Technical Support
Bulletin Nr. 4 – PID

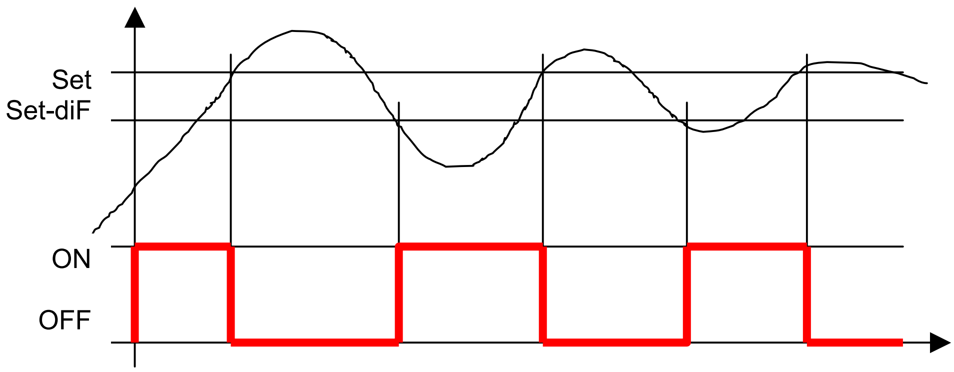
Contents

Introduction

The aim of this bulletin is to explain how PID control works, identify the field of application based on demand and indicate the models in the Eliwell range that are suitable for performing this type of control.

PID control

This is an alternative to on-off control that is used where greater precision is necessary as well as reduced oscillation with regard to the set point, typically in “heat” applications. PID control is also possible in cool applications although only for some models. In these controllers, two PID controls, one heat and one cool, coexist in order to reach the same set point. To understand the advantages of PID control, on-off control operating must be checked. This is done by enabling a dedicated output until the set point is reached. Once this has been reached, the output is disabled and is re-enabled if the temperature drops to a value that is equal to the set point minus a differential:
Output enabled if T<Setpoint-differential
Output not enabled if T>=Setpoint
This very simple type of control can cause errors to the set point that are not acceptable in some applications. These errors are gradually reduced but initial overheating can cause irreparable damage to the product.



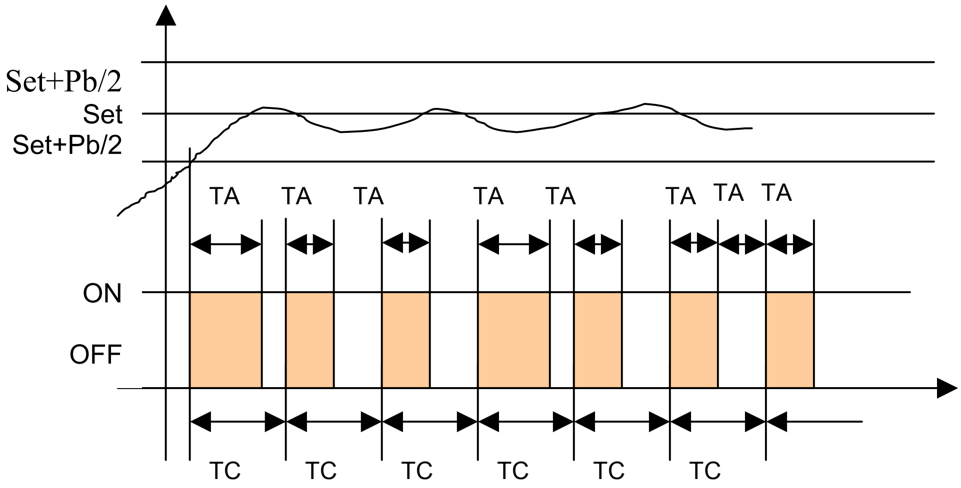
To avoid this problem, P.I.D. control can be used, i.e.:

- P Proportional: considers the offset between the value read by the sensor and the set point by inserting an action that is directly proportional;
- I Integral: integrates the detected error in time and reduces the final offset of the set point,
- D Derivative: considers the speed with which the temperature varies in the process;

The interaction between the three actions is transformed into a calculation of the relay enabling period with regard to a reference called “Cycle time-TC”

Cycle time=20s, every 20s the relay is enabled by the "Enabling time-TA" in this window is the result of the P+I+D action.

