Open Tank Level Control System and Controller Comparison Study

by

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Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Electrical and Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Electrical & Electronics Engineering Programme
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TRONOH, PERAK

June 2004

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(JEFFERI BIN KAMARUDIN)

ABSTRACT

The control system to be improved is an open tank level control system designed by previous Final Year Project student. The previous control system utilized a local PI controller and did not have any safety features. This improvement project involves connecting the plant to a distributed control system, and safe guarding and interlocking features such as tank overflowing prevention and pump interlock.

In designing the control system, both experimental and simulation methods were used. After the project is completed, the plant is intended to be used by students to allow them to have a better understanding of process control and implementation of a distributed control system.

The author was successful in developing a remotely automated open tank level control system, carrying out SIMULINK simulations and carrying out controller comparison studies. Thus achieving all objectives set by the author.

Additional interlocks and protective devices were implemented and installed to protect the equipment from damage and minimize danger to the operator. The DCS pages allow for the user to monitor, control the process and provide the user with guidelines on how to tune PID controller and to obtain the process model.

After performing MATLAB simulations of the control system and comparing the performance of the PI controller and Fuzzy PI controller, the author can conclude that there are significant improvements in the process response of a open tank water level control system when a Fuzzy PI controller is used.

ACKNOWLEDGEMENTS

The author would like to take this opportunity to thank all parties who were directly or indirectly involved in making this final year project a success. Deepest gratitude goes to UNIVERSITI TEKNOLOGI PETRONAS's staff, for their support and patience in providing quality education, throughout the duration of the project. The author would also like to thank the following for their professionalism and selfless sharing of knowledge throughout the duration of the project.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

This improvement project is based on work done by previous Final Year Project (FYP) student. The existing level control system consists of a single closed loop feedback system which is used to regulate the water level in an open tank. The equipment currently used are valves, transmitter, local Proportional Integral Derivative (PID) controller and pump. The disturbance introduced into the system is through a hand valve located below the tank. Based on his findings, Ziegler Nichols controller tuning methods produced the best controller, these controller parameters where then implemented and used by the system.

1.2 PROBLEM STATEMENT

Previous work done by FYP student on an open tank level control system did not feature any remote control of the plant nor did it have any safeguarding and interlocking features. Therefore the author aims to improve this project to provide other students with a simple experiment in the instrumentation and control laboratory which can be used as a study module. This will enable the student's to experiment with the Distributed Control System, controller parameters, learn to interpret Piping and instrument diagram's, troubleshooting etc.

1.3 OBJECTIVES

1. To develop a remotely automated open tank level control system.
2. To carry out control system simulations using SIMULINK.
3. To carry out comparison study between PI controller and Fuzzy PI controller.

1.4 SCOPE OF STUDY

1. To develop a control strategy to maintain the water level in an open tank. The control system is to use level sensor, controllers, pump and control valve as its final control element.
2. The controllers of interest are conventional PID controllers and intelligent controllers such as Fuzzy Logic Controllers.
3. To implement Distributed Control System to allow for remote control of the system.
4. Obtaining the systems model to help in carrying out simulations to assist in determining the performance of the two different controllers.
5. To install local display panel on pilot plant to allow for emergency shutdown of plant through push button and to view status of pump.
6. To develop a manual to assist students in familiarizing themselves with the Honeywell Plantscape set-up.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION TO FUZZY LOGIC CONTROLLER

Fuzzy logic was first introduced by Professor Lotfi Zadeh in 1965. After 1991 fuzzy technology came out of scientific laboratories and became an industrial tool. The inference engine is the heart of a fuzzy controller. Its actual operation can be divided into three steps:

- Fuzzification – actual inputs are fuzzified and fuzzy inputs are obtained.
- Fuzzy processing – processing fuzzy inputs according to the rule set and producing fuzzy outputs.
- Defuzzification – Producing a crisp real value for a fuzzy output.[8]
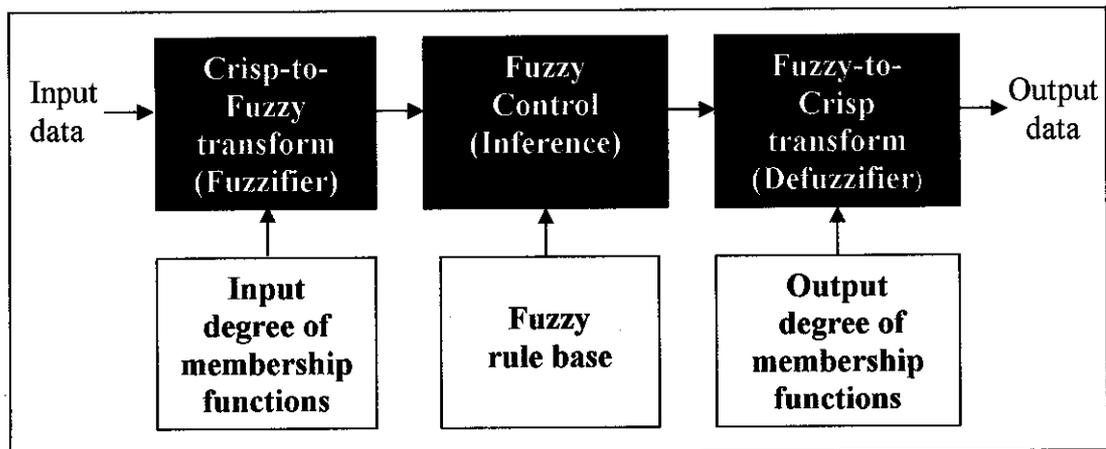
Figure 2.1: Fuzzy rule-based system can be broken down into 3 stages

There are two inference process methods currently used in the industry, namely Mamdani and Sugeno. However, the Mamdani's fuzzy inference method is the most commonly seen fuzzy methodology. The following table lists the similarity, differences and advantages of the two methods.

Table 2.1: Mamdani versus Sugeno[8]

	Mamdani	Sugeno
Similarity	• The antecedent parts of the rules are the same	
Difference	• The consequent parts are fuzzy sets	• The consequent parts are singletons (single spikes) or mathematical functions of them
Advantages	• Easily understandable by a human expert. Simpler to formulate rules • Proposed earlier and commonly used	• More effective computationally. More convenient in mathematical analysis and in system analysis. Guarantees continuity of the output surface.

2.1.1 Limitation of conventional controllers[8]

1. Plant nonlinearity. The efficient linear models of the process or the object under control are too restrictive. Nonlinear models are computationally intensive and have complex stability problems.

2. Plant uncertainty. A plant does not have accurate models due to uncertainty and lack of perfect knowledge.

3. Multivariables, multiloops and environment constraints. Multivariate and multiloop systems have complex constraints and dependencies

4. Uncertainties in measurements. Uncertain measurements do not necessarily have stochastic noise models.

5. Temporal behavior. Plants, controllers, environments and their constraints vary with time. Moreover, time delays are difficult to model.

2.1.2 Benefits of fuzzy controller[8]

1. Fuzzy controllers are more robust than PID controllers because they can cover a much wider range of operating conditions than PID can, and can operate with noise and disturbance of different natures.

2. Developing a fuzzy controller is cheaper than developing a model-based or other controller to do the same thing.

3. Fuzzy controllers are customizable, since it is easier to understand and modify their rules, which not only use a human operator's strategy but also are expressed in natural linguistic terms.

