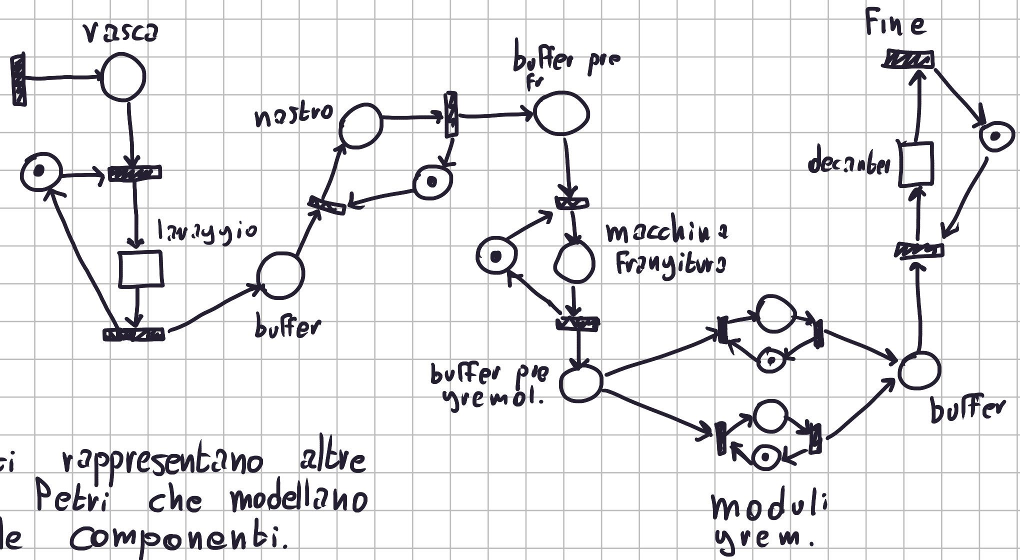
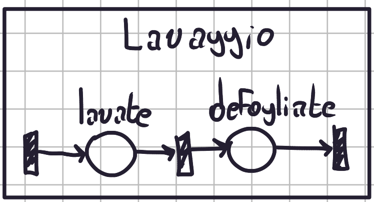
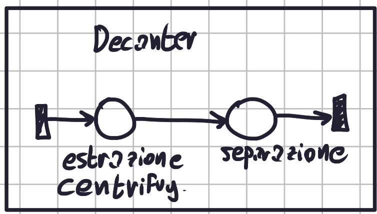
Es 2) I token rappresenteranno 1 lotto di olive.



i quadrati rappresentano altre reti di Petri che modellano le singole componenti.





Es 3)

in 1 ciclo devono susseguirsi le posizioni per ψ

$\psi(0) = M$

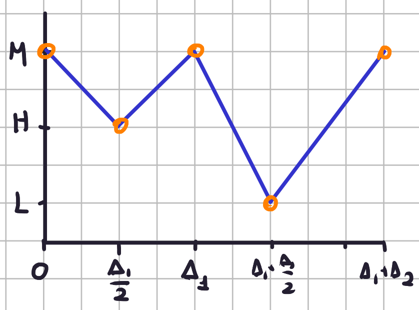
$\psi(\frac{\Delta_1}{2} v) = H$

$\psi(\Delta_1 v) = M$

$\psi((\Delta_1 + \Delta_1 \frac{1}{2}) v) = L$

$\psi(\Delta_1 + \Delta_2) = M$

Qualitativamente:



Scelgo una legge polinomiale per ψ in funzione di t

$\psi(x)$ ogni ciclo la funzione e' questa. Individuo 4 intervalli $[0, \frac{\Delta_1}{2}], [\frac{\Delta_1}{2}, \Delta_1], [\Delta_1, \Delta_1 + \frac{\Delta_1}{2}], [\Delta_1 + \frac{\Delta_1}{2}, \Delta_1 + \Delta_2]$

