Power Electronics No. 10: PI-controller for DC motor speed control

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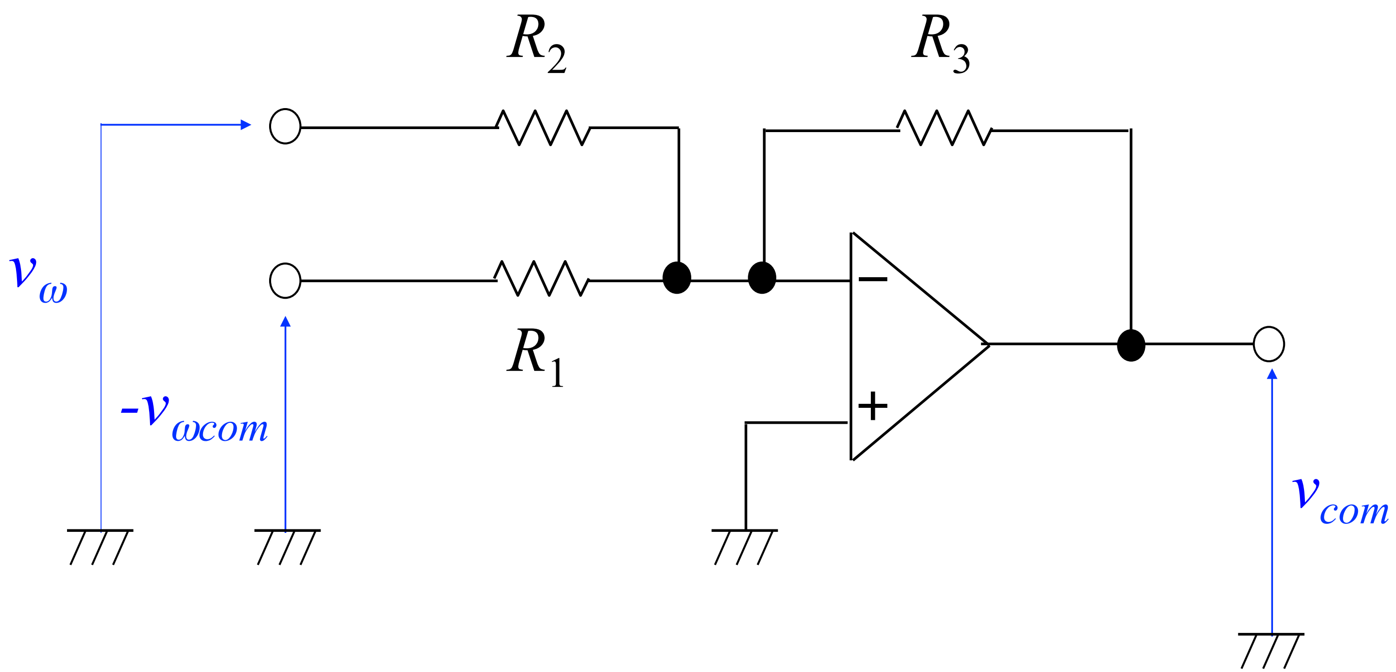
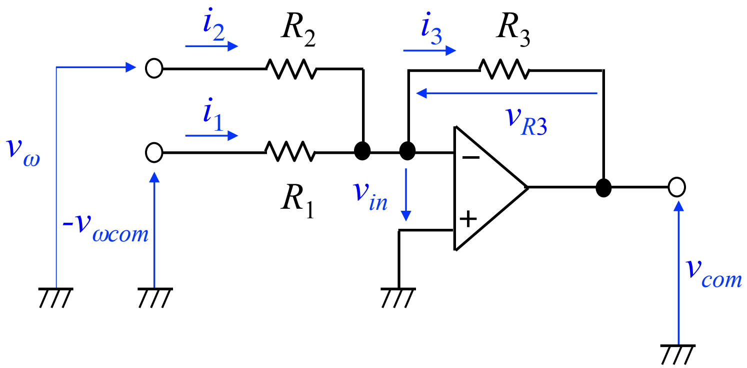
P-controller