4. It is easy to learn how fuzzy controllers operate and how to design and apply them to a concrete application.

2.2 HONEYWELL PLANTSCAPE PROCESS

The Distributed Control System being used to achieve the author's objectives is the Honeywell PlantScape Process. Plantscape process is a cost-effective, open-control system, which is suited for both small and large systems, and includes the PlantScape Hybrid Controller. It provides the power and flexibility required to handle the full spectrum of process control applications. The DCS architecture currently being used at the instrumentation and control laboratory is shown in Figure 2.2.
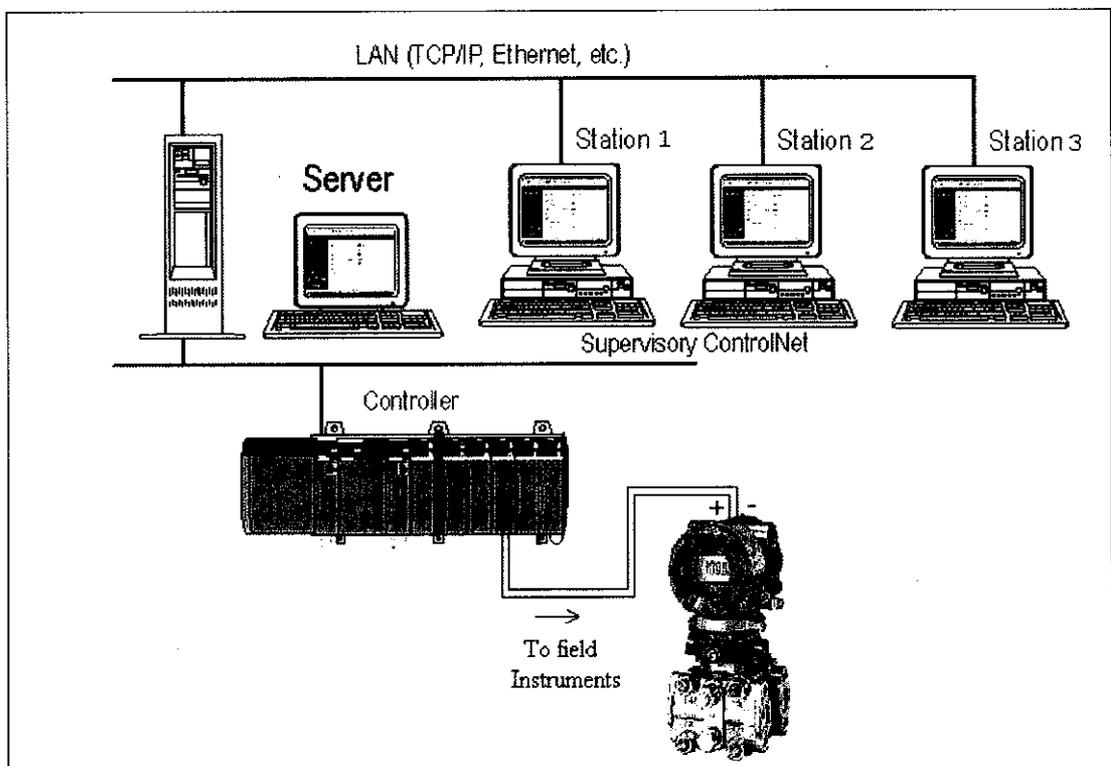
Figure 2.2: Plantscape Process Instrumentation and Control Laboratory DCS Architecture

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2.3 OBTAINING THE PROCESS MODEL

2.3.1 Empirical Modelling

The author has decided to use the process reaction curve for identifying the dynamic model of the system. Although it is simple to perform it provides adequate models for many applications.[2] There are two different graphical techniques used method I and method II. The author plans to use method II as method I has larger errors in the parameter estimates. This is due to the difficulty involved when evaluating the slope, especially when the signal has high-frequency noise. The steps involved when identifying the dynamic model of the system is as follows:

1. Allow the process to reach steady state
2. Introduce a single step change in the input variable
3. Collect input and output response data until the process gain reaches steady state.
4. Perform the graphical process reaction curve calculation as shown in figure 2.3.

$$G_{FODT}(s) = \frac{Ke^{-\theta_D s}}{\tau_1 s + 1}$$

$$y(t) = K\left(1 - e^{-(t-\theta_D)/\tau_1}\right)$$

$$K = \frac{\Delta PV}{\Delta MV}; \qquad \tau_1 = 1.5(T_4 - T_3); \qquad \theta_D = T_4 - \tau_1 - T_1$$
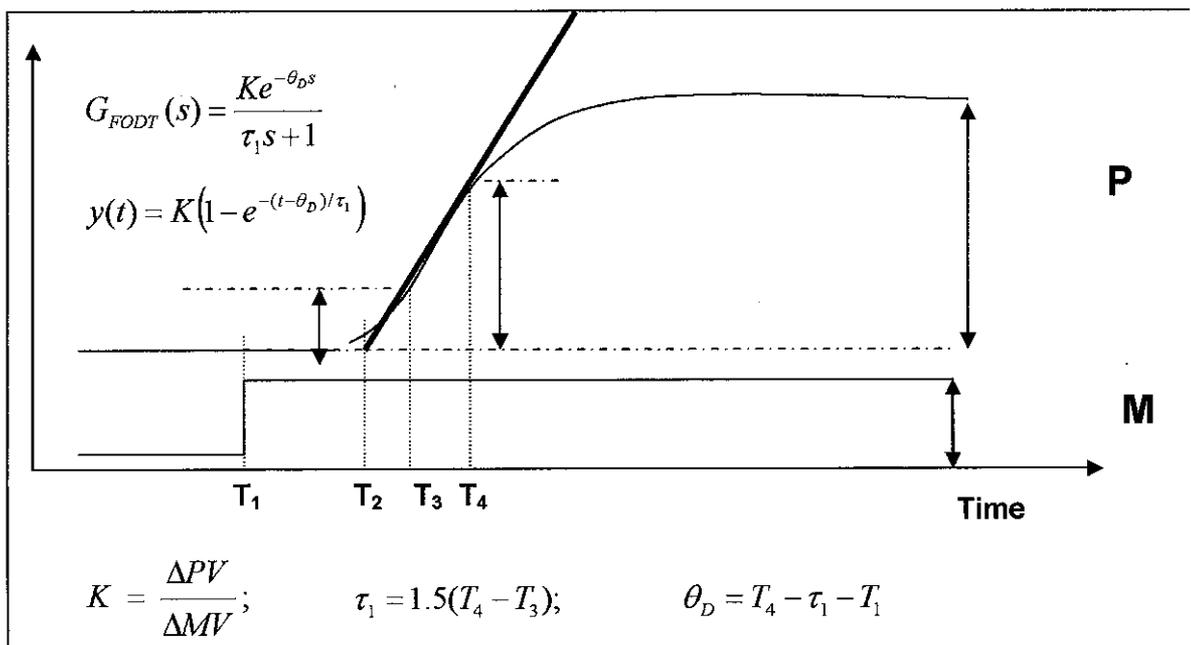
Figure 2.3: Process Reaction Curve

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2.3.2 Mathematical Modelling

The process model can also be obtained through mathematical modelling. Mathematical modelling of a process can be defined as a system of equations whose solution, given specific input data, is representative of the response of the process to a corresponding set of inputs. (Denn, 1986).

The model of the process obtained through this method is based on fundamental laws and theories such as the conservation of mass. The reason for choosing a fundamental model in understanding the physical system are the analytical expression it provides relating key features of the physical system (flow and volume) to its dynamic behaviour and its simplicity.

The block diagram above shows the level control system of interest. It is a single closed-loop feedback system. The system designed needs to maintain the operators desired liquid level when a continuous out flow occurs in the tank. Feedback control strategy is used to rectify, achieve and maintain the desired set point.
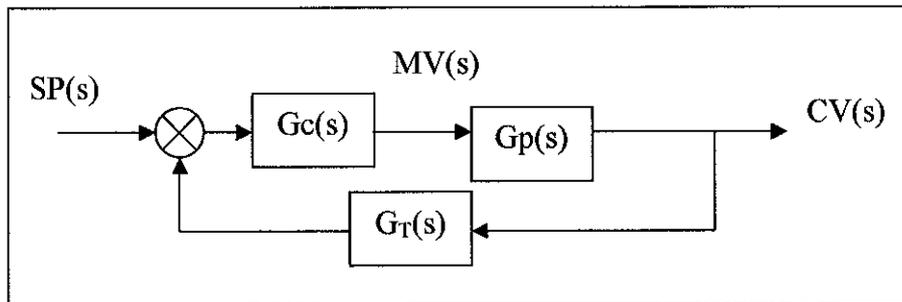
Figure 2.4: Feedback Control System Block Diagram

In carrying out mathematical modelling, all the elements that make up the level control system must be considered in the modelling. The block diagram shown in figure 2.4 has the tank response gain, Gp(s) which has an input of inlet flow rate and the transmitter, $G_T(s)$ with an input of the sensor's differential pressure measurement. The computing element is the controller, Gc(s), which handles the error signal or differences between controlled variable and set point value.

