

Remote PID Control of a DC Motor

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Abstract—This paper presents a remote experiment for controlling a DC motor. This work was part of a final year graduation project of the Industrial Electronics Course at the University of Minho. It was implemented by an undergraduate student for students use. The experiment is controlled using a PID algorithm programmed in LabView environment. The remote user can test PID digital algorithms and parameters, change reference velocity values and register the motor output velocity profile.

Index Terms— Remote control, PID control, LabView.

I. INTRODUCTION

Most of the industrial control requirements are still met by proportional-integral-derivative (PID) type controllers [1]. Richalet [2] argued that an impressive majority of control problems can be solved by using simple and factual PI (proportional-integral) controllers. Model based predictive control methods seem to meet all the conditions to become standards, because they combine superior performance with reasonably accessible concepts to non-experts. But the simple to understand, simple to operate and reasonably efficient as well as user-friendly, PID will stay operational for many years.

Therefore, the PID control teaching at undergraduate level is of utmost importance. Computer-aided or web-aided teaching of process control is the answer for teaching continuous and digital control problems in an active learning. Over the years, engineering students are partially supporting their knowledge increase and improvement, in specific fields, based on available websites information.

A remote controlled DC-motor was developed for undergraduate control studies, allowing PID algorithm testing. This system is intended to be a supplemental to the traditional class teaching, where students can remotely observe how a PID controller works on a DC motor. The controller was implemented in a microcontroller from Microchip, PIC16F876. The user interface was developed in a LabView environment and linked to the hardware by the RS-232 serial port. Twelve motor velocity reference values were established (from 7m/min up to 335m/min).

II. PID ALGORITHM

A diagram block of the PID algorithm is showed in figure 1. The controller has a subtractive block that calculates the error (difference between reference signal and the measured value), an integral block, that calculates the integral of the error, a differential block (responsible

for the determination of error derivative), a sum and a gain block [3-5].

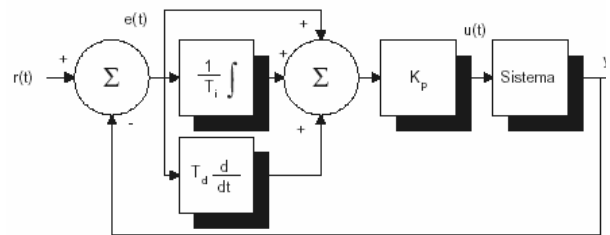


Figure 1. Diagram block for the PID controller

The continuous control signal, $u(t)$, is defined as a function of the error, $e(t)$, by equation 1.

$$u(t) = Kp \left(e(t) + \frac{1}{Ti} \int e(t)dt + Td \frac{de(t)}{dt} \right) \quad (1)$$

Where Kp is the proportional constant
 Ti is the integral time constant
 Td is the derivative time constant.

Four different digital versions of PID algorithm are available:

Control Algorithm 1 (position form):

$$u(k) = Kp \times e(k) + Ki \times e(k) + i(k-1) + Kd \times (e(k) - e(k-1)) \quad (2)$$

Where ΔT is the sampling period
 $i(k-1)$ is the k-1 sum integral

$$Ki = \frac{Kp \times \Delta t}{Ti} \quad \text{and} \quad Kd = \frac{Kp \times Td}{\Delta t}$$

Control Algorithm 2 (modified position form):

$$u(k) = Kp \times e(k) + Ki \times \sum_{i=0}^k \left[\frac{e(i) - e(i-1)}{2} \right] + Kd \times (e(k) - e(k-1)) \quad (3)$$

Control Algorithm 3 (modified position form):

$$u(k) = Kp \times e(k) + Ki \times \left(\sum j \right) + Kd \times (e(k) - e(k-1)) \quad (4)$$

Where j , is an unit value that is incremented, in the case of a positive error, or decremented, if the error is negative.

