Review of Performance Of Tuned PID Controller For Speed Control Of DC Motor

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Abstract: The function of speed control in DC motors is very essential in the achievement of desirable outputs. DC motors are designed for use in industrial and commercial applications such as the pump and blowers, material handling, system and gear drives, and adjustable speed drives. Both the nonlinear and linear of DC motor mathematical model is derived and the system model also represented in the form of continuous state space equation. Four type of controllers namely Proportional-Integral-Derivative (PID) controller are considered for controlling the speed of dc motor by giving the step input signal. The system is simulated using MATLAB/SIMULINK software. The system responses under the four different controllers are also analysed and discussed in term of their performances.
Keywords: : DC Motor, PID Controller, Existing tuning, Steady State Error, , Simulink, MATLAB.

1. INTRODUCTION

DC motors are designed for use in industrial and commercial applications such as the pump and blowers, material handling, system and gear drives, and adjustable speed drives. These motors are used to give rotary speed and position to a various electromechanical system. The purpose of developing a control system is to enable stable control since it has parameters tuning difficulties, non-linear, poor stability and imprecise control. The whole system is needed to be modeled first by using a state space equation. It has been found that this system results a non linear model. From this nonlinear model, the linearization process has to be done to simplify the model. After the linearized model has been acquired, the next task to do is to control the DC motor according to the required specifications. In this project, the main task is to control the speed of the DC motor. If the speed is equal to the reference signal, it can be concluded that the designed controller is successful in controlling the speed of the system become stable. There are four types of controllers considered namely, PID controller. The performance of the controllers in controlling the speed of DC motor system is evaluated via computer simulation using MATLAB/SIMULINK platform.

The development and applications of power electronics in industry has directly increased the use of Direct Current (DC) machine, because they have many good characteristics, high start torque characteristic, high response performance, easier to be linear control [1]. Nowadays, their uses are not limited to the car application (electrics vehicle), but also find applications in weak power using battery system (motor of toy) and for the electric traction in the multi-machine systems. The speed of DC motor can be adjusted or controlled easily to a great extend to provide easy controllability and high performance [2]. There are many techniques used to control DC motor, for example proportional integral derivation (PID) and Fuzzy Logic controller (FLC). Today most famous and most frequently used type of controller in industry is PID controller, The PID controller can be reduced the rise time since the proportional controller has effect on this. It can also eliminate the steady-state error by using the integral controller and lastly it can increase the stability of the system by using the derivative control [5

2. LITERATURE REVIEW

On extensive literature survey we can conclude that the PID controller has become the most widely used controller in various application domains because of its simple structure and easy implementation. The emerging features of automatic tuning have greatly simplified the use of PID control PID, self-tuning of PID can be extend it for numerical control systems applications. Also, it can be concluded that the PID can able to provide automatic tuning facility due to which it has received a more attention from the industrial users. The tuning of PID controllers would be a large research area. A PID controller has the general form which is:

$$U(t) = MV(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t)$$

In (Killingsworth, 2006), where Kp is proportional gain, Ki is the integral gain, and Kd is the derivative gain. The PID controller calculation (algorithm) involves three separate parameters there are the Proportional, the Integral and Derivative values. The Proportional value determines the reaction to the current error, the Integral determines the reaction based on the sum of recent errors and the Derivative determines the reaction to the rate at which the error has been changing. The manual tuning of PID controllers, which require optimization of three parameters, is a time consuming task (Killingsworth, 2006). The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve, the power supply of a heating element or DC motor speed and position. A PID controller is found in large number of company in all industries. The controller is come into different forms. There are many industrial process implement the PID controller. The reason is because it is simple structure and well known Ziegler- Nicholas tuning algorithm have been develop. Other reason is the controlled process in an industrial almost can be controlled by PID controlled with the PID control (Nascu. et al, 2006). But, the conventional PID controller design usually needs to retune the parameters like proportional gain, integral time constant and derivative time constant is mutually by the skill operator. By Nascu et al, (2006) present work there are

renewed interest in PID controllers because of two reasons. The first reason is they extensively used in application in all industries. Second, despites the existence of some results modern optimal control methods are not suitable to deal with fixed structure and fixed controllers. So, there is much that remains to be done to modernize PID design methods.
Closed loop controller is keeping motor speed at require set point under varying load conditions to keep at point value where (Ogata, 2002). For example, the set point is ramping up or down at the define rate. The system works if an error of speed is positive. The motor is running too fast so that the controller output is reduce. If the load is applied the motor is slow down and produce negative error. The output then increase by proportional amount to try and restore the speed.
PID TUNING There is several methods for tuning a PID. The most useful model shown in Table 2.1, then by the most effective methods generally involve the development of some form of process model, then choosing P, I, and D based on the dynamic model parameters.
Table 2.1: PID tuning methods

	Method	Advantages	Disadvantages
1	Manual tuning	Not math require, online method	Requires experience personnel
2	Ziegler-Nichols	Proven method, online method	Process upset, some try and error, very aggressive tuning
3	Cohen-Coon	Good process model	Some math offline method. Only good for first order process
4	Extremum Seeking	Proven by method	Some math method, good in various tunes.

