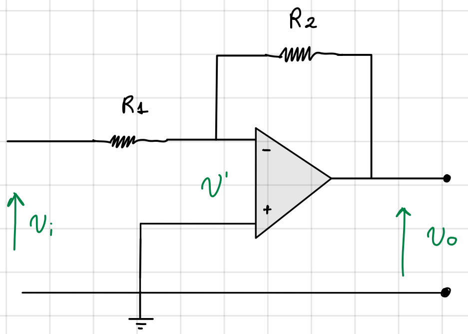
Nel contesto dei controllori, **PID** é l'acronimo di:
- **Proporzionale**
- **Integrale**
- **Derivativo**

PROPORZIONALE

$U(t) = K_p \cdot e(t) \rightleftarrows U(s) = K_p \cdot E(s) \Rightarrow \boxed{G(s) = \frac{U(s)}{E(s)} = K_p}$

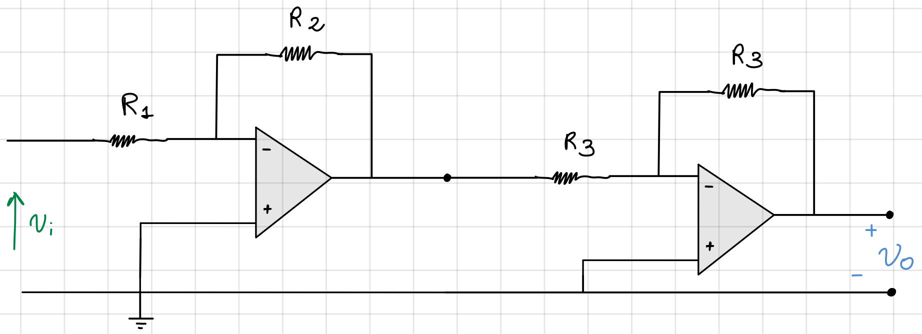


dal metodo delle impedenze: $V_o = -\frac{Z_2}{Z_1} V_i$

ma se abbiamo solo resistenze $Z_1 = R_1$, $Z_2 = R_2$

$\Rightarrow V_o = -\frac{R_2}{R_1} V_i$ e se $R_2 = R_1 \rightarrow V_o = -V_i$

$\Rightarrow$ Ci bastano due circuiti in serie:



$\Rightarrow V_o = K_p \cdot V_i$

con $K_p = \frac{R_2}{R_1}$

ES: Voglio $K_p = 3$ ed ho $R_1 = 4\,\Omega$

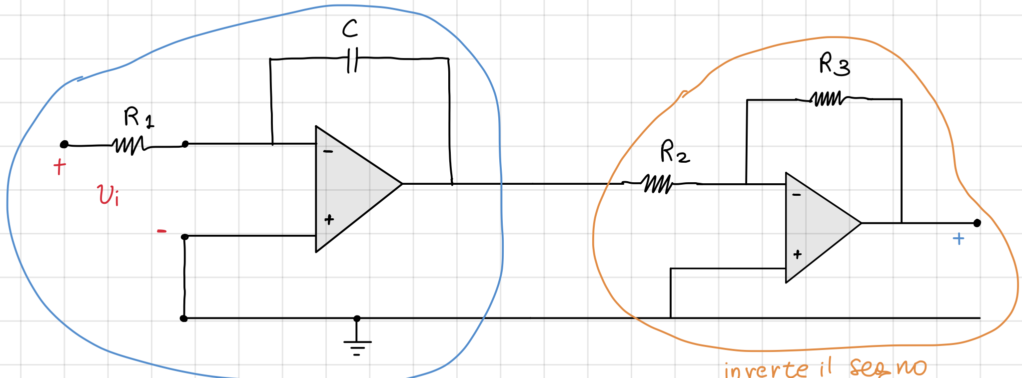
$\Rightarrow K_p = \frac{R_2}{R_1} = 3 \Rightarrow \frac{R_2}{4} = 3 \Rightarrow R_2 = 12\,\Omega$

Se non prendo $R_3 = R_3 \rightarrow K_p = \frac{R_4}{R_3} \cdot \frac{R_2}{R_1}$

INTEGRATORE

$U(t) = K_i \int_0^{\tau} e(t)\,dt \rightleftarrows U(s) = \frac{K_i}{s} E(s) \Rightarrow G(s) = \frac{K_i}{s}$

Sfrutto che $Z_C = \frac{1}{sC}$ e che $V_o = -\frac{Z_2}{Z_1} V_i$ Pongo $Z_2 = Z_C$ e $Z_1 = R_1$