P-controller using op-amp



P-controller using op-amp

$$v_{in} = 0, \text{then } \; i_1 = \frac{-v_{\omega com}}{R_1}, \quad i_2 = \frac{v_\omega}{R_2}$$

$$R_{in} = \infty, \text{then } \quad i_3 = i_1 + i_2$$

$$v_{R3} = R_3 i_3 \quad \text{and} \quad v_{com} = -v_{in} - v_{R3}$$

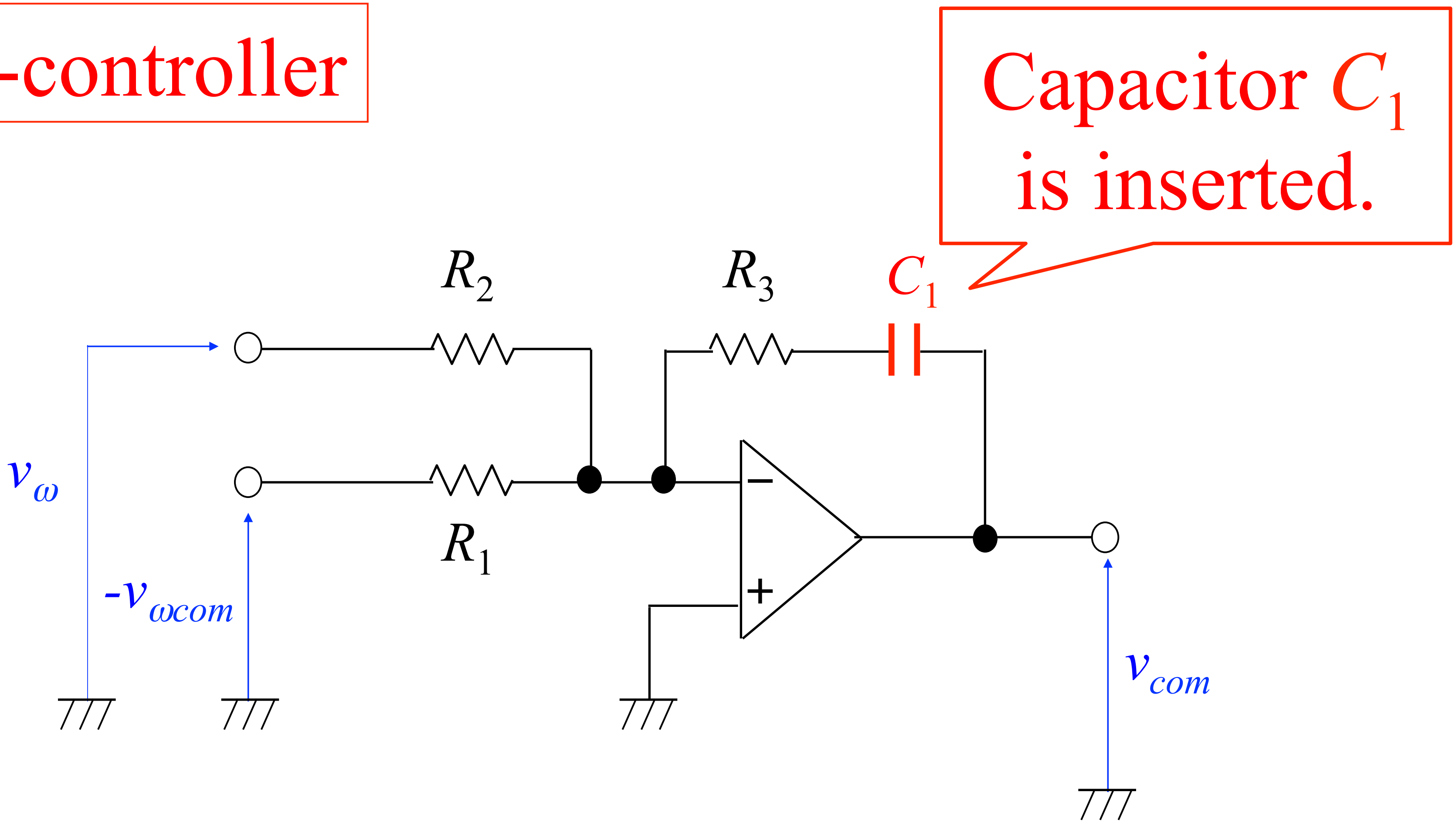
$$v_{com} = \frac{R_3}{R_1} v_{\omega com} - \frac{R_3}{R_2} v_\omega$$

