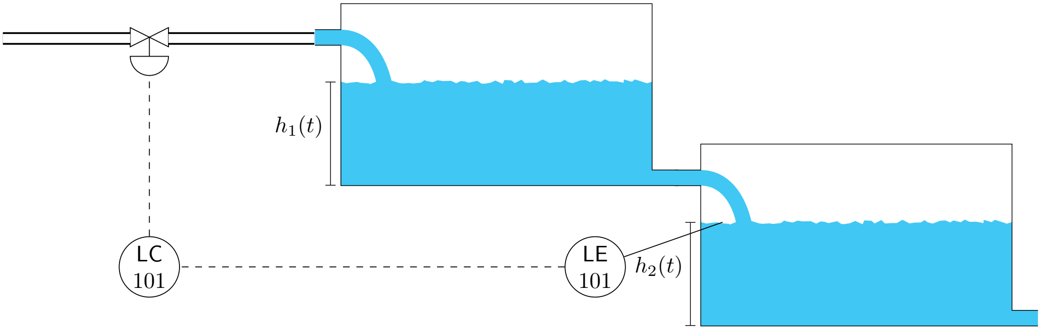
Process Automation Laboratory - Anti windup

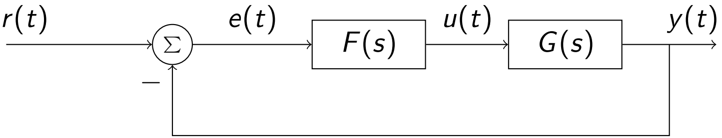
Kjartan Halvorsen

2020-09-21

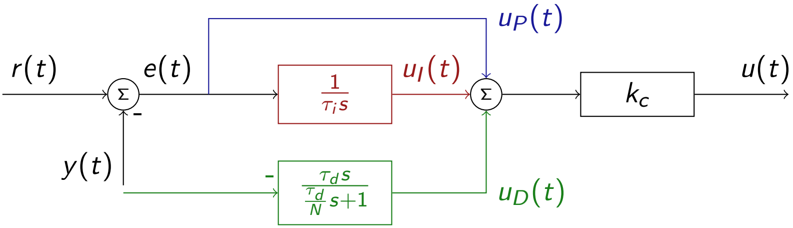
Two -tank model



Feedback control



The PID - practical form



The parameter N is chosen to limit the influence of noisy measurements. Typically,

$$3 < N < 20$$

The PID - practical aspects

Åström & Hägglund (1988) *PID controllers: Theory, design and tuning, 2nd ed* Instrument Society of America.

Approximating nonlinear systems with linear models

- Model is accurate only in neighborhood of operating point for which system is approximated.
- Solution: Divide operating range into many regions, with separate PID parameters for each region

Approximating high-order systems with low-order models

- Only accurate for low frequencies
- Beware of behavior for high-frequency input to the closed-loop system

The PID - practical aspects, contd

When do PID controllers work well?

- The plant dynamics can be well approximated with low-order model
- Demands on performance not too high

