

PID Controller based DC Motor Speed Control

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Abstract – Due to extensive use of motion control system in industry, there has been growing research on proportional-integral-derivative (PID) controllers. DC motors are widely used various areas of industrial applications. The aim of this paper is to implement efficient method for controlling speed of DC motor using a PID controller based. Proposed system is implemented using arduino microcontroller and PID controller. Motor speed is controlled through PID based revolutions per minute of the motor. This encoder data will be send through microcontroller to Personal Computer with PID controller implemented in MATLAB. Results shows that PID controllers used provide efficient controlling of DC motor.

Keywords – DC Motor; Control System; PID Controller; MATLAB Simulation: Arduino

I. INTRODUCTION

PID controller is becoming very important since in last few years its demand is increasing from various industries as it gives the consistency and maintains the output even if its input is changed. The DC motor are also popular in the industry control applications since long time, they have good characteristic such as high response performance, high start torque characteristics, and easy for linear control. DC motor gives good speed control respond. They have wide speed control range and they are used in speed control systems which needs high control requirements like high precision digital tools, rolling mill, double-hulled tanker etc[1]. For example, suppose DC motor is used in a robot, constant power is applied to each motor on a robot, in this case poor robot cannot maintain a steady speed. It goes slower over carpet, faster over smooth flooring, slower up hill, faster downhill, etc. So, it is important to take into account a controller to control the speed of DC motor in desired speed [2].

Many control schemes such as proportional, integral, derivative, proportional integral, PID, adaptive, and FLCs are used for speed control of dc motors. For controlling speed of the DC motor, voltage to the armature of dc motor is varied [3]. Control system is a system which controls other system.

Open Loop Control System

In Open Loop Control System, it cannot correct the variation in output automatically. In these systems the output remains constant for a constant input signal. By approximately changing input output may change to desired value and variations in external Conditions may cause the output to change [1].

Closed Loop Control System

In closed Loop Control System, it can correct the variation in output automatically. In these systems the output remains constant for a changing input signal. The measured response of the system is compared with a desired response of the system. The difference between two response gives the actual response of the system[1].

This paper is organized as follows: Section II gives introduction to the PID controllers and importance of the DC motor. Proposed work and system flow is given Section III. Software design, Hardware components and its implementation is discussed in Section IV. Section V describes results of proposed system. Finally, conclusion is given in Section VI.

II. PROPOSED WORK

A. Block Diagram of the Proposed system

Figure 1 shows the block diagram of the proposed work.

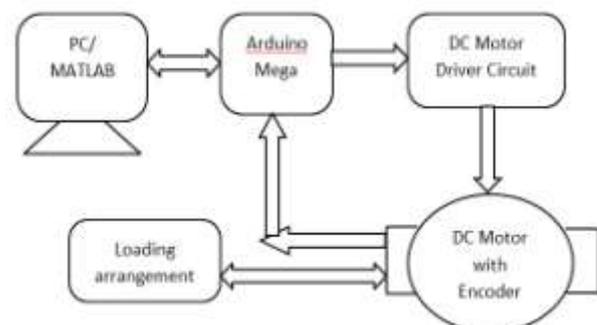


Fig.1 Block Diagram of the Proposed System

Proposed system consists of Arduino mega controller development board, DC motor driver, servomotor and PC with MATLAB code. In proposed system speed of the DC motor is controlled through PID controller using MATLAB. The system works in the form of closed loop. Feedback about the

status about the RPM of the motor is given to microcontroller then data is send to PC through serial communication. PID controller is implemented in MATLAB it receives data and give command to arduino controller according to the set threshold. Microcontroller gives command to dc motor driver through PWM. It drives the servomotor according to the command received.

B. System Flow

Algorithm

1. Start and initialize the system
2. Read motor data through microcontroller
3. Send this data to PC and take decision using PID controller
4. Send this data back to microcontroller and send command to motor driver
5. Motor speed is controlled

System implementation flow is shown in Fig. 2.

