Optimal PID-Control for First Order Plus Time Delay Systems & Verification of the SIMC Rules

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Abstract: Optimal cascade PID-settings are found for first-order with delay processes for specified levels of robustness (M_s-value) and compared with a modified SIMC-rule for PID-control (Figure 1). Optimality (performance) is defined in terms of the integrated absolute error for combined step changes in load output and load input disturbances. The SIMC method for PID-controller tuning (Skogestad, 2003) has already found wide industrial usage. For a first-order system with time delay,

$$G(s) = \frac{k}{(\tau_1 s + 1)} \cdot e^{-\theta s}$$

the SIMC-rules are given as

$$K_C = \frac{1}{k} \frac{\tau_1}{\tau_c + \theta}$$
$$\tau_I = \min\{\tau_1,\ 4(\tau_c + \theta)\}$$

and results in a PI-controller. If a PID-controller is desired for a first-order system, we propose to introduce derivative action with $\tau_D = \theta/3$ to counteract the time delay θ. With the SIMC-rule, the robustness level is adjusted by changing the tuning parameter τ_c. The added derivative action was found to give surprisingly good settings with near Pareto-optimal performance. However, to take advantage of this increase in performance the tuning parameter τ_c should be reduced to about half of the recommended value $\tau_c = \theta$.

Keywords: Optimality, PID controllers, Pareto-optimal, robustness, performance evaluation.

REFERENCES

Skogestad, S. (2003). Simple analytic rules for model reduction and PID controller tuning . 13, 291–309.

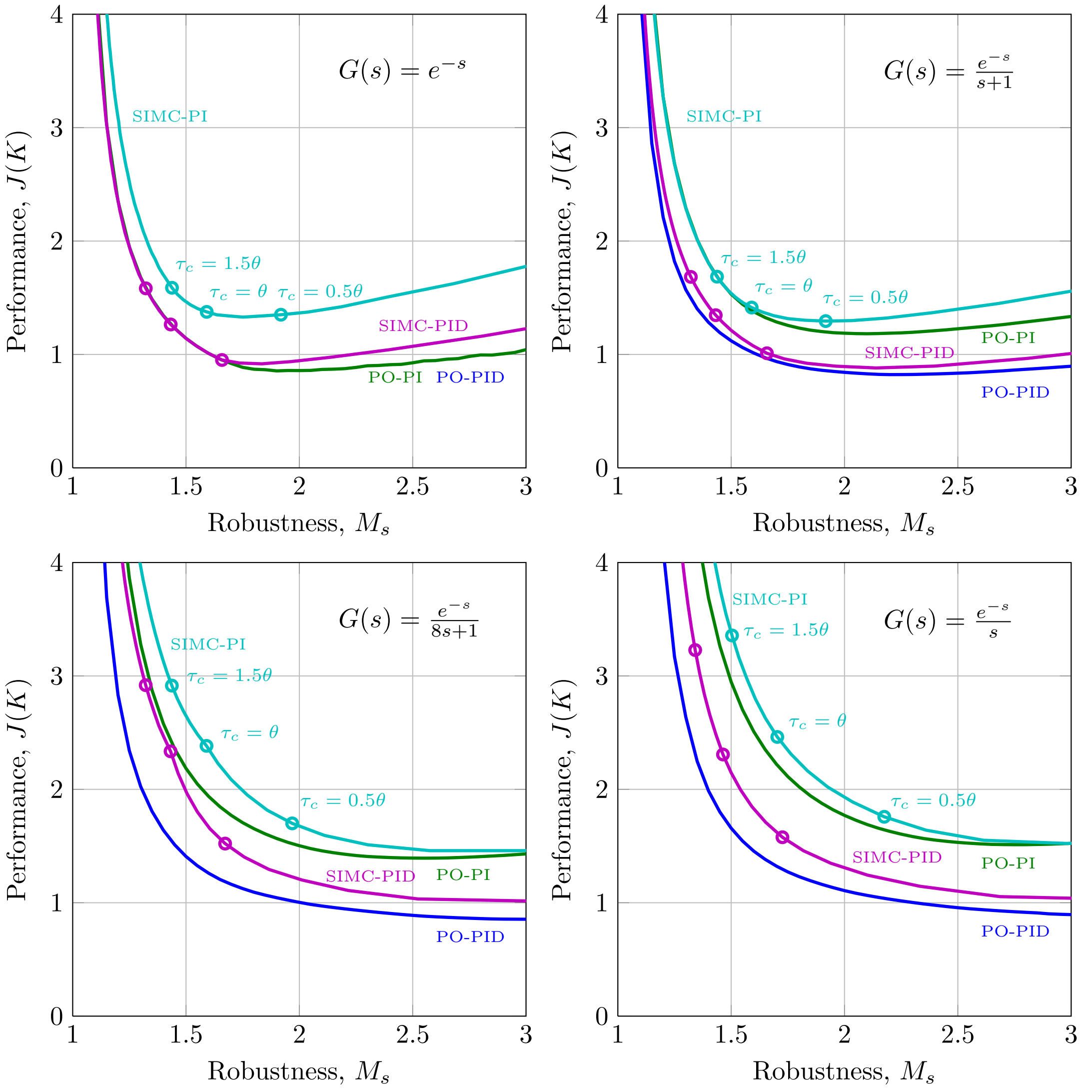

Fig. 1. Pareto-optimal trade-off between robustness (M_s) and performance (J) with PI and PID control for four lower order processes processes.