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In this system, the differential pressure transmitter is used as the level measuring device. The level measuring device measures the level of the tank by measuring the differential pressure. To model this transducer we need to consider:

1. The relationship between liquid level and pressure.
2. The relationship between pressure and current signal.

In obtaining the model, the density of the liquid, ρ is assumed constant and the cross-sectional area of the main tank , A does not change with respect to the tank's height. Available data are as follows:

1. Cross-sectional area of the cylindrical tank, A is 551.55cm2, where the diameter of the tank is about 26.5cm.
2. The height of the liquid when it is at 100% level is 83cm
3. The initial steady-state condition is the tank's level L

The level depends on the total amount of liquid in the tank; thus the conservation equation selected is an overall material balance on the system.

$$\frac{d(mass)}{dt} = \rho F_i(t) - \rho F_o(t)$$

Observing the above equation it can concluded that the accumulation of the liquid in the tank at the time, t is equal to the differences between the total amount of liquid going into the tank and the total amount of liquid going out from the tank.

$$F_i(t) - F_o(t) = A\frac{dL(t)}{dt}$$

The flow out to the tank, where

$$F_o = C_d a\sqrt{2gL} = k_{Fo}L^{0.5} \text{ and } k_{Fo} = C_d a\sqrt{2g} = 39.23$$

F_o is the flow rate of water out of the tank (cm3/sec)

C_d is the discharge coefficient of the tank outlet = 0.7

A is the area of the tank outlet = 1.266cm^2

G is the gravitational constant = 9.8ms^{-2} = 980cms^{-2}

After all the equations are combined, the system can be described by a single first order differential equation:

$$F_i - k_{Fo}L^{0.5} = A\frac{dL}{dt}$$

The resulting equation, after subtracting the linearized balance at steady-state conditions and noting that the input is a constant step, is as below

$$\Delta F_i(t) - (0.5k_{Fo}L_s^{-0.5})L' = A\frac{dL'}{dt}$$

The linearized differential equation can be rearranged and solved as before

$$\tau\frac{dL'}{dt} + L' = \frac{\tau}{A}\Delta F_i \text{ With } \tau = \frac{A}{19.62L_s^{-0.5}}$$

$$\text{With } K_p = \frac{\tau}{A} = \frac{1}{19.62L_s^{-0.5}}$$

The laplace transform of the draining level response equation above can be written as

$$L'(s) = \frac{K_p}{\tau s + 1}F_i'(s)$$

The transfer function obtained above is a general, form because this value depends on the initial level of the liquid as it has the effects on the outlet flow rate from the tank.[7]

2.4 ZIEGLER-NICHOLS CLOSED-LOOP CONTROLLER TUNING

This closed loop tuning method was originally proposed by Ziegler and Nichols (1942). The tuning process is characterized by finding the gain at which the system is marginally stable and the frequency of oscillation at this point. From these two parameters, the controller parameters can then be calculated. These calculations are intended to produce a closed-loop damping ratio of ¼.

The methods used are as follows:

1. Start any trending (plotting) of the process variable.

2. Set the K_p and T_D to their minimum values and the T_i time constant to its maximum value. Now place the controller in the Automatic state.

3. Increase the proportional gain in small steps. After each adjustment, observe the process variable response to a set point change.

4. When sustained oscillations (amplitude is not increasing or decreasing) are observed, note the value of the proportional gain and the period (in minutes) of the oscillation, for better accuracy take the time it takes for 4 cycles to occur, and then find the average time for 1 cycle:

G_u = proportional gain for sustained oscillations

P_u = period of oscillations (in minutes)

5. Calculate the controller settings as shown in the table below

Table 2.2: PID Coefficients Formula

	Interacting equation	Non interacting equation
P controller K_p	$0.5G_u$	$0.5G_u$
PI Controller K_p T_i (min)	$0.45G_u$ $P_u/1.2$	$0.45G_u$ $P_u/1.2K_p$
PID Controller K_p T_i (min) T_D (min)	$0.6G_u$ $P_u/2.0$ $P_u/8.0$	$0.6G_u$ $P_u/2.0K_p$ $K_pP_u/8.0$

6. Finally final adjustments are made to K_p, T_i or T_D to obtain the desired process variable response.[2]

2.5 GENERAL PRACTICAL DESIGN METHOD FOR FUZZY PID CONTROL FROM CONVENTIONAL PID CONTROL (IEEE PAPER)

The paper written by Yongli Huang and Seiji Yasunobo on General Practical Design Method for Fuzzy PID Control from Conventional PID Control proposed a practical design method of fuzzy proportional-integral-derivative (PID) control system.

Like conventional PID controller there are several kinds of fuzzy PID controllers. Being as simple structure, the research on how to choose the type of conventional PID controllers for different controlled plants was successful. Based on the analysis of relationships between conventional PID controller and fuzzy PID controller, they proposed a method on how to choose the type of fuzzy PID controller suitable for the controlled plant.

Firstly the selected fuzzy PID controller is designed to have the same control property with corresponding PID controller because the parameters of its control rule base are calculated according to tuned parameters of PID controller. Then the parameters of this fuzzy rule base of fuzzy logic PID controller are tuned by sequential quadratic programming (SQP) algorithm. The tuned control surface is non-linear corresponding to the property of controlled plant. This method is applied to linear and non-linear controlled plants.

Simulation results show that it is an effective method to design fuzzy controller. The study shows that fuzzy PI controller out performs PI and PID controllers. The results of the study are shown below.
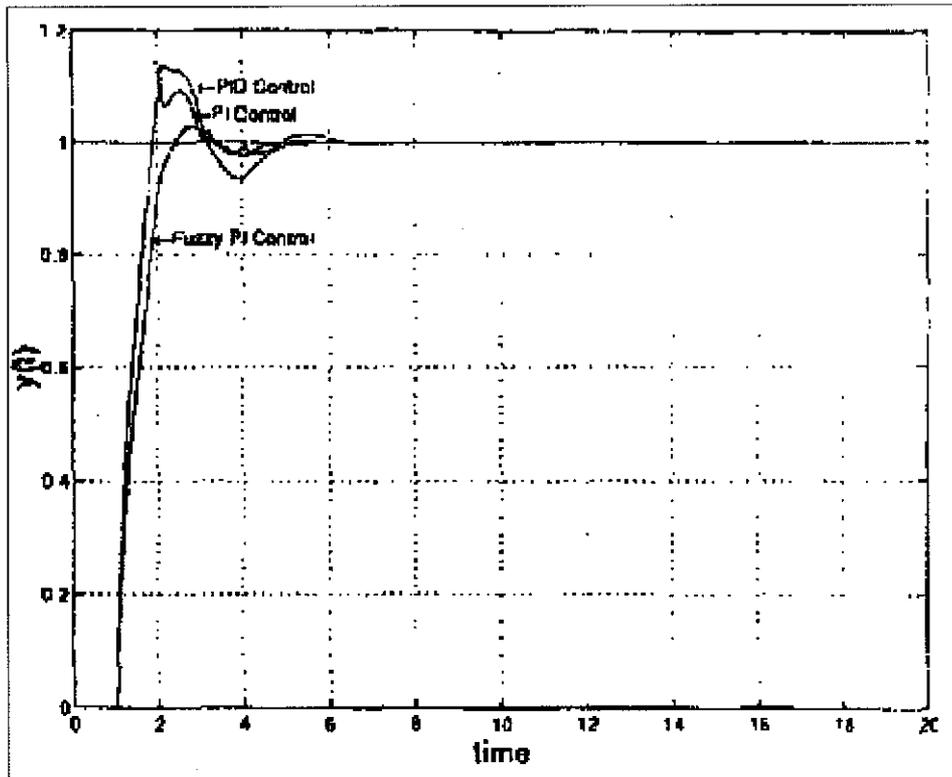
Figure 2.5: PID and Fuzzy control results on a 1ˢᵗ order lag system

