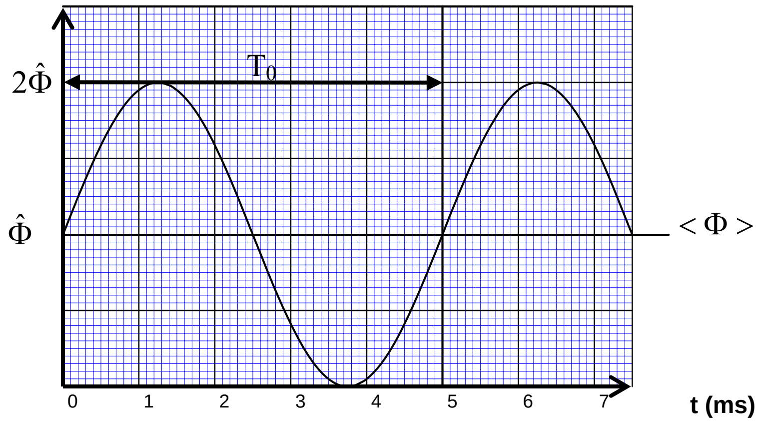
Etude d'un analyseur d'Ozone

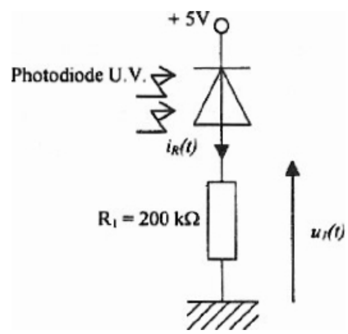
Partie 1 : Etude de la fonction F_1 : détecteur optique.

1.a)



$$\Phi(t) = \hat{\Phi}\left[1 + \sin(2\pi F_0 t)\right]$$

$$T_0 = \frac{1}{F_0} = 5\ ms \rightarrow F_0 = \frac{1}{T_0} = \frac{1}{5\times10^{-3}} = 200\ Hz$$



1.b)

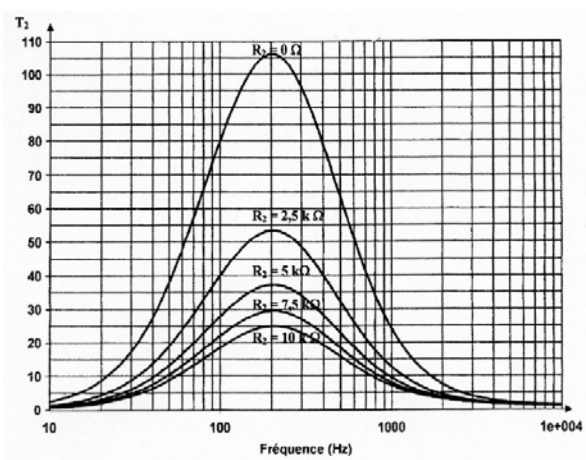
Loi d'Ohm : $u_1(t) = R_1 i_R(t) = R_1\gamma\Phi(t) = R_1\gamma\ \hat{\Phi}\left[1 + \sin(2\pi F_0 t)\right] = R_1\gamma\hat{\Phi} + R_1\gamma\hat{\Phi}\sin(2\pi F_0 t)$

$u_1(t) = \langle u_1\rangle + \hat{U}_1 \sin(2\pi F_0 t)$. En identifiant : $\langle u_1\rangle = \hat{U}_1 = R_1\gamma\widehat{\Phi}$.

1.c)

- Pour $\hat{\Phi}$ = 1,5 µW = $1,5\times10^{-6}$ W, $\langle u_1\rangle = \hat{U}_1 = 200\times10^3\times0,1\times1,5\times10^{-6} = 3,0\times10^{-2}$ V = 30 mV
- Pour $\hat{\Phi}$ = 5,0 µW = $1,5\times10^{-6}$ W, $\langle u_1\rangle = \hat{U}_1 = 200\times10^3\times0,1\times5,0\times10^{-6} = 1,0\times10^{-1}$ V = 100 mV

Partie n°2 : Etude de la fonction F_2 : amplification et filtrage.



2.a) D'après le diagramme de Bode, la fonction F2 réalise un filtre passe bande.

