# ALCUNE CONSIDERAZIONI:

- É possibile che una piccola parte degli esercizi sia scorretta
- Alcuni esercizi possono essere risolti in modi diversi, ma ugualmente corretti
- Gli esercizi sono svolti in ordine cronologico, quindi più si va in fondo nel file più sarà probabile che con più esperienza alle spalle saranno corretti.

BUON LAVORO!

1)

$A_{nom} = 15 kVA$

$\frac{V_{1N}}{V_{2N}} = \frac{2300}{230}$


- PROVA IN CORTO

$V_{cc} = 37 V$

$P_{cc} = 100 W$

- PROVA IN APERTO

$I_{CA} = 0.21 A$

$P_{CA} = 40 W$

$Z_c = (3+2j)\Omega$

PROVA IN CORTO: Ho corrente nominale e tensione piccola.

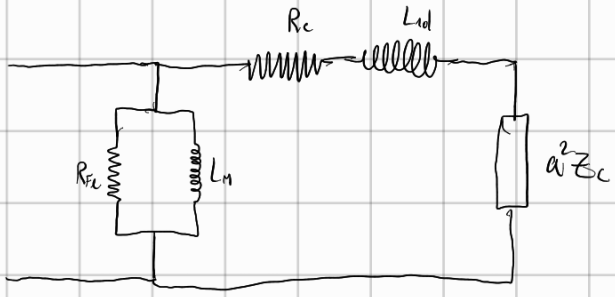
$A_{nom} = I_{1N} V_{1N} \Rightarrow I_{1N} = \frac{A_{nom}}{V_{1N}} = 6.52 A$

$P_{cc} = I_{1N} V_1 \cos\varphi_{cc}$ $\quad R_c = \frac{P_{cc}}{I_{1N}^2} = 2.35 \Omega$

$\cos\varphi_{cc} = \frac{P_{CA}}{I_{1N} V_1} = 0.41$ $\quad \varphi_{cc} = 1.15 rad$

$X_d = R_c \tan\varphi_{cc} = 5.11 \Omega$

PROVA IN CIRCUITO APERTO:




PROVA IN APERTO:

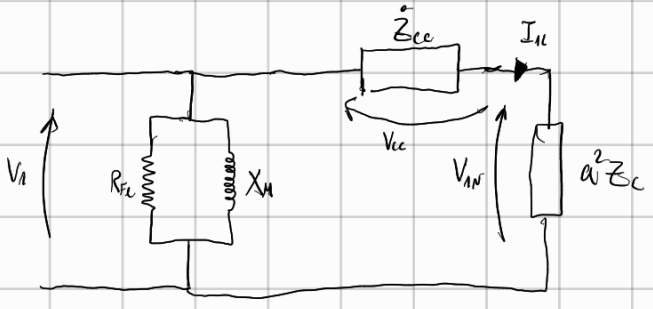
$I_{ca} = 0.21A \quad P_{ca} = 40W \quad V_{1N} = 2300V$

$$P_{ass}\ R_{Fe} = \frac{V_{1N}^2}{R_{Fe}} \Rightarrow R_{Fe} = \frac{V_{1N}^2}{P_{ca}} = 1.32 \cdot 10^6 \Omega$$

$P_{ca} = V_{1N} I_{ca} \cos\varphi_{ca}$

$$\cos\varphi_{ca} = \frac{P_{ca}}{V_{1N} I_{ca}} = 0.083 \qquad \varphi_{ca} = 1.487$$

$X_M = R_{Fe} \operatorname{tg} \varphi_{ca} = 1.57 \cdot 10^6 \Omega$




$$\tilde{I}_{1L} = \frac{\tilde{V}_{1N}}{a^2 Z_c} = \frac{\tilde{V}_{1N}}{300+200J} = 5.31 - 3.54J = 6.38\, e^{-0.59J}\ A$$

$\varphi_{sfasato} = 0.59$ rad

$P_{out} = V_{1N} \cdot I_{1L} \cos\varphi_{sf} = 12193\ W$

$\tilde{V}_{cc} = \dot{Z}_{cc} \tilde{I}_{1N} = 30.57 + 18.8J\ V$

$$\tilde{V}_1 = \tilde{V}_{cc} + \tilde{V}_{1N} = 2330.57 + 18.8\,\mathrm{J} = 2330.64\, e^{\mathrm{J}(8\cdot10^{-3})}\ \mathrm{V}$$

$$\tilde{I}_{Fe} = \frac{\tilde{V}_1}{R_{Fe}} = 0.018 + 1.4\cdot10^{-4}\,\mathrm{J}$$

$$\tilde{I}_M = \frac{\tilde{V}_1}{\vec{Z}_M} = 1.2\cdot10^{-5} - 1.48\cdot10^{-3}\,\mathrm{J}$$

$$\tilde{I}_1 = \tilde{I}_{Fe} + \tilde{I}_M + \tilde{I}_{1L} = 5.33 - 3.54\,\mathrm{J} = 6.4\, e^{-0.58\,\mathrm{J}}$$

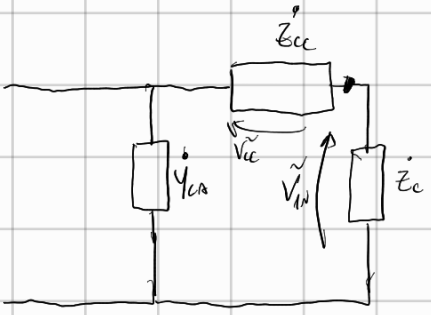
$$P_{IN} = V_1 \cdot I_1 \cos\varphi = 12394.4\ \mathrm{W}$$

$$\eta = \frac{P_{OUT}}{P_{IN}} = 0.98$$

3)

$A_0 = 50\,kVA$ $\quad I_{1N} = 10\,A$

$\frac{V_{1N}}{V_{2N}} = \frac{5000}{250}\,V$




$\dot{Z}_{cc} = 2 + 5j\,\Omega$

$Y_{cA} = 10 - 100j\,\mu S$

$P_{out} = 45\,kW$

$\cos\varphi_{out} = 0.90_{ind}$

$P_{out} = V_{1N} \cdot I_{1L} \cos\varphi_{out} \Rightarrow I_{1L} = \frac{P_{out}}{V_{1N}\cos\varphi_{out}} = 10\,A$

$\varphi_{out} = 0.45$ $\quad \tilde{I}_{1L} = 10\,e^{-0.45j}\,A$

$\tilde{V}_{cc} = \dot{Z}_{cc}\,\tilde{I}_{1L} = 39.76 + 36.32j$

$0.054 - 0.5j$

$\tilde{V}_{1N} = \tilde{V}_{cc} + \tilde{V}_{1N} = 50\,39.76 + 36.32j$

$\tilde{I}_M = \tilde{V}_{1N} \cdot Im(Y_{cA}) = -0.5j + 3.63\cdot10^{-3} = 0.5\,e^{-1.565j}$

$|\tilde{I}_M| = 0.5\,A$

$P_{cc} = I_{1N}^2 R_{cu} = 200\,W$

1)

$P_{NOM} = 15\,KW$

$V_{nom} = 400\,V$

$n_{nom} = 1800\ rpm$

PERDITE:

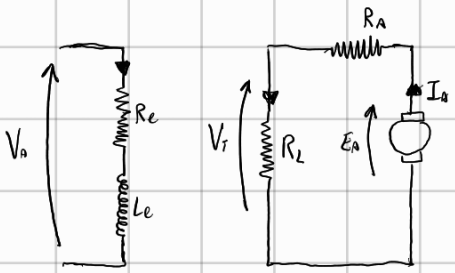
$R_A = 1\,\Omega \quad R_e = 25\,\Omega$

ESERCIZIO:

$R_L = 10\,\Omega$

$n = 1900\ rpm$

$P_c = 9\,KW$




Tensione nominale via sul carico

$P_c = R_L I_A^2 \Rightarrow I_A = 30\,A$

$V_T = 300\,V$

$E_A = R_L I_A + R_A I_A = 330\,V \Rightarrow$

$$\frac{E_A}{E_A^*} = \frac{n}{n^*} \Rightarrow E_A^* = \frac{E_A \cdot n^*}{n} = \frac{330 \cdot 1800}{1900} = 312{,}6\ V$$

$I_E \cong 3{,}3\,V$

$$\eta = \frac{P_c}{E_A I_A} = 0{,}9\,A$$

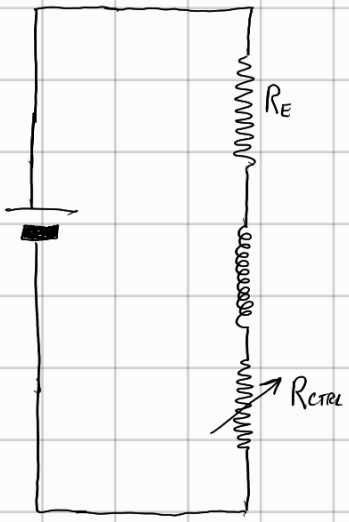
NON USIAMO $V_{nom}$ ???

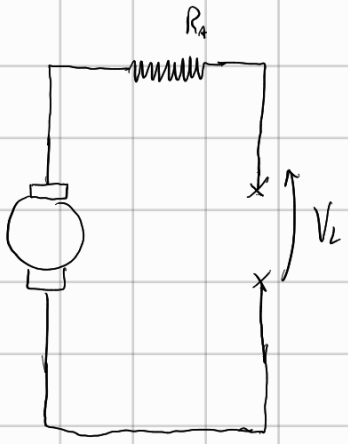
2)

$P_{NOM} = 6KW$

$V_N = 120\,V$

$n = 1800\,rpm$




$R_A = 250\,m\Omega$

$R_E = 10\,\Omega$

VUOTO:

$V_L = 110\,V$

$n_{al} = 1700\,rpm$

CONDIZIONI DI CARICO

$I_A = 40\,A$

$E_{ADES} = V_L$

Se $E_A = 110\,V$ quando ho $1700\,rpm$

Calcolo $E_A$ a $1800\,rpm$

$$\frac{E_{A1700}}{E_{A1800}} = \frac{n_{1700}}{n_{1800}} \Rightarrow E_{A1800} = n_{1800}\frac{E_{A1700}}{n_{1700}} = 116{,}5\,V$$

$I_E = \frac{116.6}{50} = 2.33\,A$

$V_E = R_E I_E = 23.3\,V$

$V_{CTRL} = V_N - V_E = 96.7\,V$ $\qquad$ $R_{CTRL} = 41.5\,\Omega$

Caso con carico:

$V_{CARICO} = 110\,V$ $\quad V_A = R_A I_A = 10\,V$

$E_A = 120\,V$ $\quad I_E$ sempre $2{,}33\,A$

$$\frac{E_{Ax}}{E_{A1800}} = \frac{n_x}{n_{1800}} \Rightarrow \quad n_x = \frac{n_{1800} E_{Ax}}{E_{A1800}} = 1854\ rpm$$