2.6 LEVEL CONTROL FOR OPEN TANK

Level control is generally quite straightforward to implement. Many different sensors can be used to determine the inventory in a vessel. The most common is the differential pressure (DP) measurement. Assuming a constant liquid density, the difference in pressure is proportional to the level in the vessel between the two measuring points, called taps. The lower tap is usually placed above the bottom of the vessel, to prevent plugging from a small accumulation of solid contaminants. In an open tank configuration, the level transmitter's low pressure tapping is vented to the atmosphere while the high pressure side of the transmitter is connected to the tanks lower tap. The level displayed to the operating personnel could be expressed in units of length; however, this would require the people to remember the maximum level in each individual vessel. Therefore, the level is normally displayed as a percentage of the measurement range.[1] The components in level measurement are[6]:
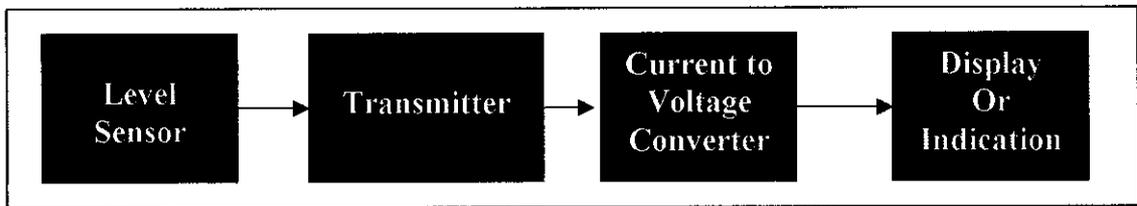
Figure 2.6: Component of level measurement

1. Level Sensor – In differential pressure transmitters a diaphragm is used

2. Transmitter- Acts as a transducer to convert sensed signal into 4-20mA or 0-20mA.

    a. The 4 to 20mA is the most commonly use rather then the 0 to 20mA as the zero reading is taken at 4mA, which is elevated. The 0mA at zero reading will have disturbances of stray current which will be cause error to reading. Another draw back is that one is not able to differentiate between an open loop and a zero reading.

b. Transmitters of this type usually use to amplify the signal dissipated by the sensors. Transmitters are made up of 2 module, that is receiver (which reads the signal and condition them) and then pass it to transmitter module (amplify the signal) and transmit the signal.

3. Current to Voltage converter – The current is converted to voltage for the computer which is 1-5volts. The voltage is then used for DCS or PLC or Display Purposes. The voltage is converted by tapping the voltage from a 250 Ohm resistor which resides within the instrument loop.

4. Display/Indication – Can be local display or thru Distributed Control System.

Feedback control provides excellent tight level control performance, because the system has little or no dead time. Proportional-only or proportional-integral with simple tuning guidelines is adequate for tight level control. The purpose of a feedback loop is to maintain a small deviation between the controlled variable and the set point by adjusting the manipulated variable. Two general types of external input changes normally used (Boyce, W 1986). The first type of input changes, involves changes to the set point; the desired value for the operating variable. Second type of changes to the close loop system involves variations in uncontrolled inputs to the process. These variables, usually termed disturbances, would cause a large sustained deviation of the controlled variable from its set point if corrective action were not taken. Therefore the relationship between the disturbance and controlled variable must be obtained through process modelling. The desired input depends on the disturbance characteristics.

2.7 DESCRIPTION OF EQUIPMENT USED

2.7.1 Sight glass

The construction of some tanks makes it impossible to touch the surface with rod or a float. A sight glass is another simple form of liquid level measurement. It provides continuous visual indication of liquid level in a process vessel or a small tank. The main disadvantage of a sight glass is that you must read it where the tank is located which is not always convenient. For example, the sight glass on the stream drum of a high pressure boiler in a power plant may be ten stories above the control room. Weather can be another disadvantage since sight glasses are located outside of tanks.

2.7.2 D/P Level Transmitter

This transmitter uses a diaphragm as its sensing element. This sensor picks up the differential pressure between the two tappings. This signal is then fed thru a transducer which is then sent to the DCS as a 4-20mA signal. There it is again converted to a 1-5volts. Please refer to appendix 16.

2.7.3 Conductance Point Level Probes

There are many applications in the process industry where continuous liquid level measurement is not needed. In some cases, the liquid level is measured at a single point. When the liquid reaches this point, some action is required to turn on a pump, start an engine or sound an alarm.

The conductance probe is one of the simplest level detectors. It is based on the principle that a liquid no matter how little current it conducts will be conductive enough to complete a circuit. Because the two rods are insulated from each other, there is essentially no conduction until the liquid rises to the point where it touches both rods and completes the circuit. This activates a relay which in turn starts a motor or sounds an alarm etc. The major advantage are that you can extend or cut off the rods as needed to match the point where you want switching action.

2.7.4 Pump

The pump being used is a centrifugal pump. The pump is used to pump the water in tank B into tank A. The pump is turned on by energizing a relay from the DCS workstation. Please refer to appendix 14.

2.7.5 Control Valve and positioner

Control valves are usually used in regulating material flow in a process. This is also known as throttling. These control valves can also be used as an emergency shut down valves. However they are not as efficient as normal shut-off valves.

There are many ways to control a valve. The most commonly used methods are pneumatic, electrical, hydraulic or mechanical. The methods used depend on the requirements of the process. Some of these requirements are as given below:

1. Continuous Process Control
2. Intermittent Process Control
3. Safety and equipment protection
4. Emergency Shutdown Systems (ESD)

A control valves positioner is primarily used to ensure that the stem's position is directly proportional to the respective value of instrument output pressure, regardless of stuffing box friction, spring hysteresis or off balance forces on the valve plug. Please refer to appendix 20 for a picture of the control valve used.

When a positioner is applied to the valve, the valve is no longer operated directly by the instrument output pressure. The positioner utilizes the instrument output pressure only as a signal, and controls an independent pressure supply to apply whatever pressure is required to force the valve stem to the correct position. Thus, the positioner is a relay capable of applying maximum force to position the valve correctly. Besides that, positioners also provide the changing of effective output pressure, range of the controller and also changing the valve action.[6]

