$$\vec{V}_{D\in 5/R_0} = a_1 \dot\beta \vec{z}_1 - r_5 (\dot\beta + \dot\theta) \vec{z}_1$$

I.2 Roulement sans glissement aux points D et E

• en E

$$\vec{V}_{E\in 2/R_0} = \vec{V}_{E\in 3/R_0}$$

$$r_2 \dot\theta = r_3 \dot\psi \Rightarrow$$

$$\dot\psi = \frac{r_2}{r_3}\cdot\dot\theta = \frac{r_2}{r_3}\omega$$

• En D. $\vec{V}_{D\in 5/R_0} = \vec{0}$

$$a_1\dot\beta - r_5(\dot\beta + \dot\theta) = 0$$

$$(a_1 - r_5)\dot\beta = r_5\dot\theta$$

$$\dot\beta = \frac{r_5}{a_1 - r_5}\cdot\dot\theta = \frac{r_5\,\omega}{a_1 - r_5}$$

.3 Vitesse de G.

$$\vec{V}_{G/R_0} = \vec{V}_{K/R_0} + \vec{\Omega}_{3/R_0} \wedge \vec{KG}$$

$$\vec{V}_{K/R_0} = b_1 \dot\beta \vec{z}_1 \quad , \vec{\Omega}_{3/R_0} = \dot\psi \vec{y}_1 + \dot\beta \vec{x}_0$$

$$\vec{KG} = x\vec{x}_3 + y\vec{y}_1$$

$$\vec{V}_{G/R_0} = b_1\dot\beta\vec{z}_1 - x\dot\psi\vec{z}_3 + x\dot\beta\sin\psi\,\vec{y}_1 + y\dot\beta\vec{z}_1$$

$$\vec{V}_{G/R_0} = (b_1 + y)\dot\beta\vec{z}_1 - x\dot\psi\vec{z}_3 + x\dot\beta\sin\psi\,\vec{y}_1$$

$$\vec{z}_3 = \cos\psi\,\vec{z}_1 + \sin\psi\,\vec{x}_0$$

$$\vec{V}_{G/R_0} = -x\dot\psi\sin\psi\,\vec{x}_0 + x\dot\beta\sin\psi\,\vec{y}_1 + \left((b_1+y)\dot\beta - x\dot\psi\cos\psi\right)\vec{z}_1$$

$$V_x = -x\dot\psi\sin\psi, \quad V_y = x\dot\beta\sin\psi$$

$$V_z = (b_1 + y)\dot\beta - x\dot\psi\cos\psi.$$

. Accélération de G.

$$\vec{\Gamma}_{G/R_0} = \frac{d\vec{V}_{G/R_0}}{dt}\Big|_{R_0}$$

$$\vec{\Gamma}_{G/R_0} = \dot V_x \vec{x}_0 + \dot V_y \vec{y}_1 + \dot V_z \vec{z}_1 + \dot\beta V_y \vec{z}_1 - V_z \dot\beta \vec{y}_1$$

avec $\dot V_x = -x\dot\psi^2\cos\psi$, $\dot V_y = x\dot\beta\dot\psi\cos\psi$,

$\dot V_z = x\dot\psi^2\sin\psi$.

$= \vec{0}$ $\quad -2x\dot\beta\dot\psi - (\dot\beta)(b_4 + y)\, m_4$

$Z_{14} - m_4 g \cos\beta = 0$

II

$$\Gamma_x = -x\dot\psi^2\cos\psi$$

$$\Gamma_y = x\dot\beta\dot\psi\cos\psi - \dot\beta\left((b_4+y)\dot\beta - x\dot\psi\cos\psi\right)$$

$$\Gamma_z = x\dot\psi^2\sin\psi + x\dot\beta^2\sin\psi$$

Partie A. III. Dynamique

$\psi = 0, \quad \dot\psi \neq 0$

$\vec{z}_3 = \vec{z}_1, \quad \vec{y}_3 = \vec{y}_1, \quad \vec{x}_3 = \vec{x}_1$

III.1 Action sur (4)

