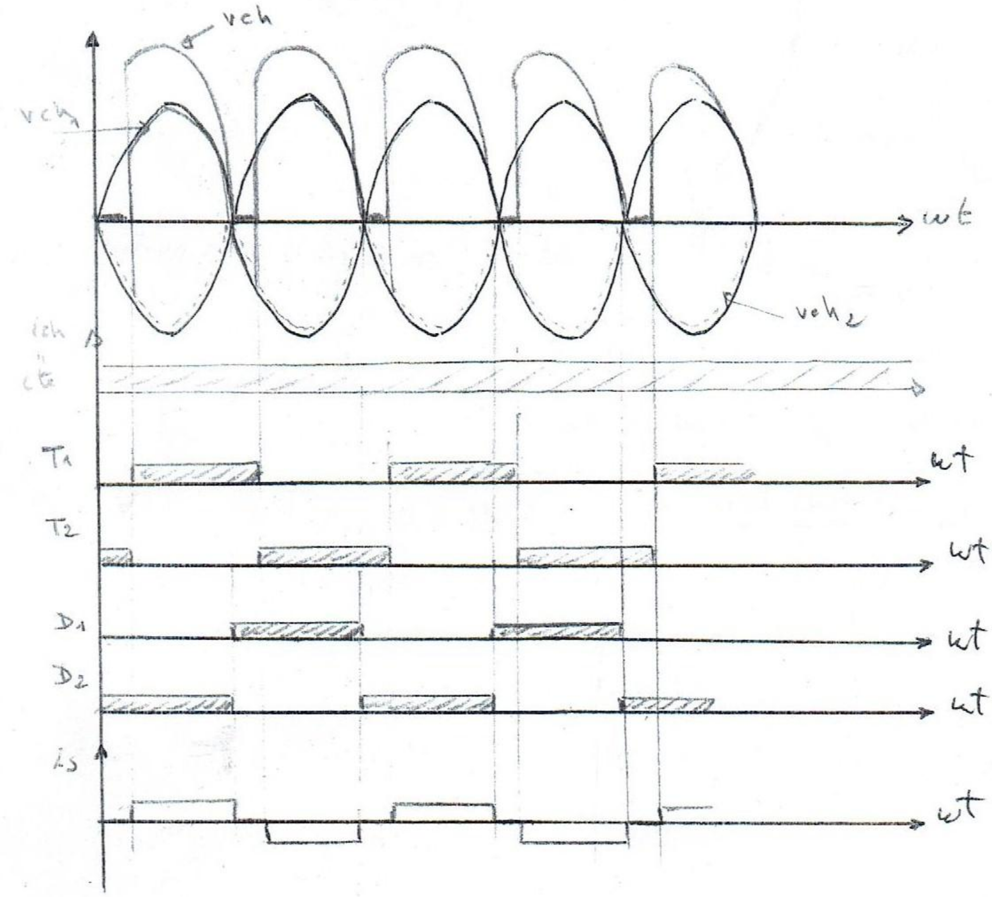
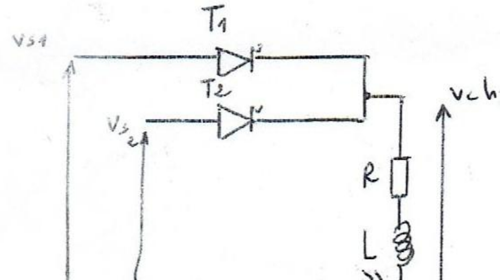
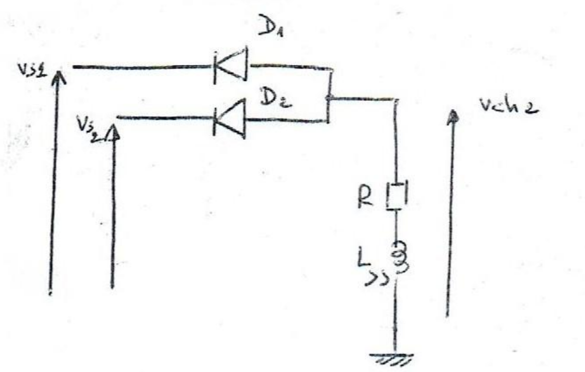
Exercice 8 :







- La tension moyenne :

$$\overline{V_{ch}} = \frac{1}{T}\int_0^T v_{ch}(t)\cdot dt = \frac{1}{\pi}\int_\alpha^\pi V_m \sin\theta \cdot d\theta = -\frac{V_m}{\pi}\cos\theta\Big|_\alpha^\pi = -\frac{V_m}{\pi}\left(\cos\pi - \cos\alpha\right)$$

$$\Rightarrow \boxed{\overline{V_{ch}} = \frac{V_m}{\pi}\left(1+\cos\alpha\right)}$$

- Le courant efficace :

$$I_{s\,eff}^2 = \frac{1}{T}\int_0^T I_{ch}^2\,dt = \frac{1}{2\pi}\left[\int_\alpha^\pi I_{ch}^2\cdot d\theta + \int_{\alpha+\pi}^{2\pi}(-I_{ch})^2\cdot d\theta\right]$$

$$= \frac{I_{ch}^2}{2\pi}\left(\theta\Big|_\alpha^\pi + \theta\Big|_{\alpha+\pi}^{2\pi}\right)$$

$$I_{s\,eff}^2 = \frac{I_{ch}^2}{2\pi}\left(\pi - \alpha + 2\pi - (\alpha+\pi)\right) = \frac{I_{ch}^2}{2\pi}\left(2\pi - 2\alpha\right)$$

$$I_{seff} = \frac{I_{ch}}{2\pi}\left(2\pi - 2\alpha\right) = \frac{I_{ch}}{\pi}\left(\pi - \alpha\right)$$

$$\Rightarrow \boxed{I_{seff} = I_{ch}\sqrt{\frac{\pi-\alpha}{\pi}}}$$

- $P_s = V_{s\,eff} \cdot I_{s\,eff} \cdot \cos\alpha$

$P_{ch} = \overline{V_{ch}} \cdot \overline{I_{ch}}$

$P_s = P_{ch} + \Delta P \Rightarrow \boxed{P_s \simeq P_{ch}}$ avec $\Delta P = 0$ (on néglige les pertes)

