NUMERO: 988 DATA: 18/06/2014

A P P U N T I

STUDENTE: Gemello

MATERIA: Elettrotecnica + Eserc.

Prof. Ragusa

4-5 LAB → VENERDÍ
LED 1
SCRITTO + ORALE → NELLO STESSO APPELLO
↓
3 PROBLEMI + DOMANDE

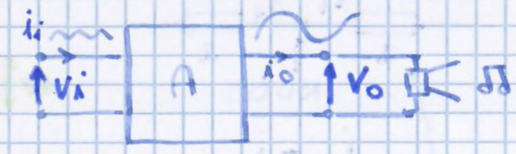
TENSIONE, CORRENTE

2 MORSETTI/POLI
↓
MISURANO TENSIONE

SCHEMATIZZAZIONE →

↓
METTIAMO IN EVIDENZA I MORSETTI

• AMPLIFICATORE AUDIO



FISICO

SCHEMATIZZAZIONE

CORRENTE ELETTRICA
FLUSSO DI CARICA → ELETTRONI

NON IN ISOLANTI

SUP. ORIENTATA (NON X FORZA PIANA)
↓
PAG. POSITIVA E PAG. NEGATIVA

VALUTO CARICHE CHE ATTRAVERSANO SUP.

$\frac{Q_t}{\Delta t} = i$ → INTENSITÀ DELLA CORRENTE ELETTRICA
SONO COME DELLE PORTATE FLUIDE

AMPEROMETRO

NON SI POSSONO SCAMBIARE MORSETTI
SENNÒ CAMBIA IL SEGNO

QUELLO GIUSTO DIPENDE DAL RIFERIMENTO

$i = 1 A$

TENSIONE ELETTRICA

L_{AB} → NON DIPENDE DAL PERCORSO

PERÒ DIPENDE SE A → B, OPPURE B → A

$L_{AB} = -L_{BA}$

DIPENDE DAI POLI DI PARTENZA E DI ARRIVO

DIPENDE DALLA CARICA

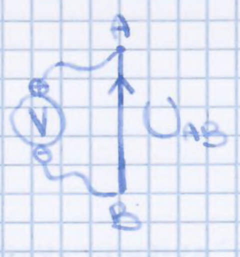
$L_{AB} \propto F_{AB} \propto q$

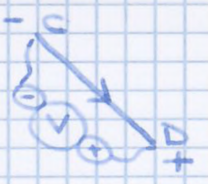
$\frac{L_{AB}}{q} = U_{AB}$ → TENSIONE ELETTRICA TRA A E B

↳ NON DIPENDE DALLA CARICA

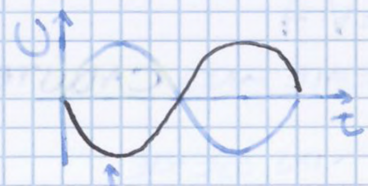
$L_{AB} \to J$

$U_{AB} \to J/C \to 1 V = 1 \frac{J}{C} = 1 \frac{J}{As}$

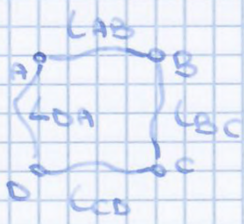




SE SCAMBIO MORSETTI
CAMBIA SEGNO



SE MORSETTI SCAMBIATI



$L_{AB} + L_{BC} + L_{CD} + L_{DA} = 0$

$L_{ABCDA} = 0$

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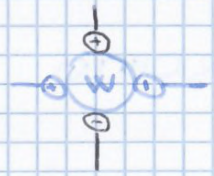
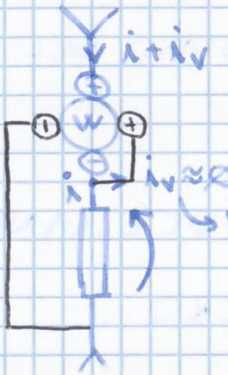
ALTRA POSSIBILITÀ:

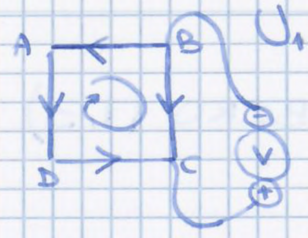




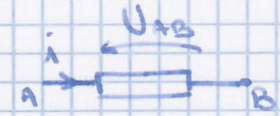
UNA PARTE DI i_{TOT} VA IN i_v

IDEALE

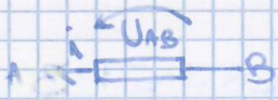
SE COLLEGO ⊕ PRIMA DEL WATT-METRO SENTO CADUTA DI TENSIONE DI QUEST'ULTIMO



$U_1 - U_2 + U_3 + U_4 = 0$

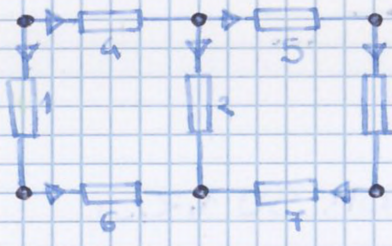


$P = i \cdot U_{AB}$ CON CONV. POT. ASSORBITA



$P' = U \cdot i'$ CONV. POT. GENERATA

*PRENDIAMO UN CIRCUITO CON + DIPOLI



$e = 7 \rightarrow$ DIPOLI

$n = 6 \rightarrow$ NODI

SOLO AMPEROMETRI NECESSARI

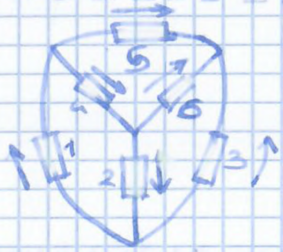
X NON USARE 7 AMPEROMETRI SFRUTTIAMO 1ª LEGGE DI KIRCHOFF

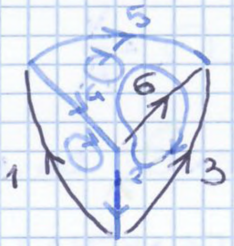
$i_4 = -i_1$ $\quad i_6 = i_1$ $\quad i_5 = i_3$ $\quad i_7 = i_3$

SE CONOSCO i_1 $\qquad$ SE CONOSCO i_3

$i_4 - i_2 - i_5 = 0 \Rightarrow i_2 = i_4 - i_5 = -i_1 - i_3$

VOLTIMETRI NECESSARI





NELL'ALBERO NO PERCORSI CHIUSO
↓
2,4,5 TENSIONI INDIPEND.
↓
LE DEVO MISURARE

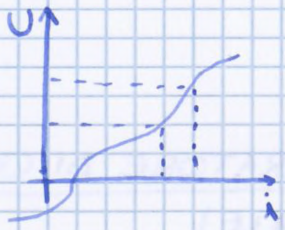
QUELLE DEL COALBERO ← LE CALCOLO DA QUELLE DELL'ALBERO

$U_6 + U_4 - U_5 = 0 \Rightarrow U_6 = U_5 - U_4$

$+U_2 + U_4 - U_5 + U_3 = 0 \Rightarrow U_3 = U_2 + U_5 - U_4$

$-U_1 - U_4 - U_2 = 0 \Rightarrow U_1 = -U_4 - U_2$

RELAZIONI COSTITUTIVE



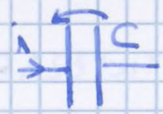
BIPOLI RESISTIVI (NON DINAMICI)

BIPOLI DINAMICI

ES: INDUTTORE  $\Rightarrow U = L \cdot \frac{di}{dt}$

COEFF.

CONDENSATORE

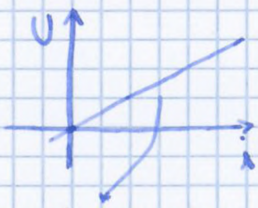


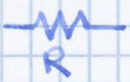
$i = C \cdot \frac{dU}{dt}$

$\boxed{\text{BIPOLI RESISTIVI}}$

* $U = R \cdot i$ LEGGE DI OHM

$R = \rho \frac{\ell}{S}$





RESISTORE LINEARE

RETTA x L'ORIGINE

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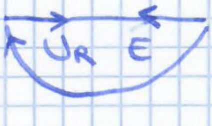
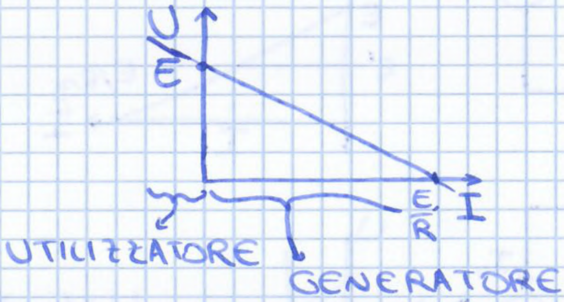


$U - E + U_R = \emptyset$

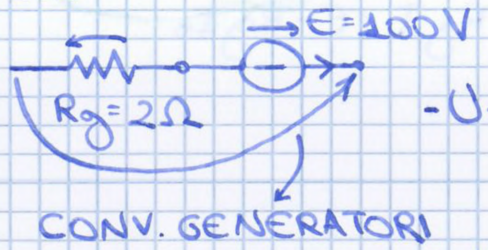
$U = E - U_R$

$U = E - R \cdot I$

SE I AUMENTA U DIMINUISCE, FINO A DIVENTARE NEGATIVA



ES

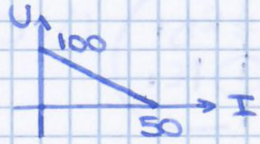


$-U + E - U_R = 0 \Rightarrow U = E - RI$

$U = 100 - 2I$

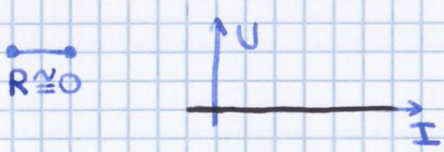
SE $U = 0 \Rightarrow I = 50$

SE $I = 0 \Rightarrow U = 100$



CORTOCIRCUITO IDEALE

$U = 0$ $\forall$ CORRENTE



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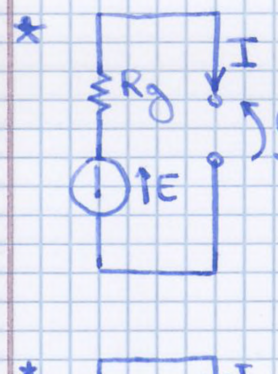
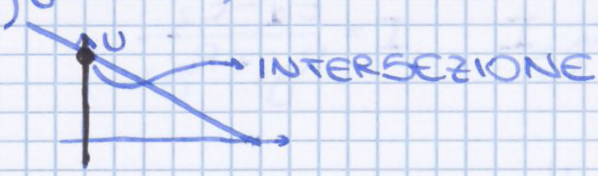


$I = 0 \rightarrow$ XKE' CIRCUITO APERTO

$U = E - \cancel{RI} \Rightarrow U = E$



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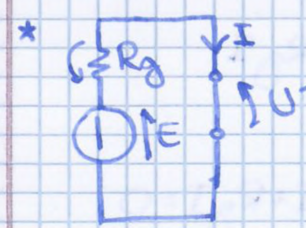
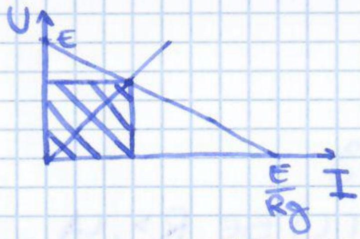


CORTOCIRCUITO $\Rightarrow U = 0$

$U_R - E = 0 \Rightarrow E = R_g I \Rightarrow I = \frac{E}{R_g}$

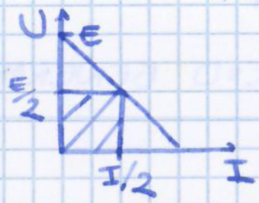
$U = R \cdot I = R \cdot \frac{E}{R+R_g}$ $\qquad U = E - R_g I$

LA POTENZA CORRISPONDE ALL'AREA



IN CASO DI CORTO CIRCUITO O CIRCUITO APERTO LA POTENZA P VALE ∅

ABBIAMO UN MAX: QUANDO $U = \frac{E}{2}$; $I = \frac{I_{cortocirc}}{2} = \frac{I_\infty}{2}$

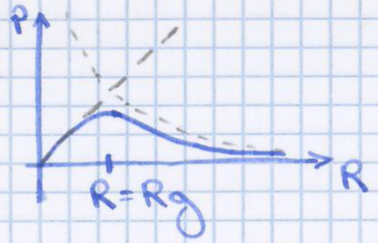


$$P = R \frac{E}{R_g+R} \cdot \frac{E}{R_g+R}$$

$$\bullet\ R \ll R_g \Rightarrow P \approx R \frac{E}{R_g} \cdot \frac{E}{R_g} = R \cdot \frac{E^2}{R_g}$$

SE R PICCOLA P CRESCE LINEARMENTE CON R

$$\bullet\ R \gg R_g \Rightarrow P \approx R \underbrace{\frac{E}{R}}_{\text{U DIPENDE POCO DA R}} \cdot \underbrace{\frac{E}{R}}_{\text{I INV. PROP. A R}} = \frac{E^2}{R} \rightarrow P \propto \frac{1}{R}$$



SE $R = R_g$ ABBIAMO P_{MAX}

$$I^* = \frac{E}{2R_g} = \frac{1}{2} I_\infty$$

$$U^* = R \cdot \frac{E}{2R_g} = \frac{E}{2}$$

$$(P)_{MAX} = U^* \cdot I^* = \left(\frac{E}{2}\right)\left(\frac{E}{2R_g}\right) = \frac{E^2}{4R_g}$$

POTENZA MAX ESTRAIBILE → POTENZA DISPONIBILE

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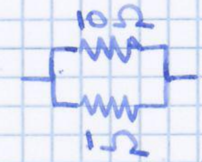
IN PARALLELO:

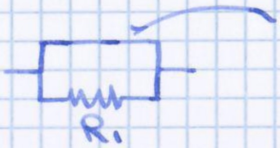
$$I = I_1 + I_2 = \frac{U}{R_1} + \frac{U}{R_2} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right) U$$

$$U = \underbrace{\frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}}_{Req} \cdot I = Req \cdot I = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

SE ABBIAMO 2 RESISTENZA DA 1 Ω, SE VOGLIO OTTENERE 0,5 Ω LE METTO IN PARALLELO



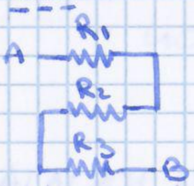
$Req = \frac{10}{11} \approx 0,9\,\Omega$ → MINORE DELLA R MINIMA



IN CORTOCIRCUITO → R=0 → Req=0

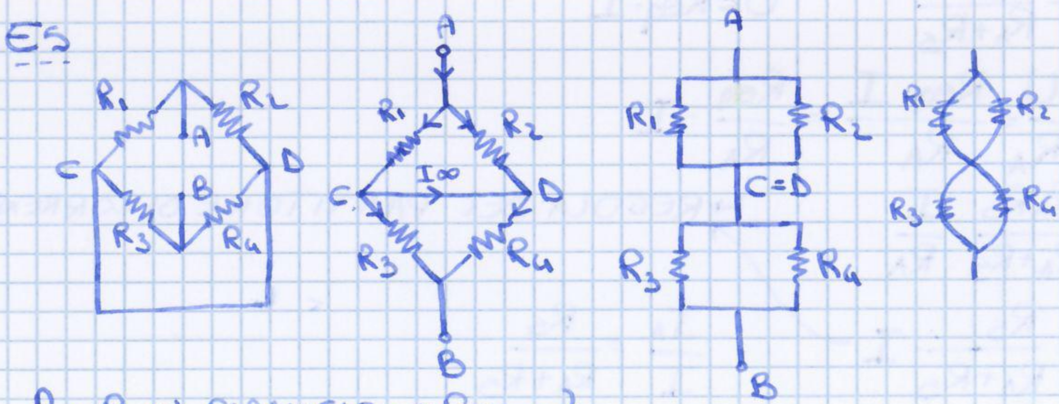
NON PASSA CORRENTE IN R_1

ES



$Req = R_1 + R_2 + R_3$

ES



$R_1; R_2$ IN PARALLELO → $Req_{1\text{-}2}$ } → IN SERIE
$R_3; R_4$; IN PARALLELO → $Req_{3,4}$ }

$$Req = \frac{R_1 R_2}{R_1 + R_2} + \frac{R_3 R_4}{R_3 + R_4}$$

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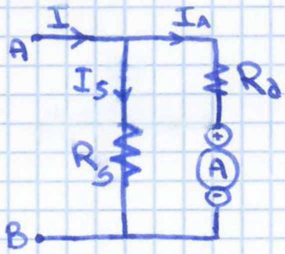
ES



$R_a = 1000\ \Omega$ $\qquad I_a = \alpha I$

$(I_a)_{MAX} = 50\ \mu A \qquad I_p = 10\ mA$

$$R_{eq} = \frac{R_S \cdot R_A}{R_S + R_A}$$

$$U_{AB} = R_{eq} \cdot I \ ; \ I_A = \frac{U_{AB}}{R_a} \ ;$$

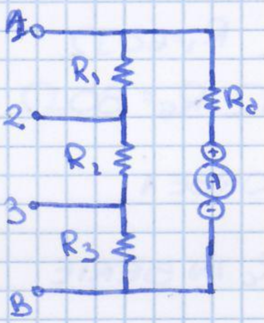
$$I_A = \frac{R_{eq} \cdot I}{R_a} = \underbrace{\frac{R_S}{R_a + R_S}}_{\alpha} \cdot I$$

$$\alpha = \frac{(I_a)_{MAX}}{I_p} = \frac{50 \cdot 10^{-6}\ A}{10 \cdot 10^{-3}\ A} = 5 \cdot 10^{-3}$$

$$\alpha = \frac{R_S}{R_a + R_S} \Rightarrow \alpha (R_a + R_S) = R_S \Rightarrow R_S = \frac{\alpha}{1-\alpha} R_a$$

$$R_S = \frac{5 \cdot 10^{-3}}{1 - 5 \cdot 10^{-3}} \cdot 1000 = \frac{5}{0{,}995} \approx 5\ \Omega$$

ES



$(I_A)_{MAX} = 50\ \mu A$ $\qquad$ A + PORTATE → 1B; 2B; 3B

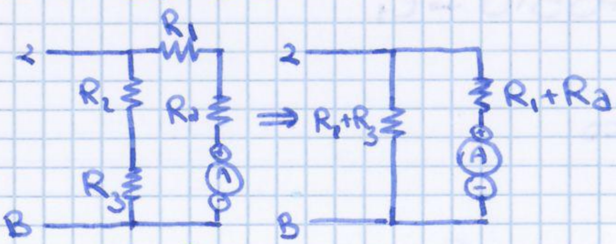
$R_a = 1000\ \Omega$

$R_1 = 900\ \Omega$

$R_2 = 90\ \Omega$

$R_3 = 10\ \Omega$

• CASO 2-B



$$\alpha_2 = \frac{R_2 + R_3}{(R_2 + R_3) + (R_a + R_1)} = \frac{100}{2 \cdot 10^3} = 5 \cdot 10^{-2}$$

$$I_a = \alpha_2 \cdot I \Rightarrow I = \frac{\overbrace{50 \cdot 10^{-6}}^{(I_a)_{MAX}}}{5 \cdot 10^{-2}} = 10^{-3}\ A = 1\ mA$$

R_1, R_3 IN SERIE SE A MORSETTO IDEALE

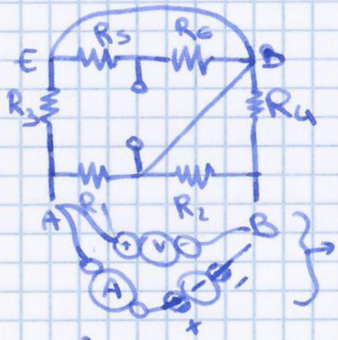
$$I_3 = \frac{U_{EC}}{R_3+R_1} = \frac{50}{40} = 1,25\,A$$

$$U_1 = R_1 I_1 = 10 \cdot 1,25 = 12,5\,V$$

$$U_{AB} = U_1 - U_2 = 12,5 - 60 = -47,5\,V$$

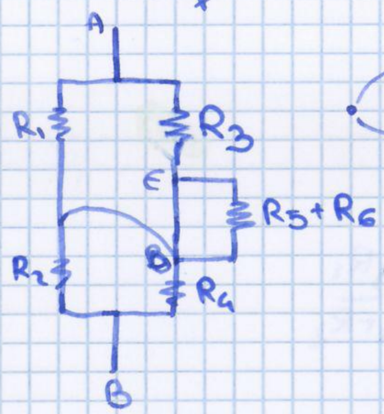
SE CI FOSSE UN UTILIZZATORE TRA A E B R_{AB} NON SAREBBE = 0, E QUINDI R_1 NON È + R_3 IN SERIE; R_2 NON CON R_4

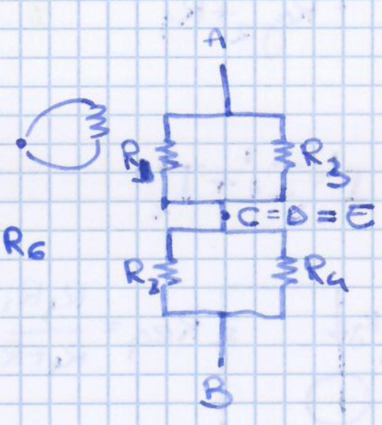
SE SPENGO LE SORGENTI → I GENERATORI DI CORRENTE E DI TENSIONE



R_5, R_6 IN PARALLELO CON CORTOCIRC.
↳ NON PASSA I → $R_{eq} = 0$

} → X MISURARE R TRA A E B IN LAB





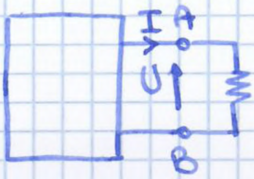
$$R_{13} = \frac{R_1 R_3}{R_1+R_3} \qquad R_{24} = \frac{R_2 R_4}{R_2+R_4}$$

$$R_{eq} = \frac{R_1 R_3}{R_1+R_3} + \frac{R_2 R_4}{R_2+R_4}$$

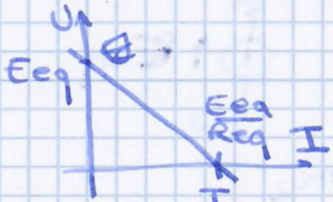
$$P_L = U \cdot I = (U' + U'')(I' + I'')$$
$$= \underbrace{U'I'} + \underbrace{U''I''} + U''I' + U'I''$$

POTENZA ASSORBITA

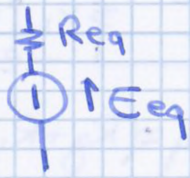
DAI MORSETTI SI OSSERVA:



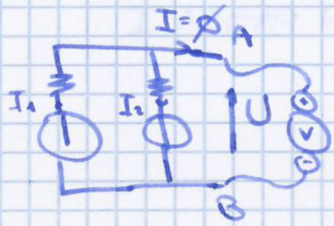
IL COMPORTAM. AI MORSETTI FA SI CHE LEGAME TRA U E I SIA UNA RETTA

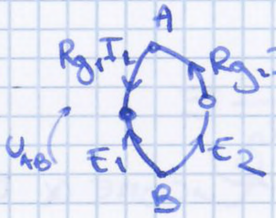


I_{cc} ↳ CORTOCIRCUITO



$$R_{eq} = R_{g1} \parallel R_{g2} = \frac{R_{g1} \cdot R_{g2}}{R_{g1} + R_{g2}}$$

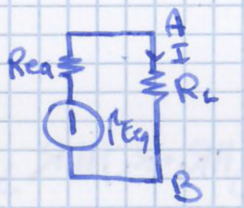




$$E_1 - E_2 - R_{g1} I_1 - R_{g2} I_1 = 0$$

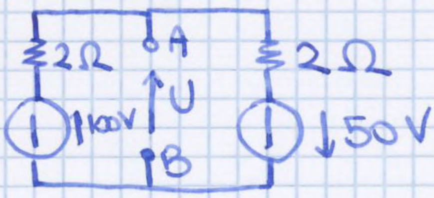
$$I_1 = \frac{E_1 - E_2}{R_{g1} + R_{g2}}$$

$$U_{AB} = E_1 - R_{g1} \cdot I_1$$



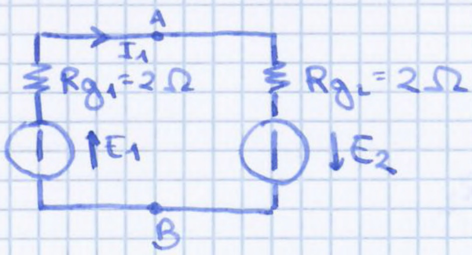
$$I = \frac{E_{eq}}{R_{eq} + R_1}$$

$$U = E_{eq} - R_{eq} I$$



$$R_{eq} = 1\,\Omega$$

$$E_1 + E_2 - R_{g1} I_1 - R_{g1} I_1 = 0$$



$$I_1 = \frac{E_1 + E_2}{R_{g1} + R_{g2}} = 37{,}5\,A$$

LED 7/8

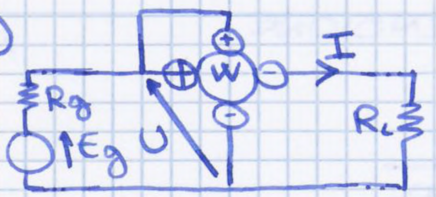
OSSERVAZIONI SULL'ESAMINO

1) $I = -0,2\ mA$ → CORRENTE OPPOSTA A VERSO e^-

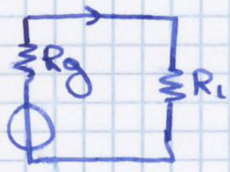
2) 

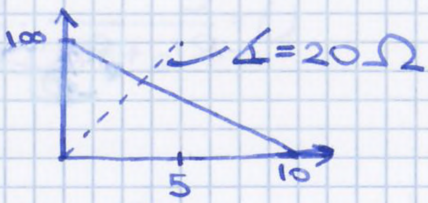
CORRENTE DA ⊕ A ⊖

3) $U_8 = V_4 + V_2 + V_1$

4) 

$$\eta = \frac{P_L}{E_g \cdot I} = \frac{P_L}{P_L + P_{PERDUTO}} = \frac{P_L}{P_L + R_g I^2}$$

5) 