Control Algorithm 4 (velocity form):

$$u_{(k)} = u_{(k-1)} + Kp \times (e_{(k)} - e_{(k-1)}) + Ki \times e_{(k)} + Kd \times (e_{(k)} - 2 \times e_{(k-1)} + e_{(k-2)}) \quad (5)$$

III. EXPERIMENTAL RIG

Figure 2 presents a schematic view of the developed system. A DC Motor from “Maxon RE36” (working at 24V_{DC}) is mounted with an encoder “HEDS-5540 A11”. The microcontroller PIC16F876 is used to directly control the motor. The control board is linked to the local personal computer by a serial RS-232 communication link for monitoring.

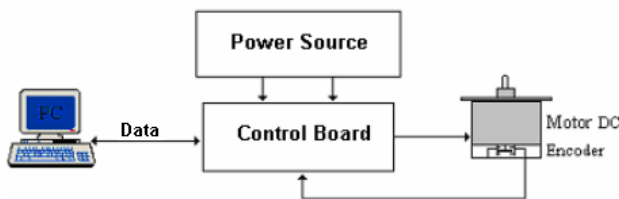


Figure 2. Developed system

The PID algorithms were programmed in “Assembly” language. The quartz crystal used works at 20 MHz which, considering the microcontroller characteristics, taking into account an instruction time cycle of 0.2µs.

The defined PWM frequency is 50 KHz, but the user can change it. It must be pointed out that a high commutation frequency can damage the semiconductor employed as its temperature starts to rise.

The user interface was developed in a LabView environment. Twelve motor velocity reference values can be selected (7m/min, 12m/min, 22m/min, 46m/min, 65m/min, 85m/min, 128m/min, 166m/min, 210m/min, 253m/m, 292m/min e 335m/min). To establish these velocity levels, it was necessary to take into account the cylinder diameter, coupled to the motor main shaft. In this case, the diameter is 3,09 cm. The sampling period used is 2 ms.

The user has to select the PID algorithm to be tested as well as the controller parameters, Kp, Ki e Kd, the proportional, integral and derivatives constants, respectively. In order to prevent controller saturation, proportional and integral terms are limited to maximum and minimum values. The actual motor velocity and the error signal are graphically represented in the developed LabView interface.

The serial communication is defined with a “Baude Rate” of 9600 bits/s, 8 data bits, even parity and one “Stop Bit”.

Figure 3 presents the designed LabView user interface.

IV. ACCESSING REMOTE CONTROL

A webpage is being created in LabView environment for remotely controlling the motor. An automatic waiting queue is managed by LabView, allowing a single control user.

All the facilities available in local control are accessible through the remote interface, namely, choosing

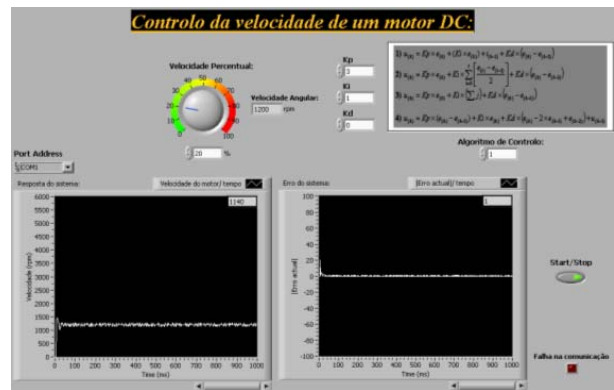


Figure 3. System developed

the PID digital algorithm, varying controller gains and altering the velocity reference value.

This functionality will enable students to test with real experiments the performance of PID controllers when and where they please.

V. CONCLUSIONS

The system was a final year graduation project, developed by a student of the Industrial Electronics Engineering course of University of Minho. During the project implementation, the student built the system, programmed the digital forms of PID controller in the microcontroller PIC16F876, used the RS232 communication protocol, and finally, designed a LabView application interface.

The system is available with either local or remote control configurations for teaching/learning purposes.

With this system students can physically test PID algorithms, in particular proportional, integral and derivative gains influence on the controller performance.

In the near future a DC-motor simulator will be running in parallel to the real experiment. This last functionality will serve to compare the performance of PID controllers in real world environments as well as in simulation ones, enabling testing the mathematical model of the DC-motor.

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