

Real-time Monitoring System Using LabView for DC Motor Position Control Embedded System with PID and Pole Placement Control

Devi Handaya¹ Resti Fauziah², Tri Listyorini³
{devi.handaya@poltek-gt.ac.id¹, resti.fauziah@gmail.com², trilistyorini@umk.ac.id³}

Electronics Engineering, Politeknik Gajah Tunggal, Tangerang, Indonesia¹, School of Electrical Engineering and Informatics, Bandung Institute of Technology, Indonesia², Department of Informatics Engineering, Univeritas Muria Kudus, Indonesia³

Abstract. This study builds a real-time monitoring system for positioning DC motors using LabView. Control parameters are obtained from DC motor modeling using Matlab Toolbox Identification. The DC motor rotation position control method chosen in this research is PID and Pole Placement-Full Order State Feedback. The experiments were performed by testing the tracking results on each of the controls and real time monitoring on LabView. Data acquisition and computer systems, utilizing LabView's VISA protocol based on Arduino Mega embedded system with data logger. Based on the experiments, LabView can be used as a real-time monitoring system in controlling the rotation of DC motor position using PID and Pole Placement.

Keywords: labview monitoring system, DC motor position control, PID, pole placement.

1 Introduction

The DC motor is a highly controlled actuator in the industry because it has good functionality, one of which is the ease of linear control [1]. In addition to speed control, DC motors can also be used as object position control. In position control, usually the DC motor used servo motor type. This time, researchers used a DC motor in general to control the rotation position. This is done so that a general DC motor, in addition to being used for speed control, can also be used as a spin position controller. In addition, DC motors are usually also cheaper than servo motors.

In the previous studies, DC motors have been performed for speed linear systems using PID [2], and position control [3]. The Pole Placement-Full order state observer controller has also been implemented on DC motors [4], [5]. Data control results need to be displayed on a system in real-time. This is so that the results of control can be proven significantly. LabView is a software that can be used to analyze and display the results of DC motor control with PID control [6], [7] and Fuzzy Logic Control [8]. In this design, the researcher will control the rotation position of the DC motor for then the data captured by the position sensor will be displayed in real-time on LabView monitoring system.

2 Research Method and Design of LabView Monitoring System

2.1 Research Method

The research was carried out by making a monitoring system design in LabView and a control system for DC motors. The LabView design is a block diagram and front panel (display), while the control system is modelling and controllers for DC motors. Controllers on embedded systems using Arduino Mega with a 10 bytes so that digital data can be more accurate. The results of the control are observed in real time through LabView which is obtained from the reading of the position sensor. The sensor used is potentiometer with the number of round readings that can reach 10 rounds. The potentiometer is coupled with a DC motor so that each round will be connected. Observed data in the form of DC motor ability to track according to reference such as peak time, overshoot, settling time, and Error Steady State (Ess).

2.2 LabView Design for Monitoring System

The form of block diagram in the monitoring system used in this study has several advantages, such as the case structure to determine the choice of control methods. The received data can be stored with the save directory file block. Utilizes LabView's VISA protocol as a link to data acquisition and computer systems.

The design of monitoring system used in this research can be seen in Fig. 1. Features that appear in the form of determination and reading set point and control mode (Send and Read Set Point / Control Mode), graphical display of real data and position references. Here are the design results.

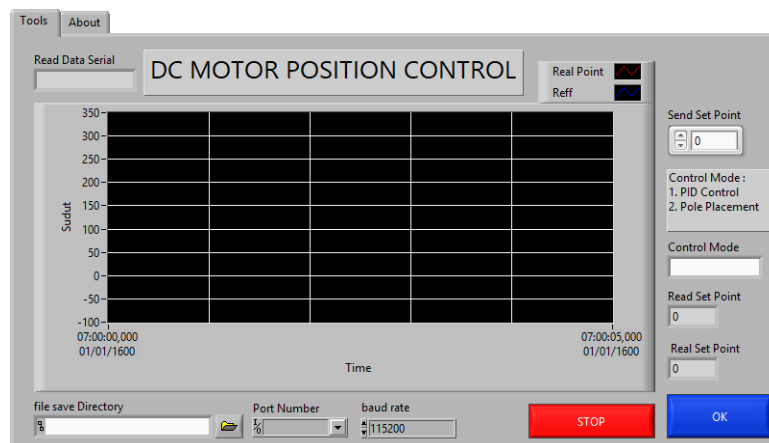


Fig. 1. Design of front panel for DC motor position control.

