

the Control Station guru

Your source for process control solutions

www.ControlStation.com

Fall 2004

SHORT COURSE FOR INDUSTRY

Practical Process Control

For Technicians, Engineers & Scientists
October 19 & 20, 2004

The course is intended for a mixed audience including those who have had prior training and seek a refresher course, and those who have had no formal training and desire an introduction to process control. There is little math presented because we focus on how to use methods rather than how to derive them.

We begin with a review of the fundamentals of modern PID control. We then explore proven controller design methods and tuning techniques popular in industrial practice.

Day 1:

- Fundamental Dynamic Process Behavior
- Process Data Collection and Analysis
- Tuning PI, PID and PID w/ Filter Controllers
- Non-Linear Behavior and Adaptive Control
- Tuning Controllers for Industrial Applications

Day 2:

- Cascade Control Design and Tuning
- Feed Forward and Decoupling Control
- Smith Predictor for Dead Time Problems
- Control of Non-Self-Regulating Processes

Leading Companies Strive for Excellence
and Train with Control Station®

*To compete with them...
... you need to join them*

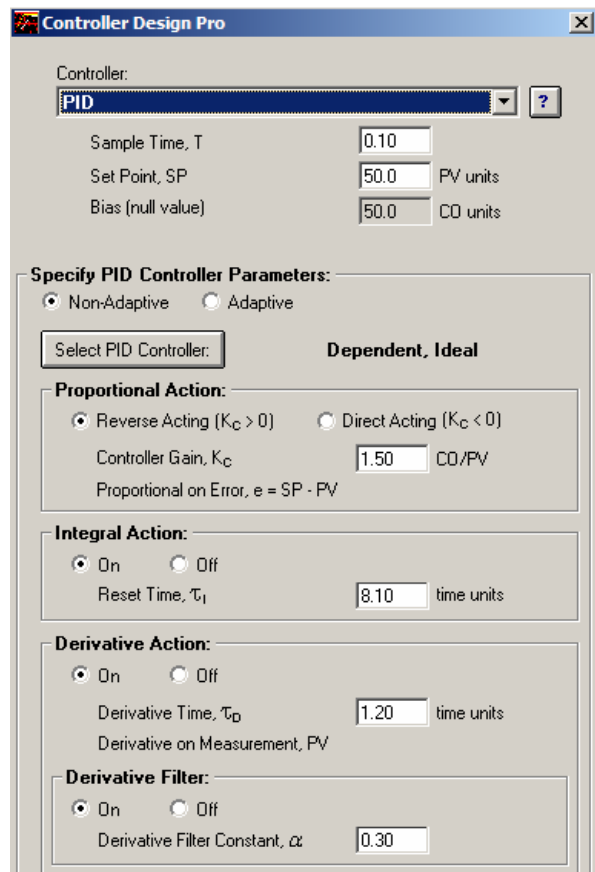
For course details and registration, visit us at
www.ControlStation.com

COMING IN SEPTEMBER 2004

Control Station® Version 4.0

Control Station® will release Version 4.0 of its process control software suite in September, including its Engineer™ and Developer™ solutions. With new custom process and OLE for Process Control (OPC) capabilities, Version 4.0 equips users to improve plant productivity, safety, and bottom-line profitability. These technologies empower engineers of all experience levels to optimize their process control systems.

Developed with process engineers in mind, Control Station® Version 4.0 products are intuitive, empowering, and guaranteed to deliver value.



Ask the Guru About PID with Derivative Filter

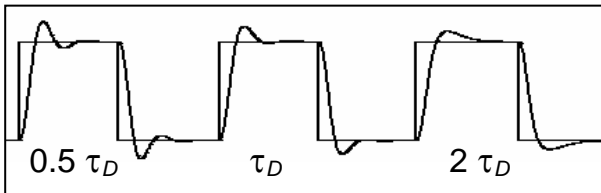
Q: Hey Guru, how does a derivative filter improve performance and reduce maintenance in my plant?

A: To answer this question, let's first consider the traditional PID controller (ideal form) that computes controller output as:

$$CO = CO_{\text{bias}} + K_C e(t) + \frac{K_C}{\tau_I} \int e(t) dt - K_C \tau_D \frac{dPV}{dt}$$

Where $e(t) = SP - PV$. Note that derivative on the measured process variable is used to avoid derivative kick. The three terms of a PID controller work to provide rapid response to error (proportional term), to eliminate offset (integral term), and to minimize oscillations in the process variable (derivative term).