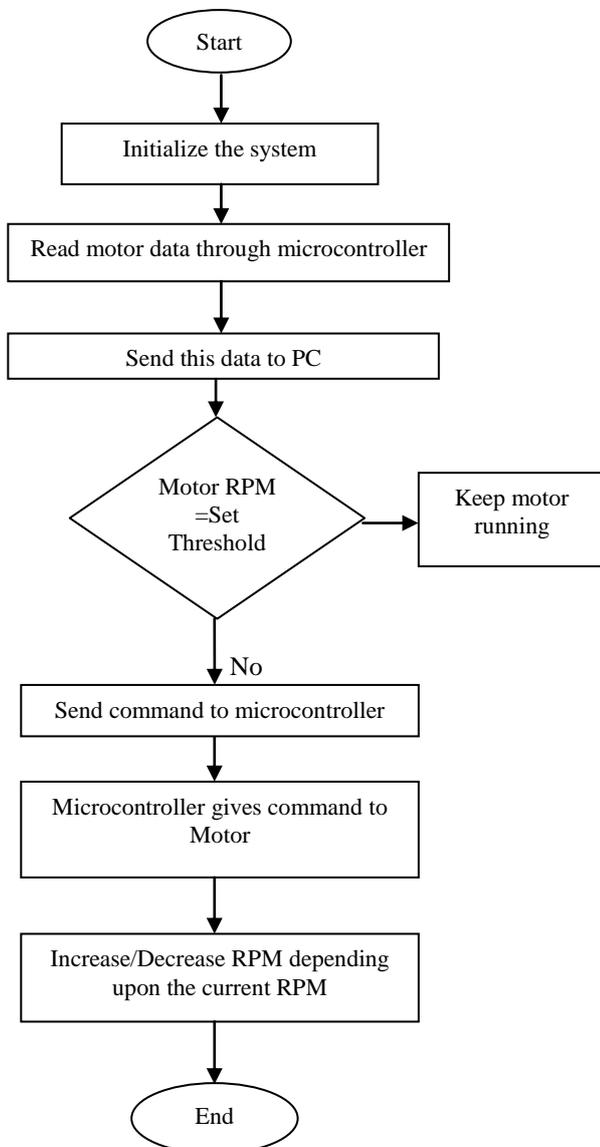


Fig.2. System Implementation Flow

III. PID CONTROLLER

A. PID Controller

PID controller algorithm provides control action for the designed process according to requirements[1]. Figure 3 shows the block diagram of PID Controller.

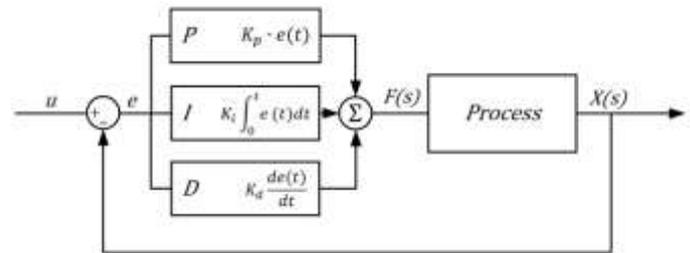


Fig.3 Blocks of PID Controller

The response of the controller can be described in terms of the responsiveness of the controller the degree to which the controller overshoots the set-point ,to an error and the degree of system oscillation. PID Controller is the combination of Proportional, Derivative and Integral controllers. PID controller works in a closed-loop system as shown in figure 3. The transfer function of the PID controller is given below:

$$K_P + \frac{K_I}{s} + K_D s = \frac{K_D s^2 + K_P s + K_I}{s} \dots\dots (1)$$

Where,

K_P = Proportional gain

K_I = Integral gain

K_D = Derivative gain

The desired input value is represented as (R) and the actual output is represented as a (Y). The difference between desired input and actual output is represented by variable (e) called as tracking error. This error signal (e) is send to the PID controller, and the controller computes the derivative and the integral of this error signal. The signal (u) just pass the controller is now equal to the proportional gain (K_P) times the magnitude of the error plus the integral gain (K_I) times the integral of the error plus the derivative gain (K_D) times the derivative of the error as given in equation (2).

$$u = K_P e + K_I \int e dt + K_D \frac{de}{dt} \dots\dots\dots (2)$$

This signal (u) is send to the plant, and it gives the new output (Y). This new output (Y) will be sent back to the sensor again to find the new error signal (e).The controller takes this new error signal and computes its derivative and its integral again. This process will continue[4].

Characteristics of P, I, and D controllers

- A proportional controller (K_P) reduces the rise time but it will never eliminate the steady-state error.
- An integral control (K_I) eliminates the steady-state error, but it makes the transient response worse.

- A derivative control (K_D) increases stability of the system, by reducing the overshoot, and it improves the transient response of the system [2].

Table No.1 Effects of each of controllers K_P , K_I , and K_D on a closed-loop system[2]

CL RESPONSE	RISE TIME	OVERSHOOT	SETTLING TIME	S-S ERROR
K_p	Decrease	Increase	Small change	Decrease
K_i	Decrease	Increase	Increase	Eliminate
K_d	Small change	Decrease	Decrease	Small change

IV. SYSTEM DEVELOPMENT

A. Software Description

1. Arduino Compiler

The Arduino Software (IDE) is an open source compiler in which we can write code and upload it to the board. It runs on Mac OS X, Linux and Windows. It is based on processing and other open-source software and environment is written in Java. Arduino compiler accepts C and C++ many of the libraries are written in C++.The Arduino environment performs some small transformations on the code to make sure that the code is correct then it gets passed to a compiler, which turns the code into machine language.

