CASCADE CONTROL OF DC MOTOR WITH ADVANCE CONTROLLER

[1]RATHOD BHAVINA, [2]NITESH JAMLIYA, [3]KEERTI VASHISHTHA

PG Student , IIT research fellow, Assistant Professor
Email: Bhavi_ic@yahoo.com, niteshjamliya@gmail.com, kpbs81@gmail.com

Abstract— The proportional- integral-derivative (PID) control is the most used algorithm to regulate the armature current and speed of cascade Control system in motor drives. The controller uses two PID controllers. One master PI controller is for speed control as an outer loop and second slave P controller is for current control as an inner loop in cascade structure. The output of the encoder is compared with a preset reference speed. The output of the PI controller is summed and is given as the input to the current controller. DC motor control system is implemented on PIC as an Advance controller.

Keywords— DC motor, system identification, cascade control, speed control, current control, PID controller, PIC18F Microcontroller

I. INTRODUCTION

Brushed DC Motors have been widely used in many industrial applications such as electric vehicles, steel rolling mills, electric cranes, and robotic manipulators due to precise, wide, simple, and continuous control characteristics. Small DC motors are used in control devices such as encoder for speed sensing and servomotors for positioning.[1]
In this type of control there are two control loops, inner one for controlling current and outer one for speed control. In cascade control, proportional-integral (PI) and proportional (P) type controllers are used, which removes the delay, overshoot, and provides fast robust control.

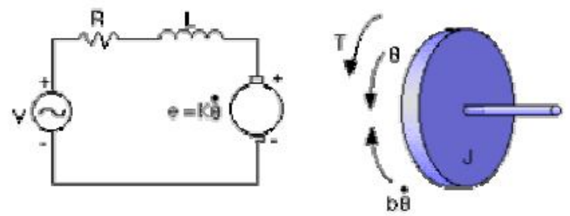

Figure -1: Permanent magnet brushed dc motor

In this paper, section-1 is system identification of the DC motor system. In section-2 cascade PID control is explained. In section-3, Hardware design is explained and in section-4, real time implementation results are shown and given the conclusion.

II. SYSTEM IDENTIFICATION

System identification is especially helpful for modeling systems that you cannot easily model from first principles or specifications. For system identification of DC motor, input voltage is applied to DC motor through full bridge driver at interval of 50 milli second. Output of Encoder is measured at regular interval of 5 milli second through counter of microcontroller. Pulse output of encoder for 5 milli second is converted in Revolution per Minute (RPM). This data is given to MATLAB "System Identification Toolbox".

III. CASCADE PID CONTROL

A. Design of the cascade control DC motor system

Cascade control is one of the most popular complex control structures implemented to improve the disturbance rejection properties of the controlled system. In cascade structure, each loop has associated its corresponding PID controller. The controller of the inner loop is called the secondary controller whereas controller of the outer loop as the primary controller, being output of the primary loop the set point to the secondary controller.

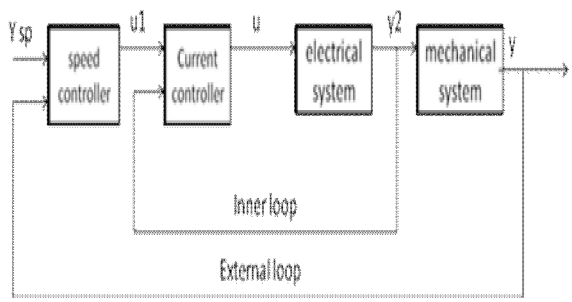

Figure-2: Cascade control of DC motor system

B. PID tuning method
There are so many methods available to find the PID parameters. The P, I & D parameters can be found by using step response method for single PID controller and relay feedback method for cascade PID control of the system.

Controller	K_P	K_I	K_D
P	$\frac{T}{L}$	0	0
PI	$0.9\frac{T}{L}$	$0.27\frac{T}{L^2}$	0
PID	$1.2\frac{T}{L}$	$0.6\frac{T}{L^2}$	$0.6T$

Table1: S- shape reaction curve method

Using S-shape curve method first find the delay time L and time constant T we get PID parameters. By using Relay feedback method, we can calculate the ultimate time (Pu) and Ultimate gain (Ku) from oscillations of output waveforms, then using Z-N technique Kp, Ki, & Kd is found.

Thus controller is tuned for that system Finding the value of relay amplitude (d) and output amplitude (a), we will get the ultimate gain by computing these values in the following equation

$$Ku = \frac{4d}{\Pi a} \qquad (1)$$

Having determined the ultimate gain Ku and the oscillation period Pu the PID controller tuning parameters can be obtained from the following table:

	K_c	τ_I	τ_D
P	$0.5K_{cu}$		
PI	$0.45K_{cu}$	$P_u/1.2$	
PID	$0.6K_{cu}$	$P_u/2$	$P_u/8$

Table-2 Zeigler Nicholas Tuning Rules

IV. HARDWARE IMPLEMENTATION

For design of system, 12 volt series DC motor is selected. Also to sense speed, encoder is connected to motor. To drive DC motor 12 volt is applied to it. To isolate DC motor and digital devices DC motor driver L298 is used.