$I_{cc} = E / R_g \Rightarrow R_g = E / I_{cc} = 10\ \Omega$

$-E + RI + R_g I = 0$

$$I = \frac{E}{R+R_g} = \frac{100}{30} = 3,33A$$

$$\eta = \frac{R_L}{R_L+R_g} = \frac{2}{3} = 66,67\%$$

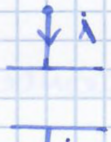
8) $W_1 = P_c + W_2$

3) APERTO: $I = \frac{E}{R_g + 2R} \approx 16,67A$

$U_1 = R \cdot I = 33,33V$

CIRCUITI DINAMICI

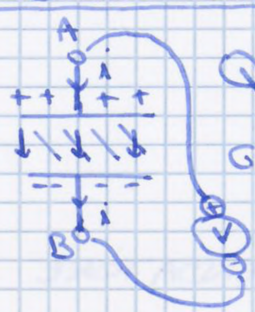
LEGATI ALLA STORIA DELLA i O DELLA U



CONDENSATORI ↝ $i = C \frac{du}{dt}$

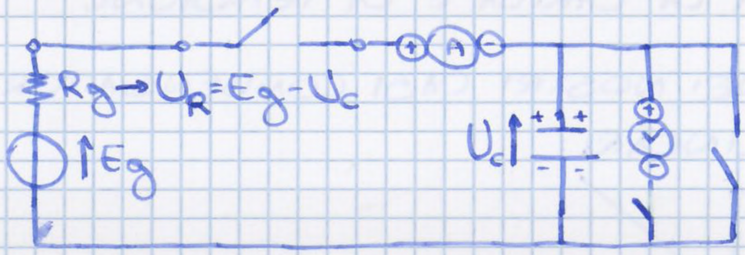
INDUTTORI ↝ $U = L \frac{di}{dt}$

$\boxed{\text{CONDENSATORE FISICO}}$



Q_f → CARICHE SEPARATE

GLOBALMENTE NEUTRO



SE CHIUDIAMO INTERRUTTORE PRINCIPALE INIZIA A PASSARE CORRENTE

U_c ACCUMULATA TENDE A COMPENSARE E_g, QUINDI I DIMINUISCE, MA U_c SI CARICA ANCORA

A UN CERTO PUNTO $U_c \approx E_g \Rightarrow I$ TRASCURABILE

EQUILIBRIO NEL CIRCUITO

$E = \frac{U}{d}$ $\quad (U)_{MAX} = d \cdot (E)_{MAX}$

LIMITATA NEL SUO VALORE MASSIMO

$Q = C \cdot U$

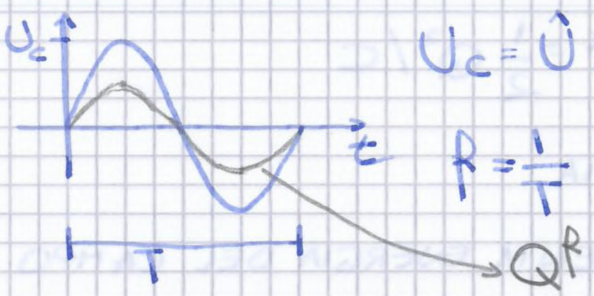
$Q + Q^{f} = C(U + \Delta U)$

SE U AUMENTA, LA Q AUMENTA ($i > 0$)

$Q^{f} = C \cdot \Delta U$

$\frac{Q^{f}}{\Delta t} = C \cdot \frac{\Delta U}{\Delta t} \Rightarrow i = C \frac{dU}{dt}$

SE U_c SEGUE ONDA SINUSOIDALE



$U_c = \hat{U} \, SEN\left(\frac{2\pi}{T} \cdot t\right)$

$f = \frac{1}{T}$

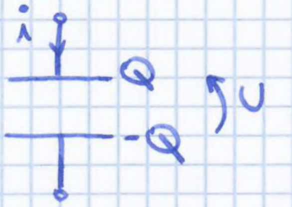
A FREQUENZE TROPPO ALTE NON VALGONO LE LEGGI DEI CIRCUITI FIN QUA USATE

LA FREQUENZA MAGGIORE, LA i MEDIA DEVE >

$$i = C\frac{du}{dt} = C\frac{d}{dt}\left[\hat{U} \, SEN\left(\frac{2\pi}{T} t\right)\right]$$

$$i = \underbrace{C \cdot \hat{U} \, \frac{2\pi}{T}}_{\hat{I}} \cos\left(\frac{2\pi}{T} t\right)$$

$$i = \hat{I} \cdot \cos\left(\frac{2\pi}{T} t\right)$$



Q_f, Q, U

$Q = C \cdot U$

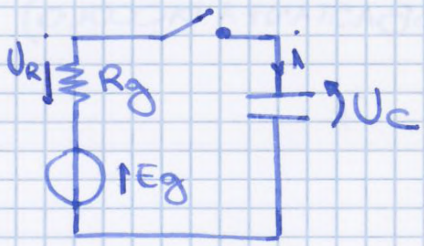
$C = \varepsilon \frac{S}{d}$ $\qquad E \cdot d = U$

$E = \frac{Q}{S\varepsilon}$ $\qquad \frac{Q}{S\varepsilon} \cdot d = U$ $\qquad Q = \underbrace{\varepsilon \frac{S}{d}}_{C} U$

PER AUMENTA LA CAPACITÀ $\rightarrow d\downarrow ; U\downarrow ; S\uparrow$

MA AUMENTA L'INGOMBRO: VOLUME $= Sd$

$E = \frac{U}{d} < (E)_{MAX}$



DA $t \geq 0$ L'INTERRUTTORE È CHIUSO

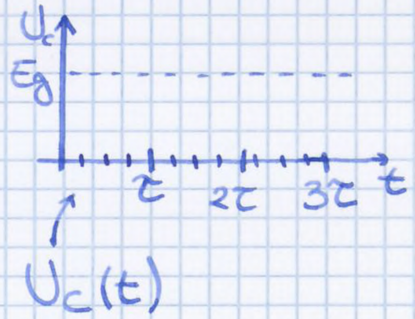
$U_c(0) = \emptyset$ VOLT

$$i = C\frac{dU_c}{dt} = \frac{U_R}{R_g} = \frac{E_g - U_c}{R_g}$$

$$\left(\frac{Q^R}{\Delta t} = C\frac{\Delta U_c}{\Delta t}\right)$$

$$C\frac{dU_c}{dt} = \frac{E_g - U_c}{R_g} \Rightarrow \frac{dU_c}{dt} = \frac{E_g - U_c}{R_g C} \Big\} \tau \rightarrow$$ COSTANTE DI TEMPO DEL CIRCUITO

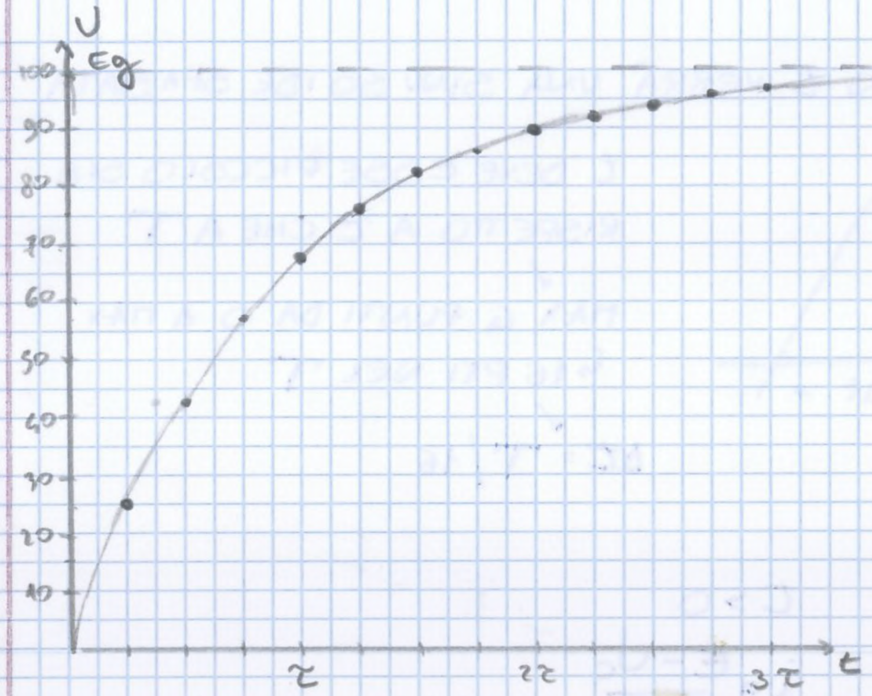
SI PUÒ RISOLVERE X VIA GRAFICA



DIVIDO OGNI INTERVALLO IN 4 INTERVALLI

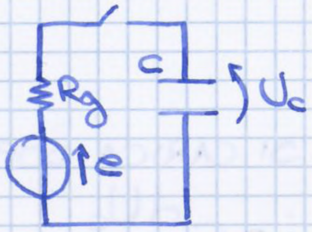
$t_0, t_1, t_2, \ldots$

$U_0, U_{c1}, U_{c2}, \ldots$



ESEMPIO

$R_g = 100\,\Omega$ $\quad C = 100\,\mu F \quad (\tau = 10^{-2}\,s)$

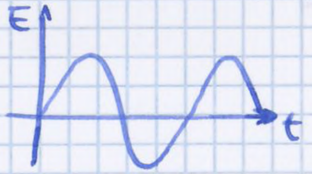


$e(t) = 100 \cdot SEN\left(\underbrace{\frac{2\pi}{T}\, t}_{RADIANTI}\right) \rightarrow$ NON STAZ.

$T = 1,2 \cdot 10^{-2}\, s$

L'INTERRUTTORE SI CHIUDE A $t = \emptyset\, s$ (PRIMA C SCARICO)

TAVOLA GRAFICO-NUMERICA → X 5/4/13

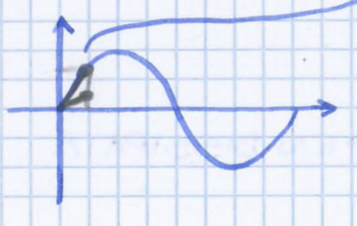


$$U_{Ck+1} = U_{Ck} + \left(\frac{e(k) - U_{Ck}}{\tau}\right)\Delta t$$

X ESSERE + RAFFINATO

$$\frac{e(t_k) + e(t_{k+1})}{2}$$

X VIA GRAFICA: → X TROVARE PENDENZA e



QUINDI POI, CONOSCENDO PEND. TROVO U_{k+1} E COSÌ VIA

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$$U_c(t) = K e^{-\frac{t}{RC}}$$

$$K\left(-\frac{1}{RC}\right)e^{-t/RC} = \frac{-1}{RC} K e^{-t/RC}$$ ← IDENTITA'

(VERIFICATA)

SE LA SORGENTE E' STAZ. SI ASSUME COME SOLUZ. PARTICOLARE QUELLA DI REGIME STAZ. (QUELLA DI EQUILIBRIO)

$$(U_c)_p = E$$

$$U_c = K e^{-\frac{t}{RC}} + E$$

$$U_c(0) = U_{c0} = K e^{-\frac{0}{RC}} + E = K + E$$

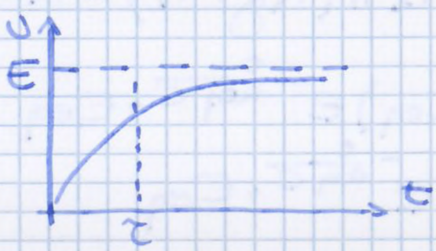
$$K = U_{c0} - E$$

$$U_c = (U_0 - E) e^{-\frac{t}{RC}} + E \quad \forall t > 0$$

SE IL CONDENSATORE E' INIZIALMENTE SCARICO

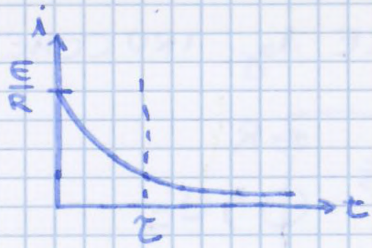
$$U_0 = 0$$

$$U_c = -E e^{-\frac{t}{RC}} + E$$



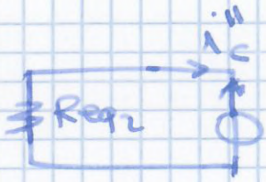
$$i = \frac{E - U_c}{R}$$

$$i = \frac{E e^{-t/RC}}{R} = \frac{E}{R} e^{-\frac{t}{RC}}$$



SE INVECE E VARIA IN MODO SINUSOIDALE $(U_c)_p$ NON E' E = COST.

+ COMPLESSO



$$R_{eq2} = R + R_2 \parallel (R_g + R_1)$$

$$i_c'' = -\frac{U_c}{R_{eq2}}$$

$$i_g'' = i_c'' \frac{R_2}{R_2 + (R_g + R_1)} = -\frac{U_c}{R_{eq2}} \cdot \frac{R_2}{R_2 + R_g + R_1}$$

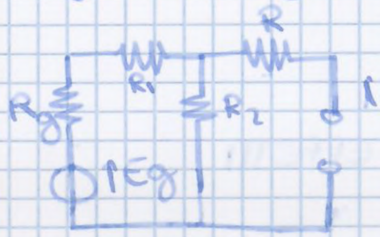
$$i_g = \frac{E_g}{R_{eq1}} - \frac{U_c}{R_{eq2}} \cdot \frac{R_2}{R_2 + R_g + R_1}$$

$$= \underbrace{\frac{E_g}{R_{eq1}} - \frac{E_{cc}}{R_{eq2}} \frac{R_2}{R + R_g + R_1}}_{\text{STAZIONARIO}} + \underbrace{\frac{E}{R_{eq2}} e^{-\frac{t}{R_{eq}C}} \frac{R_2}{R_2 + R_g + R_1}}_{\text{TRANSITORIO}}$$

METODO ALTERNATIVO X TROVARE i_g

$$i_g = \underbrace{I_g}_{\text{STAZ.}} + \underbrace{K' e^{-\frac{t}{R_{eq}C}}}_{\text{TRANSIT.}}$$

$i_g(0) = I_g + K'$; I_g È IL TERMINE DI REGIME S.



$$I_g = \frac{E_g}{R_g + R_1 + R_2}$$

APPENA CHIUSO L'INTERRUTTORE, $U_c(0) = \varnothing$ VOLT

IN $t = 0^+$

$$i_g(0) = \frac{E_g}{R_{eq1}}$$

$$K' = i_g(0) - I_g$$

$$i_g = \frac{E_g}{R_g + R_1 + R_2} + (i_g(0) - I_g)\, e^{-\frac{t}{R_{eq}C}}$$

$U = U' + U'' = E_{eq} - R_{eq} \cdot i$

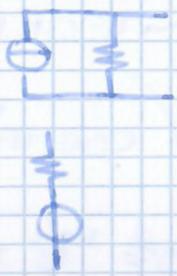
SOVRAPPOSIZ. EFFETTI

X NORTON:

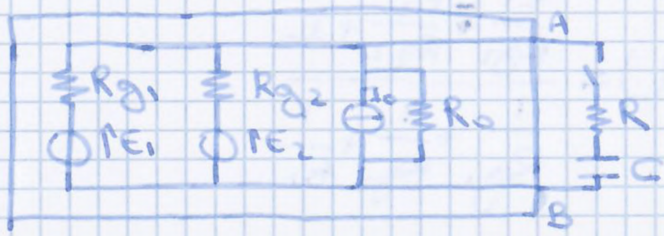
$i = I_0 - U / R_{eq}$

$U = E_{eq} - R_{eq} \cdot i$

$i = \underbrace{\frac{E_{eq}}{R_{eq}}}_{= I_0} - \frac{U}{R_{eq}}$

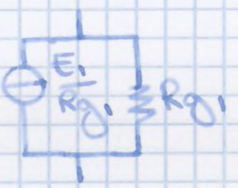


UTILIZZIAMO AD ESEMPIO THEVENIN:

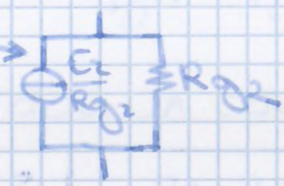


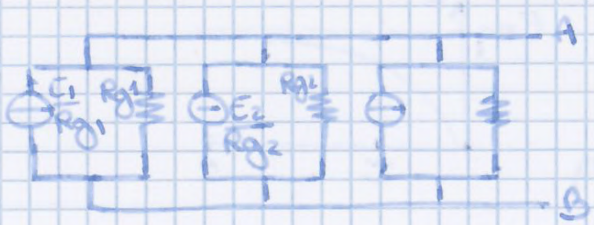
$R_{eq} = R_{g1} \| R_{g2} \| R_0$

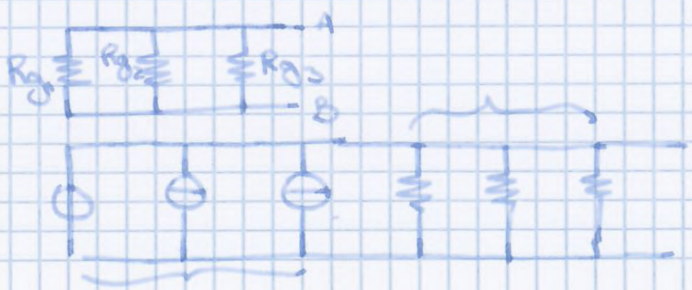
POSSO VOLENDO CONVERTIRE $E_1 ; R_{g1}$ DA THEVENIN A NORTON



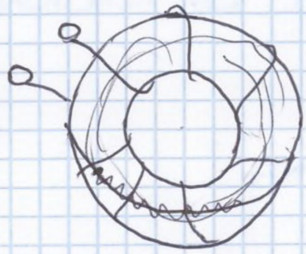
ANCHE CON E_2 →







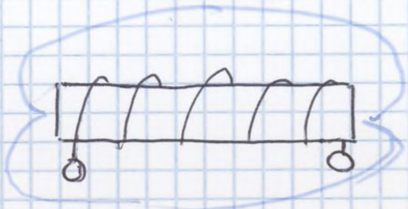
INDUTTORE



Fe, Ni, Co

INDUTTORI IN ARIA

INDUTTORI IN "Fe" ⇒ MATERIALI FERROMAGNETICI COME SUPPORTO
↳ INDUTTANZA + ELEVATA



AVVOLGIMENTO MAGNETIZZANTE

LA CORRENTE DIVENTA SORGENTE DI CAMPO MAGNETICO

AL CAMPO È ASSOCIATA UN ENERGIA

SI IMMAGAZZINA EN. MAGNETICA

+ INTENSO SE + DENSO → + SPIRE

DENSITÀ ENERGIA $\propto$ (DENSITÀ FLUSSO)^2

$F = N \cdot I$

FORZA MAGNETOMOTRICE

FLUSSO MAGNETICO È ASSOCIATO A UN PERCORSO CHIUSO

X DETERMINARE FLUSSO USO LEGGE DI FARADAY

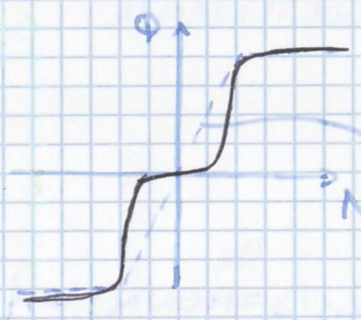
SE LA RIBALTO DIVENTA −

SE RIBALTO SUP, RIBALTO ANCHE IL VERSO DEL FLUSSO

$\Delta\phi = 2\phi$

LEGGE DI FARADAY X ELETTROMAGN:

F = 1 A x 100 SPIRE = 2 A x 50 SPIRE



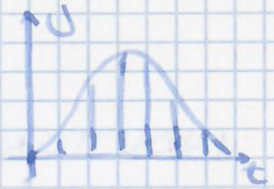
$\phi = f(F)$

FORZA MAGNETOMOTRICE

A PARITÀ DI FLUSSO MI BASTA CORRENTE + BASSA SE MATERIALE FERROMAGNETICO

NUCLEO INTERO

$\phi = I_u$



$d\phi = U\,dt$

$U = \frac{d\phi_c}{dt} = N\frac{d\phi}{dt}$

FLUSSO CONCATENATO

FLUSSO NEL NUCLEO (1 SPIRA)

$[\phi] = V \cdot s = \text{WEBER}$

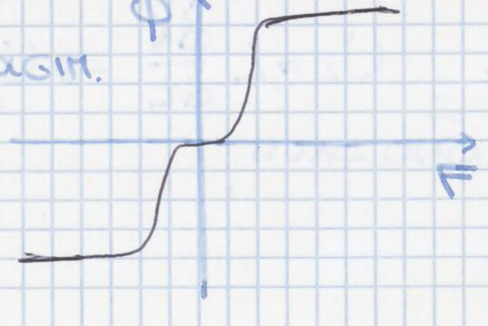
VARIABILI IN GIOCO:
- ϕ = FLUSSO MAGNETICO NEL NUCLEO
- F = FORZA MAGNETICA

LEGGI DELL'ELETTROMAGNETISMO:
- LEGGE DI FARADAY (TENSIONE INDOTTA AI MORSETTI DI UN AVVOLGIMENTO)

$U = N\frac{d\phi}{dt}$

NUM. SPIRE DELL'AVVOLGIM. DEL MEDESIMO

- LEGGE COSTITUTIVA (LEGAME TRA F E φ)



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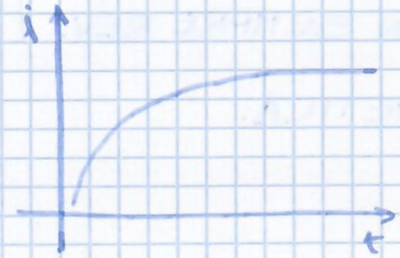
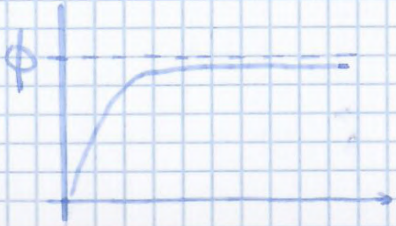
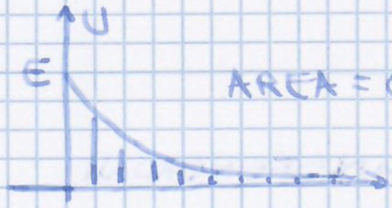


ALL'EQUILIBRIO

$$i = \frac{E}{R}$$





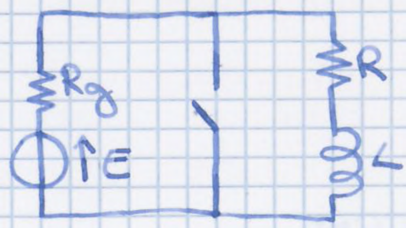
AREA $= \phi = L \cdot i_{eq}$

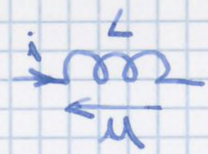
$$L\frac{di}{dt} = E - Ri \qquad \frac{di}{dt} = \frac{E}{L} - \frac{R}{L}i = \frac{(E-Ri)R}{L/R}$$

$$\frac{di}{dt} = \frac{E/R - i}{L/R} = \frac{i_{eq} - i}{\tau}$$

$$\frac{dU_c}{dt} = \frac{E - U_c}{\tau}$$

ES



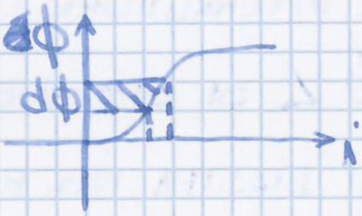


$\phi = L \cdot i$

LEGGE DI FARADAY $\quad U = \frac{d\phi}{dt} = L\frac{di}{dt}$

$$\delta L_e = U \cdot i\,dt = \underbrace{U dt}_{d\phi}\, i$$

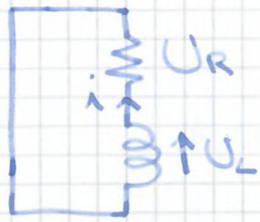
LAVORO ELETTRICO



ANCHE SE NON METTO R, C'È LA R STESSA DEI FILI DELL'INDUTTORE

↓

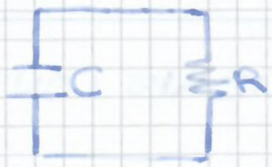
SENNÒ USO SUPERCONDUTTORI → SUPERINDUTTORI



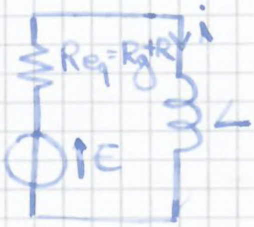
$U_R + U_L = 0$

$Ri + L\frac{di}{dt} = 0$

$\frac{di}{dt} = -\frac{i}{L/R}$



$\frac{dU_C}{dt} = -\frac{U_C}{RC}$ CONFRONTO



$i = Ke^{-\frac{t}{L/R}} = Ke^{-\frac{R}{L}t}$

$= i(0)e^{-R/L \cdot t}$

$E = \underbrace{R_{eq}\, i}_{U_R} + \underbrace{L\frac{di}{dt}}_{U_L}$

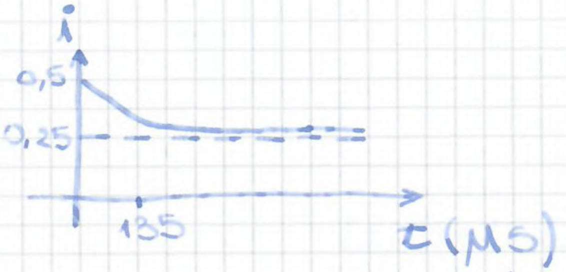
$\frac{di}{dt} = \frac{E/R_{eq} - i}{L/R}$ ⟵ $\frac{dU_C}{dt} = \frac{E - U_C}{RC}$

EQUAZIONI DI STATO

i COME VARIABILE STATO — U_C COME VAR. STATO

$i = Ke^{-\frac{R_{eq}}{L}t} + \frac{E}{R_{eq}}$

$i(0) = K + E/R_{eq} \Rightarrow K = i(0) - \frac{E}{R_{eq}}$

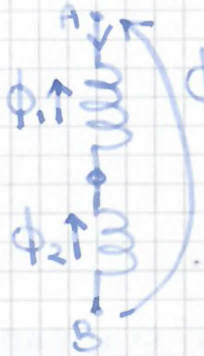


$$i = [i(0) - i'_{eq}]\, e^{-t/(L/R_{eq})} + i'_{eq}$$

$$= 0{,}25\, e^{-\frac{t}{135 \cdot 10^{-6}}} + 0{,}25 \text{ A}$$

$$\frac{di}{dt} = \frac{\frac{E}{2R} - i}{L/2R} \qquad i(0) = 0{,}5 \text{ A}$$

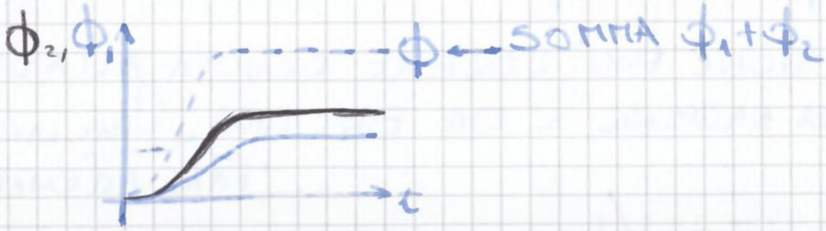
SE 2 IN SERIE



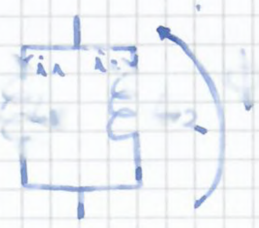
$$\phi = \phi_1 + \phi_2 = L_1 i + L_2 i = (L_1 + L_2)\, i$$

SE LINEARI

SE NON LINEARI:



SE 2 IN PARALLELO



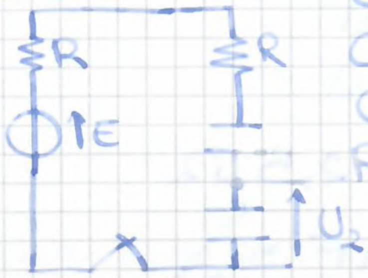
$$i = i_1 + i_2$$

$$= \frac{\phi}{L_1} + \frac{\phi}{L_2} = \phi\left(\frac{1}{L_1} + \frac{1}{L_2}\right)$$

$$\phi = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2}} \cdot i$$

1 μF
100 V   NE USO PERO' 4 !!