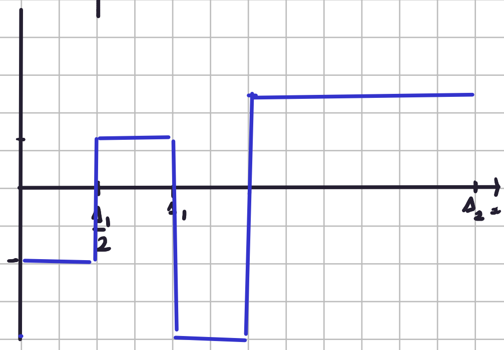
$$\psi(x) = \begin{cases} M - x \cdot (H - M) \frac{2}{\Delta_1} & \text{se } x < \frac{\Delta_1}{2} \\ (M - H) \frac{2}{\Delta_1} x - M & \text{se } x \in [\frac{\Delta_1}{2}, \Delta_1] \\ 3M - 2L - (M - L) \frac{2}{\Delta_1} x & \text{se } x \in [\Delta_1, \Delta_1 + \frac{\Delta_1}{2}] \\ (\Delta_2 - \frac{1}{2}\Delta_1)^{-1} (M - L)(\Delta_1 + \Delta_2) + M + \left(\frac{L - M}{\frac{1}{2}\Delta_1 - \Delta_2}\right) x & \text{altrimenti} \end{cases}$$

A questo punto devo imporre θ_s, essendo il rapporto N_s, si ha che $N_s = \frac{\psi}{\theta_s} \Rightarrow \theta_s = \frac{1}{N_s} \psi \Rightarrow \dot{\theta}_s = \frac{1}{N_s} \dot{\psi}$ devo trovare $\psi(t)$. Conosco $\psi(x)$ e $x(t) = vt \Rightarrow \psi(x) = \psi(v t)$

$$\dot{\theta}_s(t) = \frac{1}{N_s}\dot{\gamma}(t) = \begin{cases} v(H-M)\frac{2}{\Delta_1}\cdot\frac{1}{N_s} & \text{se } t < \frac{\Delta_1}{2}\frac{1}{v} \\ (M-H)\frac{2}{\Delta_1}v\cdot\frac{1}{N_s} & \text{se } vt \in [\frac{\Delta_1}{2}, \Delta_1] \\ -(M-L)\frac{2}{\Delta_1}v\,\frac{1}{N_s} & \text{se } vt \in [\Delta_1, \Delta_1 + \frac{\Delta_1}{2}] \\ (L-M)(\frac{1}{2}\Delta_1 - \Delta_2)^{-1}\cdot v\cdot\frac{1}{N_s} & \text{altrimenti} \end{cases}$$

$$\dot{\theta}_s(x) = \frac{1}{N_s}\dot{\gamma}(x) = \begin{cases} (H-M)\frac{2}{\Delta_1}\cdot\frac{1}{N_s} & \text{se } x < \frac{\Delta_1}{2} \\ (M-H)\frac{2}{\Delta_1}\,\frac{1}{N_s} & \text{se } x \in [\frac{\Delta_1}{2}, \Delta_1] \\ -(M-L)\frac{2}{\Delta_1}\cdot\frac{1}{N_s} & \text{se } x \in [\Delta_1, \Delta_1 + \frac{\Delta_1}{2}] \\ (L-M)(\frac{1}{2}\Delta_1 - \Delta_2)^{-1}\cdot\frac{1}{N_s} & \text{altrimenti} \end{cases}$$

profilo di $\dot{\theta}_s(x)$



Es 4) Voglio risolvere in funzione di $\gamma = \dot{\theta}$ e trovare la risposta indiciale: $\frac{d\gamma}{dt} + \frac{B}{J}\gamma - \frac{K_T}{J} = 0 \Rightarrow$ $\left| \begin{array}{l} x = (B\gamma - K_T)\frac{1}{J} \\ \frac{d\gamma}{dt} \Rightarrow dx = -\frac{B}{J}d\gamma \Rightarrow d\gamma = -\frac{J}{B}dx \end{array}\right.$

$$\Rightarrow -\frac{J}{B}\frac{dx}{dt} = x \Rightarrow -\frac{J}{B}\frac{dx}{x} = dt \Rightarrow -\frac{J}{B}\int_{x(0)}^{x(t)}\frac{1}{x}dx = \int_0^t dt \Rightarrow \ln\left(\frac{x(t)}{x(0)}\right) = -\frac{B}{J}t$$

