GENIE ELECTRIQUE BTS 2016

MSP

ELECTROTECHNIQUE

1/ 1.1. Facteur de puissance $\cos\varphi_0$

$$\cos\varphi_0 = \frac{P_{10}}{U_{10} I_{10}} = \frac{300}{1500 \times 2} \Rightarrow \boxed{\cos\varphi_0 = 0{,}1}$$ (2pts)

1.2. Composante active I_a et reactive I_r

$$I_a = \frac{P_{10}}{U_{10}} = \frac{300}{1500} \Rightarrow \boxed{I_a = 0{,}2A}$$ (2pts)

$$I_r = \sqrt{I_{10}^2 - I_a^2} = \sqrt{2^2 - 0{,}2^2} \Rightarrow \boxed{I_r = 1{,}989A}$$ (2pts)

1.3. Calcul de R_m et X_m

$$R_m = \frac{U_{10}}{I_a} = \frac{1500}{0{,}2} \Rightarrow \boxed{R_m = 7500\Omega}$$ (2pts)

$$X_m = \frac{U_{10}}{I_r} = \frac{1500}{1{,}989} \Rightarrow \boxed{X_m = 753{,}778\Omega}$$ (2pts)

1.4. Nombre de spires au primaire N_1

$$N_1 = \frac{U_{10}}{4{,}44 \times B_{max} \times f \times S} = \frac{1500}{4{,}44 \times 1{,}2 \times 50 \times 108{,}281 \cdot 10^{-4}}$$

$$\boxed{N_1 = 520 \text{ spires}}$$

1.5. Tension secondaire à vide si $N_2 = 78$ spires

$$U_{20} = \frac{U_1 N_2}{N_1} = \frac{1500 \times 78}{520} \Rightarrow \boxed{U_{20} = 225V}$$

2/ Elements ramenés au secondaire R_s et X_s.

$$R_s = \frac{P_{1cc}}{\left(\frac{I_{1cc}}{m}\right)^2} = \frac{225}{\left(\frac{22{,}5}{0{,}15}\right)^2} \Rightarrow \boxed{R_s = 0{,}01\Omega}$$

$$Z_s = \frac{m^2 U_{1cc}}{I_{1cc}} = \frac{0{,}15^2 \times 22{,}5}{22{,}2} \Rightarrow \boxed{Z_s = 0{,}0228\Omega}$$

$$X_s = \sqrt{Z_s^2 - R_s^2} = \sqrt{0{,}0228^2 - 0{,}01^2} \Rightarrow \boxed{X_s = 0{,}0205\Omega}$$

3.1. Impédance de la charge Z_2.

$$P_2 = U_2 I_2 \cos\varphi_2 = \frac{U^2}{Z_2}\cos\varphi_2 \Rightarrow Z_2 = \frac{U^2\cos\varphi_2}{P_2}$$

$$Z_2 = \frac{220^2 \times 0{,}8}{35200} \Rightarrow \boxed{Z_2 = 1{,}1\,\Omega}$$

3.2. Elements de la charge R_2 et L_2.

$$R_2 = \frac{P_2}{\left(\frac{U_2}{Z_2}\right)^2} = \frac{Z_2^2 \times P_2}{U_2^2} = \frac{1{,}1^2 \times 35200}{220^2}$$

$$\boxed{R_2 = 0{,}88\,\Omega}$$

$$L_2 = \frac{\sqrt{Z_2^2 - R_2^2}}{2\pi f} \Rightarrow L_2 = \frac{\sqrt{1{,}1^2 - 0{,}88^2}}{100\pi}$$

$$\boxed{L_2 = 2{,}1\,mH}$$

3.3. Courant de ligne absorbé par la charge I_2

$$I_2 = \frac{U_2}{Z_2} \Rightarrow I_2 = \frac{220}{1{,}1} \Rightarrow \boxed{I_2 = 200\,A}$$

