SPEED AND POSITION TRAINER FOR ANALOG P, PI, PD, AND PID CONTROLLER

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This Report Is Submitted In Partial Fulfillment of Requirements for the Degree of Bachelor in Mechatronics Engineering

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July 2009

"I hereby declare that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering."

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Date : JULY 2009

"I hereby declare that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

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Date : JULY 2009

ABSTRACT

The objective is to design and develop of a Graphic User Interface (GUI) software using Microsoft Visual Basic 6.0 for speed and position control system. Four type of controller namely P, PD, PI and PID will be used in order to control the output response. Interactive software will be developed to visualize and analyze the system. The scope of this project is to design software application using the software development tool of Microsoft Visual basic 6.0 thus develops the Graphical User Interface (GUI) to make the user become easier and clearer to see and comprehend the output response of the system. This GUI also will be interface with hardware of P, PI, PD and PID control system and Data Acquisition System with a personal computer. It also involves understanding on how to interface personal computer (PC) with the controller through Data Acquisition System (DAQ). Finally, the software will be integrated to produce a GUI speed and position control system.

ABSTRAK

Satu perisian akan direka bentuk bagi kelajuan dan posisi bagi sistem motor DC untuk pengawal P, PI, PD dan PID yang bertujuan untuk kegunaan pembelajaran. Perisian interaktif akan direka dengan menggunakan Microsoft Visual Basic 6.0 yang berupaya memaparkan dan menganalisa kedudukan motor dan kelajuannya dalam sistem motor. Pengawal P, PI, PD, dan PID akan digunakan untuk mengawal isyarat keluaran motor. Skop projek ini adalah untuk membina perisian dengan menggunakan Microsoft Visual Basic seterusnya membina pengantara muka grafik untuk memudahkan pengguna untuk memahami dan melihat output sambutan sistem itu. Perisian ini akan hubungkan dengan perkakasan sistem DC motor bersama pengawal P, PI, PD dan PID dengan komputer peribadi melalui kad pengantaramukaan atau lebih dikenali sebagai kad pemerolehan data (DAC). Ini juga melibatkan pemahaman dalam menghubung antara muka komputer dengan perkakasan tersebut. Akhir sekali, perisian tersebut akan disatukan untuk menjadikan satu perisian yang dapat memaparkan respon output daripada sistem kawalan tersebut.

To my dearest and loving parents,
brother and sister
for their unending love, encouragement,
sacrifice, and moral support

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE PROJECT

This project is about research, simulating and developing Graphic User Interface (GUI) software using Microsoft Visual Basic for speed and position in dc motor control system. This GUI software will display the output response of speed and position of dc motor control system. This project consists of two core element that is hardware and software.

In the hardware part, thing need to be concentrate is on how to integrate and communicate between the hardware and GUI that will be developed. The hardware of this project is already designed and fabricated by previous student. The hardware that mentioned is the analog PID controller with speed and position control of dc motor system. This hardware is designed for educational and learning purposes. The output response will be control using analog signal of PID controller and will be vary by applying some techniques of tuning method in order to get the best output response.

In the software part, the GUI application of this system will be develop using Microsoft Visual Basic. The thing need to be focus is on how to develop the program, design the layout of the program, simulate and integrate the GUI with the hardware.

Lastly, the hardware and software will be combining and will be integrate in order to get and display the output response of the system in personal computer. This firmware can be use as a training kit for student to gain the skill and knowledge about the basic control system.

1.2 THE CONCEPT OF SYSTEM

The plant which is the analog PID controller with speed and position of dc motor system will be connect to a personal computer through Data Acquisition System (DAQ). The analog signal from the hardware will convert to digital signal through DAQ and will be transfer to personal computer to evaluate and show the output response though GUI. The concept of the system can be illustrated as shown in Figure 1.1 below.