$\Delta n = 154\ rpm$

3)

4)

$P_N = 6\,KW$

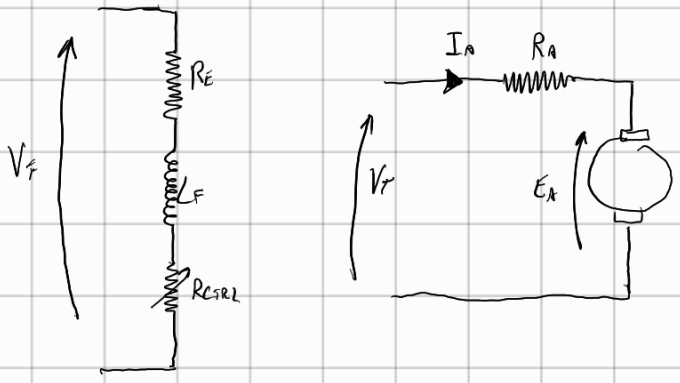
$T_E = 300\,V$

$I_A = 20\,A$ NOMINALE

$V_{NOM} = 1800$ rpm

$I_E = 2.2\,A$

$R_A = 1\,\Omega$




$E_A = 280\,V$ $\quad V_T = E_A + R_A I_A = 300\,V$

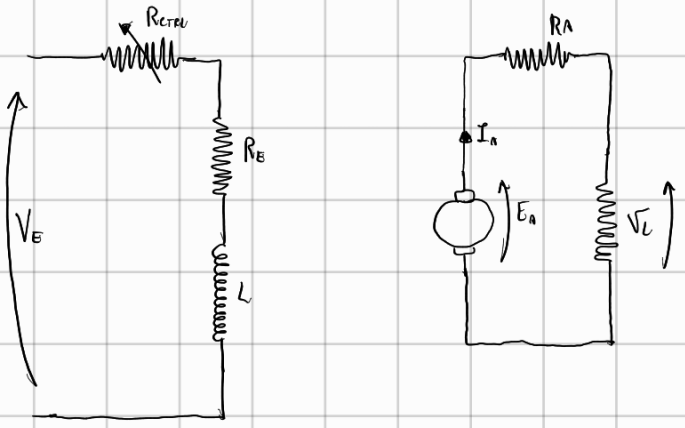
$P_{OUT} = E_A I_A = 5600\,W = T_m \omega_m \Rightarrow T_m = \frac{5600}{\omega_m} = 29\,Nm$

$$\eta = \frac{T_m \omega_m}{T_m \omega_m + R_A I_A^2 + R_E I_E^2} = \frac{5600}{5600 + 1.400 + 300 \cdot 2.2} = 0.84$$

$R_E = \frac{V_E}{I_E} =$

$R_E I_E^2 \uparrow V_E I_E$

4)




$P_N = 8KW$ $n = 1800 rpm$

$V_E = 400V$

$R_A = 20m\Omega$ $R_E = 10m\Omega$

$I_E = 7A$ $E_{A_{des}} = 350V$

$R_L = 20\Omega$

Voglio $E_A = 350V$ con $I_E = 7A$.

A 1800 rpm ho $E_A \simeq 330V$

$$\frac{E_{A1800}}{E_{Ax}} = \frac{n_{1800}}{n_x} \Rightarrow n_x = \frac{n_{1800} E_{Ax}}{E_{A1800}} \simeq 1909 rpm$$

Se sul carico ho $V_L = 350V$

allora ho $I_A = \frac{V_A}{R_L} = 17.5A$

$E_A = V_L + R_A I_A = 350.35V$

Se sono a 1800 rpm ho bisogno di circa $7.8A = I_E$

per avere $E_A$.

$$\Rightarrow V_F = R_E I_E + R_{CTRL} I_E \Rightarrow R_{CTRL} = \frac{V_F - R_E I_E}{I_E} = 51.3\Omega$$

4)

$P_N = 20\,kW$

$V_F = 300\,V$

$n = 1800\,rpm$

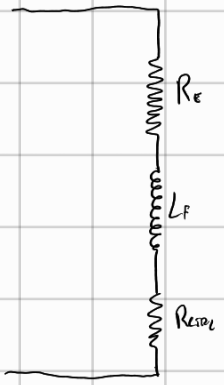
$R_A = 0.2\,\Omega$

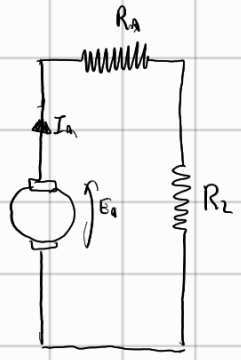
$R_E = 20\,\Omega$

$R_{CTRL} = 40\,\Omega$

$V_T = 320\,V$

$R_L = 20\,\Omega$




Se $E_{DES} = V_T = 320\,V$, calcolo la $I_E = \frac{V_F}{R_E + R_{CTRL}} = 5\,A$

$E_{A1800} \cong 415\,V$

Quindi:

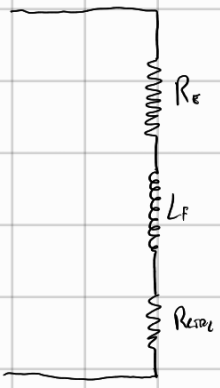
$$\frac{E_{A1800}}{E_{DES}} = \frac{n_{1800}}{n_{DES}} \Rightarrow n_{DES} = \frac{n_{1800} E_{DES}}{E_{A1800}} = 1388\,rpm$$

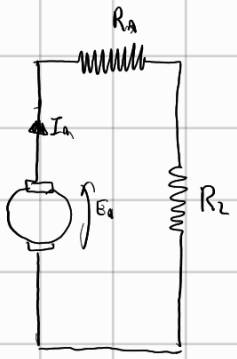
Se ho carico,

$E_{DES} = V_T + R_A \cdot \frac{V_T}{R_L} = 323.2\,V$

$$n_{DES} = \frac{n_{1800} E_{DES}}{E_{A1800}} = 1402\,rpm$$

4)




$P_N = 10kW$

$V_N = 430V$

$n_N = 1800 rpm$

$R_A = 0.2\Omega$

$R_E = 6\Omega$

$R_{CTRL} = 66\Omega$

$R_L = 20\Omega$

$P_{OUT} = 8KW$

$$I_E = \frac{V_N}{R_E + R_{CTRL}} = 5.97A \approx 6A \qquad E_{A_{1800}} = 450V$$

$$I_A^2 = \frac{P_{OUT}}{R_L} \Rightarrow I_A = 20A \qquad E_A = R_A I_A + R_L I_A = 404V$$

Con $I_E = 6A$:

$$\frac{E_{A_{DES}}}{E_{A_{1800}}} = \frac{n_{DES}}{n_{1800}} \Rightarrow n_{DES} = 1616 rpm$$

$$P_{meec} = E_A I_A = 8080W = T_m \omega_m$$

$$T_m = \frac{P_{meec}}{\frac{2\pi}{60} n_{DES}} = 47,75 N \cdot m$$

$$\eta = \frac{P_{OUT}}{E I_A + V_E I_E} = 0,75$$

4)

$P_N = 6KW$

$V_N = 120V$

$n_{max} = 1800$ rpm

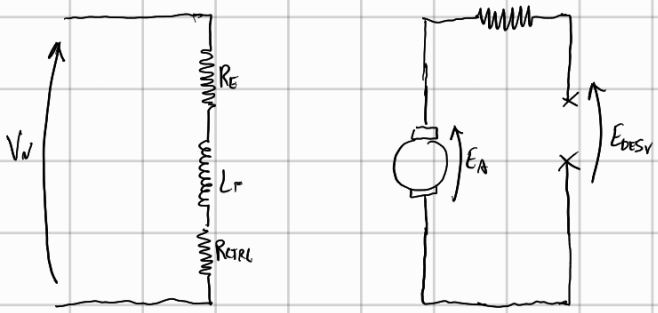
$R_A = 250m\Omega$

$R_E = 10\Omega$

$E_{DESV} = 110V$

$n_{ab} = 1700$ rpm

$I_A = 40A$



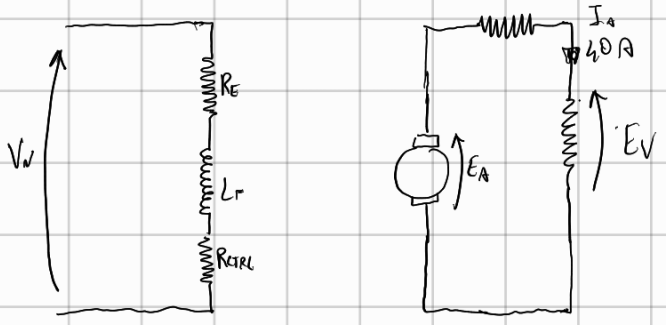

Se sono a vuoto $E_A = 110V$ perché non c'è carico.

$$\frac{E_{A1700}}{E_{A1800}} = \frac{n_{1700}}{n_{1800}} \Rightarrow E_{A1800} = \frac{1800}{1700} E_{A1700} = 116,5V$$

$$I_E = \frac{E_{A1800}}{50} = 2.33A$$

$$I_E = \frac{V_T}{R_E + R_{CTRL}} \Rightarrow R_E + R_{CTRL} = \frac{V_T}{I_E} \Rightarrow R_{CTRL} = 41.5\Omega$$

Ora ho carico:




$$E_A = E_V + R_A I_A = 120\ V$$

$$\frac{E_{Ax}}{E_{A1700}} = \frac{n_x}{n_{1700}} \Rightarrow n_x = 1855\ rpm$$

4)

$P_N = 8000\,W$

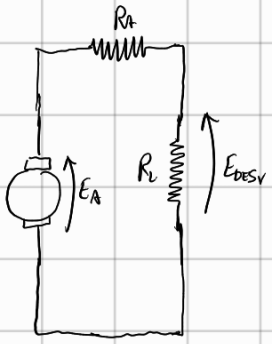
$V_E = 400\,V$

$n = 1800\,rpm$

$I_E = 7\,A$

$E_A = 350\,V$

$R_L = 20\,\Omega$


A 1800 giri con $I_E = 7A$, $E_A = 340\,V$

Devo cambiare velocità:

$$\frac{E_{A,1800}}{E_{AX}} = \frac{n_{1800}}{n_X} \Rightarrow n_X = 1853\,rpm$$

Se ho 350 V su curva, $I_A = \frac{V_L}{R_L} = 17.5\,A$

$E_{A2} = R_A I_A + V_L = 350,35\,V$

Verifico con quale $I_E$ devo lavorare:

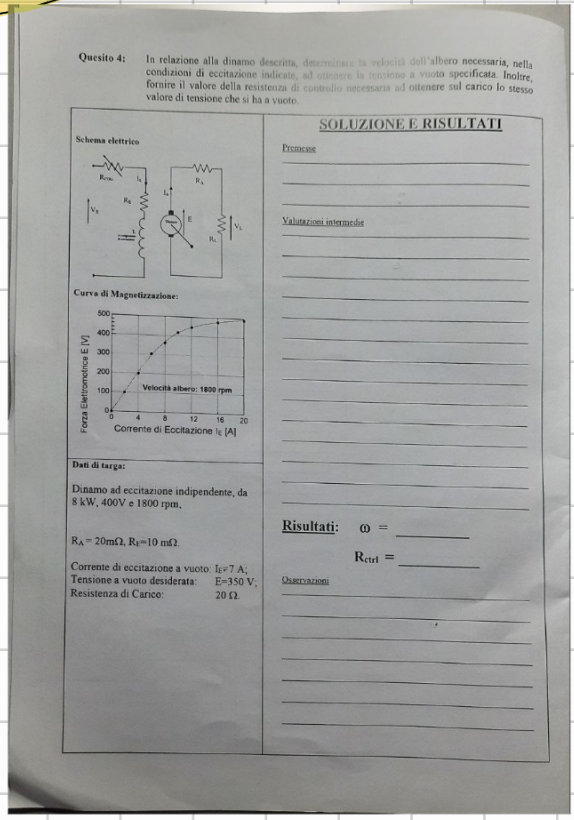
$$\frac{E_{A2}}{E_{A1800}} = \frac{n_X}{n_{1800}} \Rightarrow E_{A1800} = 340,3\,V$$

($n_X \to 1853$)

$I_E \approx 7.1\,A$

$$R_{CTRL} = \frac{V_T}{I_E} - R_E = 57.13\,\Omega$$

ASK



**Quesito 4:** In relazione alla dinamo descritta, determinare la velocità dell'albero necessaria, nella condizioni di eccitazione indicate, ad ottenere la tensione a vuoto specificata. Inoltre, fornire il valore della resistenza di controllo necessaria ad ottenere sul carico lo stesso valore di tensione che si ha a vuoto.

**Schema elettrico**

**Curva di Magnetizzazione:**

Forza Elettromotrice E [V]

Velocità albero: 1800 rpm

Corrente di Eccitazione $I_E$ [A]

**Dati di targa:**

Dinamo ad eccitazione indipendente, da 8 kW, 400V e 1800 rpm.

$R_A = 20m\Omega$, $R_E = 10\,m\Omega$.

Corrente di eccitazione a vuoto: $I_E = 7\,A$;
Tensione a vuoto desiderata: $E = 350\,V$;
Resistenza di Carico: $20\,\Omega$.

**SOLUZIONE E RISULTATI**

Premesse

Valutazioni intermedie

**Risultati:** $\omega =$ _____

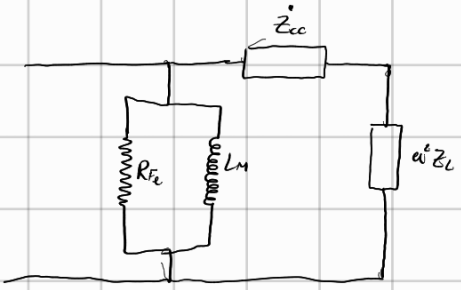
$R_{ctrl} =$ _____

Osservazioni

4)

$P_N = 15000\ VA$

$V_{1N}/V_{2N} = \frac{2300\ V}{230\ V}$




$I_{ca} = 0.22\ A$

$P_{ca} = 35\ W$

$V_{cc} = 40\ V$

$P_{cc} = 90\ W$

$P_N = 11\ kW$

Potenza fattore = 0.8 ritardo

$P_N = V_{1N} I_{1N} = 6.52\ A$

Prova a vuoto:

$R_{Fe} = \frac{V_{1N}^2}{P_{ca}} = 15113\ W = 1.5 \cdot 10^5\ \Omega$

$P_{ca} = V_{1N} I_{1a} \cos\varphi_{ca}$

$\cos\varphi_{ca} = 0.069 \qquad \varphi_{ca} = 1.5\ rad$

$X_M = R_{Fe} \tan\varphi_{ca} \simeq 2.13 \cdot 10^6\ \Omega$

$R_{cu} = \frac{P_{cc}}{I_{1N}^2} = 2.12\ \Omega$

$\cos\varphi_{cc} = \frac{P_{cc}}{V_1 I_{1N}} = 0.345$

$X_L = R_{cu} \tan\varphi_{cc} = 5.77\ \Omega$

Supposo (sul carico) $P_{1m} = V_{1N} I_1 \cos\varphi$

$I_1 = \frac{P_{1m}}{V_{1N} \cos\varphi} = 5.98\ A$

$\tilde{I}_1 = 5.98\, e^{-0.85}$

$\tilde{V}_{cc} = \dot{Z}_{cc} \tilde{I}_1 =$

**QUESITO 4:** Determinare il circuito equivalente a Γ del trasformatore monofase descritto. Inoltre, per il carico indicato, valutare la caduta di tensione sull'impedenza longitudinale $Z_{cc}$.

**Dati Targa:**
Potenza Nominale = 15 kVA;
Tensioni = 2300V/230V;

**Prova a Vuoto:**
$I_{ca}$ = 0.22 A,
$P_{ca}$ = 35 W;

**Prova in CortoCircuito:**
$V_{cc}$ = 40 V,
$P_{cc}$ = 90 W.

**Dati sul Funzionamento Sotto Carico:**
Potenza in ingresso = 11 kW;
Fattore di potenza = 80% (rit.)

**SOLUZIONE E RISULTATI**

Premesse

Calcoli

Che cos'è la potenza in ingresso? È sul carico?

3)

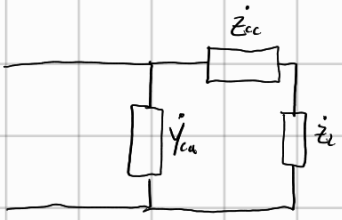
$A_{nom} = 200\,kVA$

$V_{1N}/V_{2N} = 20000/500$

$\dot{Y}_{ca} = 1.5 \cdot 10^{-6} e^{-j\frac{\pi}{2}}\ S$

$\dot{Z}_{cc} = 4\sqrt{2}\, e^{j\frac{\pi}{4}}\ \Omega$

$\dot{Z}_L = 100\, e^{j\frac{\pi}{2}}\ \Omega$



4) $P_{NOM} = 15\,KW$

$V_{nom} = 400\,V$

$n_{nom} = 1800\,rpm$

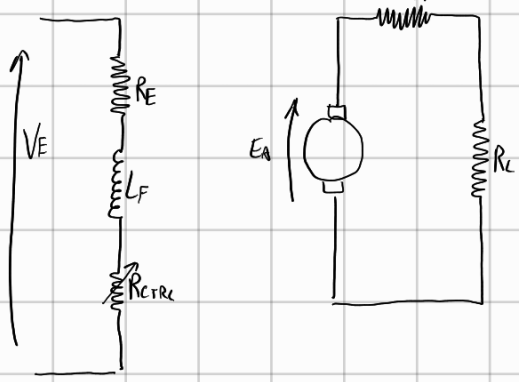
$R_A = 1\,\Omega$

$R_F = 30\,\Omega$

$R_L = 10\,\Omega$

$n_{eff} = 1600\,rpm$

$P_L = 9\,KW$







$P_L = R_L I_A^2 \Rightarrow I_A = \sqrt{\frac{P_L}{R_L}} = 30\,A$

$V_L = 300\,V$

$V_A = I_A \cdot R_A = 30\,V \qquad E_A = 330\,V$

Se lavoro a 330 V a 1600 giri:

$\frac{E_{A1600}}{E_{AX}} = \frac{n_{1600}}{n_{1800}} \Rightarrow E_{AX} = \frac{18}{16} E_{A1600} = 371.25\,V$

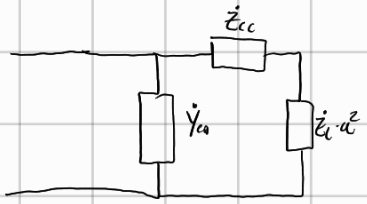
La $I_E \approx 4\,A$

$\eta = \frac{P_L}{E_R I_A + V_E I_E} \cong 0.78$

4)

$P = 15\,kVA$

$\frac{V_{1N}}{V_{2N}} = \frac{2300\,V}{230\,V}$




$I_{ca} = 0.21\,A$

$P_{ca} = 40\,W$

$V_{cc} = 37\,V$

$P_{cc} = 100\,W$

$\dot{Z}_c = (3+2j)\,\Omega$

$P = V_{1N} I_{1N} \Rightarrow I_{1N} = P/V_{1N} = 6.52\,A$

$P_{ca} = I_{ca} V_{1N} \cos\varphi_{ca} = \frac{V_{1N}^2}{R_{FE}}$

$R_{FE} = V_{1N}^2 / P_{ca} = 1.32 \cdot 10^5\,\Omega$

$\cos\varphi_{ca} = 0.08$

$X_M = R_{FE} \tan\varphi_{ca} = 1.64 \cdot 10^6\,\Omega$

$\dot{Y}_{ca} = \frac{1}{R_{FE}} + \frac{1}{jX_M} = (7.58 \cdot 10^{-6} - 6.1 \cdot 10^{-7} j)\,S$

$P_{cc} = V_c I_{1N} \cos\varphi_{cc} = I_{1N}^2 R_{cu}$

$R_{cu} = 2.35\,\Omega$

$\cos\varphi_{cc} = P_{cc}/V_c I_{1N} = 0.414$

$X_{cd} = R_{cu} \tan\varphi_{cc} = 5.16\,\Omega$

$\dot{Z}_{cc} = (2.35 + 5.16j)\,\Omega$

Lavoro con $V_{1N}$ su $\dot{Z}_L$:

$\tilde{I}_L = \frac{\tilde{V}_{1N}}{a^2 \dot{Z}_c} = 5.31 - 3.54j\,A$

$\tilde{V}_{cc} = \tilde{I}_L \cdot \dot{Z}_{cc} = 30.73 + 19j\,V$

$\tilde{V}_{1N} = \tilde{V}_{cc} + \tilde{V}_{1N} = 2330.7 + 19.1j\,V$

$\tilde{I}_0 = \tilde{V}_{1N} \cdot \dot{Y}_{ca} = 0.018 - 1.28 \cdot 10^{-3} j\,A$