From Chien and Jang (2010) state that an auto-tuner is something capable of computing the parameters of a regulator connected to a plant automatically and possibly without any user interaction apart from initiating the operation.auto-tuning method of PID controller is proposed, which combines: modelling of the closed-loop system, modelling of the process, and tuning formulas in terms of the relative damping of the transient response to set point changes. The auto tuned Proportional-Integral-Derivative (PID) Controllers are designed for applications where large load changes are expected or the need for extreme accuracy Method Advantages Disadvantages 1 Manual tuning Not math require, online method Requires experience personnel 2 Ziegler- Nichols Proven method, online method Process upset, some try and error, very aggressive tuning 3 Cohen-Coon Good process model Some math offline method. Only good for first order process Extremum Seeking Proven by method Some math method, good in various tunes. 11 and fast response time exists. The PID parameters are tuned based on the results of step response simulations to produce a response with minimal settling time and overshoot.

To address the difficulty, much effort has been invested in developing systematic tuning method (Killingsworth, 2006) which PID controller is usually used the Ziegler-Nicholas method. The Ziegler–Nichols rules for tuning PID controller have been very influential. The rules do, however, have severe drawbacks, they use insufficient process information and the design criterion gives closed loop systems with poor robustness (Cong and Liang, 2009). The Ziegler and Nichols developed their tuning rules by simulating a large number of different processes, and correlating the controller parameters with features of the step response (Cong and Liang, 2009). So, the process of this method is to obtain the parameters according Ziegler-Nicholas tuning rule can find the desired value

3.CONVENTIONAL CONTROLLER

Conventional controllers were used widely in industry due to their simplicity and ease of implementation, furthermore it has given reasonable response in numerous applications. The most famous conventional feedback controller is PID controller. 2.6.1 PI Controller P-I controller is mainly used to eliminate the steady state error resulting from P controller. However, in terms of the speed of the response and overall stability of the system, it has a negative impact. This controller is mostly used in areas where speed of the system is not an issue. Since P-I controller has no ability to predict the future errors of the system it cannot decrease the rise time and eliminate the oscillations. If applied, any amount of I guarantees set point overshoot

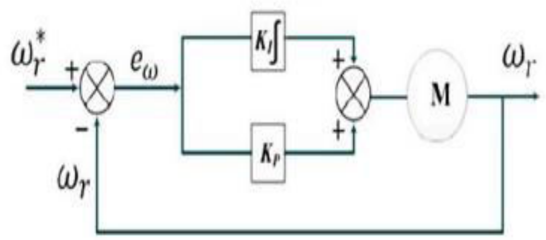

Fig 1 shows the block diagram of PI controller.

PD Controller

The aim of using P-D controller is to increase the stability of the system by improving control since it has an ability to predict the future error of the system response. In order to avoid effects of the sudden change in the value of the error signal, the derivative is taken from the output response of the system variable instead of the error signal. Therefore, D mode is designed to be proportional to the change of the output variable to prevent the sudden changes occurring in the control output resulting from sudden changes in the error signal. In addition, D directly amplifies process noise therefore D-only control is not used

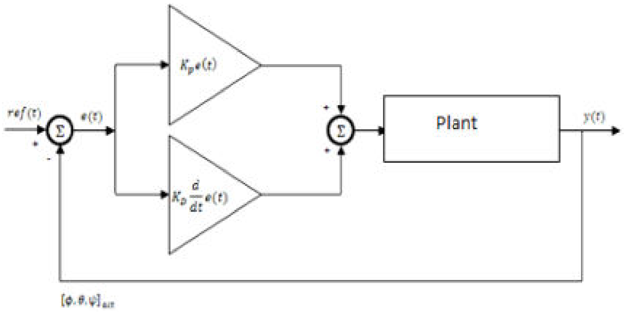

Fig 2block Diagram of PD controller.

PID Controller A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems a PID is the most commonly used feedback controller. 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 control inputs. In the absence of knowledge of the underlying process, PID controllers are the best controllers. However, for best performance, the PID parameters used in the calculation must be tuned according to the nature of the system, while the design is generic, the parameters depend on the specific system. Figure 2.7 shows the block diagram of PID controller

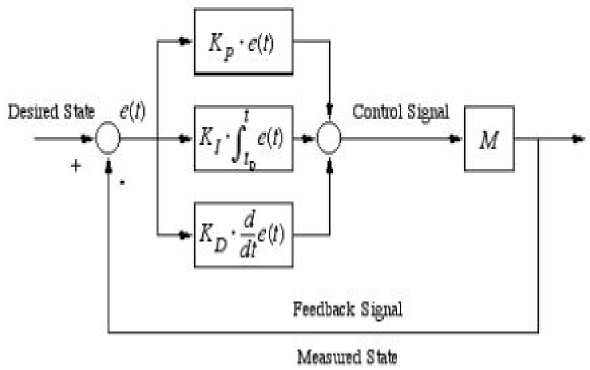

Fig 3 Block Diagram of PID controller.

