Controller

$$\dot{v} = a$$

$$F = m \cdot a$$

$$F = G_p \cdot \mathrm{K} \qquad \frac{m \cdot a}{G_p} = \mathrm{K} \qquad G_p \in [-1,1]$$

$$a = \frac{K}{m} \cdot G_p$$

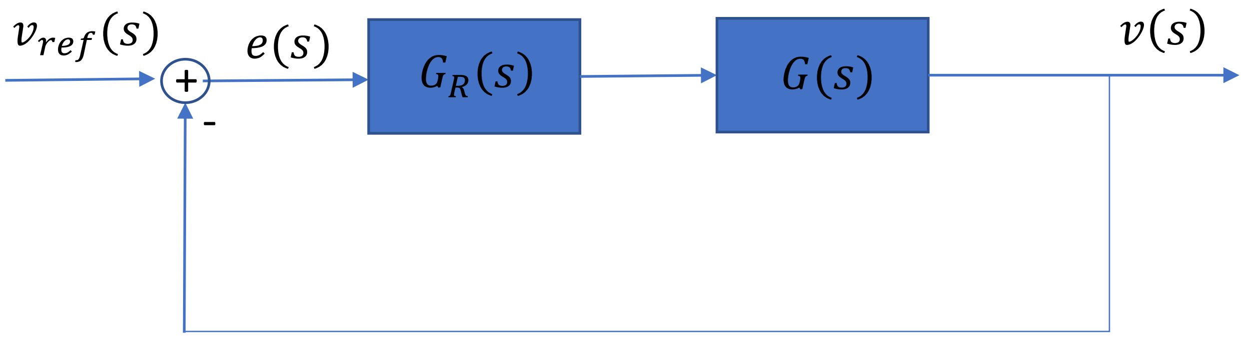
$$\dot{v} = \frac{K}{m} \cdot G_p$$

Laplace

$$v(s) = \underbrace{\frac{1}{s} \cdot \frac{K}{m}}_{G(s)} \cdot G_p$$

$$G_p(s) \longrightarrow \boxed{G(s)} \longrightarrow v(s)$$

PI-Controller: $G_R(s) = k_p + \frac{k_i}{s}$



$$G_{tot}(s) = \frac{G_R(s) * G(s)}{1 + G_R(s) * G(s)}$$

$$= \frac{\frac{K}{m} * \frac{1}{s} * (k_p + \frac{1}{s} * k_i)}{1 + \frac{K}{m} * \frac{1}{s} * (k_p + \frac{1}{s} * k_i)}$$

$$= \frac{k_p * s + k_i}{\frac{m}{K} * s^2 + k_p * s + k_i}$$

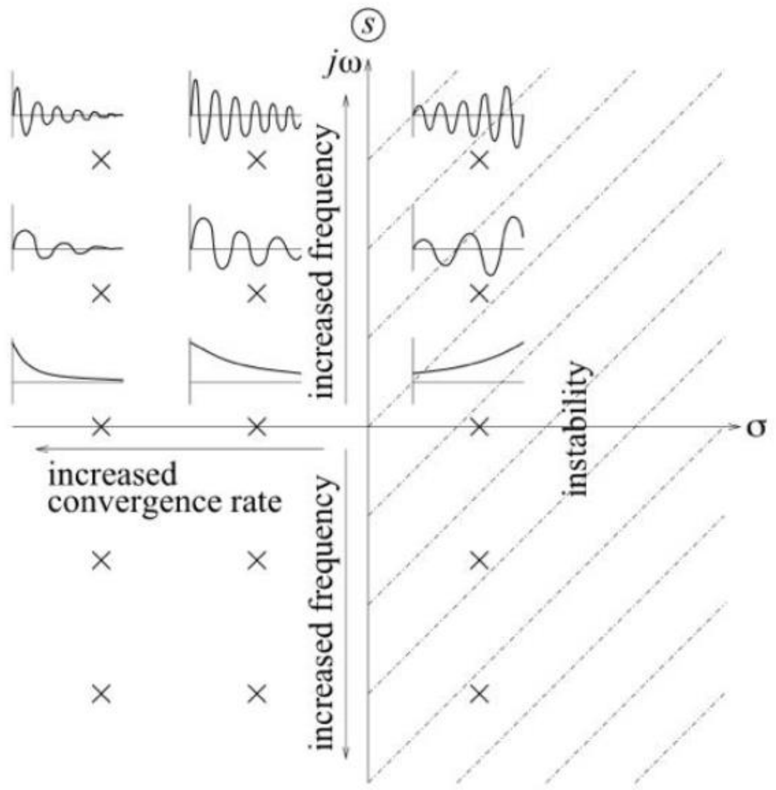
$$G_{tot}(s) = \frac{k_p * s + k_i}{\boxed{\frac{m}{K} * s^2 + k_p * s + k_i}}$$

$$s^2 + \frac{K}{m} * k_p * s + \frac{K}{m} * k_i = 0$$

$$-\frac{K * k_p}{m * 2} +/- \sqrt{\left(\frac{K * k_p}{m * 2}\right)^2 - \frac{K}{m} * k_i}$$

$$\frac{K * k_p}{m * 2} > \sqrt{\left(\frac{K * k_p}{m * 2}\right)^2 - \frac{K}{m} * k_i} \qquad (1)$$

$$\left(\frac{k_p}{2}\right)^2 * \frac{K}{m} > k_i \qquad (2)$$



Only approximation!

Current Gains:

$$k_p = 0{,}08$$
$$k_i = 0{,}01$$
$$k_d = 0{,}0015$$

$$0.26 > 0.06 \quad (1)$$
$$0.0105 > 0.01 \quad (2)$$

$\Rightarrow$ Slow system