CHAPTER 3

METHODOLOGY

3.1 PROCEDURE IDENTIFICATION

The procedure flow chart describes graphically the steps that have to be carried out to ensure the projects success.

```
                    ┌─────────────────────┐
                    │   Topic Selection   │
                    └─────────────────────┘
                               │
                    ┌─────────────────────┐
                    │  Literature Review  │
                    └─────────────────────┘
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             ┌──────────────────────────────────────┐
             │  Instrumentation Wiring to DCS       │
             └──────────────────────────────────────┘
                               │
        ┌──────────────────────┼──────────────────────┐
        │                      │                      │
  ┌─────────────┐      ┌─────────────────┐    ┌─────────────┐
  │Configuration│      │Creating DCS      │    │Configuration│
  │of DCS Points│      │graphics          │    │Of Control   │
  └─────────────┘      └─────────────────┘    │Module       │
                               │              └─────────────┘
                  ┌──────────────────────────────┐
                  │ Determine system Model through│
                  │ empirical modeling            │
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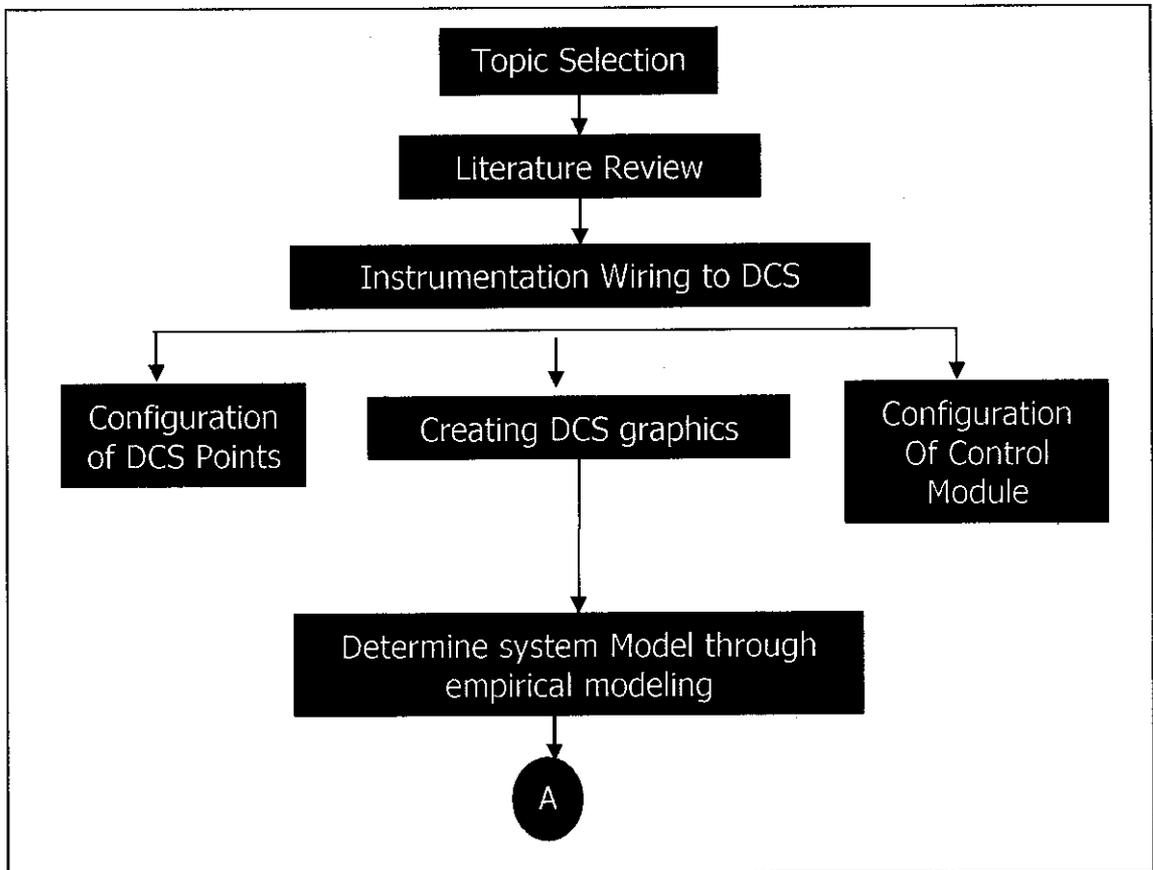
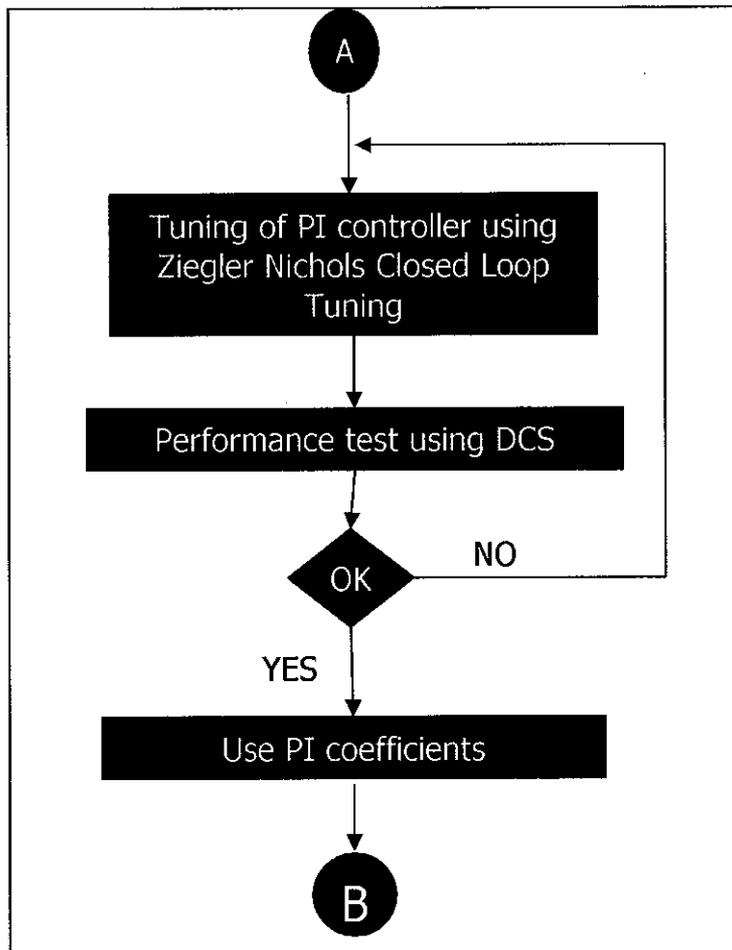**Figure 3.1: Procedure flow chart**

19
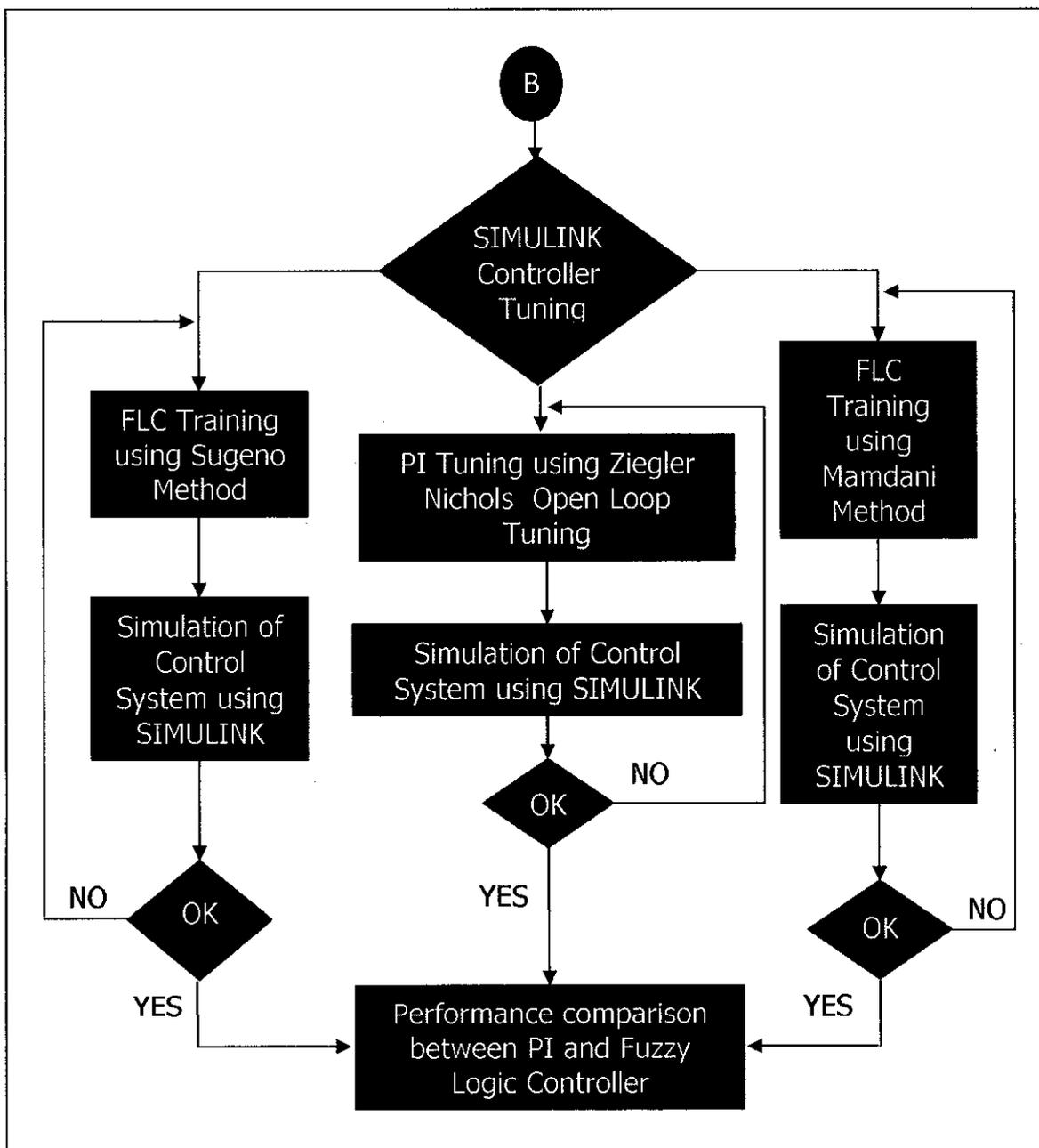
Figure 3.2 Procedure flow chart (continued)

Figure 3.3 Procedure flow chart (continued)

3.2 TOOLS REQUIRED

3.2.1 Hardware

The existing plant consists of a differential pressure level transmitter, pump, two tanks, a trolley and a control valve. However, additional hardware is needed to achieve the projects objectives:

a. Circuit breakers for use with the pump
b. 0.5A Fuses
c. Relays to allow turning on/off of pump and point water level detection circuits.
d. Emergency off button and pump status indicators to be installed at local display panel.
e. Water proof junction box.
f. 3 terminal blocks
