10 mH;
C = 200 μF;
α = 2;
J = 10 A;
E = 100 V;

2. Per il circuito di figura scrivere un sistema di equazioni di equilibrio con il metodo delle tensioni nodali, supponendo il sistema in condizioni di regime sinusoidale.



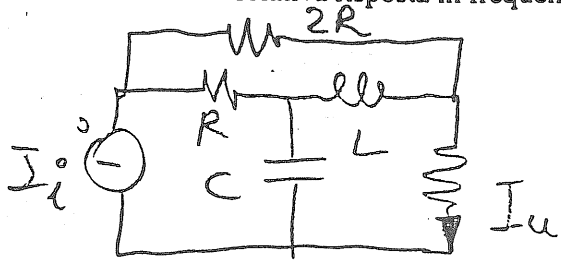
3. Per il doppio bipolo rappresentato in figura, determinare la matrice dei parametri T alla pulsazione ω=1000 rad/sec.



R = 10 Ω;
L = 20mH;
α = 2;

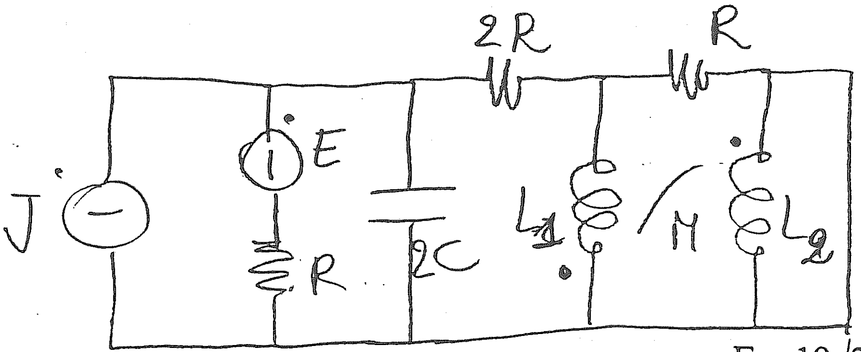
versione provvisoria 23/5/94

4. Per la rete di figura determinare la funzione di trasferimento I_u/I_i e tracciarne i diagrammi di Bode di modulo e fase della relativa risposta in frequenza.



R = 20
L = 10 mH
α = 0.5
C = 100 μF

5. Considerando in condizioni di regime periodico la rete di figura determinare l'energia elettromagnetica media immagazzinata nel condensatore C.



R = 10 Ω;
$L_1 = L_2 = 10$ mH;
M = 10 mH;
C = 100 μF;
α = 2;
J = 10 A;
E = 10√2 sin (1000t+pi/4) V;

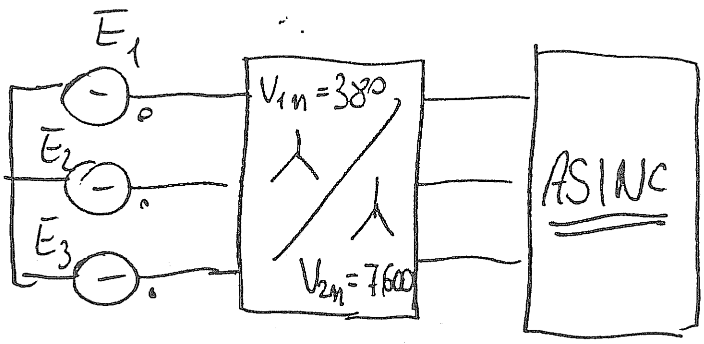
6. Un generatore trifase simmetrico con tensioni di fase 220 V e frequenza 50 Hz, alimenta una macchina asincrona tramite un trasformatore con fase primarie e secondarie a stella. Determinare le perdite nel ferro del trasformatore e la potenza trasferita all'asse dell'asincrono quando funziona con scorrimento s = 0.7.

TRASFORMATORE
Prova a vuoto:
$V_{10} = 380V; \quad I_{10} = 2A \quad P_{10} = 205W$

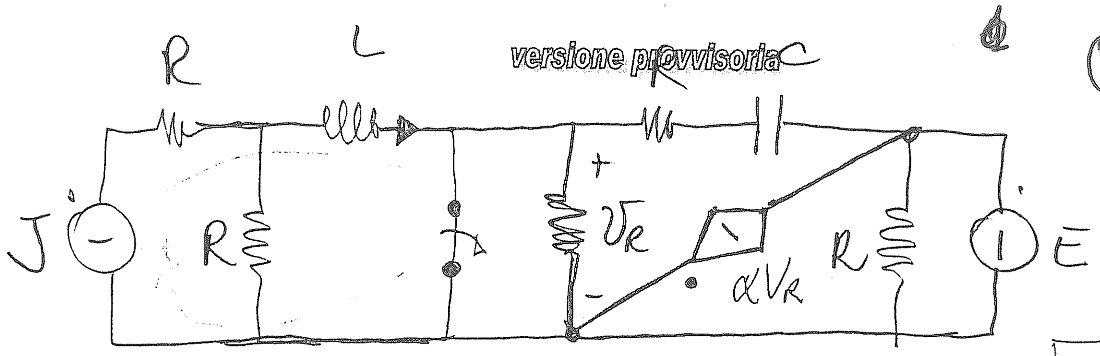
Prova in corto circuito:
$V_{1cc} = 300V; \quad I_{1cc} = 10A \quad P_{1cc} = 3kW$

MACCHINA ASINCRONA
Prova a vuoto:
$V_{10} = 7600V; \quad I_{10} = 20A \quad P_{10} = 41.2kW$

Prova in corto circuito:
$V_{1cc} = 60V; \quad I_{1cc} = 10A \quad P_{1cc} = 675W$; R1s=1.1 Ohm; X1s=1.3 Ohm; K=0.5; (E1=kE2)



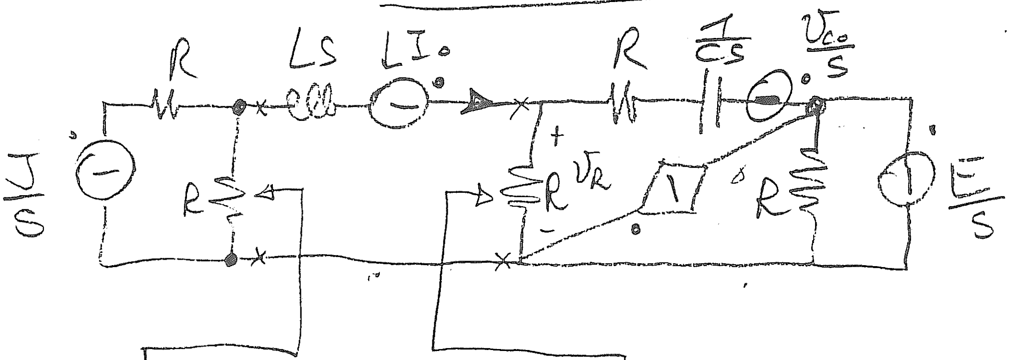
23/5/09



R = 10
L = 10 mH
C = 200 μF
J = 10 A
E = 100 V
α = 2

Per $t<0$ $\quad I_{0L} = J$

$V_{C0} = E$

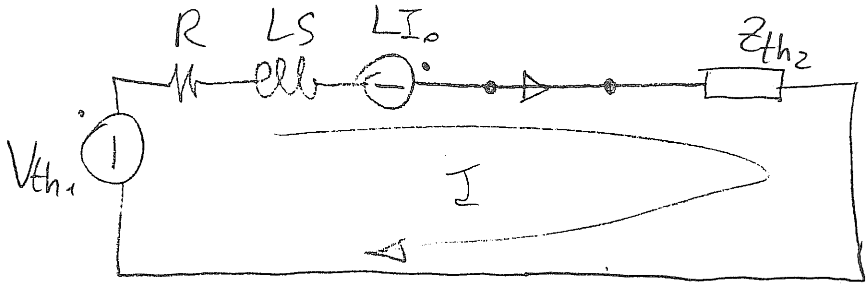


$V_{th1} = \frac{RJ}{S}$

$Z_{th1} = R$

$V_{th2} = 0$

$Z_{th2} = \frac{R(RCS+1)}{2RCS+1}$



$$I = \frac{V_{th1} + LI_0}{R + LS + Z_{th2}} = \frac{RJ + LI_0 S}{S\left[R + LS + \frac{R(RCS+1)}{2RCS+1}\right]}$$