3.4. Chute de tension ΔU_2

$$\Delta U_2 = R_s I_2 \cos\varphi_2 + X_s I_2 \sin\varphi_2$$
$$= 0{,}01 \times 200 \times 0{,}8 + 0{,}0205 \times 200 \times 0{,}6$$

$$\boxed{\Delta U_2 = 4{,}06\,V}$$

3.5. Tension primaire U_1.

$$\frac{U_{20}}{U_{10}} = \frac{U_{20}'}{U_1}$$

$$\Delta U_2 = U_{20}' - U_2 \Rightarrow U_{20}' = \Delta U_2 + U_2$$

$$\Rightarrow U_1 = \frac{(\Delta U_2 + U_2)\,U_{10}}{U_{20}} = \frac{(4{,}06 + 220)\,1500}{225}$$

$$\boxed{U_1 = 1493{,}733\,V}$$

3.6. Randement du transformateur.

$$\eta = \frac{P_2}{P_2 + P_{fer} + P_J} = \frac{P_2}{P_2 + P_{fer} + R_S I_2^2} \quad \text{avec} \quad P'_{fer} = \frac{P_{fer}}{\left(\frac{U_1}{U'_1}\right)^2}$$

$$= \frac{35200}{35200 + 297,498 + 0,01 \times 200^2}$$

$$\boxed{\eta = 0,98}$$

4°/ 4.1. Courant secondaire pour avoir un rendement maximal. (I_{2max})

$$I_{2max} = \sqrt{\frac{P_{10}}{R_S}} = \sqrt{\frac{300}{0,01}} \Rightarrow I_{2max} = 173,205A$$

$$\boxed{I_{2max} = 173,205A}$$

4.2. Randement maximal

$$\eta_{max} = \frac{U_2 I_{2max}}{U_2 I_{2max} + 2\sqrt{P_{10} \times R_S}} \quad \text{avec} \; \Delta U_2 = R_S I_{2max}$$

$$\Delta U_2 = R_S I_{2max} = U_{20} - U_2 \Rightarrow U_2 = U_{20} - R_S I_{2max}.$$

$$= 225 - 0,01 \times 173,205$$

$$\boxed{U_2 = 223,267 V.}$$

$$\eta_{max} = \frac{223,267 \times 173,205}{223,267 \times 173,205 + 2\sqrt{300 \times 0,01}}$$

$$\boxed{\eta_{max} = 0,999 \simeq 1}$$

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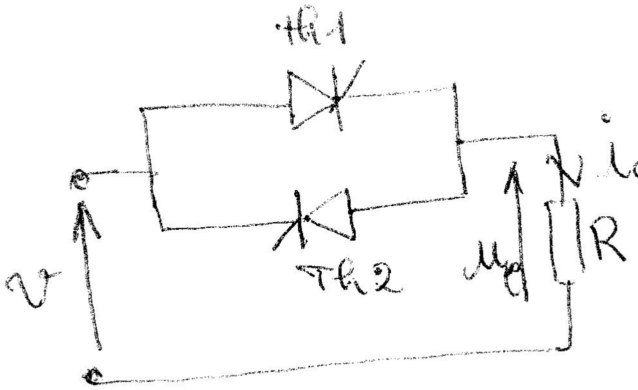
Génie Electrique (Eln de puissa