• Poids appliqué en G. $\vec{P} = -\underbrace{(M + m_4 + m)}_{m_4} g\vec{z}_0$

$\vec{\mathcal{M}}_G(\vec{P}) = \vec{0} \quad , \vec{P} = -m_4 g(\cos\beta\,\vec{z}_1 + \sin\beta\,\vec{y}_1)$

$$\vec{\mathcal{M}}_K(\vec{P}) = (x\vec{x}_3 + y\vec{y}_1) \wedge (m_4 \vec{g}$$

$$= -m_4 g \begin{pmatrix} x \\ y \\ 0 \end{pmatrix} \wedge \begin{pmatrix} 0 \\ \sin\beta \\ \cos\beta \end{pmatrix}$$

$\vec{g} = -g\vec{z}_0 = -g(\sin\beta\,\vec{y}_1 + \cos\beta\,\vec{z}_1)$

$$= -m_4 g \begin{pmatrix} y\cos\beta \\ -x\cos\beta \\ x\sin\beta \end{pmatrix}$$

$$\{\mathcal{T}(P)\}_K = \left\{ \begin{matrix} 0 \\ -m_4 g\sin\beta \\ -m_4 g\cos\beta \end{matrix} \middle| \begin{matrix} -m_4 g\, y\cos\beta \\ m_4 g\, x\cos\beta \\ -m_4 g\, x\sin\beta \end{matrix} \right\}_{(\vec{x}_0, \vec{y}_1, \vec{z}_1)}$$

• Action de 1 sur (4) en K

$$\{\mathcal{T}_{4/1}\}_K = \left\{ \begin{matrix} X_{14} \\ Y_{14} \\ Z_{14} \end{matrix} \middle| \begin{matrix} L_{14} \\ 0 \\ N_{14} \end{matrix} \right\}_{(\vec{x}_0, \vec{y}_1, \vec{z}_1)}$$

• action de (3) sur (4) en K.

$$\{\mathcal{T}_{4/3}\}_K = \left\{ \begin{matrix} 0 \\ N_J \\ 0 \end{matrix} \middle| \begin{matrix} 0 \\ C_J \\ 0 \end{matrix} \right\}_{(\vec{x}_3, \vec{y}_1, \vec{z}_1)}$$

III.3 Théorème de la résultante dynamique

$$\begin{cases} X_{14} = -m_4 x\dot\psi^2 \\ N_J + Y_{14} - m_4 g\sin\beta = \left(2x\dot\beta\dot\psi - \dot\beta^2(b_4+y)\right) m_4 \\ Y_{14} = m_4 g\sin\beta + m_4\left(2x\dot\beta\dot\psi - \dot\beta^2(b_4+y)\right) - \frac{3 m_4 g x / 4\beta}{2\ell} \end{cases}$$

Partie A : Géométrie des masses

I.1. Position du centre G de l'ensemble (4)

• cylindre (masse M)

$\vec{KG_c} = \frac{H}{2}\vec{x_3} + \cancel{L\vec{Y_1}} + (L-a_4)\vec{Y_1}$

• tige (masse m_t)

$\vec{KG_t} = (\frac{L}{2} - a_4)\vec{Y_1}$

• disque (masse m)

$\vec{KG_d} = -a_4\vec{Y_1}$

On applique la relation du barycentre

$$\vec{KG} = \frac{M\vec{KG_c} + m_t\vec{KG_t} + m\vec{KG_d}}{M+m_t+m}$$

$$x = \frac{M\frac{H}{2}}{M+m_t+m}$$

$$y = \frac{ML + m_t(\frac{L}{2}-a_4) - m a_4}{M+m_t+m}$$

I.2. Matrices centrales d'inertie

• cylindre :

$$[II(cy)] = \begin{bmatrix} \frac{Mr^2}{2} & 0 & 0 \\ 0 & \frac{Mr^2}{4}+\frac{MH^2}{12} & 0 \\ 0 & 0 & \frac{Mr^2}{4}+\frac{MH^2}{12} \end{bmatrix}_{(\vec{x_3},\vec{Y_1},\vec{Z_3})}$$

• tige.

$$[II(tig)] = \begin{bmatrix} \frac{m_tL^2}{12} & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \frac{m_tL^2}{12} \end{bmatrix}_{(\vec{x_3},\vec{Y_1},\vec{Z_3})}$$

• disque.

$$[II(disque)] = \begin{bmatrix} \frac{mR^2}{4} & 0 & 0 \\ 0 & \frac{mR^2}{2} & 0 \\ 0 & 0 & \frac{mR^2}{4} \end{bmatrix}_{(\vec{x_3},\vec{Y_1},\vec{Z_3})}$$

