SELECTRONIX, INC.
WOODINVILLE, WA

SUPERSTEP SERIES 4000

SEQUENCING STEP

CONTROLLERS

INSTALLATION & OPERATING

TECH NOTE 203

PID Tuning Procedure and Information

Rev 08/27/25

Introduction

This addendum describes the procedure to tune the PID loop contained within the Selectronix Building Management Interface.

1 PID Tuning Procedure

The PID control loop is designed to accommodate a very large range of control installations, and as such may require adjustments from the default values to provide the desired control characteristics. The following steps provide a guideline for establishing the correct settings.

1. Start with the actual temperature or pressure well below the high limit so that the recovery rate-of-change, and overshoot may be monitored. Ideally, the initial starting point is a cold plant.
2. Enter a set point which is above the actual temperature or pressure by the worst-case differential, but still well below the high limit so that overshoot may be monitored.
3. Start with a typical P = 1000, I = 5, and D=0,
4. Enable the system and observe:
    a. the initial rate of change of the step command output, which drives the step controller or flame controller.
    b. the initial rate of change of the actual temperature or pressure.
    c. the rate of change of the step command output as the actual temperature approaches the setpoint.
    d. the amount and duration of temperature or pressure overshoot.
5. If the output response is too slow, adjust the P value higher or vice versa. The approximate output contribution by the P value is calculated in the example below:
    a. As the actual temperature approaches the setpoint, the P contribution decreases to 0, and any step command output is due to the accumulated integral.
    b. If an unacceptable amount of overshoot occurs, then decrease the P value and set the I value to 0.
        i. Retest until the P value results in little or no overshoot
        ii. Adjust the I value by observing the amount of droop below the setpoint and the desired recovery time. If the actual temperature does not recover within the desired time, slowly increase the I until the recovery time to setpoint is acceptable.
    c. Repeat adjustments until the desired response is achieved.
    d. Set the desired setpoint and retest to verify the response.
6. TSGW Version 2.15 and on includes a Trend graph Page 22 that shows:
    a. Step Command %
    b. RTD1
    c. GPA1 in Engr units

    The graph is continually updated on a 60 second time period, which may be helpful in tuning the PID. The logged data is not saved.

7. *New feature with TSGW Version 2.17+ and PGW V1.70+ PID Terms*

The PID term's contribution as a percentage of the step command is displayed on the active PID page. This provides invaluable information in the PID tuning process.

a. The percentage of step command provides insight when determining the initial value of each of the PID multipliers, as well as when optimizing the interactive integral and derivative values. It shows the relative interaction between the PID terms under dynamic conditions.

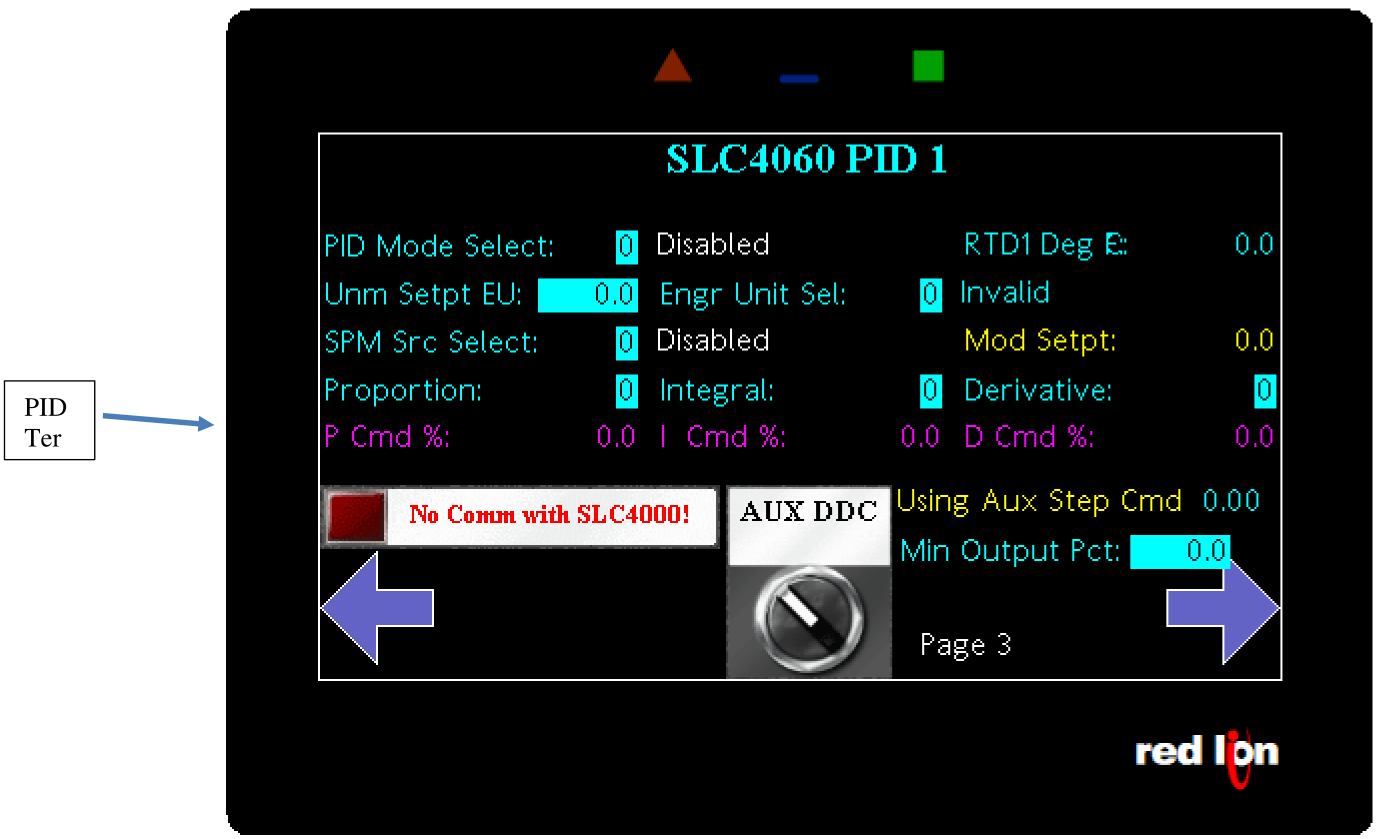
b. The sum of the PID term percentages may add up to more than 100%, even though each term is individually limited to 100% output.