ES.

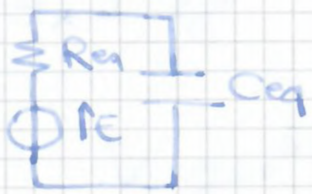


$E = 100\,V$

$C_1 = 5\,\mu F$, $C_2 = 20\,\mu F$ $\Big\}$ $C_{eq} = \frac{5\cdot 20}{5+20} = \frac{100}{25} = 4\,\mu F$

$R = 10\,\Omega \rightarrow R_{eq} = 20\,\Omega$

C_{eq} = CIRCUITO EQUIVALENTE



$$i = C_{eq}\frac{dU_{c,eq}}{dt}$$

$$\frac{E - U_{c,eq}}{R_{eq}} = C_{eq}\frac{dU_{c,eq}}{dt}$$

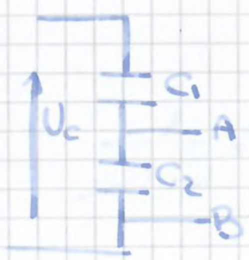
$\tau = 2R\cdot C_{eq} = 80\,\mu s$

$U_c = (U_c)_{omog} + (U_c)_p$

$(U_c)_{omog} = K e^{-t/\tau}$ $(U_c)_p = E$

$U_0 = 0 = K + E \Rightarrow K = -E$

$U_c = -E e^{-t/\tau} + E = -100\, e^{\frac{t}{80\cdot 10^{-6}}} + 100$ VOLT



$$U_2 = \frac{Q_2}{C_2} = \frac{C_{eq}\cdot U_c}{C_2} = \frac{C_1}{C_1+C_2}\cdot U_c$$

$$= \frac{1}{5}U_c = -20\, e^{t/\tau} + 20$$

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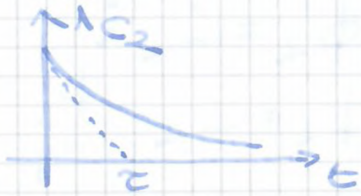
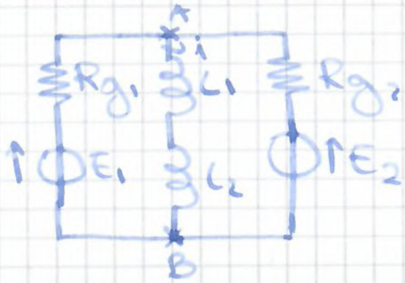
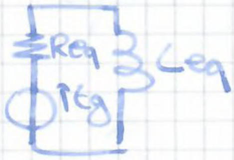
$$i_{C2} = \frac{C_2}{C_1+C_2} \cdot \frac{E_{eq}}{R_{eq}} e^{-\frac{t}{R_{eq}(C_1+C_2)}}$$

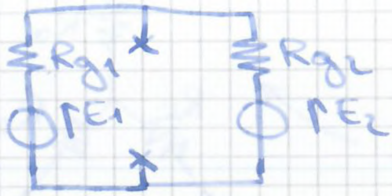


ESERCIZIO



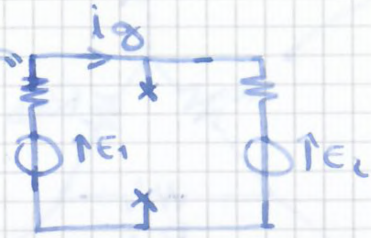


CIRC. THEVENIN:



$$R_{eq} = \frac{R_1 R_2}{R_1+R_2} =$$

$$E_{eq} = \frac{E_1 R_{g1} + E_2 R_{g2}}{R_{g1}+R_{g2}}$$



$$L_{eq} = L_1 + L_2$$

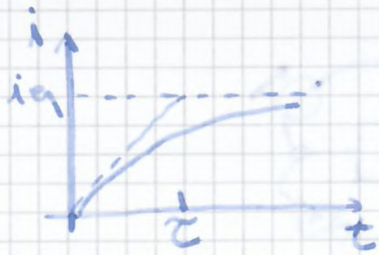
$$-E_1 + E_2 + R_2 i_g + R_1 i_g = 0$$

$$i_g = \frac{E_1 - E_2}{R_{g1}+R_{g2}}$$

$$i_{eq} = E_{eq}/R_{eq}$$

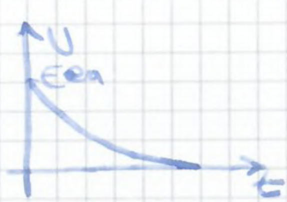
$$E_{eq} = E_1 - R_{g1} i_g$$

$$\frac{di}{dt} = \frac{i_{eq} - i}{L_{eq}/R_{eq}}$$



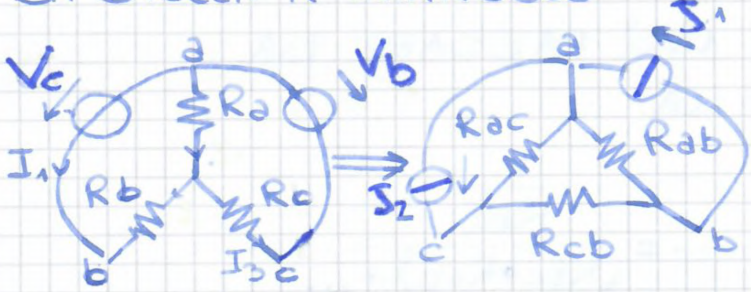
$$i = -i_{eq} e^{-t/\tau} + i_{eq}$$

$$U = E_{eq} - R_{eq} \cdot i = E_{eq} e^{-t/\tau} \ V$$



GEMELLO LUCA

DA STELLA A TRIANGOLO



SECONDO LA LEGGE DELLE MAGLIE ALLA STELLA

$$(R_a+R_b)I_1 - R_a I_2 = -V_b$$

$$(-R_a)I_1 + (R_a+R_c)I_2 = V_c$$

$$I_1 = -V_b \frac{R_a}{R_aR_b+R_aR_c} - V_b \frac{R_c}{R_aR_b+R_aR_c+R_bR_c} + V_c \frac{R_a}{R_aR_b+R_aR_c+R_bR_c}$$

SECONDO LA LEGGE DEI CIRCUITI AL TRIANGOLO

$$\left(\frac{1}{R_{ab}}+\frac{1}{R_{bc}}\right)V_b - \frac{1}{R_{bc}}V_c = -I_1$$

$$\left(+\frac{1}{R_{bc}}\right)(+V_b) + \left(\frac{1}{R_{ab}}+\frac{1}{R_{bc}}\right)V_c = I_2$$

EGUAGLIAMO LE 2 EQUAZIONI

$$\frac{1}{R_{bc}} = \frac{R_a}{R_aR_b+R_aR_c+R_bR_c}$$

ALLO STESSO MODO:

$$\frac{1}{R_{ac}} = \frac{R_b}{R_aR_b+R_aR_c+R_bR_c}$$

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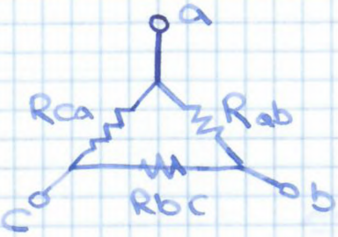
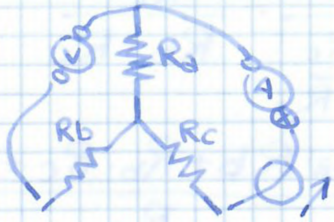
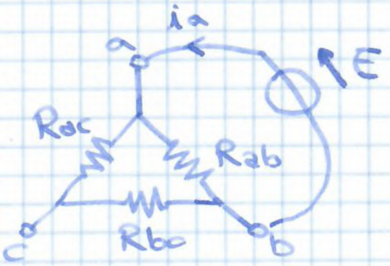




$$R_a = \frac{V}{A}$$



$$U_{ac} = \frac{R_{ac}}{R_{ac}+R_{bc}} \cdot E$$

$$i_a = E\left(\frac{1}{R_{ab}} + \frac{1}{R_a + R_{bc}}\right)$$

$$R_a = \frac{U_{ac}}{i_a} = \cancel{E} \cdot \frac{R_{ac}}{R_{ac}+R_{bc}} \cdot \frac{\frac{1}{R_{ab}} + \frac{1}{R_{ac}+R_{bc}}}{\cancel{E}}$$

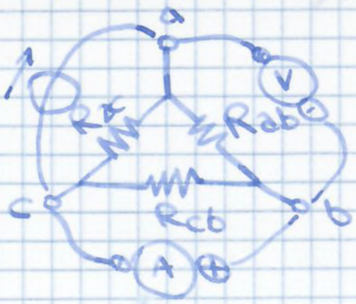
$$= \frac{R_{ac}}{\cancel{(R_{ac}+R_{bc})}\ \frac{R_{ab}+R_{ac}+R_{bc}}{R_{ab}\cancel{(R_{ac}+R_{bc})}}}$$

$$= \frac{R_{ac} R_{ab}}{R_{ab}+R_{ac}+R_{bc}}$$

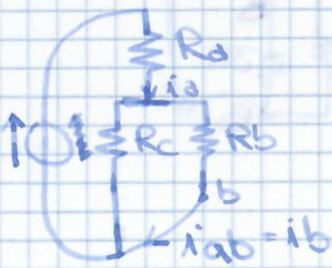
$$R_b = \frac{R_{bc} \cdot R_{ab}}{R_{ab}+R_{ac}+R_{bc}}$$

$$R_c = \frac{R_{ca} \cdot R_{cb}}{R_{ab}+R_{ac}+R_{bc}}$$

PASSAGGIO DA STELLA A TRIANGOLO

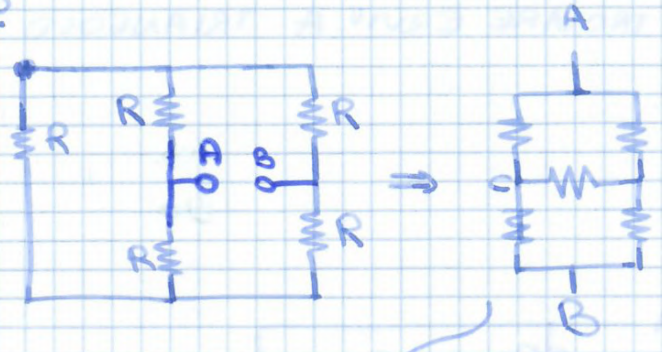


$$R_{ab} = \frac{V}{A}$$

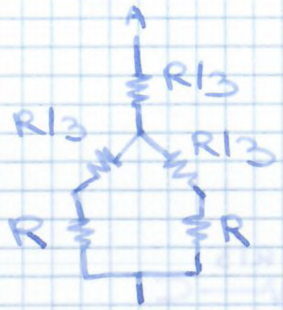


$$i_a = \frac{E}{R_a + \frac{R_b \cdot R_c}{R_b + R_c}}$$

ES

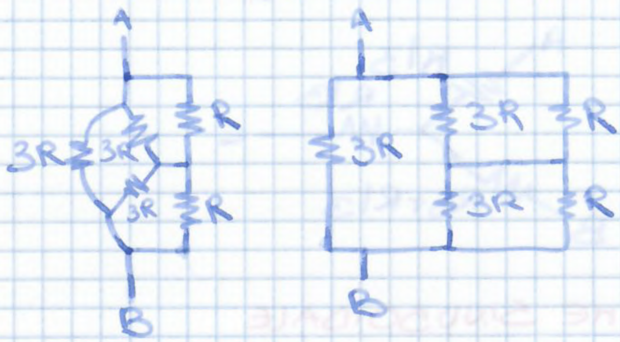


RISOVO D'INVUOVO CON TRASF. IN STELLA



$$R_{eq} = \frac{R}{3} + \left(\frac{R}{3}+R\right) // \left(\frac{R}{3}+R\right) = R$$

OPPURE DA STELLA CON CENTRO STELLA C



$$R_{eq} = \left(\frac{3R \cdot R}{3R+R}\right) \cdot 2 // 3R$$

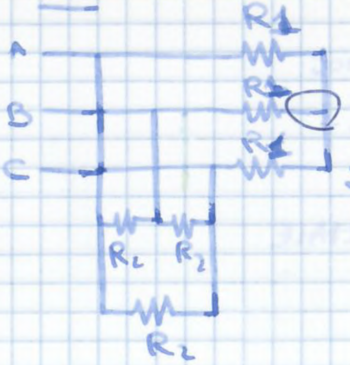
$$= \frac{6R^2}{4R} // 3R$$

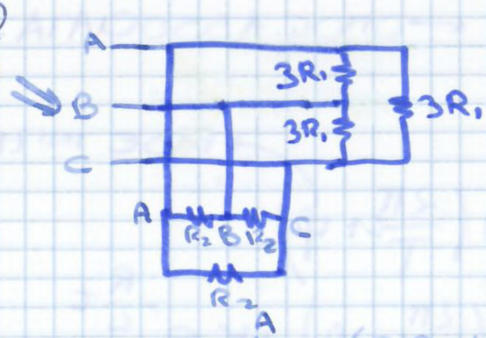
$$= \frac{6/4 \cdot 3}{6/4+3} R =$$

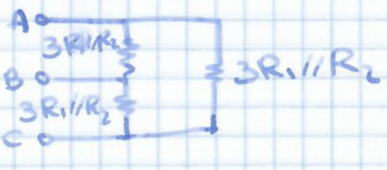
$$= \frac{18}{4} \cdot \frac{4}{18} R = R$$

