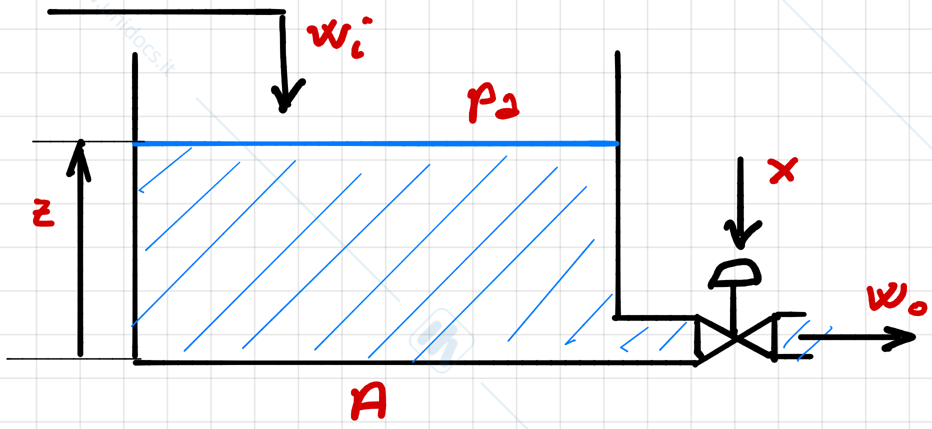
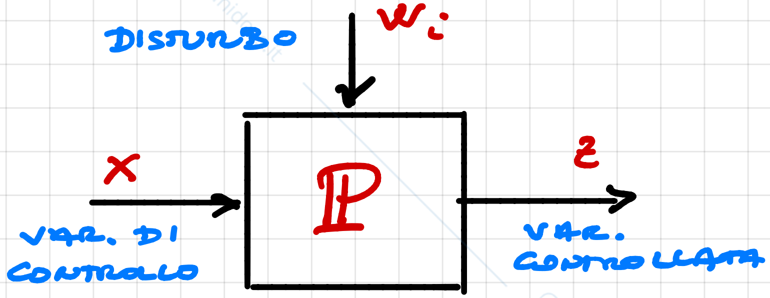
CONTROLLO DI LIVELLO IN UN SERBATOIO

PROGETTO DEL SISTEMA DI CONTROLLO E SIMULAZIONI

- Controllo di livello in un serbatoio





- Esempio Numerico

- DATI

$A = 1 \; [m^2]$

$A_v = 14 \cdot 10^{-4} \; [m^2]$

$k = \frac{\sqrt{2}}{C_r} = 4 \qquad (C_r \simeq 0.35) \implies \varphi = k A_v \sqrt{g} \simeq 1.75 \cdot 10^{-2}$

$\rho = 1000 \; [kg/m^3]$

$g = 9.8 \; [m/s^2]$

$\tau_M = 3 \; [s]$

- EQUILIBRIO

$\bar{z} = 1.3 \; [m]$

$\bar{w}_i = 10 \; [kg/s]$

$\implies \bar{x} = \frac{\bar{w}_i}{\varphi \rho \sqrt{\bar{z}}} = 0.5$ (valvola lineare)

