"I hereby declared that I have read through this report and found that it was complying the partial fulfillment for awarding the Degree of Bachelor In Electrical Engineering (Industrial Power)".

Signature : ....

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WATER LEVEL CONTROL SYSTEM: TWO TANK

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"I hereby declared that this report is a results as my own work except for the excerpts that have been cited clearly in the references ".

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Date : 4TH MAY 2006

Dedicated to my lovely family for providing moral support and encourage.

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Firstly I want to give grateful respect to Allah SWT the Mighty that gave me strength to complete this report on time, without His blessed I might not complete this report on time. Also thanks to my supervisor, Pn. Azrita binti Alias with his patient to guide me always through the process to make this project and report. To all lecturers and technician of KUTKM that involved because all of the helps and advices that had been given to finish my project in order to make sure this project will show as expected result. Thanks a lot to my parents that gave me morale support and also give me strength not to give up. And lastly, to my course mate and friends because of the support, strength, helps and advices that had been given to me during the process of completing the progress report. I really appreciate what you guys had done to me and only God can pay it back.

Thank you.

ABSTRACT

This report present about analysis of water level control system using two tanks. Type of the tank is Coupled Tank CTS-001. The objective of this project is to study about "the coupled tank manual", open loop and closed loop system, transfer function of the system, first order and second order system, and the controller. Then collect the data from coupled tank CTS-001 to determine mathematical modeling of coupled tank for first order and second order system to get the transfer function. After that, make simulation using MATLAB to get the output response from the transfer function for first order and second order system. It also to get the open loop output response. Then design the controller.

ABSTRAK

Laporan ini mengenai analisis tentang sistem kawalan paras air dengan menggunakan dua tangki iaitu jenis 'Coupled Tank CTS-001'. Objektif projek ini adalah untuk mengkaji tentang dua tangki(coupled tank) menggunakan manual dua tangki, gelung terbuka dan gelung tertutup sistem, fungsi pindah sistem, peringkat pertama dan peringkat kedua sistem, dan pengawal. Kemudian mengumpulkan data daripada dipadankan tangki CTS-001 untuk menentukan pemodelan matematik yang dipadankan dengan tangki untuk peringkat pertama dan peringkat kedua sistem mendapat fungsi pemindahan. Selepas itu, simulasi menggunakan MATLAB dibuat untuk mendapat pengeluaran sambutan daripada pemindahan berfungsi untuk peringkat pertama dan peringkat kedua sistem. Ia juga bagi mendapatkan gelung terbuka pengeluaran sambutan. Seterusnya reka sistem pengawal.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This proposed project is about design a water level control system for two tank system. It consists of subsystems and processes (or plant) assembled for the purpose of controlling the output of the process. In this process, subsystems called of water level control are used to regulate the water level of the two tank system by controlling the controller system. The level of the water in the measuring tank could be used to tell level. This two tank system had to keep at a constant level.

Collect data from the CTS-001 software and the real value from the tank to make analysis about coupled tank. These projects are already axis using CTS-001 software (simulation and real time).

CTS-001 is a computer-controlled coupled-tank system used for liquid level control. The concept of virtual instrumentation is introduced in CTS-001. Instead, the computer can be used to provide the interface normally required on each of the individual instruments, reducing cost and complexity. The software performs data acquisition, data storage, graphical representation and control of system parameters. The coupled tank apparatus that will use in this project is coupled tank CTS-001 as a liquid level control system

Actually MATLAB is using to test the transfer function to get the output response. MATLAB related links, tools, libraries, and resources for scientists and engineers. The MATLAB is the worlds leading developer of technical computing software for engineers and scientists in industry, government, and education. They cover the basics of Matlab, the most common classical control design techniques (PID, root locus, and frequency response), as well as some modern (state-space) control design.

1.2 Objective

The important thing should to do is to become familiar with the main components of the coupled-tank control apparatus and estimate the important system parameters. So the objectives are:

(a) To study about the coupled tank manual to become familiar with the main components of the coupled tank and how to use the coupled tank.