   i. The Integral term's range is 0 to 100%

   ii. Both Proportional and Derivative terms are limited to +/- 100%.

   iii. A negative Proportion term occurs when the process variable is above the set point in heat mode, and vice versa in cooling mode.

   iv. A positive Derivative term occurs during a deceasing change in error in heat mode, and vice versa in cooling mode.



1.1 Steam Boilers or plants with high thermal inertia

a. For a plant that has a high thermal inertia, such as a steam plant, the application of heat may be applied more gently, while maintaining a high Proportional value and low Integral value, by increasing the "On Time Delay" of the SLC4000 master. The delay is adjusted using RV1 in combination with SW2-2 through SW2-4 for a time delay between steps, from 1 second to 8 minutes. For an SLC4000-1, this time delay is between the application of the next 1/7th of the full output. The application of the amount of heat is delayed on an increasing demand, while allowing the rapid removal of heat as the process variable approaches the setpoint. This maintains the benefit using a high Proportional and low Integral values, resulting in a slower approach to the set point, but a rapid removal of heat as the process variable approaches the setpoint, minimizing overshoot. The SLC4000 master has an "Off Time Delay" set by SW2-5, which sets either a 2 or 5 second delay. Verify that this switch is set to ON for a 2 second delay. This approach is preferable over using a lower P or using a higher I value, as it minimizes "Integral windup", which can occur on either plants with high thermal inertia or loads that can rapidly change.

b. If the BMS is online, the On Delay may be remotely set using AV0004. Once an acceptable On Delay is determined, the time may be set into the SLC4000. Setting AV0004 to -1, selects the SLC4000 On Delay.

c. The PID Derivative term is an optional method of adjusting the output during periods of relative rapid changes in the process variable.

1.2 Startup - Low Fire Hold

The BMS may set a Load Limit command at AV0003, to hold the output of the SLC4000 step controller or the SLC4000-1 analog output for a gentle startup. Any value between 0 to 99 causes the inverse proportion of the full output to be available.

The SLC4000 master has a load limit input, as well. See SLC4000Addendum_LoadLimitCfgs.pdf available at selectronix.us which allows an alternative, hardware method to implement an automatic low fire hold. The solution requires an external relay and the appropriate resistors to implement a 2 stage Load Limit.

2 PID Information

a. The **P**roportion component of the output is the Proportion value multiplied by the process error.

b. The **I**ntegral component of the output is the Integral value multiplied by the process error and added to the accumulated integral value.

c. The **D**erivative component of the output is the Derivative value multiplied by the rate-of-change of the process error.

d. The **P**roportion value that will result in the full output command can be calculated by the following:

   a. For Temperature in Degrees F:

      i. **P = 3413/d**, where d = the temperature differential in degrees F which results in 100% output

      ii. Example 1:

         1. Desire temperature differential = 3 degrees F
         2. P = 1137

      iii. Example 2:

         1. Desire temperature differential = 10 degrees F
         2. P = 341

   b. For Pressure in % Span

      i. **P = 10000/ d**, where d = the pressure differential in % span which results in 100% output

      ii. Example 1:

         1. Full scale pressure is 15 PSI
         2. Desired pressure differential = 1.5 PSI or 10%
         3. P = 10000 /d = 1000, where d is the desired pressure differential in % span

3 Hunting in Large Multi-step systems

If the system short cycles steps, the cause is usually noise that is induced in the process variable sensor. This can be caused by:

1. Sensor wiring is close proximity to AC wiring.
    a. See SLC4000TechNote09_GroundingShieldingAndWireRouting.pdf
2. Incorrect shield termination.
    a. See SLC4000TechNote09_GroundingShieldingAndWireRouting.pdf
3. Change PID settings.
    a. Reduce the Proportional term until the hunting is reduced or eliminated.
    b. Increase the Integral term to provide acceptable level of response, while limiting overshoot to an acceptable level.