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Design PI, PD,PID controller for motor speed control using simulation package / Mohd Izzuwan My Yusoff.

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This Report Is Submitted In Partial Fulfillment Of Requirement For The Degree of Bachelor In Electrical Engineering (Control, Instrumentation and Automation)

Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

April 2008

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

Signature : ....

Name : MOHD IZZUWAN BIN MY YUSOFF

Date : 7 MAY 2008

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"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrument and Automation)"

Signature	:..	
Supervisor's Name	:	PUAN AZRITA BT ALIAS
Date	:	7 MAY 2008

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Dedicated to my beloved parents and family

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Acknowledgement

I want to dedicate the honor and many thankful to the people who involved developing this project. I want to thank especially my beloved parent who had support me a lot to make this project done successfully. Not forget to my supervisor and all lecturers who had taught me a lot.

Thank you to all of you

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Abstract

Projek Sarjana Muda that will be building is about motor speed control using computer software (Microsoft Visual Basic). This project more focused on the stimulation how to control speed of the motor. The speed of the motor can show through the Graphical User Interface system. Output of the motor can be determine trough this system. The speed of the motor can be controlled using PI, PD and PID controller. GUI system can make the user or student to control the whole system by using it. This stimulation package can be easily used by user, just key in the parameter of the motor, and then the settling time, peak time and percent overshoot will appear for the motor control. It's all by the GUI system. This stimulation will process the data and then it will show all the parameter like transient response type of the output graph and also the type of the controller need to use which is PI, PD and PID. From this output the user can choose by itself which controller they want to use. Only the parameter of the motor circuit needs to be inserted into this stimulation package.

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Abstrak

Projek Sarjana Muda yang dibina adalah mengenai kawalan kelajuan/ halaju sesebuah motor dengan menggunakan perisian computer (Microsoft visual basic). Projek ini lebih memfokuskan kepada simulasi tentang kawalan kelajuan sesebuah motor. Kelajuan sesebuah motor dapat dilihat menerusi sistem Pengantaramuka Grafik Pengguna (GUI). Keluaran bagi sesebuah motor dapat diperhatikan menerusi sistem ini. Kelajuan motor ini dapat dikawal dengan menggunakan pengawal PI, PD dan PID. Sistem Pengantarmuka Grafik Pengguna (GUI) membolehkan pengguna ataupun pelajar untuk mengawal keseluruhan sistem bagi projek ini. Perisian ini dapat memudahkan pengguna atau pelajar untuk mencari nilai masa puncak Tp ,masa selesai Ts dan peratus lamapau %OS dan paparan bagi graf keluaran (time response) bagi sistem kawalan kelajuan motor ini. Pengguna hanya perlu memasukkan nilai parameter yang dikehendaki ke dalam perisian ini iaitu system (GUI). Perisian ini akan memproses data untuk mengeluarkan nilai masa puncak Tp ,masa selesai Ts dan peratus lamapau %OS , paparan graf keluaran jadual dan sistem pengawal yang hendak digunakan seperti pengawal PI,PD dan PID. Daripada nilai – nilai keluaran inilah pengguna dapat menetukan sendiri untuk menggunakan system pengawal (PID controller) yang hendak digunakan untuk mengawal kelajuan motor itu. Untuk memudahkan pengguna, hanya nilai parameter bagi rangkap pindah (transfer function) sesebuah litar motor perlu di masukkan ke dalam system paparan (GUI) ini.Kemudian Perisian ini akan memproses data tentang rangkap pindah (transfer function) tersebut.Pengguna dapat memilih sendiri jenis pengawal yang hendak digunakan untuk mengawal kelajuan motor itu Sistem perisian ini dapat disambungkan kepada motor menerusi antaramuka (interface) antara komputer dan motor.

