"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, Instrumentation and Automation)".

Signature : ………………………………………...
Supervisor's Name : MR. SYED NAJIB BIN SYED SALIM
Date : …………………………………………

REAL-TIME FUZZY LOGIC POSITION CONTROLLED DC MOTOR DRIVES

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MAY 2009

"I hereby declared 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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Student Name : GWYNNIE CHEMBAT AKIN
Date : MAY 2009

ACKNOWLEDGEMENT

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ABSTRACT

This project involves computer simulation and followed by hardware implementation for the real application. In order to understand the characteristic of the fuzzy logic controller, this project will be built to improve the teaching and learning quality in control system subject. The aim of this project is to perform an analysis to investigate the performances of DC motor with different load. The use of fuzzy logic can help to avoid the need for precise mathematical modeling. Thus anything that was built using conventional design techniques can be built with fuzzy logic. The investigation and comparison of the output response from the simulation and hardware can be done. Fuzzy logic controller will be design to improve its performance.

ABSTRAK

Projek ini dilaksanakan dengan menggunakan kaedah simulasi dan perlaksanaan perkakasan. Pengawal logik samar digunakan dalam perlaksanaan projek ini. Dengan memahami ciri-ciri logik samar, maka projek ini dilaksanakan bagi membuktikan kualiti pengajaran dan pembelajaran dalam subjek sistem kawalan. Tujuan projek ini dilaksanakan adalah untuk membuat analisis dan penyelidikkan keatas pergerakan DC motor dengan beban yang berbeza. Penggunaan logik samar boleh membantu bagi mengelakkan ketepatan dalam bentuk matematik. Oleh itu, sesuatu yang diperbuat dengan menggunakan teknik konvensional boleh dibuat dengan menggunakan logik samar. Dengan membuat pembandingan dan penyelidikkan keatas tindakbalas keluaran daripada simulasi dan perkakasan dengan ini boleh dilaksanakan. Maka, pengawal logik samar dicipta bagi membuktikan perlaksanaan projek ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

COA	Center-of-Area
COG	Center-of-Gravity
CMOS	Complementary Metal-Oxide Semiconductor
DMOS	Double-Diffused Metal Oxide Semiconductor
DC	Direct Current
FLC	Fuzzy Logic Controller
GUI	Graphical User Interface
IEEE	International Electrical Electronic Engineering
I/O	Input/Output
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
PIC	Programmable Integrated Circuit
PID	Proportional, Integral, Derivative
PSM	Projek Sarjana Muda
PWM	Pulse Width Modulation

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

The “Real-Time Fuzzy Logic Position Controlled DC Motor Drives” project is needed interface software and hardware. This project is build to control the performance of dc motor for positioning purpose and controlled by fuzzy logic controller. Beside that, this project is build to comprehend the basic concepts of fuzzy logic. In this chapter will discuss about general background, concept of project, objective, scope, problem statement and report outline.

1.1 Background

Motion control deals with the use of high performance electric motor and is a very important part industrial control systems. Motion control includes application for position control in practically all branches of industry. An important advance in this field has been made during the last years by the introduction of microprocessor control systems. These systems are becoming a standard in motion control because of fast advances in microelectronics technology and well-known benefits such as greater accuracy, parameter sensitivity and higher interconnection capacity.

As a consequence of this progress, more and more applications that have used simple electric drives for economic reasons are being replaced by motion control systems. This is a natural evolution considering the benefits offered by motion control systems in meeting the ever-increasing needs for improved quality and greater productivity in all industries. To facilitate this move towards motion control solutions, efforts are being made to continuously decrease the cost of these systems, especially considering their power electronics and control parts.

1.2 Concept of Project

The concept of this project is shown in figure 1.1. Firstly, the controller works by receiving a user position command then drive a dc motor to desire position by using Serial Watcher. After receiving direction and position command from computer, the controller will compare the actual and desire position to determine the required pulse width modulation to drive a dc motor. The controller observes the actual position of the position output shaft from the position encoder. The position encoder attached at the output shaft motor.