(b) To review on open loop and closed loop system, transfer function of the system, first order and second order system, and the controller

(c) To collect data using coupled tank CTS-001 software and to get the transfer function of first order and second order system.

(d) This project to determine mathematical modeling of coupled tank for first order and second order system.

(e) After that, using MATLAB/simulink software the transfer function will be test. It's because to get the output response from that simulation.

(f) To design a controller to satisfy the desired performance. Choose the best controller to use like PID controller.

(g) Analyze the results from first order and second order system, closed loop and open loop system, and write the thesis

1.3 Problem Statement

Usually, level control exists in some of the control loops of a process control system. Actually, in industries department they have more than one the shape of coupled tank. Examples of coupled tank are already use in industries are in figure 1(a) and figure 1(b) below.

Level control is also important for mixing reactance process. So to keep quality of the product, water level control system using two tank systems is suitable to control the quality of reactance process to ensure that the quality is maintained.

Besides that, to control the water level in two tanks system using MATLAB simulation for interacting tanks. Actually in this project, MATLAB is used to test the transfer function to get the output response.

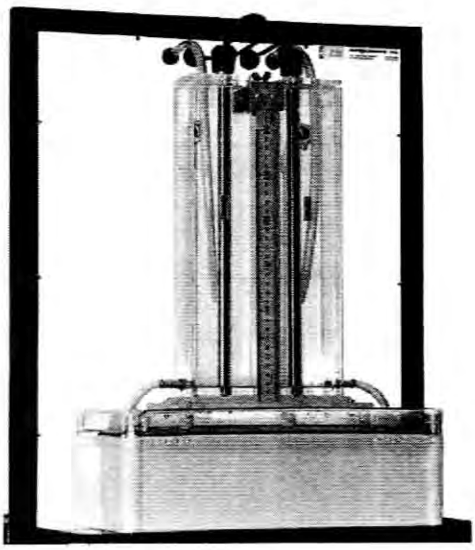

Figure 1(a): Coupled-tank control apparatus Model PP-100

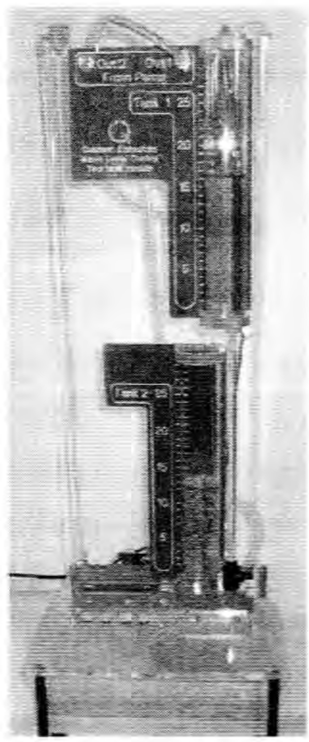

Figure 1(b): Coupled Water Tanks

1.4 Project Scopes

Collect all data from coupled tank using CTS-001 software for first order and second order systems to analyze the coupled tank. Then determine the mathematical modeling of first order and second order system. Also to analyze the transfer function that has been obtained from first order and second order system.

Make simulation and real analysis about the process of the system will be used from the CTS-001 software system and coupled tank liquid level computer-controller. For this time more to make analysis with real analysis. From collecting data, analyse the results of the coupled tank for first order and second order. See the result either same or not same between those results and compare with simulation using MATLAB results. Actually the process are mostly used to make analysis is real process. It is because more efficient and easy to understand.

CHAPTER 2

LITERATURE REVIEW

2.1 Open Loop System

Those systems in which the output has no effect on the control action are called open loop control system [2]. An input transducer that converts the form of the input to that used by the controller is called a subsystem. The controller drives a process or plant. The input is call reference while the output can be called the controlled variable.