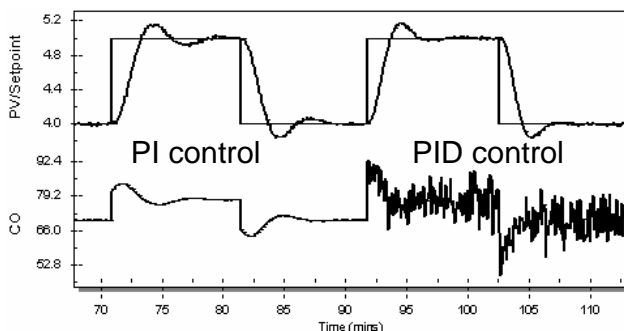
The figure below shows how derivative action impacts performance. The middle trace shows the base case. The trace to the left shows that oscillations increase as derivative action is decreased. The trace to the right shows that large derivative action inhibits rapid movement in the process variable.



Impact of derivative action on PID control performance

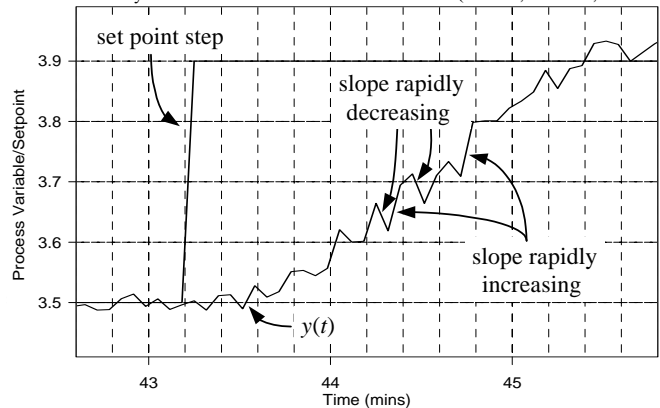
One challenge of derivative action is balancing three interacting tuning parameters to achieve the desired level of control. Control Station® is invaluable for tuning for best performance. A second challenge relates to the uncertainty in the derivative computation for processes that have either noise or random error in the measured process variable.

Below is a process first under PI and then PID



Comparing PI and PID controllers

control. The obvious difference between these controllers is that derivative action causes random noise in the process variable to be both amplified and reflected in the controller output signal. Such extreme control action will lead to increased maintenance and can harm performance. The figure below shows the reason for this controller output activity. Noise in the process variable signal produces conflicting derivatives as the slope repeatedly changes direction. Derivative action compensates for these changes by computing rapidly alternating control moves, resulting in the chatter shown in the previous figure.



Noise causes uncertainty in the derivative computation

The PID controller can be modified with a derivative filter to improve performance in the presence of noise. The filter limits large fluctuations in controller output, thereby reducing controller output chatter. Even if noise does not pose a performance problem, the derivative filter can reduce fluctuations in controller output that cause valve wear.

The PID with filter algorithm (ideal form) computes controller output as:

$$CO = CO_{\text{bias}} + K_C e(t) + \frac{K_C}{\tau_I} \int e(t) dt + K_C \tau_D \frac{dPV(t)}{dt} - \alpha \tau_D \frac{dCO}{dt}$$

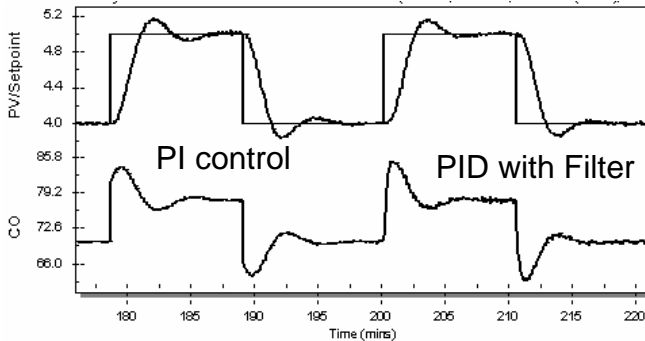
This controller is identical to the PID controller except for the last term (the filter term) on the right side of the equation. The filter term subtracts a derivative or rate of change in controller output from the traditional PID computation.

When the traditional PID terms compute a large and sudden change in output, the rate of change (derivative) also becomes large. This controller output derivative is subtracted from the traditional computation as shown in the above equation.

If the derivative is large, then the actual change in controller output sent to the valve is filtered – it is smaller than with the traditional PID controller. The

size of the filter constant, α , dictates how much of each change is filtered out of the final output signal.

The figure below shows the performance of a PI and PID with Filter controller for the same process as in the previous example. Comparison of the plots shows that the benefit of a derivative filter can be remarkable.



