SPEED CONTROL OF DC MOTOR USING PID CONTROLLER
IMPLEMENTATION WITH VISUAL BASIC

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Date   : <u>10 NOVEMBER 2008</u>

Specially dedicated to

My beloved parents, brothers and sister.

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

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ABSTRACT

The project focused on speed control of DC motor. The main objective is to design and develop GUI software for speed control experiment, where PID controllers' design approaches has been applied. The controllers have been designed and the system is simulated using MATLAB to analyze their initial performance. The computer is connected to DC Motor via data acquisition card (DAQ Card) and Visual Basic is used to conduct the experiment. Field-testing is implemented to compare the results between the original and modified system with the PID controller. Finally, the performance of the system is analyzed and validation is done in terms of time response, robustness and percentage of error.

ABSTRAK

Projek ini memfokuskan kepada sistem kawalan halaju bagi motor arus terus. Objektif utama projek ini adalah untuk merekabentuk dan membangunkan perisian interaktif komputer untuk ujikaji sistem kawalan halaju, di mana teknik Kawalan PID diaplikasikan bagi rekabentuk sistem kawalan untuk motor tersebut. Sistem kawalan telah direkabentuk dan simulasi bagi sistem dilakukan untuk menilai prestasi asal dengan menggunakan perisian MATLAB. Komputer telah disambungkan kepada motor arus terus menerusi kad DAQ dan perisian Visual Basic telah digunakan untuk menjalankan eksperimen. Ujian terhadap sistem dijalankan untuk tujuan perbandingan di antara sistem asal dengan sistem yang telah diubahsuai. Prestasi sistem dianalisa dan pengesahan telah dibuat dari aspek tindakbalas masa, ketegapannya dan peratus sisihan dengan nilai yang dikehendaki.

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LIST OF ABBREVIATIONS

K_{cr}	-	Critical Gain
$K_d.$	-	Derivative controller
$K_i.$	-	Integral controller
$K_p.$	-	Proportional controller
P_{cr}	-	Critical Period
CV	-	Control Variable
D	-	Derivative
DAQ	-	Data Acquisition Card
I	-	Integral
P	-	Proportional
PD	-	Proportional-Derivative
PI	-	Proportional Integral
PID	-	Proportional Integral Derivative
PV	-	Process Variable
SP	-	Set Point
VB	-	Visual Basic

CHAPTER 1

INTRODUCTION

1.1 Background

This chapter explains the overview of this project which includes all three essential components in this project which is motor speed control, Proportional Integral Derivative (PID) controller and Visual Basic. This chapter also explains the objectives and the scopes of this project.

1.2 Project Overview

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 [1]. DC motor has a good speed control respondence, 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 [4].

There are two major parts of this system:
  i.   Hardware Interfacing
               - connecting the computer to external equipment.
  ii.   Software Design

- programming the computer to carry out its control calculation (control laws) while interacting with external components. Visual Basic will be used to program the DAQ card since this program is easy to learn its code programming and user friendly.

Figure 1.1: Equipment Setup

Figure 1.1 show the equipment setup for this s project. The system (plant) under control is a continuous-time system. The 'heart' of the controller is a digital computer. The problem of realizing this system is mainly one of developing computer program. Figure 1.2 show the basic feedback system block diagram and figure 1.3 show the block diagram of the project.

Input   Output
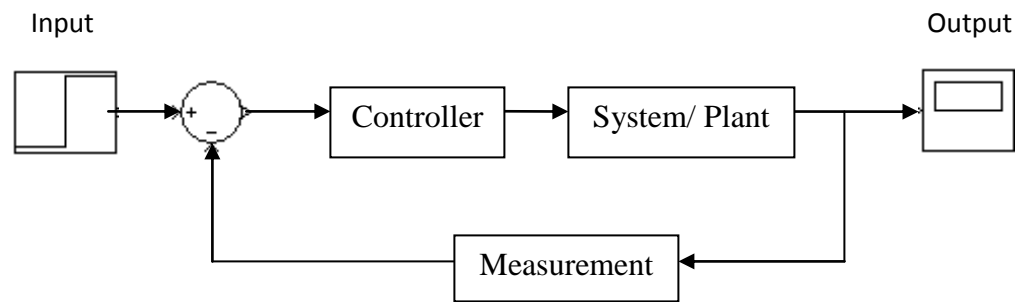
Figure 1.2: Basic feedback system block diagram