ES

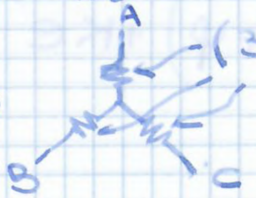
VOGLIO TROVARE TRIPOLO EQUIV. A TRIANGOLO







$\Rightarrow$



$(3R_1//R_2)/3$

$\parallel$

$R_1 // (R_2/3)$

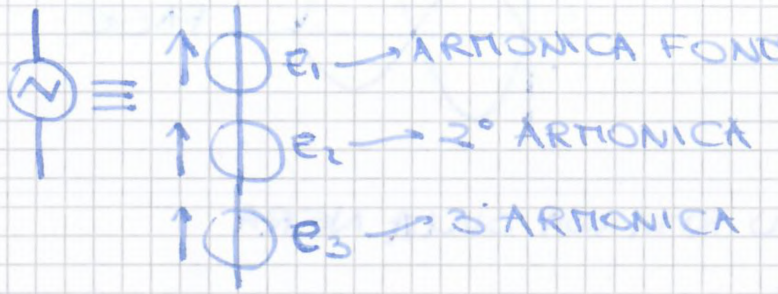
$0 = \hat{I} \cdot \text{SEN}\,\varphi + K \Rightarrow K = -\text{SEN}\,\varphi \cdot \hat{I}$

$i(t) = \hat{I}\,\text{SEN}\left(\frac{2\pi}{T}t + \varphi\right) - \hat{I}\,\text{SEN}\,\varphi\, e^{-\frac{R}{L}t}$

SE ALL'INIZIO $e_S \neq 0 \Rightarrow$ SFASAM. φ

TERMINE DI REGIME SINUSOIDALE PERMANENTE — TRANSITORIO

↳ RISPOSTA ARMONICA



AL VARIARE DELLA FREQUENZA ABBIAMO ≠ RISPOSTE

NON PUÒ RISP. A TUTTE LE FREQUENZE

$a(t) = \hat{A}\,\text{SEN}\left(\frac{2\pi}{T}t + \varphi_a\right)$

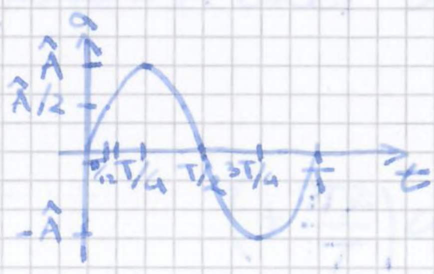
FASE INIZIALE

RADIANTI

PERIODO

AMPIEZZA

$-A : +A \Rightarrow 2A \leftarrow$ AMPIEZZA PICCO PICCO A_{PP}



$a = \hat{A} \cdot \text{SEN}\left(\frac{2\pi}{T}t + \varphi_a\right)$

$b = \hat{B}\,\text{SEN}\left(\frac{2\pi}{T} + \varphi_b\right)$

$L \qquad i(t) = \hat{I}\,\mathrm{sen}\left(\frac{2\pi}{T}t\right)$

$\phi = L \cdot i = \underbrace{L\hat{I}}_{\hat{\phi}}\,\mathrm{sen}\left(\frac{2\pi}{T}t\right)$

$U = \underbrace{L \cdot \hat{I}\,\frac{2\pi}{T}}\cdot\cos\left(\frac{2\pi}{T}t\right)$

$\hat{U} = \frac{2\pi}{T}\hat{\phi} = \frac{2\pi}{T}L\hat{I}$

$U = \frac{2\pi}{T}L\hat{I}\,\mathrm{sen}\left(\frac{2\pi}{T}t + \frac{\pi}{2}\right)$

$\varphi_U - \varphi_i = \pi/2 \rightarrow$ QUADRATURA DI FASE

$C \qquad U_c(t) = \hat{U}_c\,\mathrm{sen}\left(\frac{2\pi}{T}t\right)$

$Q = CU = C\hat{U}\,\mathrm{sen}\left(\frac{2\pi}{T}t\right)$ SE U_c A $\varphi_U = \emptyset$

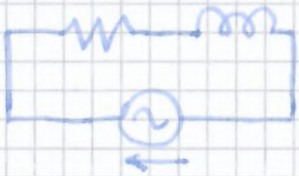
$i = \frac{dQ}{dt} = C\frac{dU_c}{dt} = \underbrace{CU\frac{2\pi}{T}}_{\hat{I}}\cos\left(\frac{2\pi}{T}t\right)$

$i = \hat{I}\sin\left(\frac{2\pi}{T}t + \frac{\pi}{2}\right)$

$\hat{U} = \frac{1}{\frac{2\pi}{T}\cdot C}\hat{I}$

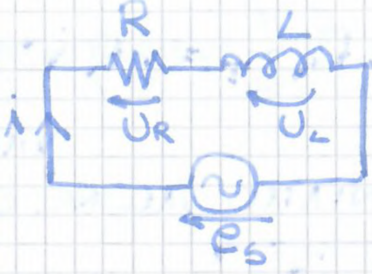
$U_c = \frac{\hat{I}}{2\pi/T}\cdot\mathrm{sen}\left(\frac{2\pi}{T}t - \frac{\pi}{2}\right)$ SE CORR. A φ NULLA

ES



$i = \hat{I}\,\mathrm{sen}\left(\frac{2\pi}{T}t\right.$

$i = \hat{I}\, \text{sen}(\omega t)$



$e_S = \hat{E}_S\, \text{sen}(\omega t + \varphi_S)$

$U_R = R \cdot i = \underbrace{R\hat{I}}_{\hat{U}_R}\, \text{sen}(\omega t)$

$U_L = L\dfrac{di}{dt} = \omega L \hat{I} \cos(\omega t) = \underbrace{\omega L \hat{I}}_{\hat{U}_L}\, \text{sen}\left(\omega t + \dfrac{\pi}{2}\right)$

$e_S = U_R + U_L = \hat{U}_R\, \text{sen}(\omega t) + \hat{U}_L\, \text{sen}\left(\omega t + \dfrac{\pi}{2}\right)$

$= \hat{E}_S\, \text{sen}(\omega t + \varphi_S)$

$\cos\varphi_S = \dfrac{\hat{U}_R}{\sqrt{\hat{U}_R^2 + \hat{U}_L^2}}$

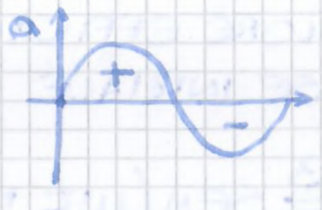
$\text{TG}\,\varphi_S = \dfrac{\hat{U}_L}{\hat{U}_R}$

$\text{SEN}\,\varphi_S = \dfrac{\hat{U}_L}{\sqrt{U_R^2 + U_L^2}}$

USIAMO NUMERI COMPLESSI:

$a(t) = \hat{A}\, \text{sen}(\omega t)$

$\langle a \rangle_T = \dfrac{1}{T}\displaystyle\int_0^T a(t)\, dt = 0$



QUINDI SI PARLA DI FUNZ. ALTERNATA

$i = \hat{I}\, \text{sen}(\omega t)$

$P_R = R i^2 = R\, \hat{I}^2 \cdot \text{sen}^2(\omega t)$

FUNZ. PERIODICA DI T/2

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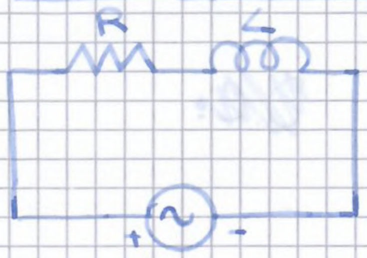
INDUTTORE REALE



$Z = 1\,\Omega$

$R = 0{,}1\,\Omega \approx R_{DC}$

$f = 50\,Hz$

$\underline{Z} = \frac{\underline{U}}{\underline{I}}$ $\qquad Z = \frac{U}{I} = 1\,\Omega$ ← PARTE Re

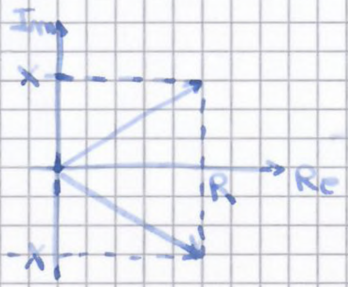
$\underline{Z} = R + \underbrace{j}_{\sqrt{-1}}X \Rightarrow Z = \sqrt{R^2 + X^2}$

REATTANZA = PARTE IMMAGINARIA

$X = \pm\sqrt{Z^2 - R^2}$

$X = \omega L = \frac{2\pi}{T} L = 2\pi f L$

QUINDI POSITIVA (IN QUESTO CASO)

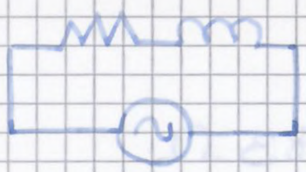


$X = \sqrt{1 - 0{,}1^2} \cong 0{,}995\,\Omega$

$L = \frac{X}{\omega} \cong 3{,}17\,mH$

ES

$f = ?$ $\quad I = 0{,}5\,A$ $\quad E = 40\,V$ $\quad R = 3\,\Omega$ $\quad L = 30\,mH$



$\underline{Z} = \frac{\underline{E}}{\underline{I}}$

$Z = \frac{E}{I} = \frac{40}{0{,}5} = 80\,\Omega$

$X = \sqrt{Z^2 - R^2} = \sqrt{80^2 - 9} \cong 79{,}9$

$X = 2\pi f L \Rightarrow f = \frac{X}{2\pi L} = \frac{80}{2\pi \cdot 30 \cdot 10^{-3}} = 424{,}4\,Hz$

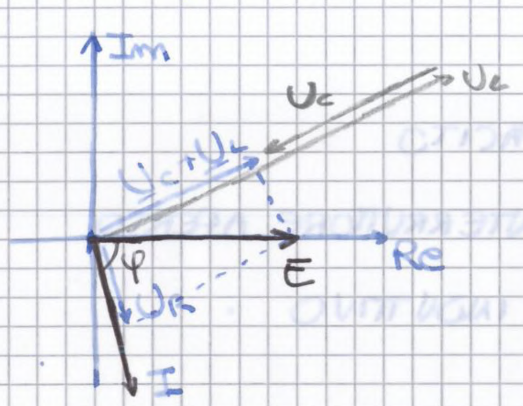
$Z_1 = \sqrt{2^2 + 92,25^2} \cong 92,25\,\Omega$

$U_1 = 92,25 \cdot 8,57 \cong 791\ V$

$U_1 >$ DI E POICHE' U_C E' NEGATIVA

$\underline{U}_C = jX_C\,\underline{I}$

$U_C = |X_C|\,I = 79,58 \cdot 8,57 = 682\ V$



$\underline{U}_R = R\,\underline{I}$; $\underline{U}_L = jX_L\,\underline{I}$

$\underline{U}_R + \underline{U}_L = \underline{U}_1$; $\underline{U}_C = jX_C\,\underline{I}$

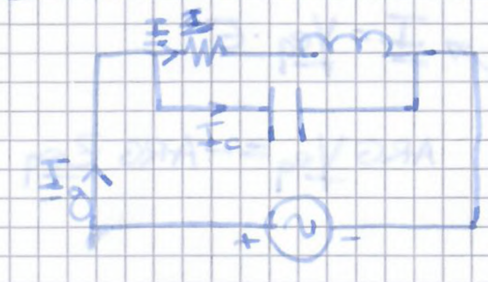
$E = \underline{U}_1 + \underline{U}_C$

$= \underbrace{U_R}_{\text{IN FASE CON } I} + \underbrace{U_L + U_C}_{\text{IN QUADRATURA CON } I}$

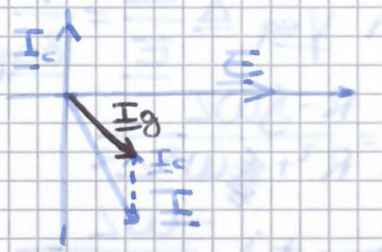
$|U_L + U_C| = \sqrt{E^2 - (RI)^2} = \sqrt{110^2 - (2 \cdot 8,57)^2} = 108\ V$

$U_L = j\omega L \cdot I'$ $\qquad U_L = \omega L \cdot \frac{E}{R} = \frac{\omega L}{R} \cdot E = 6,9\,E = 19,6\,V$

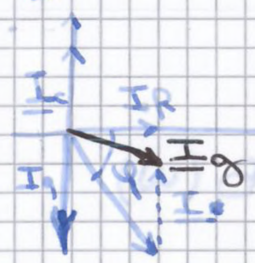
SE INVECE METTO C IN PARALLELO



$I_g = I + I_c$



I_g SI PUÒ SCOMPORRE IN I_f (IN FASE) E I_q (IN QUADRAT.)