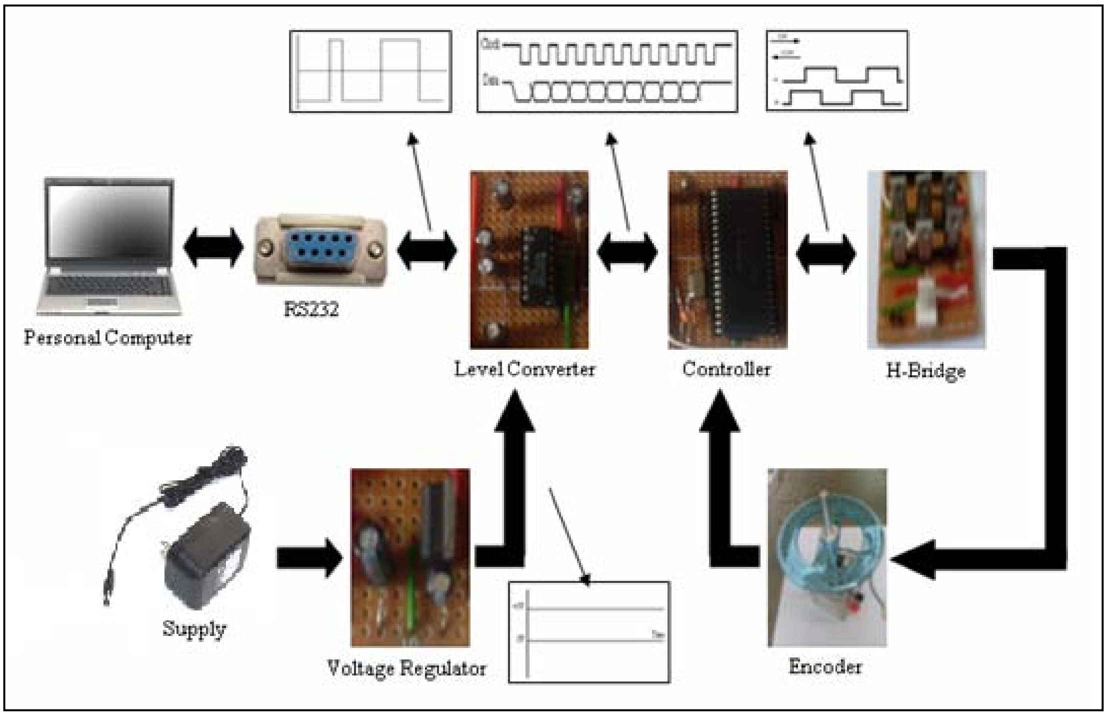


Figure 1.1: Concept of Project Block Diagram

1.3 Objective

The objectives of the project are:

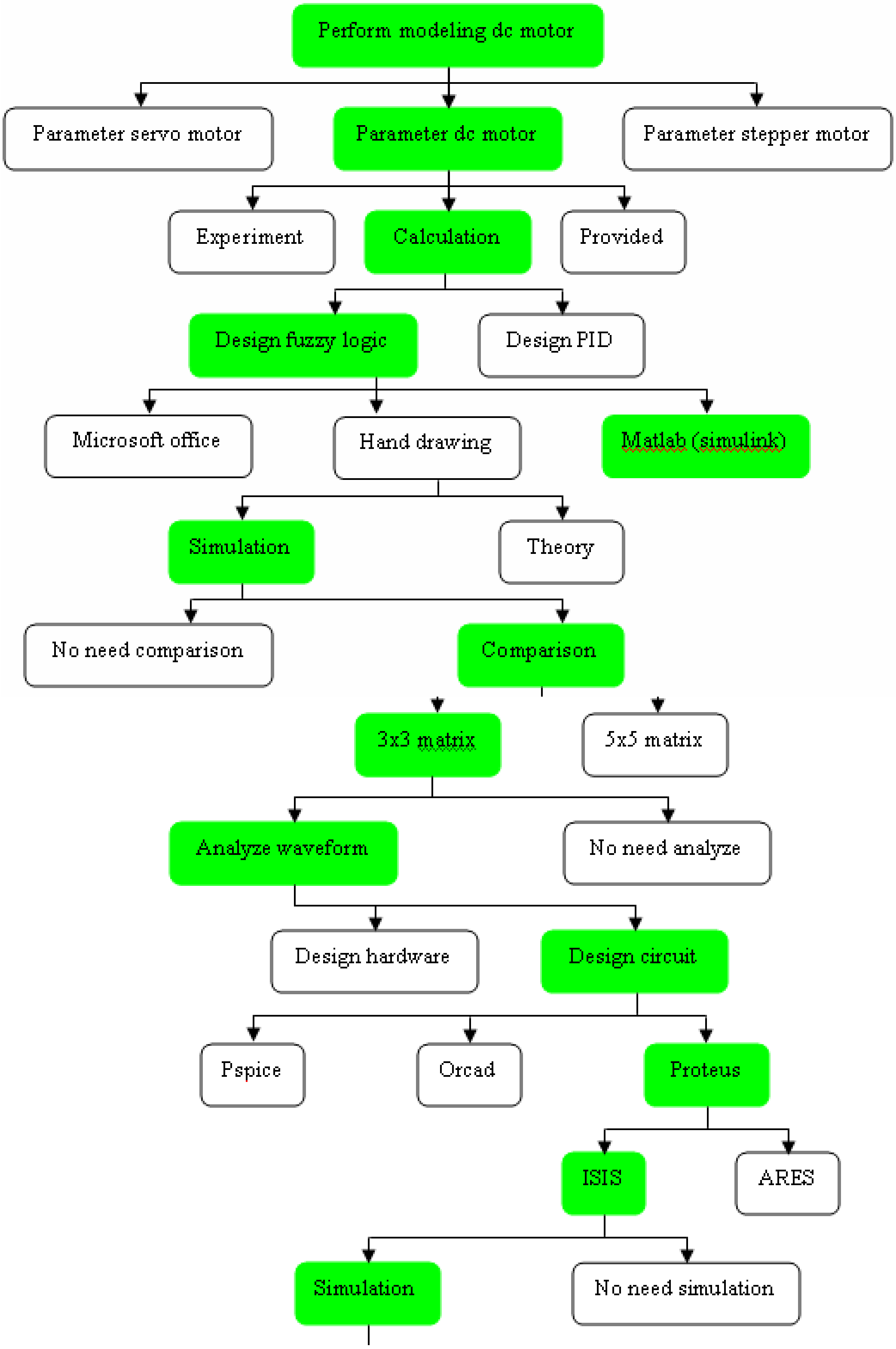
- To perform a modeling of dc motor.
- To make comparison between difference matrix.
- To realize the operation of fuzzy logic for dc motor.
- To investigate the result of output response according to a controller, load and input.