Open loop control can be used in practice only if the relationship between the input and output can be known and if there are neither internal nor external disturbances [2]. The system is no feedback control system. Any control system that operates on a time basic is open loop. Figure 2.1(a) show the block diagram of open loop control and more relate to coupled tank and 2.1(b) show the basic/example of block diagram of open loop system.

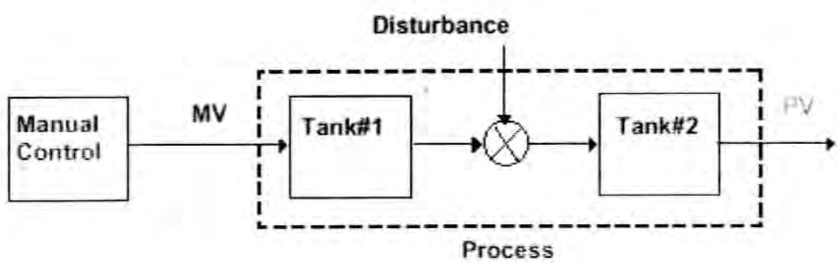

Figure 2.1(a): Block diagram of open loop control

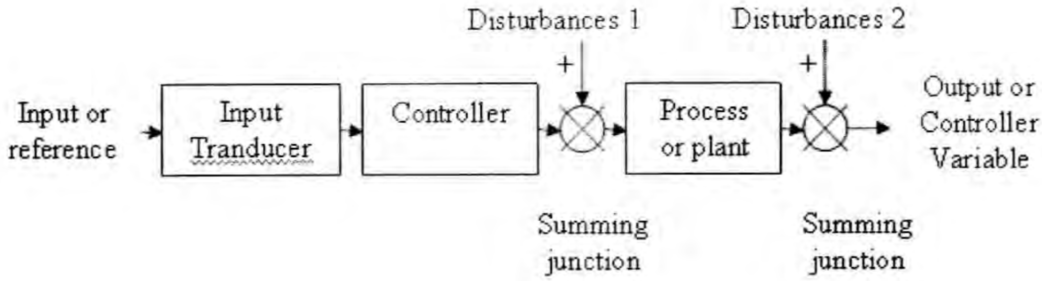

Figure 2.1(b): Example of Block diagram of open-loop system

In industrial control, wish to set the process variable (PV) to some desired set point profile by adjusting the manipulated variable (MV). On the coupled tank apparatus, the MV is the input flow rate (through the pumps). The process may be subject to disturbances e.g. a change in water outflow or a change in the second pump inflow [3].

The process variable should track the set point both dynamically and at steady state. If the set point is constant, this is called the regulation problem. If the set point varies, this is called the servo problem. Furthermore, we would like to achieve this tracking of the set point even if there are plant load changes or disturbances. A disturbance can be emulated by changing the flow of water into the second tank. Naturally, we also need a stable response. The MV is set to a value which the human operator estimates will yield a PV at the desired set point [3].

2.2 Closed Loop System

The input transducer converts the form used the controller. An output transducer, or sensor, measures the output response and converts it into the form used by the controller. The closed-loop system compensates for disturbances by measuring the output response, feeding that measurement back through a feedback path, and comparing that response to the input at summing junction.

An advantages of the closed-loop control system is the fact that the used of feedback makes that the system response relatively insensitive to external disturbances and internal variations in system parameters [2]. The basic of block diagram of closed-loop system are shows in figure 2.2 below:

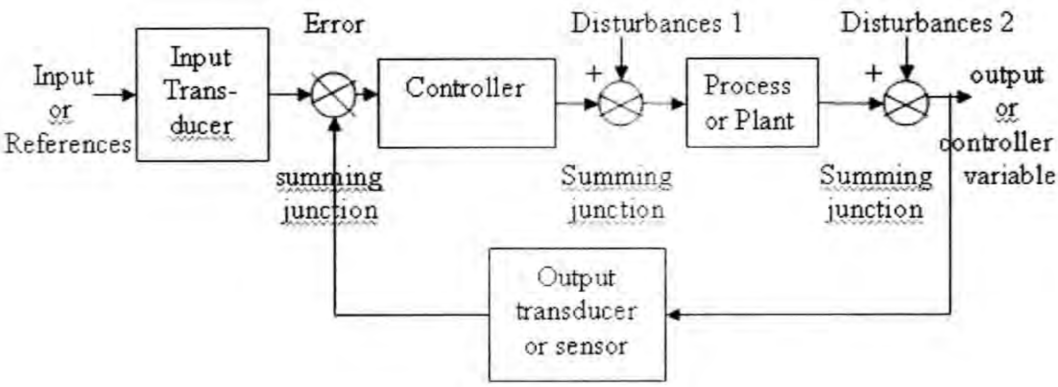

Figure 2.2: Example of block diagram of closed-loop system

2.3 The Transfer function

Transfer functions are commonly used to characterize the input-output relationships of components or system that can be described by linear, time-invariant, and differential equation. The transfer function approach however is extensively used in the analysis and design of such systems.

The transfer function can be represented as a block diagram, with the input on the left, the output on the right, and the system transfer function inside the block [1].

$$C(s) = R(s) \cdot G(s) \quad (2.1)$$

The transfer function of a system is a mathematical model in that it is an operational method of expressing the differential equation that relates the output variable to the input variable [2].

If the transfer function of a system is known, the output or response can be studied for various forms of inputs with a view toward understanding the nature of the system. If the transfer function of the system is unknown, it maybe established experimentally by introducing known inputs and studying the output of the system [2].

Poles of a transfer function is the value of Laplace transform variable, s that cause the transfer function to be come infinite; or any roots of the denominator of transfer that are common to roots of numerator.

Zeros of a transfer function is value of the Laplace Transform variable, s that cause to become zero; or any roots of numerator of the transfer function that common to roots of denominator.

2.4 The Design Process

To design the process are follow the steps below and it show also in figure 2.3.

Step 1: Transform Requirements into a Physical System

Step 2: Draw a Functional Block Diagram

Step 3: Create a Schematic

Step 4: Develop a Mathematical Model (Block Diagram)

Step 5: Reduce the Block Diagram

Step 6: Analyze and Design

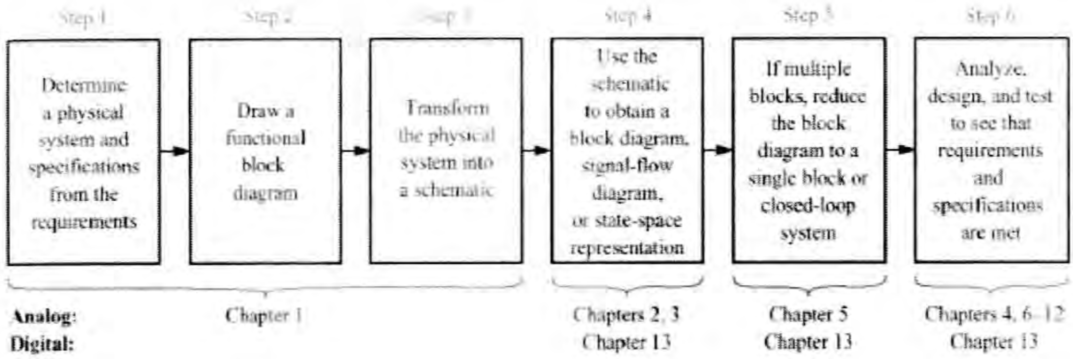

Figure 2.3: The step of design process [1]

2.5 First Order System

This system may represent an RC circuit. A simplified block diagram is shown below:

$$\frac{C(s)}{R(s)} = \frac{1}{Ts+1} \tag{2.2}$$

In the following, analyze the system responses to such input as the unit-step, unit-ramp, and unit-impulse functions. The initial conditions are assumed to be zero [2].