2.b) pour f = 200 Hz, $|\underline{U_2}| = |\underline{T_2}|\times|\underline{U_1}|$

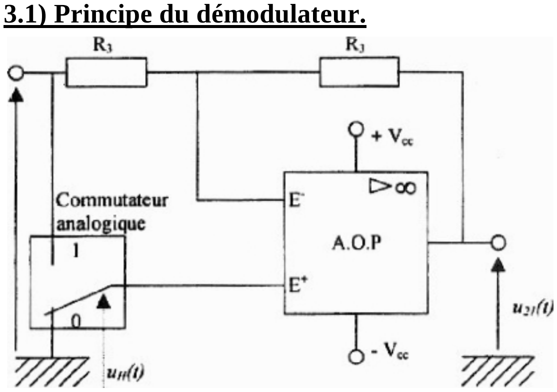
soit $\hat{U}_2 = |\underline{T_2}|\hat{U}_1 = 2\times10^4|\underline{T_2}|\ \hat{\Phi} = \beta\hat{\Phi}$ avec $\beta = 2\times10^4|\underline{T_2}|$

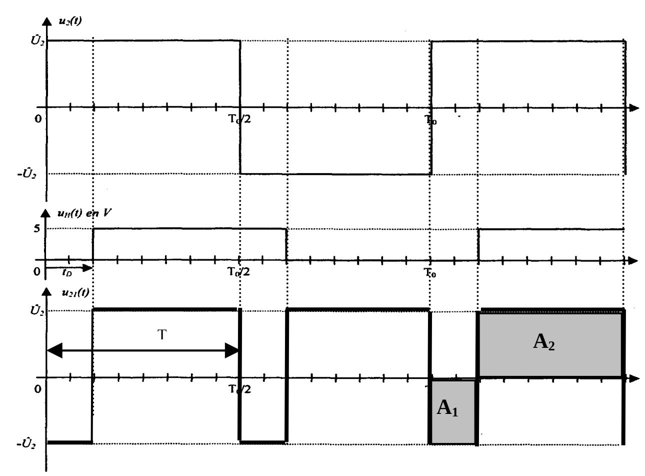
2.c) Pour R = 0 Ω, $|\underline{T_2}| = 106 \rightarrow \beta = 2\times10^4\times106 = 2,12\times10^6$ V/W

Pour R = 10 kΩ, $|\underline{T_2}| = 25 \rightarrow \beta = 2\times10^4\times25 = 5,0\times10^5$ V/W

Partie *n ° 3 :* Etude de la fonction F_3 : démodulateur synchrone.

3.1) Principe du démodulateur.





3.1.b) $T = \frac{T_0}{2} \rightarrow f = 2F_0$

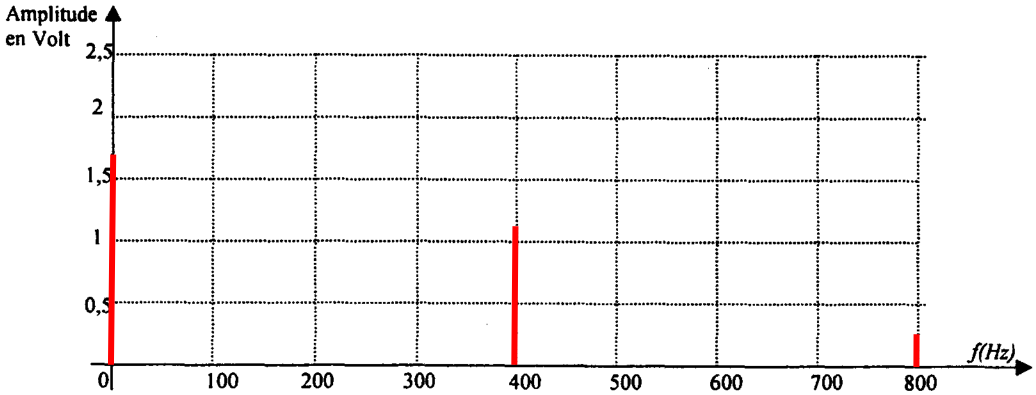
3.1.c) $<u_{21}> = \frac{1}{T}(A_2 - A_1) = \frac{2}{T_0}\left[\left(\frac{T_0}{2} - t_D\right)\times \hat{U}_2 - t_D \times \hat{U}_2\right] = \hat{U}_2\left(1 - 2\frac{t_D}{T_0} - 2\frac{t_D}{T_0}\right) = \hat{U}_2\left(1 - 4\frac{t_D}{T_0}\right)$

3.2) Application du démodulateur.