2

2

29/5/09

$$I(s) = \frac{(RJ + LI_0 s)(2RCs + 1)}{s\left[2R^2Cs + 2RLCs^2 + R^2Cs + R + R + Ls\right]}$$

$$I(s) = \frac{2\cancel{RC}LI_0}{2\cancel{RLC}} \frac{\left(s + \frac{RJ}{LI_0}\right)\left(s + \frac{1}{2RC}\right)}{s\left(s^2 + \left(\frac{3R^2C + L}{2RLC}\right)s + \frac{\cancel{2R}}{\cancel{2R}LC}\right)}$$

$$I(s) = I_0 \frac{(s + 1000)(s + 250)}{s(s + 1390.4)(s + 359.6)}$$

$$I(s) = I_0\left[\frac{A}{s} + \frac{B}{s + 1390.4} + \frac{C}{s + 359.6}\right]$$

$$A = I(s) \cdot s \Big|_{s=0} = 0.5$$

$$B = I(s) \cdot (s + 1390.4)\Big|_{s=-1390.4} = 0.3106$$

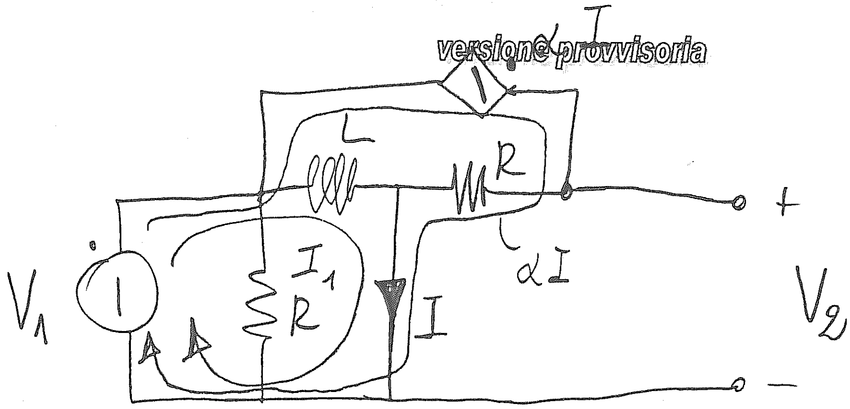
$$C = I(s)(s + 359.6)\Big|_{s=-359.6} = 0.1894$$

$$\boxed{i(t) = 10 \cdot \left[0.5 + 0.3106 \cdot e^{-1390.4t} + 0.1894\, e^{-359.6t}\right] u(t)}$$

3

1

23/5/09

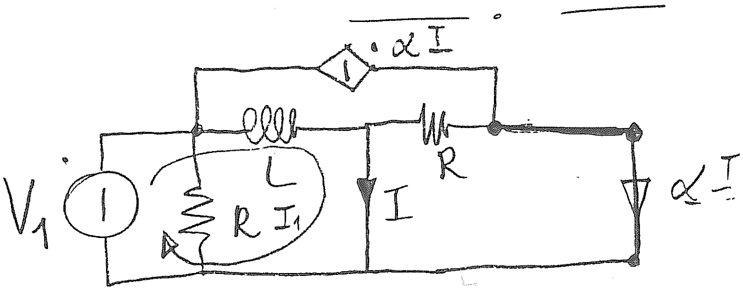


$$V_1 = j\omega L I_1 \Rightarrow I_1 = \frac{V_1}{j\omega L}$$

$$I = I_1 + \alpha I \Rightarrow I(1-\alpha) = I_1 \Rightarrow I = \frac{I_1}{1-\alpha}$$

$$V_2 = R\alpha I = \frac{R\alpha}{1-\alpha} I_1 = \frac{\alpha R}{1-\alpha}\cdot\frac{V_1}{j\omega L}$$

$$\frac{1}{A} = \frac{V_2}{V_1} = \left(\frac{\alpha R}{1-\alpha}\cdot\frac{1}{j\omega L}\right) =$$

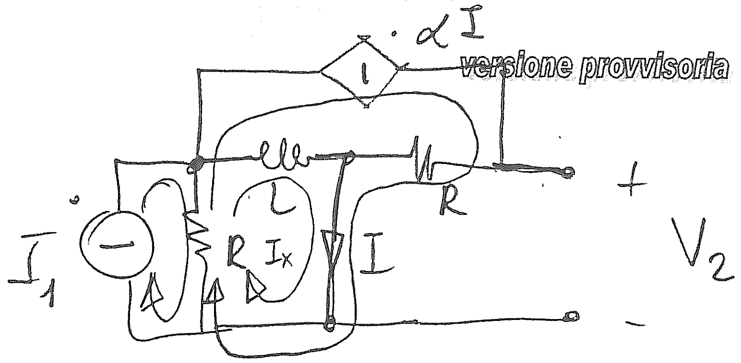


$$I_1 = \frac{V_1}{j\omega L}\ ; \quad I = I_1$$

$$-I_2 = \alpha I = \alpha I_1 = \frac{\alpha V_1}{j\omega L}$$

$$\frac{1}{B} = \frac{(-I_2)}{V_1} = \frac{\alpha}{j\omega L} =$$

23/5/05



$$\begin{cases} (R+j\omega L)I_x - RI_1 + R\alpha I = 0 \\ I = I_x + \alpha I \Rightarrow I = \dfrac{I_x}{1-\alpha} \\ V_2 = R\alpha I = \dfrac{R\alpha}{1-\alpha} I_x \end{cases}$$

$$\left(R+j\omega L + \frac{R\alpha}{1-\alpha}\right) I_x = R I_1$$

$$I_x = \frac{R(1-\alpha)}{(R+j\omega L)(1-\alpha)+\alpha R} I_1 = \frac{R(1-\alpha) \quad I_1}{R+j\omega L \cancel{-R\alpha} - j\omega L\alpha \cancel{+\alpha R}}$$

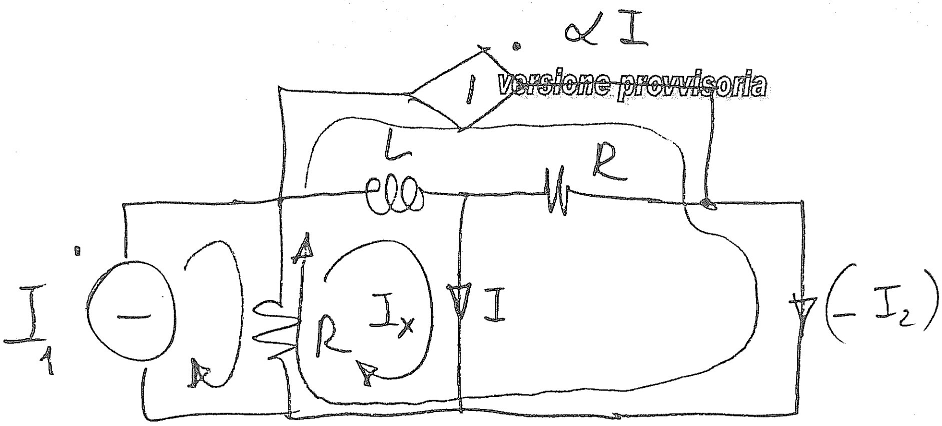
$$I_x = I_1 \frac{R(1-\alpha)}{R+j\omega L(1-\alpha)}$$