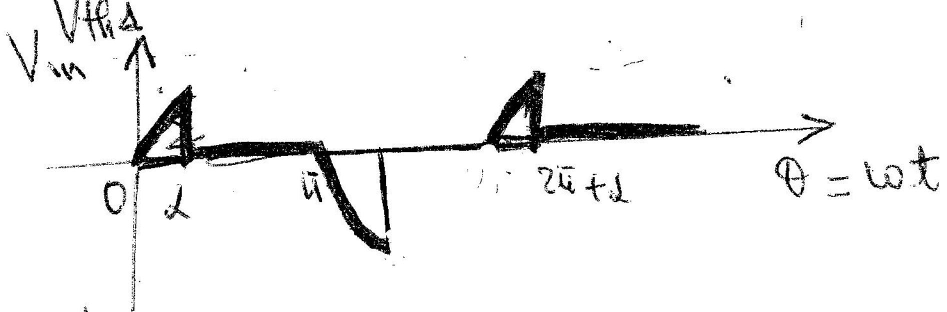
$v(\theta) = V\sqrt{2}\sin(\theta)$

$V = 110V$

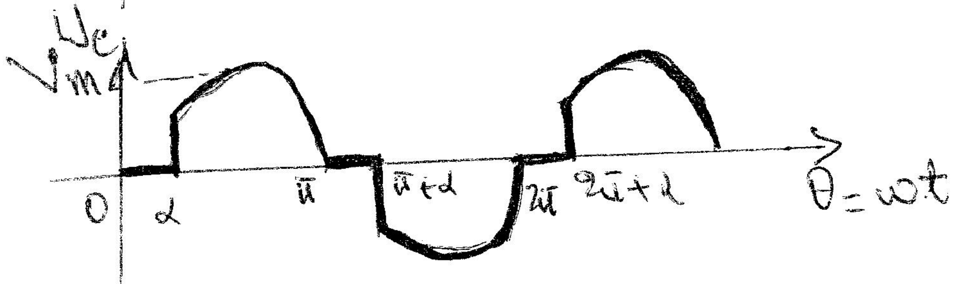
$R = 80\Omega$

1) pour $\alpha = \frac{\pi}{6}$

1-1) Tracer des chronogrammes des tensions:



(4)



(4)

1-2 Valeurs moyenne et efficace de la tension aux bornes de la charge

$\overline{U_c} = 0$ (3)

$$U_{ceff} = \sqrt{\frac{1}{2\pi}\left(\int_{\alpha}^{\pi} V\sqrt{2}\sin(\theta)d\theta + \int_{\pi+\alpha}^{2\pi} V\sqrt{2}\sin(\theta)d\theta\right)}$$

$$U_{ceff} = V\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin 2\alpha}{2\pi}}$$ (3)

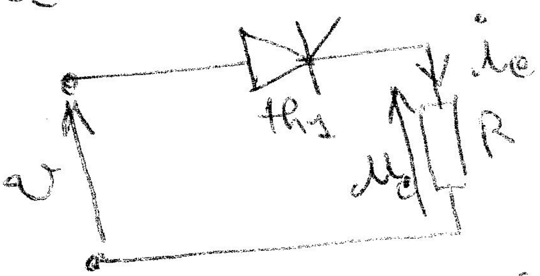
AN : $U_{eff} = 110\sqrt{1 - \frac{\pi/6}{\pi} + \frac{\sin(2\times\frac{\pi}{6})}{2\pi}}$

$U_{eff} = 91,774\ V$

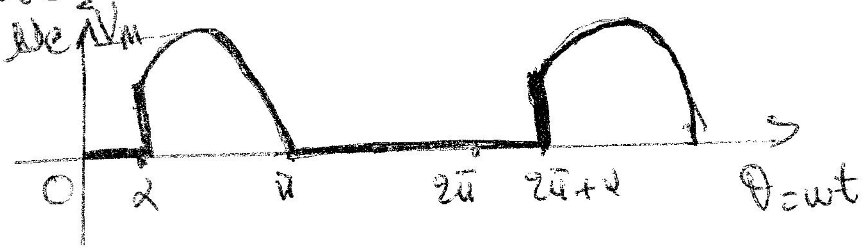
1.3 Valeur moyenne de la puissance consommée

$P = \frac{U_{eff}^2}{R}$ AN : $P = \frac{91,774^2}{80}$ $P = 105,2\ W$ (3)

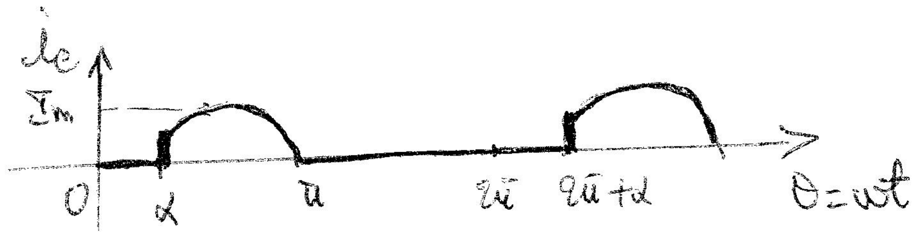
2) Th2 en circuit ouvert



2.1 Tracer de $u_c(\theta)$ et $i_c(\theta)$



(3)



(3)

2.2 Pour $\alpha = \frac{\pi}{6}$, calcul de U_{eff} et P

* $U_{eff} = \frac{1}{2\pi}\int_{\alpha}^{\pi} V\sqrt{2}\sin\theta\, d\theta$ $U_{eff} = \frac{V\sqrt{2}}{2\pi}(1$ [illegible]$)$ (3)

AN : $U_{eff} = \frac{110\sqrt{2}}{2\pi}\left(1 + \cos\frac{\pi}{6}\right)$ $U_{eff} =$ [illegible] V