I.3 Matrice d'inertie de l'ensemble (4).

le plan $(K,\vec{x_3},\vec{Y_1})$ est un plan de symétrie, par suite $(K,\vec{Z_3})$ est un axe principal d'inertie

$$[II_K(4)] = \begin{bmatrix} A_4 & -F_4 & 0 \\ -F_4 & B_4 & 0 \\ 0 & 0 & C_4 \end{bmatrix}_{(\vec{x_3},\vec{Y_1},\vec{Z_3})}$$

$v_3 = x4\ sin\varphi.$

$= 0$

$$A_4 = \frac{Mr^2}{2} + ML^2 + \frac{m_tL^2}{12} + m_t(\frac{L}{2}-a_4)^2 + \frac{mr^2}{4} + m a_4^2$$

$$B_4 = \frac{Mr^2}{4} + \frac{MH^2}{12} + \frac{mr^2}{2} + \frac{MH^2}{4}$$

$$C_4 = \frac{Mr^2}{4} + \frac{MH^2}{12} + \frac{MH^2}{4} + ML^2 + \frac{m_tL^2}{12} + (\frac{L}{2}-a_4)^2 m_t + \frac{mr^2}{4} + m a_4^2$$

?

$$F_4 = M\frac{H}{2}.L$$

Partie A.II. Cinématique.

II.1 Vitesses

• $\vec{V}_{A/R_0} = \vec{V}_{O/R_0} + \vec{\Omega}_{1/R_0} \wedge \vec{OA}.$

$\vec{V}_{O/R_0} = \vec{0}$, $\vec{\Omega}_{1/R_0} = \dot\beta\vec{x_3}$, $\vec{OA} = a_1\vec{Y_1}$

$$\vec{V}_{A/R_0} = a_1\dot\beta\vec{Z_1}$$

• $\vec{V}_{I/R_0} = \vec{V}_{O/R_0} + \vec{\Omega}_{1/R_0} \wedge \vec{OI}$

$\vec{OI} = a_3\vec{X_0} + b_1\vec{Y_1}$

$\vec{V}_{I/R_0} = b_1\dot\beta\vec{Z_1}$

• $\vec{V}_{K/R_0} = \vec{V}_{O/R_0} + \vec{\Omega}_{1/R_0} \wedge \vec{OK}$

$\vec{OK} = a_3\vec{X_0} + b_2\vec{Y_1}$

$\vec{V}_{K/R_0} = b_2\dot\beta\vec{Z_1}$

• $\vec{V}_{E\in2/R_1} = \vec{V}_{A/R_1} + \vec{\Omega}_{2/R_1} \wedge \vec{AE}$

$\vec{V}_{A/R_1} = \vec{0}$, $\vec{\Omega}_{2/R_1} = \dot\theta\vec{x_0}$, $\vec{AE} = r_1\vec{X_0} + r_2\vec{Y_1}$

$$\vec{V}_{E\in2/R_1} = r_2\dot\theta\vec{Z_1}$$

• $\vec{V}_{E\in3/R_1} = \vec{V}_{I/R_1} + \vec{\Omega}_{3/R_1} \wedge \vec{IE}$

$\vec{V}_{I/R_1} = \vec{0}$, $\vec{\Omega}_{3/R_0} = \dot\varphi\vec{Y_1}$, $\vec{IE} = -r_3\vec{X_0} - r_2\vec{Y_1}$

$$\vec{V}_{E\in3/R_1} = r_3\dot\varphi\vec{Z_1}$$

• $\vec{V}(D\in5/R_0) = \vec{V}_{A/R_0} + \vec{\Omega}_{2/R_0} \wedge \vec{AD}$

$| \ddot{J} + Y_{14} - m_4 g \sin\beta = R\, 2x\beta\dot\varphi - \beta(b_4+y) | m_4$

$Y_{14} = m_4 g \sin\beta + m_4(2x\beta\dot\varphi - \beta(b_4+y)) - \frac{3m_4 g x 14\beta}{2fR}.$

III.3 Moment dynamique en K.