$$\Leftrightarrow V_{s\,eff} \cdot I_{seff} \cdot \cos\varphi = \frac{V_m}{\pi}\left(1 + \cos\alpha\right) \cdot I_{ch}$$

$$\Leftrightarrow \frac{V_m}{\sqrt{2}} \cdot I_{seff} \cdot \cos\varphi = \frac{V_m}{\pi}\left(1 + \cos\alpha\right) \cdot I_{ch}$$

$$\Rightarrow \cos\varphi = \frac{\sqrt{2} \cdot (1+\cos\alpha) \cdot I_{ch}}{\pi \cdot I_{seff}} \quad \text{avec: } I_{seff} = I_{ch} \cdot \sqrt{\frac{\pi-\alpha}{\pi}}$$

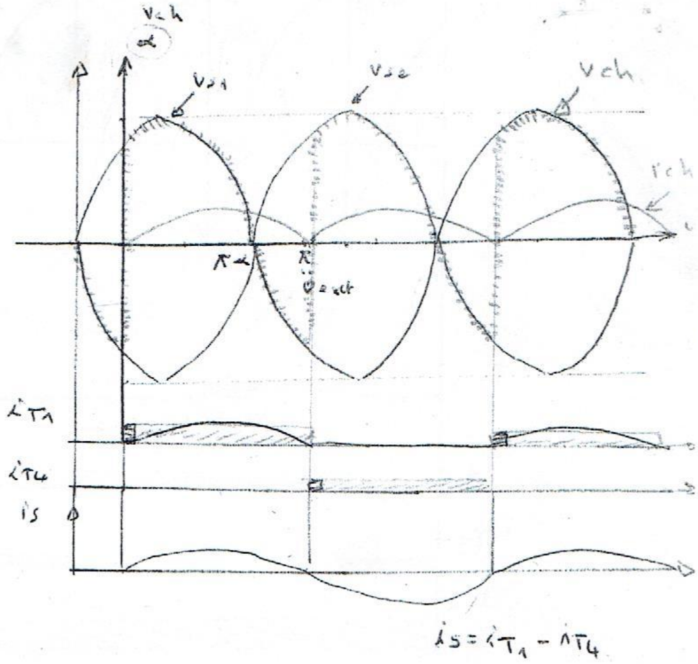
donc: $$\boxed{\cos\varphi = \frac{\sqrt{2} \cdot (1+\cos\alpha)}{\pi \cdot \sqrt{\frac{\pi-\alpha}{\pi}}}}.$$

Série d'exercice N°:2

Exercice 1:

a/ $\alpha = ?$, $\overline{U_{ch}} = 99\ V$, $\theta_{exct} = \pi$

on déterminer α à partir de $\overline{V_{ch}}$, on doit tracer $U_{ch}(t)$ pour un angle d'extinction $\theta_{exct} = \pi$



• on a $\overline{U_{ch}} = \frac{1}{\pi}\int_0^{\pi} V_m \sin(\theta+\alpha)\cdot d\theta$

avec : $V_m = 220.\sqrt{2}$

$\Rightarrow \overline{V_{ch}} = \frac{-V_m}{\pi}\left[\cos(\theta+\alpha)\right]_0^{\pi}$

$= \frac{-V_m}{\pi}\left[\cos(\pi+\alpha) - \cos\alpha\right]$

$\Rightarrow \boxed{\overline{V_{ch}} = \frac{2V_m}{\pi}\cos\alpha}$

$\cos\alpha = \frac{\overline{V_{ch}}.\pi}{2.V_m} = \frac{99.\pi}{2\times 220\sqrt{2}} = 0{,}499 \simeq 0{,}5 \Rightarrow \boxed{\cos\alpha = 60°}$

b/ $i_{ch}(t) = ?$

on a : $R i_{ch}(t) + L\frac{di_{ch}}{dt} = V_{ch}(t) = V_m \sin(\omega t+\alpha)$

$\Rightarrow \boxed{i_{ch}(t) = \frac{V_m}{Z}\sin(\omega t+\alpha-\varphi) + A e^{-t/\tau}}$

avec : $\tau = L/R = \frac{4}{\omega.R} = \frac{4}{314.3} = 0{,}004\ 2.$

$Z = \sqrt{(3)^2+(4)^2} = 5\ \Omega$

$\varphi = tg^{-1}\frac{L\omega}{R} = tg^{-1}\frac{4}{3} = 53{,}13°$

a partir de la condition initiale $i_{ch}(0) = 0$

$\frac{V_m}{Z}\sin(\alpha-\varphi) + A = 0 \Rightarrow A = \frac{-220\sqrt{2}}{Z}\sin(\alpha-\varphi)$

$\Rightarrow A = \frac{-220\sqrt{2}}{5}\sin(60-53{,}13)$, d'où $\boxed{A = -7{,}44}$

$\Rightarrow i_{ch}(t) = \frac{220\sqrt{2}}{5}\sin(\omega t+\alpha-\varphi) - 7{,}44 e^{-t/\tau}$

donc : $\boxed{i_{ch}(t) = 62{,}22\sin(\omega t + 6{,}87) - 7{,}44 e^{-t/0{,}042}\ (A)}$