* $P = \frac{U_{eff}^2}{R}$ $P = \frac{[illegible]^2}{80}$ $P =$ [illegible] W (4)

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1/2

AUTOMATIQUE

1) $F(p) = \dfrac{T(p)}{1+T(p)} \Rightarrow \boxed{F(p) = \dfrac{1}{0{,}01p^2 + 0{,}11p + 1{,}1}}$ **4pts**

2)

2.1) Stabilité en boucle fermée

$$F(p) = \frac{1}{0{,}01p^2 + 0{,}11p + 1{,}1}$$

$$D(p) = 0{,}01p^2 + 0{,}11p + 1{,}1$$

système du second ordre : Tous les coefficients sont positif donc système stable. **4pts**

2.2) système de classe 0 donc $\varepsilon(p) = \dfrac{1}{1+K}$.

$\varepsilon(p) = \dfrac{1}{1+1} \Rightarrow \boxed{\varepsilon(p) = 0{,}5}$ **4pts**

2.3) $t_{r\,5\%} = \dfrac{3}{z\omega_0}$

$$F(p) = \frac{1}{0{,}01p^2 + 0{,}11p + 1{,}1} = \frac{1/1{,}1}{\frac{0{,}01}{1{,}1}p^2 + \frac{0{,}11}{1{,}1}p + 1}$$

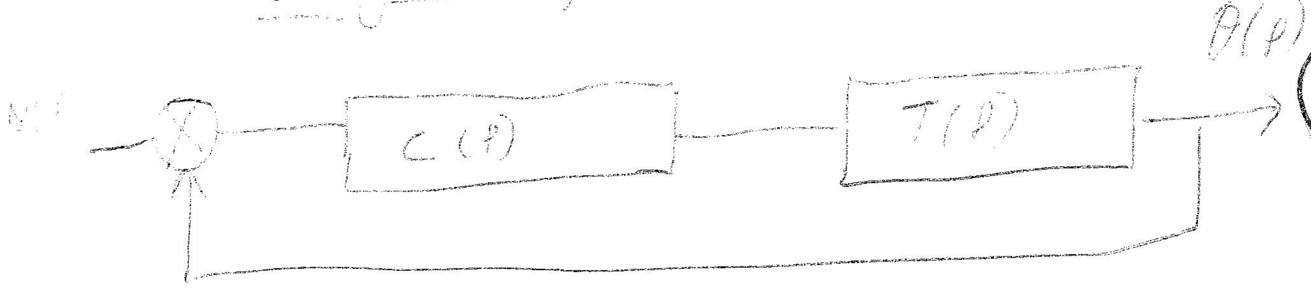
$$\frac{1}{\omega_0^2} = \frac{0{,}01}{1{,}1} \Rightarrow \omega_0^2 = \frac{1{,}1}{0{,}01} \Rightarrow \omega_0 = \sqrt{\frac{1{,}1}{0{,}01}} = 10{,}49$$

$$\frac{2z}{\omega_0} = \frac{0{,}11}{1{,}1} \Rightarrow z = \frac{\omega_0 \times 0{,}11}{2 \times 1{,}1} = \frac{10{,}49 \times 0{,}11}{2{,}2}$$

$z = 0{,}525$ $\quad T_{r\,5\%} = \dfrac{3}{0{,}525 \times 10{,}49} \Rightarrow \boxed{T_{r\,5\%} = 0{,}55\ s}$ **4pts**

3)

3.1 Diagramme fonctionnel 2/2



3pts

3.2)

a) FT en BO

$$F(p)_{BO} = C(p) \times T(p) = \frac{1}{0{,}01p^2 + 0{,}11p + 0{,}1} \times 5 + 0{,}3p + \frac{33{,}33}{p}$$

$$F(p)_{BO} = \frac{0{,}3p^2 + 5p + 33{,}33}{0{,}01p^3 + 0{,}11p^2 + 0{,}1p}$$

3pts

b) FT en BF

$$FTBF = \frac{N(p)}{N(p) + D(p)} = \frac{0{,}3p^2 + 5p + 33{,}33}{0{,}01p^3 + 0{,}41p^2 + 5{,}1p + 33{,}33}$$

$$FTBF = \frac{0{,}3p^2 + 5p + 33{,}33}{0{,}01p^3 + 0{,}41p^2 + 5{,}1p + 33{,}33}$$