$$V_2 = \frac{R\alpha}{\cancel{1-\alpha}} \cdot \frac{R\cancel{(1-\alpha)}}{R+j\omega L(1-\alpha)} I_1$$

$$\frac{1}{C} = \frac{V_2}{I_1} = \frac{\alpha R^2}{R+j\omega L(1-\alpha)} =$$

5 3

29/5/04



$$\begin{cases} (R+j\omega L)\, I_x + R\alpha I - R I_1 = 0 \\ I = I_x \\ -I_2 = \alpha I = \alpha I_x \end{cases}$$

$$(R+j\omega L+\alpha R)\, I_x = R I_1 \Rightarrow I_x = \frac{R}{R(1+\alpha)+j\omega L} I_1$$

$$-I_2 = \frac{\alpha R}{R(1+\alpha)+j\omega L} I_1$$

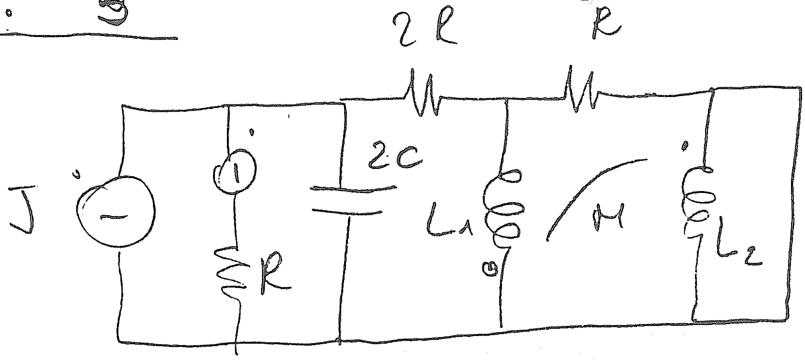
$$\frac{1}{D} = \frac{-I_2}{I_1} = \frac{\alpha R}{R(1+\alpha)+j\omega L} =$$

Es. 5

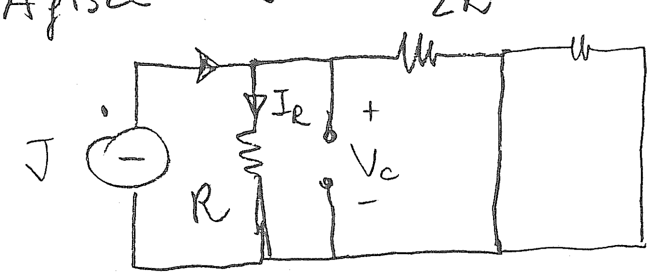
versione provvisoria

6 7

23/5/05



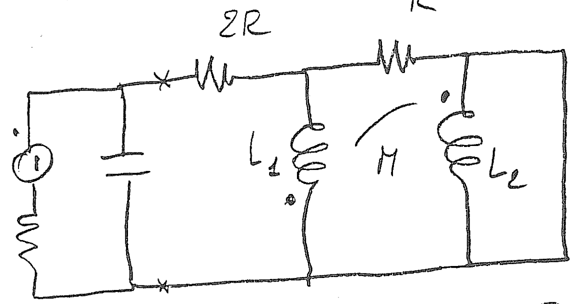
Agisce J :



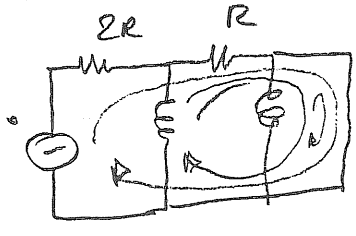
$$\left.\begin{aligned} V_c &= R I_R \\ I_R &= \frac{J \cdot 2\cancel{R}}{3\cancel{R}} = \frac{2}{3} J \end{aligned}\right] \quad V_c = \frac{2}{3} R J$$

$$\overline{W}' = \frac{1}{2} C V_c^2 =$$

Agisce E



$V_{th} = 0 \qquad Z_{th} =$



$$\begin{cases} 0 = (j\omega L_1 + R) I_1 + R I_p - j\omega M I_2 \\ 0 = j\omega L_2 I_2 - j\omega M I_1 \end{cases}$$

$$\Downarrow$$

$$I_2 = \frac{M}{L_2} I_1$$

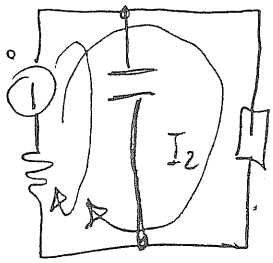
$$0 = \left[(R + j\omega L_1) - j\frac{\omega M^2}{L_2}\right] I_1 + R I_p \Rightarrow I_1 = \frac{R I_p}{(R + j\omega L_1) - j\omega M^2}$$

7 · 8

23/5/05

$$V_p = 3R\,I_p + \frac{R^2\, I_p}{R + j\omega L_1 - j\omega \frac{M^2}{L_2}}$$

$$Z_{th} = 3R + \frac{R^2}{R + j\omega L_1 - j\omega \frac{M^2}{L_2}} =$$



Z_{th}

$$\begin{cases} \dot{E} = (R + Z_{th})\,\dot{I}_2 + R\,\dot{I}_1 \\ \dot{E} = \left(R + \frac{1}{j\omega C}\right)\dot{I}_1 + R\,\dot{I}_2 \end{cases}$$

$\Rightarrow I_1 = 0.1552 + j\,0.0172$

$I_2 = -0.07 + j\,0.62$

$$\dot{V}_{cs} = \bar{Z}_{th} \cdot \dot{I}_2 = -2.76 + j24 \ V$$

$\Rightarrow V_{cseff} \cong 25\,V$

$$\bar{W}'' = \frac{1}{2} C V_{cseff}^2 = 0.0312$$

$$\boxed{\bar{W} = \bar{W}' + \bar{W}'' = 0.2534 \ J}$$

versione provvisoria

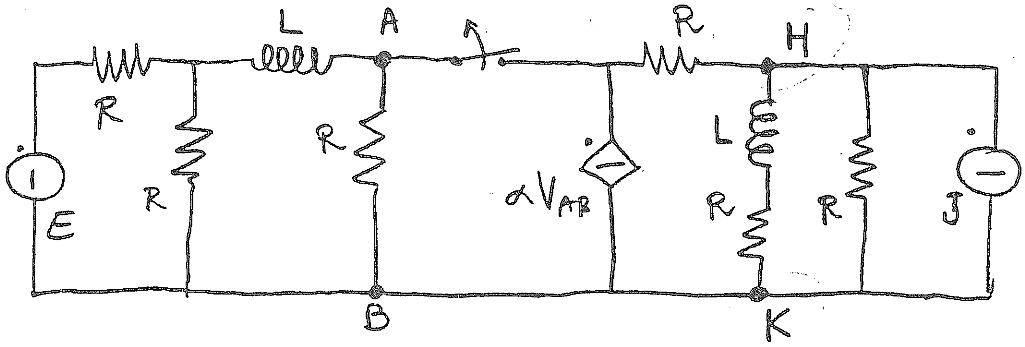
Corso di Laurea in Ingegneria Informatica

Prova Scritta di Elettrotecnica

(12 cred.: 1, 3, 4, 5; 9 cred.: 1, 2 or 5, 3, 6; 6 cred.: 2, 5, 6)

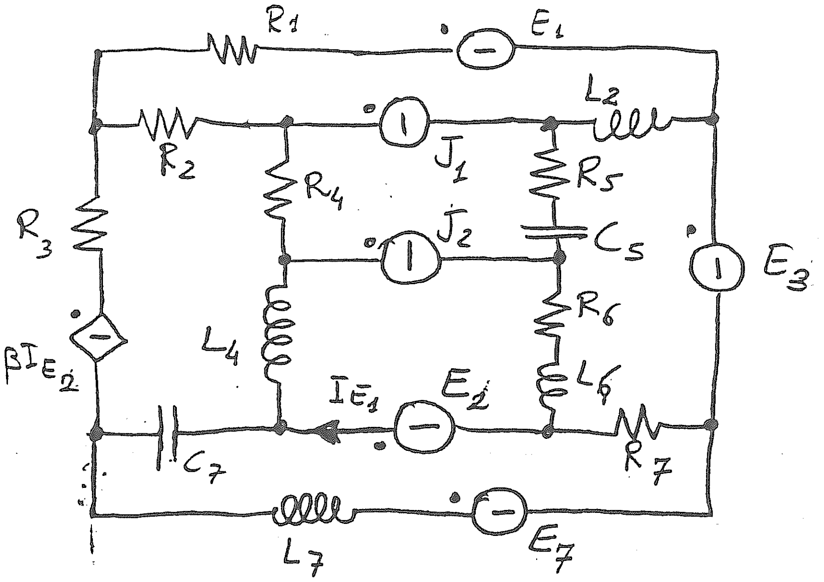
Pisa, 10 luglio 2004 Allievo ....