To communicate between PC and system PIC controller is used. The communication between PC and microcontroller is established with RS-232 standard. This microcontroller takes commands from PC by RS-232 link and converts it into PWM signal which are applied to interfacing circuit. Also Encoder counts are given to PC with RS-232 link.

Figure 3 shows the block diagram of the system hardware. Encoder gives the PWM signals from the DC motor and sends the digital signals to microcontroller. Microcontroller gives the low level digital signal (5V) which is converted by isolator in high level digital signal (12V) sufficient for DC motor. System implementation requires the basic equipments: isolator, RS-232 USB driver, power supply. Figure 4 shows the hardware of the system.

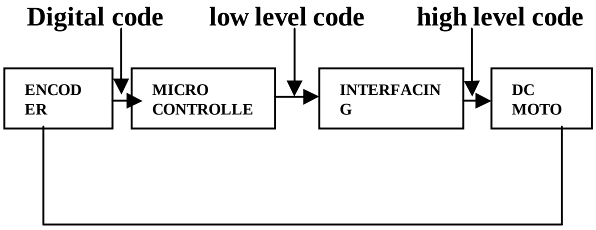

Figure 3: Block diagram of the system

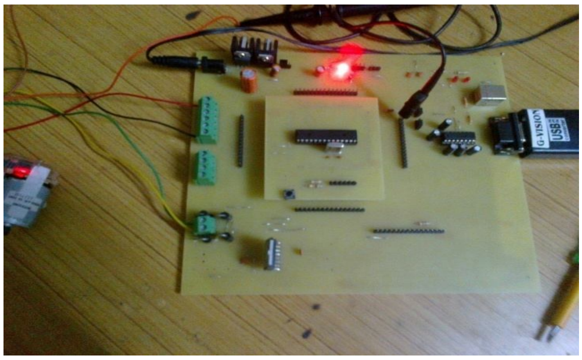

Figure 4: Hardware of the system

V. IMPLEMENTATION RESULTS

(1) Single PID control:
  Kp=12.5
  Ki=3.74

(2) Cascaded PID control:
  Inner loop parameters:
  Proportional (kp) value=9
  Tuned Propotional (kp1) value=0.84
  Outer loop parameters:
  Proportional (kp) value=91
  Integral (ki) value=1864

Results are carried out on MATLAB 2011. As shown in figure 4, if we give step to system then it will carry out output speed response in the figure 5. In figure 6 & 8, using single PID control and in figure 7 & 9, using cascade PID control we have carried out current and speed response.