- PARAMETRI MODELLO LINEARIZZATO

$\tau = 260 \; [s]$

$\mu_G = -5.2 \; [m]$

$\mu_M = 0.26 \; [ms/kg]$

dati_serbatoio_valvola

serbatoio_aa

- SPECIFICHE DI PROGETTO

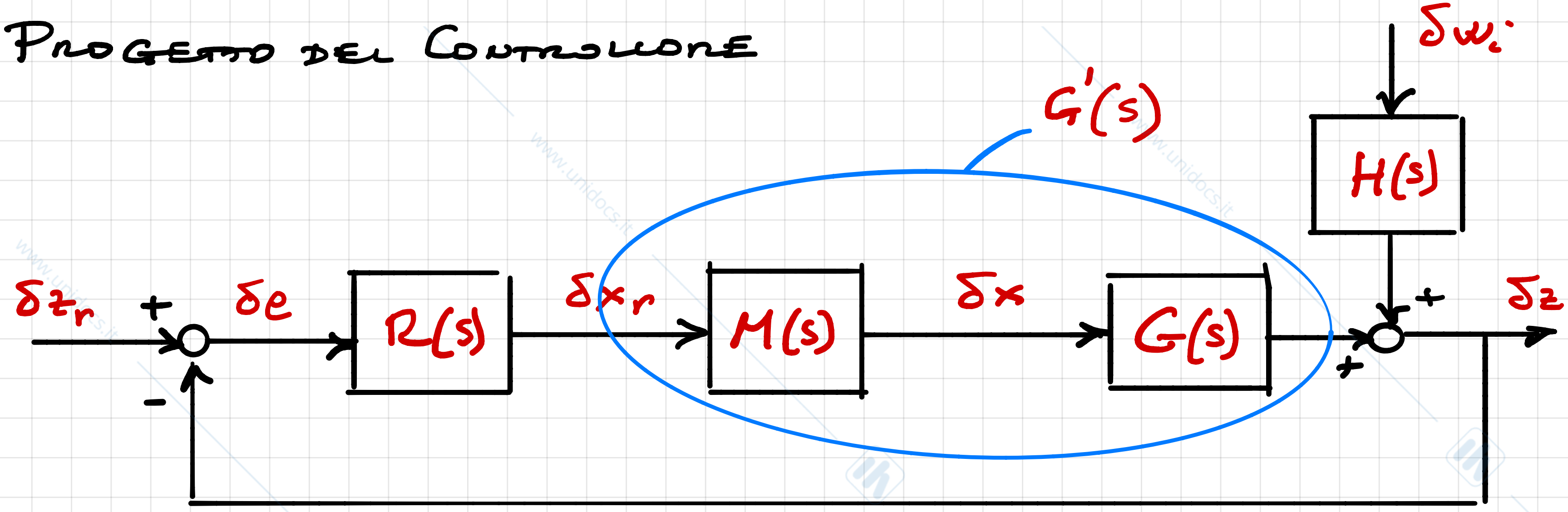
- CON $\delta z_r = 0.3\ sca(t)$

(a) $e(\infty) = 0$

(b) $t_a \leq 60\ [s] \implies \omega_c \geq \frac{5}{36} \simeq 0.14$

(c) $\varphi_m \geq 60°$

- Progetto del Controllore



$$G'(s) = G(s)M(s) = \frac{\mu_G}{(1+s\tau)(1+s\tau_M)}$$

$\mu_G = -5.2 < 0$

$\tau = 260 \qquad \tau_M = 3$

$$R(s) = -\frac{K_p}{T_i}\,\frac{1+sT_i}{s}$$

$K_p > 0$

$T_i = \tau = 260$

$$L(s) = R(s)G'(s) = -\frac{K_p}{T_i}\mu_G \frac{1}{s(1+s\tau_M)}$$

$$\omega_c \simeq \frac{|K_p \mu_G|}{T_i} \geq 0.14$$

$$\Longrightarrow K_p \geq \frac{0.14\,T_i}{|\mu_G|} = 7$$

p.e. $K_p = 10$ $\Longrightarrow$ $\begin{cases} \omega_c \simeq 0.18 & \text{OK} \\ \varphi_m \simeq 62^\circ & \text{OK} \\ t_2 \simeq 45 & \text{OK} \end{cases}$

serbatoio_lineare

- SIMULAZIONI

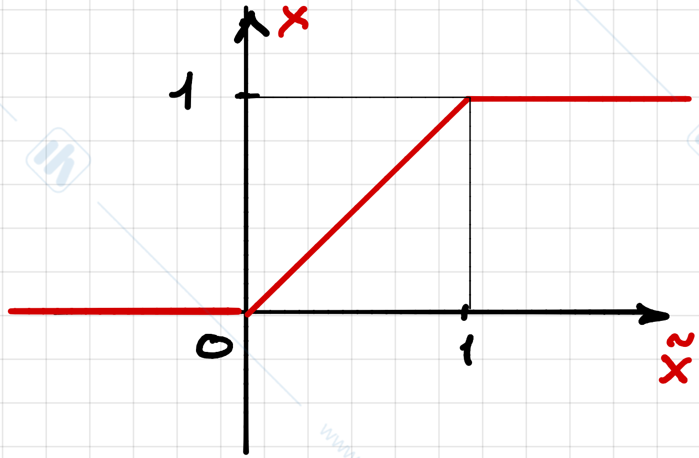
- RIFERIMENTO

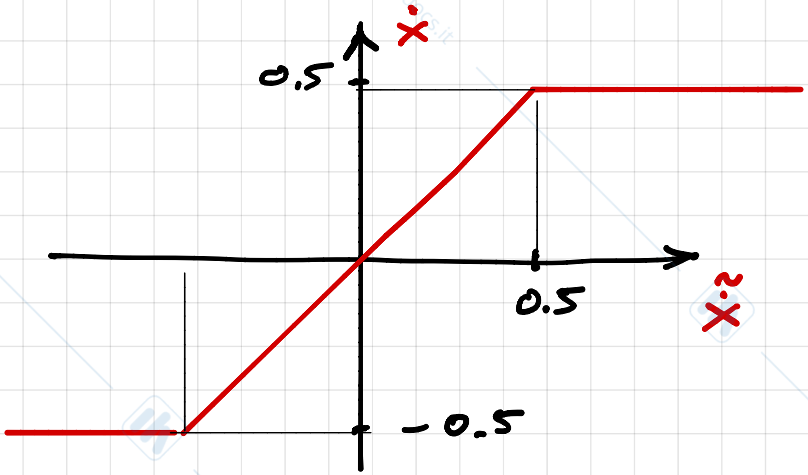
$$\delta z_r(t) = 0.3 \, \mathrm{sca}(t)$$

