Shridhar S Bilagi et al. International Journal of Recent Research Aspects ISSN: 2349-7688, Special Issue: Conscientious Computing Technologies, April 2018, pp. 76-79

Review of Speed Control of DC Motor using Various Controllers

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Abstract- **This paper presents a review study on analysis of speed control of DC motor. A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. DC motor speed control is one of the most useful features of the motor .By controlling the speed of the motor we can vary the speed of the motor according to the requirements and can get the desired operation. DC motors find extensive applications in industries where precise speed control over a wider range of speed both above and below the rated speed is required like process control, manufacturing, automation, aerospace etc. usually speed control of DC motor is achieved with PID controller.**

Index Terms- DC Motor, PI and PID Controller, Ziegler-Nichols, Neural Network Controller, Fuzzy logic controller.

I. INTRODUCTION

DC motor is a device which converts DC energy into mechanical energy. DC motor can provide a high starting torque and it is also possible to obtain speed control over wide range. A large number of DC motors are being used for general purposes in our surroundings from house-hold equipment to machine tools in industrial facilities. The dc motor is now a necessary and indispensable source of power in many industries. The function and the performance required for these DC motors are wide-ranging. When focusing attention on the speed control segment of the dc motor market, DC motors control speed with an external resistor and/or DC voltage. A motor controller is a device or group of devices that serves to govern in some predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and Faults. Why do we need a speed motor controller? For example, if we have a DC motor in a robot and we just apply a constant power to each motor on a robot, then the poor robot will never be able to maintain a steady speed. It will go slower over carpet, faster over smooth flooring, slower up hill, faster downhill, etc. So, it is important to make a controller to control the speed of DC motor in desired speed [1]. Characteristics of DC motors are much more superior to that of AC motors and also DC motors provide excellent control of speed for deceleration and acceleration. DC motors have a long tradition of use as adjustable speed machines and a wide range of options have evolved. The controllers of the speed that are conceived for goal to control the speed of DC motor to execute many tasks [3-4]. There are several controller types of Conventional controllers, Proportional Integral Controller, PID Controller, Ziegler-Nichols, Neural Network Controller and Fuzzy Logic Controller. In industries 90% controllers are PID type because of its feasibility and easy to be implemented.

II. CONVENTIONAL CONTROLLERS

Many industrial processes are controlled using conventional controllers like PI, PD, and PID etc. The PI controller is very popular because of their robust performance over a wide range of operating conditions and functional simplicity. The basic purpose of process control systems such as is two-fold: To manipulate the final control element in order to bring the process measurement to the set point whenever the set point is changed, and to hold the process measurement at the set point by manipulating the final control element. The control algorithm must be designed to quickly respond to changes in the set point (usually caused by operator action) and to changes in the loads (disturbances). The design of the control algorithm must also prevent the loop from becoming unstable, that is, from oscillating. There are varieties of control actions that are used, in order to achieve the desired response from the designed process satisfactorily and efficiently. The traditional and easiest approach to the controller design problem for non-linear systems involves linearizing the modeling equations around a steady state and applying linear controller theory results. However, the controller performance will deteriorate as the process moves further away from the steady state around which it was linearized. Therefore application of PI controller becomes more attractive for controlling tool wear.

A. Proportional Integral Controller

It is well-known that, despite many sophisticated control theories and techniques that have been devised in the last decades, PI controllers are still the most adopted in practical cases. In fact, due to their simple structure, PI controllers are relatively easy to tune and their use is well understood by a great majority of industrial practitioners and automatic control designers. It is also well-known that PI controllers are particularly adequate for processes whose dynamics can be effectively modeled by a first or third order system. Proportional - means a value varying relative to another value. The output of a proportional controller is relative to (or a function of) the difference between like temperature being controlled and the set point. Accordingly it is expressed as:

$U(t) = Kce(t)= Kc\{r(t)-y(t)\}$

In its pure form, the output of the controller is the error times the gain added to a constant known as "proportional gain". The proportional control produces an offset. Using the manual reset removes offset. The gain, however, cannot be made infinite. In most loops there is a limit to the amount of gain that can be used. If this limit is exceeded the loop will oscillate causing instability for the system. The mathematical expression of the PI Controller is:

$$U(t) = K_P e(t) + K_i \int_0^t e(t)\, dt$$

The block diagram of PI controller of PI Controller is shown in Fig.1.