$\gamma(t) = \frac{K_T}{B}(1 - e^{-\frac{B}{J}t}) \Rightarrow$ applico il 1° metodo Z-N valutando la risposta si trovano

$$\dot{\gamma}(0) = \frac{K_T}{J} \Rightarrow \frac{K_T}{J}t \text{ incontra } \frac{K_T}{B} : \frac{K_T}{J}t^* = \frac{K_T}{B} \Rightarrow t^* = \frac{J}{B} = \tau$$

$$K = \frac{K_T}{B} \quad \theta = 0 \quad \tau = \frac{J}{B} \Rightarrow K = \frac{K_T}{B} \quad \theta = \alpha\frac{J}{B} \quad \tau = (1-\alpha)\frac{J}{B}$$

provo un regolatore PI:

$$\frac{K_T}{B}\cdot K_p = \frac{9}{10}\cdot\frac{(\alpha-1)}{\alpha} \Rightarrow K_p = \frac{B}{K_T}\cdot\frac{9}{10}\cdot\frac{(\alpha-1)}{\alpha}$$

$$T_i = 3.33\cdot\alpha\cdot\frac{J}{B} \Rightarrow K_I = \frac{B^2}{K_T}\cdot\frac{9}{10}\cdot\frac{(\alpha-1)}{\alpha^2}\cdot\frac{1}{J}$$

La F.d.t del processo e' $P(s) = \frac{K_t}{Js+B}$, ad anello aperto c'e' un polo in $s = -\frac{B}{J}$, ad anello chiuso $W(s) = \frac{P(s)}{1+P(s)} = \frac{K_t}{Js+B+K_t}$ il sistema e' ancora stabile e per avere errore nullo serve un'azione integrale.

Considero un controllore PI: $C(s) = K_p + \frac{K_I}{s} \Rightarrow F(s) = \frac{(K_p + \frac{K_I}{s})K_t}{s(Js+B)} = \frac{K_pK_ts + K_IK_t}{s\,(Js+B)}$ il den. di $W(s)$ e' $s^2(Js+B) + K_pK_ts + K_IK_t = Js^3 + Bs^2 + K_pK_ts + K_IK_t$. La tabella del criterio di Routh e':

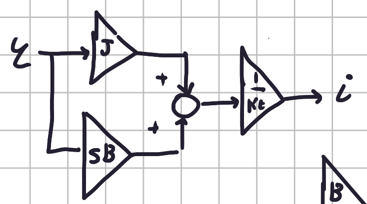
J	$K_p K_t$
B	$K_I K_t$
$\frac{K_t(BK_p - JK_I)}{B}$	0
$K_I K_t$	0

$\Rightarrow$ il sistema e' as. stabile finche' $K_I > 0$ e $\frac{1}{B}K_t(BK_p - JK_I) > 0 \Rightarrow BK_p - JK_I > 0 \Rightarrow K_p > \frac{J}{B}K_I$. Inoltre l'errore a regime e' nullo: $\lim_{s \to 0} W(s) = 1$:

$$\lim_{s \to 0} \frac{K_p K_t s + K_I K_t}{s^2(Js + B) + K_p K_t s + K_I K_t} = \frac{K_I K_t}{K_I K_t} = 1$$

Non essendo note K_t, B e J e' difficile scegliere K_I e K_p che annullino oscillazioni ed abbiano un transitorio veloce.

Supponiamo siano noti, consideriamo l'azione di Feedforward invertendo la dinamica del sistema $\gamma = \dot\theta \Rightarrow J\dot\gamma + B\gamma = K_t i \Rightarrow K_t i - J\dot\gamma = B\gamma \Rightarrow \frac{K_t i}{B} - \frac{J}{B}\dot\gamma = \gamma$



$\dot\theta_d = \frac{K_t i}{B} \Rightarrow i = \frac{B}{K_t}\dot\theta_d$

$\ddot\theta_d = 0$