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SÈRIE 1

Exercici 1

Q1 b Q2 c Q3 b Q4 a Q5 c

Exercici 2

a) $I_1 = \frac{U_{ab}}{R} = \frac{400}{25} = 16 \text{ A}$

$$I_2 = \frac{U_{bc}}{X_L} = \frac{400}{50} = 8 \text{ A}$$

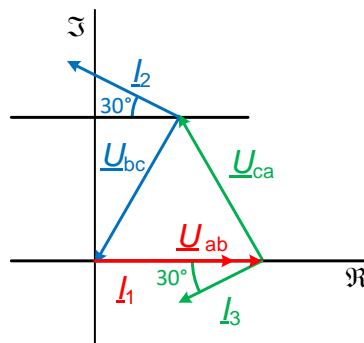
$$I_3 = \frac{U_{ca}}{X_C} = \frac{400}{80} = 5 \text{ A}$$

b)

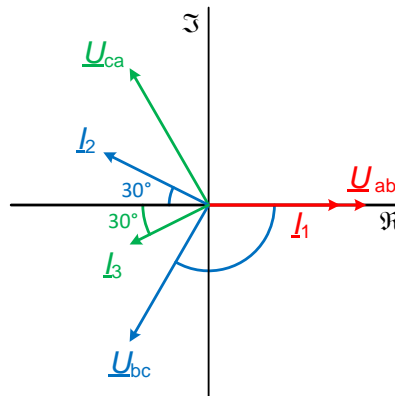
$$P = R I_1^2 = \frac{U^2}{R} = 25 \cdot 16^2 = \frac{400^2}{25} = 6,4 \text{ kW}$$

$$Q = X_L I_2^2 - X_C I_3^2 = \frac{U^2}{X_L} - \frac{U^2}{X_C} = 50 \cdot 8^2 - 80 \cdot 5^2 = \frac{400^2}{50} - \frac{400^2}{80} = 1,2 \text{ kvar}$$

c)



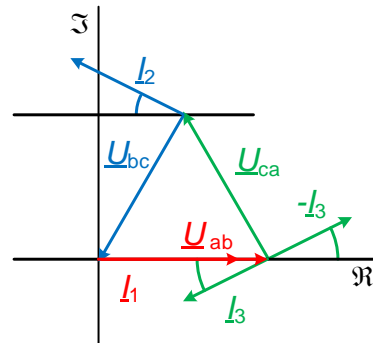
Alternativament, recordant que els fasors no tenen punt d'aplicació,





Informació addicional (que no es demanava en la resolució de l'exercici):

Si s'hagués de calcular el valor del corrent I_a de la fase a consumit per la càrrega, llavors:



$$\underline{I}_a = \underline{I}_1 - \underline{I}_3 = \underline{I}_1 + (-\underline{I}_3) \quad \rightarrow \quad I_a = \sqrt{(I_1 + I_3 \cos 30^\circ)^2 + (I_3 \sin 30^\circ)^2}$$

$$I_a = \sqrt{\left(16 + 5 \frac{\sqrt{3}}{2}\right)^2 + \left(5 \frac{1}{2}\right)^2} = 20,48 \text{ A}$$

Exercici 3

a)

$$\Gamma = \frac{P_N}{\omega_N} = \frac{P_N}{n_N \frac{2\pi}{60}} = \frac{7500}{1755 \frac{2\pi}{60}} = 40,81 \text{ N m}$$

b)

$$U_{\text{estrella}} = \sqrt{3} U_{\text{triangle}} = \sqrt{3} \cdot 400 = 692,8 \text{ V}$$

$$I_{\text{estrella}} = \frac{I_{\text{triangle}}}{\sqrt{3}} = \frac{13,5}{\sqrt{3}} = 7,79 \text{ A}$$

c)

$$\eta(\%) = 100 \frac{P_N}{\sqrt{3} U_N I_N \cos \varphi_N} = 100 \frac{7500}{\sqrt{3} \cdot 400 \cdot 13,5 \cdot 0,86} = 93,24 \%$$

d)

$$s_N = \frac{\omega_s - \omega_{\text{mec}}}{\omega_s} = \frac{n_s - n_N}{n_s} \quad \rightarrow \quad n_s = \frac{n_N}{1 - s_N} = \frac{1755}{1 - 0,025} = 1800 \text{ min}^{-1}$$

$$\omega_s = \frac{\omega}{p} = \frac{2\pi f_N}{p} \quad \rightarrow \quad f_N = \frac{\omega_s p}{2\pi} = \frac{n_s \frac{2\pi}{60} p}{2\pi} = \frac{n_s p}{60} = \frac{1800 \cdot 2}{60} = 60 \text{ Hz}$$

e)

$$Q = \sqrt{3} U_N I_N \sin \varphi_N = \sqrt{3} \cdot 400 \cdot 13,5 \sqrt{1 - 0,86^2} = 4773 \text{ var}$$