$\tilde{I}_{1N} = \tilde{I}_0 + \tilde{I}_L = 5.33 - 3.54j\,A$

$P_{1N} = V_{1N} I_{1N} \cos\varphi = 12485\,W$

$P_{out} = V_{1N} \cdot I_L \cos\varphi = 12213\,W$

$\eta = \frac{P_{out}}{P_{1N}} = 0.98$

4)

$P_N = 8000\,W$

$V_E = 400\,V$

$n_{max} = 1800\,rpm$

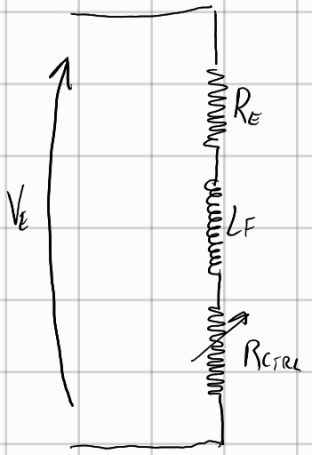
$R_A = 20\,m\Omega$

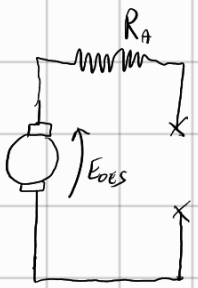
$R_E = 666\,m\Omega$

$R_{CTRL} = 66\,\Omega$

$E_{DES} = 350\,V$

$R_L = 20\,\Omega$




$$I_E = \frac{V_E}{R_E + R_{CTRL}} = 6\,A \Rightarrow E_{A1800} = 6 \cdot 50 = 300\,V$$

$$\frac{E_{1800}}{E_x} = \frac{n_{1800}}{n_x} \Rightarrow n_x = \frac{E_x \cdot 1800}{300} = 2100$$

Se sul carico voglio 350V,

$I_A = V_A \cdot \frac{1}{R_L} = 17.5\,A$

$E_{DES} = V_L + I_A R_A = 350.35\,V$

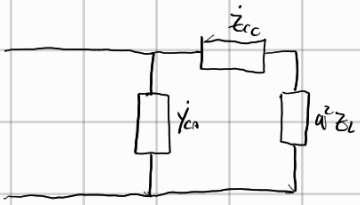
$$\frac{E_{DES}}{E_{2100}} = \frac{n_x}{n_{2100}} \Rightarrow n_x = 2102.1$$

$\Delta n = 2.1\,rpm = 0.22\,rad/s$

4)

$P_N = 20000$ VA

$V_{1N}/V_{2N} = 2000/500$




$\dot{Y}_{ca} = 1.2 \cdot 10^{-6} e^{-j\frac{\pi}{2}}$ S

$\dot{Z}_{cc} = e^{j\frac{\pi}{6}}$ Ω

$\dot{Z}_L = 10$ Ω

$\eta_{eff} = ?$ $\eta_{conv} = ?$

NON DOVREBBE USCIRE $P_{Fe}$! Come funziona?

$V_{1N}$ su $\dot{Z}_L \Rightarrow \tilde{I}_L = 12.5$ A

$\tilde{V}_{Zc} = \dot{Z}_{cc}\tilde{I}_L = 10.8 + 6.25j$ V

$\tilde{V}_{IN} = \tilde{V}_{Zc} + \tilde{V}_{1N} = 2010.83 + 6.25j$ V

$\tilde{I}_Y = \tilde{V}_{IN} \cdot \dot{Y}_{ca} = 7.5 \cdot 10^{-6} - 2.41 \cdot 10^{-3} j$ A

$\tilde{I}_{IN} = \tilde{I}_L + \tilde{I}_Y = 12.5 - 2.41 \cdot 10^{-3} j$ A

$P_{IN} = V_{IN} I_{IN} \cos\varphi = 25135$ W

$P_{OUT} = V_{1N} \cdot I_L \cos\varphi = 25000$ W

$P_{Fe} = V_{IN} \cdot I_Y \cos\varphi = 0$

$P_{Cu} = V_{Zc} \cdot I_L \cos\varphi = 135$ W

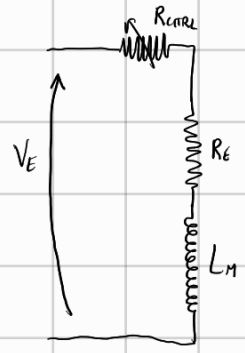
$\eta_{eff} = 99\%$

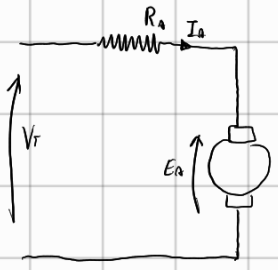
$$\eta_{conv} = \frac{P_{OUT}}{P_{OUT} + P_{Fe} + P_{Cu}} \simeq 99\%$$

$P_N = 40 kW$

$V_E = 300 V$

$n_n = 1800 rpm$




$R_A = 2 \Omega$

$R_E = 25 \Omega$

$n_{al} = 1750 rpm$

$C_c = 210 N \cdot m$

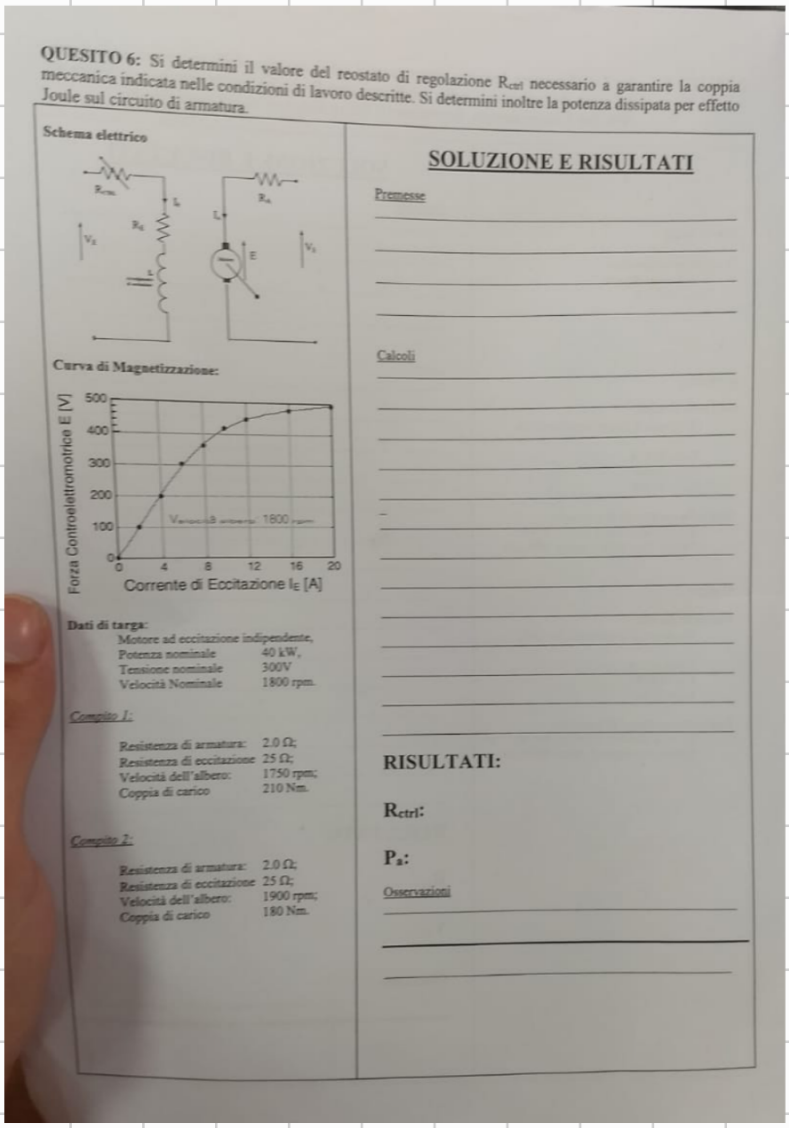
COME SI PROCEDE?

$$E_A I_A = P_{mecc} = C_c \cdot n_{al} \cdot \frac{2\pi}{60} = 38484.5 W = P$$

$$\begin{cases} V_E = E_A + R_A I_A \\ E_A I_A = P \end{cases}$$

$$V_E = E_A + \frac{R_A P}{E_A}$$

$$E_A^2 - V_E E_A + R_A P = 0$$



**QUESITO 6:** Si determini il valore del reostato di regolazione $R_{ctrl}$ necessario a garantire la coppia meccanica indicata nelle condizioni di lavoro descritte. Si determini inoltre la potenza dissipata per effetto Joule sul circuito di armatura.

**Schema elettrico**

**Curva di Magnetizzazione:**

Forza Controelettromotrice E [V]

Corrente di Eccitazione $I_E$ [A]

**Dati di targa:**

Motore ad eccitazione indipendente,
Potenza nominale 40 kW,
Tensione nominale 300V
Velocità Nominale 1800 rpm.

*Compito 1:*

Resistenza di armatura: 2.0 Ω;
Resistenza di eccitazione 25 Ω;
Velocità dell'albero: 1750 rpm;
Coppia di carico 210 Nm.

*Compito 2:*

Resistenza di armatura: 2.0 Ω;
Resistenza di eccitazione 25 Ω;
Velocità dell'albero: 1900 rpm;
Coppia di carico 180 Nm.