3 Modelling and Controlling for DC Motor Position Control

3.1 Determination of DC motor transfer function

Modelling a DC motor to get the transfer function using Matlab Toolbox System Identification. The DC motor rotation results are observed by potentiometer. The Best Fits results are assumed as DC motor overtones with the following results.

Table 1. Test results for the determination of the transfer function.

Gain	Set Point	Best Fits
10	10	1.78%
10	15	80.63%
15	10	89.05%
15	15	92.12%

The test result with Best Fits 92.12%, then got the transfer function as follows.

$$G(s) = \frac{83.54}{s^2 + 13.81s + 83.54} \quad (1)$$

3.2 Determination of PID control parameters

The PID tuning method usually use Ziegler Nichols [7], [9], but in this study using Root Locus, because the others method does not meet the criteria. Root Locus is an analysis that describes shift of the closed loop poles position from change in the magnitude of open loop with gain adjustment [10]. Based on the transfer function, then root locus results as follows.

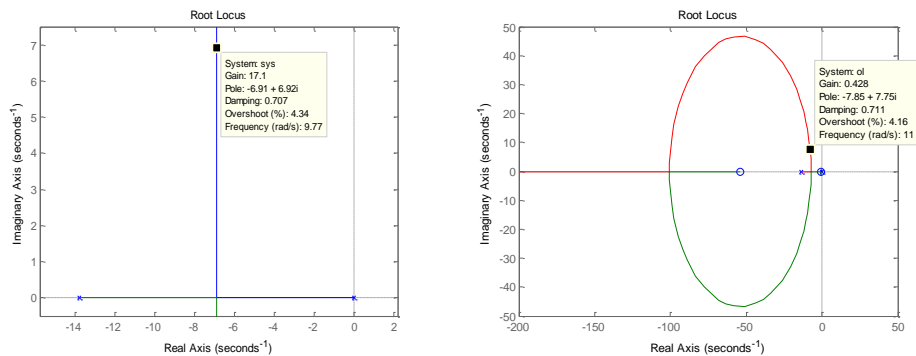


Fig. 2. (a) The result of mapping the root locus graph in a closed loop system, (b) The result of mapping the root locus graph corresponds to the desired pole.

Based on the mapping in Fig. 2., found the desired pole is $-7.85 \pm 7.85i$ and the gain of root locus plotting is 0.428. Result of the desired pole, then it can be determine the parameter of PID using the following equation [10].

$$G_c(s) = \frac{K_d s^2 + K_p s + K_i}{s} = K_d s + K_p + \frac{K_i}{s} \quad (2)$$

Based on the equation, the results obtained K_p is 23.617, K_i is 11.6999, and K_d is 0.4343.

3.3 Determination of Pole Placement control parameters with Full Order State Feedback

The determination of “K” to get result for the desired rotation position of DC motor. The application of Pole Placement design can follow the following block diagram [11].

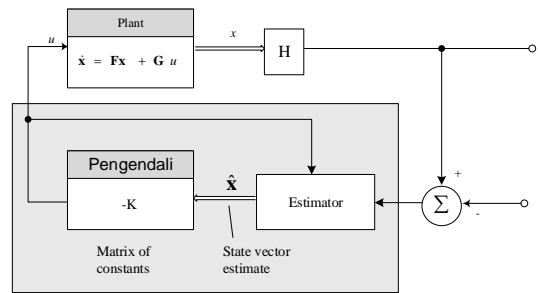


Fig. 3. The block diagram of pole placement with full order state feedback.

To be able to control the plant, it is necessary to strengthen (K) [5] and estimator (L) [11], [12]. The determination of such reinforcement may use the Ackerman Formula as follows.

$$K = [0 \ 0 \ \dots \ 1] \psi^{-1} \alpha_c (F) \quad (3)$$

$$L = \alpha_c (F) \varphi^{-1} [0; 0; \dots \ 1] \quad (4)$$

In the pole placement control form, the transfer function is converted to the status space first, so the form becomes the following.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -13.81 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 5.57 \end{bmatrix} u, y = [1 \ 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad (5)$$

Using the design principles according to Fig 3. and equation (3) and (4), we obtain the gain matrix $K = [22.1266 \ 0.3393]$ and $L = [111.8; 6434.9]$. With the resultant reinforcement, the transfer function of the plant can be given in the following equation.

$$D(s) = -K * [SI - A + BK + LC] * L \quad (6)$$

3.4 Flowchart of Embedded System for DC motor control

The test on a DC motor with the monitoring system according to the following flowchart in Fig. 4.

