1^ PARTE:

SOLUZIONE T.E. 2023

MAT 4 poli

$V_{1n} = 400V - 50Hz$

$I_{1n} = 58A$

$\cos\varphi_n = 0,88$

$s_n\% = 3\%$

$R_{20c} = 210m\Omega$

$P_0 = 1450W \quad \cos\varphi_0 = 0,20$

$P_{av} = 410W$

$I_a = 7,5 \cdot I_{1n} \quad \cos\varphi_a = 0,35$

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a) C_{rc}, η

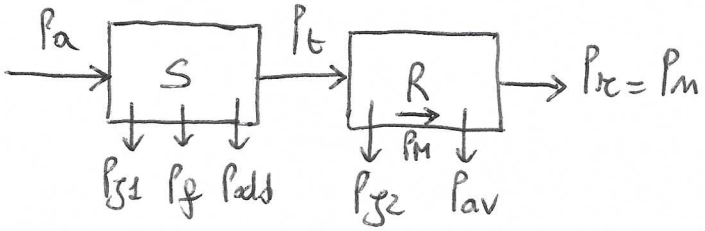
$$I_0 = \frac{P_0}{\sqrt{3} V_{1n} \cos\varphi_0} = \frac{1450}{\sqrt{3}\, 400 \cdot 0,2} = 10,46A$$

$$P_{J10} = \frac{3}{2} R_{20} \cdot I_0^2 =$$

$$P_{J10} = \frac{3}{2} \cdot 0,21 \cdot 10,46^2 = 34,46W$$

$P_0 = P_{J10} + P_g + P_{av} \Longrightarrow$

$$P_g = P_0 - P_{J10} - P_{av} = 1450 - 34,46 - 410 \cong 1006W$$



$$P_a = \sqrt{3} V_{1n} I_{1n} \cos\varphi_n = \sqrt{3} \cdot 400 \cdot 58 \cdot 0,88 \cong 35'362W$$

$$P_{J1} = \frac{3}{2} R_{75} I_{1n}^2$$

$$R_{75} = \frac{234,5+75}{234,5+20} \cdot R_{20} = 0,255\Omega$$

$$P_{J1} = \frac{3}{2} 0,255 \cdot 58^2 = 1287W$$

$$P_{add} = \frac{0,5}{100} \cdot P_a \cong 177W$$

$$P_t = P_a - (P_{J1} + P_f + P_{add}) = 35'362 - (1287 + 1006 + 177) = 32'892\,W$$

$$P_{J2} = s \cdot P_t = 0{,}03 \cdot 32'892 \cong 987\,W \qquad \left(P_M = (1-s)\cdot P_t = 31\,905\,W\right)$$

$$P_r = P_m = P_t - (P_{J2} + P_{ov}) = 32'892 - (987 + 410) = 31\,495\,W$$

$$C_r = C_m = \frac{60}{2\pi} \cdot \frac{P_r}{n_2} \qquad n_2 = n_1 \cdot (1-s) =$$

$$n_2 = 1500(1-0{,}03) = 1455\,g/1'$$

$$C_r = \frac{60}{2\pi} \cdot \frac{31495}{1455} = 206{,}7\,Nm$$

$$C_t = \frac{60}{2\pi} \cdot \frac{P_t}{n_1} = \frac{60}{2\pi} \cdot \frac{32'892}{1500} \cong 209{,}4\,Nm.$$

$$\eta_m = \frac{P_r}{P_a} = \frac{31495}{35'362} = 0{,}8906 \qquad (89{,}06\%)$$

b) AVVIAMENTO MOTORE CON $C_{RES} = 150\,Nm$

C_a = COPPIA AVVIAMENTO DIRETTO.

