IMPLEMENTATION OF INTEGRAL CONTROL STATE FEEDBACK CONTROLLER FOR COUPLED TANK LIQUID LEVEL SYSTEM.

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Power System)

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NOVEMBER 2008

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Date : 01 NOVEMBER 2008

Dedicated to my beloved parent and friends for their support

ACKNOWLEDGEMENTS

For this two semester, I have received a lot of help and guidance from En Mohd Syakirin bin Ramli as my supervisor for this project for both practical and academic experiences. This knowledge I apply it 100 % throughout my PSM project that title Implementation of integral control state Feedback Controller for Coupled Tank Liquid Level System.

I also want to thanks to En Salmizan bin Mohd Zain because of his generosity to lend me laboratory Advantech USB DAQ card no matter day or night and also to En Hamka bin Embong that gave me authorization to use Control and Process laboratory during my PSM period.

I also want to say thank you to everybody that involved directly or indirectly to my project until it completion.

Thank you very much to all of you, all of effort that you gave to me I am very appreciate it. Thanks

ABSTRACT

This project presents the design of Integral Control State Feedback Controller to implement it at Coupled Tank Liquid Level System. By using feedback it control the liquid level in the coupled tank as required and also to understand the habit and effectiveness of Integral Control State Feedback Controller. This coupled tank is using second order system. The Integral Control State Feedback Controller is designed using pole placement method. The DAQ card is been used to interfacing between hardware and software. The software that been used are Visual Basic 6.0 (VB 6) and MATLAB.

ABSTRAK

Projek ini mengenai cara-cara untuk mereka Integral Control State Feedback Controller untuk di aplikasikan kepada penyukat ketinggian cecair tangki berkembar. Dengan menggunakan kaedah suapbalik, ia mengawal ketinggian cecair yang terdapat di dalam tanki tersebut seperti yang dimahukan dan juga untuk memahami karenah dan keberkesanan pengawal ini dengan cara mengaplikasikannya. penyukat ketinggian cecair tangki berkembar ini menggunakan system kuasa tertinggi kedua. Bagi mendapatkan Integral Control State Feedback Controller, kaedah pole placement telah digunakan. Kad DAQ juga digunakan sebagai pengantara diantara perisian dan perkakasan . Antara peisian yang digunakan sepanjang projek ini ialah Visual Basic 6.0(VB 6) sebagai pengantara muka grafik dan MATLAB untuk mengesahkan dan melakukan simulasi untuk sistem ini.

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ζ	= Damping Ration
ω_n	= Natural frequency
PID	= Propotional Integral Differential
LQR	= Linear Quadratic regulator
VB6	= Visual Basic 6
DAQ	= Data Acquisition
GUI	= Graphic User Interface

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Coupled tank liquid level system consists of double tank mounted on a reservoir for liquid storage. At the centre of the double tank, there placed a baffle to divide it into two different small tanks. At the base of each tank, there have a flow valve connected to reservoir. Each of the small tanks has water pump to pump water from reservoir. Capacitance sensor is used to detect the level of the water. To measure the liquid level a scale placed in front of the tank. This equipment widely use in the food processing and chemical industries.

Using State Feedback control system to control the level of the liquid return to the reservoir as wanted. State feedback will control the water pump so that liquid in tank 2 is maintained as required.

To connect the system and equipment, the DAQ card is used as the interface between both of them. Two software such as visual basic 6.0 and MATLAB has been used as graphic user interface and as simulation respectively.

1.2 Problem statement

Nowadays, many of countries in this world facing the same problem because of the world economy are down. So to overcome this problem, many of factories must cut cost in term of workforce to maintain the same price or to reduce the price of their product. The thing that can overtake human responsibility is a computer. But the computer can not work itself without human set the suitable program for it, so the program that been used named controller.

All equipment in this world wanted to be automatically operated without human attendant. So to do this, we must use a controller, so that the machine or equipment can run itself according to what we want. To do this we must have a medium to control it so that it can run automatically. Normally controller such as PID and Fuzzy Logic are widely used to control many of the instrument or machine, but in this project the controller that have been used is Integral Control State Feedback Controller.

The Integral Control State Feedback Controller will control the liquid level at tank 2 at real time. This plant system are in second order system and the Integral Control State Feedback Controller will be derived directly from the plant using pole placement method, by using this method we can not manipulate anything of the controller value that we get. It is different between PID or LQR controller because it can simply be tuned to get the result as desired.

We need continuous data from the plant as the feedback, so to overcome this problem an Advantech DAQ card have been used as the interfacing between the hardware and software.

1.3 Objectives

The objectives of the project are as following:

- Able to control Coupled Tank Liquid Level Using Integral Control State Feedback Controller.
- Able to understand the State Feedback control system.
- Able to compare result between experiment and simulation.

