QUADRUPLE TANK SYSTEM WITH FUZZY LOGIC CONTROLLER

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To my beloved Father, Mother, Brother, Sister and my dear friend

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ABSTRACT

This project attempts to control a quadruple tank system using fuzzy logic controllers. The quadruple tank system consists of four interconnected tanks and two valves attaches to the system. The valve 1 is attached to inlet pipe of tank 1 and tank 4, while valve 2 is attached to inlet pipe of tank 2 and tank 3. Two controllers are designed to control the level of water in the bottom tanks, tank 1 and tank 2. The first controller controls the opening of valve 1 depends on the water level in tank 1 and tank 4. The same goes to the second controller which controls the valve 2. However, the water level of tank 1 and tank 2 are not solely dependent on main inlet pipe, but they also depend on the outlet pipe of tank 3 and tank 4. Eventually, the water level of both tanks can be controlled.

ABSTRAK

Projek ini bertujuan untuk mengawal sistem empat tangki dengan menggunakan pengawal logik fuzzy. Sistem empat tangki terdiri daripada empat tangki yang saling berhubung dan dua injap yang berada pada sistem. Injap 1 terletak pada paip masukan tangki 1 dan tangki 4, manakala injap 2 pada paip masukan tangki 2 dan tangki 3. Dua pengawal dicipta untuk mengawal aras air pada tangki bawah iaitu tangki 1 dan tangki 2. Pengawal pertama mengawal bukaan injap 1 bergantung kepada aras air pada tangki 1 dan tangki 4. Perkara yang sama berlaku pada pengawal kedua yang mengawal injap 2. Walau bagaimanapun, aras air tangki 1 dan tangki 2 tidak bergantung sepenuhnya pada paip masukan utama tetapi bergantung juga pada paip keluaran tangki 3 dan tangki 4. Akhirnya, aras air pada kedua-dua tangki boleh dikawal.

TABLE OF CONTENTS

II LITERATURE REVIEW

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANFIS	–	Adaptive Neuro Fuzzy Inference System
PID	–	Proportional Integrate Derivative
NASA	–	National Aero Space Association
NTIS	–	National Technical Information Service
FL	–	Fuzzy logic
GUI	–	Graphical User Interface
FIS	–	Fuzzy Inference System
MUX	–	Multiplexer

CHAPTER I

INTRODUCTION

1.1 Introduction

In this project, two controllers are designed to control a quadruple tank system using fuzzy logic controller. The quadruple tank system is consists of four tanks which are interconnected with each other as shown in Figure 1.1. The controllers are designed to control the water level for tank 1 and tank 2 which are at the bottom of the quadruple tank system. The water level for tank 3 and tank 4, which are at the top of the system are considered to control the water level for tank 1 and tank 2.

The first controller is Controller 1 and the second controller is Controller 2. Both of this controllers used fuzzy logic to control. For the Controller 1, the inputs are water level tank 1 and water level tank 4. The water level means the height of the respective tank. Meanwhile the output is voltage 1. Controller 1 is designed to control tank 1 and tank 4.

For Controller 2, the inputs are water level tank 2 and water level tank 3. Then the output is voltage 2. Controller 2 is designed to control tank 2 and tank 3.

