Student report

ATTEMPT OF REALIZATION 3-LEVEL-STEP CONTROLLER WITH PID BEHAVIOR

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Abstract: This paper presents review of how to model 3-level-step controller with PID behavior. There is often used 3-level-step controller with PI behavior in industry. We know from experience that there is the need in some occasion for controller to react faster. The goal was to make acting "like PID". Here are given general model of this controller for level measuring , existent model (with PI behaviour) and attempts of realisation 3-level-step controller with PID behavior. This is interesting to investigate, because PID behavior can give extended possibility of the use 3-level-step controller.

Keywords: 3-level-step controller, action "like PID"

INTRODUCTION

There are 2 systems in studies of Control Systems: open-loop control and closed-loop control. Controllers act in closed-loop control systems (Figure1). Their task is to decrease deviation xd (deviation xd is difference between input value and output value), that on output (actual value) gets equal value as is on input (set point).

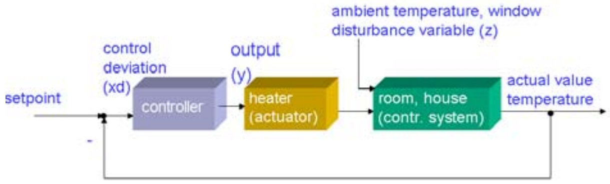

Figure 1

There are two groups of controllers: discontinuous controllers and continuous controllers. 3-level step controller , short name TLS controller ,pertain to group discontinuous controllers. Controllers can have three effects: P-proportional effect, I-integrated effect and D-derivate effect and combination of these effects can provide different construction of controllers.

In following text will be explained general model of 3-level-step controller for level measuring , 3-level-step controller with PI behavior (existent model) and attempts of improving existent model to become PID behavior.

GENERAL MODEL

In Figure 2 is given general model of 3-level-step controller for level measuring .

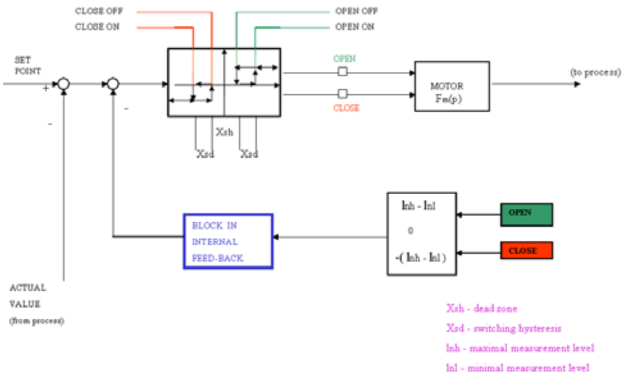

Figure 2

Set point is required value on input which should be got on output of process. Input in nonlinear block is xd , and depends of set point, actual value and value which provide block in internal feed-back. Nonlinear block contain three parts which are depending of value xd : 2 switching hysteresis loop, one react when xd is positive , and other react when xd is negative and third part, named as dead zone, when xd is in width Xsd and has no reaction. Constants that characterize nonlinear block are: Xsh - hysteresis loop width, and , already mentioned , Xsd – dead zone. Nonlinear block has 4 points of switching : two for providing signal *open*: open off and open on , and two to providing signal *close*: close off and close on. Nonlinear block gives two signals: *open* or *close* to motor. Motor transfer function is :

$$F_m(p) = \frac{1}{T_m \cdot p}$$

where Tm is motor time constant. Signals *open* or *close* also goes to switch , and depending on the current signal, this switch provides different input for block in internal feed-back. There are three possibilities: (lnh-lnl) , 0 and -(lnh-lnl) , where lnh is maximal measurement level and lnl is minimal measurement level. Block in internal feed-back can have various transfer function.

3-LEVEL-STEP CONTROLLER WITH PI BEHAVIOR

When function in internal feed-back is PT1 function , than it is get 3-level-step controller with PI behavior. PT1-block transfer function is:

$$F_1(p) = \frac{K_r}{T_n \cdot p + 1}$$

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Parameters of PT1-block are: K_r-gain and T_n-time constant. This construction is given in Figure 3 .

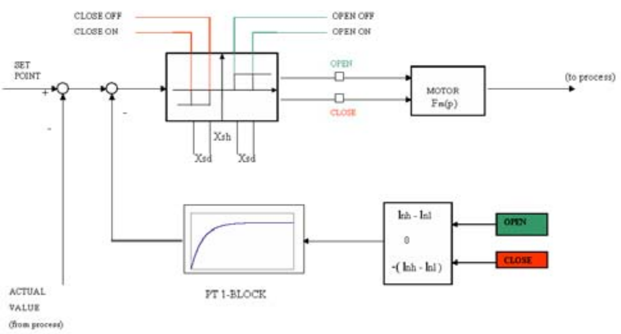

Figure 3

In Figure 4 are given transfer functions of continuous PI controller and 3-level-step controller with PI behavior :

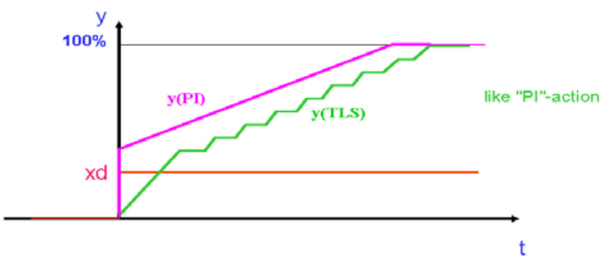

Figure 4

This transfer functions are not identical, but they are similar , so it can be said that TLS transfer function is 'like PI' .

To provide faster reaction of controller , as it is showed in Figure 5 , beside P-part and I-part, controller must have also and D-part, i.e. transfer function should be 'like PID'. Improvement via D-part: faster reaction, depended of velocity of changing the control difference xd.

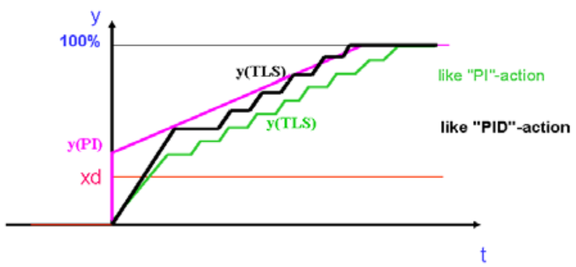

Figure 5

ATTEMPTS OF REALIZATION 3-LEVEL-STEP CONTROLLER WITH PID BEHAVIOR

With D-part controller reacts faster, but this part makes some unwished effects on stability of whole system. If we change function in internal feed-back , reaction of whole controller will change .Goal was to find appropriate function for feed-back , which together with nonlinear block and motor make PID construction. Attempt was to replace PT1-block by block which at the beginning of step-response react a little slower. With this new reaction we get longer first step in transfer function (Figure 5), and that provides PID behavior. Beside PID behavior , goal was also to find solution that has simple algorithm and uncoupled parameters ,that is simple for tuning and that we have feeling which parameter makes P, which D and which I part. Here will be given 3 attempts to make TLS controller with PID behavior. This attempts are done in turn (in time):

1)PT2-block in internal feed-back
2)hold-block in internal feed-back
3)DT1-block in internal feed-back

1)PT2-block in internal feed-back - this form of function is the result of mathematical calculation which function form together with nonlinear block and motor makes action 'like PID'. In Figure 6 is given this construction where we can see that block in feed-back react slower than PT1-block (Figure 3):

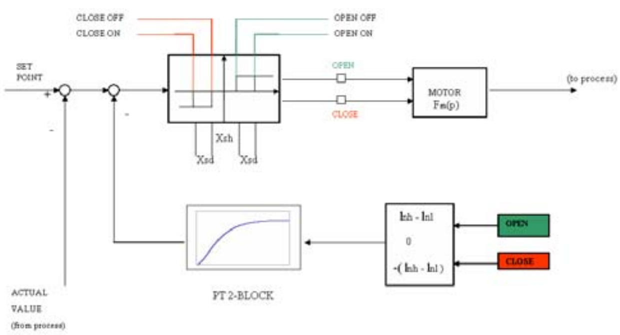

Figure 6

PT2-block transfer function is :

$$F_1(p) = \frac{K_r}{T_1 \cdot T_2 \cdot p^2 + (T_1 + T_2) \cdot p + 1}$$

PT2-block has 3 parameters : K_r-gain and 2 time constants T_1 and T_2.

This construction has PID behaviour and simple algorithm, but does not show good results in stability of whole system, parameters are not simple for tuning . Also , parameter K_r makes P part , but we have not feeling which parameter makes I and which D part.

2)hold-block in internal feed-back - this model is the result of attempt to make block in feed-back at start to react slower , but with existing PT1-block in feed-back. In Figure 7 is given this construction : hold-block is before PT1-block , and holds signal from switch for some duration of time T_d, and for that time input in PT1-block is 0. That provides that block in feed-back reacts slower (Figure 8).

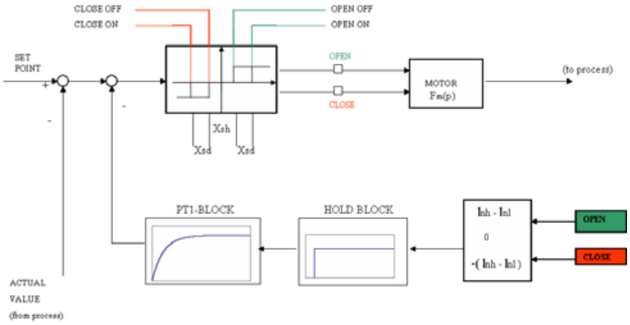

Figure 7

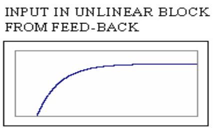

Figure 8

This construction has PID behaviour, but is not very stabile. Hold block makes also some unwished effects during the tuning of parameters for PT1-block. Idea for this model was product of thinking how to exploit foregoing experience of PT1-block , but it did not shown satisfactory results.

3)DT1-block in internal feed-back - this model has DT1-block in feed-back parallel with PT1-block. This construction is given in Figure 9. Resultant signal from feed-back is difference between output from PT1-block and output from DT1-block (Figure 10), and that provides that block in feed-back react slower.

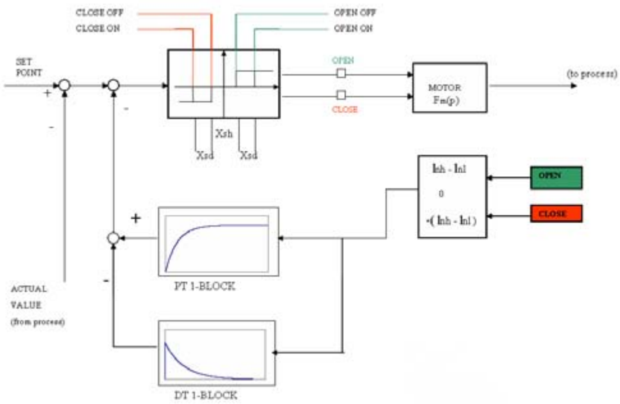

Figure 9

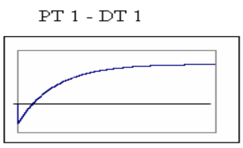

Figure 10

DT1-block transfer function is :

$$F_2(p) = \frac{T_v \cdot p}{T_1 \cdot p + 1}$$

DT1-block has 2 parameters: T_v-gain and T_1-time constant.

This construction has PID behaviour and simple algorithm, show satisfactory resultants in stability of whole system, parameters are simple for tuning . Also , parameter K_r makes P part , parameter T_n makes I part and parameters T_v and T_1 make D part.

CONCLUSION

3-level-step controllers have significant place in industry, so its developing is important for progress. Foregoing models are products of mathematical and also of practical consideration. It was not problem to find solution to provide PID behaviour , but other request are also important and must be satisfied for practical approach.

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[2] Regelungstechnik und Simulation , Anatoli Makarov , Braunschweig/Wiesbaden,

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He received many prestigious world-known awards and certificates for his creative work. Hence, he is included in the work of world groups of creativity, research and new technology in Brussels, Moscow, Pittsburgh and other world cities. He is also involved in research projects from the field of theoretical electrical engineering in Germany, Belgium and Russia.