1. Il circuito di figura è in condizione di regime per t<0. Determinare l'evoluzione temporale della tensione $V_{HK}(t)$ a seguito dell'apertura del tasto che avviene all'istante t=0.

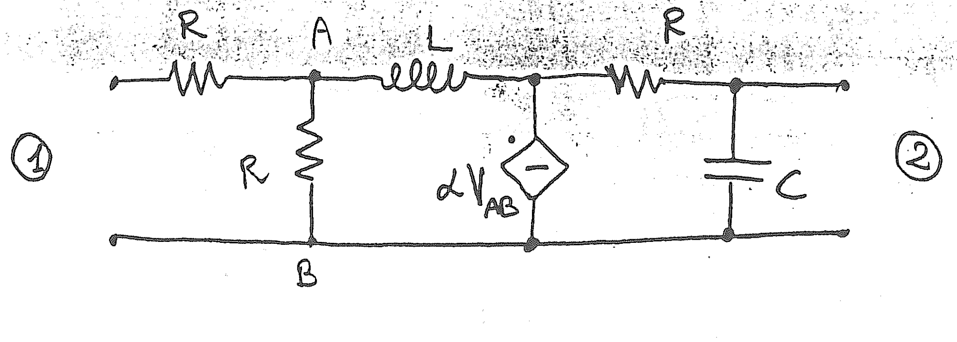


R = 10 Ω;
L = 10 mH;
α = 2;
J = 10 A;
E = 100 V;

2. Per il circuito di figura scrivere un sistema di equazioni di equilibrio con il metodo delle correnti di maglia, supponendo il sistema in condizioni di regime sinusoidale.

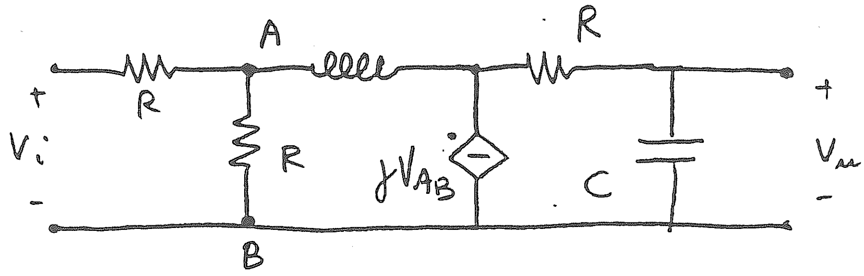


3. Per il doppio bipolo rappresentato in figura, determinare la matrice dei parametri *h* alla pulsazione ω=1000 rad/sec.



R = 10 Ω;
L = 20mH;
α = 3;
C = 100 μF

4. Per la rete di figura determinare la funzione di trasferimento V_u/V_i, studiare la stabilità al variare del parametro γ e tracciarne i diagrammi di Bode di modulo e fase della relativa risposta in frequenza.

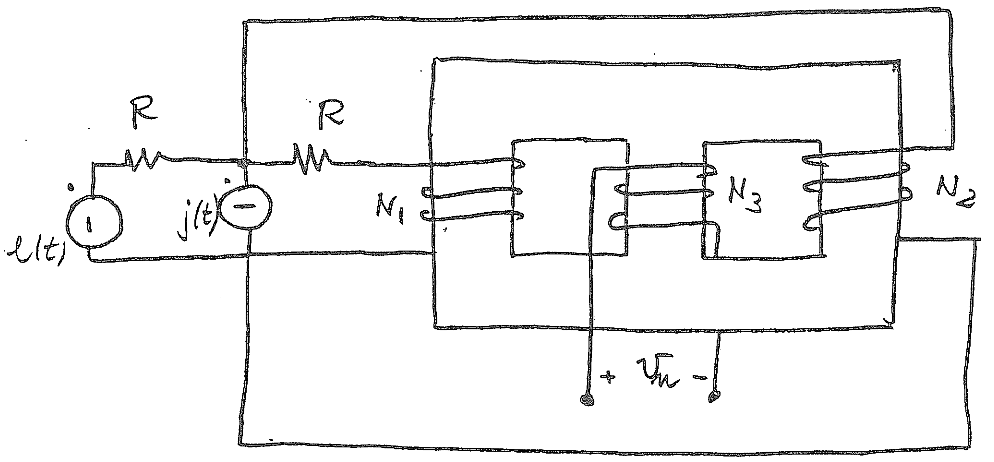


$R = 10\ \Omega$

$L = 20\ mH$

$C = 100\ \mu F$

5. Considerando in condizioni di regime [redacted] la rete di figura determinare la tensione $V_u(t)$ ai morsetti dell'avvolgimento composto da N_3 spire.



$\mu = 2000$; $R = 10\ \Omega$

$S = 9\ cm^2$, $l = 5\ cm$

$e(t) = 100 \operatorname{sen} 314t$

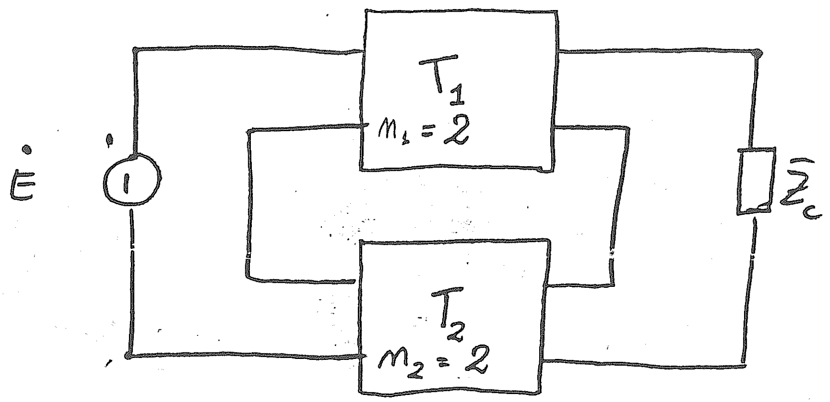
$j(t) = 2\cos(314t + \frac{\pi}{6})$

$N_1 = 50$; $N_2 = 100$

$N_3 = 150$

6. Con riferimento al sistema in figura, trovare la potenza attiva sul carico e determinare come si ripartisce tale potenza tra i due trasformatori.