g. Workstation to provide human interface to the system.
h. Honeywell Plantscape Hybrid Controller

3.2.2 Software

a. *Honeywell Plantscape* will be used to create DCS graphics to allow control of the plant.
b. *Matlab-SIMULINK* will be used for control system simulation

3.3 GANTT CHART

To ensure proper planning of the project, a Gantt chart was prepared. The Gantt chart will help in meeting important deadlines and keeping the project on the right track. Please refer to appendix 22 and 23.

3.4 PETRONAS TECHNICAL STANDARDS

The installations methods and procedures are based on the PETRONAS Technical Standards (PTS). PTS is the standard guidelines and handbook that serves as a reference to PETRONAS employees when carrying out any work. The objective of these standards is to set the recommended standard for good technical practice to be applied by PETRONAS OPUs in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and there by to achieve maximum technical and economic benefit from standardisation.

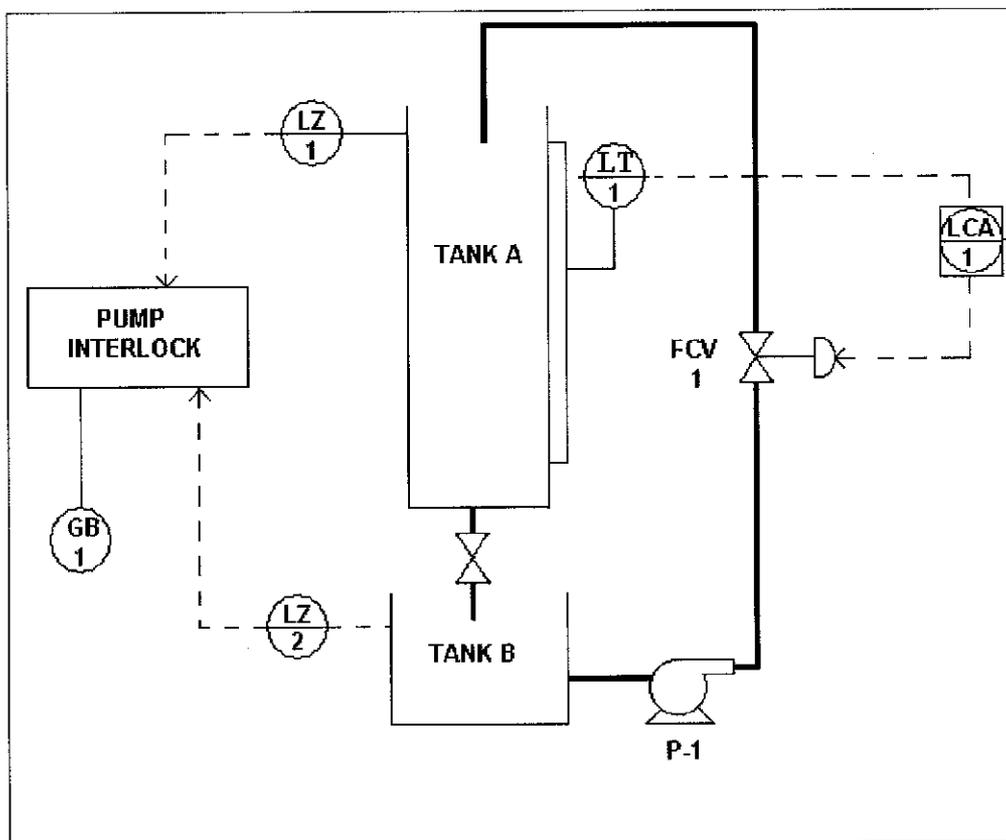## 3.5 PROJECT DOCUMENTATION

Figure 3.4: P&ID of level control system using feedback control

In order to carry out the project, proper documentation is needed to ensure its smooth flowing. Such documentation includes instrumentation loop diagrams, piping and instrumentation diagrams (P&ID). The detailed explanation of the field wiring and the DCS configurations are explained in the appendices. Figure 2 shows the P&ID diagram for the open tank level control system. The plant consists of two tanks (Tank A and B), one level transmitter, one pump, one control valve with positioner and 2 point level detection devices. Please refer to appendix 13 for the completed system in the laboratory.

The instrumentations are connected to a Junction Box (JB) located at the plant. The junction box houses the two point level detection circuits, pump circuit breaker, terminal blocks, pump push buttons and Pump control selector (DCS/LOCAL). The reason for connecting the instruments to the JB before being connected to the main marshalling cabinet is to make troubleshooting easier. For example if there were a bad process variable (BAD PV) reading in the DCS, it would be easier to detect whether the problem is being caused from the field or from the marshalling cabinet to the control room. The JB layout is shown in figure 3.5.