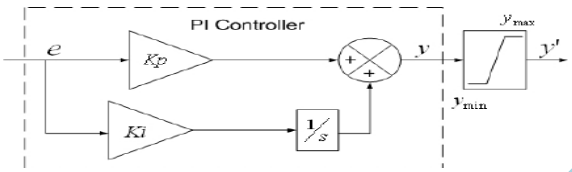

Fig.1.Block diagram of PI Controller

Where, Ki = Integral gain of the PI controller. The response is sluggish at the high value of the integral time Tn and control loop may oscillate at the small value integral time Tn

B. PID Controller

PID is a most common control algorithm used in industrial automation & applications and more than 95% of the industrial controllers are of PID type. PID controllers are used for more precise and accurate control of various parameters.

Most often these are used for the regulation of temperature, pressure, speed, flow and other process variables. Due to robust performance and functional simplicity, these have been accepted by enormous industrial applications where a more precise control is the foremost requirement. Combination of proportional, integral and derivative actions is more commonly referred as PID action. It gets the input parameter from the sensor which is referred as actual process variable. It also accepts the desired actuator output, which is referred as set variable, and then it calculates and combines the proportional, integral and derivative responses to compute the output for the actuator. In manual control, the operator may periodically read the process variable (that has to be controlled such as temperature, flow, speed, etc.) and adjust the control variable (which is to be manipulated in order to bring control variable to prescribed limits such as a heating element, flow valves, motor input, etc.). On the other hand, in automatic control, measurement and adjustment are made automatically on a continuous basis. In modern industrial controllers are of automatic type (or closed loop controllers), which are usually made to produce one or combination of control actions. These control actions include ON-OFF control, proportional control, proportional-integral control, proportional-derivative control and proportional-integral-derivative control. In case of ON-OFF controller, two states are possible to control the manipulated variable, i.e., either fully ON (when process variable is below the set point) or Fully OFF (when process variable is above the set point). So the output will be of oscillating in nature. In order to achieve the precise control, most industries use the PID controller. There are different types PID controllers available in today's market, which can be used for all industrial control needs such as level, flow, temperature and pressure. When deciding on controlling such parameters for a process using PID, options include use either PLC or standalone PID controller.

Standalone PID controllers are used where one or two loops are needed to be monitored and controlled or in the situations where it difficult to access with larger systems. These dedicated control devices offer a variety of options for single and dual loop control. Standalone PID controllers offer multiple set point configurations and also generates the independent multiple alarms.

The mathematical equation is given by:

$$u = K_P e + Ki \int edt + Kd \frac{de}{dt}$$

The block diagram of PID Controller is shown in Fig.2 and Table.1 shows the time domain specifications of closed loop system for different values of Kp.

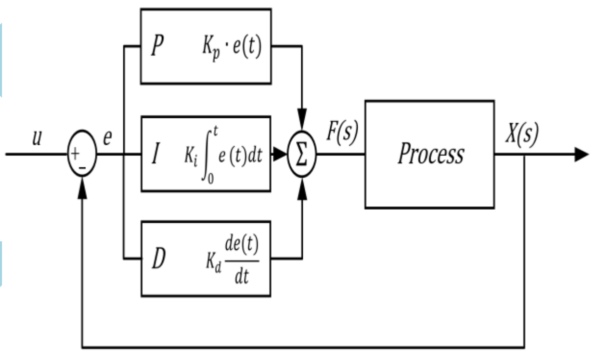

Fig.2. Block diagram of PID Controller

Table.1: Time domain specifications of closed loop system for different values of Kp

Closed loop Response	Rise Time(sec)	Maximum Overshoot (%)	Maximum Overshoot (%)	Steady state error
As increase of K_p	Decrease	Increase	Small change	Decrease
As increase of K_i	Decrease	Increase	Increase	Eliminate
As increase of K_d	Small change	Decrease	Decrease	Small change

III. ZIEGLER-NICHOLS

To tune in the parameters for the PID controller can be a challenge, and if the time constants in the process are huge and the time to do the optimization can be too long! But there are some rule of thumb, of which the rule lined out by Ziegler-Nichols back in 1942 is well known.Table.2 shows the tuning formula for P, PI and PID Controller using Ziegler-Nichols method.