TRASFORMATORE 1	TRASFORMATORE 2
Prova a vuoto:	Prova a vuoto:
$V_{10} = 400V$; $I_{10} = 2.5A$ $P_{10} = 250W$	$V_{10} = 420V$; $I_{10} = 3.5A$ $P_{10} = 300W$
Prova in corto circuito:	Prova in corto circuito:
$V_{1cc} = 150V$; $I_{1cc} = 18A$ $P_{1cc} = 2200W$	$V_{1cc} = 110V$; $I_{1cc} = 14A$ $P_{1cc} = 1100W$;

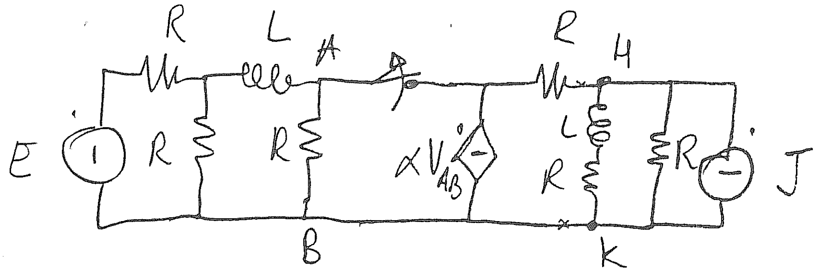


$\bar{Z}_c = 10 + j4$

$\dot{E} = 400\ V$

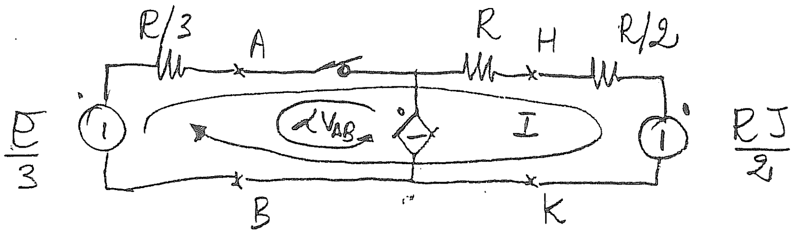
10/7/04

Es 1



Per $t<0$

Appl. Thevenin tra AB e H-K



$$E_{th} = \frac{E}{\frac{3}{\cancel{2}}\cancel{R}} \cdot \frac{\cancel{R}}{\cancel{2}} = \frac{E}{3}$$

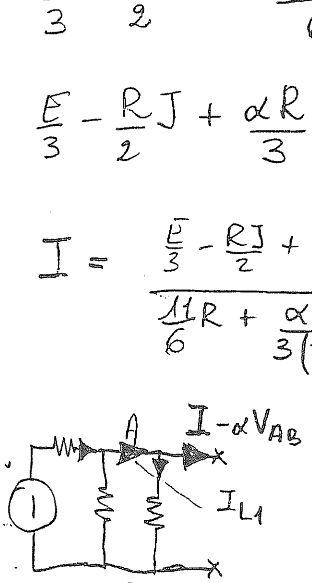
$$R_{th} = \frac{R}{3}$$

$$\begin{cases} \frac{E}{3} - \frac{RJ}{2} = \left[\frac{R}{3} + R + \frac{R}{2}\right] I - \frac{R}{3}\alpha V_{AB} \\ V_{AB} = \frac{E}{3} - \frac{R}{3} I + \frac{R}{3}\alpha V_{AB} \Rightarrow V_{AB}\left(1 - \frac{\alpha R}{3}\right) = \frac{E}{3} - \frac{R}{3} I \Rightarrow V_{AB} = \frac{1}{\cancel{3}}(E-RI)\frac{\cancel{3}}{3-\alpha R} \end{cases}$$

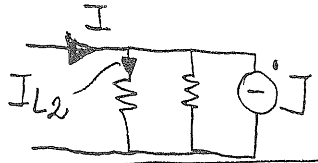
$$\frac{E}{3} - \frac{RJ}{2} = \frac{11}{6} R I - \frac{\alpha R}{3} E\left(\frac{1}{3-\alpha R}\right) + \frac{\alpha R^2}{3}\frac{I}{(3-\alpha R)}$$

$$\frac{E}{3} - \frac{R}{2}J + \frac{\alpha R}{3}\left(\frac{E}{3-\alpha R}\right) = I\left[\frac{11}{6}R + \frac{\alpha R^2}{3(3-\alpha R)}\right]$$

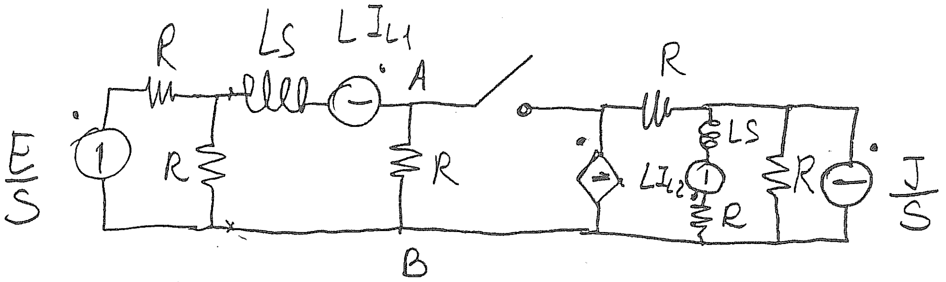
$$I = \frac{\frac{E}{3} - \frac{RJ}{2} + \frac{\alpha R E}{3(3-\alpha R)}}{\frac{11}{6}R + \frac{\alpha R^2}{3(3-\alpha R)}} = -3.8776 \text{ A} \quad ; \quad V_{AB} = -8.1633 \text{ V}$$

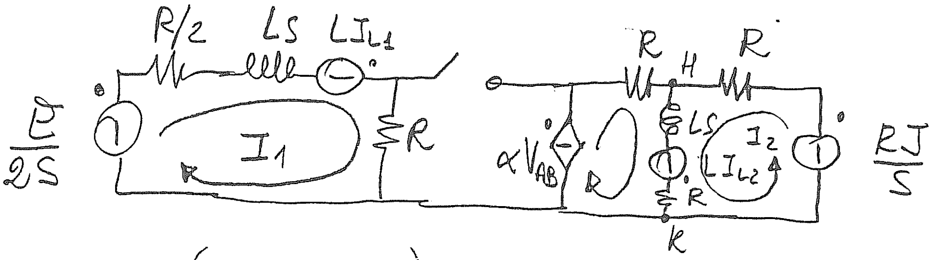


$$\boxed{I_{L1} = (I - \alpha V_{AB}) + \frac{V_{AB}}{R} = 11.63 \text{ A}}$$



$$\boxed{I_{L2} = \frac{I}{2} + \frac{J}{2} = 3.0612 \text{ A}}$$





$$I_1 = \frac{\left(\frac{E}{2S} - LI_{L1}\right)}{\frac{3}{2}R + LS} \Rightarrow V_{AB} = RI_1 = \frac{R\left(E - 2LI_{L1}S\right)}{S\left(3R + 2LS\right)}$$

$$\frac{RJ}{S} + LI_{L2} = \left(2R + LS\right)I_2 + \left(R + LS\right)\alpha\frac{R\left(E - 2LI_{L1}S\right)}{S\left(3R + 2LS\right)}$$

$$I_2 = \frac{\frac{RJ + LI_{L2}S}{S} - \frac{\alpha R\left(R+LS\right)\left(E - 2LI_{L1}S\right)}{S\left(3R+2LS\right)}}{\left(2R + LS\right)}$$

$$I_2 = \frac{\left(RJ + LI_{L2}S\right)\left(3R+2LS\right) - \alpha R\left(R+LS\right)\left(E - 2LI_{L1}S\right)}{S\left(2R+LS\right)\left(3R+2LS\right)}$$

$$V_{HK} = \frac{RJ}{S} - RI_2 = \frac{RJ\left(2R+LS\right)\left(3R+2LS\right) - R\left(RJ + LI_{L2}S\right)\left(3R+2LS\right) + \alpha R^2\left(R+LS\right)\cdot\left(E - 2LI_{L1}S\right)}{S\left(2R+LS\right)\left(3R+2LS\right)}$$

$$V_{HK} = \frac{-0.4514S^2 - 224.5\cdot S + 23\times10^4}{S\left(20 + 10^{-3}S\right)\left(30 + 2\times10^{-3}S\right)} = \underbrace{\frac{-0.4514}{10^{-3}\cdot 2\cdot 10^{-3}}}_{=-2.25\times10^3}\cdot\frac{\left(S + 1.0045\times10^3\right)\left(S - 507.21\right)}{S\left(S+2000\right)\left(S+1500\right)}$$