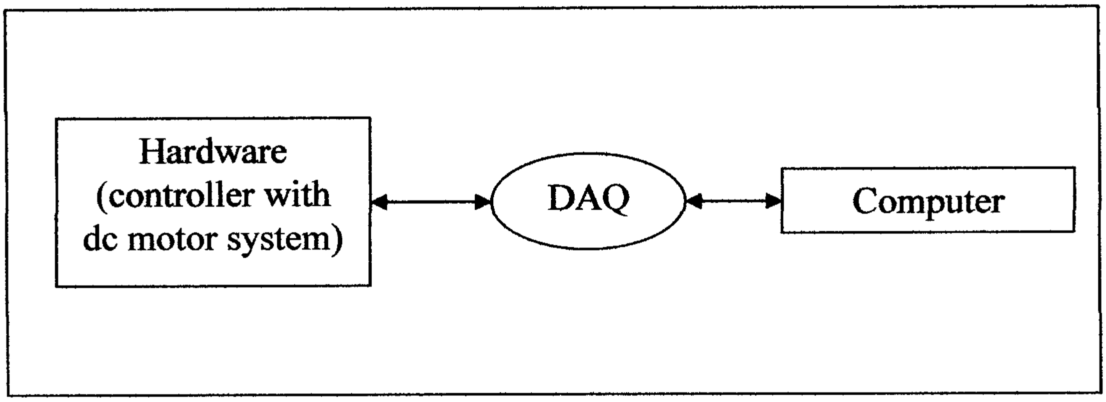

Figure 1.1 : The concept of system

1.3 OBJECTIVE OF PROJECT

The several objectives have been identified in order to achieve the goal of this project. There are:

- To develop software based program using Graphical User Interface (GUI) in order to analyze and monitor the position and speed of motor.

- To integrate and communicate between hardware and GUI using Data Acquisition System.
- To shows the output response and the characteristics of each controller output response from controller using GUI.
- To compare the output response of the system that using GUI with simulation.
- To redevelop the position of dc motor system.

1.4 THE SCOPE OF THE PROJECT

In order to develop successful Speed and Position Trainer for Analog P, PD, PI and PID controller, the scope should be identified and planned to achieve the objective of the project successfully on time. The scopes of the project is about design software application using the software development tool of Microsoft Visual basic to develop the Graphical User Interface (GUI) to make the user become more easier and clearer to see the output response of the system.

1.5 PROBLEM STATEMENT

This project is continuation of previous project that done by ex-student of UTeM. The hardware of this project is already completed but existing DC motor system with analog P, PI, PD and PID controllers does not have GUI that can evaluate and show the speed and position of motor. So, it will be huge achievement if the hardware and software combine to produce a good Control System application for make it simpler for student in order to understand the control system engineering.

1.6 THE OUTLINE

This thesis is organized into six chapters and an appendix. It can be referred as follow; for Chapter 1 shows the introduction and overview of the project. It is includes background of the project, objective of the project, the scope of the project, the concept of the project and the outline of this thesis.

As for chapter 2, it is contain of the literature review of the project. This chapter also shows the theory that related to this project. It is comprises of basic concept of the control system, theory of PID controller, basic operation of DC motor, the description of Graphical User Interface (GUI) and explanation about Microsoft Visual Basic 6.

In chapter 3, it is explain about methodology of this project. The flow chart of the project and the explanation of the stages and phases that will be used in order to achieve the objectivity of the project also stated in this chapter.

For chapter 4, it is contain result and discussion of analysis and simulation of the system. The result had been comparing with Matlab software to shows the consistence result and the simulation result will be used to assist in building the GUI using Microsoft Visual Basic 6.

Chapter 5 presents the final conclusion and suggestion for future work for this project. The accomplishment of the project is also being explained in this chapter. The suggestion includes the idea and recommendation that can make this project more reliable in future.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a review of previous research projects that are related to this project will be discussed. The information of the control system, PID controller, programming languages and software development tools are also being mentioned in this chapter.

2.1 CASE STUDY

(Performance Comparison between PID and Fuzzy Logic Controller in Position Control System of DC Servomotor by Mohd Fua'ad Rahmat and Mariam Md. Ghazaly)

This research is all about to design based program GUI that can in controlling the position of a servomechanism or also known as servomotor. It also involves the knowledge about how to interface personal computer (PC) with position control system through Data Acquisition System (DAS). In this research PID controller is because it can usually provide good closed loop response characteristics, can be tuned using relatively simple rules and are easy to construct using either analogue or digital components.

The Direct Digital Control System (DDC) is used in this research which is controlled the analogue signal that enters the controller then it converted to a digital form so that the data can acted according to a set of formula. The integral and the derivative terms need to be approximate to forms suitable for computation by a computer in order to discretise the PID controller. The analogue PID controller can be discretise by using z-transform, to obtain the pulse transfer function for the digital PID controller. Then, equation $u\ (k)$ is used to develop the coding program for the PID controller which corresponds with the sequence operation.

2.2 THEORY

2.2.1 CONTROL SYSTEM

A control system is an interconnection of the components forming a system configuration that will provide a desired system response. The basis for analysis of a system is the foundation provided by linear system theory, which assumes a cause-affect relationship for the component of a system. [1]

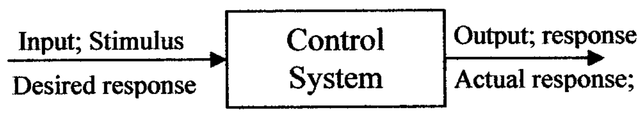

Figure 2.1: Simplified description of a control system

Source: [2]

Control system is a system or a device or set of device to manage, conduct command, order and direct or regulate the behaviour of the other device or one system. There are two type of system that have in Control System which is open loop system and closed loop system.