$$Let, R_1 = R_2, \text{then}$$

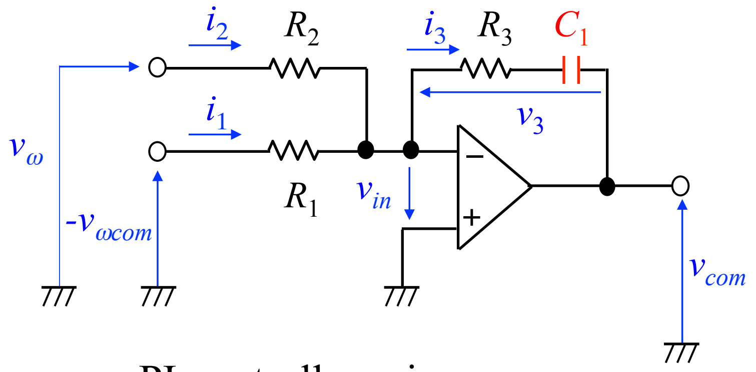
$$v_{com} = \frac{R_3}{R_1}(v_{\omega com} - v_\omega) = \underline{K_P}(v_{\omega com} - v_\omega)$$

Proportinal gain

PI-controller



PI-controller using op-amp



PI-controller using op-amp

$$v_{in} = 0, \text{ then} \quad i_1 = \frac{-v_{\omega com}}{R_1}, \quad i_2 = \frac{v_\omega}{R_2}$$