Integratore

inverte il segno se $R_2 = R_3$

$V_o = \frac{1}{R_1 C s} \cdot \frac{R_3}{R_2} V_i = \frac{1}{s} \cdot \frac{R_3}{R_1 R_2 C} V_i$

integratore $\qquad K_i$

PROPORZIONALE INTEGRALE

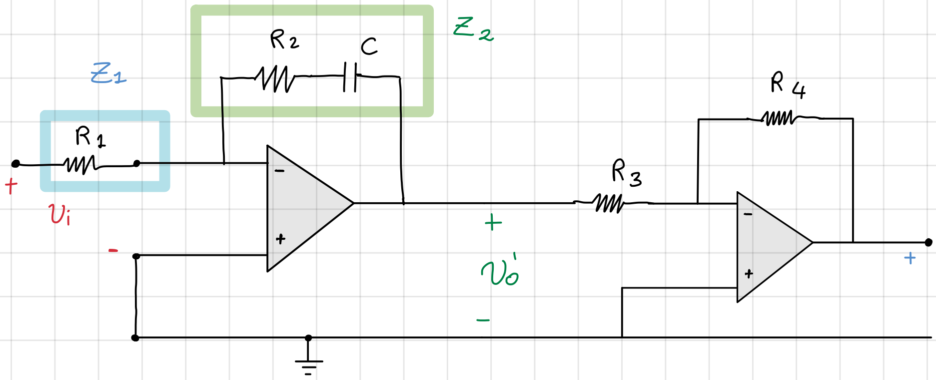
$$U(t) = K_p \cdot e(t) + K_i \int_0^t e(t)\,dt \quad \xrightarrow{C.I.=0} \quad U(S) = K_p E(S) + K_i \cdot \frac{E(S)}{S}$$

$$= E(S)\left[K_p + \frac{K_i}{S}\right]$$

$$\Rightarrow \boxed{G(S) = \frac{U(S)}{E(S)} = K_p + \frac{K_i}{S}}$$

mi serve $K_p + \frac{K_i}{S}$ e so realizzarli singolarmente.

→ Siccome Z_1 (serie) $Z_2 = Z_1 + Z_2$



$$Z_2 = R_2 + \frac{1}{Cs} = \frac{R_2Cs+1}{Cs}, \quad Z_1 = R_1 \quad \Rightarrow \quad V_o' = -\frac{\frac{R_2Cs+1}{Cs}}{R_1} = -\frac{R_2Cs+1}{R_1C\cdot s}$$

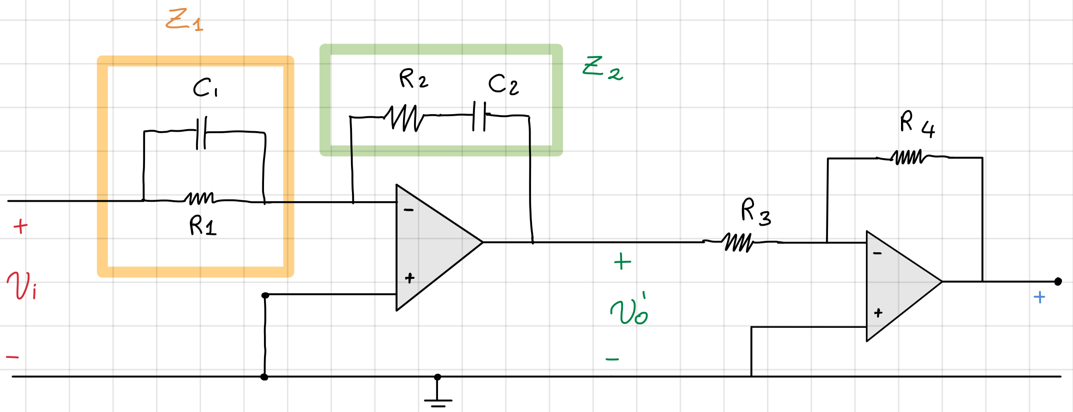
Integrazione

$$\rightarrow V_o = \frac{R_4}{R_3} \cdot \frac{R_2Cs+1}{R_1C\cdot s} = \frac{R_4}{R_3}\left[\frac{R_2\cancel{Cs}}{R_1\cancel{Cs}} + \frac{1}{R_1Cs}\right] = \frac{R_4}{R_3}\left[\frac{R_2}{R_1} + \frac{1}{R_1Cs}\right]$$

PROPORZIONALE INTEGRALE DERIVATIVO

$$U(t) = K_p \cdot e(t) + K_1 \int_0^t e(t)\, dt + K_d \cdot \frac{d\, e(t)}{dt} \rightleftharpoons U(S) = K_p\, E(S) + K_i \cdot \frac{E(S)}{S} + K_d S\, E(S)$$

$$\Rightarrow \boxed{G(S) = \frac{U(S)}{E(S)} = K_p + \frac{K_i}{S} + S\, K_d}$$



$$V_o = \frac{R_4}{R_3}\; \frac{R_2}{R_1}\; \frac{(R_1 C_1 S + 1)\,(R_2 C_2 S + 1)}{R_2\, C\, S}\; V_i$$