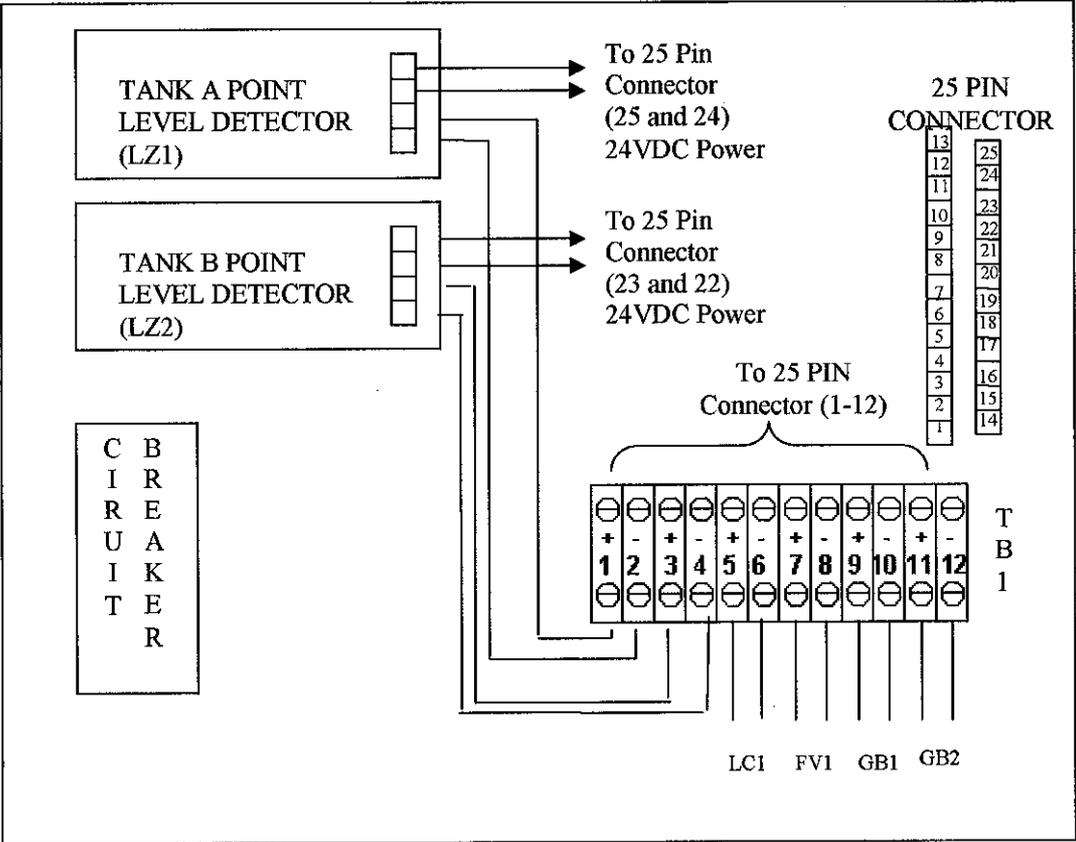
Figure 3.5: Junction Box Layout

The JB front panel also provides push buttons to locally start and stop the pump as required. In order for these buttons to function the selector switch has to be in LOCAL mode. The JB front panel is show in appendix 17.

The following diagram shows the Local Pump Interlock Wiring Configuration. A circuit breaker is used to open the circuit should an over current occur.[3] This is to prevent the pump from being damaged and possibly cause harm to the plant operators.
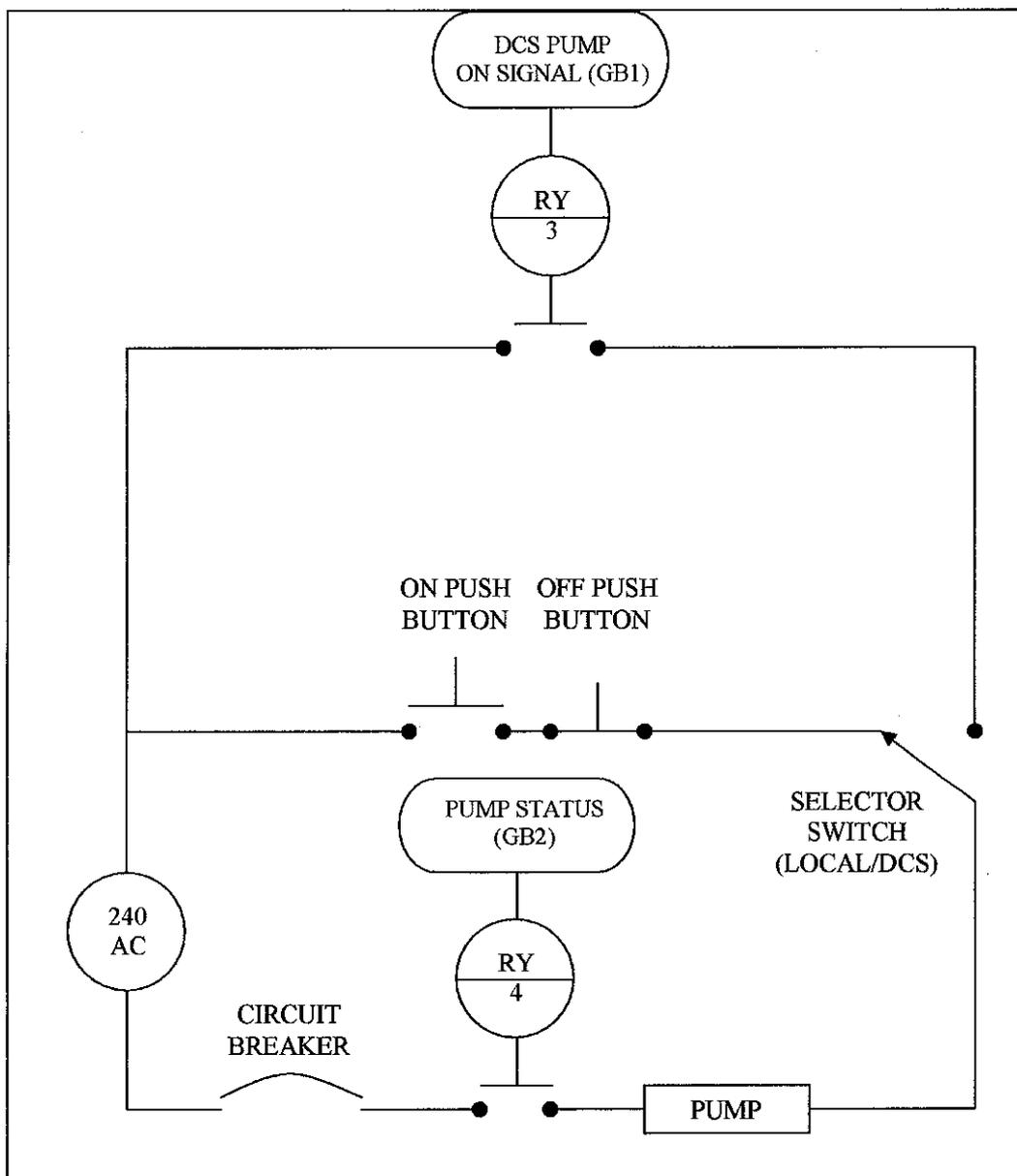
Figure 3.6: Local Pump Interlock Wiring Configuration

The wiring in the JB is then connected to the marshalling cabinet through a 25 DIM Cable. At the marshalling cabinet, each loop is connected to a 0.5A fuse.[4] The purpose of the fuse is to protect the instruments from any over current that should occur.

Figure 3.7: Terminal Block 2 Connections

Detail information regarding the wiring of the instrumentation used for the plant can be found in the instrumentation loop diagram. Please refer to appendix 12.1 to 12.4. These diagrams allow for easy troubleshooting and adding new equipment to the system. The instrumentation labelling and wiring are as per PETRONAS Technical Standards (PTS) 32.37.20.10 *Instrument Signal Lines*.

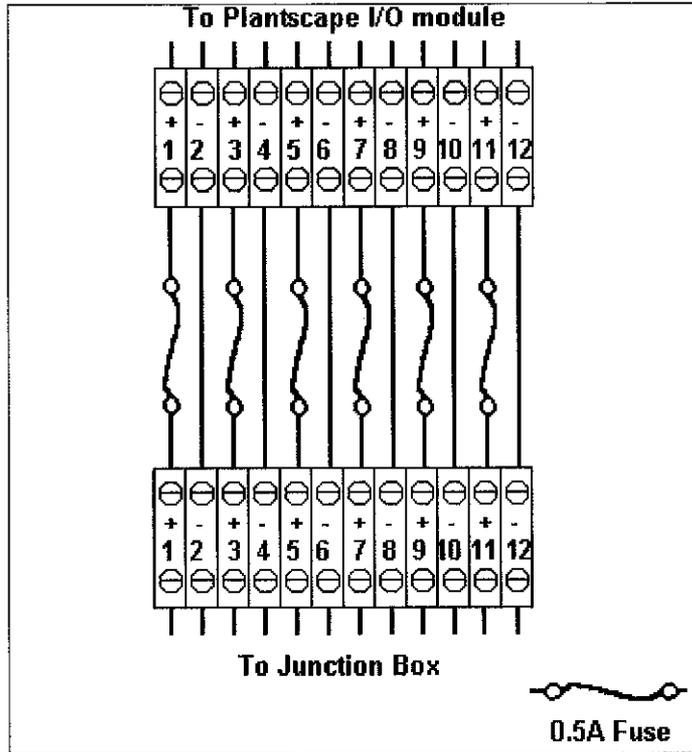Once the instrumentation loops have been connected, the next step is to configure the DCS to allow proper display and control of the process variables. The following table shows the DCS points being used. The channel name consists of two parts, the control module and the point name.

Table 3.1: DCS Point Detail

	Tank A Level Transmitter	Pump On/Off	Control Valve
Channel Name	CM_JEF_LIC1.AI_JEF_ LT1	CM_JEF_LEVEL.DO_JEF _PI_CMMD	CM_JEF_LIC1.AO_JEF_ LCV1
Module Type	Analogue Input, 16ch, 10V/ 4-20mA	Digital Output, 32ch, 24V DC	Analog Output, 8ch, 10V/4-20mA