*** Exercice 2:**

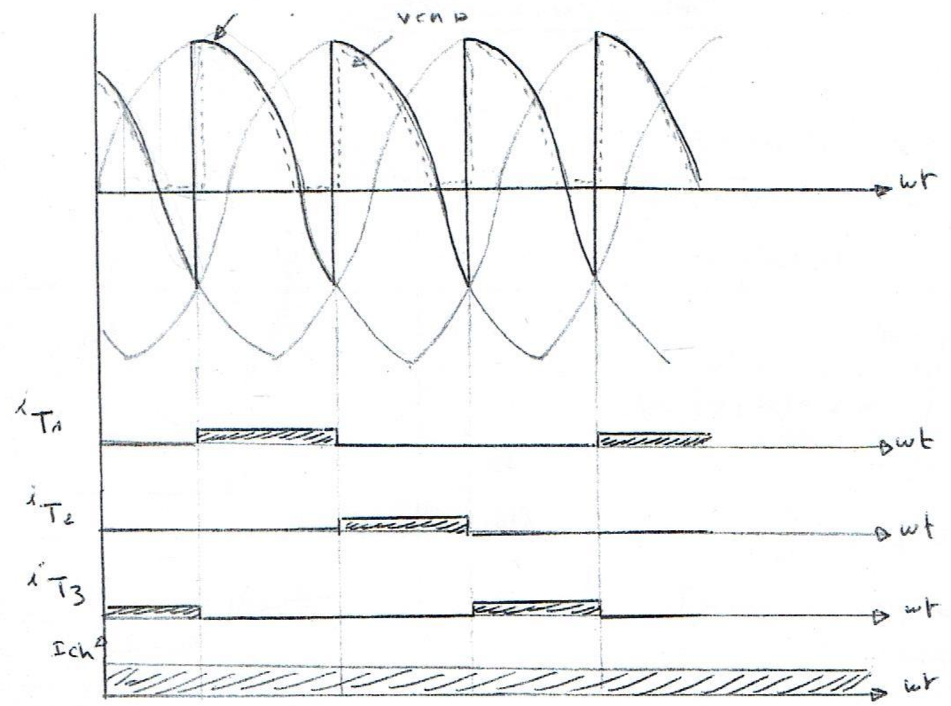
a/ L'allure de vch.

b/ $\overline{V_{ch}} = ?$

$\overline{V_{ch}} = \frac{1}{T}\int_0^T v_{ch}(t)\cdot dt = \frac{1}{2\pi/3}\int_{\pi/6+\alpha}^{5\pi/6+\alpha} \sin\theta\cdot d\theta$

$\overline{V_{ch}} = \frac{-3V_m}{2\pi}\left(\cos(\alpha+5\pi/6) - \cos(\alpha+\pi/6)\right)$

$\alpha = 60$



$\cos(\alpha + 5\pi/6) = \cos\alpha \cdot \cos 5\pi/6 - \sin\alpha \cdot \sin 5\pi/6 = -\frac{\sqrt{3}}{2} \cdot \cos\alpha - \frac{1}{2}\sin\alpha \longrightarrow ①$

$\cos(\alpha + \pi/6) = \cos\alpha \cdot \cos\pi/6 - \sin\alpha \cdot \sin\pi/6 = \frac{\sqrt{3}}{2}\cos\alpha - \frac{1}{2}\sin\alpha \longrightarrow ②$

$① - ② = -\frac{\sqrt{3}}{2}\cos\alpha - \frac{\sqrt{3}}{2}\cos\alpha = -\sqrt{3} \cdot \cos\alpha$

$\bar{V}ch = -\frac{3Vm}{2\pi}(-\sqrt{3})$ d'ou $\boxed{\bar{V}ch = \frac{3\sqrt{3}}{2\pi} Vm \cos\alpha}$

AN: $\bar{V}ch = \frac{3\sqrt{3} \cdot 300}{2\pi}\cos 60 = 123,96\ V$

c/ $I_1eff = ?$

$$I_1eff^2 = \frac{1}{T}\int_0^T i_1^2(t)\, dt = \frac{1}{2\pi}\int_{\alpha+\pi/6}^{\alpha+5\pi/6} Ich^2 \cdot d\theta = \frac{Ich^2}{2\pi}\,\theta\Big|_{\alpha+\pi/6}^{\alpha+5\pi/6} = \frac{Ich^2}{2\pi}\left(\cancel{\alpha} + 5\pi/6 - \cancel{\alpha} - \frac{\pi}{6}\right)$$

$$I_1eff^2 = \frac{Ich^2}{2\pi}\left(\frac{4\pi}{6}\right) = \frac{Ich^2}{\cancel{2\pi}}\left(\frac{\cancel{2\pi}}{3}\right)$$

d'ou $\boxed{I_1eff = \frac{Ich}{\sqrt{3}}}$

AN: $I_1ff = \frac{50}{\sqrt{3}} = 28,9\,(A)$

3/ on pose une diode en // avec la charge (diode de roue libre Dr)