2.2.1.1 Open-loop Control System

One type of control system is open-loop control system. It also called linear control system or non-feedback control system. This type of system may compute its input into a system using only the value of set point from the input and its model of the system. A characteristic of the open-loop controller is that it does not use feedback to determine if its input has achieved the desired goal. This means that the system does not observe the output of the processes that it is controlling. Consequently, a true open-loop system can not engage in machine learning and also cannot correct any errors that it could make. It also may not compensate for disturbances in the system.

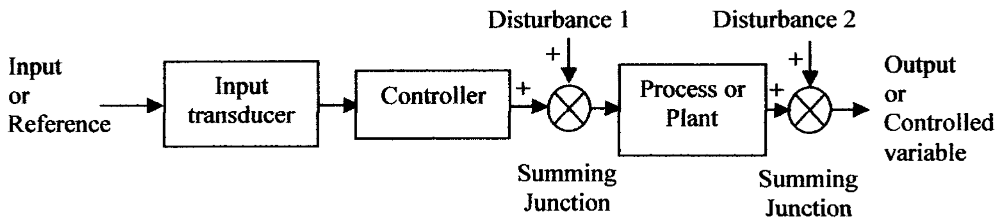

Figure 2.2: Block diagram of an open-loop control system

2.2.1.2 Closed-loop Control System

A closed-loop control system is a contrast to an open-loop control system. A closed-loop control system utilizes an additional measure of the actual output is called feedback signal. A feedback control system is a control system that tends to maintain a prescribed relationship of one system variable to another one by comparing functions of these variables and using the difference as a means of control [1].

A closed-loop control system is one in which an input forcing function is determined in part by the system response. The measured response of a physical system is compared with a desired response. The difference between these two responses initiates actions that will result in the actual response of the system to approach the desired response. This in turn drives the difference signal toward zero. Typically the difference signal is processed by another physical system, which is called a compensator, a controller, or a filter for real-time control system applications. A closed-loop control system can be represented by the general block diagram shown below:

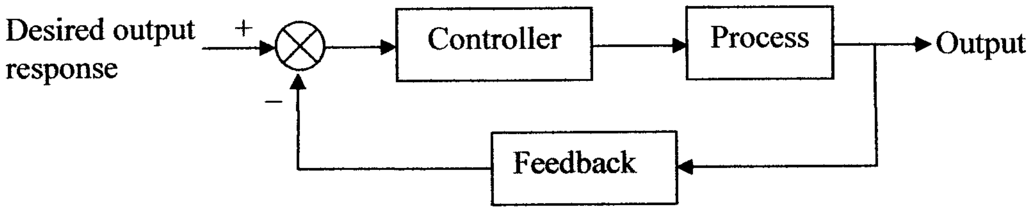

Figure 2.3: Block diagram of closed-loop control system

2.2.2 PID CONTROLLER

A proportional integral derivative controller (PID controller) is a basic control loop feedback mechanism that widely used in industrial control system. Their robust performance in a wide range of operating conditions and simple of functionality makes the PID controller popular in engineering field and also in education field. 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 algorithm is involves three separate parameter which are the Proportional, the Integral and the Derivative value. The proportional gain determines the ratio of output response to the error signal and it is depends on the difference between the set point ant the process variable that called as Error term. As an example, if the error term has a magnitude of a 5 and proportional gain of 5, proportional response of 25 will produce. In other words, the rising of proportional gain will increase the speed of the control system response. However, if the proportional gain is too large, the process variable will begin to oscillate. Thus, when proportional gain increased further, the oscillation became larger and the system will become unstable.

The integral component sums the error term over time. The result is that even a small error term will cause the integral component to increase slowly. The integral response will continually increase over time unless the error is zero, so the effect is to drive the Steady-State error to zero. Steady-State error is the final difference between the process variable and set point. A phenomenon called integral windup results when integral action saturates a controller without the controller driving the error signal toward zero [13].

For the derivative gain, the component will cause the output to decrease if the process variable is increasing rapidly. The derivative response is proportional to the rate of change of the process variable. In other words, with increasing of the derivative time parameter will cause the control system to react more strongly to changes and will increase the speed of the overall control system response. Most practical control systems use very small derivative time (Td), because the Derivative Response is highly sensitive to noise in the process variable signal. If the sensor feedback signal is noisy or if the control loop rate is too slow, the derivative response can make the control system unstable [13]. The following Table 2.1 shows the effect of the increasing of proportional gain, integral gain and the derivative gain to the control system response.