Comparing PI and PID with Filter controllers

Because a derivative filter works to limit sudden changes in controller output, an aggressive filter with a large filter constant, α , can degrade performance. The filter constant should be just large enough to contain the erratic fluctuations in the output, but not so large that it degrades the overall performance of the controller.

To learn more about PID with Derivative Filter and other process control topics, visit us at our corporate website – www.ControlStation.com.

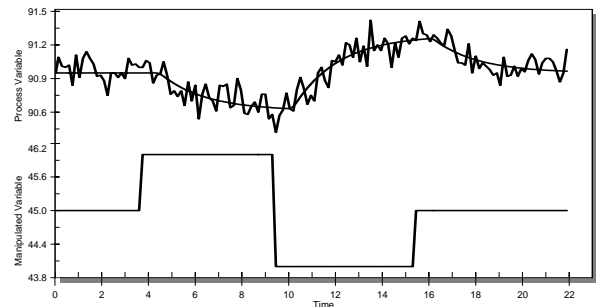
- The Control Station Guru

Checklist For Good Process Data

No software can provide quality output if the data inputs are poor. The old adage "garbage in, garbage out" remains a fact of life. Whether you are fitting a model for simulation, tuning, or model-based control, the answer to the following questions should be "yes":

1. Was the process at steady state at the beginning of your data set?
2. Did the test dynamics clearly dominate the process noise?
3. Were the disturbances quiet during the dynamic test?
4. Does the model visually appear to approximate the data plot as shown below?

You need to consider all of these items to ensure success. If any of these questions is not true, your analysis may be inaccurate, regardless of the software you use, and your results should be used with caution.



Control Station® model visually approximates PV data

Doug Cooper – *the Control Station Guru* – is Founder and Chief Technology Officer of Control Station LLC, a process control solutions company based in Tolland, Connecticut. He has contributed significantly to the advancement of process control technologies through his work in industry as well as through his academic research. In addition to his role at Control Station, Dr. Cooper is a full professor and department head at the University of Connecticut, School of Chemical Engineering. He is a recognized specialist in the fields of advanced process modeling, monitoring and control; intelligent technologies and adaptive process control; and software tools for process control system analysis, tuning, and training. Dr. Cooper is lead instructor for the short course for industry: Practical Process Control. For information about Control Station software and our short course for industry, please contact:

Doug Cooper, Ph.D.
 Phone: (860) 486-4092
Doug.Cooper@controlstation.com
www.ControlStation.com

PROFITABILITY - PRODUCTIVITY - QUALITY - SAFETY - EFFICIENCY

Control Station® Process Control Solutions

Control Station®: Helping Companies Across the Process Industries

Top companies maintain their competitive advantage by maximizing productivity and minimizing costs – by optimizing and controlling critical processes. Training is an essential element in equipping engineers for success and achieving that advantage. Some of the companies that have attended Control Station® courses and improved their process control skills include:

Analysis & Control: Fisher Rosemont, Foxboro, GE Fanuc, Honeywell, MathWorks, Pavilion Technology

Chemical: Akzo Nobel, AlliedSignal, Dow, Dupont, Monsanto, Owens Corning, Uniroyal, Westinghouse

Consumer Products: Benjamin Moore, Colgate Palmolive, Estee Lauder, Kimberly-Clark, Proctor & Gamble, Unilever

Food & Beverage: Best Foods, Gerber, Kraft, National Starch, Nestle, Ocean Spray, Sara Lee

Pharmaceutical/Biotechnology: Amgen, Bayer, Chiron, Eli Lilly, Genzyme, MedImmune, Schering-Plough, Wyeth

Power & Automotive: ABB, Delphi Automotive, Dominion Nuclear, General Motors, PSEG, UTC Fuel Cells

Courses are conducted regularly at our offices in New England and they can also be held at your facility. If process control is critical to your company's success, contact us to see how Control Station® can provide you with that competitive advantage.

The Control Station guru

Your source for process control solutions

In this Issue:

- Ask the Guru about PID with Derivative Filter
- Checklist for Collecting Good Process Data
- Upcoming Short Course for Industry

Short Course for Industry

Practical Process Control

For Technicians, Engineers & Scientists

October 19 & 20, 2004

For more information see inside or visit

www.ControlStation.com

NONPROFIT ORG.
U.S. POSTAGE
PAID
STORRS, CT
PERMIT NO. 3

University of Connecticut
Doug Cooper, PhD
Chemical Engineering Dept., Unit 3222
191 Auditorium Road
Storrs, CT 06269-3222