2. MATLAB

MATLAB is a high-performance language its basic data element is an array that does not require dimensioning. Matrix and vector formulations allow us to solve many technical computing problems. It integrates computation with the programming visualization which gives easy-to-use environment where problems and solutions can be expressed in the mathematical notation. Areas in which MATLAB toolboxes are available include control systems, simulation, signal processing, neural wavelets, fuzzy logic, and many others.

B. Hardware Description

The block diagram of the implemented model which is used in this work is shown below in figure 4. Also the different parameters of the individual component are explained below.The motor used in this work is a permanent magnet DC motor. An encoder is connected to the motor. The encoder is of 2000 ppr. The encoder is used to count the output pulses of motor.

The specifications of the same are listed below.

Rated voltage (V)	24
No load speed (rpm)	6600
Rated speed (rpm)	6000
Rated torque (kgcm)	5.2
Stall torque (kgcm)	22
Rotor inertia (Gcm ²)	600
Starting current (A)	29.5

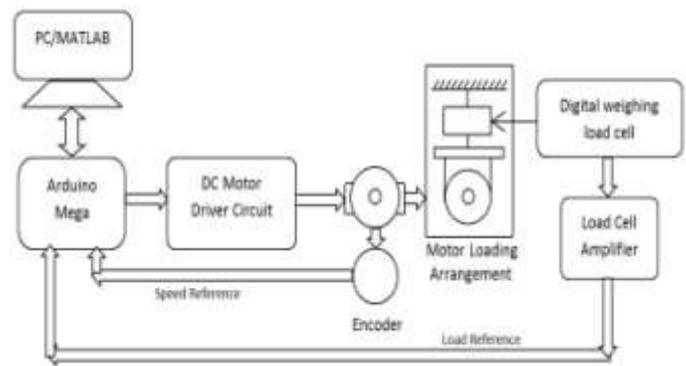


Fig.4. Implemented Model

PWM pulses for the motor are given through the arduino board and driver circuit from PC/MATLAB. The loading arrangement consists of a digital weight, load cell and load cell amplifier. The output of the load cell amplifier is given as feedback to the arduino to measure the pulses and accurate weight.

V. RESULTS AND DISCUSSIONS

Figure 5 and 6 shows the MATLAB simulation results of the system. Figure 5 shows the graph of the motor RPM vs number of samples, error signal and the control signal for the threshold RPM of 1500. Initially RPM is 2500 then at sample 110, 170 RPM goes below 1500. Hence, it is seen that error signal is present at samples 0, 110 and 170. Control signal for the given error signal is shown in figure.

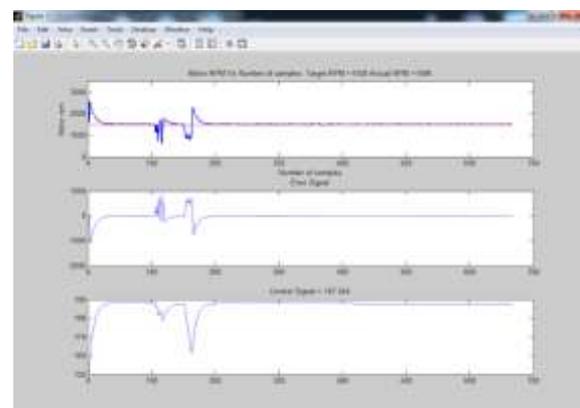


Fig.5 Motor RPM vs Number of Samples for threshold RPM=1500

Figure 6 shows the graph of the motor RPM vs number of samples, error signal and the control signal for the threshold RPM of 2000. Initially RPM is 3500 then at sample 60, 85 RPM goes below 2000. Hence, it is seen that error signal is present at samples 0, 60 and 85. Control signal for the given error signal is shown in figure.

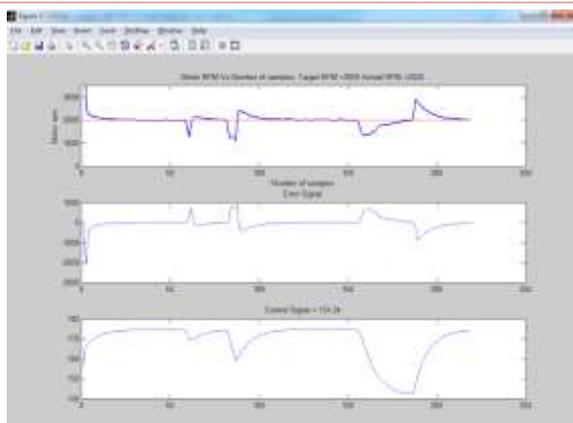


Fig.6 Motor RPM vs Number of Samples for threshold RPM=2000

VI. CONCLUSION

Proposed system consists of servomotor and PID controller. System is designed and implemented using MATLAB and arduino IDE software tools. PID controller collects data from microcontroller to calculate the error and control the speed with in operated range Results shows that PID controllers used provide efficient controlling of DC motor.

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