This report has been read and certified by:

Signature : ....

Supervisor Name : MISS CHONG SHIN HORNG

Date : 11th March 2005

DC MOTOR SPEED CONTROL WITH PID CONTROL

TAMAIYANTHI A/P ARMIHAM @ ARUMUGAM

This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree Of Bachelor In Electrical Engineering (Industry Power)

Fakulti Kejuruteraan Elektrik
Kolej Universiti Teknikal Kebangsaan Malaysia

March, 2005

I hereby certified that this report is of my own work except for the extracts and summaries, in which the sources have clearly noted.

Signature : ....

Name : TAMAIYANTHI A/P ARMIHAM @ ARUMUGAM

Date : 11th March 2005

Dedicated to my beloved family…

ACKNOWLEDGEMENT

First of all I would like to express my gratitude to my supervisor, Miss Chong Shin Horng for her valuable guidance and advise throughout the development of this project.

I would also like to take this opportunity to thank my beloved family for their encouragement, care and moral support.

Not forgetting to all my fellow friends, thanks for the suggestions and the help in this project.

Last but not least, I would like to extend my appreciation to all those who have directly or indirectly played a part in the completion and the success of this project.

ABSTRACT

DC motors are motors that run on direct current from a battery or DC power supply. DC is the term used to described electricity at a constant voltage. A DC motor has speed dynamics when mechanical properties such as inertia and damping as well as electrical properties such as inductance and resistance are taken into account. The controller's objective is to maintain the speed of rotation of the motor shaft with a particular step response. PID where P stands for Proportional controller will have the effect of reducing the rise time and will reduce but never eliminate the steady-state error. I stand for Integral control will have the effect of eliminating the steady-state error but it may make the transient response worse. And D stands for Derivative control will have the effect of increasing the stability of the system, reducing the overshoot and improving the transient response. The PID controller is designed by using Visual Basic program to generate a set of coefficients associated with a desired controller's characteristics. The controller coefficients are then included in an assembly language program that implements the PID controller. This program is used to activate the PID controller, calculate and plot the time response of the control system. When the program is run, it plots the time response of the system on the pc screen, assembles the PID assembly language program and loads/ runs the resulting. Speed control is investigated on the DC motor system with speed feedback.

ABSTARK

Motor arus terus ialah motor yang boleh beroperasi dengan menggunakan arus terus daripada bateri ataupun arus terus tenaga. Kebanyakkan motor mempunyai putaran kelajuan yang tidak stabil dan membisingkan keadaaannya. Untuk keadaan ini, projek ini dihasilkan untuk membantu mendapatkan sistem yang stabil bagi motornya. Objektif kawalan ialah untuk mengawal putaran kelajuan motor dengan sambutan langkah yang telah ditetapkan. P ialah kawalan berkadaran yang digunakan untuk mengurangkan masa naik dan juga kurang tetapi tidak menghapuskan ralat keadaan mantap. I ialah kawalan kamiran dimana ia mempunyai sedikit kesan penghapusan keatas ralat keadaan mantap tetapi ia boleh membawa kesan yang buruk keatas sambutan fana. D pula ialah pengawal hasil bezaan yang membantu untuk meningkatkan sistem yang stabil, mengurangkan "overshoot" bagi sistem dan juga membantu untuk mendapatkan sambutan fana yang baik. PID ini direkabentuk dalam bahasa Visual Basic 6.0. Dalam Visual Basic ini PID akan membuat pengiraan dan lukiskan graf mengikut masa sambutan bagi mengawal sistemnya. Apabila aturcara ini sedang berjalan, kita boleh menukarkan nilai-nilai PID pada masa tersebut untuk melihat grafnya keatas kelajuan motor.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Control systems are an integral part of modern society. Its consists of subsystems and processes assembled for the purpose of controlling the outputs of the processes. With control systems we can move large equipment with precision that would otherwise be impossible. The advantages of a control system, the ability to compensator for disturbances. Typically we control such variables as temperature in thermal systems position and velocity in mechanical systems and voltage, current, or frequency in electrical systems. The system must be able to yield the correct output even with a disturbance.

An open-loop system consists of a subsystem called an input transducer that converters the form of the input to that used by the controller. The controller drives a process or plant. The input is sometimes called the reference, while the output can be called the controlled variable. Other signals, such as disturbances, are shown added to the controller and process outputs via summing junctions that yield the algebraic sum of their input signals using associated signs. The disadvantage of open-loop systems, namely sensitivity to disturbances and inability to correct for these disturbances, may be overcome in closed-loop systems. The input transducer converts the form of the input to the form used by the controller. An output transducer or sensor, measures the output response and converts it into form used by the controller.

The closed-loop system compensates for disturbances by measuring the output response, feeding that measurement back through a feedback path, and comparing that response to the input at the summing junction. If there is any difference between the two responses, the system drives the plant, via the actuating signal, to make a correction. If there is no difference, the system does not drive the plant, since the plant's response is already the desired response.