**SOLUZIONE E RISULTATI**

Premesse

Calcoli

**RISULTATI:**

**$R_{ctrl}$:**

**$P_a$:**

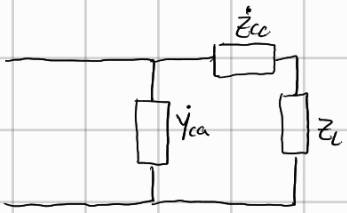
Osservazioni

4)

$V_{1N}/V_{2N} = \frac{16000}{400}$

$A_m = 40\,kVA$

$X_d = 50\,\Omega$




$P_{cc} = V_{cc} I_{1N} \cos\varphi_{cc}$

$X_d = R_{cu} \tan\varphi$

C.A.:

$P_{CA} = 200\,W$

$I_{CA} = 30\,mA$

$P_{ass\,carico} = 20\,kW$

Fattore di potenza: 60% ritardo

Se lavoro a $V_{1N}$,

$P_{OUT} = V_{1N} I_1 \cos\varphi_L$

$I_1 = 1.51\,A$

$\tilde{I}_1 = 1.51\, e^{-0.93j}\,A$

Dalla prova in C.A.:

$P_{CA} = V_{1N} I_{ca} \cos\varphi_{CA}$

$P_{CA} = \frac{V_{1N}^2}{R_{Fe}} \Rightarrow R_{Fe} = 1.28\,M\Omega$

$\cos\varphi_{CA} = \frac{5}{12}$ $\qquad \varphi_{CA} = 1.14\,rad$

$X_M = R_{Fe} \tan\varphi = 2.79\,M\Omega$

$P_{cu} = Re\left[ \left( R_{cu} \tilde{I}_1 \right) \tilde{\tilde{I}}_1 \right] =$

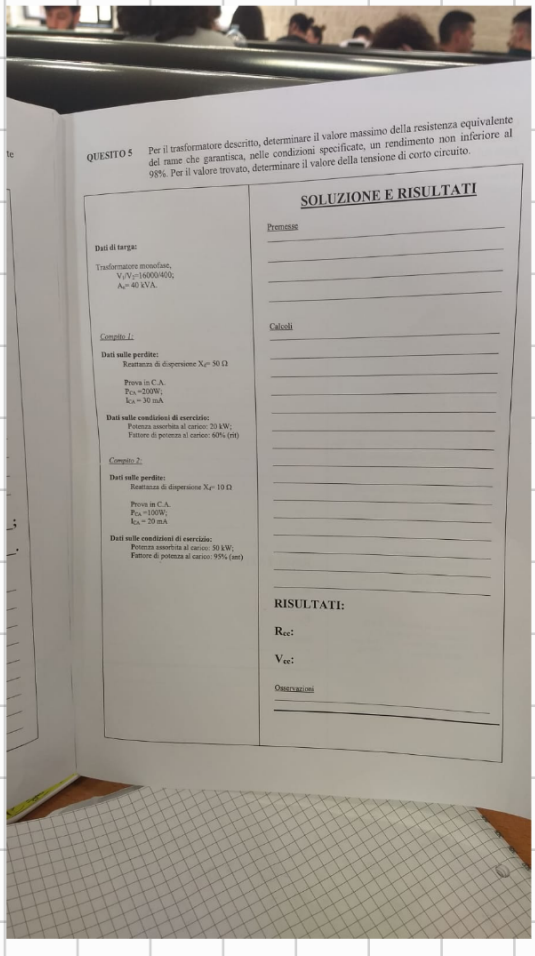
$= 2.28\, R_{cu}$

$\eta_{conv} = \frac{P_{OUT}}{P_{OUT} + P_{cu} + P_{ca}} > 0.98$

$0.98\left(20000 + 2.28 R_{cu} + 200\right) < 20000$

$19796 + 2.23 R < 20000$

$R < 91.48$



QUESITO 5 Per il trasformatore descritto, determinare il valore massimo della resistenza equivalente del rame che garantisca, nelle condizioni specificate, un rendimento non inferiore al 98%. Per il valore trovato, determinare il valore della tensione di corto circuito.

SOLUZIONE E RISULTATI

Dati di targa:

Trasformatore monofase,
$V_1/V_2$=16000/400;
$A_n$= 40 kVA.

Compito 1:

Dati sulle perdite:
Reattanza di dispersione $X_d$= 50 Ω

Prova in C.A.
$P_{CA}$=200W;
$I_{CA}$ = 30 mA

Dati sulle condizioni di esercizio:
Potenza assorbita al carico: 20 kW;
Fattore di potenza al carico: 60% (rit)

Compito 2:

Dati sulle perdite:
Reattanza di dispersione $X_d$= 10 Ω

Prova in C.A.
$P_{CA}$ =100W;
$I_{CA}$ = 20 mA

Dati sulle condizioni di esercizio:
Potenza assorbita al carico: 50 kW;
Fattore di potenza al carico: 95% (ant)

Premesse

Calcoli

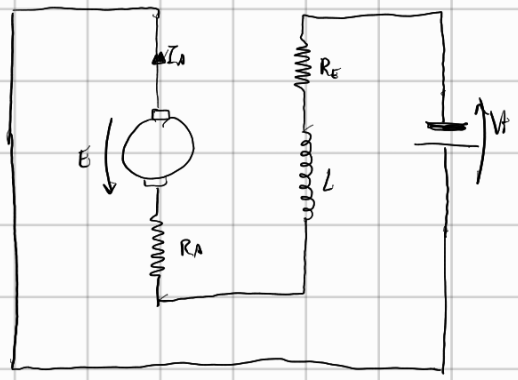
RISULTATI:

$R_{cc}$:

$V_{cc}$:

Osservazioni

4)




$V_t = 400V$

$R_A = 5\Omega$

$R_E = 15\Omega$

$C_s = 200 N\cdot m$

$P_{ass} = 4KW$

$$C_s = \frac{K K_\phi V_t^2}{(R_A + R_E)^2} \Rightarrow K K_\phi = 0.5$$

$$P_{ass} = V_t I_A \Rightarrow I_A = 10\ A$$

$$V_t = R_E I_A + R_A I_A + E$$

$$E = 200\ V$$

$$\omega_m = \frac{E_A}{K K_\phi I_A} = 40\ rad/s$$

$$T_m = K K_\phi I_A^2 = 50\ N\cdot m$$

$$\eta = \frac{T_m \omega_m}{T_m \omega_m + R_A I_A^2 + R_E I_A^2} = 50\%$$

$P_N = 40 kW$

$V_E = 300 V$

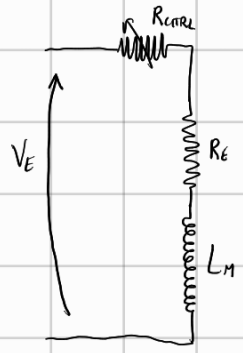
$n_M = 1800 rpm$

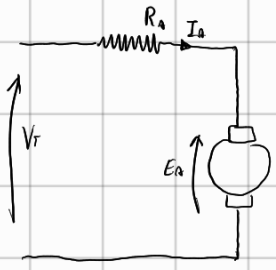
$R_A = 2 \Omega$

$R_E = 25 \Omega$

$n_{al} = 1750 rpm$

$C_c = 210 N \cdot m$




$\omega_M = 183.26 rad/s$

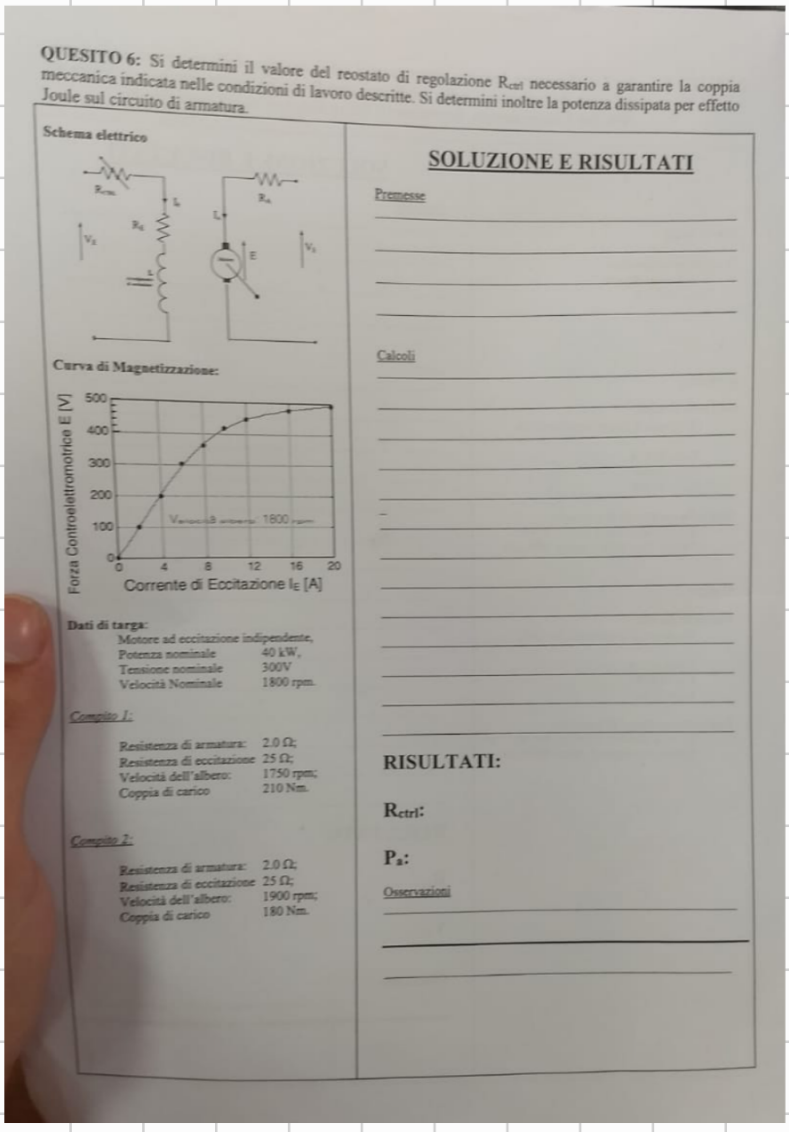
COME SI PROCEDE?

$$E_A I_A = P_{mecc} = C_c \cdot n_{al} \cdot \frac{2\pi}{60} = 38484.5 W = P$$

$$V_T = \frac{R_A T_m}{K\Phi} + K\Phi \omega_M$$

$$R_A T_m = \alpha V_T - \alpha^2 \omega_M$$

$$\alpha^2 \omega_M - \alpha V_T + R_A T_m = 0$$



**QUESITO 6:** Si determini il valore del reostato di regolazione $R_{ctrl}$ necessario a garantire la coppia meccanica indicata nelle condizioni di lavoro descritte. Si determini inoltre la potenza dissipata per effetto Joule sul circuito di armatura.

**Schema elettrico**

**Curva di Magnetizzazione:**

Forza Controelettromotrice E [V]

Corrente di Eccitazione $I_E$ [A]

**Dati di targa:**

Motore ad eccitazione indipendente,
Potenza nominale 40 kW,
Tensione nominale 300V
Velocità Nominale 1800 rpm.

*Compito 1:*

Resistenza di armatura: 2.0 Ω;
Resistenza di eccitazione 25 Ω;
Velocità dell'albero: 1750 rpm;
Coppia di carico 210 Nm.

*Compito 2:*

Resistenza di armatura: 2.0 Ω;
Resistenza di eccitazione 25 Ω;
Velocità dell'albero: 1900 rpm;
Coppia di carico 180 Nm.