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Exercici 4

a)

$$P_{R3} = \frac{U_2^2}{R_3} \rightarrow U_2 = \sqrt{P_{R3} R_3} = \sqrt{28,8 \cdot 5} = 12 \text{ V}$$

b)

$$P_{R3} = R_3 I_{R3}^2 \rightarrow I_{R3} = \sqrt{\frac{P_{R3}}{R_3}} = \sqrt{\frac{28,8}{5}} = 2,4 \text{ A}$$

$$\frac{1}{2} P_{R3} = U_2 I_2 \rightarrow I_2 = \frac{\frac{1}{2} P_{R3}}{U_2} = \frac{\frac{1}{2} 28,8}{12} = 1,2 \text{ A}$$

$$I_1 + I_2 = I_{R3} \rightarrow I_1 = I_{R3} - I_2 = 2,4 - 1,2 = 1,2 \text{ A}$$

$$I_1 = \frac{U_1 - U_2}{R_1 + R_2} \rightarrow U_1 - U_2 = R_1 I_1 + R_2 I_1 \rightarrow R_2 = \frac{U_1 - U_2 - R_1 I_1}{I_1}$$

$$R_2 = \frac{24 - 12 - 6,5 \cdot 1,2}{1,2} = 3,5 \Omega$$

c)

$$P_{U1} = U_1 I_1 = 24 \cdot 1,2 = 28,8 \text{ W}$$

d)

$$P_{U2} = U_2 I_2 = 0 \text{ vol dir } I_2 = 0 \text{ i, per tant, } I_1 + I_2 = I_{R3} = I_1$$

$$I_1 = \frac{U_1 - U_2}{R_1 + R_2} = \frac{24 - 12}{6,5 + 3,5} = 1,2 \text{ A} = I_{R3}$$

$$U_2 = R_3 I_1 = R_3 I_{R3} \rightarrow R_3 = \frac{U_2}{I_1} = \frac{U_2}{I_{R3}} = \frac{12}{1,2} = 10 \Omega$$



Exercici 5

a)

$$X_1 = \omega L_1 = 2 \pi f L_1 = 2 \pi 50 \cdot 250 \cdot 10^{-3} = 78,54 \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2 \pi f C} = \frac{1}{2 \pi 50 \cdot 100 \cdot 10^{-6}} = 31,83 \Omega$$

$$A = I = \frac{U}{Z} = \frac{U}{\sqrt{R^2 + (X_1 + X_2 - X_C)^2}} = \frac{100}{\sqrt{12^2 + (78,54 + 25 - 31,83)^2}} = 1,375 \text{ A}$$

b)

$$W = P_R = R I^2 = 12 \cdot 1,375^2 = 22,69 \text{ W}$$

c)

Per què el corrent (potència) sigui màxim (màxima), el circuit ha d'estar en resonància sèrie:

$$L_2 = \frac{X_2}{2 \pi f} = \frac{25}{2 \pi 50} = 79,58 \text{ mH} \quad \rightarrow \quad L = L_1 + L_2 = 250 + 79,58 = 329,58 \text{ mH}$$

$$f = \frac{1}{2 \pi \sqrt{LC}} \quad \rightarrow \quad C = \frac{1}{(2 \pi f)^2 L} = \frac{1}{(2 \pi 50)^2 329,58 \cdot 10^{-3}} = 30,74 \mu\text{F}$$

d)

$$W = P_R = \frac{U^2}{R} = \frac{100^2}{12} = 833,3 \text{ W}$$



Exercici 6

a)

$$\Delta U_{\text{màx}} = \frac{5}{100} U_{\text{N Línia}} = \frac{5}{100} 230 = 11,5 \text{ V}$$

Amb un 5% de caiguda de tensió, la tensió en els borns del motor és:

$$U_{\text{motor}} = U_{\text{N Línia}} - \Delta U_{\text{màx}} = 230 - 11,5 = 218,5 \text{ V}$$

El corrent que circula pel motor:

$$I = \frac{U_{\text{motor}}}{Z} = \frac{218,5}{\sqrt{7,5^2 + 4,8^2}} = 24,54 \text{ A}$$

$$2 R_{\text{màx}} = \frac{\Delta U_{\text{màx}}}{I} \rightarrow R_{\text{màx}} = \frac{\Delta U_{\text{màx}}}{2 I} = \frac{11,5}{2 \cdot 24,54} = 0,2343 \Omega$$

$$R_{\text{màx}} = \rho \frac{L}{S_{\text{mín}}} \rightarrow S_{\text{mín}} = \frac{\rho L}{R_{\text{màx}}} = \frac{0,01786 \cdot 10^{-6} \cdot 100}{0,2343} = 7,62 \cdot 10^{-6} \text{ m}^2 = 7,62 \text{ mm}^2$$