3.2.a) $<u_{21}> = \frac{2\hat{U}_2}{\pi} = \frac{2\times 2,60}{\pi} = 1,66\ V$

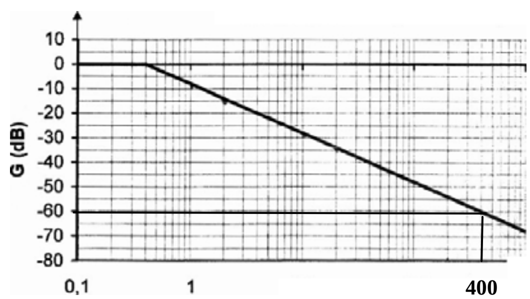
$\hat{U}_{21f} = \frac{4\hat{U}_2}{3\pi} = \frac{2}{3}<u_{21}> = 1,10\ V$; $\hat{U}_{21h2} = \frac{4\hat{U}_2}{15\pi} = \frac{2}{15}<u_{21}> = 0,22\ V$

3.2.b)



3.2.c)

Le filtre est du premier ordre car l'atténuation est de 20 dB/décade.



3.2.d) $G_0 = 0 \rightarrow T_0 = 1 \rightarrow <u_3> = <u_{21}> = 1,66$ V

3.2.e) $G_{400} = -60$ dB et $G_{400} = 20\log T_{400} \rightarrow T_{400} = 10^{\frac{G_{400}}{20}}$

$T_{400} = 10^{-\frac{60}{20}} = 10^{-3}$; $\hat{U}_{3f} = T_{400}\hat{U}_{21f} = 10^{-3}\times 1,10 = 1,10\times 10^{-3}$ V

3.2.f) $\delta = \frac{\hat{U}_{3f}}{<u_3>} = \frac{1,10\times 10^{-3}}{1,66} = 6,6\times 10^{-4} = 0,07\%$

$u_3(t)$ est quasi continue : $u_3(t) = <u_3> = 1,66$ V

<u>Partie n°4 :</u> Etude de la fonction F_4 : décalage, mise à niveau.

$$u_{ref}(t) = 18\left(u_3(t) - \frac{u_R(t)}{2}\right) \quad u_4(t) = \frac{-2^{12}}{N_C}u_{ref}(t) = \frac{-2^{12}}{N_C}18\left(u_3(t) - \frac{u_R(t)}{2}\right)$$

4.b) $N_D = 2^{10} - 1 = 1023$

4.c) $$N_D = 2^{10}\frac{u_4(t)}{u_R(t)} = \frac{-2^{10}\times 2^{12}\times 18}{N_C u_R(t)}\left(u_3(t) - \frac{u_R(t)}{2}\right) = \frac{-9\times 10^{23}}{u_R(t)N_C}\left(u_3(t) - \frac{u_R(t)}{2}\right)$$

$$N_D = \frac{-9\times 10^{23}}{u_R(t)N_C}\left(u_3(t) - \frac{u_R(t)}{2}\right) = \frac{9\times 10^{23}}{N_C}\left(\frac{1}{2} - \frac{u_3(t)}{u_R(t)}\right) = \frac{A}{N_C}\left(B - \frac{u_3(t)}{u_R(t)}\right)$$

$A = 9\times 10^{23}$; $B = \frac{1}{2}$

Partie n°5 : Algorithme de traitement numérique.

5.a) $s_n = 0{,}25\,(e_n + e_{n-1} + e_{n-2} + e_{n-3})$

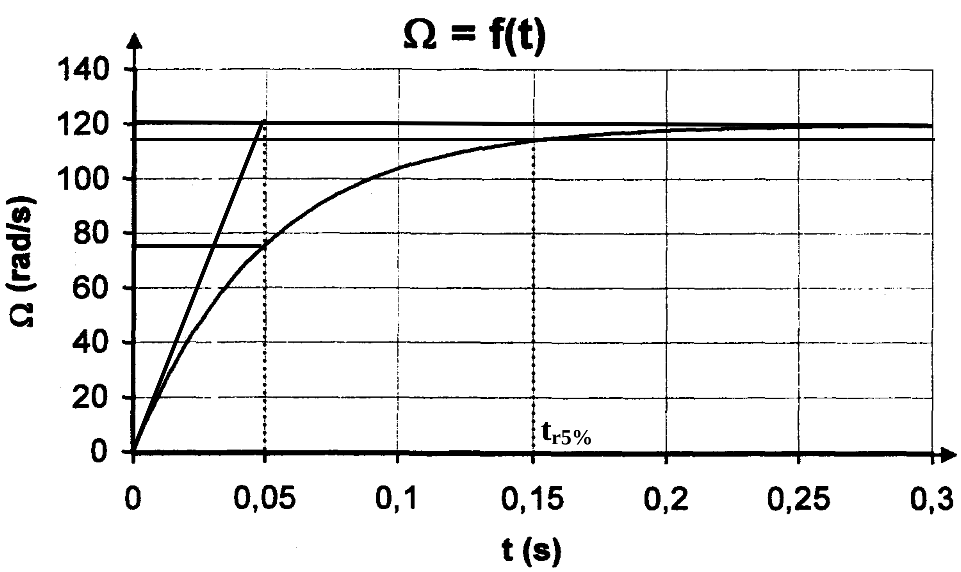
n	-3	-2	1	0	1	2	3	4	5	6	7	8	9	10
e_n	0	0	0	1000	1020	1000	980	1020	990	1000	990	980	1010	1000
s_n	0	0	0	250	505	755	1000	1005	997,5	997,5	1000	990	995	995