- SATURAZIONI

$x \in [0, 1]$

$\dot{x} \in [-0.5, 0.5]$





serbatoio_2c

- RISULTATI DELLE SIMULAZIONI

  - SPECIFICHE SU t_2 NON RISPETTATE
  - OSCILLAZIONI DOVUTE A RIPETUTE SATURAZIONI
  - CAUSA DELLE OSCILLAZIONI: INTEGRATOR WINDUP

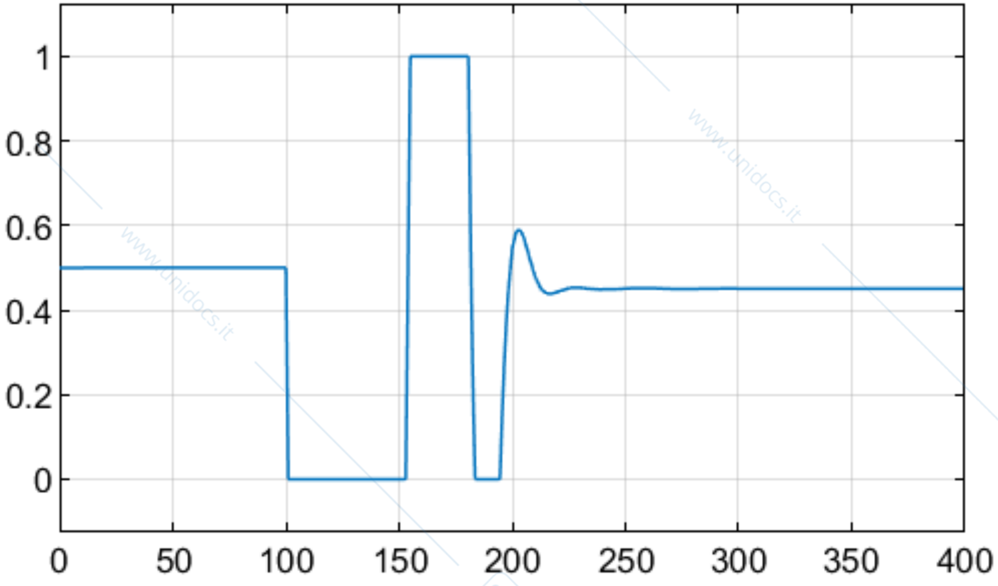
- MODIFICANDO IL PROGETTO CON $K_p = 2$

  - NO OSCILLAZIONI
  - SPECIFICA SU t_2 NON RISPETTATA

(MOD. LINEARE)

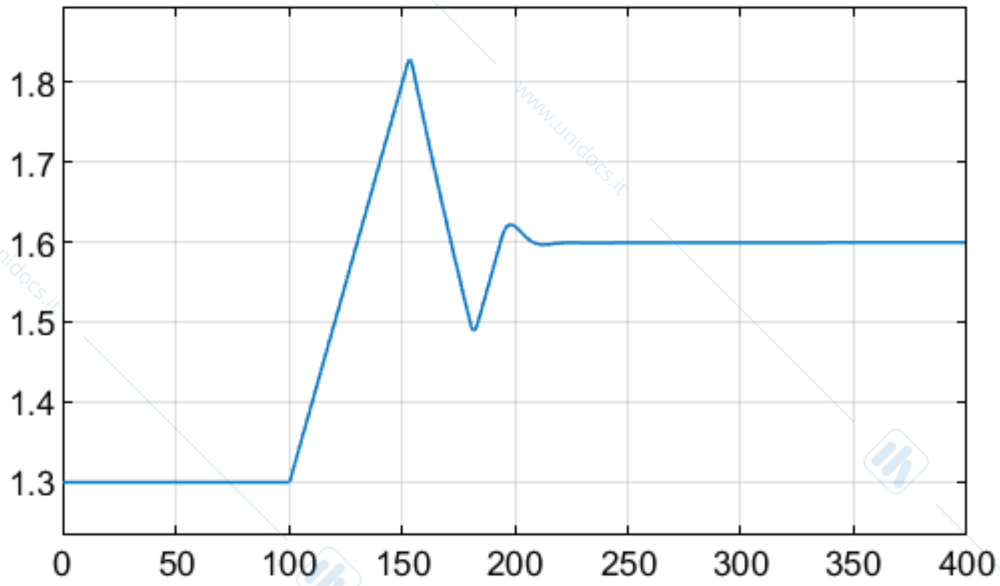
$$\begin{cases} \omega_c \simeq 0.04 \\ \varphi_m \simeq 83^\circ \\ t_2 \simeq 125 \end{cases}$$

!