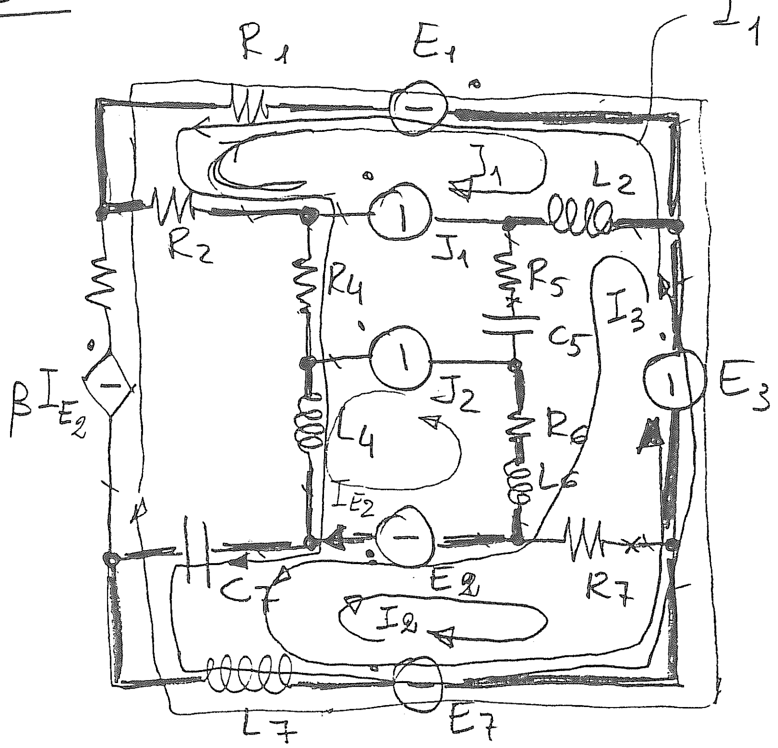
$$V_{HK} = K\left[\frac{A}{S} + \frac{B}{S+2000} + \frac{C}{S+1500}\right]$$

$$A = V_{HK}\cdot S\Big|_{S=0} = -0.1698;\quad B = V_{HK}\left(S+2000\right)\Big|_{S=-2000} = 2.4959;\quad C = V_{HK}\left(S+1500\right)\Big|_{S=-1500} = -1.3261$$

$$V_{HK} = K\left[A + Be^{-2000t} + Ce^{-1500t}\right]u(t)$$

10/7/04

Es 2



$n_{eq} = r - (n-1) - n_{gc}$

$15 - 9 - 3 = \underline{\underline{3\ eq}}$

$$-\dot E_1 - \dot E_7 + \dot E_3 = \left(R_1+R_2+R_4+j\omega L_4 + \frac{1}{j\omega C_7} + j\omega L_7\right)\dot I_1 - (R_1+R_2)\dot J_1 - (R_1 + j\omega L_7)\beta \dot I_{E_2} +$$
$$+ j\omega L_4 \dot J_2 - \left(j\omega L_7 + \frac{1}{j\omega C_7}\right)\dot I_2 + \left(j\omega L_7+\frac{1}{j\omega C_7}\right)\dot I_3$$

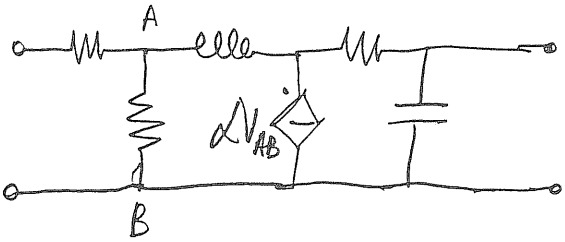
$$-\dot E_2 + \dot E_7 = \left(R_7 + j\omega L_7 + \frac{1}{j\omega C_7}\right)\dot I_2 - \left(j\omega L_7 + \frac{1}{j\omega C_7}\right)\dot I_3 - \left(j\omega L_7+\frac{1}{j\omega C_7}\right)\dot I_1 + j\omega L_7 \beta \dot I_{E_2}$$

$$\dot E_2 + \dot E_3 - E_7 = \left(j\omega L_2 + R_5 + \frac{1}{j\omega C_5} + R_6 + j\omega L_6 + \frac{1}{j\omega C_7} + j\omega L_7\right)\dot I_3 - \left(j\omega L_7 + \frac{1}{j\omega C_7}\right)\dot I_2 +$$
$$+ \left(j\omega L_7 + \frac{1}{j\omega C_7}\right)\dot I_1 - j\omega L_7 \beta \dot I_{E_2} - (R_6 + j\omega L_6)\dot J_2 + j\omega L_2 \dot J_1$$

$$\dot I_{E_2} = \dot I_3 - \dot I_2 - \dot J_2$$

---

es 3

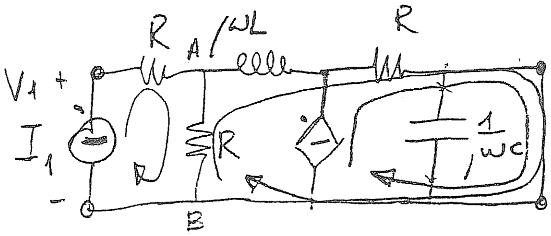


$$\begin{cases} V_1 = h_{11} I_1 + h_{12} V_2 \\ I_2 = h_{21} I_1 + h_{22} V_2 \end{cases}$$

$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} ; \quad h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0}$$

$$h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0} ; \quad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$$

h_{11}



$$\begin{cases} 0 = (2R + j\omega L) I_x + R\alpha V_{AB} - R I_1 \\ V_{AB} = R I_1 - R I_x \end{cases}$$

$$0 = (2R + j\omega L) I_x + \alpha R^2 I_1 - \alpha R^2 I_x - R I_1$$

$$I_x = I_1 \frac{R(\alpha R - 1)}{[R(2 - \alpha R) + j\omega L]}$$

$$V_1 = 2R I_1 - R I_x = \left\{ 2R - \frac{R^2(\alpha R - 1)}{[R(2-\alpha R) + j\omega L]} \right\} I_1$$

$$\boxed{h_{11}} = \frac{V_1}{I_1} = \frac{\cancel{4}^{5}R^2 - \cancel{2}^{3}\alpha R^3 + 2j\omega L R \cancel{- \alpha R^3 + R^2}}{[R(2-\alpha R) + j\omega L]} = \boxed{30.30 + j\,0.736}\ \Omega$$

$$\dot{I}_2 = -I_x - \alpha V_{AB} = -\dot{I}_1 \left[\frac{R(\alpha R - 1)}{(R(2-\alpha R) + j\omega L)} \right] - \alpha R \dot{I}_1 + \alpha \frac{R\,(R(\alpha R - 1))}{(R(2-\alpha R) + j\omega L)} \dot{I}_1$$

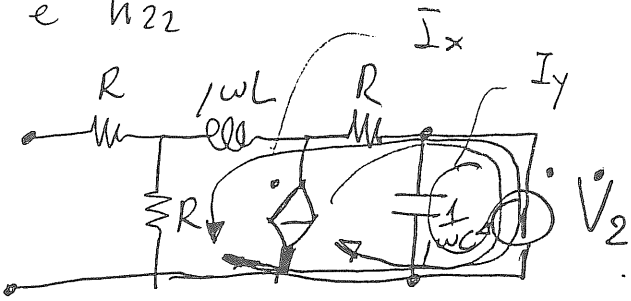
$$\boxed{h_{21}} = \frac{\dot{I}_2}{\dot{I}_1} = \boxed{-59.88 - j\,2.134}$$

