Formulario Digital Control

PID Controller

PD Controller

$$C_{PD}(s) = K_P\left[1 + sT_D\right]$$

$$C_{PD}(s) = K_P\left[\frac{1+sT_D}{1+sT_L}\right]$$

PI Controller

$$C_{PI}(s) = K_P\left[1 + \frac{1}{sT_I}\right]$$

$$C_{PI}(s) = \frac{K_I}{s}[1 + sT_I]$$

PID Controller

$$C_{PID}(s) = \frac{K_I}{s}\left[1 + sT_I + s^2T_IT_D\right]$$

$$C_{PID}(s) = K_P\left[1 + \frac{1}{sT_I} + sT_D\right]$$

$$C_{PID}(s) = K_P\left[1 + \frac{1}{sT_I} + \frac{sT_D}{1+sT_I}\right]$$

$$K_P = \frac{K_I}{T_I}$$

Emulation Methods

Forward Euler

$$\frac{z-1}{T}$$

Backward Euler

$$\frac{1-z^{-1}}{T} = \frac{1-\frac{1}{z}}{T} = \frac{z-1}{zT}$$

Tustin

$$\frac{2}{T}\frac{z-1}{z+1}$$

Specifications

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Time	$\longrightarrow$	Frequency
m_p (overshoot)		m_φ (phase margin) $= 1.04 - 0.8\mathrm{m}_p$
t_r (rise time)		w_c (crossover frequency) $= \frac{2}{t_r}$

Choice of the Sampling Time

Delay of the Sampler: $T \leqslant \frac{t_r}{10}$ $\Omega \geqslant \frac{20\pi}{t_r}$

Delay of the Holder: $\Delta\varphi = \frac{w_cT}{2}$ $\varphi_M \geqslant \frac{w_cT}{2}$ $\Omega \geqslant \frac{w_c\pi}{P_M}$

Anti-aliasing filter: $\Omega\varphi_M \geqslant 4\xi w_c\sqrt{a}$

Z-Transform Property

Time advance	Time delay
$y(k+a)$	$y(k-a)$
$\downarrow Z$	$\downarrow Z$
$z^aY(z) - \sum_{l=0}^{a-1} y(l)z^{a-l}$	$z^{-a}Y(z) + \sum_{l=1}^{a} y(-l)z^{-(a-l)}$