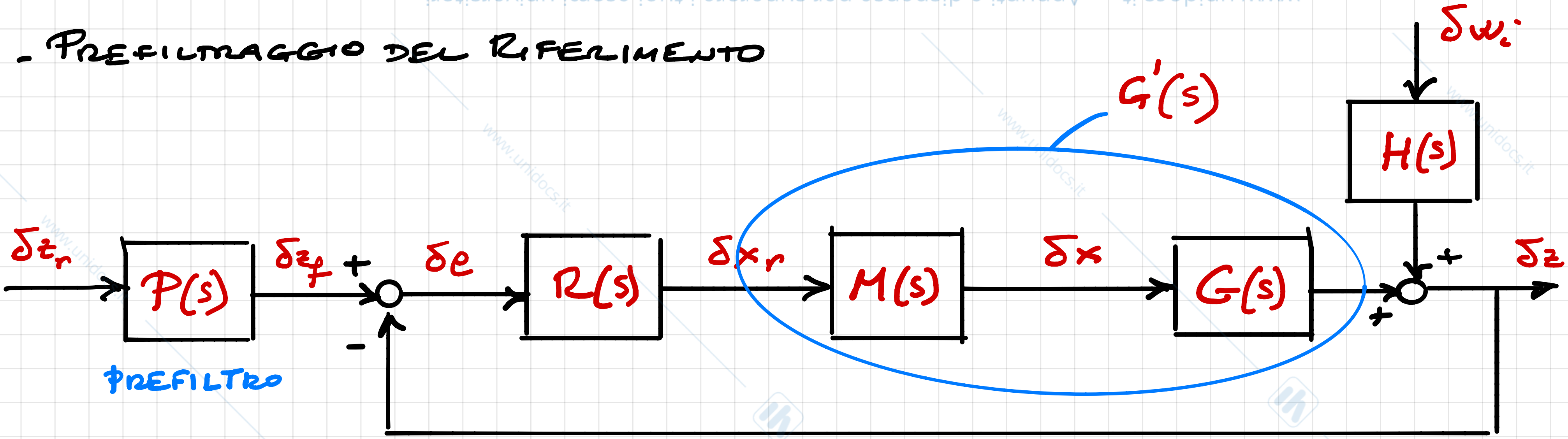


posizione valvola x(t)

livello z(t)