Term	**Effect on control system**
Proportional, P	Typically the main drive in a control loop, K_p reduces a large part of the overall error.
Integral, I	Reduces the final error in a system. Summing even a small error over time produces a drive signal large enough to move the system toward a smaller error.
Derivative, D	Counteracts the K_p and K_I terms when the output changes quickly. This helps reduce overshoot and ringing. It has no effect on final error.

Table 2.1: Effect of the increasing of proportional, Integral and the derivative gain to the control system response.

2.2.2.1 Analog PID Controller

The PID controller is defined by the following relationship between the controller input *e(t)* and the controller output *v(t)* that is applied to the motor armature:

$$v(t) = K_P E(t) + K_I \int_0^t e(\tau) d\tau + K_D \frac{de(t)}{dt} \tag{2.1}$$

Taking the Laplace transform of this equation gives the transfer function of K(s):

$$K(s) = \frac{V(s)}{E(s)} = \left(K_P + \frac{K_I}{s} + K_D s \right) \tag{2.2}$$

This transfer function clearly illustrates the proportional, integral, and derivative gains that make up the PID compensator. Select new definitions for the gain terms according to;

$$K_P = K \tag{2.3}$$

$$K_I = \frac{K}{T_I} \tag{2.4}$$

$$K_D = KT_D \tag{2.5}$$

Then, the transfer function can be expressed to easily show that the PID controller leads to a pole at the origin of the Laplace plane and design freedom over two zeros:

$$K(s) = \frac{KT_D}{s}\left(s^2 + \frac{1}{T_D}s + \frac{1}{T_I T_D}\right) \tag{2.6}$$

The block diagram for the PID controller can be sketched in several different ways. One possible block diagram is shown in figure 2.5.

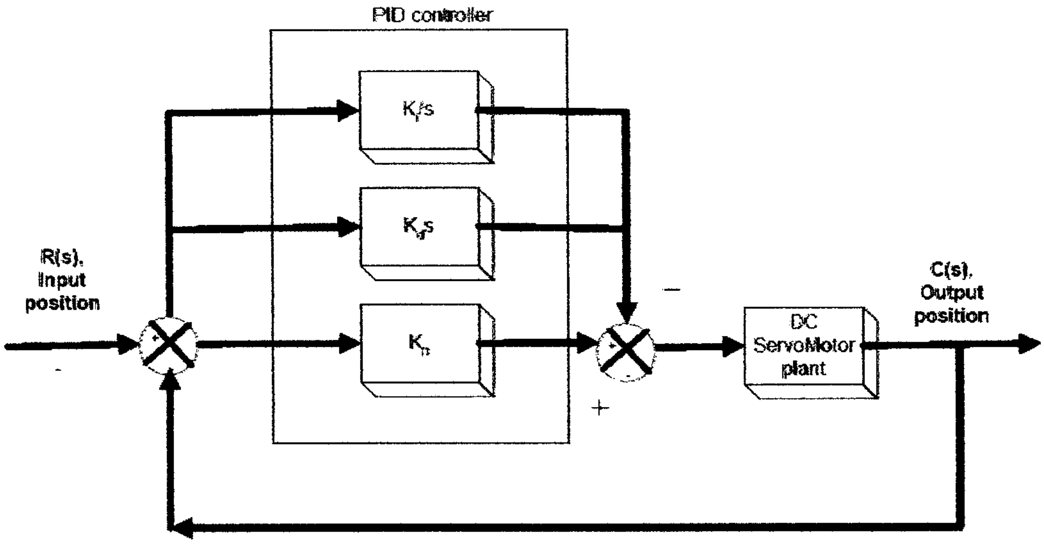

Figure 2.5: Block diagram for PID Controller

Proportional mode is the heart of a closed-loop control system. It provides an output, which is directly proportional to the error signal. It is the only control mode, which can be used alone. Integral and derivative modes can only be used when combined with at least the proportional mode. Proportional control amplifies the error to motivate the plant towards the desired response. It can reduce but not eliminate stead-state error. Proportional control can also produce excessive overshoot and oscillation. Remember that by increasing *K* will increase the overshoot of the system, but it will decrease the system rise time. If the process response to a change in set point is not sufficient and a large offset error persists then, perhaps the proportional gain is too low. Increase the proportional gain till a satisfactory response is obtained. On the other hand if the proportional gain is too high, then the oscillations may be developed in the system.