Table.2: Tuning formula for P, PI, and PID Controllers using Ziegler-Nichols method.

Types of Controllers	K_p	T_i	T_d
P	$\frac{T}{KL}$	∞	0
PI	$\frac{0.9T}{KL}$	3.3L	0
PID	$1.2\frac{T}{KL}$	2L	0.5L

Ziegler-Nichols presented a tuning formula [13], based on time response and experiences. Although it lacks selection of parameters and has an excessive overshoot in time response, still opens the way of tuning parameters.

The PID controller tuning methods can be classified into two main categories
(1)Closed loop methods
(2)Open loop methods.
In 1942, Ziegler and Nichols presented two standard methods to tune a PID-controller. These methods, due to their simplicity and practicality, are still widely used in different industrial and other tuning.

IV. NEURAL NETWORK CONTROLLER

A Neural Network Controller plays the role of a controller (a device which monitors and alters the operating conditions of a dynamic system using electrical or mechanical signals generally) in a control system. Neural Nets are specifically used when the control problems are non-linear in nature. Before a neural network can be used as a controller, it must first learn the model of the plant. There are several learning architectures proposed whereby the neural network may be trained. In this method, the network is trained offline to learn a plant's (which needs to be controlled) inverse dynamics directly. It is similar to the normal training procedure for a neural network. By applying the desired range of inputs to the plant, its corresponding outputs can be obtained and a set of training patterns are then selected. Once the net is trained with the collected data, it can be used to produce the correct control input as a function of the desired plant output (like every other control system). There is an online method that was proposed where the weights of the net is adjusted at every sample using back propagation. The performance error is the difference between the desired output and the actual plant output. But it has its limitations in the sense that the initial stability of the plant is not guaranteed and it also requires the knowledge of some important plant parameters (Jacobean, for example) neural networks resemble the human brain in the following two ways: A neural network acquires knowledge through learning. A neural network's knowledge is stored within inter-neuron connection strengths known as synaptic weights. The neural network consists of junctions which are connected with LINKS, also called processing units. For each junction a number is ordered, this number is called weight. The weights are the tools for the long distance information storing in the neural network, the learning process occurring with the appropriate modification of weights.
The block diagram of Neural Network Controller is shown in Fig.3.

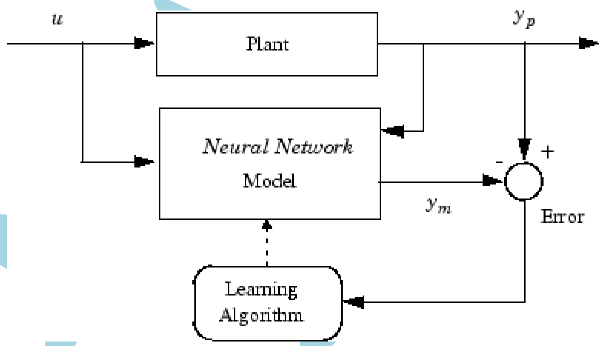

Fig.3 Block diagram of Neural network Controller

V. FUZZY LOGIC CONTROLLER

In an effort to improve performance, some instrumentation manufacturers are exploring the value of using "fuzzy logic" for process control. This OMEGA Engineering White Paper explores both the weaknesses of PID systems and the potential benefits of fuzzy logic controllers, with particular reference to issues in temperature control. Individual sections address:

- PID challenges
- Introduction to fuzzy logic for control
- PID plus adaptive fuzzy logic
- Applications

Fuzzy Logic is a particular area of concentration in the study of Artificial Intelligence and is based on the value of that information which is neither definitely true nor false. The information which humans use in their everyday lives to base intuitive decisions and apply general rules of thumb can and should be applied to those control situations which demand them. Acquired knowledge can be a powerful weapon to combat the undesired effects of the system response.Fig.4 shows basic structure of fuzzy logic control system.

