Analysis of The Use of Pid Control System By Way of Simulink

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ABSTRACT

In control systems, there are several known types of control actions, such as proportional control actions, integral control actions, and derivative control actions. Each of these control measures has its own advantages. The action of proportional control has the advantages of rapid risetime. The action of integral control has advantages in reducing errors. While the action of derivative control has advantages in reducing errors or reducing overshoot/undershoot. Thus, as a result, these three control measures are united into one, namely the Proportional Integral Derivative (PID) control action. Determination of PID controller parameters so that the close loop system meets the desired criteria is called controller tuning. This PID control tuning aims to determine the action parameters of proportional, integrative, and derivative control. This process can be done by trial and error. The advantage of this method is that we do not need to identify plants, make mathematical models of plants, determine plant parameters graphically or analytically. It is enough to try to give the constant P-I-D to the PID formula so that the desired result is obtained by referring to the characteristics of each P-I-D control.

Keywords: PID Control System, Simulink

1. Introduction

PID Control System Material

The basic structure of the PID controller according to the mathematical equation is as follows which is also addressed in the following figure:

$$U^{PID} = K_P e + K_I \int e\,dt + K_D \frac{de(t)}{dt} \quad (1)$$

$$U^{PID} = K_P\left(e + \frac{1}{T_I}\int e\,dt + T_d \frac{de(t)}{dt}\right) \quad (2)$$

Where e is the tracking error, conventional PID control is the sum of three different control actions. The proportional gain Kp, the integral gain Ki, and the derivative gain KD, have different control action advantages. Proportional action can reduce *steady-state* errors, but still cause too much system instability. Integral action will eliminate steady-state. And the action of derivatives will increase the stability of the system in a closed loop. So the relationship between the three controls is:

$$K_I = K_P / T_i$$
$$K_D = K_P * T_d \quad (3)$$

Where TI and TD are integral time and derivative time.

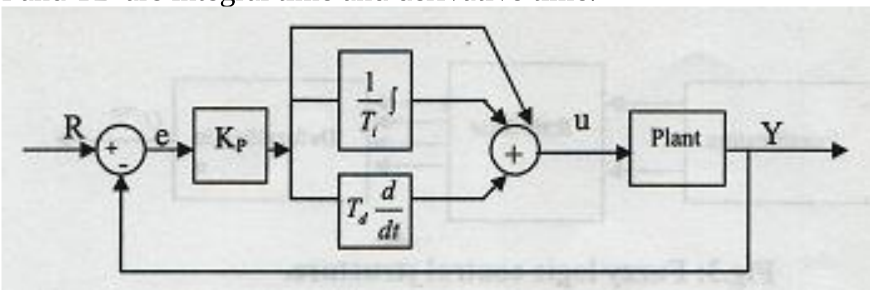

Figure 1. Closed-loop PID control.

The H(s) transfer function in the PID control system is a quantity whose value depending on the value of the constants of the systems P, I and D.

$$H(s) = \frac{K_D s^2 + K_P s + K_I}{s^3 + K_D s^2 + K_P s + K_I}$$

The PID control system consists of three ways of setting, namely P (Proportional), D (Derivative) and I (Integral) controls, with each having advantages and disadvantages. In its implementation, each method can work alone or a combination of them. In designing a PID control system, what needs to be done is to set the parameters P, I or D so that the system's output signal response to certain inputs as desired.

Table 1. PID control system responses to parameter changes.

Closed-loop responses	Boarding time	Overshoot	Time down	Error steady state
Proportional (KP)	Decreased	Increase	Small changes	Decreased
Integral (KI)	Decreased	Increase	Increase	Disappear
Derivatives (KD)	Small changes	Decreased	Decreased	Small changes

To design a PID control system, most of them are done by trial and error. This is because the parameters Kp, Ki and Kd are not independent. To get a good control action, trial and error with a combination of P, I and D is needed until the values of Kp, Ki and Kd are found as desired.

