Reviews of Cascade Control of Dc Motor with Advance Controller

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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 PI controller is for speed control and second PID controller for current control in cascade structure. Inner loop is for the current control which is faster than the outer loop. Outer loop is for speed control. 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.

Keywords: DC motor, encoder, cascade control, speed control, current control, PI controller and 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 (in fractional power rating) are used in control devices such as encoder for speed sensing and servomotors for positioning. [4]

In this type of control there are two control loops, inner one for controlling current and outer one for speed control. In cascade control, two proportional-integral-derivative (PID) controllers are used, which removes the delay and provides fast control.

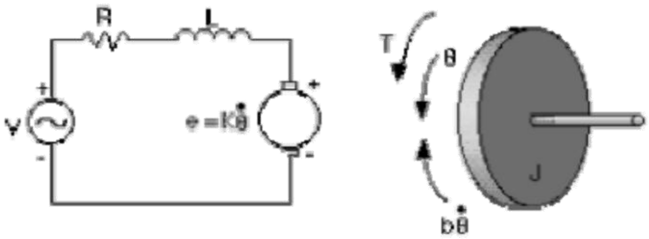

Fig. 1: Permanent magnet brushed dc motor

In this paper, section-1 is the fundamentals of the DC motor. In section-2, cascade PID structure is explained. In section-3, papers reviews are shown. In section-4, future scope is explained and given the conclusion.

II. FUNDAMENTALS OF DC MOTOR

DC motor transfer function can be obtained by the following equations

The armature circuit equation is:

$$v_a(t)=R_a i_a + L_a di_a/dt + e \quad (1)$$

Where

$v_a(t)$ is the armature voltage, e is the back EMF, i_a is the armature current, R_a and L_a are the armature resistance and armature inductance respectively.[4]

The back EMF can be written as

$$e=k_e w \quad (2)$$

Where

k_e is a constant for the machine and w is the angular speed of rotation.

The equation of mechanical part is:

$$T = \frac{Jdw}{dt} + bw \quad (3)$$

Where J is the moment of inertia, b is the viscous friction coefficient.

Developed torque is:

$$T = k_e i_a \quad (4)$$

Taking Laplace transform of all forgoing equations assume zero initial conditions for all variables, the DC motor transfer function can be obtained as[4]

$$G = \frac{Km}{LaJs^2+(RaJ+BLa)s+(Km^2+RaB)} \quad (5)$$

So, DC motor is second order system. When there are no parameters specifications of the system, system identification is used to build mathematical modeling of the dynamic system based on measured data. Overall system is represented in block diagram form as shown in Figure-2, In which voltage signal Va is applied to electrical system and then by multiplying with K1-back emf, torque-T will go to mechanical system. W is the output speed which is measured by K2- speed sensor and then go back to the reference signal.

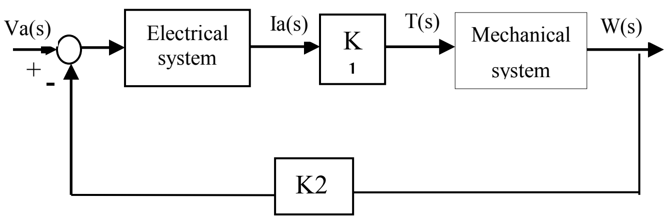

Fig. 2: DC motor block diagram

III. CASCADE CONTROL STRUCTURE

In a cascade control system there is one or more control loops inside the primary loop, and the controllers are in cascade The (first) loop inside the primary loop is called the secondary loop, and the controller in this loop is called the secondary controller (or slave controller). The outer loop is called the primary loop, and the controller in this loop is called the primary controller (or master-controller). The control signal calculated by the primary controller is the set point of the secondary controller. The purpose of the secondary loop is to compensate quickly for the disturbance so that its response in the primary output variable of the process is small. For this the secondary loop must have register the disturbance. Cascade control can give substantial compensation improvement. Cascade control can also give improved tracking of a varying set point, but only if the secondary loop has faster dynamics than the second process.