Closed-loop systems, then have the obvious advantage of greater accuracy than open-loop systems. They are less sensitive to noise, disturbances, and changes in the environment. Transient response and steady-state error can be controlled more conveniently and with greater flexibility in closed-loop, and sometimes by redesigning the controller.

Transient response is also important for structural reasons are too fast a transient response could cause permanent physical damage. One of the most common uses of feedback control is to position an inertia load. The inertia load may consist of a very large, massive object such as a radar antenna or small object such as a precision instrument. An important aspect of the control system design is the selection of a suitable actuator, capable of size, weight, etc. electric motors, hydraulic motors and linear actuators and pneumatic linear actuators are the commonly used positioning widely used actuators in servo systems requiring speed control of inertia loads.

Electric power is more readily available, cleaner and quieter, and easier to transmit, these are some of the factors that lead to the choice of electric motors as actuators.

The dc motors are expensive because of brushes and commuters. These motors have relatively lower torque-to-volume, and torque-to-inertia ratios. However the characteristic of dc motors are quite linear and these motors are easier to control. The dc motors have been generally used for large-power applications such as in machine tools and robotics.

Developments in technology are opening new applications for dc motor and other type of motor. Today, with the development of the rare-earth magnet, dc motors with very high torque-to-volume ratio at reasonable costs have become possible. Furthermore, the advances made in brush and commutator technology have made these wearable parts practically maintenance-free. The advancements made in power electronics have made brushless dc motors quite popular in high-performance control systems. Advanced manufacturing techniques have also produced dc motors with rotor of very low inertia, thus achieving very high torque to inertia ratios. These properties have made it possible to use dc motors in many low power control applications that formerly used ac motors.

It is interesting to note that more than half of the industrial controllers in use today utilize PID or modified PID control schemes. Because most PID controllers are adjusted on-site, many different types of tuning rules have been proposed in the literature. Using these tuning automatic tuning methods have been developed and some of the PID controllers may process on-line automatic tuning capabilities.

The PID controls lies in their general applicability to most control systems. In particular, when the mathematical model of the plant is not known and there fore analytical design methods cannot be used, PID controls prove to be most useful. In the field of process control system, it is well known that the basic and modified PID control schemes have proved their usefulness in providing satisfactory control, although in many given situations they may not provide optimal control.

1.2 Literature Review

DC motor should operate at given speed. At that speed, the controller should react to changes in motor loading to correct the speed as quickly as possible. If the motor is told to change speeds, this change should likewise occur as quickly as possible. In both cases, there should be minimal overshoot of the target speed, and no "hunting" for the correct speed. To satisfy these requirements, a PID controller will be implemented in software whose job will be to compensate for speed errors by adjusting the voltage applied to the motor.

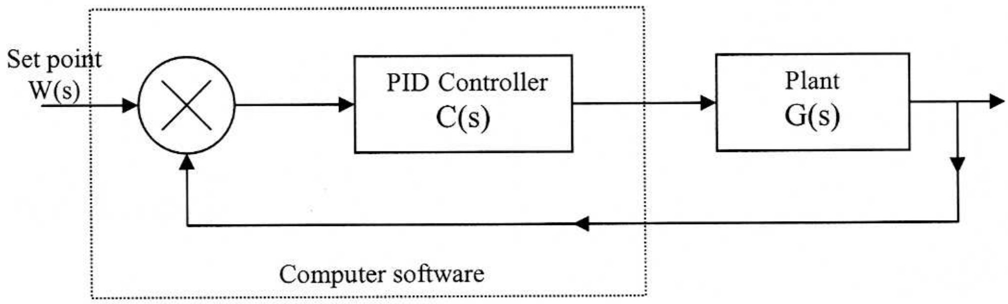

Figure 1.2.1: Feedback control system model

1.2.1 Proportional Gain

Gives fast response to sudden load changes and can reduce instability caused by high integral gain. This gain is typically many times higher than the integral gain so that relatively small deviations in speed are corrected while the integral gain slowly moves the speed to the set point. Like integral gain, when set too high, proportional gain can cause a "hard" oscillation of a few Hertz in motor speed.

1.2.2 Integral Gain:

Ensures that under steady state conditions that the motor speed (almost) exactly matches the set point speed. A low gain can make the controller slow to push the speed to the set point but excessive gain can cause hunting around the set point speed. In less extreme cases, it can cause overshoot whereby the speed passes through the set point and then approaches the required speed from the opposite direction. Unfortunately, sufficient gain to quickly achieve the set point speed can cause overshoot and even oscillation but the other terms can be used to damp this out.

1.2.3 Derivative Gain:

Can be used to give a very fast response to sudden changes in motor speed. Within simple PID controllers it can be difficult to generate a derivative term in the output that has any significant effect on motor speed. It can be deployed to reduce the rapid speed oscillation caused by high proportional gain. However, in many controllers, it is not used.

