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DEVELOPMENT OF A MICROCONTROLLER PID MODULE FOR DC MOTORS THAT ARE LOW POWERED

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ABSTRACT

Proportional-Integral-Derivative (PID) is used basically for the feedback system of industrial machines. This system has a controller that tries to adjust the error in the variable that is processed with the setpoint that is desired. This is done by calculating first the error in the two values and then tries to produce corrective action that can accordingly adjust the process. There are different PID controllers and have been used in several ways in the industry. The cost of the DC motor is Php 10,000 - 20,000 per unit. This research implements a PID controller by using a microcontroller to control DC motors that are low powered. This is done for educational purposes. The angular velocity of the specified target velocity of the input module is accurately achieved. This research also validates the effects of changing the dissimilar PID gains like Proportional, Integral, and Derivative systems.

Keywords: pulse width Modulation (PWM), DC motor, proportional integral-derivative (PID) controller.

1. INTRODUCTION

A PID controller is a device used in control systems. It utilizes simple and generally applicable control the technique is known as PID control [1, 2, 3]. This control technique uses the concept of applying a feedback system that makes the necessary corrections or output variations to the system [4, 5].

A PID loop is used to automate tasks that a human operator would usually do. Moreover, the PID system is developed for many application processes that need automated control [6, 7, 8]. It is used for applications that require DC motors like conveyor belts, elevators, mobile robots, and similar applications that deal with variable weight input [9, 10]. In all these applications, it is observed that PID gives more stability to the system when employed. This shows that the PID is an efficient way of solving real world control problems [11, 12, 13].

Recently, several PID controllers have been available that are being used in different applications. They also have Neural, Rough Set and Fuzzy Network Applications just like in the studies of [14, 15, 16]. For program implementation it can be patterned in the studies of: [17, 18, 19]. A DC motor PID controller can be very costly for students and enthusiasts alike. This research gives an alternate option for such inefficient PID controls. It is important to know the basic concepts of PID and control systems, but for students and enthusiasts to grasp these issues in a broader, more realistic way [20, 21, 22]. Experience is of utmost importance. It confirms what is being addressed in the classes and lecture rooms.

2. PROTOTYPE DESIGN

The block diagram of the motor speed controller, shown in Figure-1, is segregated to its general functional parts and interfaces. This serves as a guide to the system's composition and on how it would function as a whole.

The PIC programmer receives an input data of the target speed and a combination of the PID gains as inputted by the user. The LCD first displays the required RPM. The PIC would then send signals of Pulse Width Modulation (PWM) to the motor driver. The motor driver, in turn, allows the motor to function. For communication a database monitoring and RFID System can be used [23, 24]. The infrared interrupter detects the passing of the peg which indicates that the motor has completed a revolution. The interrupter is directly coupled to the PIC for the feedback information [25, 26, 27].

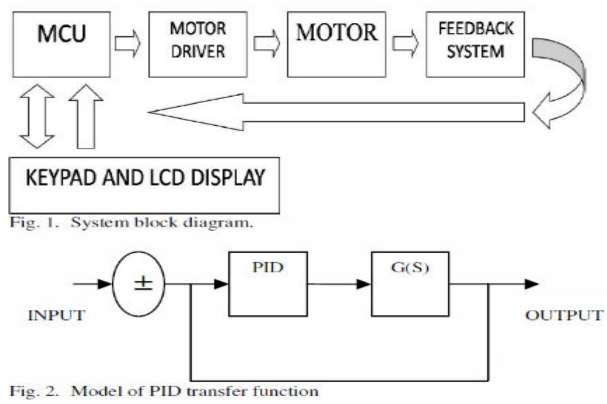

Figure-1. Motor Speed Control.

2.1 PID Controller

The transfer function of the PID controller is:

KI KDs KPs KI
KP KDs
s s
+ +
+ + =

where: KP = Proportional gain
KI = Integral gain
KD = Derivative gain

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The primary objective of a PID controller is to maintain the output level so that no difference occurs between the process variable (PV) and the desired the output of the system, known as the set point (SP). In our case, the output being measured is the motor speed. Based on the model shown in Figure-2, the PID input is multiplied with the gains and part of it is sent to the output. Part of the output is then fed back to the system for additional information [28, 29, 30].

3. DC MOTOR OPERATION

3.1 DC Motor Speed Control

Adaptive Control can be used to increase performance and control on a wide range of variable load parameters. This includes tracking of the system. Figures 2 and 3 shows the Voltage vs RPM and Voltage vs Current respectively.