1° Modo: $P_{acc} = \sqrt{3}\, V_{1m} \cdot I_a \cdot \cos\varphi_{cc}$ $\qquad I_a = 7{,}5 \cdot I_{1m} = 435A$

$$P_{acc} = \sqrt{3} \cdot 400 \cdot 435 \cdot 0{,}35 \cong 105'482\,W$$

$$P_{J1(1)} = \frac{3}{2} R_{75} \cdot I_a^2 = \frac{3}{2} \cdot 0{,}255 \cdot 435^2 \cong 72'373\,W$$

(TRASCURO P_f e P_{add})

$$P_{t(1)} \cong P_{acc} - P_{J1(1)} = 105'482 - 72'379 = 33103\,W$$

$$C_a = C_{t(1)} = \frac{60}{2\pi} \cdot \frac{P_{t(1)}}{n_1} = \frac{60}{2\pi} \cdot \frac{33103}{1500} \simeq 210{,}7\ Nm.$$

2° MODO

OPPURE CON LA FORMULA DELLA COPPIA C_a:

$$C_a = \frac{3}{2\pi} \cdot \frac{P}{\vartheta_1} \cdot V_{1f}^2 \cdot \frac{R_2'}{2_{1cc}^2}$$

$$2_{1cc} = \frac{V_{1n}}{\sqrt{3} \cdot I_a} = \frac{400}{\sqrt{3} \cdot 435} = 0{,}5309\,\Omega = 530{,}9\,m\Omega$$

$$R_{1cc} = 2_{1cc} \cdot \cos\varphi_{cc} = 530{,}9 \cdot 0{,}35 = 185{,}8\,m\Omega \qquad R_{1cc} = R_1 + R_2'$$

IPOTIZZO AVV. A (λ): $R_1 = \frac{R_{15}}{2} = \frac{0{,}255}{2} = 127{,}5\,m\Omega$.

$$R_2' = R_{1cc} - R_1 = 185{,}8 - 127{,}5 = 58{,}3\,m\Omega$$

$$C_a = \frac{3}{2\pi} \cdot \frac{2}{50} \cdot \left(\frac{400}{\sqrt{3}}\right)^2 \cdot \frac{58{,}3 \cdot 10^{-3}}{(530{,}9 \cdot 10^{-3})^2} \simeq 210{,}7\ Nm$$

SCELGO UN AVVIAMENTO CON AUTOTRASFORMATORE:

SCELGO: $C_a' = 170\ Nm$ $(> C_{res})$

$$C_a' = \alpha \cdot C_a \quad \Rightarrow \quad \alpha = \frac{C_a'}{C_a} = \frac{170}{210{,}7} \simeq 0{,}807$$

$$K_{AT} = \sqrt{\frac{1}{\alpha}} = \sqrt{\frac{C_a}{C_a'}} \simeq 1{,}113$$

$$V_S = \frac{V_{1n}}{K_{AT}} = \frac{400}{1{,}113} \simeq 359{,}4\,V \qquad \text{e} \qquad I_a' = \alpha\, I_a \simeq 351\,A \quad (I_a' \simeq 6\, I_{1n})$$

$S_p = \sqrt{3}\, V_{1m} \cdot I_a' = \sqrt{3} \cdot 400 \cdot 351 = 243178\ VA$

SCELGO:

$S_m = 120\ kVA$
$V_{1m} = 400V$
$V_{20m} = 359{,}4V$

NB: IPOTIZZANDO UN AVVIAMENTO CON MOTORE "FREDDO" AVREI AUTO UNA C_a MAGGIORE.

$$P_{J1(1)} = \frac{3}{2} R_{2S} \cdot I_a^2 = \frac{3}{2} \cdot 0{,}21 \cdot 435^2 \cong 58606\ W$$

$$P_{t(1)} = P_{acc} - P_{J1(1)} = 105482 - 59606 = 45876\ W$$

$$C_a = \frac{60}{2\pi} \cdot \frac{P_{t(1)}}{n_1} \cong 292\ Nm$$

Con: $C_a' = 170\ Nm \rightarrow \alpha = \frac{C_a'}{C_a} = \frac{170}{292} = 0{,}582$ $\quad K_{AT} = \sqrt{\frac{1}{\alpha}} = 1{,}31$

$$V_S = \frac{V_{1m}}{K_{AT}} = 305{,}3V \qquad I_a' = \alpha\, I_a \cong 253{,}2A$$

$$S_p = \sqrt{3}\, V_{1m}\, I_a' = 175422VA \rightsquigarrow S_m = 80\ kVA$$

c) RIDURRE VELOCITÀ DEL 15%. INVERTER SCALARE $\frac{V}{f} = K$.