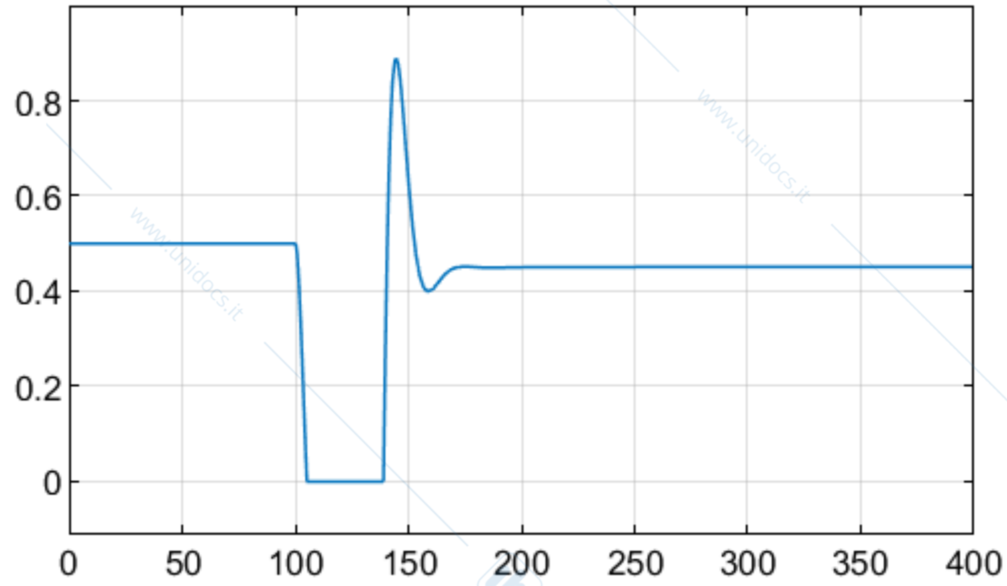
- Prefiltraggio del Riferimento



$$P(s) = \frac{1}{1 + s\tau_p} \quad , \quad \tau_p = 12$$

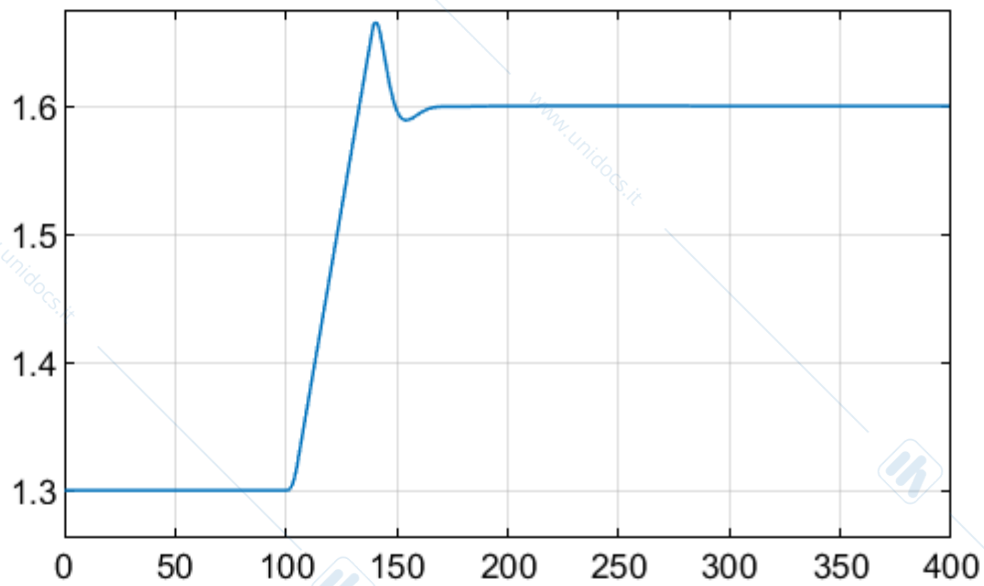
- SIMULAZIONE:
  - INSUFFICIENTE A EVITARE LA SATURAZIONE
  - PRESENZA DI UN PICCO ELEVATO
  - SPECIFICA SU t_a "QUASI" RISPETTATA

serbatoio_prefilt_lin



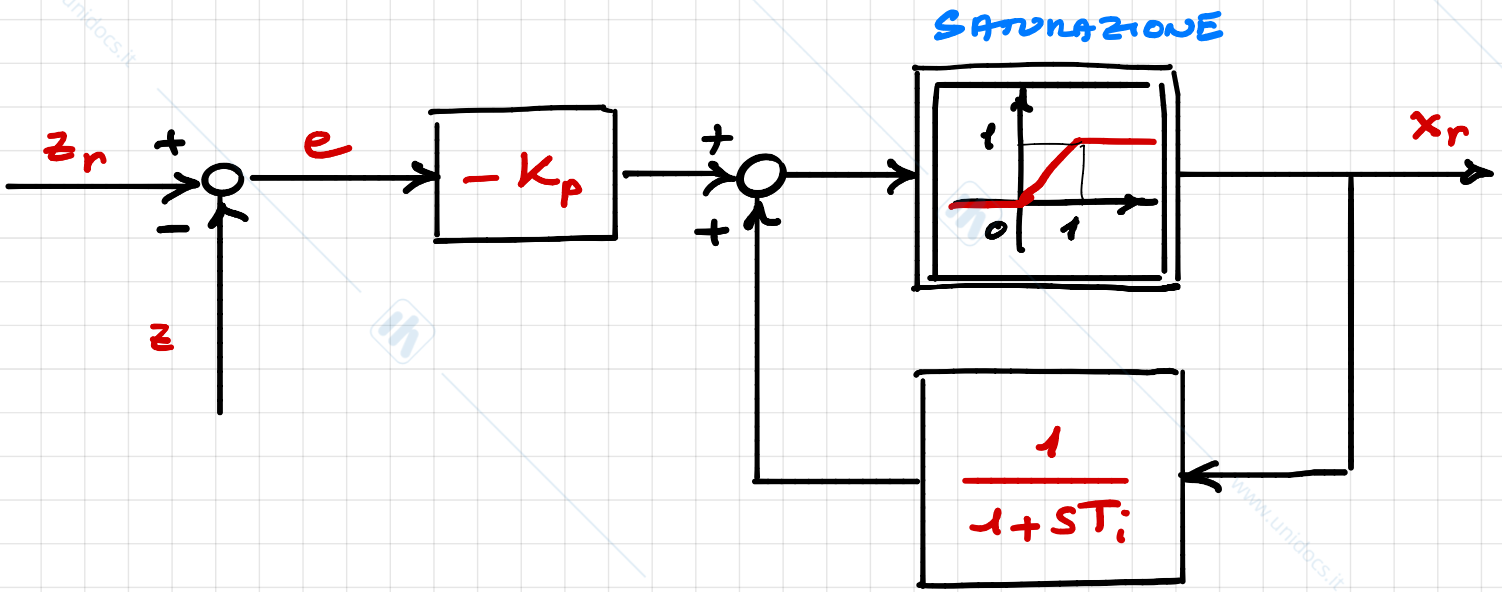
posizione valvola x(t)

livello z(t)