The action begins within a band that can usually be preset by the user called a proportional band. The duration of enabling is at a minimum near the set point and increases as it moves away from it.



As can be seen in the functional diagram, the controller output is much more stressed than with on-off control. The load control by way of the controller output can be:

- Relay: a contact directly controls the load or an auxiliary contactor. In view of the high number of required switchings, the service life of the relay or auxiliary contactor can be reduced (the relays are guaranteed for a certain number of switchings because of the mechanical action that occurs on them);
- SSR: here, the controller supplies a direct voltage output that is used to enable the external solid state relay that is capable of activating the load. Since there is no mechanical action, this solution guarantees increased service life although it is more expensive.

Autotuning

Insertion of parameters for optimum PID control is fairly complicated because of the multiple correlations with the environment to be controlled. In this regard, PID controllers usually but not always have an additional option called "Autotuning". Using this algorithm, the controller can automatically calculate the parameters for improved control of the process. However, small manual adjustments are necessary to fully optimize control. There are two different types of autotuning:

- Closed loop: The system operates around a preset value (Set point or settable value) and checks the process using this reference and calculating the parameters. It is called a closed loop because the starting point reference is the final result to be obtained – Recommended solution.
- Open Loop: after operating steadily around a preset value (usually different from the set point), the controller applies a "step", by increasing the output enabling time, for example, and calculating the effect on the application. In actual fact, two comparisons are made at different points to obtain the parameters.

In conclusion, autotuning allows three control coefficients (P, I, D) to be calculated.

Applications

- Oil heating machines then used to harden moulds: the PID relay activates an electric heater that heats the oil (it prevents excessive overheating or cooling)
- Control in climatic rooms: heat control (or heat + cool) normally performed by heating or cooling the air;
- Machines for processing of plastic material, extrusion or other similar processing by heating the mechanical part of the equipment and keeping it constant;
- Heated plates, mobile or fixed, for dosage and application of waxes. also on mobile equipment;
- Test tube heaters, also multi-block: heating with electric heater of the test tube holder block (usually in aluminium) to reach the operating temperature;
- Gas ovens for cooking food: the relay output activates the igniter that allows the flame to heat the environment;
- Electric ovens: as above but with activation of an electric heater;
- Varnishing ovens;

Models and functions

Eliwell can supply a number of solutions for PID controllers both in terms of size and options (the number in brackets states the output, 1= output 1…).

Name	Size	Control	Other	Notes
IC917 different models for NTC-PTC, TCJ&K-Pt100	32X74	• PIDheat(1)+on-off(2) • on-off(1)+on-off(2)	Up to 3 sets of PID parameters can be saved in memory; Autotuning;	2 outputs Single display
EWTQ915 universal for TCL,J,K,N,T and Pt100	48X48	• PIDheat or cool(1) +Alarm(2) • On-off heat or cool (1) +Alarm(2)	Autotuning; SMART: Continuous autotuning;	2 outputs Single Display + bar graph
EWTQ925 universal for TCL,J,K,N,T and Pt100	48X48	• PIDheat or cool(1) +Alarm(2) • On-off heat or cool (1) +Alarm(2) • PIDheat(1)+PIDcool (2)	Autotuning; SMART: Continuous autotuning;	2 outputs Single Display
EWTQ985 universal for TCL,J,K,N,T and Pt100	48X48	• PIDheat or cool(1) +Alarm(2) • On-off heat or cool (1) +Alarm(2) • PIDheat(1)+PIDcool (2)	Autotuning SMART: Continuous autotuning	2 outputs; Dual Display, process value + set point;
EWTQ995 universal for TCL,J,K,R,S,N,Pt100 mV, mA,V	48X48	• PIDheat(1)+PIDcool(2)+alarm (3) • PIDheat(1)+alarm(2)+alarm(3) • PIDcool(1)+alarm(2)+alarm(3)	Autotuning SMART: Continuous autotuning	3 outputs; Dual Display, process value + set point; HB input;
EWTN970 models for TCJ, K,L,N,R,S,T,U and 0…50mV	48X96	• PID heat or cool(1) +Alarm(2) • PID heat or cool(1) +Alarm(2)+Alarm(3) • PIDheat(1)+PIDcool(2)+alarm (3)+alarm (4)	Autotuning	4 outputs max; Models with analogue control outputs
EWTN980	48X96	• PIDheat(1)+PIDcool(2)+alarm (3) • PIDheat(1)+alarm(2)+alarm(3) • PIDcool(1)+alarm(2)+alarm(3)	Autotuning SMART: Continuous autotuning	3 outputs; Dual Display, process value + set point HB input;
EWPC 907 different models for PTC, TCJ&K, Pt100	32X74	• PIDheat(1)+on-off(2) • on-off(1)+on-off(2)		2 outputs Single display
EWTR910 (special code) different models for PTC, TCJ&K, Pt100	72X72	• PID heat		1 output Single display
EWTR940 (special code) different models for PTC, TCJ&K, Pt100	72X72	• PID heat (1)+on-off(2)		2 outputs Single display