I used Visual Basic to create this program because VB is a good language to create a program and possible to develop programs very quickly.

1.3 Objectives

The main objective of this project is to develop and design a PID control in controlling the dc at desire speed response with the input voltage and physical parameter given. This project will implemented in simulation and graphical display using Visual Basic 6.0.

The second objective of this project is to a package for learning purpose in controlling the system using PI, PD and PID control

1.4 Scope

a. Conduct literature survey on methods of controlling the DC motor Speed control with PID control.
b. Familiarized with Visual Basic 6.0, programming and transient response.
c. Develop the mathematical modal for control the DC motor Speed control with PID control.
d. Program the plant model using Visual Basic.
e. Test the program to get smooth graph.
f. Doing analysis and improvement.
g. Project report write-up.

1.5 Layout of Thesis

The thesis divided into six chapters. Chapter 1 gives the overview of the entire project with a summary of the project background and the objectives of the project.

Chapter 2 introduces Direct Current Speed Control with PID Control. Steps to obtain a completing mathematical modeling are presented here. The formulation of the control system based on the system model.

Chapter 3 discuss about the principles of Proportional plus Integral plus Derivative control.

Chapter 4 discusses about the software development. The software development introduces the chosen software, Visual Basic 6.0 programming

Chapter 5 will show example experiment result or expected result.

Chapter 6 gives the conclusion of the thesis and highlights the suggestion for the future development.

CHAPTER 2

DC MOTOR SPEED CONTROL WITH PID CONTROL

2.1 DC Motor

Electric motors can be of many types, such as DC motors, AC motors, wound brushless, synchronous, asynchronous, stepper, brushless permanent magnet servo and switched reluctance, but their basic function is the same. Motors of all types serve to convert electrical energy into mechanical energy.

D.C. motors are motors that run on ***Direct Current*** from a battery or D.C. power supply. Direct Current is the term used to describe electricity at a constant voltage. When a battery or D.C. power supply is connected between a D.C. motor's electrical leads, the motor converts electrical energy to mechanical work as the output shaft turns.

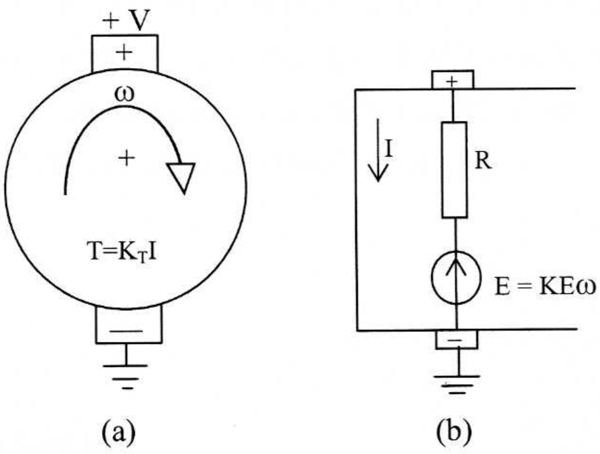

Figure 2.1: Schematic representation of an electric motor
(a) End view, (b) Side view.

2.1.1 Principles of Operation

Consider a simple direct current motor consisting of a wound rotor and a permanent stator (Figure 2.1). Voltage is a applied across the motor terminals and current flow through the motor from the positive terminal to the negative terminal. The system consists of brushless, and collectors transfer the current from the sationary terminals of the rotor coils. Current flowing through the rotor coils interacts with the magnetic field of the permanent-magnet stator and generator and electromagnetic force, in accordance with ampere's law. The electromagnetic force turns the rotor and sets the DC motor into action. In order to keep the DC motor rotating in the same direction, the collector switches (commutates) the rotor coils as the rotor turns. The rotation of the rotor causes its coils to intersect the magnetic field lines. Thus, an electromotive force (*emf*) is induced in the oils in accordance with Faraday's law. The induced *emf* is referred to as a counter electromotive force (back *emf*) because it oppose the applied voltage. In Figure 2.1, the back *emf* is designated by the letter E. Also shown Figure 2.1 is the internal resistance of the DC motor (R). This represents the resistance of the rotor windings, brushes, collector, etc. The internal resistance is the cause of power loss in the electrical motor. As current flows through the motor, energy is converted into heat through the Joule effect. The resulting power must be dissipated; otherwise the DC motor overheats which may result in burn-out of the insulation and short-circuit.

2.1.2 DC Motor Equation

The torque developed by the DC motor originates in the electromagnetic force applied to rotor windings. Recall that the electromagnetic force on a conductor is proportional with the current flowing through the conductor; hence, the torque generated by a DC motor is proportional with the current flowing through the rotor windings. The constant of proportionality is K_T

$$T = K_T I \qquad (2.1)$$

A schematic represent of equation (2.1) is given in Figure 2.2. The amplitude of the back *emf* is proportional with the angular speed of the rotor. The constant of proportionality is K_E

$$E = K_E \omega \qquad (2.2)$$