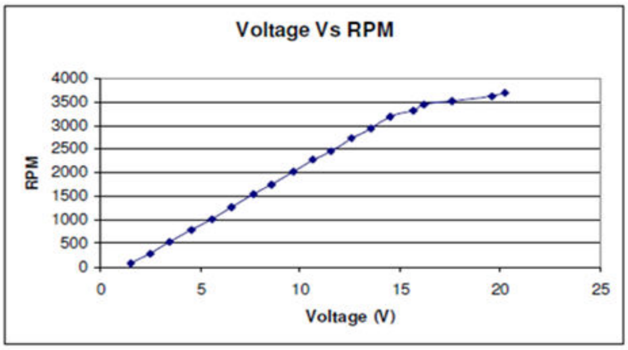

Figure-2. Voltage vs RPM.

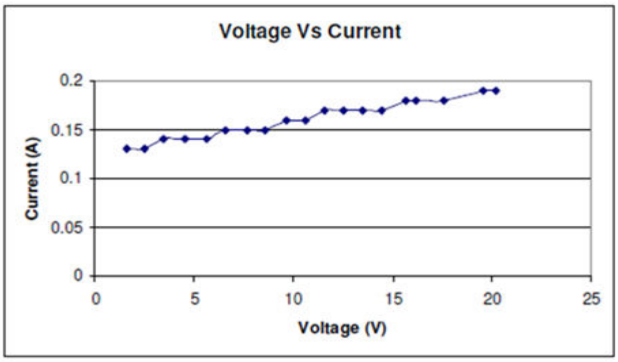

Figure-3. Voltage vs Current.

It is monitored after for the quality of the estimated parameters such as PID optimized using Logic Scoring of Preference (LSP) [31, 32].

3.2 DC Motor Loading

For the reason of torque in the highest zero speed, DC motors are used for systems with stiction. The system depends on the mechanical load drive especially if it can manage to start the load. In designing the system, the start torque must have greater stiction in the system because the dynamic mechanical load has lower stiction.

3.3 Digital Control of DC Motor

Power consumption and system cost can be reduced drastically by controlling analog circuits digitally. PWM has been implemented to control the DC motor. Given a bandwith that is sufficient, any analog value can be encoded with PWM. This can be the source with which controlling the speed of the motor is made possible. The sequences of the pulses determine whether the machine is on or off.

4. ACTUAL RESULTS

4.1 DC Motor Characteristics

The DC motors acquired should be tested for their characteristics to determine their response to obtain the specifications needed for the design of the driver to be used. Relationship between voltage, current and its corresponding rpm is needed to be obtained. Tables 1 and 2 shows the PID gains with corresponding operational behaviour and the tabulated actual output of the system

Table-1. PID gains with corresponding operational behaviour.

KP	KI	KD	Operational Behaviour
0.25000	0.76700	0.33670	Stable
0.32250	0.46132	0.65620	Fluctuating
0.39800	0.17500	0.16350	Oscillating

Table-2. Tabulated actual output of the system.

Motor 1 Actual Output with PID						
Trial#	INPUT	1	2	3	…	15
1	1025	1080	1020	960	…	1020
2	1100	1080	1020	1020	…	1020
3	1175	1140	1140	1200	…	1140
4	1250	1320	1320	1320	…	1320
5	1325	1380	1440	1380	…	1380
6	1400	1380	1500	1440	…	1500
7	1475	1500	1500	1500	…	1440
8	1550	1620	1560	1560	…	1500
9	1625	1500	1680	1500	…	1680
10	1700	1860	1740	1860	…	1740

This gives an insight as to what should be the maximum current to be utilized for the driver. A maximum current rating is also vital for the design of the driver.

4.2 System Identification

To obtain the characteristic and response of the DC motor, a system identification program is needed. It

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was encoded using the MATLAB platform. After simultaneously running the program along with the DC motor, the hypothetical transfer function of the motor was generated. These gains will be used in the speed regulation of the DC motor to show the different operational behaviour namely stable, fluctuating and oscillating operation. This then can be programmed in a Computer System [33].

