DEVELOPMENT OF FUZZY LOGIC : TEMPERATURE CONTROLLER IMPLEMENTATION – MICROCONTROLLER BASED

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This report is submitted in partial fulfilment of the requirements for the award of Bachelor of Electronic Engineering (Industrial Electronic)

Faculty of Electronic Engineering & Computer Engineering
University Teknikal Malaysia Melaka

APRIL 2009

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek	:	Development of Fuzzy Logic : Temperature Controller Implementation – Microcontroller Based
Sesi Pengajian	:	2008/2009

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I would to dedicate this thesis to my family and somebody special,
whose encouragement and support with a great help in completing it

ACKNOWLEDGEMENT

Alhamdulillah, first of all, thanks to God with His bless, I manage to complete this Final Year Project report. I want to thank my parents for their support during this report. I also would like to thank my supervisor, Mrs Sharatul Izah Binti Samsudin for her guidance and advices during completing this project. I also want to thank the technician of PSM lab for his cooperation. Not forgetting to all of my friends as they help me by giving ideas and share their information to complete this project report especially in writing the PIC programming code. Thanks also to individuals who directly or indirectly helped me in completing my project.

ABSTRACT

Temperature is the most often-measured environmental quantity and some processes work well only within a narrow range of temperatures. Certain chemical reactions, biological processes, and even electronic circuits perform best within limited temperature ranges. One of the most important process variables to be controlled is temperature of liquid in many chemical engineering plants. In brief, changes of temperature of a water bath are one of the industrial problems needed to be controlled. This project will focus on designing a microcontroller based temperature control by fuzzy logic to control the temperature of a water bath. It will utilize a temperature sensor (LM35) to measure the temperature of the water inside the bath. This system will utilize PIC 16F877A (40 pins) microcontroller as it main processing units to accepts the analog output of the temperature sensor and processes it further for getting the actual temperature value in digital form. The microcontroller also is provided with a keypad interface and a display interface. The keypad will use to select the controller mode and to input the set point and the display interface will use to display the set point and the actual temperature of the water. This system also used a heater coil surrounding the water bath assembly to heat the water. The fuzzy logic controller used to control the water bath temperature.

ABSTRAK

Suhu merupakan kuantiti persekitaran yang paling kerap menjadi ukuran memandangkan beberapa pelaksanaan sesuatu proses hanya berjaya jika berada pada suhu yg tertentu. Ini termasuklah cecair kimia, proses biologi, malahan komponen elektronik juga hanya memberikan hasil yang terbaik pada suhu tertentu sahaja. Pemboleh ubah yang paling utama yang perlu dikawal adalah suhu cecair dalam kebanyakan loji cecair kimia. Projek ini menumpukan pembangunan bagi mencipta sebuah sistem kawalan berasaskan logic fuzzy yang mampu mengawal suhu suhu air di dalam tangki air. Sebiji komponen pengesan suhu digunakan bagi mengesan suhu semasa air di dalam tangki air tersebut. Sebiji PIC 16F877A juga digunakan sebagai komponen utama bagi menerima dan membaca keluaran analog dari komponen pengesan suhu dan menterjemahkan dalam bentuk digital. Selain itu, papan kekunci dan paparan LCD turut dibekalkan bagi melengkapi sistem kawalan-mikro ini. Papan kekunci berperanan bagi membenarkan pengguna memilih menu kawalan dan masukan nilai suhu yang dikehendaki oleh pengguna. Paparan LCD pula akan memaparkan nilai masukan suhu yang ditetapkan oleh pengguna dan suhu air sebenar yang dikesan oleh komponen pengesan suhu. Sistem ini juga dilengkapi dengan gegelung pemanas bagi meningkatkan suhu apabila perlu. Logik kawalan fuzzy pula digunakan bagi mengawal dan memastikan suhu air agar sentiasa dalam julat suhu yang ditetapkan.

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LIST OF ABREVIATIONS

PSM	-	Projek Sarjana Muda
PIC	-	Peripheral Interface Controller
PCB	-	Printed Circuit Board
I/O	-	Input and Output
A/D	-	Analog to Digital
IR	-	Infrared
DC	-	Direct Current
MOSFET	-	Metal Oxide Semiconductor Field-Effect Transistor
IC	-	Integrated Circuit
UART	-	Universal Asynchronous Receiver Transmitter
CPU	-	Central Processing Unit
BASIC	-	Beginner's All-Purpose Symbolic Instruction Code
PWM	-	Pulse Width Modulation
V	--	Voltage
LCD	-	Liquid Crystal Display
LED	-	Light-Emitting Diode
FLC		Fuzzy Logic Controller

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CHAPTER I

INTRODUCTION

Chapter I will explain about the introduction of project, problem statement, objectives, scopes of the work, and methodology that was used in the project.