$$\vec{\sigma}_K(4/R_0) = m_4 \overrightarrow{KG} \wedge \vec{V}_{K/R_0} + [\mathbb{I}_K(4)]\,\vec{\Omega}_{4/R_0}$$

$$\cdot\ \vec{\delta}_K(4/R_0) = \frac{d\vec{\sigma}_K(4/R_0)}{dt} + m_4 \vec{V}_{K/R_0} \wedge \vec{V}_{G/R_0}$$

$$\overrightarrow{KG} \wedge \vec{V}_{K/R_0} = (x\vec{x}_3 + y\vec{y}_1) \wedge (b_2\dot{\beta}\vec{z}_1)$$

$$= -b_2\dot{\beta}x\cos\psi\,\vec{y}_1 + b_2\dot{\beta}y\,\vec{x}_0$$

$$\vec{\Omega}_{4/R_0} = \dot{\psi}\vec{y}_1 + \dot{\theta}(\cos\psi\,\vec{x}_3 + \sin\psi\,\vec{z}_3)$$

$$[\mathbb{I}_K(4)]\cdot\vec{\Omega}_{4/R_0} = \begin{bmatrix} A_4 & -F_4 & 0 \\ -F_4 & B_4 & 0 \\ 0 & 0 & C_4 \end{bmatrix}\begin{bmatrix} \dot{\theta}\cos\psi \\ \dot{\psi} \\ \dot{\theta}\sin\psi \end{bmatrix}$$

$$= \begin{bmatrix} A_4\dot{\theta}\cos\psi - F_4\dot{\psi} \\ -F_4\dot{\theta}\cos\psi + B_4\dot{\psi} \\ C_4\dot{\theta}\sin\psi \end{bmatrix}$$

$$(A_4\dot{\theta}\cos\psi - F_4\dot{\psi})\vec{x}_3 +$$

$$(-F_4\dot{\theta}\cos\psi + B_4\dot{\psi})\vec{y}_1 +$$

$$C_4\dot{\theta}\sin\psi\,\vec{z}_3$$

$$\frac{d\vec{\sigma}_K}{dt}\Big|_{R_0} = (m_4 b_2\dot{\beta}\dot{\psi}\cancel{x}\sin\psi)\vec{y}_1 +$$

$$\dot{\theta}(B_4\dot{\psi} - F_4\dot{\theta}\cos\psi - m_4 b_2\dot{\beta}x\cos\psi)\vec{z}_1$$

$$- A_4\dot{\theta}\dot{\psi}\cancel{\sin\psi}\,\vec{x}_3 + (A_4\dot{\theta}\cos\psi - F_4\dot{\psi})(\dot{\theta}\cancel{\sin\psi}\vec{y}_1 - \dot{\psi}\vec{z}_3)$$

$$+ C_4\dot{\theta}\dot{\psi}\cos\psi\,\vec{z}_3 + C_4\dot{\theta}\cancel{\sin\psi}(\dot{\psi}\vec{x}_3 - \dot{\theta}\cos\psi\,\vec{y}_1)$$

$$\frac{d\vec{\sigma}_K}{dt}\Big|_{R_0} = \dot{\beta}(B_4\dot{\psi} - F_4\dot{\theta} - m_4 b_2\dot{\beta}x)\vec{z}_1 + -(A_4\dot{\theta} - F_4\dot{\psi})\dot{\psi}\vec{z}_1 + C_4\dot{\theta}\dot{\psi}\vec{z}_1$$

$$m_4\vec{V}_{K/R_0} \wedge \vec{V}_{G/R_0} = m_4 . b_2\dot{\beta}\vec{z}_1 \wedge ((b_2+y)\dot{\beta} - x\dot{\psi})\vec{z}_1 = \vec{0}$$

$$\vec{\delta}_K(4/R_0) = \left(B_4\dot{\beta}\dot{\psi} - F_4\dot{\theta}\dot{\beta} - m_4 b_2\dot{\beta}^2 x + (C_4 - A_4)\dot{\theta}\dot{\psi} + F_4\dot{\psi}^2\right)\vec{z}_1$$

Equations dynamiques

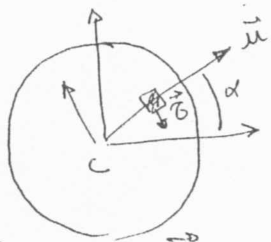
$$\begin{cases} L_{14} - m_4 g y\cos\beta = 0 \\ C_J + m_4 g x\cos\beta = 0 \\ N_{14} = (B_4\dot{\beta}\dot{\psi} + F_4(\dot{\psi}^2 - \dot{\theta}\dot{\beta}) - m_4 b_2 x\dot{\beta}^2 + (C_4 - A_4)\dot{\theta}\dot{\psi}) \end{cases}$$

III.4 Expression de N_J

On considère une surface d'appui circulaire de rayon. R.

