DC Motor Speed Control using PID Algorithm

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Abstract— The DC motor has been popular in the industry control area for a long time, because they have many good characteristics, for example: high start torque characteristics, high response performance and easier to be linear control. DC motor has good speed control response, wide speed control range. And it is widely used in speed control systems which need high control requirements, such as rolling mill, double-hulled tanker, high precision digital tools, etc. There is difficulty when using the traditional or conventional method because those methods cannot deal with any application that using complex mathematical model. However, a working knowledge of PID does not require the operator to be familiar with advanced mathematical developments.
Key words: DC Motor, PID Control, Microcontroller, Serial Communication

I. Introduction

The system proposed, uses PID Algorithm to reduce the disturbances that occur in the DC motor due to shaft vibration, load variation. The Basic block Diagram of the system includes a controller, Plant which refers to DC Motor and the Feedback loop with consist of Encoder Pulse Separator. The feedback loop allows us to sense the motor current condition and its variation with respect to Disturbances. The Disturbances are reduced by PID algorithm. The speed of the DC motor is controlled by microcontroller which transmits, receives and displays the PID graph variations. PC also provides serial Communication. The 'heart' of the controller is a digital computer.

The problem of realizing this system is mainly one of developing computer program. Fig. 1 shows the basic feedback system block diagram.

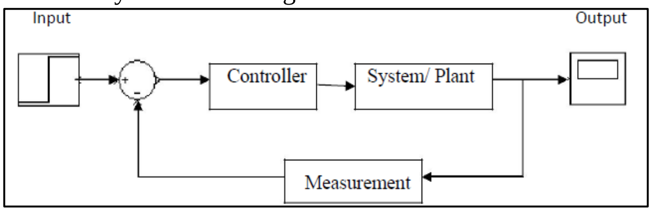

Fig. 1: Basic Feedback system

II. Motivation

There is difficulty when using the traditional or conventional method because those methods cannot deal with any application that using complex mathematical model.

However, a working knowledge of PID does not require the operator to be familiar with advanced mathematical developments. This is because the three terms are reasonable intuitive, allowing non-specialist of the controller action. The PID framework solves many control problems and is sufficiently flexible to incorporate additional capabilities. Machines are easily damage without implementation of control methodology in it system. Frequently, the desired performance characteristics of control systems are specified in terms of the transient response. The transient response of a practical control system usually exhibits damped oscillation before reaching steady state. As for machines, having a high overshoot is an undesired condition since the starting current is very high. Thus, control methodology such as PID controller is used to limit the maximum overshoot as well as to reduce the starting current of the machine.

III. Analysis

The analysis is done by providing the external force on the DC motor shaft. The external force can be provided manually by holding the shaft or applying the force on shaft. Due to this the load will be increased and there will be current variation in the motor which will then be nullified by the Controller. The time required for the PID algorithm to reduce the error is presented here with the help of Plot.

IV. Methodology

The main objective here is to develop the PID Controller which can control the speed of DC Motor and to analyze the performance of the Proposed Controller.

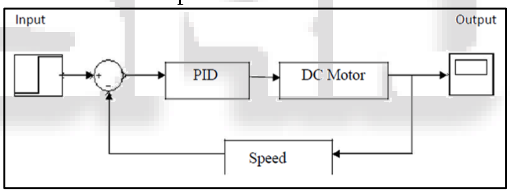

Fig. 2: Block Diagram of the Proposed System.

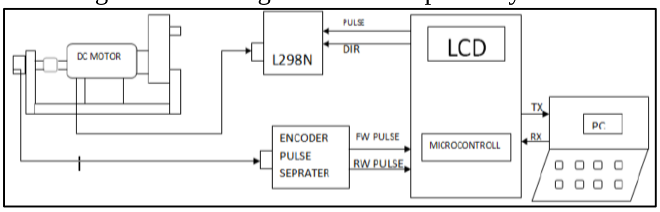

Fig. 3: Basic Interfacing of the System

The stated block Diagram used the high torque DC motor which is driven by motor driver L298N. This motor driver helps the motor to achieve its maximum performance without any fluctuations. The motor can withstand voltage 0> 48V. The Encoder pulse generator will sense the motor current along with that it will identify the motor speed and direction. The direction and speed are controlled by controller and monitored with the help of Encoder pulse generator.

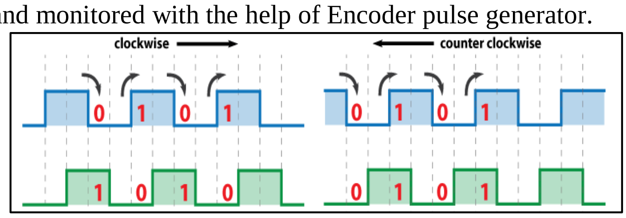

Fig. 4: Realizing Direction of Motor by encoder

The encoder has a disk with evenly spaced contact zones that are connected to the common pin C and two other separate contact pins A and B.