1.4 Scope of The Project

- Generally
  - Implement controller using VB on coupled tank water level system
- Software
  - Create GUI using Visual Basic 6.
  - Using MATLAB to verify modeling.
- Hardware
  - Communication between DAQ card, Software and equipment.
  - Assemble the coupled tank until it working.

1.5 Summary

This section is all about the overall project and explains the objectives as well as the scope of the project in order to give an insight and idea of the project. On the next chapter will discuss about the literature review about this controller but use at different plant and also same plant but with different controller.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter will discuss about usage of this controller but at different system or plant and also same system or plant with different controller and also about the DAQ card itself.

2.2 Coupled Tank liquid level system

The scope of coupled tank liquid level system is widely used, in term of process it can process any liquid rather than only can process water. This coupled tank liquid level system widely used at process industries for example in a fertilizer plant, the level of the solution and the pressure of the solution and the pressure of the evaporator have to be controlled in order to get the required concentration[1]. In order to do this, the plant must be controlled either single input single output (SISO) or multi input multi output (MIMO) [1]

2.3 Controller

There are various controllers that can be used to control this coupled tank such as Fuzzy logic and PID controller [2]. As known, the integral state feedback is one of the modern controller [3] same like LQR controller. The different between these two methods is way to determine it coefficient (K). Pole placement is one method than can determine the value of coefficient (K) for state feedback controller. The word integral means, the integral function will be put at the last of the controller system. Many of process plant using conventional controller or old controller as mention before so by using integral state feedback as controller for this plant, the advantages and disadvantages between conventional controller and modern controller can be determine.

2.4 Hardware and Software

The DAQ card will be used as communication between computer and coupled tank. Visual Basic 6 as GUI is used to help user define or put the desire value for the controller as they wanted and read the visual result [4]. Other software may be used as interface such as Labview, BASIC, Java and MATLAB [4]. This DAQ card used for switch either analog input or output to digital input or output or vice versa [4].

2.5 Summary

Literature reviews have been interpreted using different part. The first part introduce the coupled tank itself about where it is widely been used and also suggest about how to advancing this coupled tank. The second part tell about the controller that been used in this project and some of the comparison between this controller with other controller. The last part of this literature review tells about the hardware and software that was used to interface the system that placed outside computer with the controller that placed inside the computer.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter explain about what is the method that has been used to complete this project. This project used liquid level plant that have been simplify from what have been use world wide. This project use coupled tank liquid level system CTS-001 that has been provided at UMP laboratory. This CTS-001 has two tanks but the tank that will be control it liquid level is tank two. To control this tank we manipulate the speed of pump one using Integral Control State Feedback Controller to obtain the desired level. Both input and ouput from plant to computer will be interface using Advantech DAQ card, the input value is from the capacitance sensor that detect the liquid level and the output is the voltage that been given to the pump that been control by controller. This plant will operate in real time. The software that been used to implement this controller is Visual Basic 6.