Parameters

The table below shows the recommended settings for PID parameters for each controller. The values must be considered as an indication for starting but may not be ideal and can therefore be modified. Refer to "Notes" for suggestions on modifying them.

Name	Size	Recommended parameters	Notes
IC917 different models for NTC-PTC, TCJ&K-Pt100	32X74	• Use autotuning • Conversion from EWPC or EWTR: see table	• See next table • Repeat Autotuning, record the values on 3 set points available and compare-average the values obtained
EWTQ915 universal for TCL,J,K,N,T and Pt100	48X48	• Use autotuning	
EWTQ925 universal for TCL,J,K,N,T and Pt100	48X48	• Use autotuning	
EWTQ985 universal for TCL,J,K,N,T and Pt100	48X48	• Use autotuning	
EWTQ995 universal for TCL,J,K,R,S,N,Pt100 mV, mA,V	48X48	• Use autotuning	
EWTQ970 models for TCJ, K,L,N,R,S,T,U and 0…50mV	48X96	• Use autotuning	
EWTQ980	48X96	• Use autotuning	
EWPC907 EWTR910 (special code) different models for PTC, TCJ&K, Pt100 EWTR940	72X72	• Pb=8…10° • it=100s • dt=20…30s • Sr=1…3s • rSt=0° • Ar=3…4° (half Pb) • Ct=10…15s	Modify following instructions in technical sheet

ONLY for conversion from EWPC or EWTR to IC917

With this procedure the IC controller can be activated using known EWPC-EWTR parameters. If results are not satisfactory, use the autotuning function. This procedure can be used with IC series instruments manufactured in July 2005.

EWPC-EWTR	IC	Notes
Pb	HP	See below:
ti	Ti	Equivalent
dt	Td	Equivalent
Sr	/	/
rSt	/	/
Ar	/	/
Ct	PEr	Equivalent

HP=(200 X Range) / Pb

Range=IC conversion range / 100

NTC	**-50…110°C**	→	**160**	→	**Range=1.6**
PTC	**-55…140°C**	→	**195**	→	**Range=1.95**
Pt100	**-200…800°C**	→	**1000**	→	**Range=10.0**
TCJ	**-40…760**	→	**800**	→	**Range=8.0**
TCK	**-40…1350**	→	**1390**	→	**Range=13.90**

Further adjustments can be performed manually using the "tt" and "n" parameters. The two variables are NOT calculated by the Autotuning function.

tt= the integral component increases when a high level of error is present (start-up with temperature a long way from the set point, for example). This increase may lead to an over-oscillation that could be unacceptable to the application. To avoid this, back-calculation is used. This function limits the integral component when the process value is greater than the SHi parameter (i.e., it is “saturated”). The back-calculation function is more effective the lower the value of the tt parameter. The tt parameter is not calculated by the auto-tuning function and the user must perform a series of tests in order to define it. Attention must also be paid to the SHi value. This establishes the maximum process value beyond which back-calculation intervenes on the integral component.
100=disabled
1=maximum effect

n= The derivative component may be subject to “high frequency” oscillations. To prevent these oscillations, parameter n must be sized so that a low-pass filter can be sized. This filter will be more effective the lower the value of this parameter.
5=disabled
1=maximum effect

DISCLAIMER

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