10/07/04

Es 3

2

h_{12} e h_{22}



$$\begin{cases} \dot V_2 = (2R + j\omega L)\, I_x - \alpha V_{AB} R \\ \dot V_2 = \dfrac{\dot I_y}{j\omega C} \Rightarrow \dot I_y = \dfrac{\dot V_2}{j\omega C} \\ \dot V_{AB} = R \dot I_x \end{cases}$$

$$\dot V_2 = \left(2R + j\omega L - \alpha R^2\right) I_x \Rightarrow I_x = \frac{\dot V_2}{2R + j\omega L - \alpha R^2}$$

$$\dot V_1 = \dot V_{AB} = R I_x = \frac{R \dot V_2}{R(2-\alpha R) + j\omega L}$$

$$\boxed{h_{12}} = \frac{\dot V_1}{\dot V_2} = \frac{R}{R(2-\alpha R) + j\omega L} = \boxed{-0.0355 - j\,0.0025}$$

$$\dot I_2 = \dot I_x + \dot I_y - \alpha \dot V_{AB} = \frac{V_2}{R(2-\alpha R) + j\omega L} + \frac{\dot V_2}{j\omega C} - \frac{\alpha R \dot V_2}{R(2-\alpha R) + j\omega L}$$

$$\boxed{h_{22}} = \frac{\dot I_2}{\dot V_2} = \frac{1 - \alpha R}{R(2-\alpha R) + j\omega L} + \frac{1}{j\omega C} = \boxed{0.103 - j8.9926}\ \Omega^{-1}$$

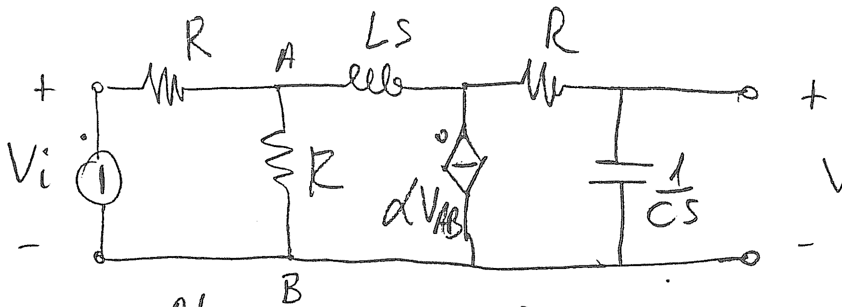
10/7/04

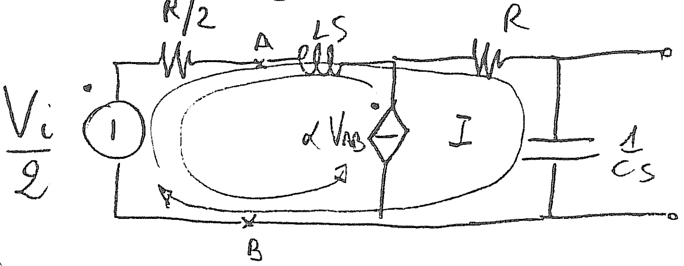
b

CS 4

versione provvisoria

1





$$\begin{cases} \frac{V_i}{2} = \left(\frac{3R}{2} + Ls + \frac{1}{Cs}\right) I - \alpha V_{AB}\left(\frac{R}{2} + Ls\right) \\ V_{AB} = \frac{V_i}{2} - \frac{R}{2} I + \frac{R}{2}\alpha V_{AB} \Rightarrow V_{AB}\left(\frac{2-\alpha R}{\cancel{2}}\right) = \frac{V_i - RI}{\cancel{2}} \end{cases}$$

$$V_{AB} = \frac{V_i - RI}{2-\alpha R} = \frac{V_i}{2-\alpha R} - \frac{RI}{2-\alpha R}$$

$$V_i\left[\frac{1}{2} + \frac{\alpha(R+2Ls)}{(2-\alpha R)2}\right] = \left[\frac{3RCs+2LCs^2+2}{2Cs} + \frac{\alpha R}{2-\alpha R}\cdot\left(\frac{R+2Ls}{2}\right)\right] I$$

$$\left[\frac{2\cancel{-\alpha R}\cancel{+\alpha R}+2\alpha Ls}{2\cancel{(2-\alpha R)}}\right] = \left[\frac{(2LCs^2+3RCs+2)(2-\alpha R)+\alpha R(R+2Ls)Cs}{\cancel{2}Cs\cancel{(2-\alpha R)}}\right] I$$

$$I = V_i\,\frac{(2+2\alpha Ls)Cs}{(2LCs^2+3RCs+2)(2-\alpha R)+\alpha RCs(R+2Ls)}$$

$$\frac{V_u}{V_i} = \frac{I}{Cs} = \cancel{V_i}\,\frac{(2+2\alpha Ls)\cancel{Cs}}{\cancel{Cs}\underbrace{\left[(2LCs^2+3RCs+2)(2-\alpha R)+\alpha RCs(R+2Ls)\right]}}$$

$$4LCs^2 + 6RCs + 4 - \cancel{2\alpha RLCs^2} - \cancel{3}2\alpha R^2Cs - 2\alpha R + \alpha R^2Cs + \cancel{2\alpha RLCs^2}$$

$$\left[4LCs^2 + 2RC(3-\alpha R)s + 2(2-\alpha R)\right]$$

Discussione stabilità:

$$3-\alpha R \geq 0 \Rightarrow \alpha \leq \frac{3}{R} = 0.3$$

$$2-\alpha R \geq 0 \Rightarrow \alpha \leq \frac{2}{R} = 0.2$$

Per $\alpha > 0.2$ instabile

Per $\alpha = 0.2$ marginalm. stabile

Per $\alpha < 0.2$ asint. stabile

$\alpha = 0$ $$W = \frac{2}{4LCs^2 + 6RCs + 4} \Rightarrow \frac{1\,\cancel{2}}{2\,\cancel{4}} \cdot \frac{1}{1 + \frac{\cancel{6}\,3}{\cancel{4}\,2}RCs + LCs^2}$$

$$W(\omega) = \frac{1}{2} \cdot \frac{1}{1 + \frac{3}{2}RC \cdot j\omega - LC\omega^2}$$

$\omega_0 = \frac{1}{\sqrt{LC}}$;

$\xi = \frac{3}{4} RC\sqrt{LC}$

$$W(\omega) = \frac{1}{2} \frac{1}{1 + 2j\frac{\omega}{\omega_0}\xi - \frac{\omega^2}{\omega_0^2}}$$

$$W(\omega) = \frac{1}{2} \frac{1}{\left(1 - j\frac{\omega}{p_1}\right)\left(1 - j\frac{\omega}{p_2}\right)}$$

$$p_1 = -375 + j599.48$$

$$p_2 = -375 - j599.48$$

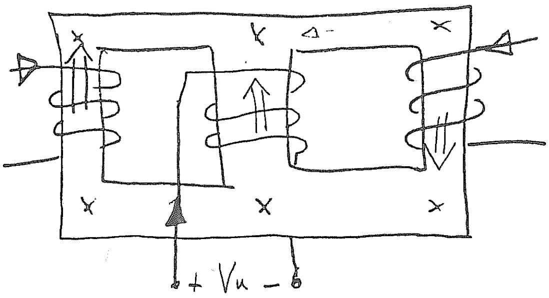
10/7/04

versione provvisoria

CS

(1)