When the disk will start rotating step by step, the pins A and B will start making contact with the common pin and the two square wave output signals will be generated accordingly.

Any of the two outputs can be used for determining the rotated position if we just count the pulses of the signal. However, if we want to determine the rotation direction as well, we need to consider both signals at the same time. We can notice that the two output signals are displaced at 90 degrees out of phase from each other. If the encoder is rotating clockwise the output A will be ahead of output B.

So if we count the steps each time the signal changes, from High to Low or from Low to High, we can notice at that time the two output signals have opposite values. Vice versa, if the encoder is rotating counter clockwise, the output signals have equal values. So considering this, we can easily program our controller to read the encoder position and the rotation direction.

A. *Proportional Integral Derivative Controller*

At industrial applications the PID controllers are preferred widespread due to its robust characteristics against changes at the system model. From the other side at industry the exact plant models could not be obtained due to too much nonlinear parts and uncertainties so at practice engineers usually find an appropriate model for the dynamic system.

For example, when a thermal system is taken into consideration, the system's overall gain changes from season to season. Changes in dynamic system parameters and unknown system variables directly affect the performance of the system. So for obtaining a better performance the controller parameters have to be renewed in some time interval.

The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). The proportional, integral, and derivative terms are summed to calculate the output of the PID controller. Defining as the controller output, the final form of the PID algorithm is:

$$u(t) = MV(t) = K_p\, e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{d}{dt}\, e(t) \quad (1)$$

Where,

K_p: Proportional gain, a tuning parameter

K_i : Integral gain, a tuning parameter

K_d: Derivative gain, a tuning parameter

e: Error= SP-PV

t : Time or instantaneous time (the present)

τ: Variable of integration; takes on values from time 0 to the present.

B. *Characteristics of P, I and D controllers*

A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism widely used in industrial control systems. A PID controller attempts to correct the error between a measured process variable and a desired set point by calculating and then outputting a corrective action that can adjust the process accordingly.

The PID controller calculation (algorithm) involves three separate parameters; the Proportional, the Integral and Derivative values. Proportional value determines the reaction to the current error the Integral determines the reaction based on the sum of recent errors the Derivative determines the reaction to the rate at which the error has been changing.

V. HARDWARE DESCRIPTION

A. *SST89E51RD Microcontroller*

1) *Introduction*

This chip is low-power; high-performance CMOS 8-bit microcomputer with 8Kbytes of Flash programmable and erasable read only memory (PEROM).

The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Philips 8051 is a powerful microcomputer, which provides a highly flexible and cost- effective solution to many embedded control applications.

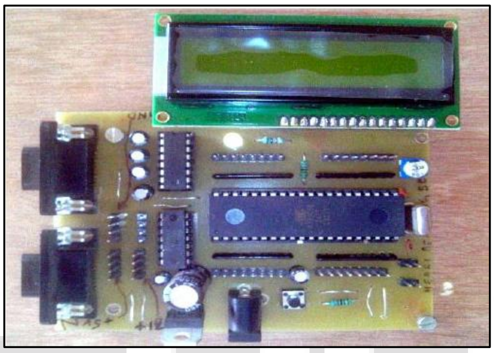

Fig. 5: Microcontroller SST89E51RD

The feature list is includes:

- Three 16-bit Timers/Counters
- 8-bit 8051-Compatible Microcontroller (MCU)with Embedded Super-Flash Memory– Fully Software Compatible– Development Toolset Compatible– Pin-For-Pin Package Compatible
- Full-Duplex, Enhanced UART– Framing Error Detection– Automatic Address Recognition
- Four 8-bit I/O Ports (32 I/O Pins) and One 4-bit Port

B. *Encoder Pulse Generator*

1) *Introduction*

Encoders have discs manufactured from Opto-plastic up to 3600 ppr (pulse per rotation) and glass above this level. Sensing is performed by LED and phototransistors via fringe grating. These features ensure a long life and resistance to shock and vibration. Double ball bearings are also used to give a rigid and robust construction.

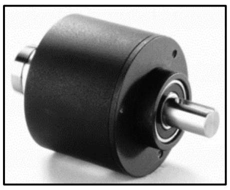

Fig. 6: Encoder

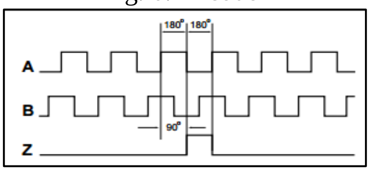

Fig. 7: Pulse Form from Encoder

The quadrature displacement of A and B channels is 90˚ electrical, +/– 10%. The Z marker is gated with channel A, unless specified otherwise. The sequence of pulses is B before A, when rotating shaft clockwise, when viewed from shaft end.

This includes features such as:

- Pulse range 1 to 5000 ppr
- Maximum speed 6,000 rpm
- Axial load 10N
- Current consumption 100mA.