a/ L'allure vch

b/ $\bar{v}ch = ?$

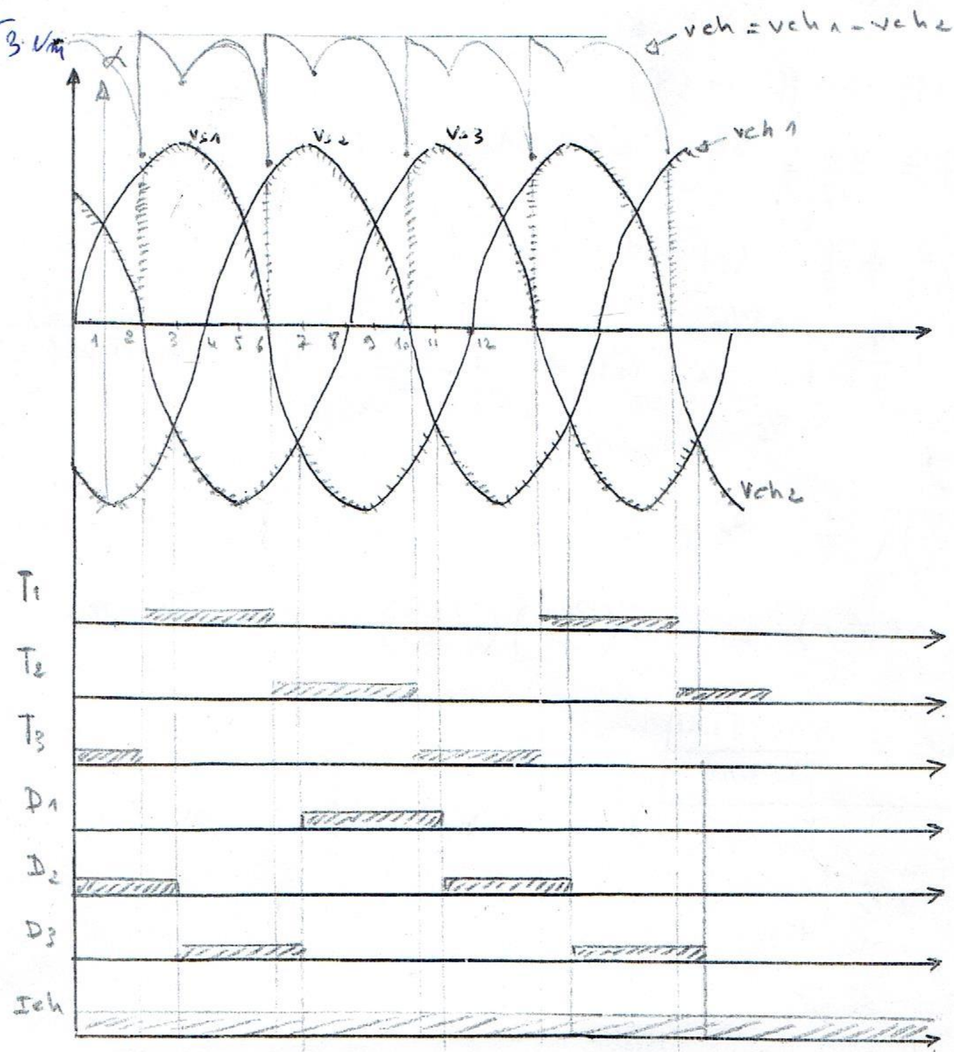
$$Vch = \frac{1}{T}\int_0^T vch(\theta) \cdot d\theta = \frac{1}{2\pi/3}\left[\int_{\pi/6+\pi/6}^{\pi/6+\frac{\pi}{3}} 0 \cdot d\theta + \int_{\pi/3+\pi/6}^{\alpha+5\pi/6} \sin\theta\, d\theta\right]$$

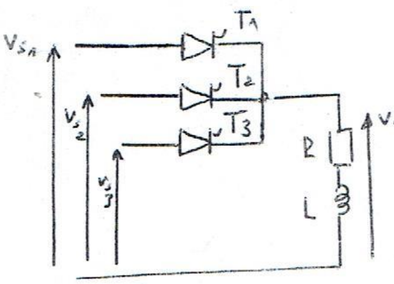
$$Vch = \frac{3}{2\pi} Vm\left(-\cos\theta\right)\Big|_{\pi/2}^{\pi} \Rightarrow vch = \frac{3Vm}{2\pi} = \frac{3\,(300)}{2\pi} = 143,23\ V$$

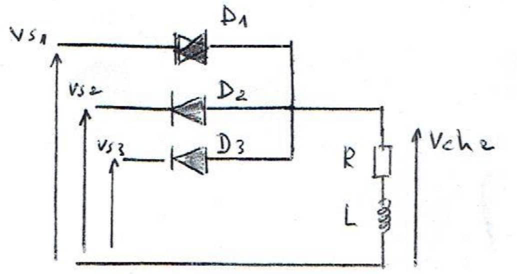
c/ Dr "Elimination de alternance (−)"

eo:

$\alpha = 30^\circ$







c/ $\overline{V_{ch}} = ?$

$$\overline{V_{ch}} = \frac{1}{T}\int_0^T v_{ch}(\theta)\,d\theta = \frac{1}{2\pi/3}\int_{\pi/6+\alpha}^{\pi/6+\alpha+\pi/6}(V_{s1}-V_{s2})\,d\theta + \int_{\pi/6+\alpha+\pi/6}^{\alpha+5\pi/6}(V_{s1}-V_{s3})\,d\theta$$

$$\overline{V_{ch}} = \frac{3}{2\pi}\int \sqrt{3}\,V_m \sin(\theta+\pi/6)\,d\theta + \int \sqrt{3}\,V_m \sin(\theta-\pi/6)\,d\theta$$

$$\overline{V_{ch_1}} = \frac{3\sqrt{3}}{2\pi}V_m\cos\alpha$$

$$V_{ch2} = -\frac{3\sqrt{3}}{2\pi}V_m\cos\alpha$$

$$\Rightarrow \boxed{V_{ch} = v_{ch_1} - V_{ch} = \frac{3\sqrt{3}}{2\pi}V_m(1+\cos\alpha)}$$

AN: $v_{ch} = \frac{3\sqrt{3}}{2\pi}\cdot 311\cdot(1+\cos 30) =$

$\cdot P_{ch} = \overline{V_{ch}} \cdot \overline{I_{ch}}$

$\cdot P_s = 3 \cdot V_{s1eff} \cdot I_{1eff} \cdot \cos\varphi$

avec : $\cdot V_{s1eff} = \frac{V_m}{\sqrt{2}} = \frac{311}{\sqrt{2}} = 219{,}91 \ V$

$\cdot I_{1eff}^2 = \frac{1}{T}\int_0^T i_1(\theta) \cdot d\theta$

$= \frac{1}{2\pi}\int_{\alpha+\pi/6}^{\alpha+5\pi/6} i_{ch}^2(\theta) \cdot d\theta = \frac{I_{ch}^2}{\cancel{2\pi}}\left(\cancel{2\pi}/3\right)$, d'où $\boxed{I_{1eff} = \frac{I_{ch}}{\sqrt{3}}}$

donc :

$P_s = 3 \cdot \left(\frac{311}{\sqrt{2}}\right)\left(\frac{I_{ch}}{\sqrt{3}}\right) \cdot \cos\varphi =$

$P_s \approx P_{ch} \ (\Delta P \approx 0) \Rightarrow 3\left(\frac{311}{\sqrt{2}}\right)\left(\underbrace{\frac{I_{ch}}{\sqrt{3}}}\right)\cos\varphi = \overline{V_{ch}} \cdot \overline{I_{ch}}$