1.4 Scope of Project

The K-Chart of the project is shown in figure 1.2. Firstly, with perform modeling dc motor to get a parameter of dc motor by calculation. Then, design fuzzy logic by using Matlab(simulink). After design a fuzzy logic block and 3x3 and 5x5 rules, there will be make a comparison between it with analyze a waveform. Then, design a circuit by using Proteus (ISIS). After that, simulate the circuit with program put inside the microcontroller and make an analysis on it. Then, implement the circuit on the board. Finally, interface software with hardware then observe the result and make an analysis.

For this project, the close loop system is needed. The close loop system is used because it has a feedback function for monitoring the output position. The project circuit parts are consist PIC controller, driver, dc motor and position encoder as a feedback. The block diagram of this project is shown in figure 1.3. This project is design and implements the hardware and the Serial Watcher as the software.

The dc motor is modeled and the dynamic parameters obtained will used to analyze and design the controller. The modeling of dc motor is simulated in simulink by using Matlab. The output response from simulink is analyzed and investigated and record. The hardware will be interface with Serial Watcher software. From that software, the user can give position command to drive the dc motor to desire position.


Perform modeling dc motor
Parameter servo motor
Parameter dc motor
Parameter stepper motor
Experiment
Calculation
Provided
Design fuzzy logic
Design PID
Microsoft office
Hand drawing
Matlab (simulink)
Simulation
Theory
No need comparison
Comparison
3x3 matrix
5x5 matrix
Analyze waveform
No need analyze
Design hardware
Design circuit
Pspice
Orcad
Proteus
ISIS
ARES
Simulation
No need simulation