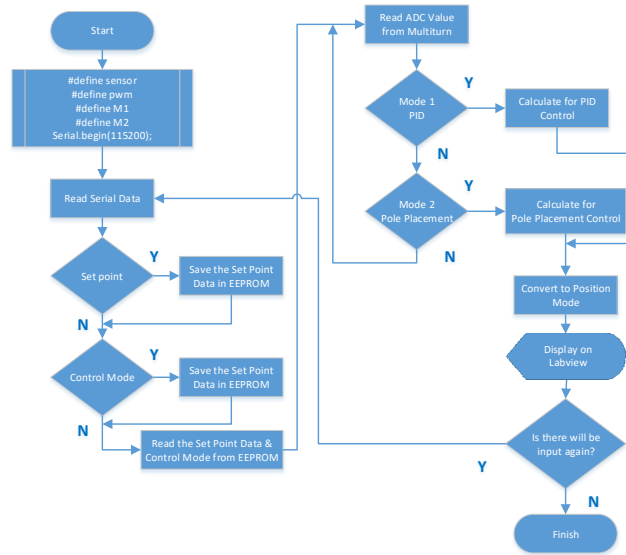


Fig. 4. Flowchart program of embedded system for DC motor control.

4 Result and Discussion

In this test, the researchers conducted tests that were implemented using embedded systems on Arduino and displayed the results on LabView.

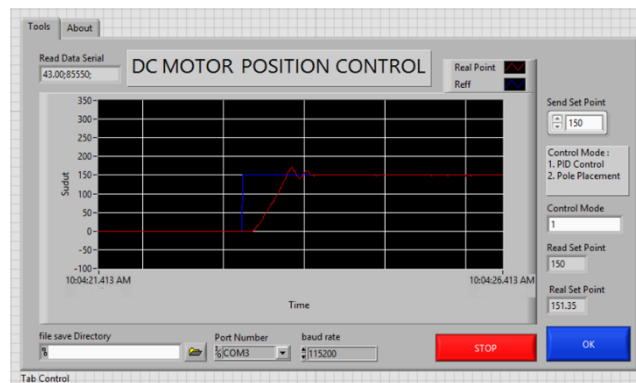


Fig. 5. Display of LabView monitoring system for DC motor position control.

4.1 Tracking test of the DC motor position control with PID Controller

In the PID test, according to the algorithm in Fig. 4, tested on different zero influences with set point is 150°. Then got the results of testing implementation on DC motor in Fig.6.

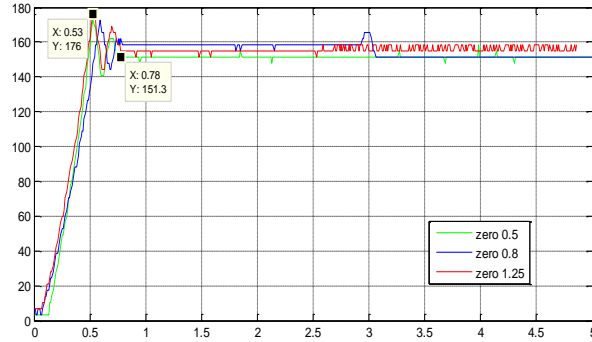


Fig. 6. The block diagram of pole placement with full order state feedback.

Table 2. Result of DC motor position control with PID.

Zero	Peak Time (s)	overshoot (%)	Settling Time (s)	Ess (°)
0.5	0.53	15	0.75	1.3
0.8	0.58	17	3.1	1.3
1.25	0.53	17	0.78	3

Based on test results, it turns out with a zero value of 0.5, resulting in the best performance have the fastest peak time and settling time. But if reviewed in Error Steady State (Ess), still has an error of 1.3°. In fact, if based on Matlab simulation, the zero value has Ess is 0°.

