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A Proportional Derivative Controller Design for High Gain and Low Sensitivity Systems

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Abstract

The problem of reducing the system sensitivity could be solved by adding a gain to the system. Adding a gin to the system may cause an oscillation to the response of the system. This paper describes how to solve the problem of adding a gain and at the same time maintains the system response at an acceptable condition. This was done by adding a PD controller to the system with high gain.

Keywords: *PD Controller, Stability, Gain****,*** *Sensitivity****.***

1. Introduction

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control system. A PID controller calculates an *error* value as the difference between a measured process variable and a desired setpoint. The controller attempts to minimize the *error* by adjusting the process through use of a manipulated variable.

The PID controller algorithm involves three separate constant parameters, and is accordingly sometimes called three-term control: the proportional, the integral and derivative values, denoted *P*, *I*, and *D*. Simply put, these values can be interpreted in terms of time: *P* depends on the *present* error, *I* on the accumulation of *past* errors, and *D* is a prediction of *future* errors, based on current rate of change.

In the absence of knowledge of the underlying process, a PID controller has historically been considered to be the most useful controller. By tuning the three parameters in the PID controller algorithm, the controller can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the setpoint, and the degree of system oscillation.

Some applications may require using only one or two actions to provide the appropriate system control. This is achieved by setting the other parameters to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are fairly common, since derivative action is sensitive to measurement noise, whereas the absence of an integral term may prevent the system from reaching its target value due to the control action.

The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). The proportional, integral, and derivative terms are summed to calculate the output of the PID controller. Defining $u(t)$ as the controller output, the final form of the PID algorithm is:

$$\mathrm{u}(t) = \mathrm{MV}(t) = K_p e(t) + K_i \int_0^t e(\tau)\, d\tau + K_d \frac{d}{dt} e(t) \quad (1)$$

Where K_p: Proportional gain, a tuning parameter K_i: Integral gain, a tuning parameter

K_d: Derivative gain, a tuning parameter
e: Error setpoint-process variable
t: Time or instantaneous time (the present)
τ : Variable of integration; takes on values from time 0 to the present t.

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Table 1 Effects of *increasing* a parameter independently

Parameter	Rise time	Overshoot	Settling time	Steady-state error	Stability
K_p	Decrease	Increase	Small change	Decrease	Degrade
K_d	Minor change	Decrease	Decrease	No effect in theory	Improve if K_d small

2. Methdolgy

The fig(1) are shown representation P-D controller with a plant G(s)

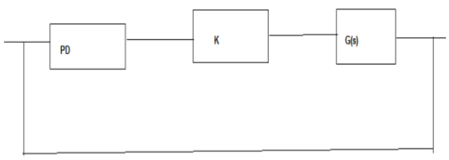

Fig.1 representation P-D controller with a plant G(s)

PD: proportional-Derivative
Controller=Kp+sKd (2)

K:gain

Assume that G(s) =1/s^2+0.5s+10 (3)

The closedloop is
Tcl=C(s)/R(s)=k/s^2+4s+3+k (4)

Sensitivity=dt/dk*k/t (5)

S=s^2+0.5s+10/s^2+0.5s+10+k (6)
s=jω

S=(10+ ω^2)+0.5 jω/(10+ ω^2)+0.5jω+k (7)

Assume ω=1

Gain=1

Sensitivity=11+0.5 jω/12+0.5 jω (8)

Assume we need to Increase gain to 10, 50, 100, 500,900

3. Result

Using the Matlab the required results obtained are shown in table 2.

Table 2 System gain and sensitivity values without PD

K	Senstivity
1	11.0133
10	11.0125
50	11.0117
100	11.0116
500	11.0114
5000	11.0114

Table 3 System gain and sensitivity values with PD

K	Sensitvity
1	10.6008
5000	10.5120

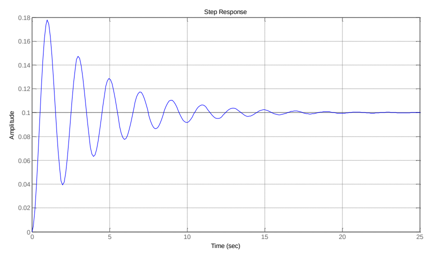

Fig.1 step response for the system with k=1

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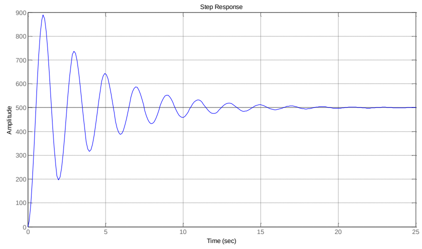

Fig.2 step response for the system with k=5000

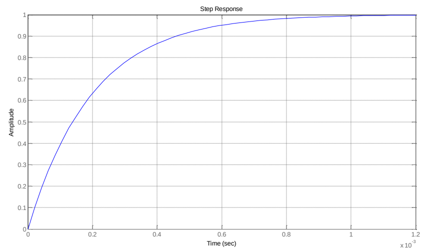

Fig.3 step response for the system with k=5000 after PD

4. Conclusions

The pepar has discussed the problem of adding a high gain to the system and maintaing the system response as required. This was done by adding a PD controller.The results have shown that inserting a PD controller will permit to add any high gain to the system and at the same time will keep the response of the system as desired.

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