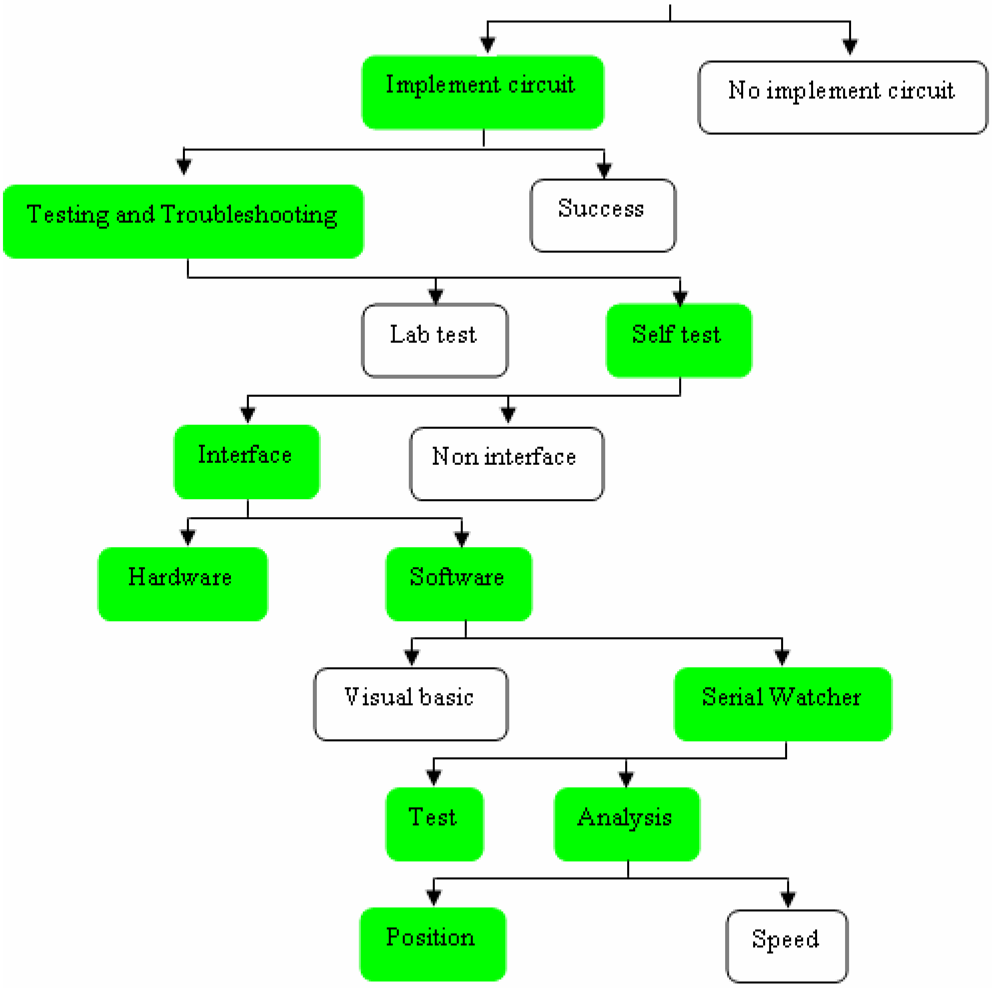


Figure 1.2: K-Chart Block Diagram

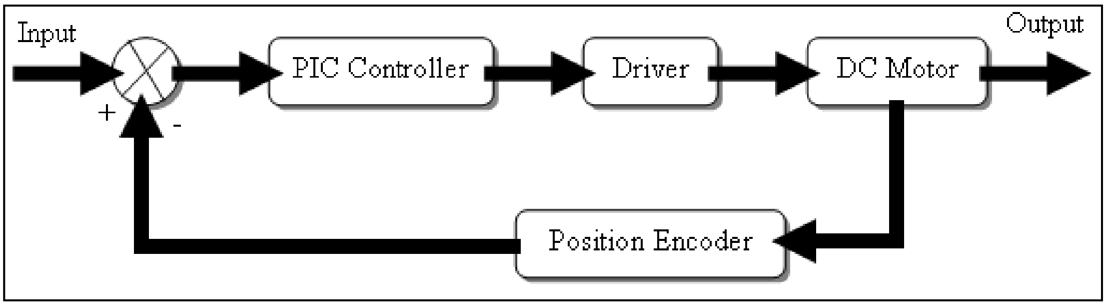


Figure 1.3: Real-Time Fuzzy Logic Position Controlled DC Motor Drives Block Diagram

1.5 Problem Statement

Most PID controller has been apply to the dc motor control position in industry but still have a weakness that need to improve it by using fuzzy logic controller.

The weaknesses of PID controller in application are the coefficients for the PID controller are tuned in Kp, Ki and Kd are still give an effect to the minimum settling time compare with the fuzzy logic controller which is the minimum settling time can be achieved by tuning the control rules, membership functions and universe of discourse of the output variable [1].

Beside that, by tuning and obtaining stable controller through trial-and-error method is still the basic method in improving the expert knowledge toward developing a tuned and stable fuzzy controller. But, it is an attempt to acquire proof of principle experience in the fuzzy logic control and not necessarily a breakthrough research in solving the proposed problem.

1.6 Outline of Report

As an outline, chapter one will discuss the background, concept, objectives, scope and problem statement. Chapter two covers the previous research and theory of control system such as fuzzy logic controller and PID controller, microcontroller, voltage regulator, level converter, motor driver, electric motor and rotary encoder. The approach and method apply in this project are present in chapter three. The result and discussion from simulation and experiment present is discussed in chapter four. The conclusion will cover in last chapter.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss about a review of control system that are usually implemented in positioning system regarding on the previous researcher with including an example of project. Besides that, some theory on several parts of the project such as microcontroller, voltage regulator, level converter, motor driver, electric motor and rotary encoder are also mentioned.

