Standard PID Tuning Methods

(tbco 2/17/2012)

I. Cohen-Coon Method (Open-loop Test)

Step 1: Perform a step test to obtain the parameters of a FOPTD (first order plus time delay) model

i. Make sure the process is at an initial steady state
ii. Introduce a step change in the manipulated variable
iii. Wait until the process settles at a new steady state

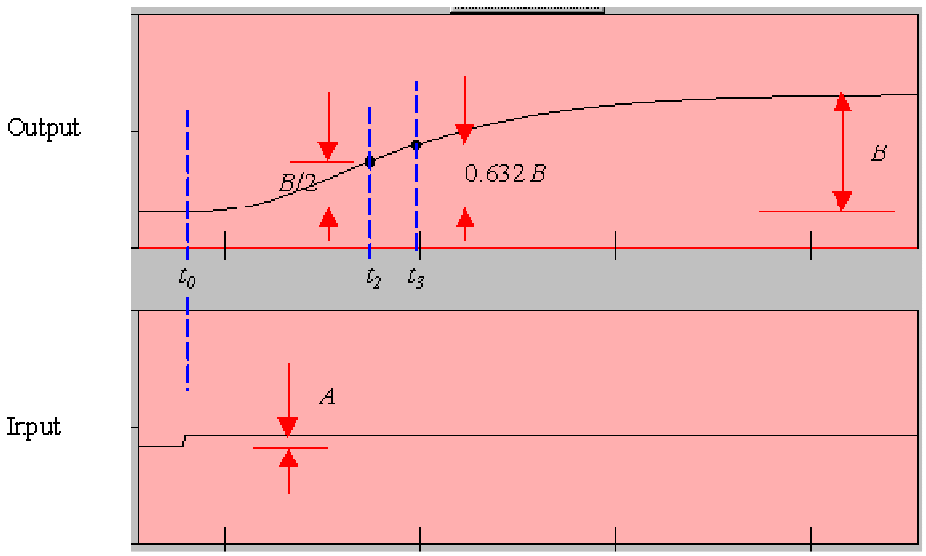


Figure 1. Step Test for Cohen-Coon Tuning.

Step 2: Calculate process parameters: $t_1, \tau, \tau_{del}, K, r$ as follows

$$t_1 = \frac{t_2 - (\ln(2))t_3}{1 - \ln(2)}$$

$$\tau = t_3 - t_1$$

$$\tau_{del} = t_1 - t_0$$

$$K = \frac{B}{A}$$

$$r = \frac{\tau_{del}}{\tau}$$

Step 3: Using the process parameters, use the prescribed values given by Cohen and Coon.

Table 1. Cohen-Coon Tuning Rules

	K_c	τ_{Int}	τ_{Der}
P	$\frac{1}{rK}\left(1+\frac{r}{3}\right)$		
PI	$\frac{1}{rK}\left(0.9+\frac{r}{12}\right)$	$\tau_{del}\frac{30+3r}{9+20r}$	
PID	$\frac{1}{rK}\left(\frac{4}{3}+\frac{r}{4}\right)$	$\tau_{del}\frac{32+6r}{13+8r}$	$\tau_{del}\frac{4}{11+2r}$

II. Ziegler-Nichols Method (Closed-loop P-ControlTest)

Step 1: Determine the sign of process gain (e.g. open loop test as in Cohen-Coon).
Step 2: Implement a proportional control and introducing a new set-point.
Step 3: Increase proportional gain until sustained periodic oscillation.
Step 4: Record ultimate gain and ultimate period: K_u and P_u.
Step 5: Evaluate control parameters as prescribed by Ziegler and Nichols

Table 2. Ziegler Nichols Tuning Rules

	K_c	τ_{Int}	τ_{Der}
P	$\frac{K_u}{2}$		
PI	$\frac{K_u}{2.2}$	$\frac{P_u}{1.2}$	
PID	$\frac{K_u}{1.7}$	$\frac{P_u}{2}$	$\frac{P_u}{8}$

III. Tyreus-Luyben Method (Closed-loop P-Control test)

Step 1-4: Same as steps 1 to 4 of Ziegler-Nichols method above

Step 5: Evaluate control parameters as prescribed by Tyreus and Luyben

Table 2. Tyreus-Luyben Tuning Rules for PI and PID

	K_c	τ_{Int}	τ_{Der}
PI	$\frac{K_u}{3.2}$	$2.2P_u$	
PID	$\frac{K_u}{2.2}$	$2.2P_u$	$\frac{P_u}{6.3}$

IV. Autotune Method (Closed-loop On-Off test)

Step 1: Let process settle to a steady state

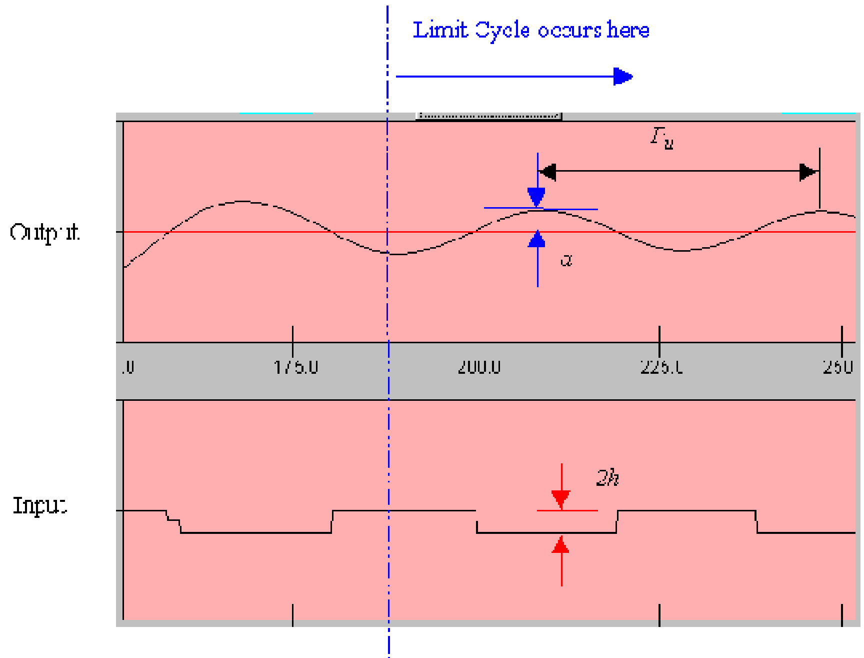
Step 2: Move the setpoint to the current steady state

Step 3: Implement an on-off (relay) controller

$$\text{If process gain is positive, } u = \begin{cases} u_0 + h & if \;\; e \geq 0 \\ u_0 - h & if \;\; e < 0 \end{cases}$$

$$\text{If process gain is negative, } u = \begin{cases} u_0 - h & if \;\; e \geq 0 \\ u_0 + h & if \;\; e < 0 \end{cases}$$

Step 4: Let the process settle to a sustained periodic oscillation



Step 5: Evaluate ultimate gain using autotune formulas (P_u can be obtain from the plots)

$$K_u = \frac{4}{\pi}\frac{h}{a}$$

Step 6: Use either Ziegler-Nichols or Tyreus-Luyben prescribed tunings