Es 5



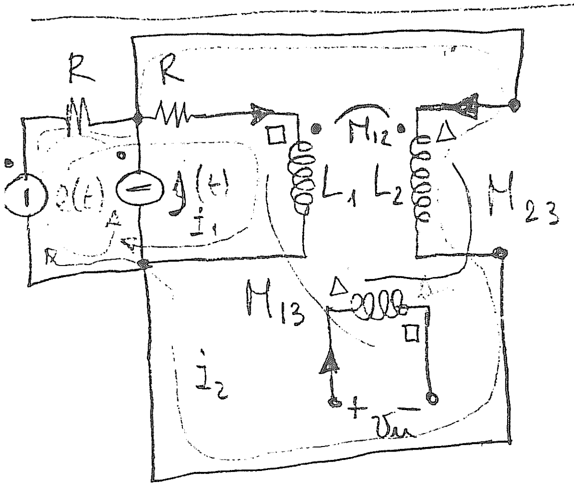
$$\mathcal{R} = \frac{l}{\mu S} = 2.21\times 10^{4}\ H^{-1}$$

$$L_1 = \frac{N_1^2}{\mathcal{R}_{V1}} \cong 30\,mH$$

$$\mathcal{R}_{V1} = \left[3\mathcal{R} \,//\, \mathcal{R}\right] + 3\mathcal{R} = \frac{15}{4}\mathcal{R}$$

$$L_2 = \frac{N_2^2}{\mathcal{R}_{V2}} \cong 120.6\ mH$$

$$\mathcal{R}_{V2} = \mathcal{R}_{V1} = \frac{15}{4}\mathcal{R}$$



$$M_{12} = \frac{N_1 N_2}{\frac{15}{4}\mathcal{R}} \cdot \frac{\cancel{\mathcal{R}}}{\cancel{4\mathcal{R}}} = 15.1\ mH \ (+)$$

$$M_{13} = \frac{N_1 N_3}{\frac{15}{4}\mathcal{R}} \cdot \frac{\cancel{3\mathcal{R}}}{\cancel{4\mathcal{R}}} = 67.9\ mH \ (-)$$

$$M_{23} = \frac{N_2 N_3}{\frac{15}{4}\mathcal{R}} \cdot \frac{\cancel{3\mathcal{R}}}{\cancel{4\mathcal{R}}} = 135.7\ mH \ (+)$$

$$\dot{E} = 100\ V \qquad \dot{J} = 2\, e^{j\left(\frac{\pi}{6}+\frac{\pi}{2}\right)} = -1 + j1.73\ A$$

$$\begin{cases} \dot{E} = (2R + j\omega L_1)\dot{I}_1 - R\dot{J} + j\omega M_{12}\dot{I}_2 + R\dot{I}_2 \\ \dot{E} = (R + j\omega L_2)\dot{I}_2 - R\dot{J} + j\omega M_{12}\dot{I}_1 + R\dot{I}_1 \end{cases} \Rightarrow \begin{cases} \dot{I}_1 = 3.80 - j0.428\ A \\ \dot{I}_2 = 0.41 - j1.2\ A \end{cases}$$

$$\dot{V}_u = -j\omega M_{13}\dot{I}_1 + j\omega M_{23}\dot{I}_2 = 42.38 - j63.40\ V$$

$$\boxed{v_u(t) = 72.26\sin(314t - 0.98)\ V}$$

$$\dot{\Phi}_1 = \frac{N_1\dot{I}_1}{\mathcal{R}_{V1}} \Rightarrow \dot{\Phi}_{13} = \dot{\Phi}_1 \cdot \frac{3}{4}$$

$$\dot{\Phi}_2 = N_2 I_2 \Rightarrow \dot{\Phi}_{\ldots} = \dot{\Phi}_2 \cdot 3$$

VERIFICA CON IL FLUSSO

$$\dot{\Phi}_3 = \dot{\Phi}_{2-3} - \dot{\Phi}_{1-3} = -0.0013 - j0.0009\ Wb$$

$\dot{V}_u = \ldots = 42.38 \ldots j63.40\ V$

10/7/04

Es. 6 (Suggerim: trascurare l'impedenza di magnetizzazione $\bar{Z}_0$)

Calcolo delle impedenze $\bar{Z}_0$ e $\bar{Z}_{cc}$

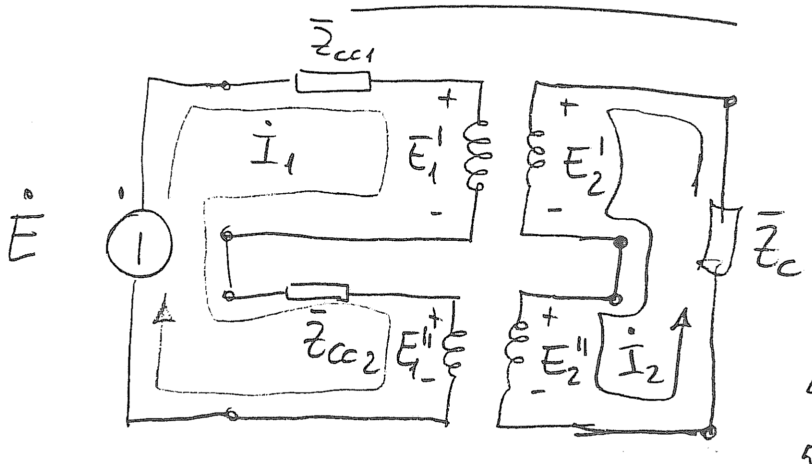
(T1) $R_{01} = \dfrac{V_{10}^2}{P_{10}}$; $|Y_0| = \dfrac{I_{10}}{V_{10}}$; $B_{10} = \sqrt{Y_{10}^2 - G_{10}^2} =$

$X_{10} = \dfrac{1}{B_{10}}$; $\bar{Z}_{01} = \dfrac{R_{10} \cdot jX_{10}}{R_{10} + jX_{10}} = 40 + j\,155\ \Omega$

$$\begin{cases} P_{1cc} = V_{1cc} I_{1cc} \cos\varphi \\ |Z_{1cc}| = \dfrac{V_{1cc}}{I_{1cc}} \end{cases} \Rightarrow \cos\varphi = \frac{P_{1cc}}{V_{1cc} I_{1cc}} = 0.8148$$

$\bar{Z}_{cc1} = |Z_{1cc}| \left[\cos\varphi + j\sin\varphi\right] = 6.8 + j\,4.8\ \Omega$

(T2) $\bar{Z}_{02} = 24.5 + j\,117.5\ \Omega$; $Z_{cc2} = 5.61 + j\,5.49\ \Omega$



$$\begin{cases} 1 & \dot{E} = (Z_{cc1} + Z_{cc2})\dot{I}_1 + \dot{E}_1' + \dot{E}_1'' \\ 2 & 0 = \dot{E}_2' + \dot{E}_2'' + \bar{Z}_c \dot{I}_2 \\ 3 & E_1' = m_1 E_2' \\ 4 & E_1'' = m_2 E_2'' \\ 5 & I_1' = -\dfrac{1}{m_1} I_2' \\ 6 & I_1'' = -\dfrac{1}{m_2} I_2'' \end{cases}$$

$m_1 = m_2 = 2 = m$

dalla 2, sostituendo la 3 e la 4:

$E_1' + E_1'' = -m \bar{Z}_c \dot{I}_2$

sostit. in 1: $\Longrightarrow \dot{E} = (\bar{Z}_{cc1} + \bar{Z}_{cc2})\dot{I}_1 - m\bar{Z}_c \dot{I}_2$

tenendo conto della 5 e 6: $\dot{E} = -(\bar{Z}_{cc1} + \bar{Z}_{cc2})\dfrac{\dot{I}_2}{m} - m\bar{Z}_c \dot{I}_2 \Rightarrow$

$\dot{I}_2 = \dfrac{-m\dot{E}}{\bar{Z}_{cc1} + \bar{Z}_{cc2} + m^2 Z_c} = -12.2 + j\,6.12\ A$

$\bar{S} = Z\, I^2 = 1.86 + j\,0.744\ kVA$; $\boxed{P = 1.86\ kW}$