Matlab is one of the software developed in the field of settings equipped with Control Toolbox. This toolbox is equipped with a variety of supporting functions used in control system analysis. Some supporting functions that are often used to analyze a system are: feedback, step, rlocus, series, etc. To analyze a system, software only needs input in the form of switching functions written in Laplace transformations (frequency regions) or state space matrices. For example, a control system has the following switching functions:

$$TF = \frac{6}{s^2+4s+11}$$

From this switching function, the system's response to various input signals will be sought. A good system response from a control system has criteria: fast rise time, minimization of overshoot and minimization of steady-state errors. The switch function above is simulated in simulink as shown below:

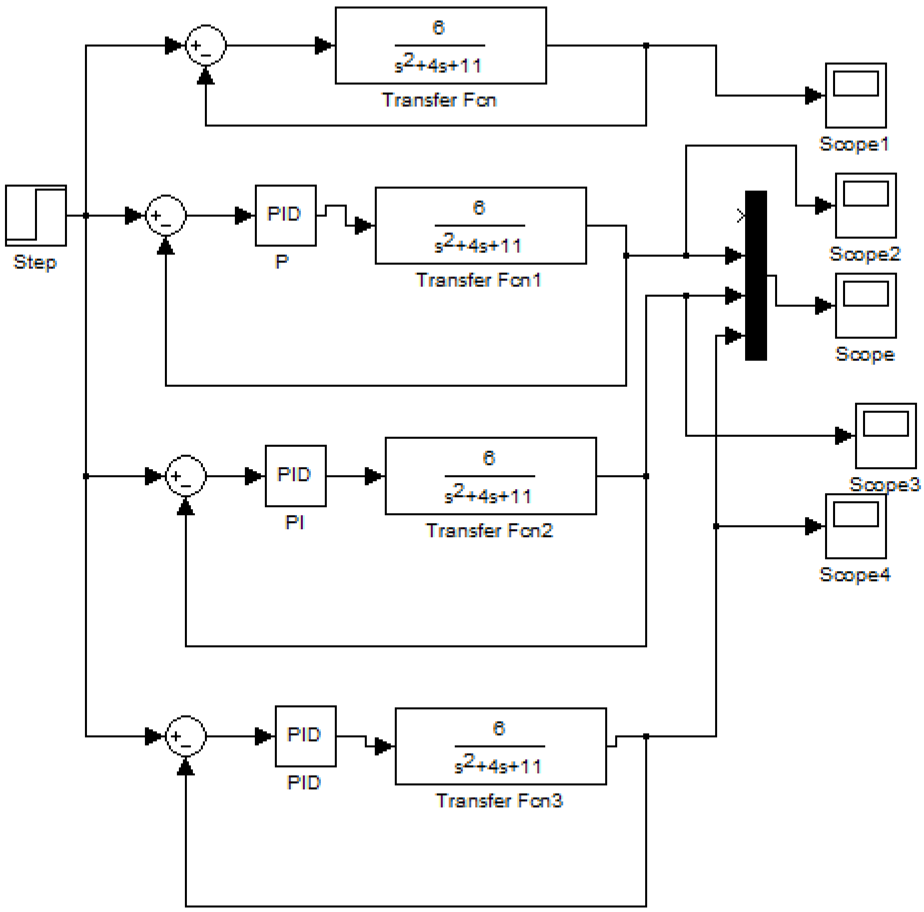

Figure 2. Experiment diagram on simulink.

From figure 2 on the scope1 component is a system that is not PID controlled in a closed loop. And the system response can be displayed as follows:

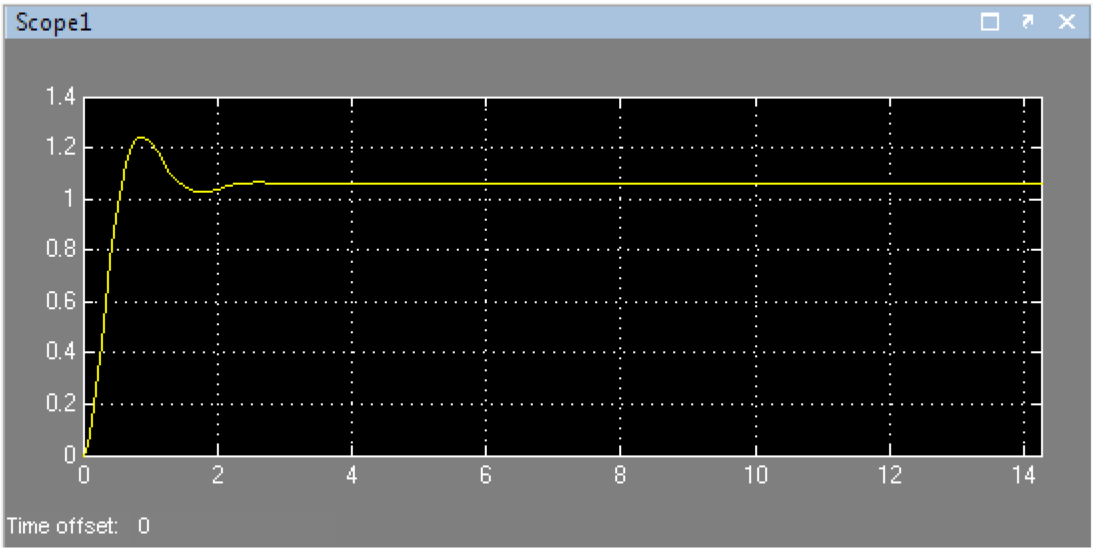

Figure 3. The system's response to the step function input is 3.