Input   Output
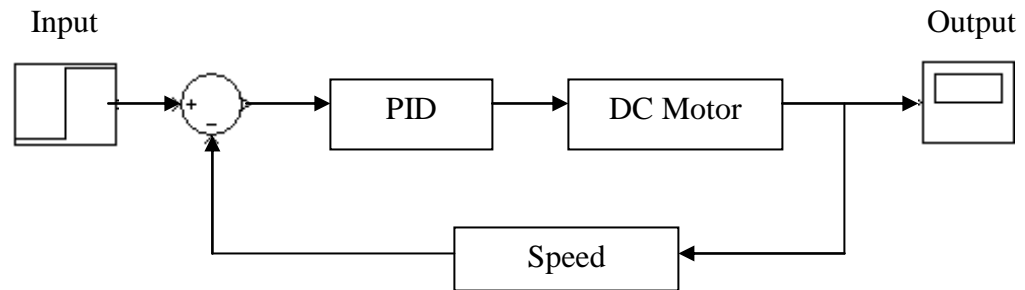
Figure 1.3: Block diagram of the project

The PID controller can be reduced the rise time since the proportional controller has effect on this. It can also eliminate the steady-state error by using the integral controller and lastly it can increase the stability of the system by using the derivative control. Many engineers are familiar with PID, and its use has become standard practice [2]. The algorithm from the PID will be implementing to the Visual Basic and together it can produce a better performance for the speed control of DC motor.

1.3 Problem Statement

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 [3]. This is because the three terms are reasonable intuitive, allowing non-specialist of the controller action. PID also is found in essentially all undergraduate control courses. The PID framework solves many control problems and is sufficiently flexible to incorporate additional capabilities [3].

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.

1.4 Objectives

The objectives of this project are as follows:
  i.   To develop the PID controller to control the speed of DC motor
 ii.   To analyze the performance of the proposed controller
iii.   To implement the controller using Visual Basic.

1.5 Scopes of Project

This project is to design a PID controller that can be use to control the speed of a DC motor. As a machine's performance is a vital factor for a big production line, this project will examine the efficiency and performance of a DC motor with implementation of control methodology. Thus, the focuses of this project are as stated below:

    i.   Perform simulation by using MATLAB

   ii.   Compare the performance of propose PID and uncontrolled system

  iii.   Implementing the proposed PID controller in the Visual Basic

  iv.   Designing the programming structure for controller via Visual Basic

   v.   Using Data Acquisition Card to interface between the computer and DC motor

1.6 Thesis Outline

Chapter 1

Explain the background of the project with problem statements, objective and also the scopes. Motor speed control, PID controller and Visual Basic are the main essential in this project.

Chapter 2

Focus on the literature review for those three parts that has been explained in Chapter 1. All the journals and books that have some attachment to this project are used as a reference to guide and help completing this project. Each of this part is explained based on this finding.

Chapter 3

Explain and discuss about the methodology that have been used in order to complete this project. There are two parts in this chapter which are the software development and hardware implementation. The discussion will be focused on how to make the programming in Visual Basic and also the integration with the hardware.

Chapter 4

Discuss about the result obtained and limitation of the project. All discussion are concentrating on the result and performance of the develop system.

Chapter 5

Discuss the conclusion of the development of this project. This chapter also discuss the recommendation for this system for future development or modification and discuss about costing and commercialization.

CHAPTER 2

LITERATURE REVIEW

2.1 Background

This chapter focused in literature review for each component in this project. All the component is describe in details based on the finding during the completion of this project.

2.2 DC Motor

DC motor has good speed control respondence, 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 and etc [4].

