Classical Speed Controlof DC motor using PID Controller

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Abstract - This paper uses PID controllers in estimating speed and controlling it for a separately excited DC motor. The rotor speed of the dc motor can be made to follow an arbitrarily selected trajectory. The purpose is to achieve accurate trajectory control of the speed of separately excited DC Motor, especially when the motor and load parameters are unknown.

In this paper we have designed a DC motor whose speed can be controlled using PID controller. The proportional, integral and derivate (Kp, Ki, Kd) gains of the PID controller are adjusted using Ziegler's Nichols technique.

Proportional-Integral-Derivative (PID) control is the most common control algorithm used in industry and has been universally accepted in industrial control.

The aim of this paper is to show how DC motor can be controlled by using a PID controller in LabVIEW.

The term continuous cycling refers to a continuous oscillation with constant amplitude and is based on the trial-and-error procedure of changing the proportional gain (K_p). K_p Is increased from small value till the point at which the system goes to unstable. Thus the gain at which system starts oscillating is noted as ultimate gain (k_u) and period of oscillations is ultimate time period (p_u). It allows us to use the ultimate gain value, Ku, and the ultimate period of oscillation (p_u) to calculate and. These two parameters, and are used to find the loop-tuning constants of the controller (P, PI, or PID)

The purpose of this technique is to achieve accurate trajectory control of the speed.

Keywords-DC Motor, PID Controller, Ziegler Nichols Method
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I. INTRODUCTION

The development of high performance motor drives is very important in industrial as well as other purpose applications such as steel rolling mills, electric trains and robotics. Generally, a high performance motor drive system must have good dynamic speed command tracking and load regulating response to perform task. DC drives, because of their simplicity, ease of application, high reliabilities, flexibilities and favourable cost have long been a backbone of industrial applications, robot manipulators and home appliances where speed and position control of motor are required. DC drives are less complex with a single power conversion from AC to DC. Again the speed torque characteristics of DC motors are much more superior to That of AC motors. A DC motors provide excellent control of speed for acceleration and deceleration. DC drives are normally less expensive for most horsepower ratings. DC motors have a long tradition of use as adjustable speed machines and a wide range of options have evolved for this purpose. In these applications, the motor should be precisely controlled to give the desired performance. The controllers of the speed that are conceived for goal to control the speed of DC motor to execute one variety of tasks, is of several conventional and numeric controller types, the controllers can be: proportional (P),proportional integral (PI), proportional integral derivative (PID). The proportional – integral – derivative (PID) controller operates the majority of the control system in the world. It has been reported that more than 95% of the controllers in the industrial process control applications are of PID type as no other controller match the simplicity, clear functionality, applicability and ease of use offered by the PID controller. PID controllers provide robust and reliable performance for most systems if the PID parameters are tuned properly.

The development of PID control theories has already been from 60 years. PID control has been one of the control system design method of the longest history. However, this method is still extensively used. PID controllers are the most widely used type of controller for industrial applications. They are structurally simple and exhibit robust performance over a wide range of operating conditions. In the absence of the complete knowledge of the process these types of controllers are the most efficient of choices. However, because of their simple structure, PID controllers are particularly suited for pure first or second order processes, while industrial plants often present characteristics such as high order time delays, nonlinearities and so on. It has been reported that more than 95% of the controllers in the industrial process control applications are of PID type as no other controller match the simplicity, clear functionality, applicability and ease of use offered by the PID controller. The PID controller is used for a wide range of problems like motor drives, automotive, flight control; instrumentation etc PID controllers provide robust and reliable performance for most systems if the PID parameters are tuned properly.

II. SYSTEM MODEL

As we know that a suitable combination of proportional, integral and derivative actions can provide all the desired performances of a closed loop system. PID controller is mainly to adjust an appropriate proportional gain (k_p), integral gain (k_i), and differential gain (k_d) to achieve the optimal control performance. These functions have been enough to the most control processes. The PID controller system block diagram is shown in Figure.

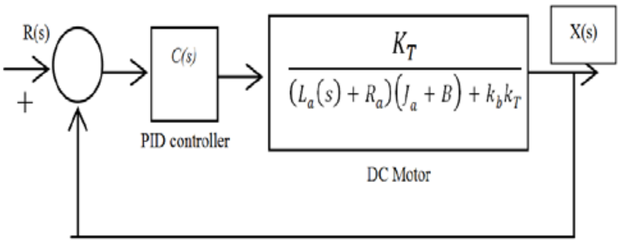

Fig.1 PID DC motor speed control system block diagram.