The graph above shows that the system has a high steady-state error of 2, this can be seen in the system's response to an amplitude value of 1.05. From Figure 3 it can also be seen that the system has an up time (1 second).

Proportional Control Action

The characteristic of the action of Proportional control is to reduce the rising time, increase overshoot, and reduce steady-state errors. System switching function by adding the control action P to :

$$TF = \frac{6.K_P}{s^2+4s+(11+K_P)}$$

For example, the constant KP = 25, then the system response displayed is as follows:

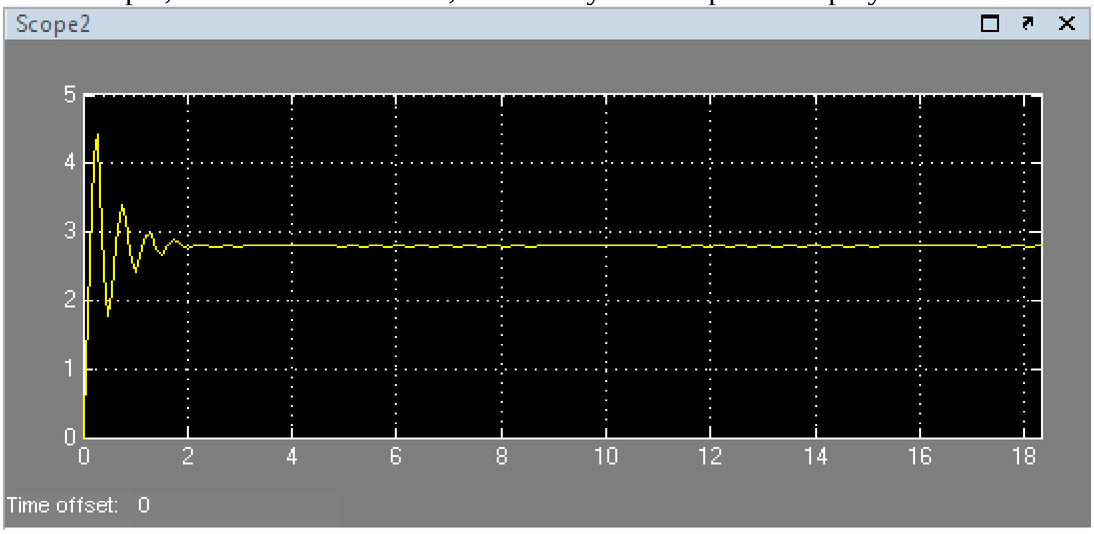

Figure 4. System response with KP to step = 3 function.

The addition of the P control action has the effect of reducing the rise time and steady-state error, but the consequences of an upward overshoot are considerable. This increase in overshoot is proportional to the increase in the value of the Kp parameter. The downward time also shows a growing trend.

Proportional-Integral Control Action

System transfer function with the addition of PI control action to:

$$TF = \frac{6(K_P s + K_I)}{s^3 + 4s^2 + (11 + K_P)s + K_I}$$

Integral Controller has the characteristics of reducing up time, increasing overshoot and down time, and eliminating steady-state errors. For example, Kp = 0.6 and Ki = 2.5, then the system response can be obtained:

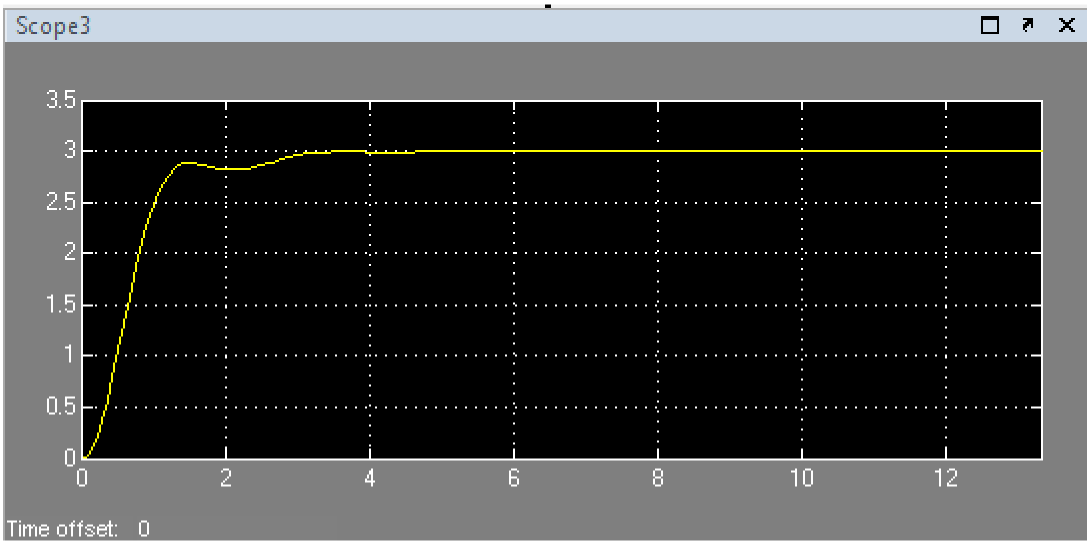

Figure 5. System response with PI control of step = 3 function.

The control action P and I have the same characteristics in up time and overshoot. Therefore, the Kp value should be reduced to avoid excessive overshoot. From the graph of figure 5 it can be seen that the system uptime decreases, with a small overshoot, as well as steady-state errors can be minimized. The response system gave better results than the previous control action but still had a slow uptime.

Action Control Proportional-Integral-Derivative

PID control action is a combination of P, I and D actions and system transfer functions into:

$$TF = \frac{6\left(K_D s^2 + K_P s + K_I\right)}{s^3 + (4 + K_D)s^2 + (11 + K_P)s + K_I}$$

For example, Kp = 0.6; Ki = 2.5; and KD = 0.3 then the system response can be obtained:

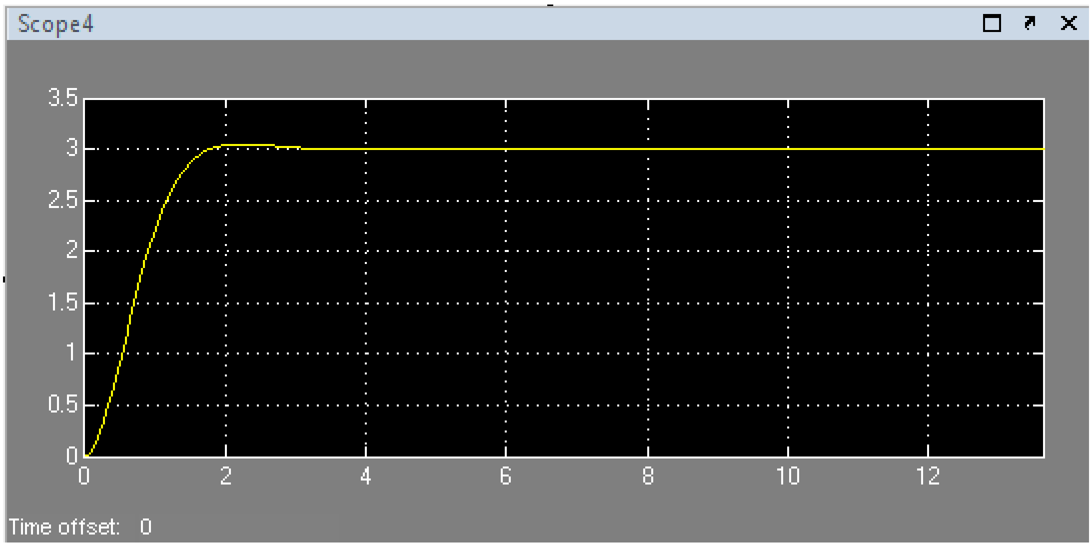

Figure 6. System response with PID control to step = 3 function.

With the control action of P, I and D, it can be seen that the desired system criteria are almost approximate, it can be seen from the response graph that the system has no overshoot, the rapid rise time, and the steady-state error is very small close to zero. Graph of the system's response to the input signals of step functions, depending on the values of the parameters Kp, Kd and Ki.

2. Conclusion

Based on the results of the discussion carried out, several conclusions can be drawn as follows :

a. A stable and good system is the system's response approach to input functions that resemble order one, the system's response has no overshoot, its rise time is fast, and its steady-state error is very small to near zero.
b. By combining the three PID control actions, the output function can be easily adjusted as needed.
c. The design of the PID control system using Matlab software makes it very easy to get the desired results by *trial and error*.

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