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Comparison of different controlling schemes (Pi, Pid And Ip) for speed control of DC motor

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Abstract
DC motors are extremely used where extensive speed control range is required. This paper presents speed control of DC motor using different controlling schemes-PI, PID and IP. Here we have analyzed their transient behavior for controlling speed of dc motor. PI controller is the most common controller applied for controlling speed of dc motor but PI controller has some disadvantages like high overshoot, sluggish response to sudden load change and sensitivity to gain parameters. To overcome these drawbacks of PI controller it is replaced with PID and IP controller. When PID controller is used overshoots(14.4%) get reduced to 6.53% than PI controller(20.93%). With IP controller there is 20.93% less overshoot than PI controller and 14.4% less than PID controller. When we consider time parameters (rise time and settling time) PID gives fastest response. Here PI, PID and IP controllers are implemented in Matlab (Simulink) and comparison of their performances on the basis of transient response is analysed. We also compared effect on speed responses of DC motor with each controlling scheme by varying load torque.

Keywords
PI, PID, IP, DC motor.

1.Introduction
High performance motor drives are very much essential for industrial applications. Most of the industries demand variable speed operation of motor. DC motor provides good control of speed for acceleration and deceleration [1]. DC motor is used in many applications such as steel rolling mills, electric vehicles, electric trains, electric cranes and robotic manipulators. These require speed control to perform its task smoothly.

Because of their simplicity, reliability and low cost DC drives have long been used in industrial applications. These are less complex compared AC drive system [12-14]. DC motor is a SISO (single input single output) system which has torque/speed characteristics compatible with most mechanical loads [1]. This makes a DC motor controllable over a wide range of speed by proper adjustment of terminal voltage.

Speed of the DC motor is controlled by in two ways (1) intentional speed control (2) speed variation due to undesirable or sudden load variation which is unintentional speed control. For first controlling scheme we can increase or decrease the speed of motor by varying either terminal voltage or field flux or armature resistance it is intentionally done as per our need [3]. But when sudden load change occurs that affect the reference speed if no controllers are used. The speed of motor gets deviated from its reference speed and high overshoots are occurred with infinite settling time. To overcome this problem we use controllers. Here our objective of designing a controller for controlling speed of DC motor is to require a signal that represents the desired speed and to drive it at that speed [11]. There are mainly two types of controllers for measurement of speed of a DC motor. (1) Open loop (2) closed loop [1]. When actual speed is measured by closed loop controller while open loop controller cannot give accurate or actual speed. Hence even after complexity of closed loop controllers these are preferable to get accurate results but are expensive due to feedback component [5-6]. PI controller is a closed loop controller and it has ability to make zero steady state error with a step change in reference speed [4]. When we compare the performance of PI controller with PID and IP controller in terms of transient response of motor, undesirable higher overshoot and steady state error get reduced DC motor with IP controller [4]. We also see that we are getting fastest response when we use PID controller with least rise time and settling time among three.

2.DC motor without any controller
Without any controlling scheme speed of DC motor never achieve its reference speed when any disturbance in load occurred. Undesirable overshoots are very high in this case. To minimize overshoots and better transient parameters we implement DC motor with different controllers.

3.DC motor with proportional integral (PI) controller

In P-I controller both the proportional (K_p) and integral (Ki) gain parameters are put in feed forward path. Due to proportional gain (K_p) in feed forward path [7]. There are two loops as shown below in block diagram of a P-I controller, one is speed loop and second is inner current loop. In the speed loop speed error E(s) which is the error between the actual speed and desired speed is given to the input of P-I controller [1]. The output of P-I controller is given to the input of second current loop which acts as a motor reference current.

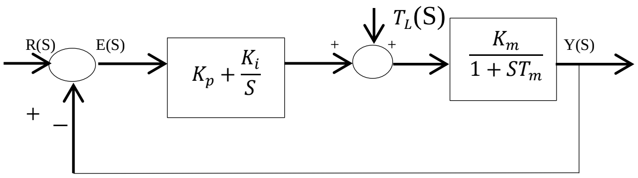

Figure 1 Block diagram of DC motor with P-I controller

4.DC motor with proportional integral and differential (PID) controller

The necessity of using a derivative gain component in addition to the PI controller in PID controller is to reduce overshoot and steady state error to zero [2]. So that to make response fast (short rise time) with no oscillations with higher stability. Here the error between reference speed and actual speed is given to input to a PID controller [10]. And its output is applied to input of a DC motor as shown in block diagram [3]:

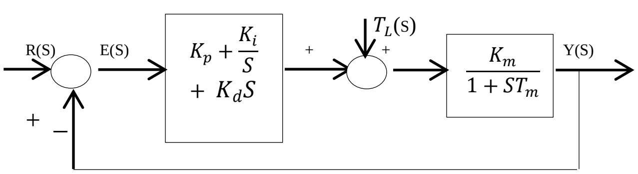

Figure 2 Block diagram of DC motor with P-I-D controller

5.DC motor with integral proportional (IP) controller

I-P controller is the advance form of P-I controller, which was first introduced in 1978 for the speed control of motors. In I-P controller the proportional gain (Kp) is kept in feedback path and the integral gain (Ki) in feed forward path as shown in block diagram [1].

There are three loops in I-P controller, speed feedback loop, current inner loop and proportional gain feedback loop[8-9].

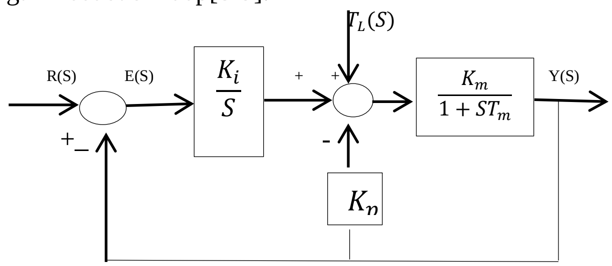

Figure 3 Block diagram of DC motor with I-P Controller

6.Results

Here separately excited DC motor is taken at 500Nm load torque at 1500 rpm.

Table 1 Transient response for speed of DC motor

Method	**Rise time (sec)**	**Maximum overshoot (%)**	**Settling time (sec)**
System response without controller	0.063	59.4%	infinity
PI	0.0233	20.93%	0.3305
PID	0.0136	14..4%	0.2044
IP	0.1538	0%	0.3645

7.Conclusion and future work

All (PI, PID and IP) controllers are implemented with separately excited DC motor to control its speed. Their performances are compared on the basis of the transient response of DC motor at different load torque. Simulation results show that I-P controller response is much better than the P-I and P-I-D controllers in terms of percentage overshoots.

Using I-P controller we are able to reduce overshoots to 0%. And if we consider time parameters we analyzed that PID controller gives fastest response among three. It takes least rise time and settling time than other schemes. In future speed of DC motor can be controlled by using evolutionary computing techniques like Genetic Algorithm (G.A), Particle Swarm Optimization (PSO), Differential Evolution (D.E) etc. based I-P controller. Evolutionary computing techniques based I-P controller can also be used for speed control of A.C motor.

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