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CHAPTER 1

MOTOR SPEED CONTROLLER

1.1 Introduction

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. In Control system there are two type of system. Open loop system and closed loop 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 setpoint 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. Open-loop control is useful for well-defined systems where the relationship between input and the resultant state can be modeled by a mathematical formula. For example determining the voltage to be fed to an electric

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motor that drives a constant load, in order to achieve a desired speed would be a good application of open-loop control. If the load were not predictable, on the other hand, the motor's speed might vary as a function of the load as well as of the voltage, and an open-loop controller would therefore not be sufficient to ensure repeatable control of the velocity. An open-loop controller is often used in simple processes because of its simplicity and low-cost, especially in systems where feedback is not critical. A typical example would be a conventional washing machine, for which the length of machine wash time is entirely dependent on the judgment and estimation of the human operator. Generally, to obtain a more accurate or more adaptive control, it is necessary to feed the output of the system back to the inputs of the controller. This type of system is called a closed-loop system.

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:

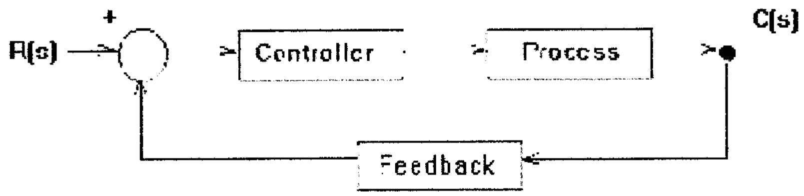

Figure 1.1 Closed-loop control systems

In this configuration a feedback component is applied together with the input R. The difference between the input and feedback signals is applied to the controller. In responding to this difference, the controller acts on the process forcing C to

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change in the direction that will reduce the difference between the input signal and the feedback component. This, in turn, will reduce the input to the process and result in a smaller change in C. This chain of events continues until a time is reached when C approximately equals R. A closed-loop system is able to regulate itself in the presence of disturbance or variations in its own characteristics. In this respect, a closed-loop system has a distinct advantage over an open-loop system.

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 setpoint 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. The Proportional value determines the reaction to the current error, the Integral determines the reaction based on the sum of recent errors and the Derivative determines the reaction to the rate at which the error has been changing. The weighted sum of these three actions is used to adjust the process via a control element such as the position of a control valve or the power supply of a heating element. By "tuning" the three constants in the PID controller algorithm the PID can provide control action designed for specific process requirements. The response of the controller can be described in terms of the responsiveness of the controller to an error, the degree to which the controller overshoots the setpoint and the degree of system oscillation. Note that the use of the PID algorithm for control does not guarantee optimal control of the system or system stability. Some applications may require using only one or two modes to provide the appropriate system control. This is achieved by setting the gain of undesired control outputs to zero. A PID controller will be called a PI, PD, P or I controller in the absence of the respective control actions. PI controllers are particularly common, since derivative action is very sensitive to measurement noise, and the absence of an integral value may prevent the system from reaching its target value due to the control action.

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1.2 Problem statement

The problem statement of this project is about a problem occurred while the development of the project wants to build. The focused of the problem is about the controller of the system that's mean the PID controller. PID controller consist three separate parameters such Proportional, derivative and Integral parameter. The problem is:

1. The proportional control determines the output control variable based on how much the process variable differs from a set point.
2. Then the integral control added with proportional and will increase the corrective signal if the error (decrease is speed) accumulates over period of time. It doesn't bring the motor back up to speed soon enough
3. If derivative added to proportional control, it will compensate for how quickly or suddenly change occurs. If motor speed Change gradually the derivative control barely kicks in, if at all.

