Robust PID Design with Adjustable Control Signal Noise Reduction

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The PID controller is by far the most common controller in industry today. The derivative part is, however, in general turned off. The main reason being to avoid severe measurement noise throughput in the control signal. Fast, high amplitude, changes in the control signal lead to wear and tear on actuators, like for instance valves. Such equipment is typically very expensive to replace. To be able to use the D-part of the controller it would therefore be advisable to have a PID design method which limits the control signal activity due to measurement noise. Naturally, the performance of the closed loop varies depending on how low this limit is set. Therefore, it would also be desirable to have knowledge about such a relation. A new method achieving these goals will be described here.

In [1] it is described how a newly developed Matlab program derives robust PID controllers such that the Integrated Absolute Error (IAE) during a load disturbance on the process input is minimized. The program was used in this work together with the extension that the relation

$$V_k = \frac{\sigma_u^2}{\sigma_n^2}$$

is limited. Where σ_n^2 is the variance of the measurement noise and σ_u^2 is the variance of the control signal due to the noise.

The noisy measurement signal is assumed to be fed through a lowpass filter of the form

$$G_f(s) = \frac{1}{(sT_f)^2/2 + sT_f + 1}.$$

The key to limit the relation V_k is to vary the time constant, T_f, of the filter. The new method works as follows,

1. Collect noise data from the process, detrend it and estimate the variance σ_n^2.

2. Choose a number of different T_f values. For each T_f

- design a PID controller using the Matlab program.
- simulate the closed loop system using the gathered noise data and estimate the variance, σ_u^2, of the control signal.

3. Plot IAE versus V_k to get a picture of how much performance costs in terms of measurement noise throughput in the control signal. Figure 1 shows how this relation could look for PID control on a real process.

Using the described method, it is possible for the user to choose a PID controller taking the trade-off between performance and low control signal activity into account. The final controller will assume either PI or PID control structure depending on how the demands are set. In other words, the method does not prefer a certain control structure. The best structure is set based on what is suitable for the given process.

The new PID design method is both fast and easy to use. It has also been tested on real processes and shown to work satisfyingly.

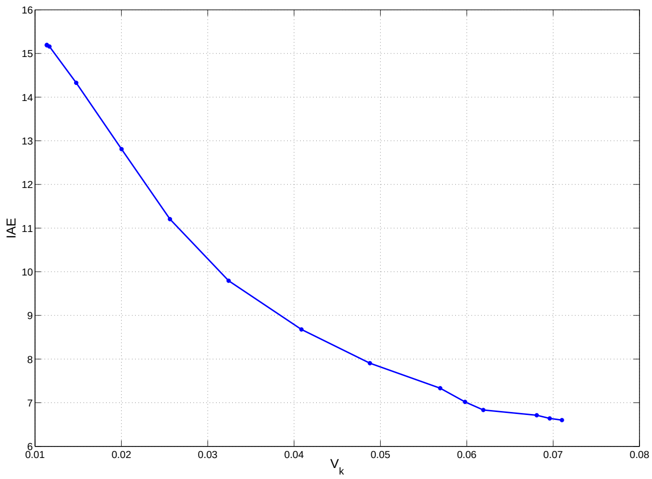

Figure 1: Trade-off curve showing how performance is related to control signal activity due to measurement noise. This particular curve was drawn after experiments on a real recirculation flow in a distillation column.

References

[1] O. Garpinger and T. Hägglund. A Software Tool for Robust PID Design. In *IFAC World Conference*, Seoul, South Korea, July 2008.