Essentially, a DC motor consists of a stator, a rotor and a commutator. The stator is the housing of the motor and contains magnet, bearing and etc. The rotor is the rotating part of the motor, which contains a coil of wire through which current flows. The coil of wire in the rotor connects to the commutator an receives current through brushes. The commutator ensures that the current flows in the proper direction while the rotor turns.
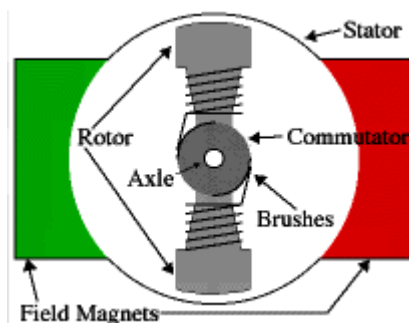
Figure 2.1: DC motor part

Traditionally, a DC motor was considered to be a variable speed motor and AC motor was considered as a constant speed motor. Although the future trend is towards the AC drives, DC drives are currently used in many industries because of the torque speed characteristics of DC motor that can be varied over a wide range while retaining high efficiency compared to AC motors. In robotic and actuations applications, a wide variety of speed or position control is required. While in many manipulators, DC motor are used to follow predetermined speed of position track under variable loads.

Thus demand for control system has increased as the industry is growth rapidly. Thus, more accurate and faster control systems are needed and better performance is expected. There are several methods for controlling the DC motor. One of it is to apply PID controller.

Basically, the speed of DC motor can be done by controlling the amount of current flow or voltage supplied into it. To interface the DC motor, an interface circuit is needed to transform the low-level control motor signal from the controller to a signal which is strong enough to run the motor. The new method to control the speed of DC motor is pulse width modulation (PWM). Power is supplied to DC motor in a pulse or square wave of constant voltage but varying the duty cycle.

2.3 Visual Basic

Since the graphical user interface (GUI) can make the learning process become more interactive, interesting and user friendly. The expert system based power modeling is in the Visual Basic (VB) environment with GUI. The main advantage of Visual Basic is the combination between graphical visual programming and code programming. The application criteria such as size, color, interface and position of each component can be decided before the coding is created. Besides, Visual Basic is easy to learn and more fun rather than using other programming language either Fortran or C++. [5]

Microsoft based Visual Basic on a programming language written for beginners called BASIC. BASIC has been around for more than 35 years in one form or another. The original language designers wanted to develop a programming language that beginners could use. With BASIC, new programmers could become proficient right away. Other programming languages of the day, such as COBOL, FORTRAN, and Assembler, required much more study than BASIC before one could use them effectively.

BASIC stands for Beginner's All-purpose Symbolic Instruction Code. A programming language is a set of commands and command options, called arguments, that you use to give instructions to the computer. Computers cannot (yet) understand human languages because people deal well with ambiguous commands, and a computer cannot understand such ambiguity. A programming language must be more precise than a spoken language.

2.4 Proportional Integral Derivative (PID) Controller

In spite of developed modern control techniques like fuzzy logic controllers or neural networks controllers, PID controllers constitute an important part at industrial control systems so any improvement in PID design and implementation methodology has a serious potential to be used at industrial engineering applications. 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 can 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 [13].

Proportional Integral Derivative (PID) controllers are widely used in industrial practice over 60 years ago. The invention of PID control is in 1910 (largely owning to Elmer Sperry's ship autopilot) and the straightforward Ziegler-Nichols (Z-N) tuning rule in 1942 [6]. Today, PID is used in more than 90% of practical control systems, ranging from consumer electronics such as cameras to industrial processes such as chemical process.

Integral action (I) was added in the beginning of the 19th century [7]. Taylor Instrument Companies announced the first commercial controller with derivative action (D), the Fulscope, in 1939. It began when James Watt equips his steam engine with a fly ball governor, the first mechanical feedback device with proportional control capabilities in 1788. Then the development of PID continues until 1940 when Taylor introduces the Fulscope 100, the first pneumatic controller with full PID controllers has since been the focus of a great deal of research [7], resulting the numerous design strategies. After that people starts using PID controllers in many ways and now a

variety of alternative control techniques begin to migrate from academia to industry for use with more difficult control loops.

The PID controller helps get our output (velocity, temperature, position) where we want it, in a short time, with minimal overshoot, and while little error [8] It also the most adopted controllers in the industry due to the good cost and given benefits to the industry [3]. Many nonlinear process can be controlled using the well-known and industrial proven PID controller [9].

There is another reason why this project using PID controller instead another method. The first is the three terms are reasonable intuitive, allowing a no specialist grasp the essentials of the controller's action [10]. Second, PID has a long history, dating back to a pre-digital, even pre-electronic period and lastly the introduction of digital control has enhanced PID's capabilities [10].

2.4 .1 The 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.