La pression étant uniforme :

$$p = \frac{N_J}{S} = \frac{N_J}{\pi R^2}$$



$$\vec{\tau} = -\tau\vec{v} = -f.p.\vec{v}$$

à la limite de l'adhérence

$$\vec{dF} = -\tau\,ds\,\vec{v} = -\tau\, r\,dr\,d\alpha.\vec{v}$$

$$\vec{dM}_C = \vec{CM} \wedge \vec{dF}$$

$$= -r\vec{u} \wedge \tau\, r\,dr\,d\alpha\,\vec{v}$$

$$= -\tau r^2 dr\,d\alpha.\vec{z}$$

$$\vec{M}_J = \int \tau r^2 dr\,d\alpha = \frac{2\pi\tau.R^3}{3}$$

$$C_J = -\frac{2\cancel{\pi} f N_J}{\cancel{\pi}R^2}.\frac{R^3}{3} = -\frac{2}{3}f N_J R.$$

$$N_J = |C_J|\,\frac{3}{2fR}.$$

III.5 inconnus de liaisons.

$$\cdot\ N_J = 3\frac{m_4 g x\,|\cos\beta|}{2fR}.$$

$$\cdot\ L_{14} = m_4 g y\cos\beta$$

$$Y_{14} = m_4 g\sin\beta + m_4(2x\dot{\beta}\dot{\psi} - \dot{\beta}^2(b_4+y)) - \frac{3m_4 g x|\cos\beta|}{2fR}.$$

Partie C-II- Asservissement de position d'un axe du bras robotisé

II-1 : Simplification du schéma fonctionnel de la figure 6 :

$$\Omega_m(p) = \frac{1}{J_m p + f_m}\left[\frac{k_c}{R}\left(U(p) - k_e\,\Omega_m(p)\right) - \frac{1}{\rho}\left(C_r(p) + \frac{1}{\rho}\left(J_c p + f_c\right)\Omega_m(p)\right)\right]$$

$\Leftrightarrow$

$$\left[1 + \frac{k_e k_c/R}{J_m p + f_m} + \frac{1}{\rho^2}\,\frac{J_c p + f_c}{J_m p + f_m}\right]\Omega_m(p) = \frac{k_c/R}{J_m p + f_m}\,U(p) - \frac{1/\rho}{J_m p + f_m}\,C_r(p)$$

$\Leftrightarrow$

$$\left[\left(J_m + \frac{J_c}{\rho^2}\right)p + \left(f_m + \frac{f_c}{\rho^2}\right) + \frac{k_e k_c}{R}\right]\Omega_m(p) = \frac{k_c}{R}\,U(p) - \frac{1}{\rho}\,C_r(p)$$

$\Rightarrow$

$$\Omega_m(p) = T_1(p)\,U(p) - T_2(p)\,C_r(p)$$

avec

$$T_1(p) = \frac{K_1}{1 + \tau_{em}\,p} \quad \text{et} \quad T_2(p) = \frac{K_2}{1 + \tau_{em}\,p}$$

$$\tau_{em} = \frac{R\,J_e}{k_e k_c + f_e R}$$: Constante de temps électromécanique

$$K_1 = \frac{k_c}{k_e k_c + R f_e}$$: Gain statique de $T_1(p)$

$$K_2 = \frac{R}{\rho\left(k_e k_c + R f_e\right)}$$: Gain statique de $T_2(p)$

$$J_e = J_m + \frac{J_c}{\rho^2}$$: Inertie équivalent ramené sur l'arbe du moteur.

$$f_e = f_m + \frac{f_c}{\rho^2}$$: Coef. de frottement visqueux équivalent ramené sur l'arbre du moteur.

