Manual Detection of **PID Parameters**

Quick Guide for Temperature Controllers of HAT Control-Series

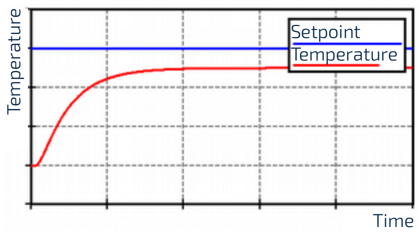
This quick guide describes a straightforward method to experimentally determine the PID control parameters with the BELEKTRONIG temperature controllers of the HAT Control series. The determination of the control parameters is shown using the example of the temperature control curve after a jump of the setpoint temperature. The PID algorithm generally follows the following equation (y ... control output value, x ... control deviation):

$$y = y \cdot \text{P-Part} + y \cdot \text{I-Part} + y \cdot \text{D-Part} = \underbrace{P \cdot x}_{\textbf{P-Part}} + \underbrace{\frac{P}{t\_N} \cdot \int x \cdot dt}_{\textbf{I-Part}} + \underbrace{P \cdot t\_V \cdot \frac{dx}{dt}}_{\textbf{D-Part}}$$

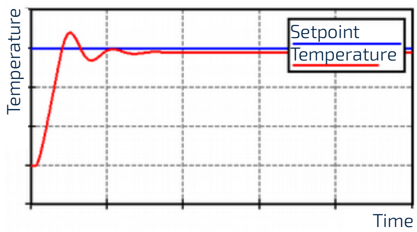
Step 1: Variation of Proportional Part P (P-Part, P-Controller)

The P parameter (proportional part, controller gain) essentially determines the speed at which the setpoint is reached. A pure P-controller always has a permanent control deviation.

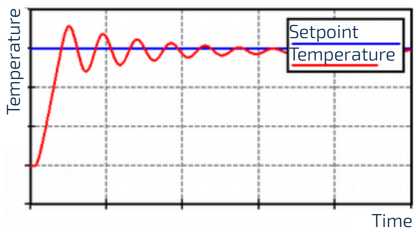
› Disable reset time t_N of the I parameter (t_N = 0)
› Deactivate the derivative time t_V of the D parameter (t_V = 0)
› Decay time T1 of the D component can remains unchanged (factory setting: T1 = 10 s)
› Set controller gain P to 5 (increase it step by step, continue with doubled values, for example: 5, 10, 20, ...)
  › Proportional part P too low: actual temperature approaches the setpoint only slowly —> increase P
  › Proportional part P too high: actual temperature oscillates strongly and long —> decrease P
  › Proportional part P is O.K.: —> continue with step 2



Proportional part P too small
(Crawl case)



Proportional part P O.K.
(Overshooting once)

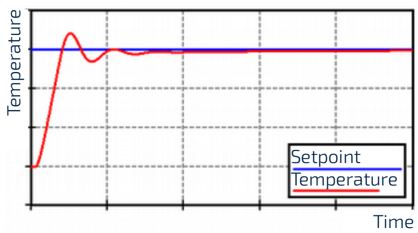


Proportional part P too high
(Controller oscillates or unstable)

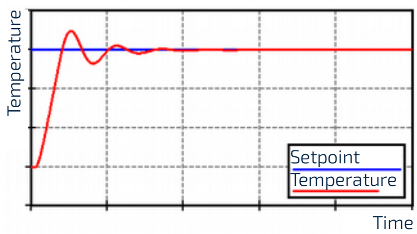
Step 2: Variation of Integral Time (I-Part, PI-Controller)

When the P parameter is determined, the integral part I is varied by adjusting the reset time t_N. The integral part I of a PID controller corrects the permanent control deviation of the pure P-controller.