1.3 Objective

Of this project is about a building or development the software simulation package using a Microsoft Visual Basic for control the output response of the motor speed controller using the Proportional plus Integral (PI) controller, Proportional plus Derivative (PD) controller, and Proportional plus Derivative plus Integral (PID) controller. This controller system is used to control the output response from the parameter of the motor that been given. This project consist the Graphical User Interface (GUI) to make the user to get the output response. It gives the user an advantage to get the output response from the motor parameters and they also can control the output response of the system to make the improvement of the system by choosing the controller that had been given. This GUI give the user the value of characteristic from the output response such as Peak value (Tp), Settling Time (Ts), Percent Overshoot (OS %), Rise Time (Tr), Steady state error (ess), Final Value. The user also can know about the type of output response which is Over damped , Underdamped and Critically damped

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1.4 Scopes

The scopes of the project is about design the simulation package using the software Microsoft Visual basic 6.0 to develop the Graphical User Interface (GUI) to make the user become more easier to find the controller for the motor speed controller. This GUI will produce the output response for the motor system by putting the value of motor parameter into the simulation system. The user will know the type of output response and also know the characteristics of each output response whether it in open loop or in closed loop system. The characteristics contains settling time Ts, rise time Tr, percent overshoot %OS, Final Value, Peak time Tp, and steady state error in this system. Then the user can choose the type of controller they want to make the system more stabile. The controller in this system is PI, PD PID controller and it also shows the output response and the characteristics of each controller output response

1.5 Layout of Thesis

Layout of the thesis will tell the flow of the whole thesis and it's contain. This could be the referring section for this project.

Chapter 1 shows the introduction of the project, the abstract as the initial summary for whole project. Then it also contains the literature review about this project .This chapter also include the main objectives of the project and the scope of whole project. The project methodology shows the flow of the project from the beginning.

Chapter 2 contains the theory of the DC motor and the parameter calculation of the motor to get the transfer function for the motor. The transfer function consist open and closed loop transfer function. The calculation controller transfer function also include in this chapter. Then the characteristic of the output response for the motor system also include such as rise time, settling time, percent overshoot, and frequency response for the system

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Chapter 3 indicates the control system design. It contains the PID compensator design which is show the way to control the system. The calculation of the PID compensator had shown in this chapter and the proportional, Derivative and Integral control also include. Each of these controllers has their own characteristics to control the stability of output response of the control system. The proportional plus derivative plus integral controller also shown in this chapter

Chapter 4 contains the information or literature review about the software development. The simulation package for this project is using a Microsoft Visual Basic 6.0 as a Graphical User Interface (GUI). This chapter shows the introduction of Visual Basic the flowchart of the GUI development and also shows the layout of the simulation package that been made by Visual Basic software.

Chapter 5 shows the experimental result of the whole system using simulation package. Few examples given and the result had been comparing with Matlab software to shows the consistence result.

Chapter 6 shows the final conclusion and suggestion for future work for this project. The suggestion includes the idea how to make this simulation package more reliable and efficient in the future.

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CHAPTER 2

DC MOTOR WITH PID CONTROLLER

2.1 DC Motor

Electric motor can be of many types, such DC motor, AC motor, wound, brushless, synchronous, asynchronous, stepper, brushless permanent magnet servo and switch reluctant, but their basis function is the same. Motor of all types serve to convert electrical energy to mechanical energy.

DC motors are motor that runs on Direct Current from battery or D.C power supply. Direct Current is the term used to describe electricity at a constant voltage. When a battery or dc power supply is connected between DC motor and electric leads, the motor convert electrical energy to mechanical work as the output shafts turn.

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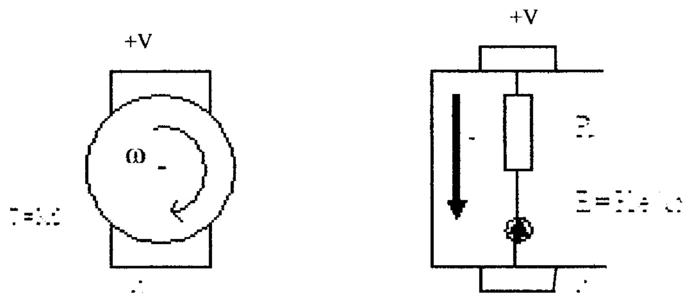