$n_2' = 0{,}85 \cdot n_2 = 0{,}85 \cdot 1455 \cong 1236{,}8$ g/1'

$\Delta n_2 = n_2 - n_2' = 1455 - 1236{,}8 = 218{,}2$ g/1'

IPOTIZZO "TRATTI PARALLELI": $\Delta n_1 = \Delta n_2 = 218{,}2$ g/1'

$n_1' = n_1 - \Delta n_1 = 1500 - 218{,}2 = 1281{,}8$ g/1'

$n_1' = \frac{60 \cdot f_1'}{p} \Rightarrow f_1' = \frac{n_1' \cdot p}{60} \cong 42{,}73$ Hz.

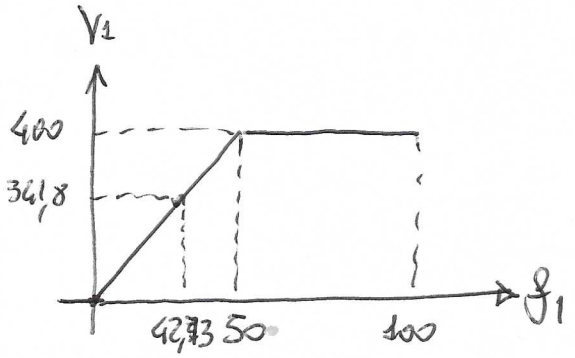
$\frac{V_{1n}}{f_{1n}} = \frac{400}{50} = 8 \Rightarrow V_1' = 8 \cdot f_1' = 341{,}8$ V

OPPURE: $f_1' = 0{,}85 \cdot f_1 = 42{,}5$ Hz $\rightarrow V_1' = 8 \cdot 42{,}5 = 340$ V

$n_1' = \frac{60 \cdot f_1'}{p} = 1275$ g/1' $\quad \Delta n_1 = n_1 - n_1' = 225$ g/1'

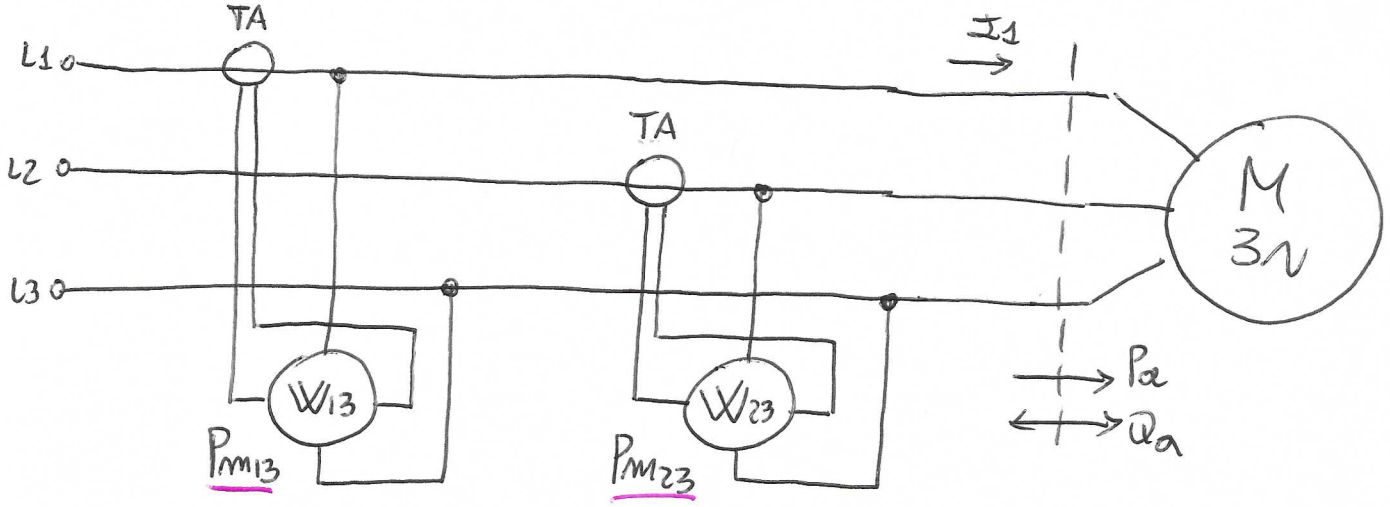
$\Delta n_2 = \Delta n_1 = 225$ g/1' $\rightarrow n_2' = n_2 - \Delta n_2 = 1455 - 225 = 1230$ g/1'