**SOLUZIONE E RISULTATI**

Premesse

Calcoli

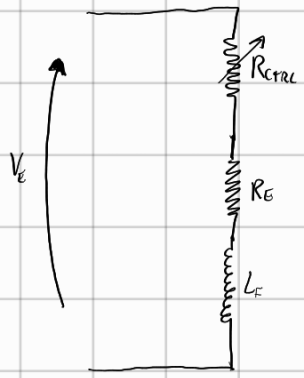
**RISULTATI:**

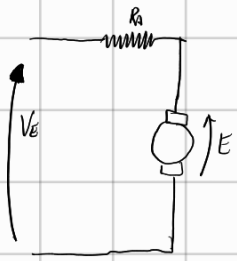
**$R_{ctrl}$:**

**$P_a$:**

Osservazioni

4)




$V_T = E_A + R_A I_A$

$P_N = 40KW$

$V_E = 300V$

$n_{max} = 1800 rpm$

$R_A = 2\Omega$

$R_E = 85\Omega$

$n = 1750 rpm$

$T_m = 210 N \cdot m$

$\omega = n \cdot \frac{\pi}{30} = 183.25 rad/s$

$P_{MECC} = E_A I_A = T_m \omega_m = 38482.5 W$

$E_A = K\Phi\omega$

$T_m = K\Phi I_A$

4)

$P_N = 10\,KW$

$V_N = 430\,V$

$\omega_m = 1800\ rpm$

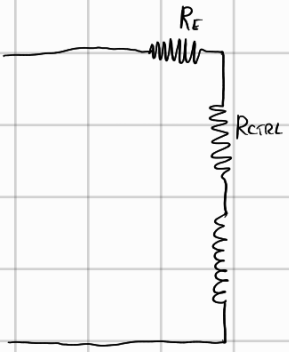
$R_A = 0.2\,\Omega$

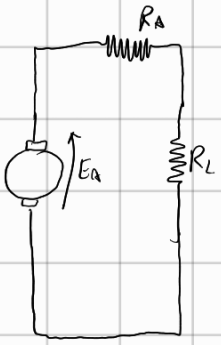
$R_E = 6\,\Omega$

$R_{CTRL} = 66\,\Omega$

$R_{LOAD} = 20\,\Omega$

$P_{OUT} = 8\,KW$




$P_{OUT} = R_L I_A^2 \Rightarrow I_A = 20\,A$

$V_L = 400\,V$

$E_A = V_L + R_A I_A = 400 + 0.2 \cdot 20 = 404\,V$

$P_{mecc} = E_A I_A = 8080\,W$

$I_E \cong 6\,A \quad E_A \approx 450\,V$

$\frac{n_{1800}}{n_x} = \frac{E_{1800}}{E_x} \Rightarrow nx = \frac{1800 \cdot 404}{450} = 1616\ rpm$

$C_m = P_{mecc} / n_x \frac{\pi}{30} = 47.7\,N \cdot m$

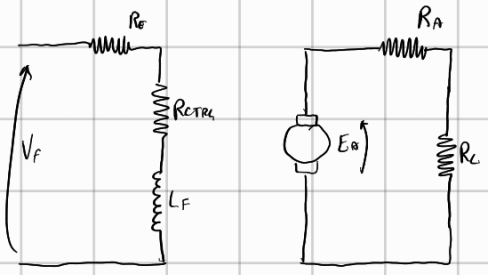
$\eta = \frac{V_L I_A}{E_A I_A + V_f I_f} = 75\,\%$

4)

$P_N = 6KW$

$V_N = 300V$

$n_m = 1800$ rpm




$R_A = 100m\Omega$

$R_E = 10\Omega$

$R_{CTRL} = 140\Omega$

$P_{OUT} = 65KW$

$R_L = 15\Omega$

$P_{OUT} = R_L I_A^2 \Rightarrow I_A = 20,8\,A$

$V_L = R_L I_A = 312\,V$

$E_A = V_L + R_A I_A = 314.8\,V$ $\quad I_E = \frac{V_N}{R_E + R_{CTRL}} = 2\,A$ $\quad E_A = 285\,V$

$\frac{E_{Ax}}{E_{A1800}} = \frac{n_x}{n_{1800}} \Rightarrow n_x = 1988$ rpm

Se $R_L = 16.5\Omega$ $I_A = 19.8\,A$

$V_L = R_L I_A = 326.7\,V$

$E_A = 328.7\,V$

$n_x = \frac{n_{1800} \cdot E_{Ax}}{E_{A1800}} = 2076$ rpm

4)

$P_{NOM} = 15kW$

$V_{NOM} = 400V$

$n_{nom} = 1800\ rpm$

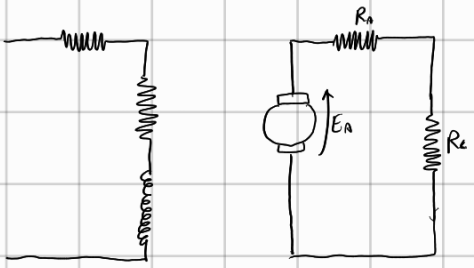
$R_A = 1\Omega$

$R_E = 25\Omega$

$R_L = 10\Omega$

$n_A = 1900\ rpm$

$P = 9KW$






$I_E = ?$

$\eta = ?$

$$P_{out} = R_A I_A^2 \Rightarrow I_A = \sqrt{\frac{P_{out}}{R_A}} = 30A$$

$$E_A = R_A I_A + V_L = 330V$$

$$\frac{E_{A,1900}}{E_{A,1800}} = \frac{1900}{1800} \Rightarrow E_{A,1800} = \frac{18}{19} 330 \simeq 312.6\ V$$

$$I_E = \frac{312,6}{100} = 3,1A$$

$$\eta = \frac{P_{OUT}}{E_A I_A + V_{NOM} I_E} = 81\%$$

4)

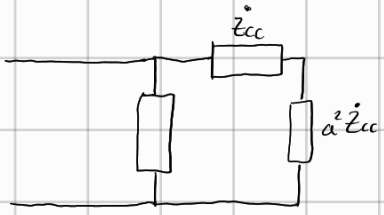
$P_N = 20\,kVA$ $\quad I_{1N} = 10\,A$

$V_{1N}/V_{2N} = 2000/500$

$\dot{Y}_{ca} = 1.2 \cdot 10^{-6} e^{-j\frac{\pi}{4}}\,S = \left(8.49 \cdot 10^{-7} - 8.49 \cdot 10^{-7} j\right) S$

$\dot{Z}_{cc} = e^{j\frac{\pi}{6}}\,\Omega = \frac{\sqrt{3}}{2} + \frac{1}{2} j$

$\dot{Z}_{carico} = 10\,\Omega$




$I_1 = \frac{V_{1N}}{Z_c} = 12.5\,A \qquad \bar{I}_1 = 12.5\,A$

$\tilde{V}_{cc} = \dot{Z}_{cc} I_1 = 10.83 + 6.25 j$

$\tilde{V}_1 = 2010.83 + 6.25 j$

$\tilde{I}_M = Im(\dot{Y}_{ca}) \tilde{V}_1 = 5.31 \cdot 10^{-6} - 1.71 \cdot 10^{-3} j$

$P_{ca} = \frac{V_{1N}^2}{R_{Fe}} = V_{1N}^2 \, Re(\dot{Y}_{ca}) = 3.4\,W$

$P_{cc} = I_{1N}^2 \, Re(\dot{Z}_{cc}) = 86.6\,W$

$P_{OUT} = I_1 V_{1N} \cos\varphi = 25000\,W$

$\eta = \frac{P_{OUT}}{P_{OUT} + P_{cc} + P_{ca}} = 99.6\,\%$

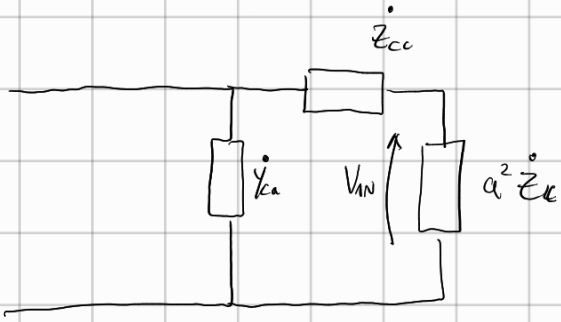
4)

$P_N = 50\,kVA$

$V_{1N}/V_{2N} = 5000\,V/250\,V$

$\dot{Z}_{cc} = 2 + 5j\,\Omega$

$Y_{ca} = 10 - j100\mu\,S$




$P_{ass_L} = 45\,kW$

$\cos\varphi = 0.9$ ind

$$I_1 = \frac{P_{ASS}}{V_{1N}\cos\varphi} = 10\ A$$

$$\tilde{I}_1 = 10\,e^{-0.45j}\ A$$

$$\tilde{V}_{TOT} = \tilde{V}_{1N} + \tilde{I}_1\dot{Z}_{cc} = 5040 + 36.3j\ V$$

$Y_M = -100\cdot10^{-6}j$

↑ ammettenza di mag.

$$\tilde{I}_M = \tilde{V}_{TOT}\,\dot{Y}_M = 3.63\cdot10^{-3} - 0.5j = 0.5\,e^{-1.56j}$$

$P_{cc} = R_{cu}\,I_{1N}^2 = 200\,W$

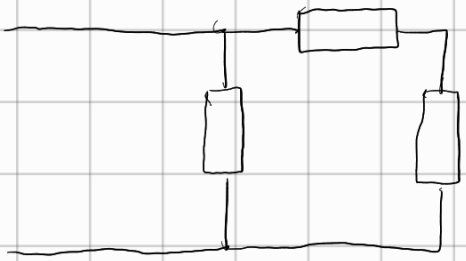
40)

$P_N = 150\,KVA$ $\quad I_{1N} = 30A$

$V_{1N}/V_{2N} = 5000/250\,V$

$I_{ca} = 1\,A$

$P_{ca} = 300\,W$



$V_{cc} = 150\,V$

$P_{cc} = 480\,W$

$P_{out} = 110\,KW$

$\cos\phi = 0.9$ ind

$P_{cc} = V_{cc} I_{1N} \cos\varphi_{cc}$ $\quad \cos\varphi_{cc} = \frac{P_{cc}}{V_{cc} I_{1N}}$

$P_{cc} = R_{eq} I_{1N}^2 \Rightarrow R_{eq} = 0.53\,\Omega$

$\varphi_{cc} = 1.46$

$X_d = R_{eq} \tan\varphi_{cc} = 4.76\,\Omega$

$P_{ca} = V_{1N} I_{ca} \cos\varphi_{ca}$ $\quad \varphi_{CA} = \cos^{-1}\left(\frac{P_{ca}}{V_{1N} I_{ca}}\right) = 1.51$

$P_{ca} = \frac{V_{1N}^2}{R_{Fe}} \Rightarrow R_{Fe} = 8{,}3 \cdot 10^4\,\Omega$

$X_M = \frac{R_{Fe}}{\tan\varphi_{ca}} = 5052\,\Omega$

$\dot{Y}_{ca} = 1.2 \cdot 10^{-5} - 1.98 \cdot 10^{-4} j\ S$

$I_1 = \frac{P_{OUT}}{V_{1N} \cos\phi} = 24.4\,A$ $\quad \tilde{I}_1 = 24.4\, e^{-0.45 j}\,A$

