MOTOR CONTROL SYSTEM DEVELOPMENT USING MICROCONTROLLER BASED ON PID CONTROLLER

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In the name of Allah, the most graceful and most merciful

Special dedication to

My beloved husband

Mohd Nor Yusri B. Zakaria

My beloved parents

Abdul Wahab B. Abu Bakar

Raimah Bt. Abd. Rahman

My beloved siblings

Mohammad Waffa B. Abdul Wahab

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Mohd Nur Farhan B. Abdul Wahab

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My dearest friends

To all my friends

Thank you for giving me all the support

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ABSTRACT

PID controllers which are one of the algorithms that can adjust the input values based on historical data and the emergence rate of differences, in order to make the system more accurate and stable. This project is focused mainly on designing and implementing PID controller for a Dc servo motor. The PID controller are used to control position of the Dc servo motor, while the speed motor are control by manually run with a specified performance requirement. PID controller are designed based on MATLAB/Simulink software to obtain the optimum position control of PID controller parameters and realized by using microcontroller to the real Dc servo motor. All codes in microcontroller are developed on MPLAB X IDE software program for embedded system.

ABSTRAK

Pengawal PID yang merupakan salah satu algoritma yang boleh menyesuaikan nilai-nilai input berdasarkan data sejarah dan kadar pengeluaran di perbezaan, untuk membuat sistem yang lebih tepat dan stabil. Projek ini menumpukan kepada bentuk dan melaksanakan pengawal PID untuk Dc servo motor. Pengawal PID digunakan untuk mengawal kedudukan Dc servo motor, semasa motor kelajuan adalah kawalan secara manual dengan keperluan prestasi yang ditetapkan. PID pengawal direka berdasarkan perisian MATLAB / Simulink untuk mendapatkan kawalan kedudukan optimum parameter pengawal PID dan menggunakan mikro pengawal sebenar Dc servo motor. Semua kod dalam mikropengawal dibangunkan dengan menggunakan program perisian MPLAB X IDE untuk sistem terbenam.

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LIST OF SYMBOLS

Symbol	Description
PID	Proportional Integral Derivative Controller
Dc	Direct Current
R_a	Armature resistance
La	Armature inductance
$V_a(t)$	Armature input voltage
$I_a(t)$	Armature current
ωm(t)	Motor Angular Velocity
θm(t)	Motor Angular Displacement
e_b (t)	Back emf
T(t)	Motor torque
J_m	Motor of inertia of motor + load
B	Viscous frictional constant of motor + load
K_T	Torque constant
K_B	Voltage constant
K_p	Proportional gain

K_i	Integral gain
K_d	Derivative gain
T_p	Peak time
T_r	Rise time
T_s	Settling time
Os%	Percentage of overshoot
e_{ss}	Steady state error
PS1	Projek Sarjana 1
PS2	Projek Sarjana 2

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CHAPTER 1

INTRODUCTION

This chapter introduces the project that has been carried out. The important overview or description including the problem statement, project objectives, project scopes and expected result are also emphasized in this chapter.

1.1 Introduction

Nowadays, several control system algorithm have been applied in control system engineering including position controls. Position control for digital servo motor exists in a great variety of automatic processes. However, the system does contain nonlinearities which have an obstructive influence on system response, such as the load effect[1].

From a practical point of view, complete information about uncertainties is difficult to acquire in advance. To deal with these uncertainties, much research has been carried out in recent years to apply various approaches in the position control [2]. When uncertainties occur, the fuzzy control method is used instead of the PID control method [3].

As a very good method, a fuzzy controller method can convert expert knowledge into regulations of control system, and the regulations can be used to determine the output value by logical inference. So it also does not need precision system model and has high robust ability. In recent years, fuzzy controllers have been widely developed, and a variety of methods have been proposed to improve the performance of fuzzy controller [4]-[6].

In this project, digital servo motor control is used to investigate the feedback control systems. This system has facilitated us to investigate different kind of control techniques and implement simple Proportional-Integral-Derivative (PID) controller with the aid of MATLAB/ Simulink which are performed by controlling the states of the system, which might be position.

1.2 Problem Statement

In industries, there are some of control techniques that can be applied to solve the problems such as DC motor speed, water tank and others. In designing a control system, factors such as the nonlinearity systems, time response, cost and reliability have to be taken into account.

Many controller have been proposed to control digital servo motors including Optimal Control, Sliding Mode Control, Adaptive Control, Neural Network, Fuzzy Logic etc., however, these controllers are complex hence difficult to implement.

On the other hand, proportional derivative integral (PID) controller is widely used in feedback control of industrial processes and is simple in both structure and principles.

In this project, the PID controller will be implemented to control the position of a digital servo motor. The advantage of use the PID controller is to obtain the output that follows the input in a short time, with minimal overshoot, and while little error.

1.3 Objectives

The main objectives of the project are:

1) To investigate the application of PID controller in digital servo motor control.
2) To design the PID controller in order to control the position of a digital servo motor.
3) To analyze the performance of the designed PID controller in terms of settling time, rise time and overshoot percentage.

1.4 Project Scope

The scopes of this project are:
1) Find the mathematical model of the digital servo motor.
2) Design and simulate the PID controller using Matlab software.
3) Implement the designed PID controller on the digital servo motor controlled by using PIC as a microcontroller.

1.5 Thesis Structure

This report consists of five main chapters. The contents of each chapter are explained as the state below.