(15,46%)



2ª PARTE)

QUESITO 1) INSERZIONE SEMIDIRETTA ARON



$$\begin{cases} P_a = 35{\cdot}362\ W \\ Q_a = P_a \cdot \operatorname{tg}\varphi_m \cong 18{\cdot}086\ VAR. \end{cases}$$

ARON: $\begin{cases} P_a = P_{13} + P_{23} \\ Q_a = \sqrt{3}\,(P_{13} - P_{23}) \end{cases}$ $\begin{cases} P_{13} + P_{23} = 35{\cdot}362 \longrightarrow P_{23} = 35362 - P_{13} \\ \sqrt{3}\,(P_{13} - P_{23}) = 18{\cdot}086 \end{cases}$

$$\sqrt{3}\,(2P_{13} - 35362) = 18{\cdot}086 \quad \Rightarrow \begin{cases} P_{13} \cong 23{\cdot}131\ W \\ P_{23} = 12{\cdot}171\ W \end{cases}$$

SCELGO: TA 500/5 A $\quad K_{TA} = 100$

$$P_{m_{13}} = \frac{P_{13}}{K_{TA}} \cong 231{,}3\ W$$

$$P_{m_{23}} = \frac{P_{23}}{K_{TA}} \cong 121{,}7\ W$$

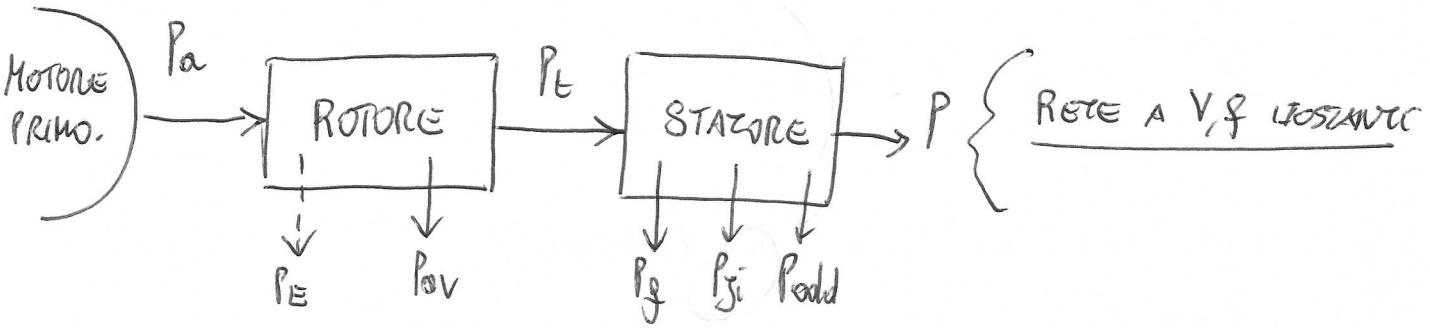
QUESITO 2)

$S_m = 70\,MVA$ $\quad n = 3000\,g/1'$ $\quad$ ii $\quad \eta = 0{,}984$ a $\cos\varphi = 1$

$P_g = 20\%\ P_p$

$P_{av} = 25\%\ P_p$ $\qquad \eta = ?$ $\quad$ a $\cos\varphi = 0{,}8$.