III. PROPOSED METHODOLOGY

The closed loop transfer function of DC motor speed control system expresses as follows,

$$X(s) = \frac{\left(k_p + k_d s + \frac{1}{k_i s}\right)\frac{k_T}{(L_a(s)+R_a)(J_a+B)+k_b k_T}}{1+\left(k_p + k_d s + \frac{1}{k_i s}\right)\frac{k_T}{(L_a(s)+R_a)(J_a+B)+k_b k_T}}$$

$$= \frac{(k_p s + k_d s^2 + k_i s)k_T}{L_a I_s{}^3 + (R_a I + BL_a + k_d)s^2 + (R_a B + k_b k_T + k_f)s + k_b k_t}$$

Ziegler- Nichols is a type of continuous cycling method for controller tuning. The term continuous cycling refers to a continuous oscillation with constant amplitude and is based on the trial-and-error procedure of changing the proportional gain (k_p). k_p Is increased from small value till the point at which the system goes to unstable. Thus the gain at which system starts oscillating is noted as ultimate gain (k_u) and period of oscillations is ultimate time period (p_u). It allows us to use the ultimate gain value, Ku, and the ultimate period of oscillation (p_u) to calculate and. These two parameters, and are used to find the loop-tuning constants of the controller (P, PI, or PID) using the formula tabulated in Table I:

Table I: for Ziegler Nichols parameters

Controller	k_p	T_i	Td
P	$0.5k_u$	∞	0
PI	$0.45k_u$	$p_u/1.2$	0
PI	$0.45k_u$	$p_u/1.2$	0
PID	$0.6k_u$	$p_u/2$	$p_u/8$

Then according to Z-N tuning rule, by using ultimate gain and ultimate period P, PI, PID gains and obtained using relation k_i = kp/t_i and kd = kp*t_d for DC motor is shown in Table II:

Table II: Simulated results for Ziegler Nichols

controller	k_p	k_i	k_d
P	0.5542	0	0
PI	0.4987	86.440	0
PID	0.6650	190.04	0.0005819

PID controller transfer function for DC motor using Ziegler Nichols tuning method is shown in equation below:

$$\frac{U(s)}{E(s)} = \frac{0.000519s^2 + 0.66504s + 190.0114}{s}$$

IV. SIMULATION/EXPERIMENTAL RESULTS

- SYSTEM MODEL USING P CONTROLLER ONLY

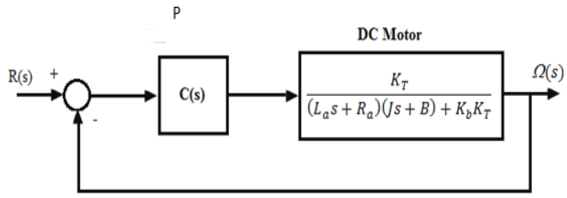

Fig.2: DC motor speed control system block diagram using p controller

$$\Omega(s) = \{c(s)\frac{k_T}{(L_a(s)+R_a)(J_a+B)+k_b k_T}\}/\{1 + c(s)\frac{k_T}{(L_a(s)+R_a)(J_a+B)+k_b k_T)}\}$$

$$= \frac{0.0155176}{(4.47296\times10^{-8})s^2 + (3.18204\times10^{-5})s + 0.01630754}$$

From MATLAB program we get the response as shown in fig. 3.