1.1 Introduction to Project

This project will focus on designing a microcontroller based temperature control by fuzzy logic to control the temperature of a water bath. It will utilize 1 temperature sensor (LM35) to measure the temperature of the water inside the bath. This system will utilize PIC 16F877A (40 pins) microcontroller as it main processing units to accepts the analogue output of the temperature sensor and processes it further for getting the actual temperature value in digital form. The microcontroller also is provided with a keyboard interface and a display interface. The keyboard will use to select the controller mode and to input the set point and the display interface will use to display the set point and the actual temperature of the water. This system also used heater coil surrounding the water bath assembly to heat the water. The fuzzy logic controller used to control the water bath temperature. The software is implemented using new microcontroller PIC 16F877A with advanced.

The entire program of the system is controlled by PIC microcontroller. It is the heart of the system. It accepts the analog output of the temperature sensor and processes it further for getting the actual temperature value in digital form. The microcontroller is provided with a keyboard interface, which is used to select the controller mode and to input the set point. It allows for the operations such as increment, decrement, execute and stop required by the user. The display interface enables to display the set point and the actual temperature of the water. The microcontroller calculates the error and change in error. Then depending on the control mode selected, it uses either Fuzzy or PID algorithms from the software to generate the control signal. This control signal is in the form of PWM output.

1.2 Problem Statement

Temperature is the most often-measured environmental quantity and some processes work well only within a narrow range of temperatures. Certain chemical reactions, biological processes, and even electronic components perform best within limited temperature ranges (sensitive to high temperature). One of the most important process variables to be controlled is temperature of liquid in many chemical engineering plants. In brief, changes of temperature of a water bath are one of the industrial problems needed to be controlled.

1.3 Objective of Project

The main objectives of this project are to design a fuzzy logic temperature controller in controlling temperature of a water bath for industrial application by using PIC.

Second objective is to develop PCB circuitry of microcontroller based fuzzy logic temperature controller. Third objective is to learn about the fuzzy logic and water bath system and how to implement the fuzzy logic to design of the water bath system.

1.4 Scope of Work

The scopes of this project consist of below main parts which are:

a) Designing a fuzzy logic controller in controlling a temperature of water bath.
b) Integrate fuzzy logic controller into Programmable Intelligence Computer (PIC) basic microcontroller.
c) Develop a prototype of water bath system.
d) Integrate designed FLC (PIC) with the prototype of water bath system.

1.5 Methodology

Phase 1:-

Discussions had been done with supervisor, Mrs Sharatul Izah Bte Samsudin to show the project progress. More information gained about the temperature controller implementation of fuzzy logic from supervisor, internet, books, journal, thesis, and so on. Firstly, the concept and desired result for the system were understood. After that, the datasheet of component was collected involved such as keypad encoder (MM74C922), temperature sensor (LM35), IC and PIC 16F877A microcontroller.

Phase 2:-

For this phase, a survey had been done to the entire previous and conventional water bath system project to find the best method and for the project. Literature survey is done from journal and internet.

Phase 3:-

For this phase, the suitable circuit of the PIC, keypad encoder and fan and heater circuit that will be used to design the temperature controller implementation of microcontroller based system, had been found.

Phase 4:-

After the circuit that will be used is decided, the circuit function is simulated using the PROTEUS (ISIS 6 Professional) software. When the heater and fan circuit successfully works in the simulation, construction of the circuit is done and tested.

Phase 5:-

C language is used in developing the program coding for the system. For the programming the Micro C software is used to test the program whether it is suitable or not. If successful, the next stage is to run the programming by using the PROTEUS (ISIS 6 Professional) software to identify the functionality of the program.

Phase 6:-

At this phase, the heater circuit and fan circuit was constructed to make sure that the fan and heater circuit that decided to use is able to work before doing etching process. After completing in testing circuit on the breadboard, the drawing of the PCB layout for heater circuit, fan circuit, keypad circuit and PIC circuit is done by using PROTEUS (ARES 6 Professional).