$\tilde{V}_{neg} = \tilde{I}_1 \cdot \dot{Z}_{cc} = 117\, e^{j}\,A$

$$\tilde{I}_M = \left(\tilde{V}_{neg} + \tilde{V}_{MN}\right)\left(-1.98 \cdot 10^{-4}\,5\right) = e^{-1.555}\ A$$

$$I_{Fe} = \frac{V_{Fe}}{R_{Fe}} \qquad \eta = 99{,}4\ \%$$

$$P_{Fe} = \frac{V_{Fe}^2}{R_{Fe}} = 309\,W$$

$$P_{Cu} = I_L^2 R_{Cu} = 315.5\,W$$

4)

$P_N = 172\,kW$

$V_N = 420\,V$

$n_N = 1800\,rpm$

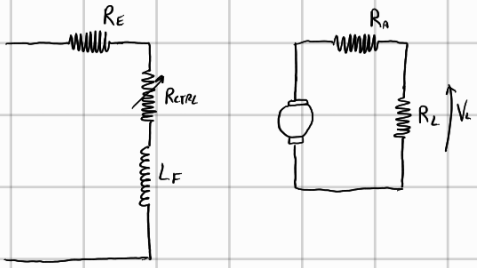
$R_{CTRL} = 60\,\Omega$

$R_A = 1\,\Omega$

$R_E = 24\,\Omega$

$V_T = 350\,V$

$P_{OUT} = 84\,kW$




$$R_L = \frac{V_T^2}{P_{OUT}} = 1.46\,\Omega$$

$$I_A = 240\,A \qquad E_A = V_T + R_A I_A = 590\,V$$

$$I_E = V_N / (R_E + R_{CTRL}) = 5\,A$$

$$E_{A1800} = 410\,V$$

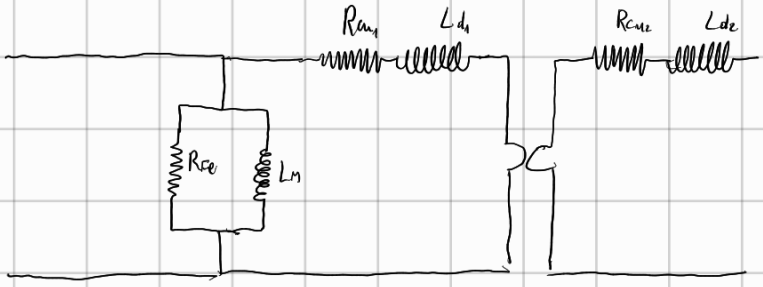
$$\frac{E_{A1800}}{E_{Ax}} = \frac{n_{1800}}{n_x} \Rightarrow n_x = \frac{1800 \cdot 590}{410} = 2590\,rpm$$

$$\eta = \frac{P_{OUT}}{P_{OUT} + R_A I_A^2 + V_E I_E} = 58.5\%$$

4)

$A_N = 150\ KVA$

$V_{1N}/V_{2N} = \frac{5000\ V}{250\ V}$




Perdite primario rame a $I_{1N} = 1800\ W$

Perdite rame al secondario $I_{2N} = 1600\ W$

Flusso disperso al primario a $I_{1N} = 400\ mWb$

Flusso disperso al secondario a $I_{2N} = 15\ mWb$

Perdite nel ferro a vuoto a $V_{1N} = 1900\ W$

Fattore di potenza a vuoto $= 0.21$ rit

$P_{pass} = 110\ KW$

Fattore di pot $= 0.90$ rit

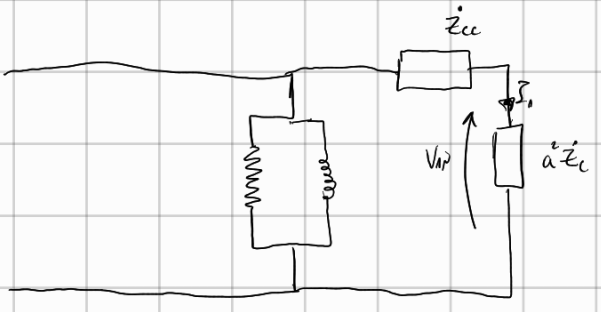
$P_{TOT\ rame} = 3400\ W = R_{cu} I_{1N}^2 \Rightarrow R_{cu} = 3.78\ \Omega$

$P_{cu} = \frac{V_{1N}^2}{R_{Fe}} \Rightarrow R_{Fe} = 13158\ \Omega$ $\qquad X_M = \frac{R_{Fe}}{\tan(\cos^{-1}(0.21))} = 2826\ \Omega$

$\varphi_{1d} = L_{1d} I_{1N} \Rightarrow L_{1d} = 0.013\ H$ $\quad X_{1d} = 0.013\ W = 100\pi \cdot 0.013 = 4.2\ \Omega$

$\varphi_{2d} = L_{2d} I_{2N} \Rightarrow L_{2d} = 2.5 \cdot 10^{-5}\ H$ $\quad X_{2d} = 7.85 \cdot 10^{-3}\ \Omega$

$X_d = X_{1d} + a^2 X_{2d} = 7.34\ \Omega$




$I_1 = \frac{P_{ass}}{V_{1N}\cos(0.9)} = 24.4\ A$ $\qquad \tilde{I}_1 = 24.4\, e^{-0.455}\ A$

$$\tilde{V}_{TOT} = \left(\tilde{V}_{1N} + \tilde{I}_1 \dot{z}_{cc}\right) = 5162.4\, e^{0.023}\ V$$

$$\tilde{I}_M = \frac{\tilde{V}_{TOT}}{jX_M} = 1.83\, e^{-1.545}\ A$$

$$P_{cu} = I_1^2 R_{cu} = 2250\ W$$

4)

$P_N = 15\,KW$

$V_N = 400\,V$

$n_{nom} = 1800\ rpm$

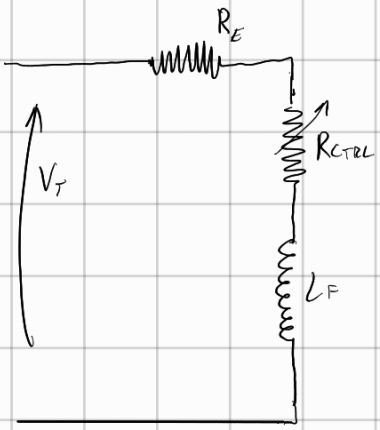
$R_A = 1\,\Omega$

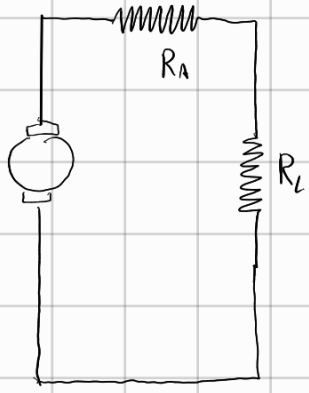
$R_E = 30\,\Omega$

$R_L = 10\,\Omega$

$n = 1600\ rpm$

$P_L = 9\,KW$




$$V_L = \sqrt{P_L R_L} = 300\,V$$

$$I_A = 30\,A$$

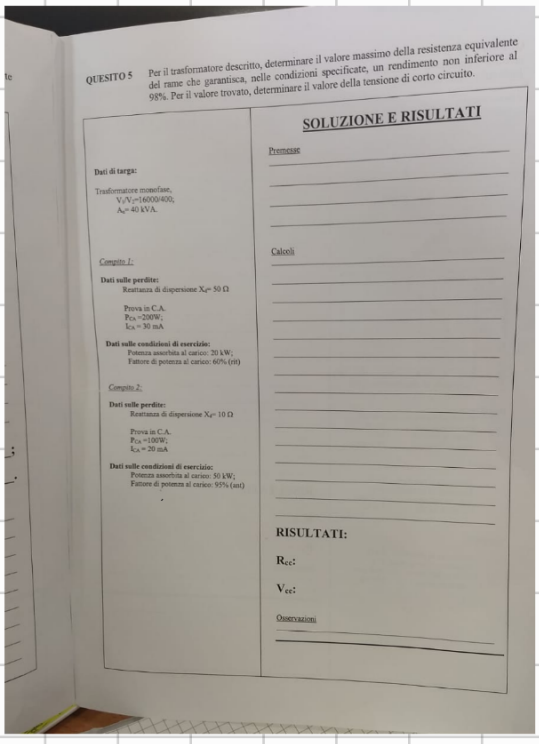
$$E_A = V_L + R_A I_A = 330\,V$$

$$\frac{E_{Ax}}{E_{A1800}} = \frac{n_x}{n_{1800}} \Rightarrow E_{A1800} = \frac{1800}{1600} \cdot 330 = 371.25\,V$$

$I_E = 4{,}2A$ con buona approssimazione

$$\eta = \frac{P_{OUT}}{P_{OUT} + R_A I_A^2 + V_E I_E} = 77.7\,\%$$

4)



QUESITO 5 Per il trasformatore descritto, determinare il valore massimo della resistenza equivalente del rame che garantisca, nelle condizioni specificate, un rendimento non inferiore al 98%. Per il valore trovato, determinare il valore della tensione di corto circuito.

**Dati di targa:**

Trasformatore monofase,
$V_1/V_2$=16000/400;
$A_n$= 40 kVA.

*Compito 1:*

**Dati sulle perdite:**
Reattanza di dispersione $X_d$= 50 Ω

Prova in C.A.
$P_{CA}$ =200W;
$I_{CA}$ = 30 mA

**Dati sulle condizioni di esercizio:**
Potenza assorbita al carico: 20 kW;
Fattore di potenza al carico: 60% (rit)

*Compito 2:*

**Dati sulle perdite:**
Reattanza di dispersione $X_d$= 10 Ω

Prova in C.A.
$P_{CA}$ =100W;
$I_{CA}$ = 20 mA

**Dati sulle condizioni di esercizio:**
Potenza assorbita al carico: 50 kW;
Fattore di potenza al carico: 95% (ant)

**SOLUZIONE E RISULTATI**

Premesse

Calcoli

**RISULTATI:**

$R_{cc}$:

$V_{cc}$:

Osservazioni

$P_N = 40\,KVA$

$\frac{V_{1N}}{V_{2N}} = \frac{16000}{400}$

$X_d = 50\,\Omega$

$P_{CA} = 200\,W$

$I_{ca} = 30\,mA$

$P_{ass_L} = 20\,KW$

$\cos\phi = 0.6$ ind

$P_{ca} = \frac{V_{1N}^2}{R_{Fe}} \Rightarrow R_{Fe} = 1{,}28\,M\Omega$ $\qquad \varphi_{ca} = \cos^{-1}\left(\frac{P_{ca}}{V_{1N} I_{CA}}\right) = 1.14$

$X_M = \frac{R_{Fe}}{\tan\varphi_{ca}} = 0{,}59\,M\Omega$

$I_1 = \frac{P_{ass}}{V_{1N} \cdot \cos\phi} = 2.1\,A$

$\eta = \frac{P_{OUT}}{P_{OUT} + P_{ca} + P_{cu}}$

↑ approssimato per calcolo.