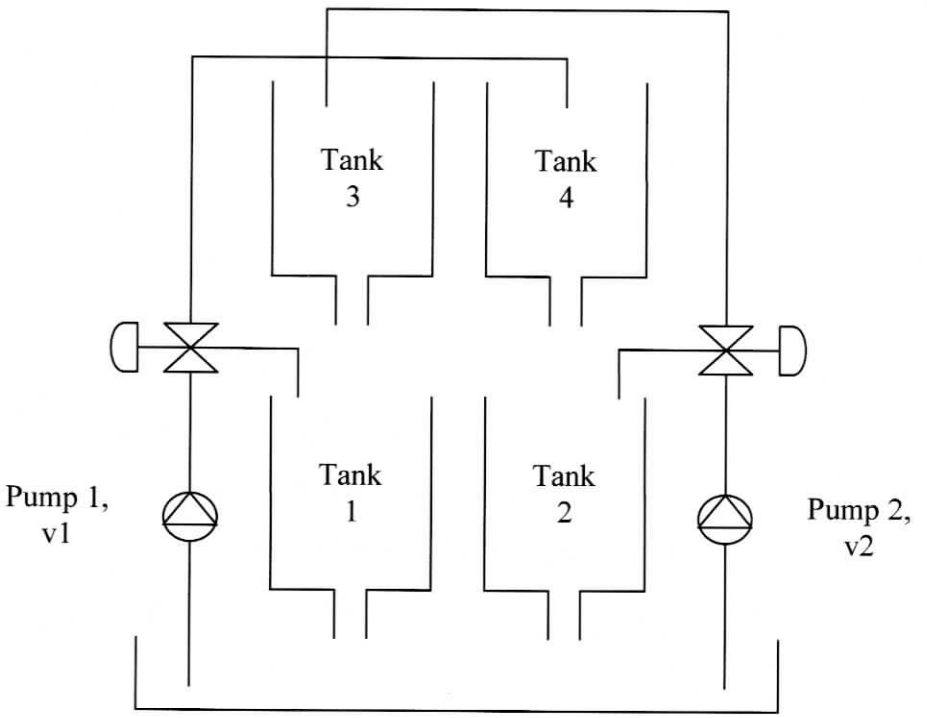

Figure 1.1 Quadruple Tank System

1.2 Objective

For this project, there are some objectives that need to be achieved. The main objective is to control the quadruple tank system by using fuzzy logic controller. There are many controllers that can be use to control the quadruple tank. In this project, fuzzy logic controller is used as the controller. Fuzzy logic controller is hugely used as the controller for many consumer products nowadays.

The other objective is to analyze and simulate the project by using MATLAB and SIMULINK software. The software is used to implement the project. After that, the output is analyzed from the results (simulation by using MATLAB and SIMULINK). All simulation are done by using this software.

1.3 Problem Statement

In this project, there are two problems that have been recognized. The first problem statement is the quadruple tank has a waste in electricity and water. The quadruple tank has four tanks that interconnected between each other. That is mean user will use more electricity to control all the tanks. When user uses more electricity, this will increases the cost for the electricity. This is because the system is power hungry. More time the user used this system, the more power being used by it. As a result, the user needs to pay more for the electricity. Other than that, by using fuzzy logic controller, user can reduce waste in electricity because the controller can reduce the power that the tanks used (electricity). This is because fuzzy logic controller can reduced the percentage of error in the system. When the system has less error, so less waste produce in it.

The second problem is not many researchers used fuzzy logic controller as the controller in the quadruple tank system. Even though fuzzy logic controller is an intelligent controller, but nobody use fuzzy logic controller as a controller in the quadruple tank system. This controller can enhance the competitive and efficiency of the quadruple tank system. Recently many products based on fuzzy logic controller such as washing machine and refrigerator.

1.4 Scope of Project

There are two scopes in this project. Firstly, inputs are water level in the tanks and output is voltage that used to control the valve. Two fuzzy logic controllers will be used in my project.

Secondly, all simulations done by using MATLAB / SIMULINK software. The fuzzy logic controller will be design in MATLAB. Then the SIMULINK block are used to integrate and implement the controllers. Finally, the output is analyzed also in MATLAB. The tanks that will be controlled are tank 1 and tank 2.

1.5 Methodology

For the methodology a flowchart is used to explain the design steps of the project. It explains about the procedures used to accomplish this project.

The important steps to complete this project are to design proper inputs and outputs, FIS (Fuzzy Inference System) and the block that can implement the function of the quadruple tank system. All the methodologies will be explained in chapter 3.