II-2 : A partir de la réponse indicielle de $T_1(p)$ à un échelon de tension d'amplitude 25 V :

On a :

$$\omega_m(\infty) = 25\,K_1 = 200 \text{ rad.s}^{-1} \Rightarrow \boxed{K_1 = 8 \text{ rad.s}^{-1}\,V^{-1}}$$

. à 63% de $\omega_m(\infty)$ on trouve $\boxed{\tau_{em} = 10 \text{ ms}}$ X

II-3 : schéma fonctionnel de la figure 8.

a/ Fonction de transfert en boucle fermée :

$$\theta_c(p) = H_1(p)\,\theta_{ref}(p) - H_2(p)\,C_r(p)$$

avec $$H_1(p) = \left.\frac{\theta_c(p)}{\theta_{ref}(p)}\right|_{C_r=0} = \frac{\dfrac{\alpha A K_1}{e\,\tau_{em}}}{p^2 + \dfrac{1}{\tau_{em}}\,p + \dfrac{\alpha A K_1}{e\,\tau_{em}}}$$

$$H_2(p) = \left.\frac{\theta_c(p)}{C_r(p)}\right|_{\theta_{ref}=0} = \frac{\dfrac{K_2}{e\,\tau_{em}}}{p^2 + \dfrac{1}{\tau_{em}}\,p + \dfrac{\alpha A K_1}{e\,\tau_{em}}} \quad X$$

Equation caractéristique :

$$p^2 + \frac{1}{\tau_{em}}\,p + \frac{\alpha A K_1}{e\,\tau_{em}} = p^2 + 2 m \omega_0\, p + \omega_0^2$$

Par identification, on déduit :

$$\omega_0 = \sqrt{\frac{\alpha A K_1}{e\,\tau_{em}}}$$: pulsation propre non amortie (rad/s)

$$m = \frac{1}{2}\sqrt{\frac{e}{\alpha A K_1 . \tau_{em}}}$$: coefficient d'amortissement.

b- Calcul de A pour avoir $m = 0,7$.

$\alpha = 0,8\ V/rad$; $K_1 = 8\ rad.s^{-1}V^{-1}$; $\tau_{em} = 10\ ms$ et $\rho = 5$

$$A = \frac{\rho}{4m^2 \alpha K_1 \tau_{em}}$$

A.N : $$A = \frac{50}{4.(0,7)^2 . 0,8 . 8 . 0,01} = 398,6$$

$$\omega_0 = \sqrt{\frac{0,8 . 398,6 . 8}{50 . 0,01}} = 71,43\ rad/s$$

Dépassement : $D\% = 100 . e^{-\frac{m\pi}{\sqrt{1-m^2}}}$

A.N : $\boxed{D\% = 4,6\ \%}$

Temps de pic : $T_p = \frac{\pi}{\omega_0 \sqrt{1-m^2}}$

A.N : $\boxed{T_p = 0,062\ s}$

c- Etude de la précision statique

$$\boxed{\varepsilon_1(p) = \theta_{ref}(p) - \theta_c(p) = \left[1 - H_1(p)\right] \theta_{ref}(p) + H_2(p)\, C_r(p)}$$

avec $$H_1(p) = \frac{\omega_0^2}{p^2 + 2m\omega_0 p + \omega_0^2}$$

$$H_2(p) = \frac{K_2}{\alpha A K_1} . \frac{\omega_0^2}{p^2 + 2m\omega_0 p + \omega_0^2} = \frac{K_2}{\alpha A K_1} H_1(p)$$

$$\boxed{\varepsilon_1(p) = \frac{p(p + 2m\omega_0)}{p^2 + 2m\omega_0 p + \omega_0^2} \theta_{ref}(p) + \frac{K_2}{\alpha A K_1} \frac{\omega_0^2}{p^2 + 2m\omega_0 p + \omega_0^2} C_r(p)}$$

$$\theta_{ref}(t) = t \cdot u(t) \xrightarrow{T.L.} \theta_{ref}(p) = \frac{1}{p^2}$$