Phase 7:-

This phase involves integrating software and hardware part to get the final result. After that, the functionality, ability & weakness of the circuit design were tested. The troubleshooting of the circuit is done if error at the hardware and software part is detected. The circuit also redesign if needed.

Phase 8:-

This phase is about the designing a casing for the system. The casing used to prevent the circuit from any damage. Finally, the submission of full report of this fuzzy logic temperature controller implementation-microcontroller based is done.

1.6 Thesis Structure

The thesis structure is related to the flow of the project. This thesis has five chapters such as introduction, literature review, research methodology, result and discussion, and conclusion and suggestion.

Chapter I explains project overview involving introduction of project, objective, problem statement, scope of work, and project methodology as to enhance readers understanding structure.

Chapter II is embracing the literature review of the project which includes the concept, theory, perspective and the method of the project that is used in order to solve the problem occurs and any hypothesis related with the research of methodology.

Chapter III covers the research methodology of the project. This chapter will discuss the methods or approaches that used in project development including in hardware and software aspect.

Chapter IV explains results and discussion in the project. It also discusses on the observation, results and the analysis of the project gain during the development of project. This chapter also consists of the recorded data analysis and the result of the project.

Chapter V is about the conclusion and suggestion of the project. Generally, the conclusion is a summary of the project and the suggestion is the recommendation for future research implement.

CHAPTER II

LITERATURE REVIEW

This chapter explains the literature review that has been studied in completing the project.

2.1 Fuzzy Logic Overview

Fuzzy logic was first proposed by Lotfi A. Zadeh of the University of California at Berkeley in a 1965 paper. He elaborated on his ideas in a 1973 paper that introduced the concept of "linguistic variables", which in this article equates to a variable defined as a fuzzy set. Other research followed, with the first industrial application, a cement kiln built in Denmark, coming on line in 1975.[3]

Fuzzy systems were largely ignored in the U.S. because they were associated with artificial intelligence, a field that periodically oversells itself, especially in the mid-1980s, resulting in a lack of credibility within the commercial domain. [3]

The Japanese did not have this prejudice. Interest in fuzzy systems was sparked by Seiji Yasunobu and Soji Miyamoto of Hitachi who in 1985 provided simulations that demonstrated the superiority of fuzzy control systems for the Sendai railway. Their ideas were adopted, and fuzzy systems were used to control accelerating, braking, and stopping when the line opened in 1987. [3]

Another event in 1987 helped promote interest in fuzzy systems. During an international meeting of fuzzy researchers in Tokyo that year, Takeshi Yamakawa demonstrated the use of fuzzy control, through a set of simple dedicated fuzzy logic chips, in an "inverted pendulum" experiment. This is a classic control problem, in which a vehicle tries to keep a pole mounted on its top by a hinge upright by moving back and forth. [3]

Observers were impressed with this demonstration, as well as later experiments by Yamakawa in which he mounted a wine glass containing water or even a live mouse to the top of the pendulum. The system maintained stability in both cases. Yamakawa eventually went on to organize his own fuzzy-systems research lab to help exploit his patents in the field. [3]

Following such demonstrations, Japanese engineers developed a wide range of fuzzy systems for both industrial and consumer applications. In 1988 Japan established the Laboratory for International Fuzzy Engineering (LIFE), a cooperative arrangement between 48 companies to pursue fuzzy research. [3]

Japanese consumer goods often incorporate fuzzy systems. Matsushita vacuum cleaners use microcontrollers running fuzzy algorithms to interrogate dust sensors and adjust suction power accordingly. Hitachi washing machines use fuzzy controllers to load-weight, fabric-mix, and dirt sensors and automatically set the wash cycle for the best use of power, water, and detergent. [3]

As a more specific example, Canon developed an autofocusing camera that uses a charge-coupled device (CCD) to measure the clarity of the image in six regions of its field of view and use the information provided to determine if the image is in focus. It also tracks the rate of change of lens movement during focusing, and controls its speed to prevent overshoot. [3]

The camera's fuzzy control system uses 12 inputs: 6 to obtain the current clarity data provided by the CCD and 6 to measure the rate of change of lens movement. The output is the position of the lens. The fuzzy control system uses 13 rules and requires 1.1 kilobytes of memory. [3]