2.1 Previous Project

This part will be mention about discussion and result from previous project. At last, there has a selection either choose fuzzy logic controller or PID controller are better. The title project is Comparison on Fuzzy Logic and PID Controls for a DC Motor Position Controller. This project was done by Paul I-Hai Lin, Santai Hwang and John Chou.

The specification of the PC-Based Position Servo which they are considering a PC-based DC motor position control (single input and single output) that will use either a PID controller or a fuzzy logic controller of the PD type. In this system, the motor angular position is to be controlled.

Both controllers are constructed based on the following basic hardware elements which are a permanent magnet dc motor, a 486-PC with 55 MHz clock, an interface card which consists of an 8-bit digital to analog converter (DAC), an 8255 programmable peripheral interface chip, an 8-bit analog to digital (ADC), a potentiometer for position feedback, a two stage preamplifier and a power amplifier. The block diagram of the system hardware is shown in figure 2.1. In addition, both fuzzy and PID control algorithms are implemented in C programming language and controllers are tuned with trial and error approach. The functions performed by both controllers are accepts user commands and reports status, reads the position feedback and calculates error, implements the transfer function and compensatory function then output the motor command.

The objectives for comparison are the maximum position error of 0.5°, no overshoot and a minimum settling time.

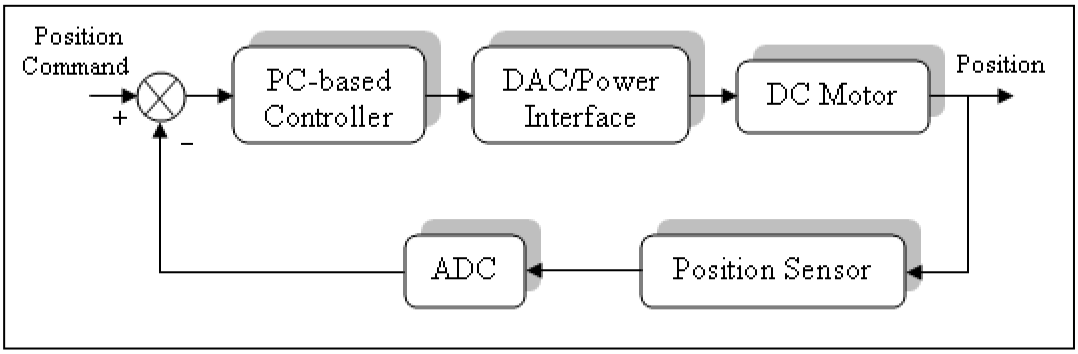


Figure 2.1: Block Diagram of the PC-Based DC Motor Positioning System

The dc motor used in the PC-based position servo is a permanent magnet dc motor with the following parameters;

Ra = 1.5 ohms, armature resistance
La = 2.3 mH, armature inductance
Kt = 0.040832 Nm/Amp, torque constant
Ke = 0.04098726 volt/rad * sec^{-1}, back emf constant
J = 4.942 x 10^{-5} kg-m^2, rotor inertia

Since Coulomb, static and viscous friction are neglected, the transfer function of the armature controlled dc motor from V to θ for position control is given as;

$$M(s) = \frac{\theta(s)}{V(s)} = \frac{\dfrac{K_t}{JL_a}}{s\left(s + \dfrac{K_e K_t}{JR_a}\right)\left(s + \dfrac{R_a}{L_a}\right)}$$

Two poles are given by;

$$\frac{K_e K_t}{R_a J} = 22.7 rad / \sec$$

$$\frac{R_a}{L_a} = 652.2 rad / \sec$$

The motor was tested under no load condition to obtain some voltage speed data. The dead zone of the dc motor is around ±1.3V. The data is shown below;

Table 2.1: Voltage-Speed Data

Motor Voltage (V)	Speed (RPM)
-5	4000
-4	2680
-3	1393
-2	812
+2.5	80
+3	450
+3.5	1307
+5	2000

An 8-bit digital to analog converter (D/A) and power amplifier provide the proper voltage levels for the dc motor. Signal amplifier stage uses two operational amplifiers to give a non-inverting voltage gain of 3.

The analog position sensor is a potentiometer with a single-turn and no rotation stops. The sensor feeds absolute position data to an 8-bit ADC (±5V, 20μs