Figure 2.1 Schematic represents of an Electric Motor
(a) End View (b) Side View

2.1.1 Principles Of Operation

Consider a simple Direct Current motor consisting of a wound rotor and permanent stator (Figure 2.1). Voltage is applied across the motor terminal and current flow through the motor from the positive terminal to the negative terminal. The system consists brushless and collectors transfer the current from the stationary terminal of the rotor coils. Current flowing through the rotor coils interacts with the magnetic fields of the permanent magnet stator, generator and electromagnetic force. In accordance with ampere's Law the electromagnetic force turn the rotor and sets the DC motor into action. In order to keep the DC motor rotating in the same direction, the collectors switches (commutates) the rotor coils as the rotor turns. The rotation of the rotors causes its coils to intersect the magnetic fields lines. Thus, electromotive force (emf) is induced in the coils in accordance with Faraday's Law. The induced emf is referred to as a counter emf (back emf) because it oppose the applied voltage . In figure 2.1 internal resistance of DC motor (R), its represent the resistance of rotor winding, 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 the insulation and short circuit.

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2.1.2 DC Motor Equation

The torque developed by the Dc motor originated in the electromagnetic force applied in the winding. Recall that the emf 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 KT

$$T = K_T . I \qquad \text{...} \ (2.1)$$

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 proportionally is K_E

$$E = K_E \omega \qquad \text{...} (2.2)$$

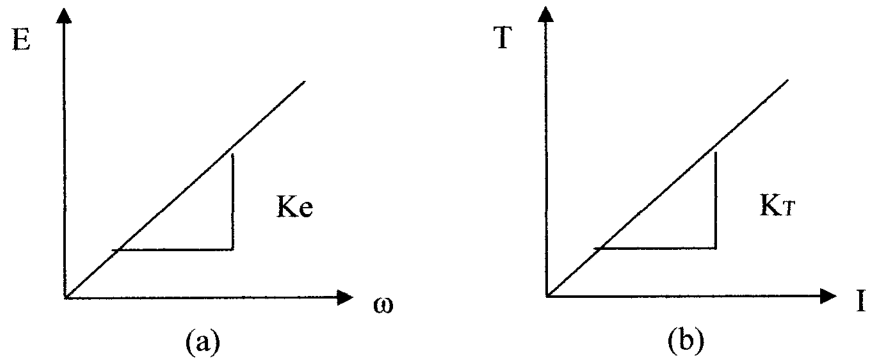

Figure 2.2 Schematic of the basis principles of DC motor equation

a) Dependence torque on electric circuit
b) Dependence pf back emf on angular rotational speed

The electric modal of the DC motor is based on ohm's and kirchoff's law

$$V = RI + E \qquad \text{....................................} (2.4)$$

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It can be shown that, in SI units, the two constant K_T and K_E are equal and can be represented by just one constant K, which the motor constant, the proof of this assertion starts with the principles of power conservation during the electromechanical transduction process. The electrical power input to the DC motor is

$$P_{in} = VI + (RI + E) = RI^2 + EI \qquad \text{.........................(2.4)}$$

On this input power, apart is lost as heat (RI^2) and the rest is transducer into mechanical power. The electrical power that is transducer into mechanical power is the total input power less the power dissipation. Using equation (2.4) we see that the transducer electrical power is;

$$P_{electrical} = EI \qquad \text{..(2.5)}$$

The mechanical power output is

$$P_{mechanical} = T\omega \qquad \text{.......................................(2.6)}$$

Equation the mechanical power with the transducer electrical power, we get;

$$T\omega = EI \qquad \text{.......................................(2. 7)}$$

Substituting of equation (2.1) and (2.2) into equation (2. 7) yields

$$K_T I\omega = K_E I\omega \qquad \text{.......................................(2.8)}$$

Simplifying by Iw given the relation

$$K_T = K_E \qquad \text{.......................................(2.9)}$$

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