More sophisticated control needed when

- Higher order dynamics
- Oscillatory modes
- Long deadtime

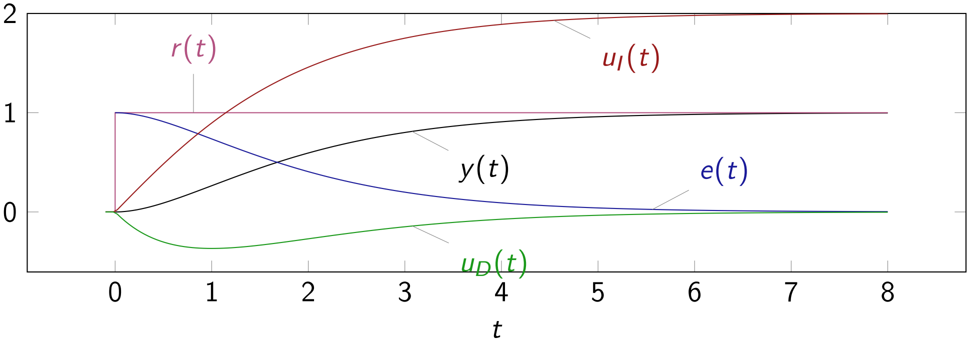
The PID - practical aspects, contd

Choice of controller

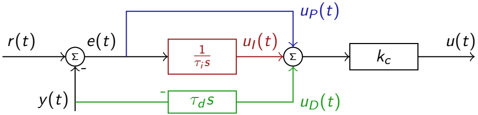
1. P-controller if damping and steady-state error satisfied
2. PI-controller if steady-state error must be zero (often 1st order dynamics)
3. PID-controller if PI does not give sufficient damping (often 2nd order dynamics)
4. Tuning parameter τ_c for SIMC tuning method:
    - Smaller (=faster) than τ if sufficiently damped and limitations on input signal not violated.
    - larger (=slower) than τ if more damping required or smaller input signal required.

The PID - Parallel form, solution

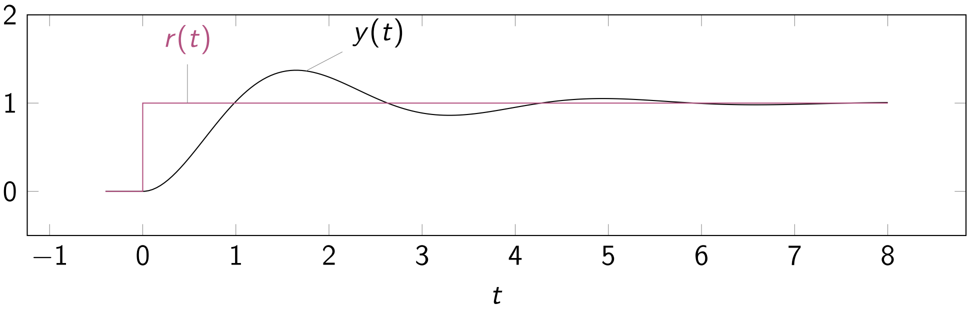
$$u(t) = k_c\left(e(t) + \overbrace{\frac{1}{\tau_i}\int_0^t e(\xi)d\xi}^{u_I(t)} + \underbrace{\tau_d\frac{d}{dt}\left(-y(t)\right)}_{u_D(t)}\right)$$



The PID - Integral signal

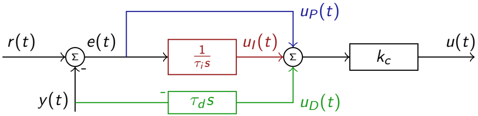


$$u(t) = k_c\left(e(t) + \overbrace{\frac{1}{\tau_i}\int_0^t e(\xi)d\xi}^{u_I(t)} + \underbrace{\tau_d \frac{d}{dt}(-y(t))}_{u_D(t)}\right)$$

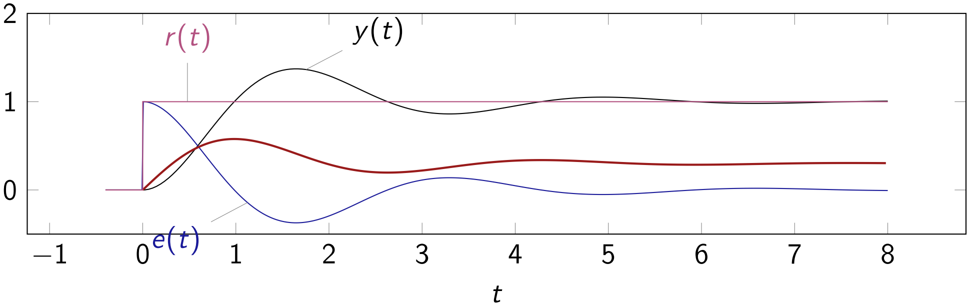


Activity Sketch the error signal $e(t)$ and the integral signal $u_I(t)$ (use $\tau_i = 1$)

The PID - Integral signal - Solution



$$u(t) = k_c\left(e(t) + \overbrace{\frac{1}{\tau_i}\int_0^t e(\xi)d\xi}^{u_I(t)} + \underbrace{\tau_d \frac{d}{dt}\big(-y(t)\big)}_{u_D(t)}\right)$$



Integral windup

Video by Tomás Alejandro Lugo Salinas (MTY)

Anti-windup using back-calculation