$\Rightarrow \boxed{\cos\varphi = \frac{V_{ch} \cdot \sqrt{3} \cdot \sqrt{2}}{3 \cdot 311}}$

AN $\quad \cos\varphi =$

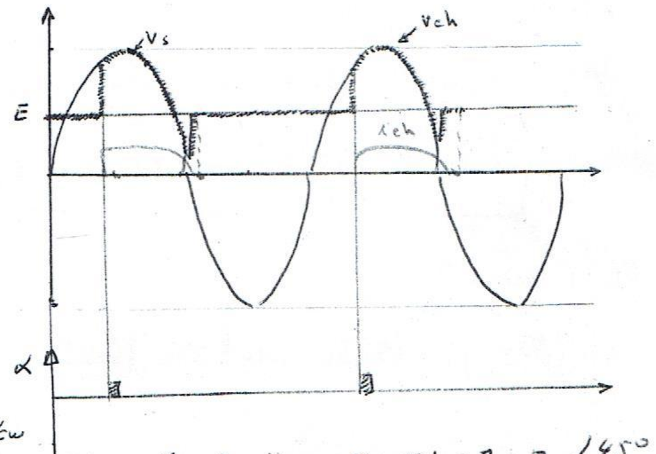
Série d'exercice 3

Exercice 1 :

$\alpha = 60°$

a/ $V_{ch} = V_s \Rightarrow V_m \sin \omega t = R i_{ch} + L \frac{di_{ch}}{dt} + E$

$$\boxed{i_{ch}(t) = \frac{V_m}{Z} \sin(\omega t - \varphi) + A e^{-t/\tau} - \frac{E}{R}}$$



$A = ?$

$i_{ch}(\alpha/\omega) = 0$

$i_{ch}(\alpha/\omega) = \frac{V_m}{Z} \sin(\alpha - \varphi) + A e^{-\frac{\alpha}{\tau\omega}} - E/R = 0$

$$A = \frac{-\frac{V_m}{Z} \sin(\alpha - \varphi) + \frac{E}{R}}{e^{-\alpha/\tau\omega}} \Rightarrow A = \left[\frac{V_m}{Z} \sin(\varphi - \alpha) + \frac{E}{R}\right] e^{\alpha/\tau\omega}$$

avec : $Z = R + jL\omega = 5 + 5j = 7{,}07 \angle 45°$

$L\omega = 5 \Rightarrow L = \frac{5}{\omega} = \frac{5}{314} = 0{,}0159\ H$

$\tau = L/R = \frac{0{,}0159}{5} = 0{,}0031$

AN :

$$A = \left(\frac{300}{7{,}07} \sin(45 - 60) + \frac{150}{5}\right) e^{\frac{\pi}{3.(314)(0{,}0031)}} =$$

$= 19{,}017 . (2{,}9307) \Rightarrow \boxed{A = 54{,}196}$

$i(60) = 0$

$i(180) = 2{,}34\ A$

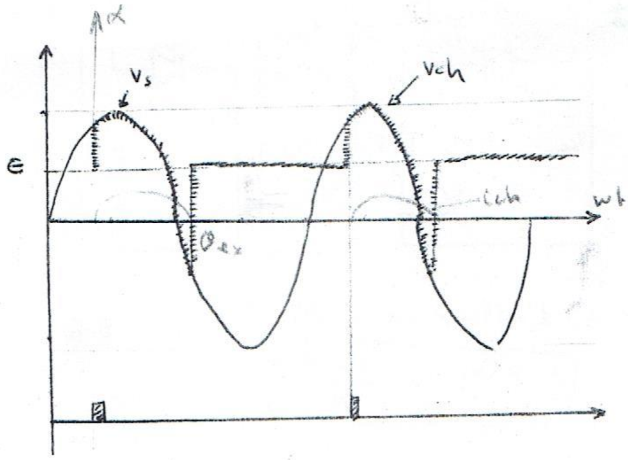
$i(240) = -10{,}4\ A$

donc : $\boxed{i_{ch}(t) = 42{,}43 \sin(\omega t - 45) + 54{,}196\ e^{-314\,t} - 30 \quad (A)}$

Exercice 2 :

$V_s = 500 \sin(\omega t + \alpha)$, $\alpha = 60°$

a/ $\alpha_{min} = ?$



$V_s = E \Leftrightarrow 500 \sin(\alpha_{min} + \cancel{\alpha}^{0}) = E$

$\Rightarrow \alpha_{min} = \arcsin \frac{E}{500} = \frac{200}{500} = 0{,}4$

$\Rightarrow \boxed{\alpha_{min} = 23{,}57°}$

b/ L'allure de Vcharge. (V_{ch})

c/ L'expression du courant de charge $i_{ch}(t) = ?$

$V_s = V_{ch}$

$\Rightarrow V_m \sin(\omega t + \alpha) = R i_{ch} + L \frac{di}{dt} + E$

$$\Rightarrow \boxed{i_{ch}(t) = \frac{V_m}{Z} \sin(\omega t + \alpha - \varphi) + A e^{-t/\tau} - \frac{E}{R}}$$

$A = ?$

$i_{ch}(\alpha/\omega) = 0$ avec $\alpha = 0$ (l'axe) $\Rightarrow i_{ch}(0) = 0$

$i_{ch}(0) = \frac{V_m}{Z} \sin(\alpha - \varphi) + A - E/R \Rightarrow \boxed{A = \frac{V_m}{Z} \sin(\varphi - \alpha) + E/R}$

$Z = R + jL\omega = 10 + 10j = 14,14 \angle$; $L\omega = 10 \Rightarrow L = \frac{10}{314} = 0,0318$

$\tau = \frac{L}{R} = \frac{0,0318}{10} = 0,003$

AN : $A = \frac{500}{14,14} \sin(45 - 60) + \frac{200}{10} = 10,84$.