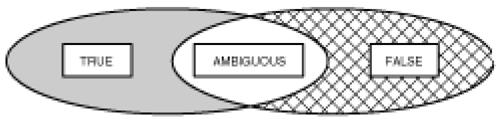

Fig.4 Basic structure of fuzzy logic control system.

Fuzzy logic controllers use a very flexible set of if-then rules. The solution is then applied to appropriate membership functions. Referring to figure 1, values which lie within the shaded area are called true beyond a shadow of a doubt. Those values which lie within the cross hatched area are called false beyond a shadow of a doubt. If all data falls to one side or the other of the overlap area, then Fuzzy Logic probably would be of little benefit.

In most applications there are some points which lie in the common area. Information which lies within the common area has to be studied, stored, and used to quantify and to classify the data. This allows for smart manipulation of the data structure in order to make inference to a solution. Information which falls in that common area can be ranked, aged, and "best guess" made after evaluation of this "gray" information.

VI. CONCLUSION

In this paper, an attempt has been made to review various literatures for the classical controller techniques introduced by the different researchers for tuning of PID controller for speed control of DC motor to optimize the best result. This review article is also presenting the current status of tuning of PID controller for speed control of DC motor using classical controller techniques.

REFERENCES

[1] Shashi Bhushan Kumar, Mohammed Hasmat Ali, Anshu Sinha, "Design and Simulation of Speed Control of DC Motor by Artificial Neural Network Technique" International Journal of Scientific and Research Publications, Volume 4, Issue 7, July 2014.

[2] Manoj Kushwah and Prof. Ashis Patra, "Tuning PID Controller for Speed Control of DC Motor Using Soft Computing Techniques-A Review" Advance in Electronic and Electric Engineering, Volume 4, Number 2 (2014), pp. 141-148.

[3] Aditya Pratap Singh, "Speed Control of DC Motor using PID Controller Based on Matlab" International Conference on Recent Trends in Applied Sciences with Engineering Applications, Vol.4, No.6, 2013.

[4] Ramesh Chandra Chourasia, Mukesh Kumar, "Speed Control of S.E.D.C. Motor by Using Pi and Fuzzy Logic Controller" International Journal of Soft Computing and Engineering (IJSCE), Volume-3, Issue-2, May 2013.

[5] Shashi Bhushan Kumar, Mohammed Hasmat Ali, Anshu Sinha, "Design and Simulation of Speed Control of International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 02 Issue: 08 | Nov-2015 www.irjet.net p-ISSN: 2395-0072 © 2015, IRJET ISO 9001:2008 Certified Journal Page 1621 DC Motor by Artificial Neural Network Technique" International Journal of Scientific and Research Publications, Volume 4, Issue 7, July 2014.

[6] Aditya Pratap Singh, "Speed Control of DC Motor using Pid Controller Based on Matlab" Innovative Systems Design and Engineering, Vol.4, No.6, 2013 - Selected from International Conference on Recent Trends in Applied Sciences with Engineering Applications.

[7] Bhaskar Lodh , "Simulink Based Model for Analysing the Ziegler – Nichols Tuning Algorithm as applied on Speed Control of DC Motor", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 3, Issue 1, January 2014.

[8] Neerparaj Rai#1, Bijay Rai#2, "Neural Network based Closed loop Speed Control of DC Motor using Arduino Uno." International Journal of Engineering Trends and Technology- Volume 4, Issue 2, 2013.

[9] Snehashish Bhattacharjee1, Samarjeet Borah2, "A Survey on the Application of Fuzzy Logic Controller on DC Motor" International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 2, Issue 6, June 2013

[10] Nader Jamali Sufi Amlashi "Design and Implementation of Fuzzy Position Control System for Tracking Applications and Performance Comparison with Conventional PID" IAES International Journal of Artificial Intelligence (IJ-AI) Vol. 1, No. 1, March2012, pp. 31 - 44 ISSN: 2252-8938.