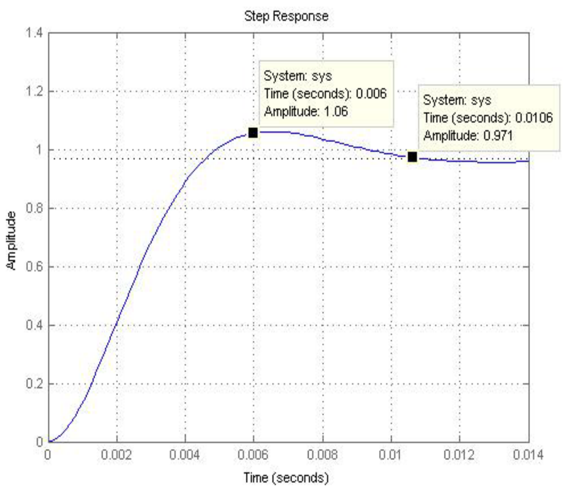

Fig.3 Response of motor with P controller

- SYSTEM MODEL USING PI CONTROLLER

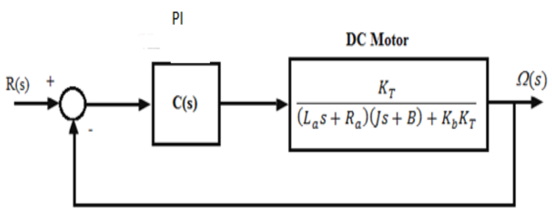

Fig. 4: DC motor speed control system block diagram using PIcontroller

$$\Omega(s) = \{c(s)\frac{k_T}{(L_a(s) + R_a)(J_a + B) + k_b k_T}\}/\{1 + c(s)\frac{k_T}{(L_a(s) + R_a)(J_a + B) + k_b k_T)}\}$$

$$= \frac{1.209433904s + 0.028}{386.6422664 \times 10^{-8} + 275.0508 \times 10^{-5} + 1.2777163176s + 0.028}$$

From MATLAB program we get the response as shown in fig.:

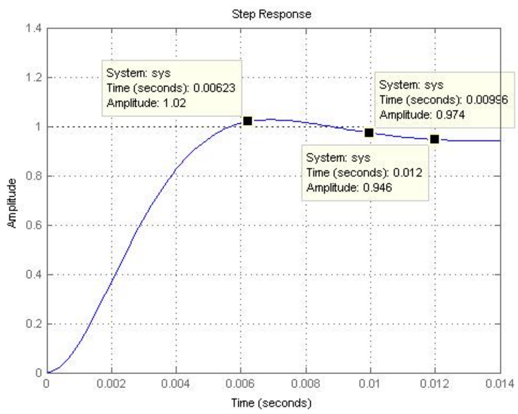

Fig.5 Response of Motor with PI Controller

- SYSTEM MODEL USING PID CONTROLLER

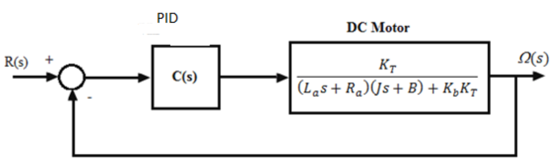

Fig.6: DC motor speed control system block diagram using PID controller

$$\Omega(s) = \{c(s)\frac{k_T}{(L_a(s) + R_a)(J_a + B) + k_b k_T}\}/\{1 + c(s)\frac{k_T}{(L_a(s) + R_a)(J_a + B) + k_b k_T)}\}$$

$$= \frac{1.62932 \times 10^{-5}s^2 + 0.01862112s + 5.320392}{4.47296 \times 10^{-8} + 4.87524 \times 10^{-5}s^2 + 0.01941054s + 5.320392}$$

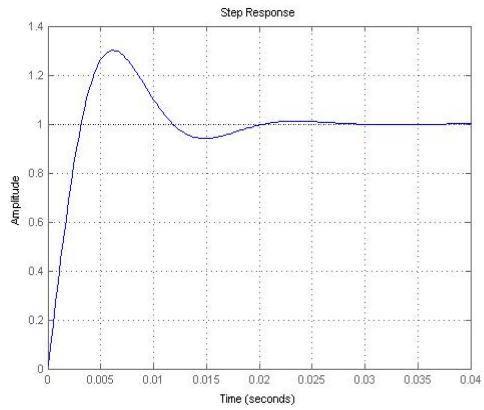

Fig.7 Response of motor with PID controller

V. CONCLUSION

Here we find that P controller can be used for slow systems. In order to speed up the system I controller is used, but it increases the maximum overshoot. In order to reduce the maximum overshoot D controller is introduced.

Thus the combination of the three i.e PID controller gives better output.

The method adopted in this paper is low cost technique of controlling the speed of the DC motor. DC motor is interfaced with PID Controller in LabVIEW. Speed of the motor is sensed by using the Infrared Sensor which is sent back to PID Controller as feedback for calculating and compensating the error produced if any. The method implemented can be used for various industrial applications. This technique helps in maintaining the stability of the system.

VI. FUTURE SCOPES

The method adopted in this paper using Zieglers Nichols technique for finding and removing the errors.

In future we will be using Fuzzy logic technique to find the errors and to tune the PID controller so that our work becomes easier and faster

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