4.2 Tracking test of the DC motor position control with Pole Placement

In the pole placement control test, given set point is 150°. Reinforcement values are modified to get the results closest to the set point. Here are the results of test.

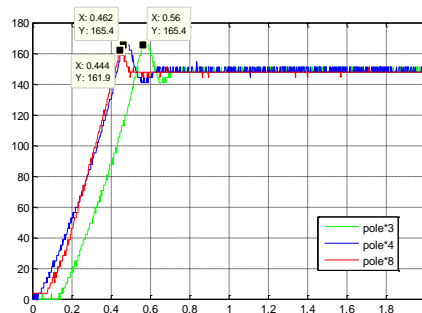


Fig. 7. Graph of pole placement test result on DC motor.

Table 3. Result of DC motor position control with Pole Placement.

Gain Value (times)	Peak Time (s)	overshoot (%)	Settling Time (s)	Ess (°)
3	0.6	10	0.7	1.3
4	0.5	10	0.6	1.3
8	0.4	7.9	0.5	2

Based on the results, it turns out on the strengthening of 8 times has the largest Ess, which is 2°. But if you look at the overshoot value, the gain of 8 times has the smallest value. In addition, the fastest peak time and settling time remain at the strengthening of 8 times.

5 Conclusion

The embedded system on DC motor rotation position control was successfully implemented in conjunction with LabView as a real-time monitoring. PID control has not been able to control overshoot with almost twice as much as Pole Placement. Whereas in this condition, Pole Placement get peak time and settling time faster. This is because PID control still performs calculations, especially on the sum of the error received from the potentiometer analog signal. The controller's imperfection to do tracking with Error Steady State of 0° can be caused due to multiturn sensor that has nonlinearity condition. If the control object does not require a high degree of precision, then multiturn is still considered capable as an alternative feedback control sensor in controlling the position of DC motor rotation.

References

- [1] J. B. Wang, *Control of Electric Machinery*. Taiwan: Gau Lih Book co., Ltd., 2001.
- [2] K. K. Tan and S. Zhao, "Precision Motion Control with A High Gain Disturbance Compensator for Linear Motors," *ISA Trans.*, vol. 43, no. 3, pp. 399–412, 2004.
- [3] D. Rawat, "LQR and PID Design Technique for an Electric Furnace Temperature Control System," in *Intl. Conf. on Intelligent Comm, Control and Devices*, 2017, vol. 479, pp. 561–567.
- [4] T. M. Rao, "Effect Of Pole Placement Of A Full Order State Observer In Sensorless Speed Estimation Of Brushed DC Motor," in *Power India International Conference 7th*, pp. 1–6.
- [5] I. Siradjuddin, "Stabilising A Cart Inverted Pendulum System Using Pole Placement Control Method," in *15th Intl. Symposium on Electrical and Computer Eng.*, 2017, pp. 197–203.
- [6] J. Liu, "Real-Time DC Servo Motor Position Control by PID Controller Using Labview," in *Intl. Conf. on Intelligent Human-Machine Syst. and Cybernetics*, 2009, vol. 2, pp. 206–209.
- [7] G. Gasparec, "PID Control of a DC Motor Using Labview Interface for Embedded Platforms," in *In Electronics and Telecommunications 2016*, 12th, 2016, pp. 145–148.
- [8] D. Handaya and Y. P. Nugraha, "Simulasi Mesin Cuci Industri Tekstil Berbasis Kendali Fuzzy dan Interface LabVIEW 2014," in *Simposium Nasional Inovasi dan Pembelajaran Sains 2016 Nasional Inovasi dan Pemb. Sains 2016*, 2017, pp. 177–183.
- [9] G. Rao, "Study on PID Controller Design and Performance Based on Tuning Techniques," in *Intl. Conf. on Control, Instrumentation, Comm. and Comp. Tech.*, 2014, pp. 1411–1417.
- [10] Q. G. Wang, T. H. Lee, H. W. Fung, Q. Bi, and Y. Zhang, "PID Tuning for Improved Performance," *IEEE Trans. Control Syst. Technol.*, vol. 7, no. 4, pp. 457–465, 1999.
- [11] G. F. Franklin, *Feedback Control of Dynamic Systems*. Pearson, 2010.
- [12] K. Ogata, *Modern control engineering*, 5th ed., vol. 17, no. 3. Prentice Hall, 2010.