C. *Motor Driver*

1) *Introduction*

The L298 is an integrated monolithic circuit in a 15- lead Multiwatt and PowerSO20 packages. 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. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

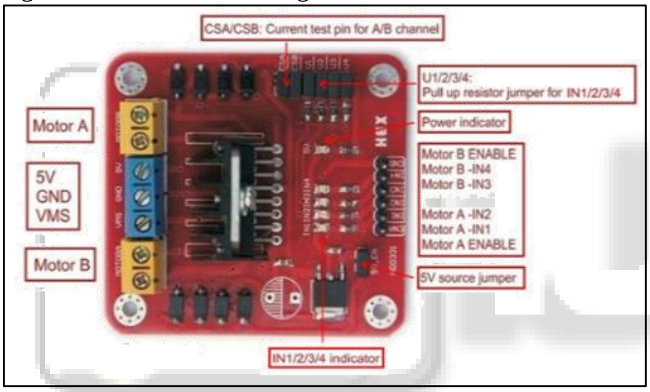

Fig. 7: L298N Motor Driver

VI. IMPLEMENTATION AND RESULTS

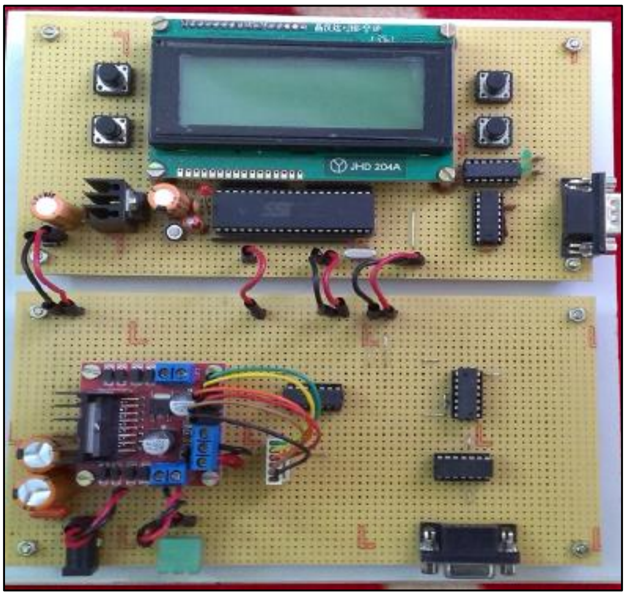

Fig. 8: Interfacing Controller and Motor Driver

Fig. 9: Interfacing the Circuit with DC motor and Encoder

The Circuit interfaced is connected to PC to given the results in terms of Initial speed, Error reduced which can be observed through the Graph and the reading obtained from the Encoder.

0	30	29.92	0.08	0	0	0	-0.01	73.55
0	30	18.42	11.58	0.12	-0.14	0	0	73.42
0.1	30	19.85	10.15	0.1	-0.04	0	0	73.94
0.2	30	21.58	8.42	0.08	0.04	0	0	76.19
0.3	30	24.53	5.06	0.05	0.1	0	0	79.54
0.5	30	28.7	1.3	0.01	0.13	0	0	83.15
0.6	30	32.57	-2.57	-0.03	0.12	0	0	85.96
0.7	30	35.22	-5.22	-0.05	0.08	0	0	87.3
0.8	30	36.03	-6.03	-0.06	0.03	0	0	87.01
0.9	30	35.11	-5.11	-0.05	-0.02	0	0	85.45
1	30	32.88	-2.88	-0.03	-0.06	0	0	83.32
1.2	30	30.53	-0.53	-0.01	-0.07	0	0	81.31
1.3	30	28.3	1.7	0.02	-0.06	0	0	79.91
1.4	30	26.97	3.03	0.03	-0.04	0	0	79.32
1.5	30	26.77	3.23	0.03	-0.01	0	0	79.5
1.6	30	27.18	2.82	0.03	0.01	0	0	80.19

Fig. 10: Readings from the Encoder.

The reading obtained from the encoder are stored in the excel file containing speed and correction value.

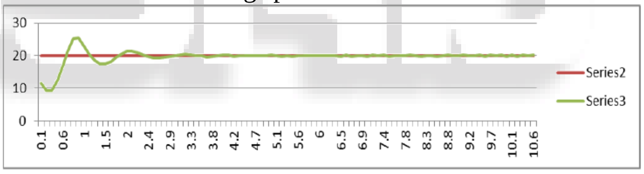

Fig. 11: Graph of motor Speed correction

From the above Graph it is observed that when a sudden disturbance occurs in the motor the PID comes in action immediately allowing the motor to maintain it desired speed. The error is being reduced with time and the motor speed obtains the desired speed.

VII. CONCLUSION

As per the results of the graph obtained, as soon as the disturbance is sensed PID algorithm comes into action.

Proportional value determines the reaction to the current error the Integral determines the reaction based on the sum of recent errors the Derivative determines the reaction to the rate at which the error has been changing.

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