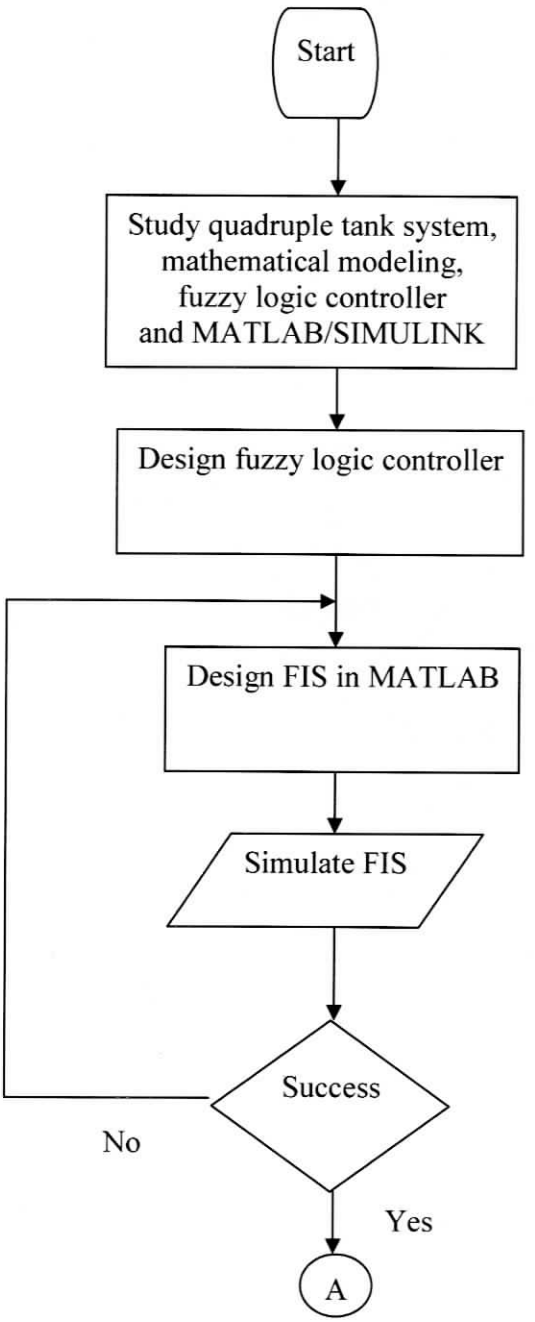

Figure 1.2 Flowchart of Methodology

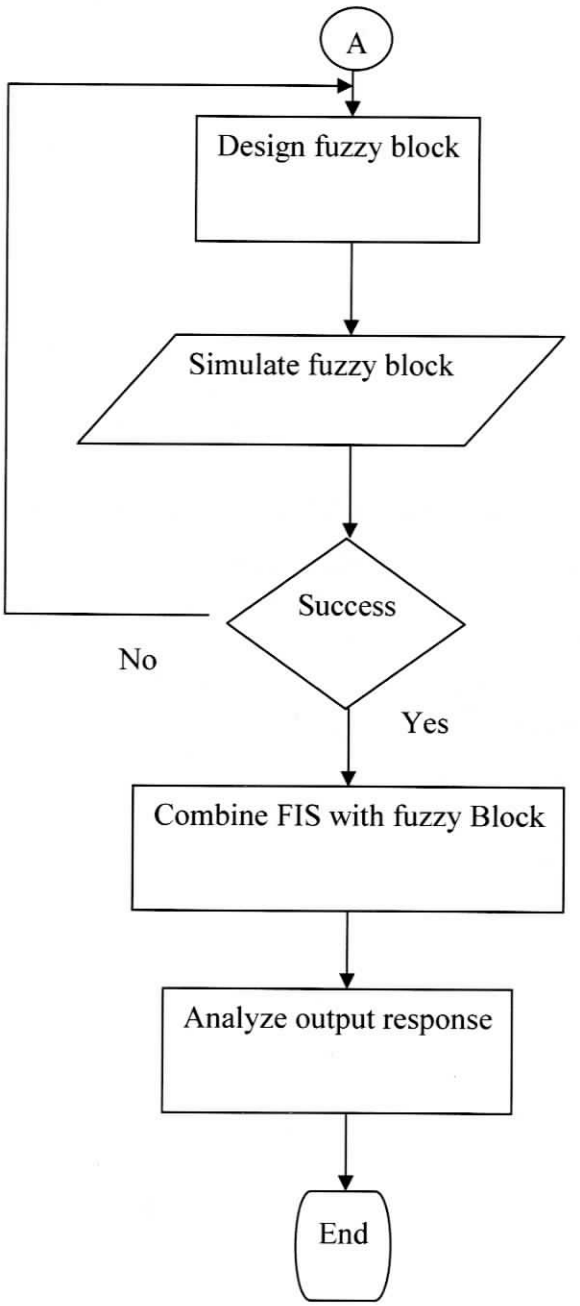

Figure 1.3 Flowchart of Methodology (Continue)

1.6 Report Structure

This thesis contains five chapters. The first chapter is about the introduction of this project. It will explain about the description of the quadruple tank system.