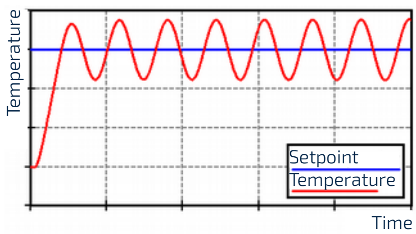
› Set Integral time t_N to a high value (for example 500)
› Afterwards decrease it cycle by cycle (initially bisect values: 500, 250, 125, ...)
  › Integral time t_N too high: actual temperature approaches only slowly to setpoint value, the controller reacts slowly to temperature fluctuations: —> reduce t_N
  › Integral time t_N too low: controller reacts too fast, control oscillates or becomes unstable —> increase t_N
  › Integral time t_N is O.K.: setpoint is reached quickly and with little overshoot —> continue with step 3 (if necessary)



Integral time t_N too high
(Crawl case)



Integral time t_N O.K.
(Setpoint value reached)

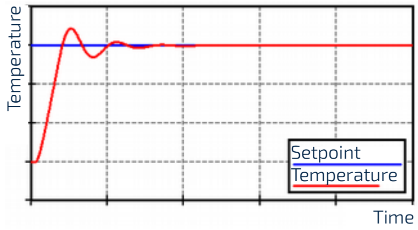


Integral time t_N too small
(Controller oscillates or unstable)

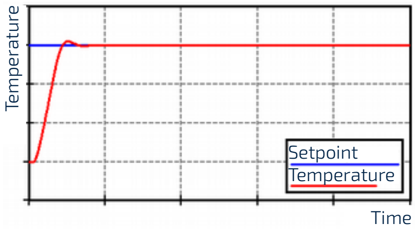
Step 3: Variation of Derivate Time (D-Part, PID-Controller)

The derivative time t_V (differential component, D component) is used to compensate for temperature fluctuations in a thermally fast system (ΔT/t > 5°C/s). We recommend working only with PI controllers for systems with lower heat and cool rates, this means t_V remains 0.

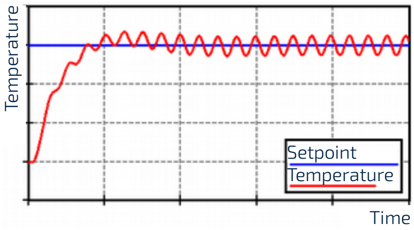
› Set derivative time t_V to 1 (increase it initially incrementally 2, 3, 4 ... 10)
  › Derivate time t_V too small: controller oscillates too much —> increase t_V
  › Derivate time t_V too high: controller is unstable —> reduce t_V
  › Derivate time t_V is O.K.: setpoint is reached quickly and with almost no overshoot



Derivate time t_V too small
(Overshooting)



Derivate time t_V O.K.
(Overshooting damped)

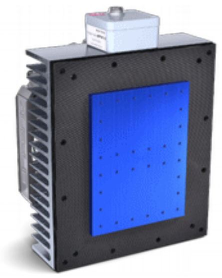


Derivate time t_V too high
(Controller oscillates or unstable)

Result

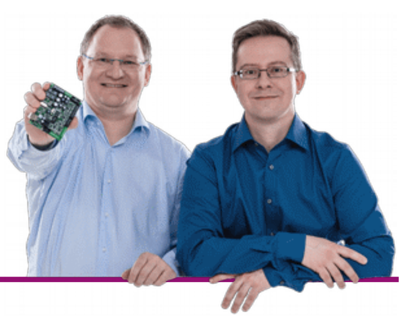
Using this straightforward method, the optimal PID control parameters for
› Low start-up time,
› Minimal overshoot and
› Fast compensation of disturbances
can be found. Depending on the temperature control task, only a small or no overshoot can be the goal. In that case one would have to work with smaller values for the proportional part P.

Sample PID Parameters for BELEKTRONIG Plate cooler/heater BPM-P140



› P = 120 1/°C
› t_N = 24 s
› t_V = 0 s (max. heating rate: ~ 1°C/s, max. cooling rate: ~ 0,22°C/s)
› t_1 = 10 s

Learn more about the quality standards of BELEKTRONIG and easily request a quote for your individual experimental setups.
Dr.-Ing. Glen Guhr and Dr.-Ing. Raimund Bruenig



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