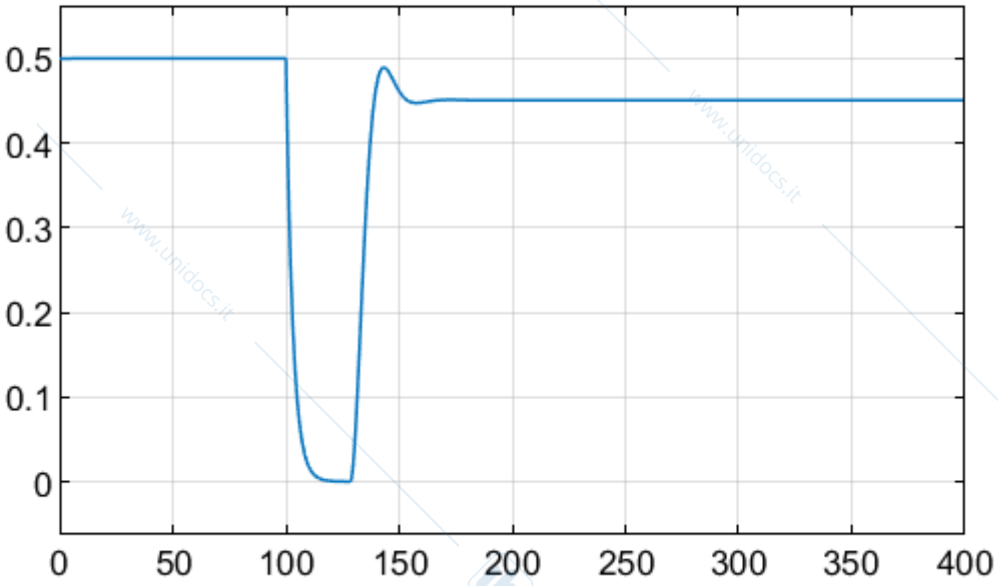
- Realizzazione PI anti-windup

$$R(s) = -\frac{K_p}{T_i}\,\frac{1+sT_i}{s}$$



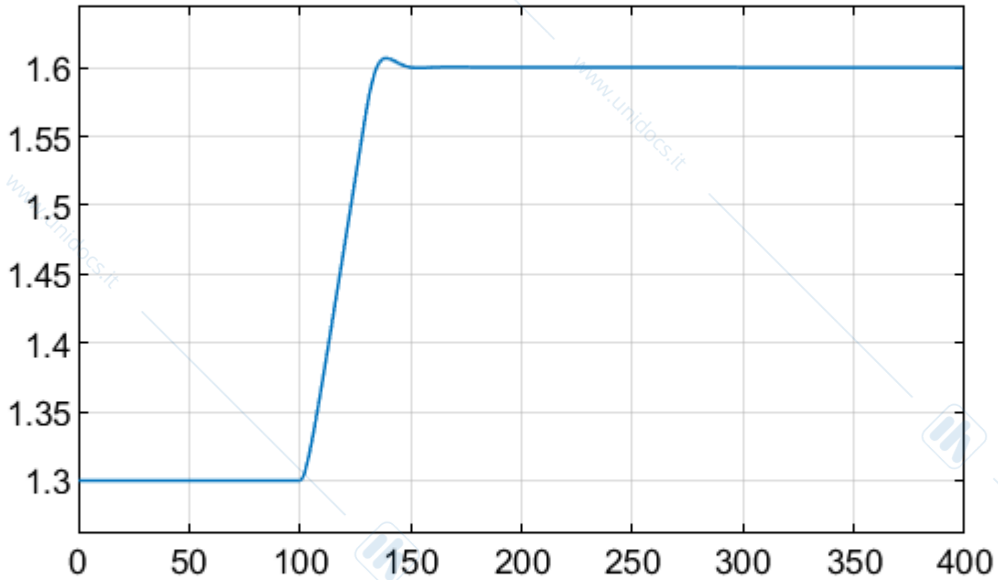
- Simulazione: - non elimina la saturazione
  - riduce i tempi della de-saturazione
  - specifica su t_a rispettata