$P_{OUT} = 0.98\,P_{OUT} + 0{,}98\,P_a + 0.98\,P_{cu}$

$\frac{P_{OUT}}{0.98} - P_{OUT} - P_a = P_{cu}$

$P_{cu} = 208.2\,W$

Ma $P_{cu} = I_1^2 R_{cu}$ $\qquad R_{cu} = \frac{P_{cu}}{I_1^2} = 47.2\,\Omega$

$\frac{R_{cu}}{X_d} = \tan\varphi \Rightarrow \varphi = 0.76$ $\qquad \cos\varphi = 0.72$

$P_{cc} = I_{1N}^2 R_{cu} = 208.2\,W$ $\qquad V_{cc} = \frac{P_{cc}}{I_{1N}\cos\varphi} = 116\,V$

4)

$A = 15\,kVA$

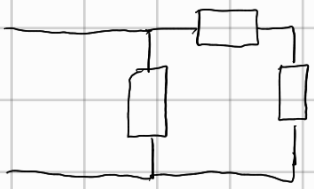
$V_{1N}/V_{2N} = \frac{2300\,V}{230\,V}$ $\quad I_{1N} = 6.52\,A$

$I_{ca} = 0.21\,A$

$P_{ca} = 40\,W$

$V_{cc} = 37\,V$

$P_{cc} = 100\,W$



$P_{ca} = \frac{V_{1N}^2}{R_{Fe}} \Rightarrow R_{Fe} = \frac{V_{1N}^2}{P_{ca}} = 132250\,\Omega$ $\quad \cos\varphi = \frac{P_{ca}}{V_{1N} I_1}$

$X_M = \frac{R_{Fe}}{\tan\varphi} = 10709\,\Omega$ $\quad \varphi = 1.49$

$P_{cc} = I_{1N}^2 R_{cu} \Rightarrow R_{cu} = 2.35\,\Omega$ $\quad \varphi = \cos^{-1}\left(\frac{P_{cc}}{V_{1N} I_{1N}}\right) = 1.14$

$X_d = R_{cu} \tan\varphi = 5.11\,\Omega$

Misurato $V_{1N}$ sul carico,

$A = V_{1N} I_1 \Rightarrow I_1 = I_{1N}$ in modulo.

$P_{cu} = P_{cc}$. Tensione sul parallelo appross. a quella nominale.

$P_{Fe} = P_{ca}$.

$$\eta = \frac{P_{OUT}}{P_{OUT} + P_{cu} + P_{Fe}} = \frac{\overbrace{A\cos\phi}^{P_{OUT}}}{A\cos\phi + P_{cu} + P_{Fe}} \Rightarrow$$

$0.9(A\cos\phi + P_{cc} + P_{ca}) = A\cos\phi$

$A\cos\phi + P_{cc} + P_{ca} = \frac{A\cos\phi}{0.9}$

$\cos\phi\left(\frac{A}{0.9} - A\right) = P_{cc} + P_{ca} \Rightarrow \frac{P_{cc} + P_{cu}}{\frac{A}{0.9} - A}$ $\quad \cos\phi = 0.084$

$I_{1N}$

4)

$P_N = 40KW$

$V_E = 300V$

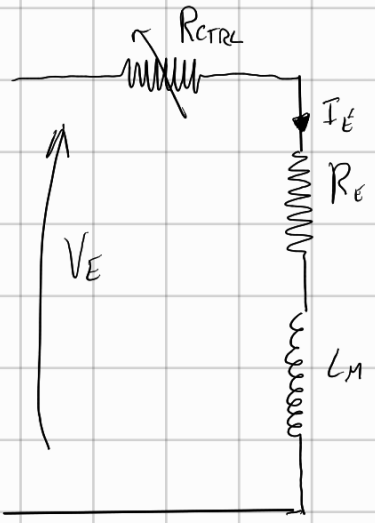
$n = 1800 rpm$

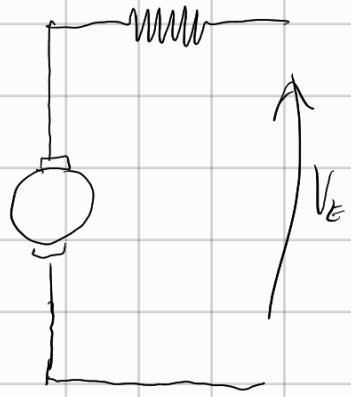
$R_A = 2.1\Omega$

$R_E = 30\Omega$

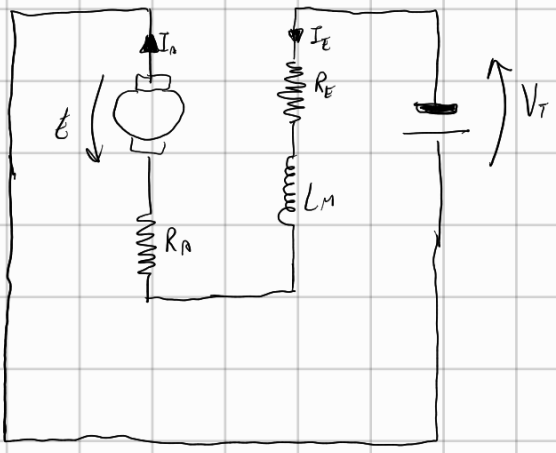
$n_0 = 1680 rpm$

$T_m = 215 Nm$



4)




$V_T = 400\,V$

$R_A = 5\,\Omega$

$R_E = 15\,\Omega$

$C_S = 200\,N\,m$

$P_{AS} = 4\,kW$

$$T_m = \frac{K K_\phi V_T^2}{(R_E + R_A + K K_\phi \omega_m)^2}$$

$$C_S = \frac{K K_\phi V_T^2}{(R_A + R_E)^2}$$

$K K_\phi = 0.5$

$V_T I_A = 4\,kW$

$I_A = 10\,A$

$V_T = (R_E + R_A) I_A + E_A$

$E_A = 200\,V$

$T_m = K K_\phi I_A^2 = 50\,N \cdot m$

$$\eta = \frac{P_{OUT}}{P_{OUT} + R_A I_A^2 + R_E I_A^2} = 50\%$$

4)

$P_N = 150\,kVA$

$V_{1N}/V_{2N} = \frac{5000V}{250V}$

$I_{cu} = 1A$

$P_{cu} = 2KW$

$V_{cc} = 200V$

$P_{cc} = 2.5kW$

$P_{out} = 110KW$

$\cos\phi_{out} = 0.75$ ind

$P_{cu} = \frac{V_{1N}^2}{R_{Fe}} \Rightarrow R_{Fe} = 12500\,\Omega$ $\qquad \varphi = \cos^{-1}\left(\frac{P_{cu}}{V_{1N} I_n}\right) = 1.16$

$X_1 = \frac{R_{Fe}}{\tan\varphi} = 5445\,\Omega$

$P_{cc} = I_{1N}^2 R_{cu} \Rightarrow R_{cu} = 2.78\,\Omega$ $\qquad \varphi = \cos^{-1}\left(\frac{P_{cc}}{V_1 I_{1N}}\right) = 1.14$

$X_d = R_{cu}\tan\varphi = 6.1\,\Omega$

$I_1 = \frac{P_{OUT}}{V_{1N}\cos\phi_{out}} = 29.3\ A$

$\tilde{I}_1 = 29.3 e^{-0.725}\ A$ $\qquad P_{cu} = I_1^2 R_{cu} = 2387W$

$\tilde{V}_{cc} = \tilde{I}_1 \dot{z}_{cc} = 196.4 e^{0.425}\ V$

$\tilde{V}_{1N} = \tilde{V}_{cc} + \tilde{V}_{1N} = 5179.7 e^{0.0165}\ V$

$$P_{Fe} = \frac{V_1^2}{R_{Fe}} = 2146\,W$$

$$\eta = \frac{P_{OUT}}{P_{OUT} + P_{Fe} + P_{Cu}} = 96\%$$

4)

$P_N = 6kW$

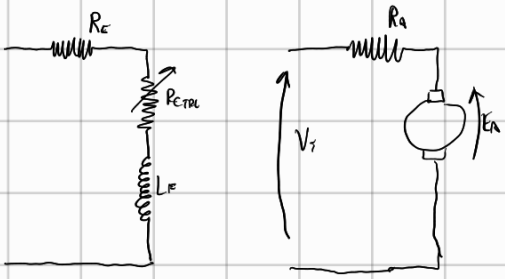
$V_T = 300\,V$

$n_m = 1800\ rpm$

$I_E\ 2.5\,A$

$R_A = 1\,\Omega$

$n_{nom} = 1600\ rpm$




$I_E \rightarrow E_A = 315\,V$

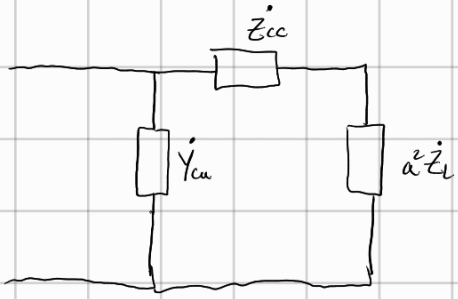
Ma se sono a 1600 rpm?

$$\frac{E_{A\,1800}}{E_{A\,1600}} = \frac{1800}{1600} \Rightarrow E_{A\,1600} = 280\,V$$

$V_A = 20\,V \Rightarrow R_A I_A = 20\,V \quad I_A = 20\,A$

4) $A_0 = 50\,KVA$

$\frac{V_{1N}}{V_{2N}} = \frac{5000\,V}{250\,V}$




$\dot{Z}_{cc} = 2 + 5j\ \Omega$

$\dot{Y}_m = 10 - 100j\ \mu S$

$P_{ass} = 45\,kW$

$\cos\varphi_{our} = 0{,}90$ rit

$P_{ass} = V_{1N} I_1 \cos\varphi \Rightarrow I_1 = 10\,A \qquad \tilde{I}_1 = 10\,e^{-0.45j}\,A$

$\tilde{V}_{cc} = \tilde{I}_1 \dot{Z}_{cc} = 53{,}85\,e^{0{,}745}\ V$

$\tilde{V}_1 = \tilde{V}_{cc} + \tilde{V}_{1N} = 5040\,e^{7.2\cdot10^{-3}j}\ V$

$\dot{Y}_m = -100\cdot10^{-6}j\ S$

$\tilde{I}_m = \dot{Y}_m \cdot \tilde{V}_1 = 0{,}5\,e^{-1{,}56j}\ A$

$P_{cc} = R_{cu} I_1^2 = 200\,W$