4pts

3.3) Etudions la stabilité

stabilité selon routh : $D(p) = 0{,}01p^3 + 0{,}41p^2 + 5{,}1p + 33{,}33$

p^3	0,01	5,1
p^2	0,41	33,33
p^1	4,287	0
p^0	33,33	0

Tous les éléments de la 1ère colonne étant de même signe donc le système est stable

4pts

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MSP ELECTRONIQUE DE COMMANDE

1) Régime de fonctionnement (1pts)

AOP1 : Régime linéaire car contre réaction négative

AOP2 : Régime linéaire car contre réaction négative

2) Etude de l'AOP1

2.1/ Relation entre U_E' et U_E (1pts)

$$V_{E^+} = V_{E^-} = \frac{\frac{U_E'}{R} + \frac{U_E}{R}}{\frac{1}{R} + \frac{1}{R}} = 0$$

$$\frac{U_E'}{R} + \frac{U_E}{R} = 0 \Rightarrow \frac{U_E'}{R} = -\frac{U_E}{R}$$

$$-U_E' \times R = U_E \times R \rightarrow U_E' = -\frac{R\,U_E}{R}$$

$$\boxed{U_E' = -U_E}$$

2-2) Le montage de l'AOP1 est un montage inverseur (1pts)

3)- Etude de l'AOP2

3-1 Relation entre U_S et U_E' (1pts)

$$V_{E^+} = \frac{\frac{U_S}{R_2} + \frac{V_{ref}}{R_3} + \frac{U_E'}{R_1}}{\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_1}} = 0$$

$$\frac{U_S}{R_2} + \frac{V_{ref}}{R_3} + \frac{U_E'}{R_1} = 0 \rightarrow \frac{U_S}{R_2} = -\left(\frac{V_{ref}}{R_3} + \frac{U_E'}{R_1}\right)$$

$$\boxed{U_S = -R_2\left(\frac{V_{ref}}{R_3} + \frac{U_E'}{R_1}\right)}$$

3-2) Le montage de l'AOP2 est un montage additionneur inverseur (1pts)

4) Vérifions que $U_S = R_2\left(\frac{U_E}{R_1} - \frac{V_{ref}}{R_3}\right)$ (1pts)

On a : $U_S = -R_2\left(\frac{V_{ref}}{R_3} + \frac{U_E'}{R_1}\right)$

or $U_E' = -U_E$

donc $U_S = -R_2\left(\frac{V_{ref}}{R_3} - \frac{U_E}{R_1}\right)$

• d'où $\boxed{U_S = R_2\left(\frac{U_E}{R_1} - \frac{V_{ref}}{R_3}\right)}$

5). Application (5 pts)

$$U_S = R_2\left(\frac{U_E}{R_1} - \frac{V_{ref}}{R_3}\right)$$

* Pour $U_E = -0,5V$; $U_S = 0,25V$

$$0,25 = R_2\left(\frac{-0,5}{R_1} - \frac{-5}{R_3}\right)$$

$$0,25 = -\frac{R_2 \cdot 0,5}{100000} + \frac{R_2 \cdot 5}{R_3}$$

$$0,25 = -5.10^{-6} + \frac{5R_2}{R_3}$$

* Pour $U_E = -1$ et $U_S = 0$

$$0 = R_2\left(\frac{-1}{100000} + \frac{5}{R_3}\right).$$

$$\frac{R_2 \times (-1)}{100000} + \frac{5R_2}{R_3} = 0$$

$$-1.10^{-5} R_2 + \frac{5R_2}{R_3} = 0$$

$$-1.10^{-5} + \frac{5}{R_3} = 0 \longrightarrow \frac{5}{R_3} = 1.10^{-5}$$

$$5 = 1.10^{-5} \times R_3$$

$$R_3 = \frac{5}{1.10^{-5}} = 500000\ \Omega$$

$$\boxed{R_3 = 500\ k\Omega}$$

$$0,25 = -5.10^{-6} + \frac{5R_2}{500.10^3}$$

$$0,25 + 5.10^{-6} = \frac{5}{500.10^3} \cdot R_2$$

$$0,25 + 5.10^{-5} = 1.10^{-5} R_2$$

$$R_2 = \frac{0,25 + 5.10^{-5}}{1.10^{-5}}$$

$$\boxed{R_2 = 25000,5\ \Omega}$$