FACCIO SOMMA VETTORIALE TRA LE COMPONENTI

POSSO REGOLARE LA CAPACITÀ IN MODO DA RIDURRE LA CORRENTE RICHIESTA COMPLESSIVA, LASCIANDO I COSTANTE

$I_q = I \cdot \sin\varphi = 6 \cdot 10^{-3} \sin 48° = 3,913\,mA$

DEVO FARE IN MODO CHE $I_c = I_q$, AFFINCHÉ SI COMPENSINO

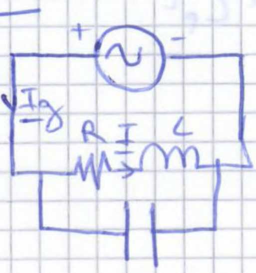
$I_c = I_q \Rightarrow I_c = \frac{E}{|X_c|} \Rightarrow |X_c| = \frac{E}{I_c} \sim 1022\,\Omega$

REATTANZA CAPACITIVA

$|X_c| = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega |X_c|} = \frac{1}{2\pi f \cdot 1022} = 77,85\,nF$

$I_g = I \cdot \cos\varphi = 0,83\,mA$

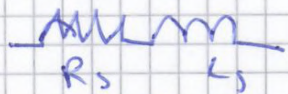
ES



$$\underline{I}_g = \underline{I} + \underline{I}_c = \frac{\underline{E}_s}{R+j\omega L} + \frac{\underline{E}}{jX_c} = \frac{\underline{E}_s}{R+j\omega L} + \frac{\underline{E}}{j\left(-\frac{1}{\omega C}\right)}$$

$$\underline{I}_g = \frac{\underline{E}_s}{R+j\omega L} + j\omega C\,\underline{E}_s = \underbrace{\underline{Y}_{eq}\underline{E}_s}_{\underline{I}} + \underbrace{\underbrace{j\omega C}_{\underline{Y}_c}\underline{E}_s}_{\underline{I}_c}$$

$$\underline{Y}_{eq} = \frac{1}{R+j\omega L} = \frac{R}{R^2+\omega^2L^2} - \frac{j\omega L}{R^2+\omega^2L^2}$$



$$\underline{Z}_{eq} = R_s + j\omega L_s$$

$$\underline{Y}_{eq} = \frac{R_s}{R_s^2+\omega^2L_s^2} - j\frac{\omega L}{R_s^2+\omega^2L_s^2}$$

$$\underline{Z}_{eq} = \frac{1}{\frac{1}{R_p} + \frac{1}{j\omega L_p}}$$

$$\underline{Z}_{eq} = \frac{1}{\frac{1}{\underline{Z}_1} + \frac{1}{\underline{Z}_2}}$$

$$\underline{I} = \underline{I}_1 + \underline{I}_2 = \frac{\underline{E}}{\underline{Z}_1} + \frac{\underline{E}}{\underline{Z}_2} = \underbrace{\left(\frac{1}{\underline{Z}_1} + \frac{1}{\underline{Z}_2}\right)}_{\underline{Y}_{eq} = \underline{Y}_1 + \underline{Y}_2}\underline{E}$$

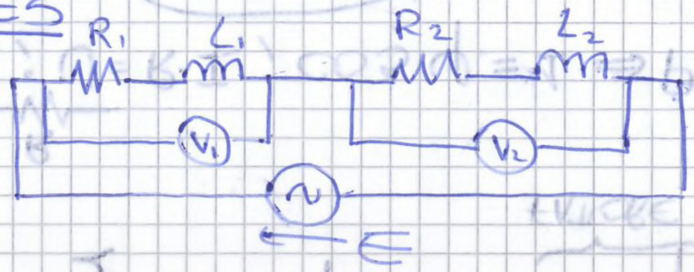
$$\underline{Z}_{eq} \triangleq \frac{\underline{E}}{\underline{I}}$$

$$\underline{Y}_{eq} = \frac{1}{R_p} + \frac{1}{j\omega L_p} = \frac{1}{R_p} - j\frac{1}{\omega L_p}$$

$$-\frac{1}{\omega L_{eqp}} + \omega C = 0$$

$$C = \frac{1}{\omega^2 L_{eqp}} \qquad L_{eqp} = L_s \frac{R_s^2 + \omega^2 L_s^2}{\omega^2 L_s^2}$$

ES



$E = 120\,V \qquad f = 50\,Hz$

$R_1 = 25\,\Omega\,;\ L_1 = 0{,}01\,H\,;\ R_2 = 5\,\Omega\,;\ L_2 = 0{,}14\,H$

$\underline{Z}_1 = R_1 + j\omega L_1 = 25 + j\,3{,}14\ \Omega$

$\underline{Z}_2 = R_2 + j\omega L_2 = 5 + j\,44\ \Omega$

$Z_{eq} = \underline{Z}_1 + \underline{Z}_2$

$$\underline{I} = \frac{\underline{E}}{\underline{Z}_{eq}} = \frac{120}{30 + j\,47{,}4} \simeq 1{,}153 - j\,1{,}81\,A$$

$$= 2{,}15 \angle -57{,}5^\circ$$

$$\underline{U}_1 = \underline{Z}_1 \cdot \underline{I} = (25 + j\,3{,}4)(1{,}153 - j\,1{,}81)$$

$$= 34{,}5 - j\,41{,}63$$

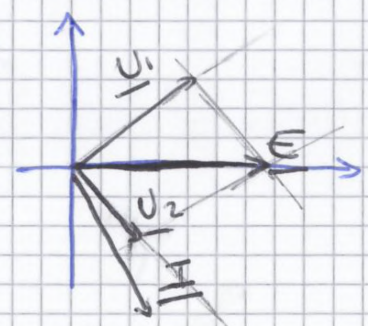
$$= 54{,}07 \angle -50{,}35^\circ\ V$$

$V_1 = 54{,}07$

$$\underline{U}_2 = \underline{E} - \underline{U}_1 = 120 - (34{,}5 - j\,41{,}63)$$

$$= 85{,}5 + j\,41{,}63$$

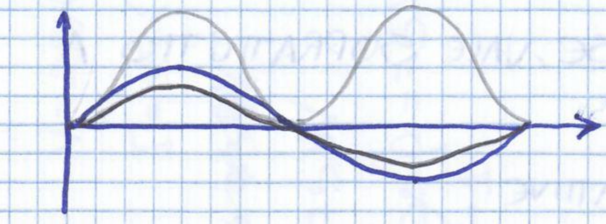
$$= 95{,}1 \angle 26^\circ$$



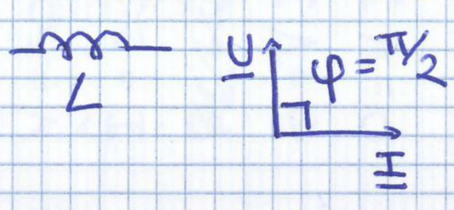
SE SONO IN FASE:

$(p)_{MAX} = 2P = P + S$

$(p)_{MIN} = 0 = P - S$



SE ABBIAMO INVECE UN INDUTTORE

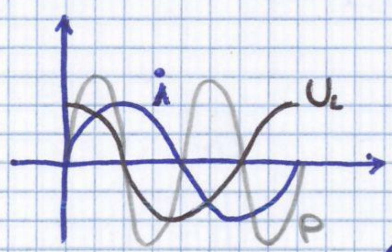


$\cos\varphi = 0$

$P = 0\ W$

$S = U\,I$

NON CONSUMA NULLA



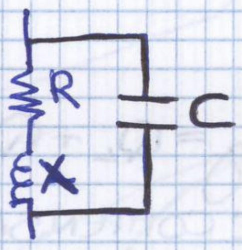
ASSORBE ENERGIA CHE VIENE IMMAGAZZINATA E POI LA RESTITUISCE

$W_L = \frac{1}{2} L \hat{I}^2$

SE LA POTENZA APPARENTE È MOLTO > DI QUELLA ATTIVA LA PAGHIAMO

$\frac{P}{S} = \cos\varphi$

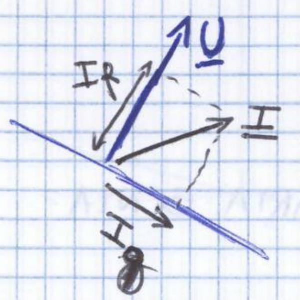
$\cos\varphi = \frac{R}{\sqrt{R^2 + X^2}}$



IN PARALLELO X RIFASARE LA CORRENTE

↓

FASAMENTO DELL'IMPIANTO



$I_R = I\cos\varphi$

$I_q = I \operatorname{sen}\varphi$

SE RITARDO VARIO SOLO S, NON P

I_C COMPENSA I_q, QUINDI NON INFLUISCE SULLA CORRENTE ATTIVA I_R

$I = \frac{P}{U\cos\varphi}$

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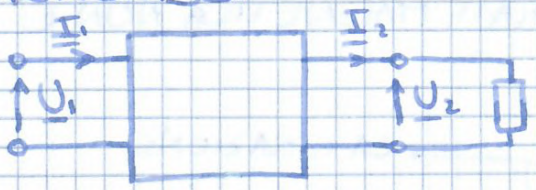
MACCHINE ELETTRICHE

TRASFORMATORE

CONVERTE I ≠ LIVELLI DI TENSIONE → SI CERCA $\eta \simeq 1$

MONOFASE:



PRIMARIO SECONDARIO

$$\eta = \frac{P_u}{P_i} = 1 - \underbrace{\frac{P_i - P_u}{P_i}}_{1-\eta}$$

DIPENDE DALLA TAGLIA ← DI QUALCHE PUNTO %

MACCHINE PICCOLE + PERDITE

TRASFORMATORE → INNALZATORE / ABBASSATORE

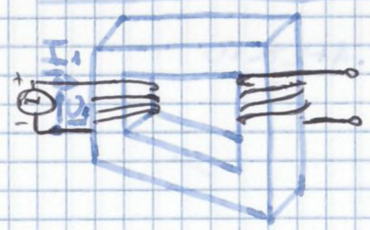
t = RAPPORTO DI TRASFORMAZIONE

$$t_1 \triangleq \frac{U_1}{U_2}$$

SE $t > 1$ → ABBASSATORE

$t < 1$ → ELEVATORE

TRASFORMATORE FISICO



E' UN INDUTTORE

ϕ_m → FLUSSO MEDIO X SPIRA

$$\underline{E}_1 = j\omega N_1 \phi_m$$

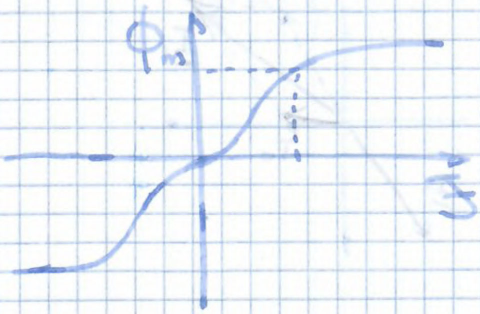
$\omega\phi_m$

ϕ È DEFINITO DAL VALORE DI PICCO

$$\phi_m(t) = \hat{\phi}_m \, \mathrm{sen}(\omega t) \qquad \phi_m = \hat{\phi}_m e^{j\phi}$$

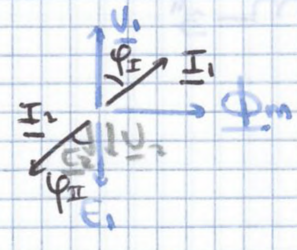
$N_1 \underline{I}_1 + N_2 \underline{I}_2 = \oint \vec{H} \, d\vec{l} = f(\Phi_m) \cong 0 \rightarrow$ APPROX

FUNZIONE DEL FLUSSO MAGNETICO



$N_1 \underline{I}_1 + N_2 \underline{I}_2 \cong 0 \qquad \underline{I}_1 = -\frac{N_2}{N_1} \cdot \underline{I}_2 = -\frac{\underline{I}_2}{t}$

$\underline{I}_1$ CON DIREZ OPPOSTA A $\underline{I}_2$



$P_1 = U_1 I_1 \cos\varphi_1$

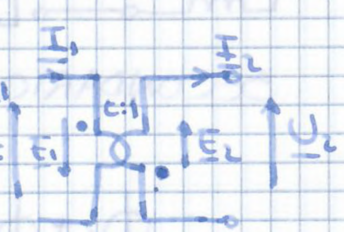
$P_2 = U_2 I_2 \cos\varphi_2 = \frac{U_1}{t} I_1 t \cos\varphi_1$

$P_1 = P_2$

NON SERVE POT. REATTIVA → TRASFORMATORE IDEALE

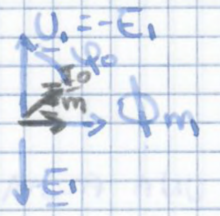
$Q_1 = Q_2$

SIMBOLO TRASF. IDEALE:



NON HA EFFETTI DISSIPATIVI

SE INVECE FMM X MAGNETIZZARE NUCLEO NON È TRASC.:



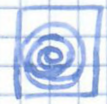
A SECONDARIO APERTO SE NON IDEALE CORRENTE IN 1 X SOSTENERE Φ_m

$\underline{I}_0$ È LA CORRENTE A VUOTO DEL TRASFORMAT.