$$R_{in} = \infty, \text{ then} \quad i_3 = i_1 + i_2$$

$$v_3 = R_3 i_3 + \frac{1}{C_1}\int i_3 \, dt$$

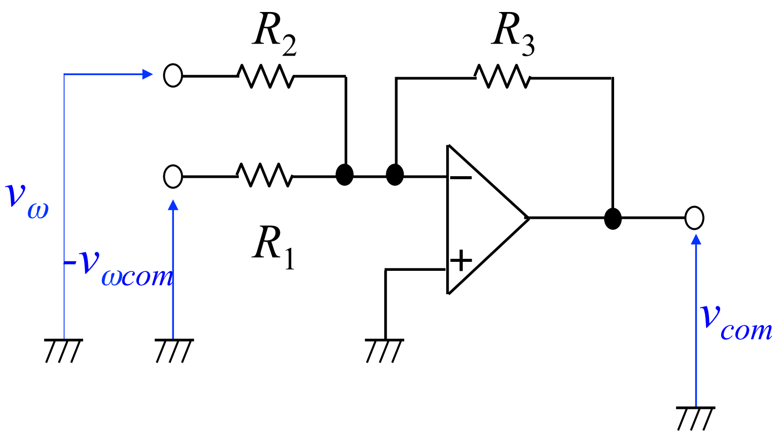
$$v_{com} = -v_{in} - v_3$$

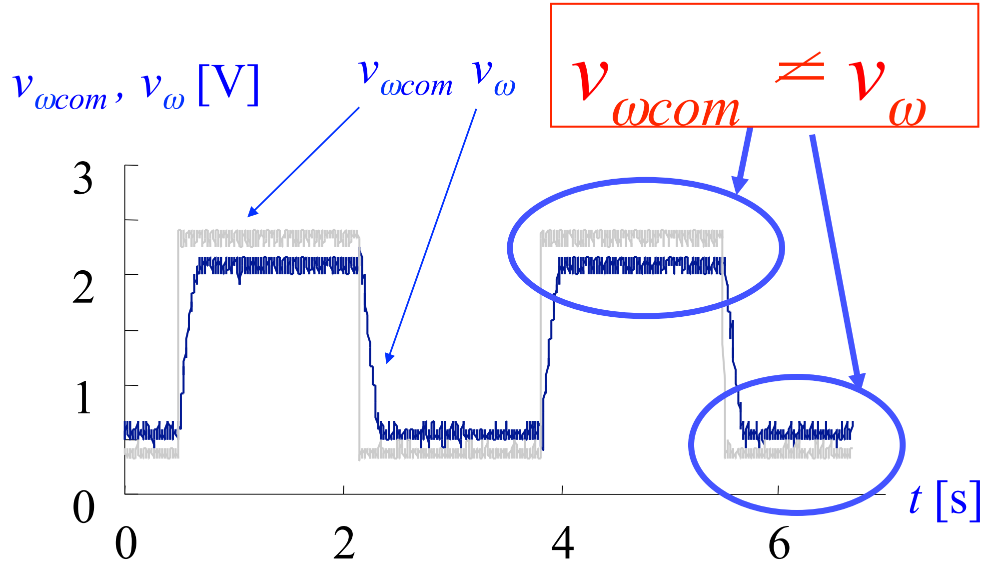
Assuming that $R_1 = R_2$,

$$v_{com} = \frac{R_3}{R_1}(v_{\omega com} - v_\omega) + \frac{1}{R_1 C_1}\int (v_{\omega com} - v_\omega)\, dt$$

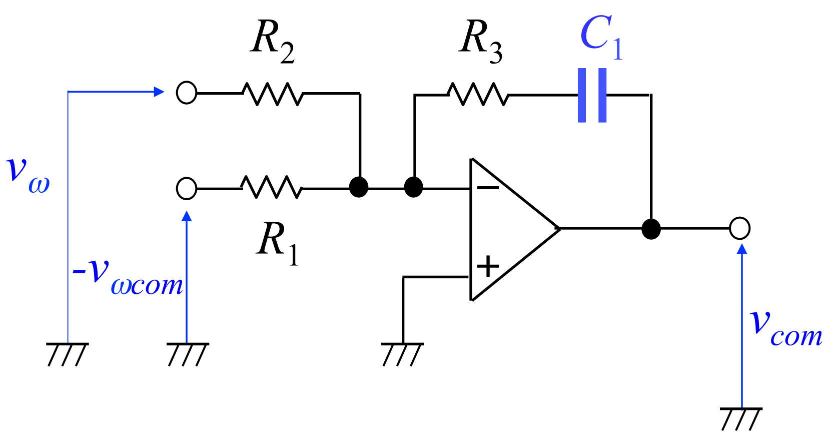
$$= K_P (v_{\omega com} - v_\omega) + K_I \int (v_{\omega com} - v_\omega)\, dt$$

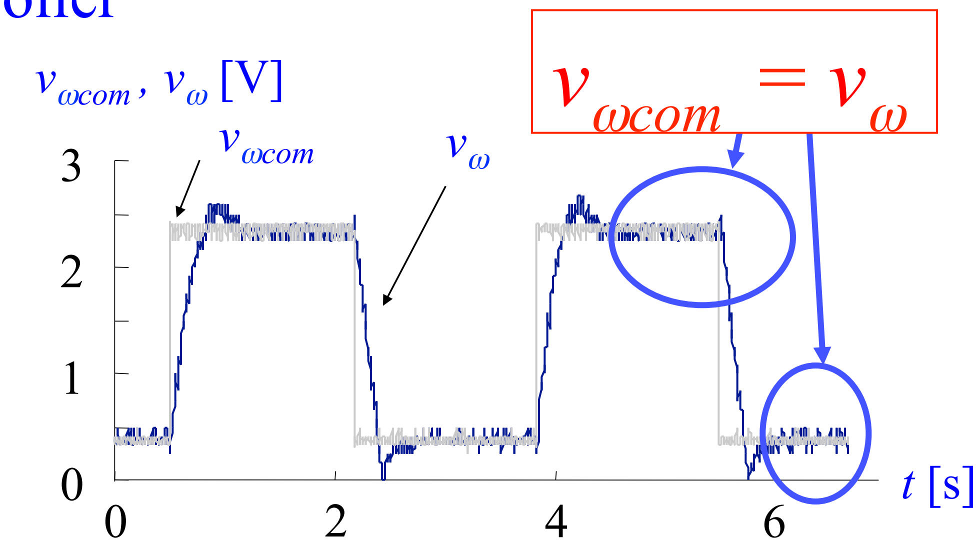
Proportional gain Integral gain





P-controller





PI-controller

Step 8. Problem

P-controller cannot make $v_{\omega com}$ and v_{ω} coincide with each other. Conversely, PI-controller can make them coincide.

Explain the reason.