3.2 Project flow chart

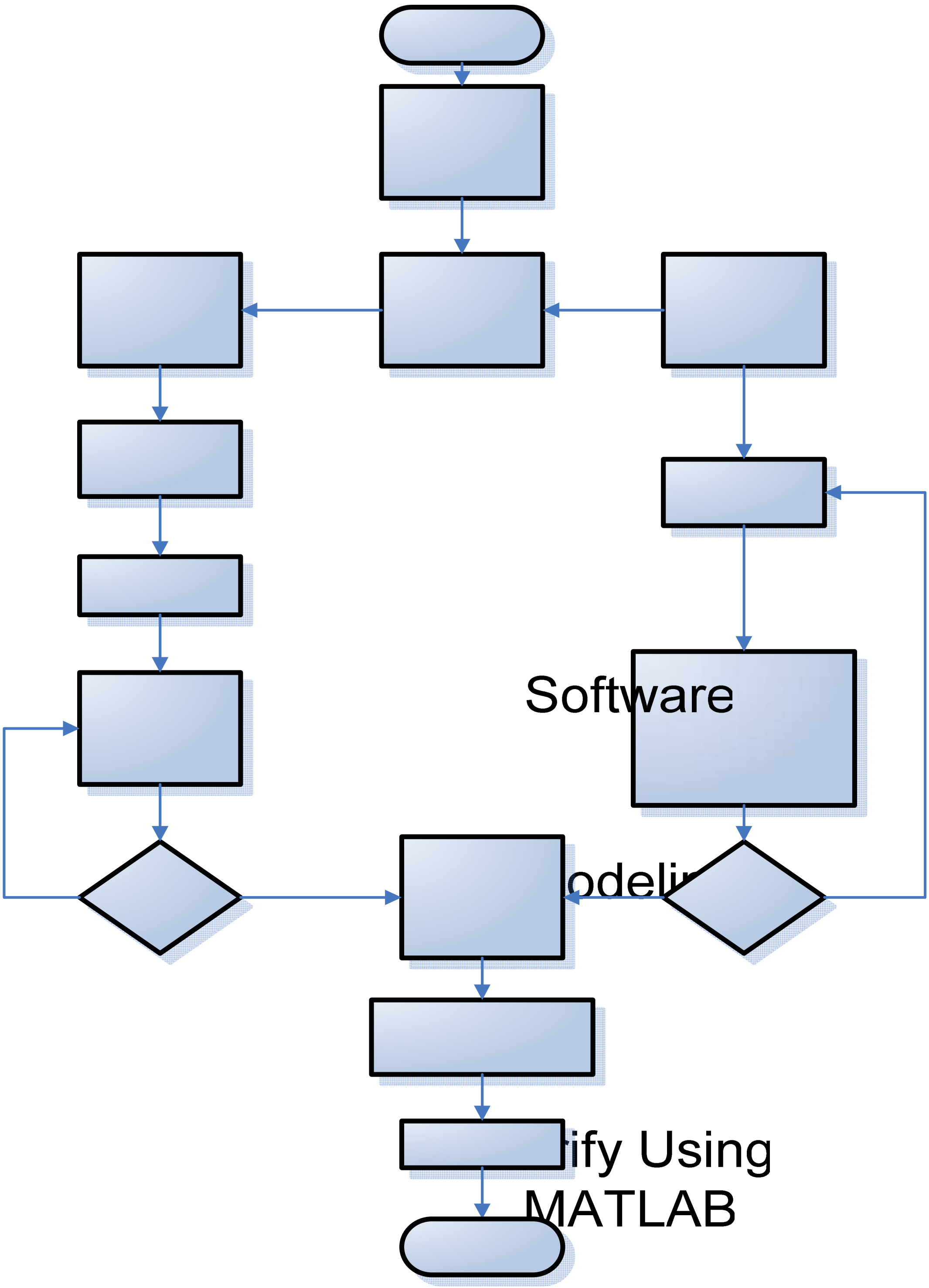

Figure 3.1 Flow chart for software and hard ware development

Design GUI

Integrate

Figure 3.1 show about the overall progress for both software and hardware development that will be discuss later. For the software part, modeling for the controller must be obtain and verify it with MATLAB before it can be implemented in Visual Basic 6 as GUI. MATLAB also has been used to run this plant simulation. For the hardware part, the plant that is coupled tank liquid level will be assemble because this plant did not been use for long period, any pipe or valve that can not work must be replace with the new one. After finish with the plant, a simple communication must be done between plant and computer using DAQ card, the DAQ card itself must be analyzed to make the interfacing easier. Both operations at this point need to refer them manual respectively.

After both part software and hardware have done and do not have problem, both of them must be integrated in order to test the designed controller. At this point, the simulation result that has been tested using MATLAB must be compared with the real time result. If there are some errors or miscalculation, troubleshooting was performed to obtain better result.

3.3 Mathematical Modeling

Mathematical model for this plant can be obtained by referring CTS-001 manual book that been provided with this plant. The mathematical model that we need in design this controller is in state space form that also can be determined in this CTS-001 manual book. The input and output general equations for this system are:

$$\dot{x} = Ax + Bu \qquad \text{................ (3.1)}$$

$$y = Cx + Du \qquad \text{................ (3.2)}$$

The state space for this system is:

$$\begin{bmatrix} \dfrac{dh_1}{dt} \\ \dfrac{dh_2}{dt} \end{bmatrix} = \begin{bmatrix} -\dfrac{1}{T_1} & \dfrac{k_{12}}{T_1} \\ \dfrac{k_{21}}{T_2} & -\dfrac{1}{T_2} \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} \dfrac{k_1}{T_1} & 0 \\ 0 & \dfrac{k_2}{T_2} \end{bmatrix} \begin{bmatrix} q_1 \\ q_2 \end{bmatrix} \qquad \text{................ (3.3)}$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + 0 \qquad \text{................ (3.4)}$$

The value of each value from equation 3.3 is derived by:

$$T_1 = \frac{A_1}{\dfrac{\alpha_1}{2\sqrt{H_1}} + \dfrac{\alpha_3}{2\sqrt{H_1 - H_2}}} \qquad \text{................ (3.5)}$$

$$T_2 = \frac{A_2}{\dfrac{\alpha_2}{2\sqrt{H_2}} + \dfrac{\alpha_3}{2\sqrt{H_1 - H_2}}} \qquad \text{................ (3.6)}$$

$$k_1 = \frac{A_1}{\dfrac{\alpha_1}{2\sqrt{H_1}} + \dfrac{\alpha_3}{2\sqrt{H_1 - H_2}}} \qquad \text{................ (3.7)}$$