È PICCOLA

$\cos\varphi_0$ = FATTORE DI POT. A VUOTO

SE NON FOSSE LAMINATO BASSA RESISTENZA



SE INVECE LAMINATI + RESIST → − PERDITE

PERDITE $= k_1 f + k_2 f^2 + \dots$

AUMENTANO ALL'AUMENTARE DI f

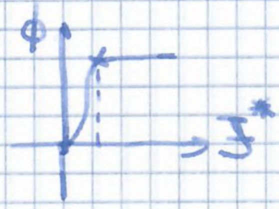
$A_{eff} = \alpha A = 0,9 A$

α → FATTORE CORRETTIVO

$\hat{B} = 1,3\,T$

$\hat{\Phi} = \hat{B} \cdot A_{eff} = 1,3 \cdot 400 \cdot 10^{-4} \cdot 0,9 = 46,8 \cdot 10^{-3}$ WB

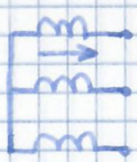
$U_1 = \omega \phi N_1 = \frac{\omega}{\sqrt{2}} N_1 \hat{\phi} = \frac{2\pi}{\sqrt{2}} f N_1 \hat{\phi} = 4,44 f N_1 \hat{\phi}$



UN FLUSSO ALTO È + CONVENIENTE XKÈ A PARITÀ DI TENSIONE POSSO AVERE UNA SEZ. + PICCOLA, RISPARMIO DI MATERIALE

$N_1 = \frac{U_1}{4,44 \cdot 50 \cdot 46,8 \cdot 10^{-3}} = 1059$ SPIRE

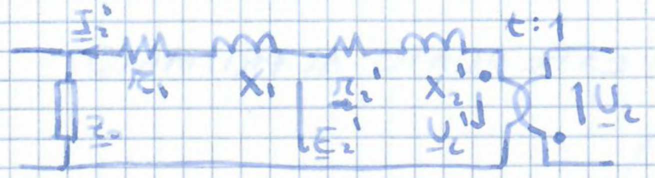
$N_2 = ?$



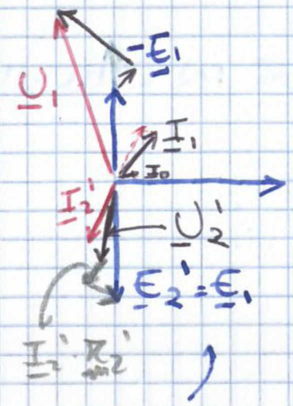
$E'' = 4,44 f N_2 \hat{\phi} = \frac{U_{2n}}{t} / \sqrt{3}$

$E'' = \frac{550}{\sqrt{3}} = 317,54\,V$

$\frac{N_1}{N_2} = \frac{E'}{E''} = \frac{11000}{317,54} \Rightarrow N_2 = N_1 \cdot \frac{317,54}{11000} = 31$ SPIRE



SEMPLICAZ. CON ERRORE TRASCURABILE



$\underline{U}_1 = -\underline{E}_1 + (r_1 + jX_1)\,\underline{I}_1$

$-\underline{I}_2' = \underline{I}_1 - \underline{I}_0$

$\underline{E}_2' = \underline{U}_2' + \underline{I}_2'(r_2' + jX_2')$

RICAVO $\underline{U}_2$ X DIFFERENZA

DIAGRAMMA DI CARICO

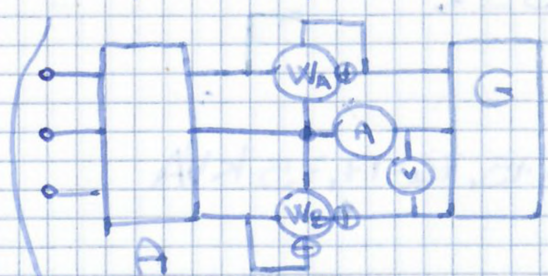
PROVA A VUOTO (X ES. DI IERI)

X DETERMINARE ε

$U_{1n}^3 = 11000\,V$

$P_0 = 1{,}3\,kW$; $I_0 = 21{,}1\,A$

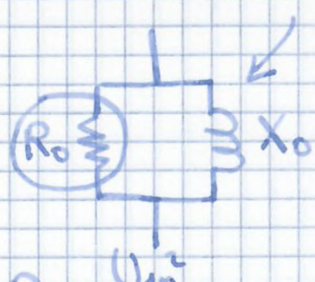
$\underline{U}_{2n} = 660\,V$



$I_{0_2} = A$

$P_0 = W_A + W_B$

QUESTA È TRIFASE, MI SERVE MONOFASE X



$P_{m0} = \frac{P_0}{3}$

$P_{m0} = \frac{U_{1n}^2}{R_0}$

NOMINALE COMPLESSIVA

$R_0 = \frac{U_{1n}^2}{P_{m0}} = 279{,}3\,K\Omega$

$X_0 = \frac{U_{1n}^2}{Q_{m0}}$

$S_0 = \sqrt{3} \cdot U_{2n} I_0$

$S_{m0} = \frac{U_{2n}}{\sqrt{3}} I_0 = 5{,}36\,KVA$

MONOFASE

$Q_{m0} = \sqrt{S_{m0}^2 - P_{m0}^2}$
$= 5{,}2\,KVAR$

ES SU TRASFORM.

$$\eta = \frac{P_2}{P_1} = \frac{P_1 - P_p}{P_1} = 1 - \frac{P_p}{P_1} = 1 - \frac{P_p}{P_2 + P_p}$$

$P_{2m} = U_2 I_2 \cos\varphi$

$P_2 = \sqrt{3}\, U_2 I_2 \cos\varphi$

$S_m, x \rightarrow x \cdot S_m$

$P_2 = x \cdot S_m \cos\varphi$

$P_p \cong P_0 + x^2 P_{cc}$

$I_2 = x I_{2n} \qquad I_2^2 = x^2 \cdot I_{2n}^2$

$$\eta = 1 - \frac{P_0 + x^2 P_{cc}}{x S_m \cos\varphi + P_0 + x^2 P_{cc}}$$

$$\eta = 1 - \frac{P_0/S_m + x^2 P_{cc}/S_m}{x \cos\varphi + P_0/S_m + x^2 P_{cc}/S_m}$$

$$\eta = 1 - \frac{p_0 + x^2 p_{cc}}{x \cos\varphi + p_0 + x^2 p_{cc}}$$

$\frac{\partial \eta}{\partial x} = 0 \rightarrow$ MAX $\eta \quad P_0 = x^2 P_{cc} \qquad x = \sqrt{\frac{P_0}{P_{cc}}}$

$$\eta_{MAX} = 1 - \frac{2 P_0}{S_m \sqrt{P_0/P_{cc}} \cos\varphi + 2 P_0}$$

$S_m = 300$ kVA

$P_0 = 1{,}5$ kW $\quad P_{cc} = 4{,}5$ kW

$x_{MAX} = x^* = \sqrt{\frac{P_0}{P_{cc}}} = \sqrt{\frac{1}{3}} \cong 0{,}58$

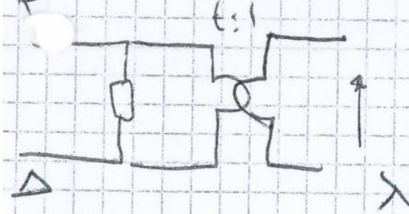
$V_{cc} = 630$ Volt

) Determinare i parametri del circuito monofase equivalente riportato a primario: è il circ. equivalente di una fase: tens. primaria = quella concatenata; secondario = stella ~~ta~~. Perché è del tipo $\Delta - \lambda$

2) Calcolare il rendimento della macchina a $\cos\varphi_2 = 0,8$ e frazione $x = \frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1$

) Ripetere lo stesso con $\cos\varphi_2 = 0,6$ e $\cos\varphi_2 = 1$

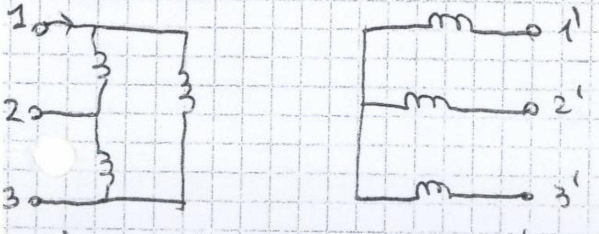
) Nella ~~macchina~~ medesime condizioni di carico trovare la caduta di tens. numerica (diff. tra i valori efficaci) riferita al secondario



rapp. tra tens. concatenate

Rapporto t non è $\frac{11000}{440}$ ma $\left(\frac{11000}{440}\right)\sqrt{3}$ xkè ~~...~~ primario è Δ e secondario è λ.

Gruppo è il modo in cui sono collegati avvolgimento primario e secondario $(\Delta - \lambda)$



$P_0 = 1,3$ kW: a vuoto, ma a carico non cambia xkè cadute di tens. piccole in una macchina fatta bene. Flussi non cambiano molto al variare delle ~~...~~ tensioni.

Se $V_{1n} = 0,9$ per esempio, ho un flusso più basso. Il circuito equivalente di una fase della macchina

~~Se diminuisco tensione~~, la P_0 a vuoto viene assorbita da $\underline{Z}$; se diminuisco tensione di poco e la $\underline{Z}$ non cambia molto (perché $\underline{Z}$ dip. un po' dalla tensione) la potenza diventa + piccola, essa dipende dal quadrato delle tensione. Se $\underline{V}_{1n} \rightarrow 0,9\,\underline{V}_{1n}$:

$P = 0,9^2\,P_0 = 0,81\,P_0$

$\cos\varphi$	η
1	98,57
0,65	97,82

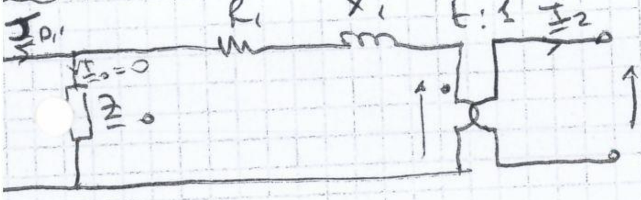
con un $\cos\varphi$ + basso perdite nelle macchine non cambiate. Si dà semplicemente no potenza: perciò conviene rifasare!

, le stesse P_{cc} ~~pf~~ ma con un x + basso, ho meno perdite nel rame ($x^2 P_{cc}$) xkè ho una corrente + bassa.

, è detto ~~pe~~ perdite nel ferro.

rifasare → $\cos\varphi$ + alto → $x^2 P_{cc}$ ↓

caduta di tensione da vuoto a carico: si usa circuito equivalente

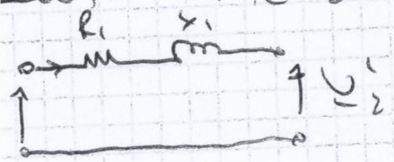


$$t = \frac{U_{1n}}{E_{2n}} = \frac{U_{1n}}{U_{2n}} \cdot \frac{U_{2n}}{E_{2n}} =$$

$\frac{11000}{440}$ ↳ $\sqrt{3}$ opp

$$= \frac{11000}{440}\sqrt{3}$$

caduta di tensione in Z_0 è trascurabile



Diff. di tensione:

$$U_1 - U_2' \cong R_1 J_1 \cos\varphi + X_1 J_1 \operatorname{sen}\varphi \ \#$$

quella relativa la posso ottenere dividendo per U_1

diff. di fase tra U_2' e la corrente in X_1 è uguale alla diff. di fase nel secondario.

in condizioni nominali e fattore di pz 0,8

$$U_{1n} - U_2' = 14,52 \cdot 9,09 + 67,79 \cdot \underbrace{0,6}_{\operatorname{sen}\varphi} \cdot 9,09 = 475\,V$$

$$\underbrace{U_{20} - U_2}_{\text{tens. concatenate}} = \frac{U_{1n}}{m} \quad ; \quad U_2 = E_2\sqrt{3} = \frac{U_2'}{t}\sqrt{3}$$

$m = \frac{11000}{440}$

Per cui $U_{20} - U_2 = \frac{U_{1n}}{m} - \frac{U_2'}{t}\sqrt{3} = \frac{U_{1n} - U_2'}{m}$ $\left(\frac{t}{\sqrt{3}} = m\right)$

$\Delta U_2 \cong 19$ Volt. Si passerebbe da 430 V a 411 V

Cosa succede a un conduttore che si muove in un campo ... ?

$$= \frac{R_1 I_1^2 \cos\varphi + X_1 I_1^2 \sin\varphi}{U_1 I_1}$$

$P_{cc} = R I_{1R}^2$; $R_1 I_1^2 = x^2 P_{cc}$

$X_1 I_1^2 - x^2 Q_{cc}$

$U_1 I_1 = x\, S_n$

$$\frac{U_{20} - U_2}{U_{20}} = \frac{x^2 P_{cc} \cos\varphi + x^2 Q_{cc} \sin\varphi}{x\, S_n}$$

$$= x\left(p_{cc} \cos\varphi + q_{cc} \sin\varphi\right)$$

ES

$S_n = 300$ kVA TRASF. TRIFASE 11000 / 440 V

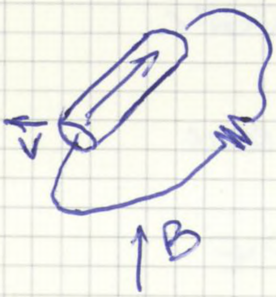
$1^a = \Delta - 2^a = \lambda$ ← AVVOLGIMENTI

FACCIO PROVA A VUOTO A BASSO V (440) POICHE' 1100 DIFFICILE DA RAGGIUNGERE

PROVA A VUOTO $P_0 = 1,3$ kW ; $I_0 = 21,1$ A
(A SECONDARIO)

PROVA DI CC A 1°
$P_{cc} = 3,6$ kW ; $U_{cc} = 630$ V

MOTORI ASINCRONI



$U = B e v$

$U = (\vec{v} \times \vec{B}) \cdot \vec{e}$

$P_g = UI = B e v i$

$P_m = B e v i = F \cdot v$ $F = B e i$

LA FEM INDUCE LA CORRENTE

$\omega_S - \omega_R$ → V. ANGOLARE SINCRONISMO

↳ VELOC. ROTORE ANGOLARE

IDEALMENTE A UN CERTO PUNTO $\omega_S = \omega_R$ A FORZA DI INSEGUIRE ACCELLERANDO

$$\Delta = \frac{\omega_S - \omega_R}{\omega_S}$$

↳ SINCRONISMO

IN REALTÀ ω_R SEMPRE DI $< \omega_S$

PICCOLA COPPIA X VINCERE ATTRITI

SE FACCIAMO RESISTENZA SULL'ALBERO LA MACCHINA RALLENTA AUMENTA $(\omega_S - \omega_R)$, QUINDI AUMENTA FEM

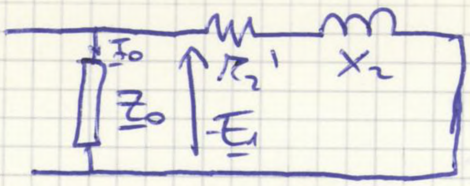
BASTA UNA PICCOLA ω_R IN MENO RISPETTO AL SINCRONISMO

QUASI ω_R COST

DA MOTORE

↳ È SIMMETRICA

DA GENERATORE



CONDIZ. CORTOCIRCUITO

A ROTORE BLOCCATO (A TENS. RIDOTTA)