BILANCIO POTENZE ALTERNATORE:



IPOTIZZO P_E A PARTE (SERVIZI DI CABINA)

$$P_p = P_{av} + P_g + P_{gi} + P_{add} \qquad \text{con} \quad P_{add} = 0{,}5\%\ P$$

Se il $\cos\varphi = 1$ $\qquad P = S_m = 70\,MVA \quad (Q = 0)$ $\qquad I = \dfrac{S_m}{\sqrt{3}V}$

$$\eta_1 = 0{,}984 \rightarrow \quad P_a = \frac{P}{\eta_1} = \frac{70}{0{,}984} \cong 71{,}14\,MW$$

$$P_p = P_a - P = 1{,}14\,MW = 1140\,kW$$

$P_g = 0{,}2 \cdot 1140 = 228\,kW$ $\qquad P_{add} = \dfrac{0{,}5}{100} \cdot P = 350\,kW$

$P_{av} = 0{,}25 \cdot 1140 = 285\,kW$

Posso calcolare $\quad P_{gi} = P_p - P_{av} - P_g - P_{add} = 277\,kW$

A PIENO CARICO ($S_n = 70\,MVA$) E CON $\cos\varphi = 0{,}8$ CAMBIANO

P e P_{add}.

$$P = S_n \cdot \cos\varphi = 70 \cdot 0{,}8 = 56\,MW \quad (Q = 42\,MVAR)$$

$$P_{add} = \frac{0{,}5}{100} \cdot P = 280\,kW$$

P_f, P_{ov} e P_{si} NON CAMBIANO (V = corrente, m = contatto, $I = \frac{S_n}{\sqrt{3}V}$)

QUINDI LE: $P_p = P_{ov} + P_f + P_{si} + P_{add} =$

$$P_p = 285 + 228 + 277 + 280 = 1070\,kW$$

$$P_a = P + P_p = 56 + 1{,}070 = 57{,}07\,MW$$

A $\cos\varphi = 0{,}8$ $\Rightarrow$ $\eta_{0,8} = \frac{56}{57{,}07} = 0{,}981$

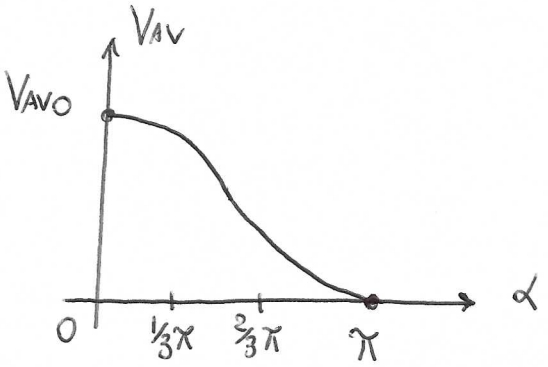
(QUESITO 3)

CIRCUITO TRIFASE A PONTE SEMICONTROLLATO.

VALORE MEDIO IN USCITA: $V_{AV} = \frac{3\sqrt{2}}{2\pi} \cdot V_2 \left(1 + \cos\alpha\right)$

α = ANGOLO DI ACCENSIONE

V_2 = TENSIONE CONCATENATA AL SECONDARIO (VALORE EFFICACE)



$\alpha = 0^\circ \quad V_{AVO} = 1{,}35\, V_2$

$\alpha = \pi \quad V_{AV} = 0$

VEDI MANUALE.