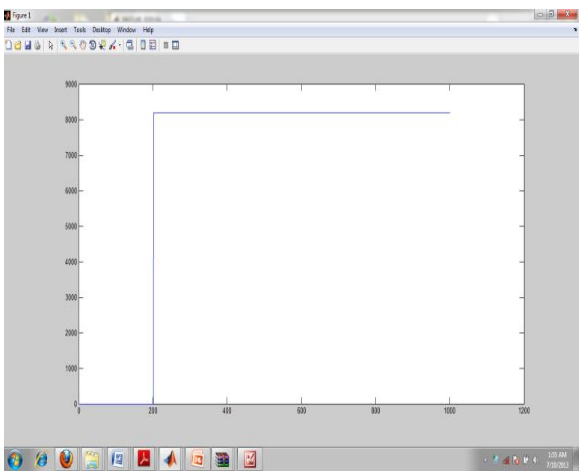

Figure 4: Step response to the system

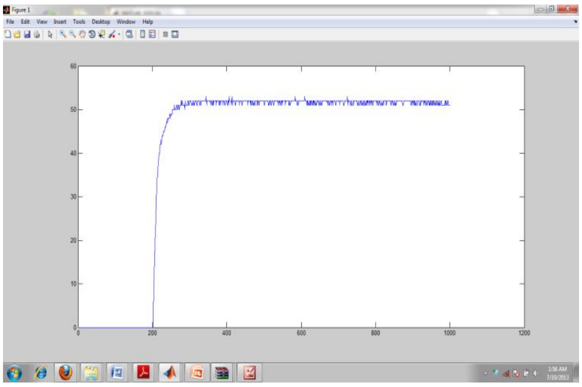

Figure 5: Step response of the system

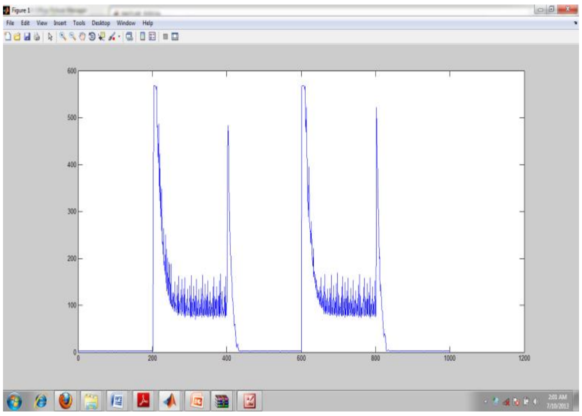

Figure 6: Result of single PID current control

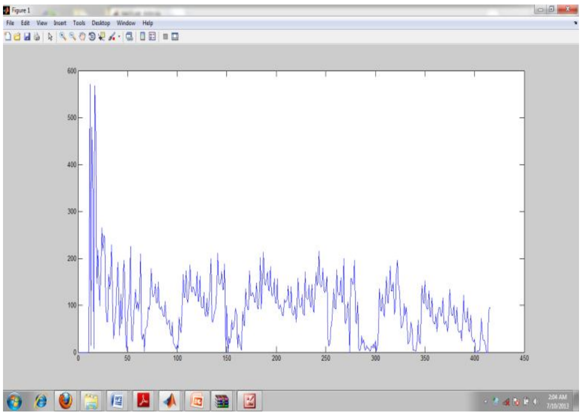

Figure 7: Result of cascade PID current control

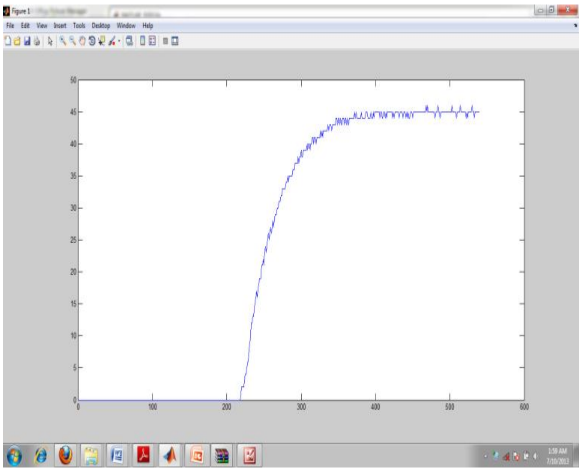

Figure 8: Result of single PID speed control

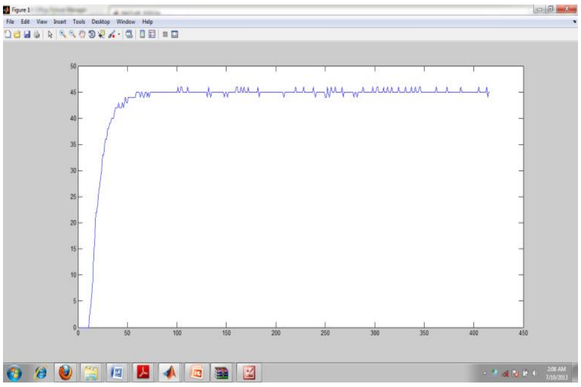

Figure 9: Result of cascaded PID speed control

CONCLUSION

In the present study, system identification of DC motor has carried out using MATLAB system identification toolbox. The cascade system is implemented on PIC18F controller using MATLAB and the time response for current loop and speed loop is plotted and investigated. We have concluded that cascade PID control gives the excellent response then single PID control. For current control loop, select the P controller to eliminate the higher peak oscillations of the current and get the robustness and negligible delay in the speed by making the PI speed controller.

REFERENCES

[1] Ibrahim K., Rateb Issa. "Overshoot Elimination in Cascade Control of Separately Excited DC Motors, 2012" European Journal of Scientific Research, pp.98-104

[2] Anirban Ghoshal , Vinod John "Anti-windup Schemes for Proportional Integral and Proportional Resonant Controller,2010" NATIONAL POWER ELECTRONIC CONFERENCE 2010

[3] Mehmet AKAR, Mahmut HEKIM, Ismail TEMIZ, Zafer DOGAN. "The Speed and Torque Control of Direct Current Servo Motors by using Cascade Fuzzy PI Controller, 2012"

[4] Lalit S. Patel, K.C.Dave. "Cascade control Technique for D.C.Motor Speed Control, 2011" International Conference on Science and Engineering.

[5] Radu Duma, Petru Dobra, Dorin Petreus, Ioan Valentin Sita, Radu Adrian Munteanu, "real-time bldc motor control using the stellaris lm3s8962 microcontroller" Proceeding of the 4th European DSP in Education and Research Conference.

[6] C. Agees Kumar, N. Kesavan Nair. "Multi Objective Cascade Control System Design for Speed Control of Permanent Magnet DC Motor Drives,2012" European Journal of Scientific Research

[7] Mohd Azri Bin Abd Mutalib. "Speed control of DC motor using PI Controller",2008.

[8] A.Purna Chandra Rao,Y. P. Obulesu, CH. Sai babu Robust internal model control strategy based pid controller for bldcm,2010" International Journal of Engineering Science and Technology.

[9] W.L. Soong. "DC Machines: Parameter Measurement and Performance Prediction, 2008" Power Engineering Briefing Note Series.

[10] M.Nizam. Kamarudin, Sahazati Md. Rozali "simulink implementation of digital cascade control DC motor model-A didactic approach,2008" IEEE Internal conference on Power and Energy.