For Unit-Step Response of First Order Systems the Laplace transform of the unit step function is 1/s, substituting R(s) = 1/s into equation below [2]:

$$C(s) = \frac{1}{T(s)+1}\frac{1}{s}$$

$$C(s) = \frac{1}{s} - \frac{T}{Ts+1} = \frac{1}{s} - \frac{1}{s+(1/T)}$$ Expanding C(s) into partial fraction

$$c(t) = 1 - e^{-t/T}, t \geq 0$$

$$c(T) = 1 = e^{-1} = 0.632$$

(2.3)

The graph for unit-step response of first order systems is shown in figure 2.4 below:

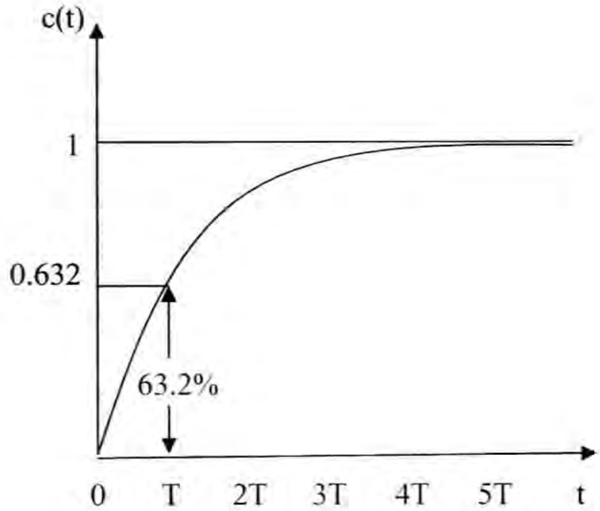

Figure 2.4: Graph for Unit-Step Response of First Order Systems

For Unit-Ramp Response of First Order System the Laplace transforms of the unit-ramp function is $\frac{1}{s^2}$, the output of the system as below [2]:

$$C(s) = \frac{1}{Ts+1}\frac{1}{s^2} \tag{2.4}$$

Expanding C(s) into partial fractions gives

$$C(s) = \frac{1}{s^2} - \frac{T}{s} + \frac{T^2}{Ts+1} \tag{2.5}$$

taking the inverse Laplace Transform, we obtain

$$c(t) = t - T + Te^{-t/T}, t \geq 0 \tag{2.6}$$

The error signal e(t) is then

$$e(t) = r(t) - c(t)$$
$$e(t) = T(1 - e^{-t/T}) \qquad (2.7)$$

The graph for unit-ramp response of first order system is show in figure 2.5 below:

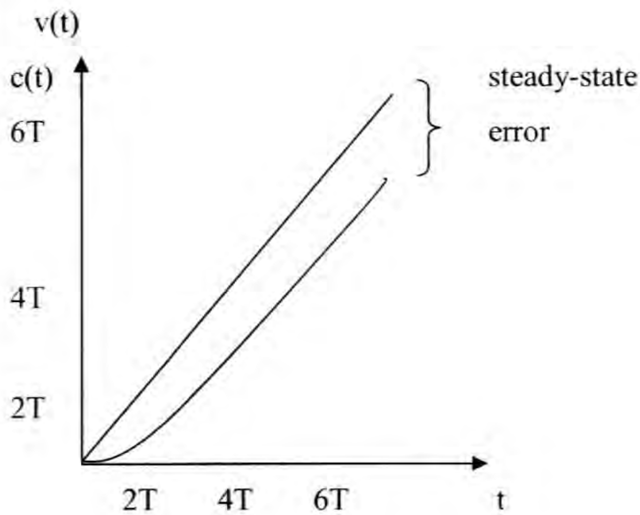

Figure 2.5: Graph for Unit-Ramp Response of First Order System

For Unit-Impulse Response of First Order System, the unit impulse input, R(s) = 1 and the output of the system is [2]

$$C(s) = \frac{1}{Ts + 1} \qquad (2.2)$$

The inverse Laplace transform gives

$$c(t) = \frac{1}{T} e^{-t/T}, t \geq 0 \qquad (2.8)$$

The response curve given in graph for unit-impulse response of first order system in figure 2.6 below: