Analysis Of PID Controller For Second Order System Using NI Labview

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Abstract— **Many processes and systems work well only within a narrow range of physical parameters like temperature, humidity, pressure etc. Certain chemical reactions, biological processes, and even electronic circuits perform best within limited parameters ranges. So, these processes need to be optimized with well designed controllers that keep physical parameters to within specified limits or constant. PID algorithm based controller is the most popular within the process industries. It is a robust easily understood algorithm that can provide excellent control performance despite the varied dynamic characteristics of process plant. This paper presents the implementation and comparison of different controller strategies like P, PD, and PID in NI LabVIEW software.**

Keywords— **LabVIEW, PID, Process Model, Steady-state error, Overshoot, Rise time, Settling time, Gain margin, Phase margin, Step Response Test, Ziegler–Nichols' tuning methods.**

I. INTRODUCTION

The Proportional-Integral-Derivative (PID) algorithm is the most common control algorithm used in industry. In PID control, a process variable and a setpoint is specified. The process variable is the system parameter that needs to be controlled, such as temperature, pressure, or flow rate, and the setpoint is the desired value for the parameter to be controlled. A PID controller determines a controller output value, such as the heater power or valve position. The controller applies the controller output value to the system, which in turn drives the process variable toward the setpoint value, shown in fig.1 as:
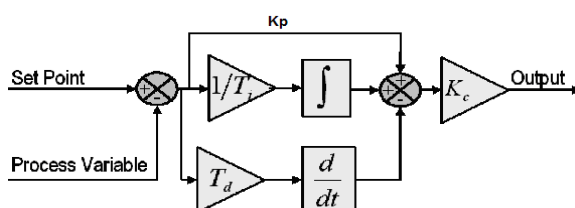

Fig. 1: Block Diagram of P,I,D Controller

The three elements of the PID controller produce outputs with the following nature:

• P element: proportional to the error at the instant t, this is the "present" error.
• I element: proportional to the integral of the error up to the instant t, which can be interpreted as the accumulation of the "past" error.
• D element: proportional to the derivative of the error at the instant t, which can be interpreted as the prediction of the "future" error.

Thus, the PID controller can be understood as a controller that takes the present, the past, and the future of the error into consideration. A PID controller is described by the following transfer function:

$H_c(s) = P + I + D$
$= K_p + K_i/s + K_ds$ ………….. (1)
Or, $H_c(s) = K_p (1 + 1/ T_is + T_ds)$ … (2)

Where K_p is the proportional gain, K_i is the integration coefficient and K_d is the derivative coefficient. T_i is known as integral action time and T_d is referred to as derivative action time. Such a controller has three different adjustments (K_p, T_i, & T_d), which interact with each other.

II. TUNING METHODS OF PID CONTROLLER

In industrial PID controlled process, two straightforward Manual Tuning procedures [2], [12] to tune a PID-controlled are widely used to get the response that is fairly close to optimum settings in most cases that is:

    a.   Trial and Error Method.
    b.   Ziegler-Nichols Method.

a. Steps involved for Trial and Error Method are:

1. Adjust the set-point value, to a typical value for the envisaged use of the system and turn off the derivative and integral actions by setting their levels to zero. Select a maximum value for output and increase the proportional gain until the system is just oscillating.

2. Note the period of oscillation then reduce the gain by 30%.

3. Suddenly decreasing or increasing the set-point value by about 5% should induce under damped oscillations. Try several values of derivative level and choose a value for that gives a critically damped response.

4. Slowly increase the integral level until oscillation just starts, then reduce this level by a factor of two or three till it should be enough to stop the oscillation to give good performance.

5. Check the overall performance of system is satisfactory under the conditions it will be used.

b. Steps involved for Ziegler-Nichols Method:

1. Adjust the set-point value, to a typical value for the envisaged use of the system and turn off the derivative and integral actions by setting their levels to zero. Select a safe value for the maximum power M and set the proportional gain to minimum.

2. Progressively increase the gain until 5% oscillations are induced that are just self-sustaining.

3. The gain at this stage will be set to the ultimate gain H_u the period of the oscillations is known as the ultimate period t_u. Note the values of each quantity.

4. Set the controller parameters as follows:
o P-Control: $P=0.50*H_u$, $I=0$, $D=0$.
o PI-Control: $P=0.45*H_u$, $I=1.2/t_u$, $D=0$.
o PID-Control: $P=0.60*H_u$, $I=2/t_u$, $D=t_u/8$

5. Check the overall performance of system is satisfactory under the conditions it will be used.

III. IMPLEMENTING P, PI AND PID ALGORITHMS ON LABVIEW:

PID Controller is implemented with LABVIEW Control Design Toolkit for which the block diagram is shown in fig. 2 as:
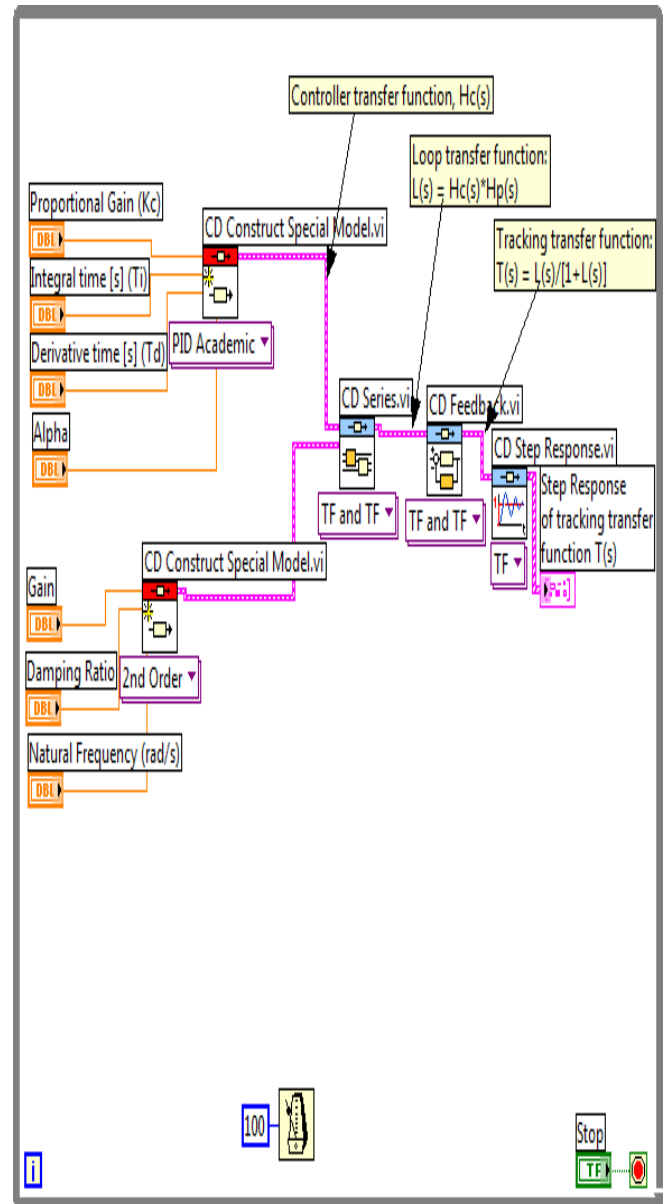

Fig. 2: Block Diagram
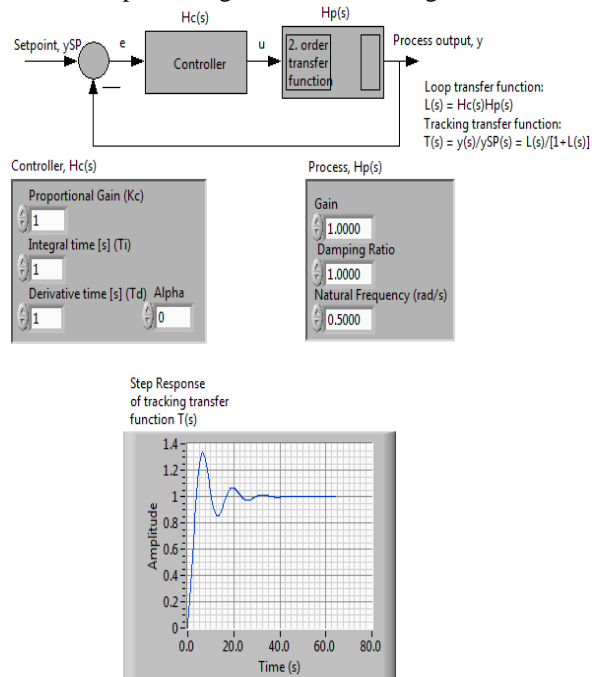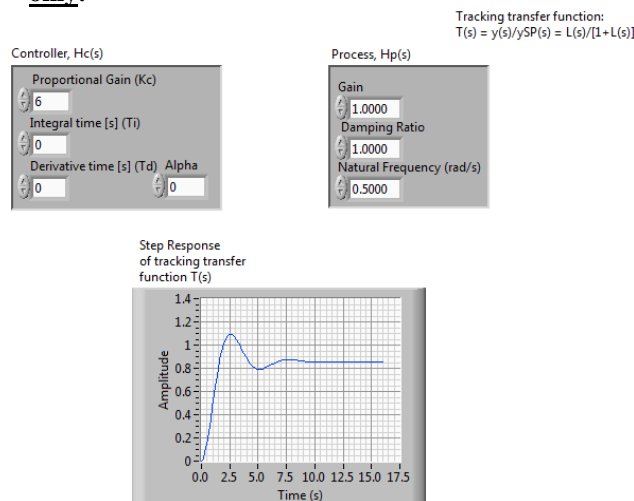
The Front panel diagram is shown in fig. 3 as:

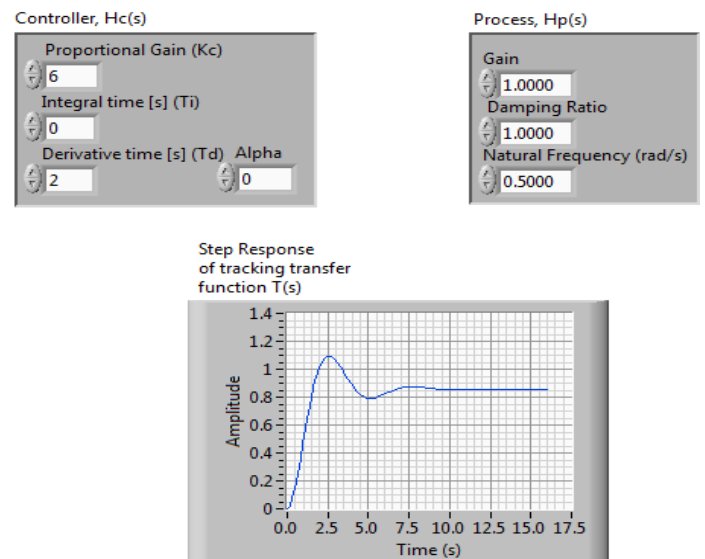**Fig. 3: Front panel Diagram**

IV. RESULTS

First of all the different control P,I,D control strategies are implemented in front panel of LabVIEW and by using Trial and Error method of tuning the controller is tuned for the step response in time domain analysis.

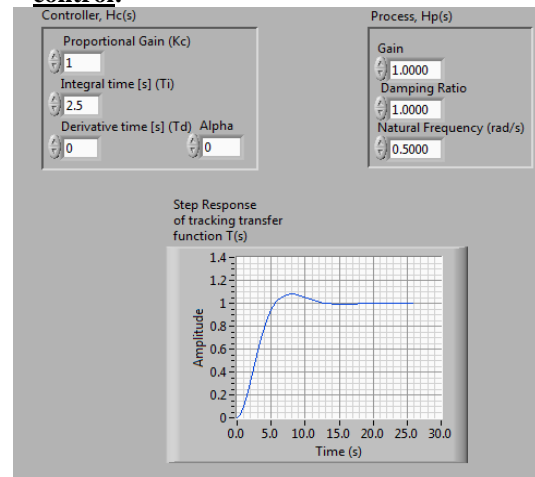**1. Controller model time response with P control only:**

From the step response for P control, it is observed that the increase in Proportional gain, K_p, makes the sluggish system faster, as the rise time t_r reduces, but the percentage overshoot (% M_p) also increases. So, P control is useful to remove the dead time of the system.

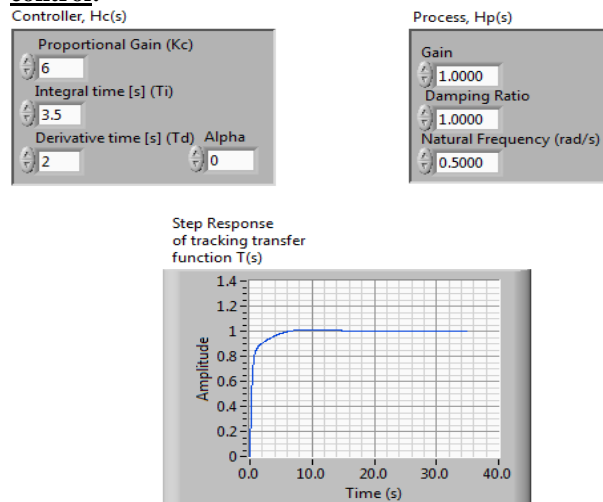**2. Controller model time response with P & D (PD) control:**

From analysis of step response for P & D or PD control, it is observed that by adding the D control along with Proportional, P control, decreases the percentage overshoot (% M_p) and hence the future error is corrected or the rate of change of error is also reduced. So, PD control is useful to correct the transient state response of the system.

3. Controller model time response with P & I (PI) control:

From analysis of step response for P & I or PI control, it is observed that by adding the, I control also called reset control along with Proportional, P control, reduces the steady state error and settling time T_s and hence the past error is corrected. So, PI control is useful to correct the steady state response of the system.

4. Controller model time response with P, I & D control:

From analysis of step response for P, I & D or PID control, it is observed that both the transient and steady state response of the system is improved and using hit and try method of tuning an almost over damped response of the system is obtained with no dead time or very fast output.

V. CONCLUSIONS

Using the trial and error approach for tuning of the PID Control algorithm for the case of step response of second order system, firstly the set-point value is adjusted with proportional control action only, to a typical value at which the system is just oscillating. Using several values of derivative level, and integral level critically damped response is achieved to stop the oscillation to give adequate performance. The performance parameters obtained for optimum PID control in time domain analysis for the step response are given as:

Delay Time T_d=0.2 Sec; Rise Time T_r=0.7 Sec; Settling Time T_s=6 Sec and Overshoot is negligible (Showing Critically Damped Response.

The PID Controller implementation requires solving of complex equations in time domain analysis or adjusting the K_p from the root locus analysis. This paper presents an approach to easily implement the PID Controller using LabVIEW that has a large number of functions for numerical analysis, design and visualization of data. Once the mathematically modelling of any system is available, the PID control can be implemented easily using the Control Design functions of LabVIEW software. For further refining of the time domain parameters the hybrid configurations of Fuzzy- PID control strategies [4],[5], [8] like Fuzzy P + ID or Self tuning by self scaled based Fuzzy- PID controller, can also be applied that can automatically tune the controller.

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