IV. LITERATURE REVIEWS

Proportional-Integral-Derivative (PID) control is the best-known controller in industries. PID offers simple structure as well as robust performance for the dc motor system. PI controller is always been compared to PID and PD controller. PI controller is suited for dominant dead time where constant>dead time and PID controller is suited for dominant time constant and no noise from the transmitter. Derivative, D is used when the loop has low noise and to increase the stability. If the loop contains high noise, D will increase the noise in high frequency and make the output jittery. D is not suitable for pure dead time process. It will cause the loop to become unstable.
From reference paper-3, it concludes that cascade PID is better than single PID speed control. In paper-1&2, there is used Anti-windup PID with limiter for current peak control application and elimination of integral error in PI speed control application. In paper-4 the PI current controller is replaced by IMC-tuned PID controller to eliminate the overshoot in current loop and then the overshoot in speed loop.
In most applications improved compensation — not improved tracking — is the main purpose of cascade control.
Cascade PID is tuned as follow:

1. First the secondary controller is tuned, with the primary controller in manual mode.
2. Then the primary controller is tuned, the secondary controller in automatic mode.

There are so many methods available to find the PID parameters. The P, I & D parameters can be found by using relay feedback technique connected with system. By using this 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.[3] 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

$$Ku = \frac{4d}{\Pi a} \quad (8)$$

V. FUTURE SCOPE

Cascade PID control will be used by making two loops, inner for current control which is as secondary loop with secondary PID type controller and outer one is for speed control as the primary loop with master PID type controller as shown in the figure-3. First current loop will be controlled and find the PID parameters and then speed loop will be controlled by making automatic current control loop.
Implementation of the cascade PID controller on the PIC18F

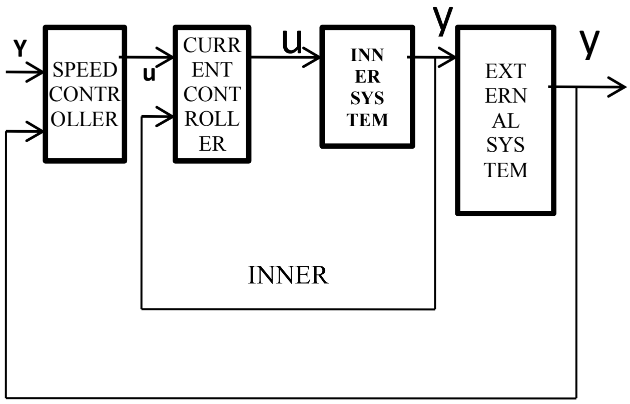

Fig. 3: Cascade control of the system

Microcontroller is as shown in figure-4. In that encoder gives the PWM signals from the DC motor and send 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.

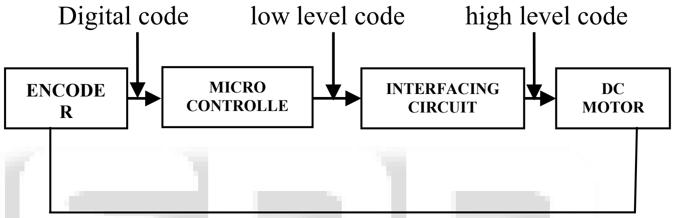

Figure 4: Implementation of the system

PID algorithm will be developed in PIC18F 2431 microcontroller.
PIC18F microcontroller has good features for dc motor speed control. It includes:

1. 14-bit Power Control PWM Module
2. Motion Feedback Module
    1. Three independent input capture channels:
    2. Flexible operating modes for period and Pulse
    3. Width measurement
    4. Special Hall Sensor interface module
    5. Special event trigger output to other modules
    6. Quadrature Encoder Interface:
    7. 2 phase inputs and one index input from encoder
    8. High and low position tracking with direction
    9. status and change of direction interrupt
    10. Velocity measurement
3. High-Speed, 200 Ksps 10-bit A/D Converter
4. Flexible Oscillator Structure
5. Two Capture/Compare/PWM (CCP) modules
6. Enhanced USART module
7. Flash/data EEPROM.[10]

For interfacing, L298 chip as dc motor isolator is used. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. [11]

VI. CONCLUSION

PID control method is accurate for output control with disturbance rejection but it will give rise to produce high starting current which can be dangerous for control circuitry or motor for high capacity motor operation, while cascade control method will give best set point tracking (Servo response) and disturbance rejection (regulation) with reduced starting current, which can be used for low as well as high capacity motors. In cascade structure, for better improvement tune the PID controller in good manner such that it will give robust response in speed and current loop. Implementation of PID control algorithm will make on PIC18F microcontroller.

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