Chapter 1 introduces the project and its objectives. It also states the problem statement of the project, project scopes as well as the thesis structure.

In Chapter 2, the theory and literature study about the DC motor system is explored and discussed. They serve as the foundation to execute the project. Besides that, several control approaches such as PID controller, as the proposed controller, are also discussed. Lastly, the components that are used in this project and previous study related to this project are also introduced.

In Chapter 3, the mathematical modeling of DC motor is discussed. It can be represented in state space equation and transfer function. The principle and physical criteria has also been studied in detail. The design requirement of the Dc motor system is set to design the controller. The PID controller used to control the speed and position of Dc motor system is also explained in this chapter.

Chapter 4 shows and discusses the result of the speed control Dc motor system using PID controller.

Chapter 5 concludes and discusses the project finding. A few commendations is also included for the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses about the DC motor, PID controller as well as the microcontroller used to realize designed controller. It also highlights some previous case studies that are related to this project from reference books, thesis, conference papers and journal.

2.2 Dc Servo Motor

Dc motor has good speed control response and wide speed control range. It is widely used in industries whose systems need high control requirements, such as rolling mill, double-hulled tanker, high precision digital tools and etc [8]. Basically, the hardware of this digital servo motor system consists of DC brush-type servo motor, motor shaft encoder and rail encoder, platform, belt drives and pulleys for moving the platform, flywheel, and friction break [10].

Dc servo motor consists of magnetic field and electrical field that interact with each other to produce a mechanical force. To correct the performance of a mechanism, error sensing feedback was used as an automatic device. The main purpose of feedback signal is to control mechanical position and speed or other parameters.

The Dc servo motor, as shown in Figure 2.1, is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. An error signal is generated if the output position differs from that required. It causes the motor to rotate in either direction and needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

Figure 2.1: Digital DC Servomotor

2.3 PID Controller

In recent years, new modern methods of control have been used, such as fuzzy control, neural networks and neuro-fuzzy controllers among others. However, about over 90% of control loops still use industrial PID controllers [9]. But it is known that the majority of these loops operate poorly tuned, creating additional costs that could be minimized. This justifies the importance of the tune of controllers[9].

2.3.1 Introduction to PID Controller

The PID controller combines the proportional, integral and derivative components obtaining the classical equation which can be seen below:

$$u(t) = K_p + \left[e(t) + \frac{1}{T_i} \int e(t)\, dt + T_d \frac{de(t)}{dt} \right]$$

where K_p is the proportional gain, T_i is the integration time constant, T_d is the derivation time constant, $e(t)$ is the controller input and $u(t)$ is the controller output. Figure 2.2 shows the block diagram that represent PID controller.

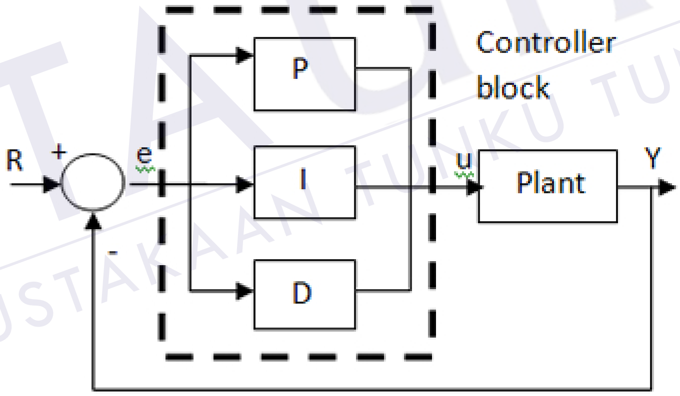

Figure 2.2 : Block diagram of PID controller

2.3.2 Proportional Action, K_p

The proportional term produces an output value that is proportional to the current error value. The proportional response can be represents as per equation below:

$$P_{out} = K_p . e(t)$$

where

P_{out}: Proportional term of output

K_p: Proportional gain, a tuning parameter

e: Error = SP − PV

t: Time or instantaneous time (the present)

2.3.3 Integral Action, K_i

The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. Summing the instantaneous error over time (integrating the error) gives the accumulated offset that should have been corrected previously. The accumulated error is then multiplied by the integral gain and added to the controller output[9]. The magnitude of the contribution of the integral term to the overall control action is determined by the integral gain, K_i. The integral term is given by:

$$I_{out} = K_i \int e(\tau)\, d\tau$$

where

I_{out} : Integral term of output

K_i: Integral gain, a tuning parameter

e: Error = SP − PV

τ: Time in the past contributing to the integral response

2.3.4 Derivative Action, K_d

The rate of change of the error is calculated with respect to time, multiplied by another constant D, and added to the output. The derivative term is used to determine a controller's response to a change or disturbance of the process. The derivative term is given by:

$$D_{out} = K_d \frac{d}{dt} e(t)$$

where

D_{out}: Derivative term of output

K_d: Derivative gain, a tuning parameter

e: Error = SP − PV

t: Time or instantaneous time (the present)

2.4 Hardware Description

This section discusses the hardware used in this project such as PIC18F46K22 microcontroller, motor driver (MD10C), Dc motor (ID23005) and encoder.

2.4.1 Microcontroller (PIC18F46K22)

In this project, PIC18F46K22 microcontroller, as shown in Figure 2.3, was used as the microcontroller. PIC18F46K22 can be easily programmed using MPLAB software. MPLAB also serves as a single, unified graphical user interface for

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