serbatoio_aw

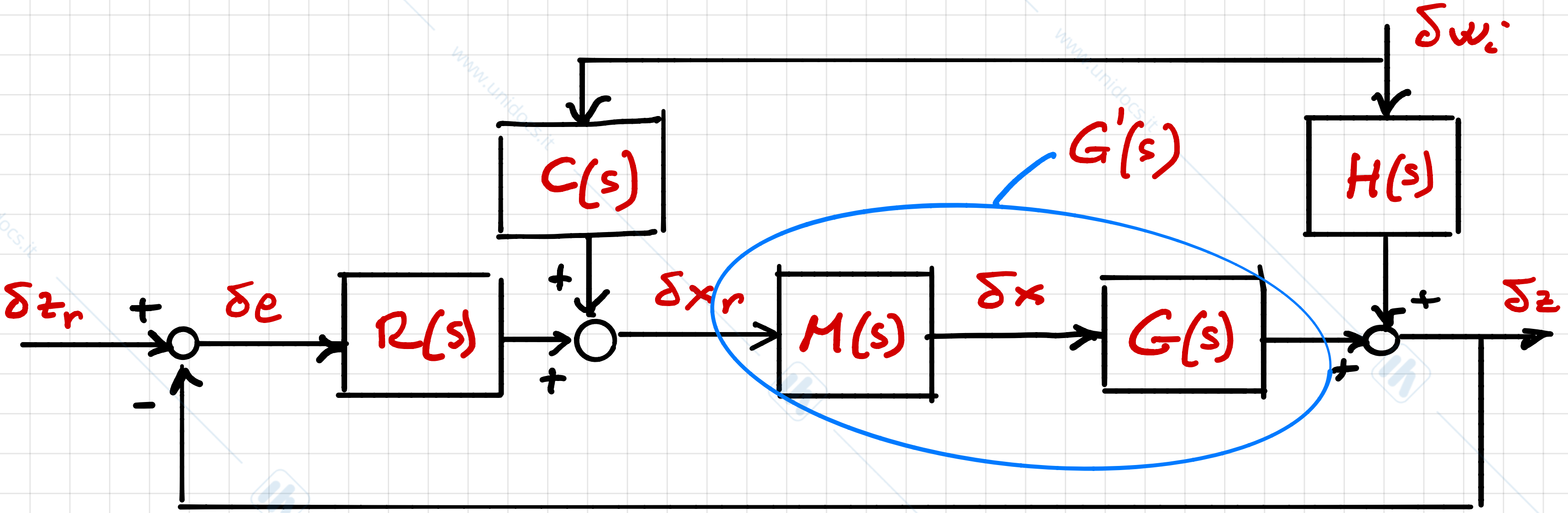


posizione valvola x(t)

livello z(t)



- COMPENSATORE IN A.A. DEL DISTURBO δw_i:



COMP. STATICO $\quad C(s) = -\frac{\mu_H}{\mu_G} = 0.05$

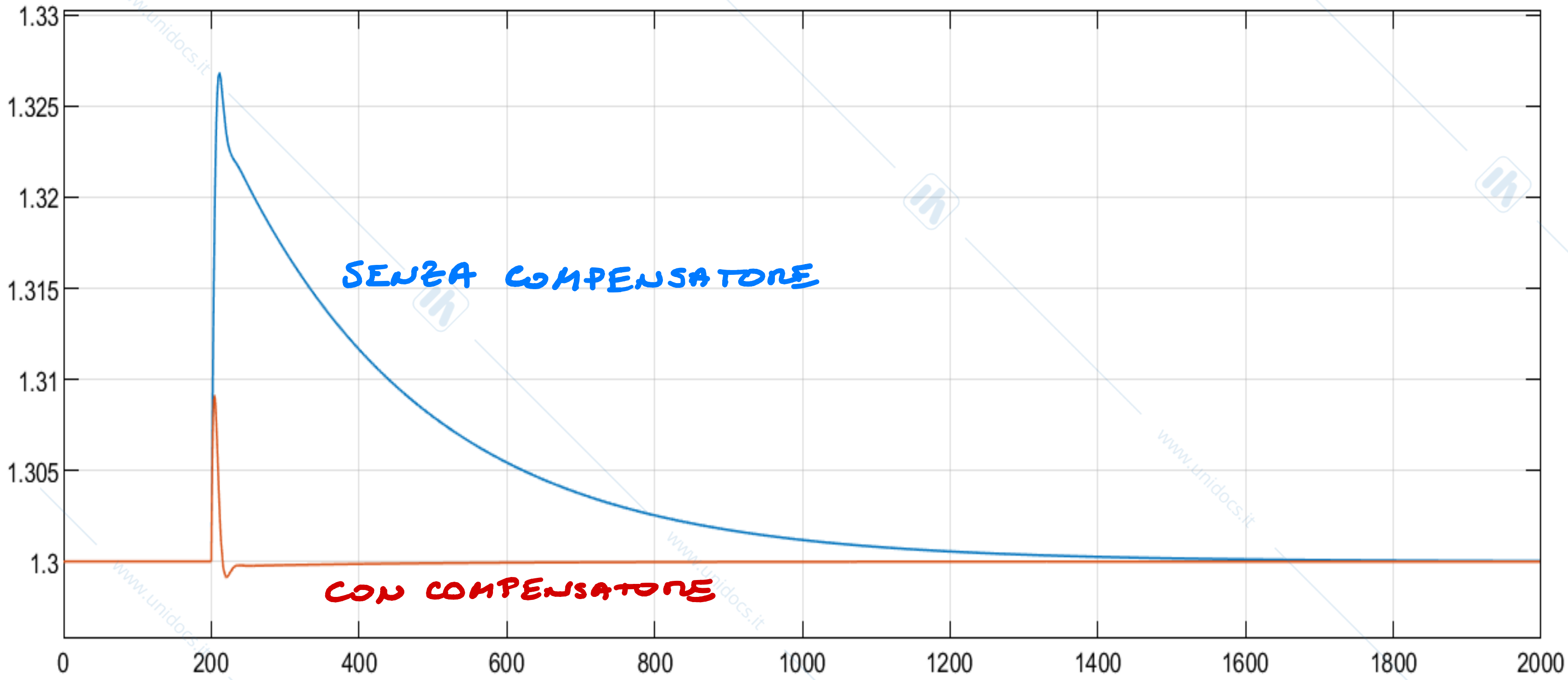
- SIMULAZIONI

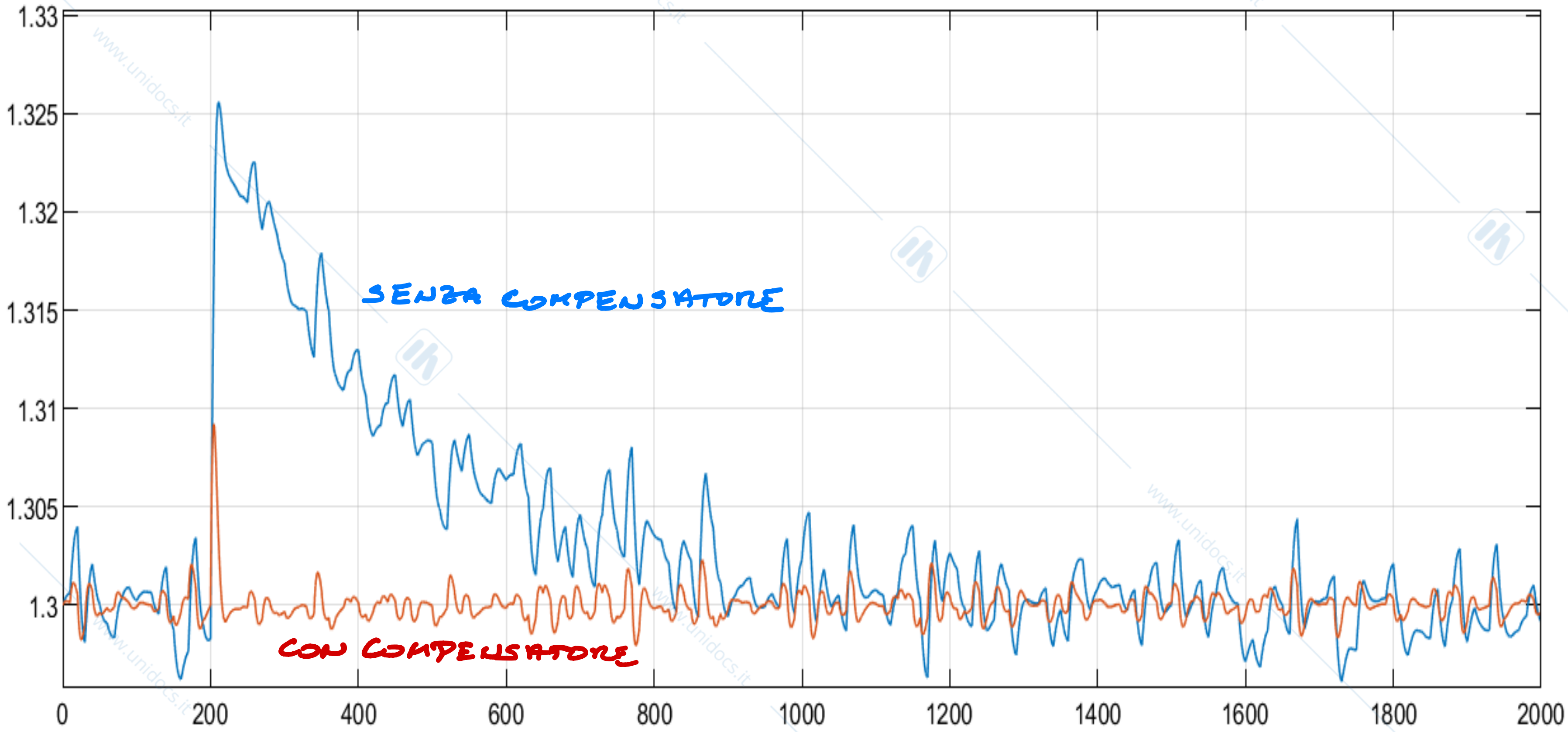
$\delta z_r = 0 \quad , \quad \delta w_i = 5\,\text{sca}(t-400)$ — REIEZIONE PIÙ RAPIDA DEL DISTURBO

$\delta z_r = 0 \quad , \quad \delta w_i = 5\,\text{sca}(t-400) + n(t)$ — REGOLAZIONE PIÙ PRECISA

($n(t)$: DISTURBO RANDOM)

serbatoio_comp


1.33
1.325
1.32
1.315
1.31
1.305
1.3
0
200
400
600
800
1000
1200
1400
1600
1800
2000
SENZA COMPENSATORE
CON COMPENSATORE


1.33
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