PID FUNCTION USER MANUAL

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PID function User Manual

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1 PID function

1-1 Introduction

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1-1 Introduction

In this manual we introduce the application of the PID instruction in the XC series PLCs main units, including call instructions, set parameters and simple programs.
The new XCP Pro (V3.0) software offers XC series PLC main units (V3.0 hardware) PID control instructions and auto tune.

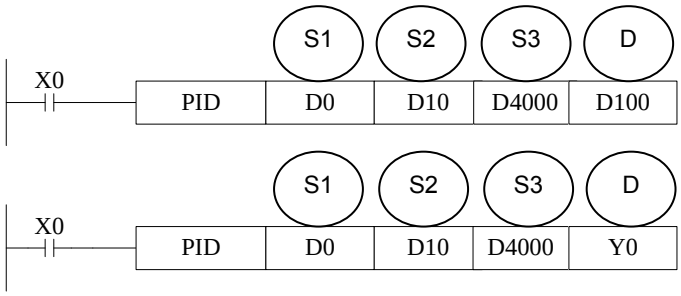
Note:
XC series PLC main units do not support this function if the version is below V3.0 (both software and hardware).

Only analog expansions and BD expansions support PID control.
The outputs can either be in analog data form (D), or in digital form (Y).

Via self- tune, you can automatically get the best sampling time and PID parameters, to improve control precision;

Choose the positive action or negative action via software; for example positive action is used in heating control, while negative action is used on cooling control.

1-2 Instruction Format



S1 : Set the set-point value (SV), operand: D.

S2 : The process value (PV), operand: D.

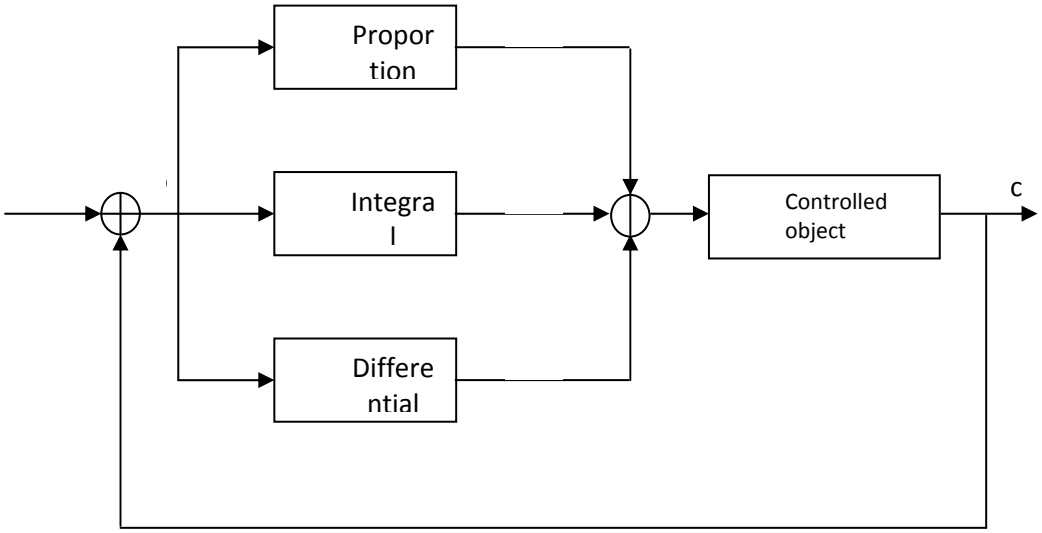
S3 ~ S3 +4: Set the control parameters, operand: D.

D : Memory Address D for operation result (MV) or output port Y, operands: D, Y, M, S, T, C.

- This instruction supports only 16bits, not 32 bits
- S3 ~ S3 + 43 will be occupied by this instruction, they shouldn't be used as the normal data registers.
- This instruction is only suitable for XC3、XC5 series PLCs, not for XC1 series PLCs.
- This instruction is executed every cycle.
- D , the data registers are used to store PID output values; the Y outputs are used to cycle in the form of ON/OFF.