The second chapter is about literature review. It will explain about the theory of fuzzy logic in general, fuzzy logic controller, the application in real world and many more.

The third chapter is about the methodology of this project. It will explain about the design process. There are many methods and illustrations to show how to design the fuzzy logic controller.

The fourth chapter is about the result and discussion. This chapter explains about the result of waveforms that appeared after simulate the fuzzy logic controller.

The final chapter is about the conclusion and suggestion for this project. It will present a full summary of the project of and the suggestion to other researcher on how to improve the efficiency and accuracy of this controller.

CHAPTER II

LITERATURE REVIEW

This section will be explained about the theories to implement the system. Literature review is about the meaning and theory of the quadruple tank project. Some sub-topics are included to explain about fuzzy logic and its theory.

2.1 Definition of Fuzzy Logic

2.1.1 Introduction

The past few years have witnessed a rapid growth in the number and variety applications of fuzzy logic. The application range is from the consumer products. To understand the growing use of fuzzy logic it is necessary to clarify what is meant by fuzzy logic.

2.1.2 What Is Fuzzy Logic

Fuzzy logic is one of many intelligent controllers along with neuro-controller and knowledge based controller. Fuzzy logic can handle some form of uncertainty and imprecision makes it suitable for handling natural language rules [1]. It has been introduced by Professor Lotfi Zadeh in 1965. There are two types of fuzzy logic which is Memdani and Sugeno. In this project, fuzzy logic Memdani is used because it is easier than fuzzy logic Sugeno. Process of fuzzifying the inputs and applying fuzzy operator are exactly the same for both types of fuzzy logic. The main difference is the output membership functions are only linear or constant for fuzzy logic Sugeno type fuzzy inference [1].

Fuzzy logic has another different meaning. In a narrow sense, fuzzy logic is a logical system, which is as extension of multivalued logic. But in wider sense, fuzzy logic is almost synonym with the theory of fuzzy sets, a theory which relates to classes of object with unsharp boundaries in which membership is a matter of degree [2]. In the other word, fuzzy logic narrows the sense in a branch of fuzzy logic. The important point is, the agenda of fuzzy logic is very different both in spirit and substance from the agendas of traditional multivalued logical system.

Fuzzy logic is all about the relative importance of precision. This is about how crucial it is to be exactly right when a rough answer will do.

2.1.3 Why Used Fuzzy Logic

Here are the general observations about fuzzy logic. Firstly, the fuzzy logic is conceptually easy to understand. The mathematical concepts behind fuzzy reasoning are very simple. What makes fuzzy nice is the naturalness of its approach and not its far-reaching complexity [1].

Secondly, fuzzy logic is flexible. With any given system, it is easy to massage it or layer more functionality on top of it without starting again from scratch [1].

Next, fuzzy logic is tolerant of imprecise data. Everything is imprecise if look closely enough but more than that, most things are imprecise even on careful inspection. Fuzzy reasoning builds this understanding into the process rather than tacking it onto the end [1].

Then, fuzzy logic can model nonlinear functions of arbitrary complexity. The user can create a fuzzy system to match any set of input-output data [1]. This process is made particularly easy by adaptive techniques like ANFIS (Adaptive Neuro Fuzzy Inference System) which are available in the Fuzzy Toolbox.

Fuzzy logic can be built at the top of the experience of experts [1]. In direct contrast to neutral networks, which take training data and generate opaque, impenetrable models, fuzzy logic let us rely on the experience of people that already understand the system.

After that, fuzzy logic can be blended with conventional control techniques [1]. Fuzzy system does not necessary replace conventional control methods. In many cases, fuzzy systems augment them and simplify their implementation.