donc : $i_{ch}(t) = 35,36 \sin(314t + 60 - 45) + A e^{-t/\tau} - \frac{200}{10}$

$$\boxed{i_{ch}(t) = 35,36 \sin(314t + 15) + 10,84 e^{-314t} - 20 \quad (A)}$$

e/ $\theta_{ext} = ?$

$$i_{ch}\left(\frac{\theta_{ext}}{\omega}\right) = 35,36 \sin\left[314 \cdot \left(\frac{\theta_{ext}}{314}\right) + \frac{\pi}{12}\right] + 10,84 e^{-314 \cdot \left(\frac{\theta_{ext}}{314}\right)} - 20$$

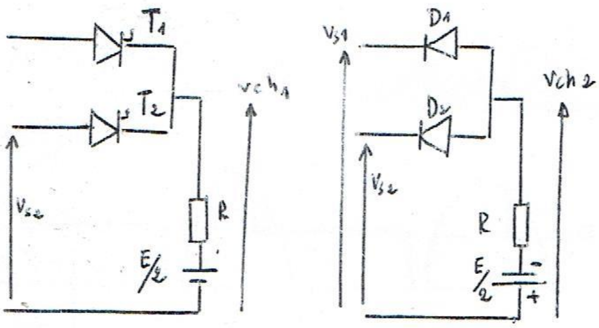
$$i_{ch}\left(\frac{\theta_{ext}}{\omega}\right) = 35,36 \sin\left(\theta_{ex} + \frac{\pi}{12}\right) + 10,84 e^{\theta_{ex}} - 20 = 0$$

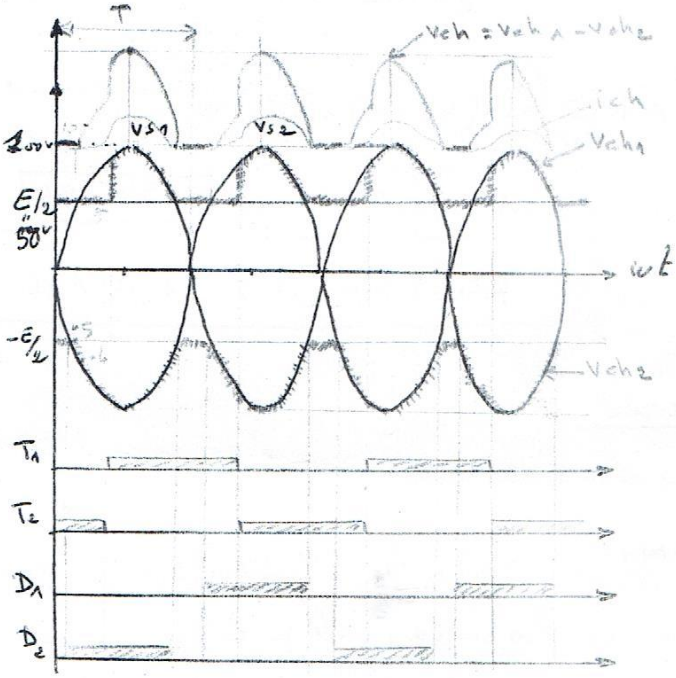
Exercice 3 :

$V_s = 200 \cdot \sin(314t)$, $R = 1\,\Omega$

$E = 100\,V$, $\alpha = 60°$

a/ tracer l'allure de $v_{ch}(t) = ?$





b/ L'allure de $i_{ch}(t)$.

$$\boxed{i_{ch}(t) = \frac{v_{ch} - E}{R}}$$

c/ $v_s = E \Rightarrow V_m \sin(\alpha_{min}) = E \Rightarrow \alpha_{min} = \arcsin \frac{E}{V_m} = \sin \frac{100}{200} = 0,5$

$$\Rightarrow \boxed{\alpha = 30°}$$

d/ $\bar{v}_{ch} = \frac{1}{T} \int_0^T v_{ch}(\theta) \cdot d\theta$

$$\bar{v}_{ch} = \frac{1}{\pi}\left[\int_0^{30} E \cdot d\theta + \int_{30}^{60} (v_s - E) \cdot d\theta + \int_{60}^{\pi - 30} E \cdot d\theta\right]$$

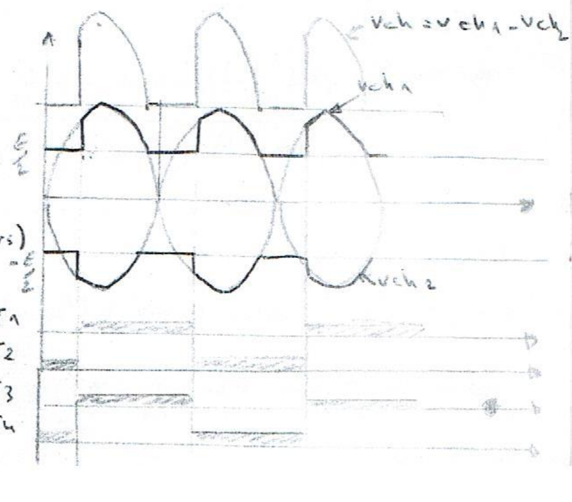
Remarque : si le pont est totalement commandé. (tout thyristors)

$$\Rightarrow v_{ch} = \frac{1}{\pi} \int_0^{60} E\,d\theta + \int_{60}^{\pi - 30} v_s\,d\theta + \int_{\pi-30}^{\pi} E \cdot d\theta$$

rad

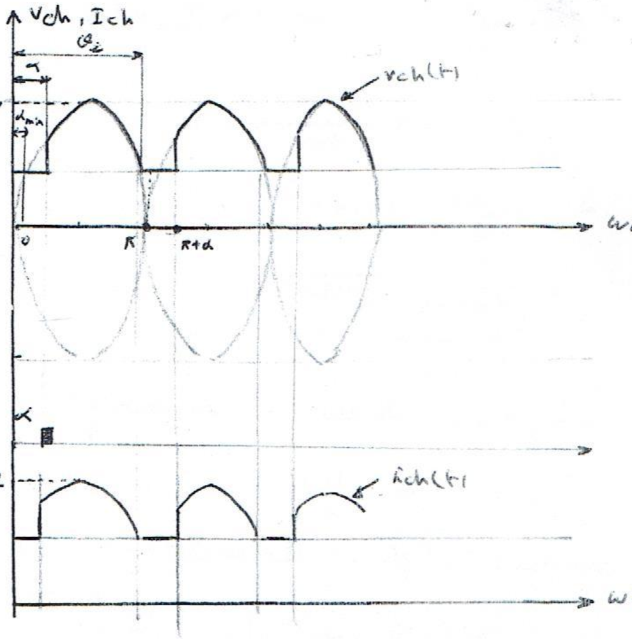
rad

$$\boxed{v_{ch} = 136,96\ V}$$



Exercice 4:

1/a/ Les allures de la tension $v_{ch}(t)$ et $I_{ch}(t)$



/ calcule de la résistance de la charge R.

au debut, on calcule la valeur moyenne de la tension de la charge.

$$\bar{V}_{ch} = \frac{1}{T}\int_0^T V_{ch}(t)\cdot dt$$

$$= \frac{1}{\pi}\int_\alpha^{\theta_2} V_m \sin\theta \cdot d\theta + \frac{1}{\pi}\int_{\theta_2}^{\pi+\alpha} E\cdot d\theta$$

$$\bar{V}_{ch} = \frac{V_m}{\pi}(\cos\alpha - \cos\theta_2) + \frac{E}{\pi}(\pi + \alpha - \theta_2)$$

avec:

$\theta_2 = \pi - \arcsin\frac{E}{V_m} = \pi - \arcsin 24/169{,}7^{rad} = \pi - 0{,}141 = 2{,}998\,\text{rad} \Rightarrow \boxed{\theta_2 = 171{,}87°}$

$\Rightarrow \boxed{\bar{V}_{ch} = 105{,}34\,V}$

ou: $\bar{V}_{ch} = R\,\bar{i}_{ch} + E$ donc: $R = \frac{\bar{V}_{ch} - E}{\bar{i}_{ch}} = 13{,}55\,\Omega \Rightarrow \boxed{R = 13{,}55\,\Omega}$

/ determination de la puissance absorbée par la résistance:

$P_R = R\cdot i_{ch\,eff}^2$, par contre $i_{ch\,eff}^2 = \frac{1}{T}\int_0^T i_{ch}^2(t)\,dt$

$$i_{ch\,eff}^2 = \frac{1}{\pi}\int_\alpha^{\theta_2}\left(\frac{V_m \sin\theta - E}{R}\right)^2 d\theta$$

$$= \frac{1}{\pi R^2}\int_\alpha^{\theta_2}(V_m^2\sin^2\theta + E^2 - 2E\,V_m\sin\theta)\,d\theta = 52{,}306$$

$\boxed{\text{alors } i_{ch\,eff} = 7{,}23(A)} \Rightarrow \boxed{P_R = R\cdot i_{ch\,eff}^2 = 709{,}27\,W}$

2/ Calcul du rendement:

$$\eta = \frac{P_{batterie}}{P_{batterie} + P_R} = \frac{6\times 24}{2\times 24 + 709{,}27} = 0{,}1688 \;\; \text{donc:} \; \boxed{\eta = 16{,}88\,\%}$$

Exercice 5:

a/ L'allure de $v_1(t)$, $v_2(t)$, $v_3(t)$ et $v_{ch}(t)$

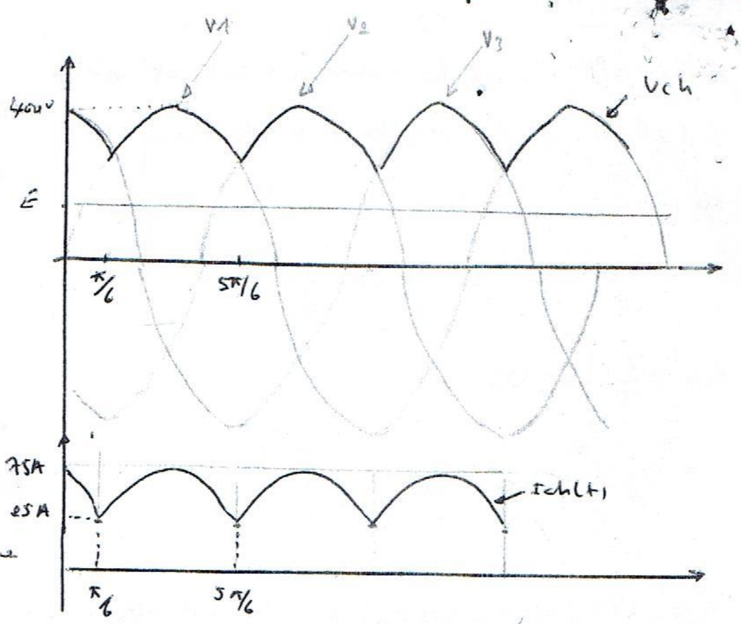
- Une diode conduit pour la tension la plus postif et suppérieur à E.
- pour avoir l'allure exacte de la tension $v_{ch}(t)$ on doit savoir la valeur de l'angle minimale de l'amorsage de thyristor) (diode) ⇔ $V_{s1} = E$. (L'angle d'entersection entre V_1 et E)

On pose $V_1 = E \Rightarrow 400 \sin \alpha_{min} = 100$

$\Rightarrow \sin \alpha_{min} = \left(\dfrac{100}{400}\right) =$

$\Rightarrow \sin^{-1} \dfrac{100}{400} = 14{,}47°$

$\Rightarrow \boxed{\alpha_{min} = 14{,}47°}$



c/ L'expression du courant de charge.