b) La secció escollida, és, doncs, $S = 10 \text{ mm}^2$

c)

$$R_{\text{màx}} = \rho \frac{L}{S_{\text{mín}}} = \frac{0,01786 \cdot 10^{-6} \cdot 100}{10 \cdot 10^{-6}} = 0,1786 \Omega$$

$$I = \frac{U_{\text{N Línia}}}{Z_{\text{Total}}} = \frac{230}{\sqrt{(2 \cdot 0,1786 + 7,5)^2 + 4,8^2}} = 24,98 \text{ A}$$

$$\Delta U(\%) = 100 \frac{U_{\text{N Línia}} - U_{\text{motor}}}{U_{\text{N Línia}}} = 100 \frac{U_{\text{N Línia}} - Z I}{U_{\text{N Línia}}}$$

$$\Delta U(\%) = 100 \frac{230 - 24,98 \sqrt{7,5^2 + 4,8^2}}{230} = 3,29 \%$$



SÈRIE 3

Exercici 1

Q1 d Q2 b Q3 a Q4 b Q5 c

Exercici 2

$$b) \quad I_1 = \frac{U_2 - U_1}{R_1 + R_4} = \frac{12 - 10}{5 + 5} = 0,2 \text{ A}$$

$$I_3 = \frac{U_3 - U_2}{R_2 + R_3} = \frac{14 - 12}{5 + 5} = 0,2 \text{ A}$$

$$I_3 = I_1 + I_2 \quad \rightarrow \quad I_2 = I_3 - I_1 = 0,2 - 0,2 = 0 \text{ A}$$

b)

Com $I_1 = I_3$,

$$P_R = (R_1 + R_2 + R_3 + R_4) I_1^2 = (5 + 5 + 5 + 5) 0,2^2 = 0,8 \text{ W}$$

c)

$$P_{U1} = -U_1 I_1 = -10 \cdot 0,2 = -2 \text{ W}$$

$$P_{U2} = -U_2 I_2 = -12 \cdot 0 = 0 \text{ W}$$

$$P_{U3} = U_3 I_3 = 14 \cdot 0,2 = 2,8 \text{ W}$$

d)

$$I_3 = \frac{U_3 - U_2}{R_2 + R_3} \text{ i, per tant, si } U_2 = U_3 = 14 \text{ V, llavors } I_3 = 0 \text{ A}$$



Exercici 3

b)

$$X_L = \omega L = 2 \pi f L = 2 \pi 50 \cdot 160 \cdot 10^{-3} = 50,27 \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2 \pi f C} = \frac{1}{2 \pi 50 \cdot 130 \cdot 10^{-6}} = 24,49 \Omega$$

$$U_{an} = I_{R_2} \sqrt{R_2^2 + (X_L - X_C)^2} = A_3 \sqrt{R_2^2 + (X_L - X_C)^2} = 3,6 \sqrt{50^2 + (50,27 - 24,49)^2}$$

$$U_{an} = 202,5 \text{ V}$$

$$A_2 = I_{R_1} = \frac{U_{an}}{R_1} = \frac{202,5}{100} = 2,025 \text{ A}$$

b)

$$P = 3 R_1 I_{R_1}^2 + 3 R_2 I_{R_2}^2 = 3 \cdot 100 \cdot 2,025^2 + 3 \cdot 50 \cdot 3,6^2 = 3174,2 \text{ W}$$

$$Q = 3 X_L I_{R_2}^2 - 3 X_C I_{R_2}^2 = 3 \cdot 50,27 \cdot 3,6^2 - 3 \cdot 24,49 \cdot 3,6^2 = 1002,3 \text{ var}$$

$$S = \sqrt{P^2 + Q^2} = \sqrt{3174,2^2 + 1002,3^2} = 3328,7 \text{ VA}$$

c)

$$S = \sqrt{3} U I = \sqrt{3} \sqrt{3} U_{an} I \rightarrow A_1 = I = \frac{S}{3 U_{an}} = \frac{3328,7}{3 \cdot 202,5} = 5,48 \text{ A}$$

Exercici 4

e)

$$f = \frac{1}{T} = \frac{1}{5 \text{ div} \cdot 2 \frac{\text{ms}}{\text{div}} \cdot \frac{1 \text{ s}}{10^3 \text{ ms}}} = 100 \text{ Hz}$$

f) En el semiperíode negatiu condueix el díode i, per tant, no circula corrent per R_2 ;

i, en canvi, si que circula corrent per R_1 . Llavors,

$$U_{\text{secundari pic}} = 5 \text{ div} \cdot 10 \frac{\text{V}}{\text{div}} = 50 \text{ V}$$