PID Controller Theory The PID controller is probably the most-used feedback control design. PID is an acronym for Proportional-Integral-Derivative, referring to the three terms operating on the error signal to produce a control signal. If u(t) is the control signal sent to the system, y(t) is the measured output and r(t) is the desired output, and tracking error:

$e(t) = r(t) - y(t)$

a PID controller has the general form:

$(t) = kp(t) + ki \int e(t) + kd\ d\ dt\ e(t)$

The desired closed loop dynamics is obtained by adjusting the three parameters kp , Ki and kd often iteratively by tuning and without specific knowledge of a plant model [4]. The proportional term Kp (sometimes called gain) makes a change to the output that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant Kp, called the proportional gain. Larger values typically mean faster response since the larger the error, the larger the Proportional term compensation. An excessively large proportional gain will lead to process instability and oscillation [2][4]. Integral term Ki the contribution from the integral term (sometimes called reset) is proportional to both the magnitude of the error and the duration of the error. Summing the instantaneous error over time (integrating the error) gives the accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain and added to the controller output. The magnitude of the contribution of the integral term to the overall control action is determined by the integral gain, . Larger values imply steady state errors are eliminated more quickly. The trade-off is larger overshoot: any negative error integrated during transient response must be integrated away by positive error before we reach steady state Derivative term Kd the rate of change of the process error is calculated by determining the slope of the error over time (i.e., its first derivative with respect to time) and multiplying this rate of change by the derivative gain kd. The magnitude of the contribution of the derivative term (sometimes called rate) to the overall control action is termed the derivative gain, kd. Larger values decrease overshoot, but slows down transient response and may lead to bad performance due to signal noise amplification in the differentiation of the error [2][4]. PID Tuning a control loop is the adjustment of its control parameters (gain/proportional band, integral gain/reset, derivative gain/rate) to the optimum values for the desired control response. Good performance (bounded oscillation) is a basic requirement, but beyond that, different systems have different behavior, different applications have different requirements, and some desiderata conflict. Further, some processes have a degree of non-linearity and so parameters that work well at full-load conditions don't work when the process is starting up from noload; this can be corrected by gain scheduling (using different parameters in different operating regions). PID controllers often provide acceptable control even in the absence of tuning, but performance can generally be improved by careful tuning, and performance may be unacceptable with poor tuning [4]. PID tuning is a difficult problem, even though there are only three parameters and in principle is simple to describe, because it must satisfy complex criteria within the limitations of PID control. There are several methods for tuning a PID loop. The most effective methods generally involve the development of some form of process model, then choosing P, I, and D based on the dynamic model parameters. Manual tuning methods can be relatively inefficient, particularly if the loops have response timeson the order of minutes or longer. The choice of method will depend largely on whether or not the loop can be taken "offline" for tuning, and the response time of the system. If the system can be taken offline, the best tuning method often involves subjecting he system to a step change in input, measuring the output as a function of time, and using this response to determine the control parameters [4].

Manual Tuning is if the system must remain online, one tuning method is to first set Ki and Kd values to zero. Increase the Kp until the output of the loop oscillates, then the Kp should be set to approximately half of that value for a quarter amplitude decay type response. Then increase Ki until any offset is correct in sufficient time for the process. However, too much Ki will cause problem. Finally, increase Kd, if required, until the loop is acceptably quick to reach its reference after a load disturbance. However, too much Kd will cause excessive response and overshoot. A fast PID loop tuning usually overshoots slightly to reach the setpoint more quickly; however, some systems cannot accept overshoot, in which case an over damped closed-loop system is required, which will require a Kp setting significantly less than half that of the Kp setting causing oscillation. Table 2-1 explain the Effects of increasing a parameter independently

4. CONCLUSION

On extensive literature survey we can conclude that the PID controller has become the most widely used controller in various application domains because of its simple structure and easy implementation. The emerging features of automatic tuning have greatly simplified the use of PID control. Recently, fractional-order PID combined with the fuzzy logic system , IMC-PID controller design, optimal PID control, combination of PID-observer structure are gradually got attention. In the future, PID based control such as optimal fractional order PID, f PID can be extend it for numerical control systems applications. Also, it can be concluded that the PID can able to provide automatic tuning facility due to which it has received a more attention from the industrial users. The tuning of PID controllers would be a large research area.

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