$$C_r(t) = 100 \cdot u(t) \xrightarrow{T.L} C_r(p) = \frac{100}{p}$$

Théorème de la valeur finale

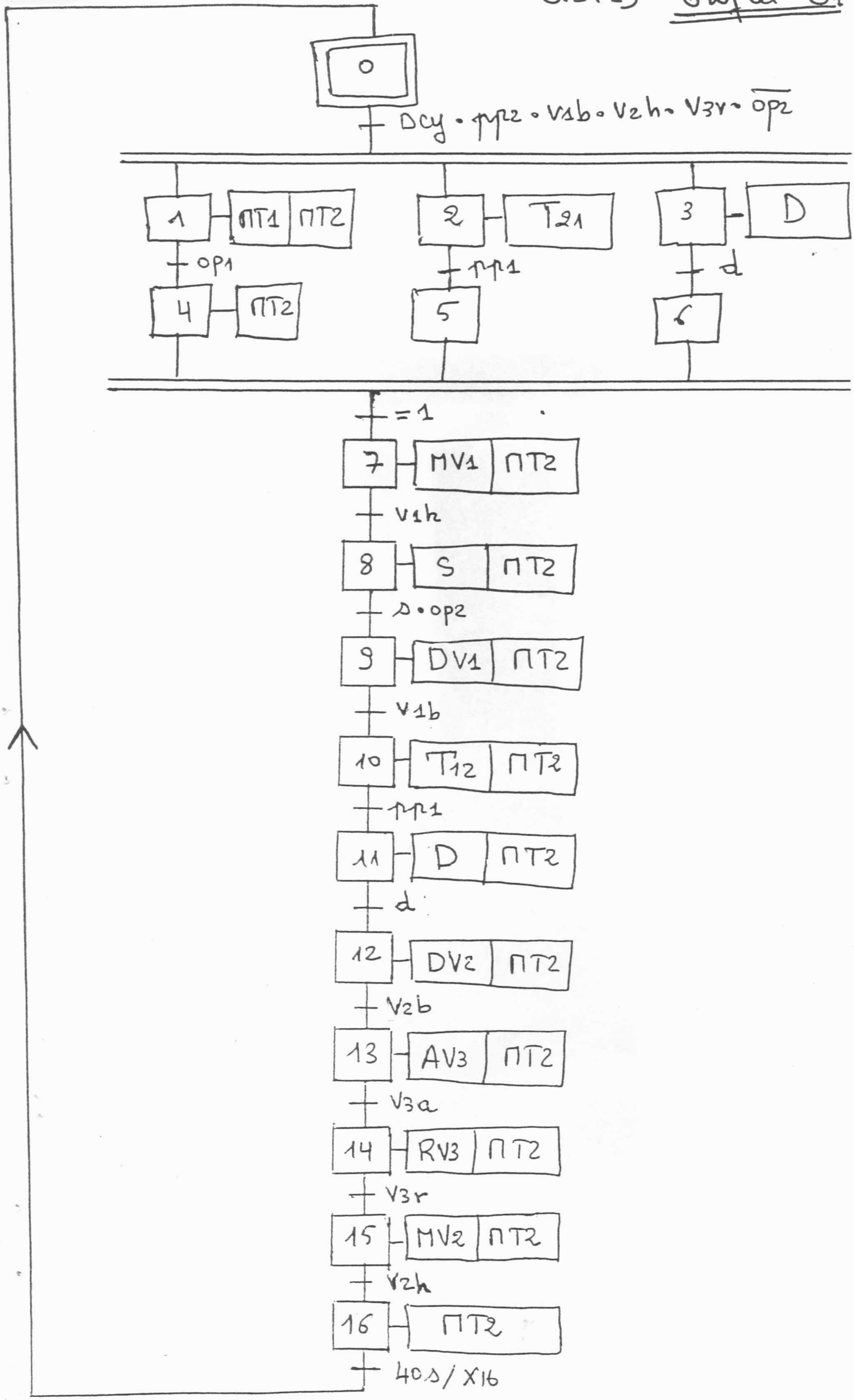
$$\varepsilon_1(\infty) = \lim_{p \to 0} p\, \varepsilon_1(p)$$

soit $$\boxed{\varepsilon_1(\infty) = \frac{2m}{\omega_0} + \frac{100\, K_2}{\alpha A K_1}}$$

A.N : $\varepsilon_1(\infty) = 0{,}0196 + 0{,}026 = 0{,}049$

$$\boxed{\varepsilon_1(\infty) = 0{,}049 \quad \text{soit } 4{,}9\,\%}$$

Grafcet G1



0
Dcy • pp2 • V1b • V2h • V3r • $\overline{op2}$
1
ПТ1
ПТ2
op1
4
ПТ2
2
T21
pp1
5
3
D
d
6
= 1
7
MV1
ПТ2
V1h
8
S
ПТ2
s • op2
9
DV1
ПТ2
V1b
10
T12
ПТ2
pp1
11
D
ПТ2
d
12
DV2
ПТ2
V2b
13
AV3
ПТ2
V3a
14
RV3
ПТ2
V3r
15
MV2
ПТ2
V2h
16
ПТ2
40s/X16

C.I.2)

Grafcet G1 modifié