$R.i_{ch}(t) + E = V_{ch}$

- pendant la phase de conduction de la diode D_1 ($\pi/6 \to 5\pi/6$) :

$R\, i_{ch}(t) + E = V_1 = 400 \sin 314\, t$

$\Rightarrow i_{ch}(t) = \dfrac{400 \sin 314}{R} - \dfrac{E}{R}$, d'où $\boxed{i_{ch}(t) = 100 \sin 314t - \dfrac{E}{R}}$ (A)

donc : $\boxed{i_{ch}(t) = 100 \sin 314t - 25}$ A

d/ $\overline{V_{ch}}$; $\overline{I_{ch}}$; $\overline{I_{D1}} = ?$

- $\overline{V_{ch}} = \dfrac{1}{T}\displaystyle\int_0^T V_{ch}(t) \cdot dt = \dfrac{3}{2\pi}\int_{\pi/6}^{5\pi/6} V_m \sin\theta \cdot d\theta$

$= \dfrac{-3\,V_m}{2\pi}\left[\cos\theta\right]_{\pi/6}^{5\pi/6} = \dfrac{-3V_m}{2\pi}\left[\cos 5\pi/6 - \cos \pi/6\right] = \dfrac{3\sqrt{3}\,V_m}{2\pi}$

$\Rightarrow \boxed{\overline{V_{ch}} = 330{,}8\ (V)}$

- $\overline{i_{ch}} = ?$, on a : $R\,i_{ch}(t) + E = V_{ch}$

$\Rightarrow \dfrac{1}{T}\displaystyle\int_0^T R . i_{ch}(t) + \dfrac{1}{T}\int_0^T E + \dfrac{1}{T}\int_0^T V_{ch}(t)$

$\Rightarrow R\,\overline{i_{ch}} + E = \overline{V_{ch}} \Rightarrow \overline{i_{ch}} = \dfrac{\overline{V_{ch}} - E}{R} = \dfrac{330{,}8 - 100}{4} = 57{,}7\,A$

$\boxed{\overline{i_{ch}} = 57{,}7\ A}$

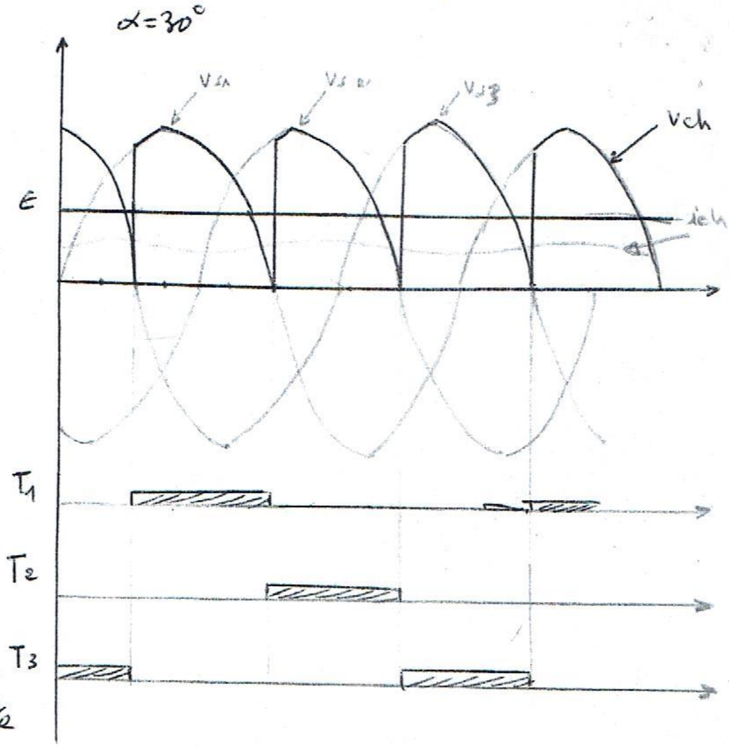
- $\overline{I_{D1}}$. D'après le principe de fonctionnement du montage, on peut déduire que :

$\overline{i_{D1}} = \dfrac{\overline{I_{ch}}}{3} = \dfrac{57{,}7}{3} = \boxed{19{,}23\ (A)}$

- $\overline{I_{Dc}} = \dfrac{1}{2\pi}\displaystyle\int_{\pi/6}^{5\pi/6} \overline{I_{ch}}(\theta) . d\theta = \dfrac{\overline{I_{ch}}}{2\pi}\, \theta \Big|_{\pi/6}^{5\pi/6} = \dfrac{\overline{I_{ch}}}{2\pi}\left(5\pi/6 - \pi/6\right)$

$\Rightarrow \boxed{\overline{I_{Dc}} = \dfrac{\overline{I_{ch}}}{3}}$

Exercice 6 :



$V_{ch} = V_s \Leftrightarrow$

$V_m \sin \omega t = R\, i_{ch}(t) + L \frac{d i_{ch}}{dt} + E$

$$\Rightarrow \boxed{i_{ch}(t) = \frac{V_m}{Z} \sin(\omega t - \varphi) + A e^{-t/\tau} - \frac{E}{R}}$$

$i_{ch}(\pi/6 + \alpha) = I_1$

$i_{ch}(\pi/6 + \alpha + 2\pi/3) = I_1$

- $i_{ch}(\pi/6+\alpha) = \frac{V_m}{Z} \sin(\pi/6 + \alpha - \varphi) + A e^{-\frac{(\pi/6+\alpha)}{\tau\omega}} - \frac{E}{R}$
- $i_{ch}(\pi/6+\alpha+\frac{2\pi}{3}) = \frac{V_m}{Z} \sin(\pi/6 + \alpha + \frac{2\pi}{3} - \varphi) + A e^{-(\pi/6+\alpha+\frac{2\pi}{3})/\tau\omega} - E/R$

avec : $\alpha = \pi/6$,

$R + jL\omega = 4 + j3 = 5 \angle 36{,}86°$ (Ω) ; $|Z| = 5\ \Omega$. $\varphi = 36{,}86°$

$\tau = L/R = \frac{0{,}0095}{4} = 0{,}0023$, $L = \frac{3}{314} = 0{,}0095$ H

$\boxed{A = 53{,}53}$

$\boxed{I_1 = 11{,}79}$

donc : $\boxed{i_{ch}(t) = 60 \sin(314 t - 36{,}86) + 53{,}53\, e^{-418{,}66 t} - 25}$ (A)