4.3 Experimental Setup

To determine the viability of the system, different runs have been done to the system with varying speeds while also subjecting it to different loads. Fifteen runs are sampled from forty assigned speeds for the 1st Motor while the 2nd Motor is sampled from thirty-five assigned speeds. Following the manual provided by the group, the testing starts with the user entering first the desired or target speed followed by the different values of PID gains [34, 35]. The motor is expected to respond according to the operational behaviour indicated by the combination of gains. Preliminary setup was done with the tray having noload to verify the system's ability in adjusting towards the user's desired speed with Rough Set Optimization [36]. After which, six different loads are then applied to determine its responsiveness. Figures 4, 5 and 6 shows the stable, fluctuating and oscillation operation of the system [37].

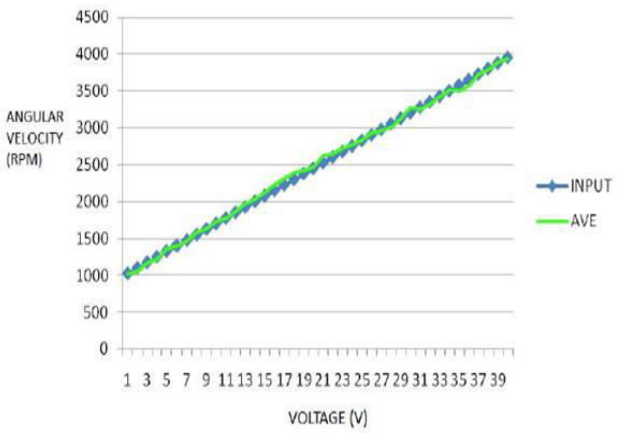

Figure-4. Stable operation of the system.

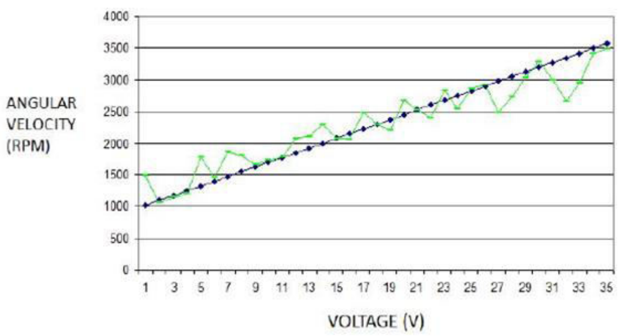

Figure-5. Fluctuating operation of the system.

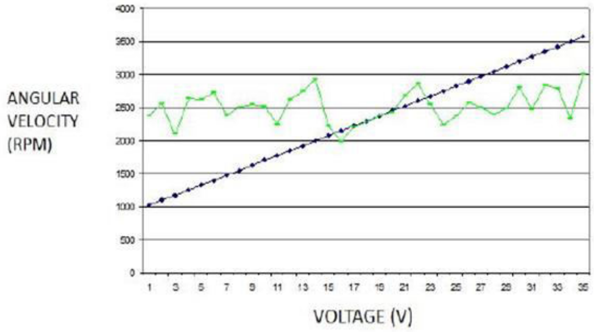

Figure-6. Oscillation operation of the system.

4.4 Input Angular Velocity vs. Actual Angular Velocity (RPM)

The research group tabulated the Actual RPM measurement of the system concerning its corresponding input RPM. The LCD integrated into the system shows both the input RPM and the Actual RPM. The system is tested for its performance during noload status, with 2.5 lbs, 3.25 lbs, 3.75 lbs, 4.2 lbs, 5 lbs, and 5.75 lbs load for both motors. The group conducted15 trials for each input RPM.

5. CONCLUSIONS

The research group has been able to design and implement a microcontroller based PID controller for low power DC motors. It has been verified experimentally from the actual data analysis presented that the PID controller is working within 90%performance evaluation. The basis for the determination of the efficiency was derived from the tabulated actual angular velocity, wherein the system underwent testing at no load status as well as subject with 6 different loads using 2.5 lbs, 3.25 lbs, 3.75 lbs, 4.2 lbs, 5 lbs, and5.75 lbs. Also, it was determined that the PID system was independent of the motor and the load subjected toit. The system responded satisfactorily with variations present in these factors.

Future researchers on the PID controllers could explore more on the system by using high power DC motors that were not entailed during the study. This could also broaden the scope of application for PID systems. Utilizing other affordable microcontrollers such as Motorola 683xx series could be used as the core of the system. The design of modules can also vary depending on the purpose. PID systems are applicable to most closed-loop systems and are not limited to DC motor speed regulation only. Constructing gear trains for modules can also help students determine the response of the system affected by transmission of power and other loading mechanisms.

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