En el semiperíode positiu no condueix el díode i el corrent circula per R_1 i R_2 :

$$U_{R1 \text{ pic}} = 2 \text{ div} \cdot 10 \frac{\text{V}}{\text{div}} = 20 \text{ V}$$

$$U_{\text{secundari pic}} = U_{R1 \text{ pic}} + U_{R2 \text{ pic}} \rightarrow U_{R2 \text{ pic}} = 50 - 20 = 30 \text{ V}$$

$$I_{\text{pic}} = \frac{U_{R1 \text{ pic}}}{R_1} = \frac{U_{R2 \text{ pic}}}{R_2} = \frac{20}{10} = 2 \text{ A} \rightarrow R_2 = \frac{U_{R2 \text{ pic}}}{I_{\text{pic}}} = \frac{30}{2} = 15 \Omega$$



c)

$$r_t = \frac{U_{\text{Nominal primari}}}{U_{\text{Nominal secundari}}} = \frac{80}{40} = 2$$

$$U = U_{\text{primari}} = r_t U_{\text{secundari}} = r_t \frac{U_{\text{secundari pic}}}{\sqrt{2}} = 2 \frac{50}{\sqrt{2}} = 70,71 \text{ V}$$

Exercici 5

b)

$$\Gamma_N = \frac{P_N}{\omega_N} = \frac{P_N}{n_N \frac{2\pi}{60}} = \frac{30000}{1750 \frac{2\pi}{60}} = 163,7 \text{ N m}$$

b)

$$E_N = \frac{P_N}{I_N} = \frac{30000}{69} = 434,8 \text{ V} \quad \rightarrow \quad R_i = \frac{U_N - E_N}{I_N} = \frac{500 - 434,8}{69} = 0,945 \Omega$$

c)

L'alternador és de dos parells de pols ($p = 2$) i, per tant, ha de girar a la velocitat de sincronisme $n_s = \frac{60f}{p} = \frac{60 \cdot 50}{2} = 1500 \text{ min}^{-1}$ per tal de generar a 50 Hz.

$$E' = \frac{n_s}{n_N} E_N = \frac{1500}{1750} 434,8 = 372,7 \text{ V}$$

$$P = \Gamma \omega_s = 100 \cdot 1500 \frac{2\pi}{60} = 15708 \text{ W}$$

$$I = \frac{P}{E'} = \frac{15708}{372,7} = 42,15 \text{ A}$$

$$U = R_i I + E' = 0,945 \cdot 42,15 + 372,7 = 412,5 \text{ V}$$



Exercici 6

a)

$$f = \frac{1}{2\pi\sqrt{L_1 C_1}} = \frac{1}{2\pi\sqrt{120 \cdot 10^{-3} \cdot 50 \cdot 10^{-6}}} = 64,97 \text{ Hz}$$

b)

$$X_{L1} = \omega L_1 = 2\pi f L_1 = 2\pi \cdot 64,97 \cdot 120 \cdot 10^{-3} = 48,99 \Omega$$

$$X_{C1} = \frac{1}{\omega C_1} = \frac{1}{2\pi f C_1} = \frac{1}{2\pi \cdot 64,97 \cdot 50 \cdot 10^{-6}} = 48,99 \Omega$$

$$I_{R1} = \frac{V_2}{\sqrt{R_1^2 + (X_{L1} - X_{C1})^2}} = \frac{V_2}{R_1} = \frac{85}{100} = 0,85 \text{ A}$$

$$P_{R1} = R_1 I_{R1}^2 = 100 \cdot 0,85^2 = 72,25 \text{ W}$$

$$X_{L2} = \omega L_2 = 2\pi f L_2 = 2\pi \cdot 64,97 \cdot 35 \cdot 10^{-3} = 14,29 \Omega$$

$$I_{R2} = \frac{V_2}{\sqrt{R_2^2 + X_{L2}^2}} = \frac{85}{\sqrt{40^2 + 14,29^2}} = 2 \text{ A}$$

$$P_{R2} = R_2 I_{R2}^2 = 40 \cdot 2^2 = 160 \text{ W}$$

c)

$$W = P = P_{R1} + P_{R2} + P_{R3} = P_{R1} + P_{R2} + R_3 I_{R3}^2 \rightarrow I_{R3} = \sqrt{\frac{W - P_{R1} - P_{R2}}{R_3}}$$

$$I_{R3} = \sqrt{\frac{351,21 - 72,25 - 160}{15}} = 2,82 \text{ A}$$

d)

$$Q = X_{L2} I_{R2}^2 = 14,29 \cdot 2^2 = 57,16 \text{ var}$$

$$S = \sqrt{P^2 + Q^2} = \sqrt{351,21^2 + 57,16^2} = 355,8 \text{ VA}$$

$$S = U I_{R3} \rightarrow U = \frac{S}{I_{R3}} = \frac{355,8}{2,82} = 126,2 \text{ V}$$