5.b) $S(z) = 0{,}25[\,E(z) + z^{-1}E(z) + z^{-2}E(z) + z^{-3}E(z)] = 0{,}25E(z)\,[\,1 + z^{-1} + z^{-2} + z^{-3}]$

$$T(z) = \frac{S(z)}{E(z)} = \frac{0{,}25}{1 + z^{-1} + z^{-2} + z^{-3}} = \frac{0{,}25z^3}{1 + z + z^2 + z^3}$$

<u>Partie n°6 :</u> Etude de la fonction Fs : contrôle de la vitesse de rotation.

6.a)



$t_{r5\%} = 3\tau = 0{,}15\ s$

$\Omega_\infty = 120$ rad/s

6.b) $K_0 = \dfrac{\Omega_\infty - \Omega_0}{U_\infty - U_0}$

$K_0 = \dfrac{120}{12} = 10\ rad.s^{-1}.V^{-1}$

$t_{r5\%} = 3\tau = 0{,}15\ s \rightarrow \tau = 0{,}05\ s$

6.c) $K_0u(t) = \tau\dfrac{d\Omega(t)}{dt} + \Omega(t).$

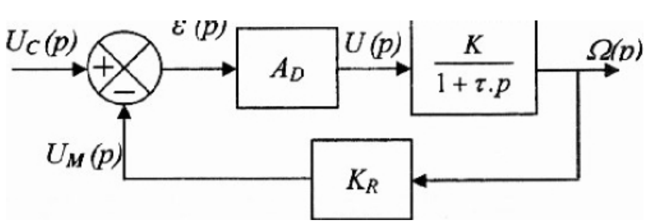
$K_0U(p) = \tau p\Omega(p) + \Omega(p)$

$K_0U(p) = \Omega(p)\left(1+p\tau\right) \rightarrow T_M(p) = \dfrac{\Omega(p)}{U(p)} = \dfrac{K_0}{\left(1+p\tau\right)}$

6.d) $T_M(p) = \dfrac{\Omega(p)}{U(p)} \rightarrow \Omega(p) = T_M(p)\times U(p)$ et $U(p) = \dfrac{U}{p} \rightarrow \Omega(p) = \dfrac{UK_0}{\left(1+p\tau\right)p}.$

6.e) $\Omega(t) = UK_0\left(1 - e^{-\frac{t}{\tau}}\right)$

6.f) $\Omega_\infty = UK_0 = 10\times 10 = 100\ rad/s.$



6.g) $T_{BF}(p) = \dfrac{\Omega(p)}{U_C(p)} = \dfrac{\left(\dfrac{A_DK}{1+p\tau}\right)\varepsilon(p)}{U_C(p)} = \dfrac{\left(\dfrac{A_DK}{1+p\tau}\right)[\,U_C(p) - U_M(p)]}{U_C(p)}$

$$T_{BF}(p) = \frac{\left(\dfrac{A_DK}{1+p\tau}\right)[\,U_C(p) - K_R\Omega(p)]}{U_C(p)} = \left(\frac{A_DK}{1+p\tau}\right)\left(1 - K_R\,T_{BF}(p)\right) = T_{BF}(p) = K_R\,T_{BF}(p)$$

$$T_{BF}(p)\left[1+\left(\frac{A_D K_R K}{1+p\tau}\right)\right]=\left(\frac{A_D K}{1+p\tau}\right)\rightarrow T_{BF}(p)=\frac{\left(\frac{A_D K}{1+p\tau}\right)}{\left[1+\left(\frac{A_D K_R K}{1+p\tau}\right)\right]}=\frac{A_D K}{1+A_D K_R K+p\tau}$$

6.h) La vitesse de rotation du moteur asservi suit la variations de $u_C(t)$

<u>Partie 7 :</u> Etude d'une mesure.

$K.D.C= 1,22\times10^{-8}N_C(N_{DM}-N_{D0})$

$$C=\frac{1,22\times10^{-8}N_C(N_{DM}-N_{D0})}{K\times D}$$

$$C=\frac{1,22\times10^{-8}\times33(500-100)}{60\times25}=1,07\times10^{-7}\ g/L=0,11\mu g/L$$

$C <_{MAX} = 0,18\ g/L$