PID control function shown below:

Graphic (function PID control system)



e (t) =r (t)-c (t) (1-1)

u(t)=Kp[e(t)+1/Ti∫e(t)dt +TD de(t)/dt] (1-2)

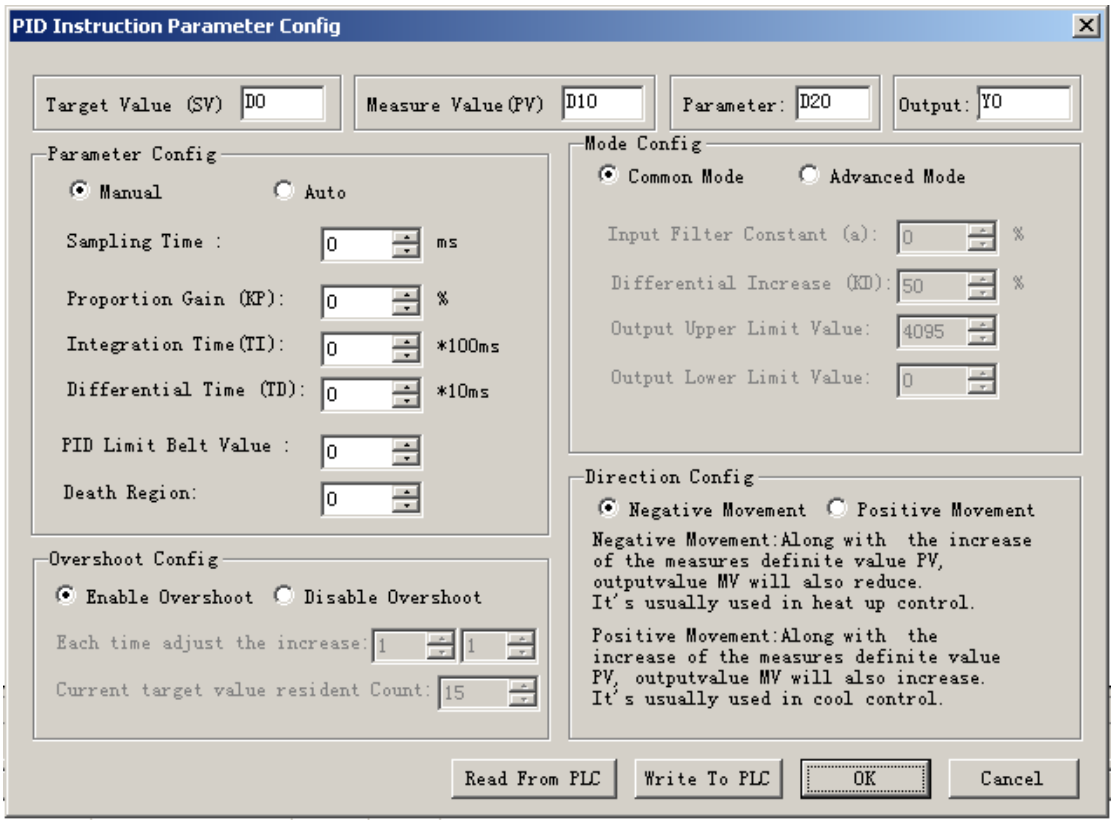
In function (1-1), is the actual output value, u (t) i= control output.

In function (1-2), Kp is the proportional coefficient, Ti is the integration time coefficient, and TD is differential time coefficient.

1. Analog output default range is 0 to 4095.
2. Digital output: Y is the output point activated by time within the control cycle. T is the control cycle, equal to the sampling time. PID output upper limit value is default to be 4095.

1-3 Features

The PID instruction can be set from XCP Pro software direct (See icon at top of XCP Pro screen). It also can be written by using MOV instruction before PID operation.



See the following register-defined table:

S3 : Sampling time, unit is ms (32digits without sign number)

S3 +1: Sampling time (32 digits without sign number)

S3 +2: set mode

Bit 0: 0: negative movement1: positive movement
Bit 1 to bit 6 not used.
Bit 7: 0: normal PID 1:self-tune PID
Bit 8: 1:self-tune complete PID
Bit 9 to bit 14 not used
Bit15: 0 is normal mode, 1 is advanced mode

S3 : Proportion Gain (Kp) 1 to 32,767[%]

S3 +4: Integration time (TI) 0 to 32,767[*100ms]
0 is taken as no integral.

S3 +5: Differential time (TD) 0 to 32,767[*10ms]
0 is taken as no differential.

S3 +6: Operation area of PID 0 to 32,767 PID limits Band value.

S3 +7: Dead band Region 0 to 32,767 PID value does not change in the dead band region

S3 +8: PID self-tune Cycle changing value *0.3 to 1 percent.

S3 +9: Overshoot. 0: enable overshoot. 1: disable overshoot.

S3 +10: Each time increase of target value at the end of self-tune.

S3 +11: current target value count at the end of self-tune.

S3 +12 to S3 +39: PID operation registers.

The following are advanced PID mode configuration parameters.

S3 +40: Input filter constant (a) 0 to 99 percent 0: no filter

S3 +41: Differential increase (KD) 0 to 100 percent 0: no differential

S3 +42: Output upper-limit value -32,767 to 32,767

S3 +43: Output lower-limit value -32,767 to 32,767

Direction of movement

1. Positive movement: Used in heating control.
2. Negative movement: Used in cooling control.

Configuration mode

1. Common mode: Using parameter register's area is from S3 to S3 +43, S3 to S3 +11 are configured by user. S3 +12 to S3 +43 are for system use only.

2. Advanced mode: Using parameter register's area is from S3 +12 to S3 +43, S3 to S3 +11 are configured by user. S3 +12 to S3 +39 are for system use only.

Sampling time

System sampling time T, must be bigger then a scanned Cycle of the PLC program. T is unlimited when AD is the output. For all other outputs, T's value should between 100 to 1000 scanned cycles of the PLC program.

1-4 Self-tuning mode

If the user is not familiar with PID tuning then choose self-tune mode instead .The system will find the optimal parameter (sample time, gain Kp, integration time Ti, differential time TD)
At the beginning of a self-tune, the user can set the cycle time as 0, after the self-tune, the user can change it manually.
Before the self-tune, the process must be given a step change. The step change can be a small change of the set point value.

Monitored value of Cycle is S3 +8, which is the scanning Cycle of self-tune. The default value is 10.
If the value is too big, the tuning cycle of PID control maybe too long.

Note:
If cycle time is too long set the default value 10 as AD value, and set 0ms as the sampling time of PID, then carry out self-tune again.

Enable overshoot of self-tune is S3 +9

Set to 0 enables overshoot; the system will get the optimal PID parameter. Set to 1 disables overshoot, when the safety complication is very strict on some control objects such as a pressure container. You can set the value of +9 to 1 to avoid overshoot in self-tune.

During self-tune, if the BIT8 of S3 +2 changes from 0 to 1 that indicates self-tuning has been successful and the system gets the optimal control. If the BIT8 of S3 +2 is 0 and BIT7 changes from 1 to 0 that indicates the end of an unsuccessful self-tune and the parameters may not be optimal, sometimes manual adjust maybe needed.

During Self-Tune
The rate of each adjustment of the process value is 2/3 (meaning S3 +10 is 67%), preliminary value of the temperature is 0°C, and target temperature is 100°C, the adjustment of the current target temperature as follows:

Next target value = current target value + (final target value – current target value) *2/3,then the order of the system's temperature value is 66°C, 88°C , 96°C , 98°C, 99°C and 100°C.

1-5 Advanced mode

Users can configure some parameters in advanced mode to improve the effect of PID control.

Enter the advanced mode, set S3 +2's bit 15 into 1, or set it using ECP Pro software.

Input Filter constant
This smoothed small spikes on the measured value. Its default value is 0%, this means no filter.

Differential Gain
The output value changes quicker when the difference between target value and the actual temperature is outside this setting.
Default value is 50 percent, decreasing this value increases the output.

Upper limit and lower limit value of the output
Users can set these to limit the value of analog output.
Defaults: Lower limit output equal to 0
Upper limit output equal to 4095

1-6 Application Outlets

Normally the user needs to fine tune the PID settings after using the self -tune option to obtain optimum process control.
The following table gives rough guide lines for PID settings. It gives first time users an insight to applied values.

Temperature control: p (%) 2000 to 6000, I (minutes) 3 to 10, D (minutes) 0.5 to 3.
Flow Control: p (%) 4000 to 10000, I (minutes) 0.1 to 1.
Pressure control: p (%) 3000 to 7000 I (minutes) 0.4 to 3.
Level Control: p (%) 2000 to 8000, I (minutes) 1 to 5, D (minutes) 0.5 to 3.

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