Module Name	AI_IOM07	DO_IOM05	AO_IOM09
IOM Slot No.	7	5	9
Channel No	9	5	3

Table 3.2: DCS Point Detail (continuation)

	Tank B Water Level Sensor	Tank A Water Level Sensor	Pump Status
Channel Name	CM_JEF_LEVEL.DI_JEF_LZ2	CM_JEF_PUMP_LEVEL.DI_JEF_LZ1	CM_JEF_PUMP_LEVEL.DI_JEF_GB2
Module Type	Digital Input, 32 ch, 24VDC	Digital Input, 32 ch, 24VDC	Digital Input, 32 ch, 24VDC
Module Name	DI_IOM04	DI_IOM04	DI_IOM04
IOM Slot No.	4	4	4
Channel No	21	23	25

In order to implement the control system, control modules have to be created. This system uses two control modules, namely CM_JEF_LIC1 and CM_JEF_LEVEL. CM_JEF_LIC1 provides the logic required to implement a Proportional, Integral and Derivative Controller. Whereas the CM_JEF_LEVEL control module provides the pump interlock logic.
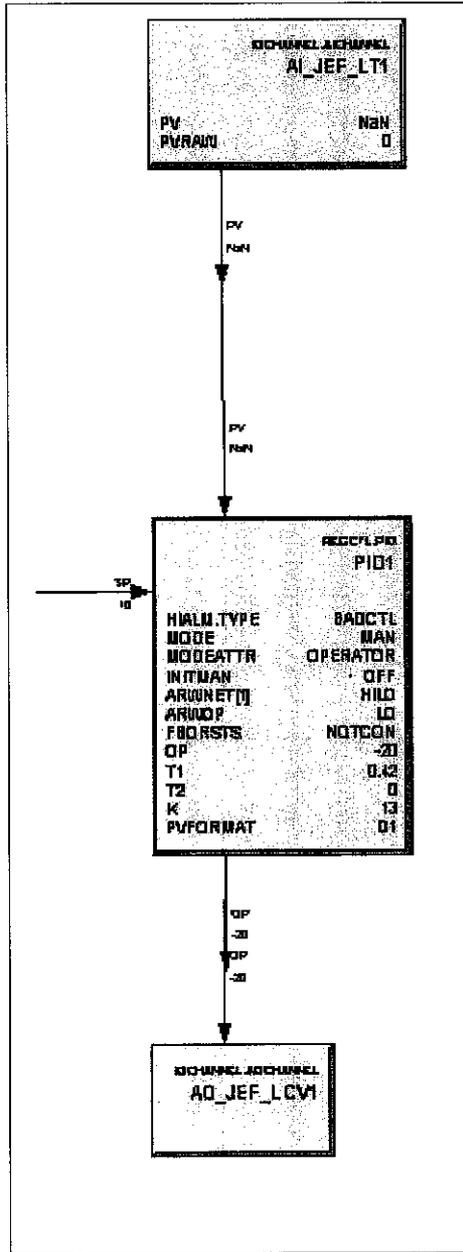
Figure 3.8: CM_JEF_LIC1 control module
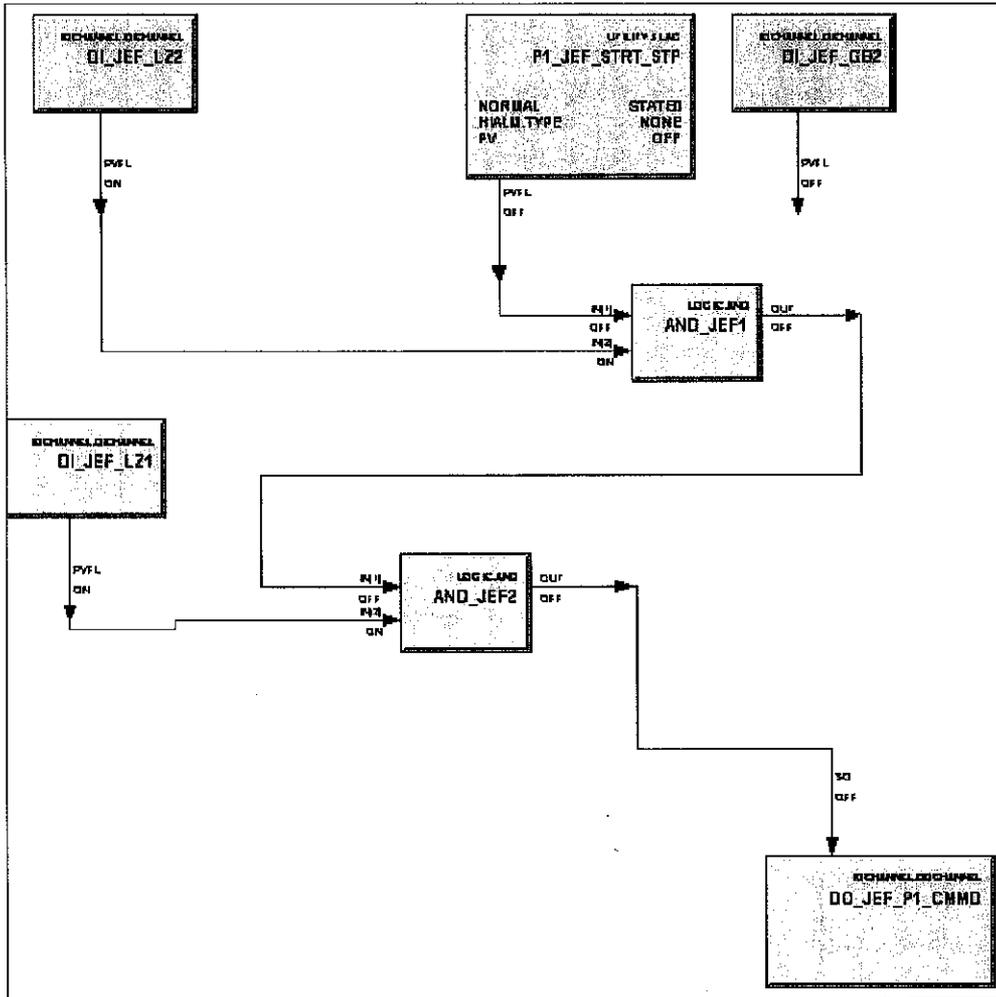
Figure 3.9: CM_JEF_LEVEL

After the DCS points and control modules have been configured then we can proceed to creating the DCS graphics. The DCS level control page (appendix 8) will allow the user to set the PID controller parameters required to control the plant. The graphics also indicate present level of tank A by using a dynamic graphic and Tank B will show a LOW indicator if water level is below its predetermined safety level. Besides that, the pump status will be indicated by changing the pump colour; Red indication the pump is off and green indicating it is on. Other DCS pages such as trending, tuning and modelling guidelines are shown in the appendix 7 to 11.

In addition to the project documentation, the author has also prepared a step by step guide that explains the instrumentation wiring, configuring DCS points, control modules and graphics. Please see appendix 12.

3.6 CALIBRATION OF D/P LEVEL TRANSMITTER

This is a simple method for measuring level in atmospheric vessels, such as tanks applied for storage of water. It consists of a connection close to the bottom of the vessel to a differential pressure transmitter.

Figure 3.10: D/P transmitter zero suppression and span
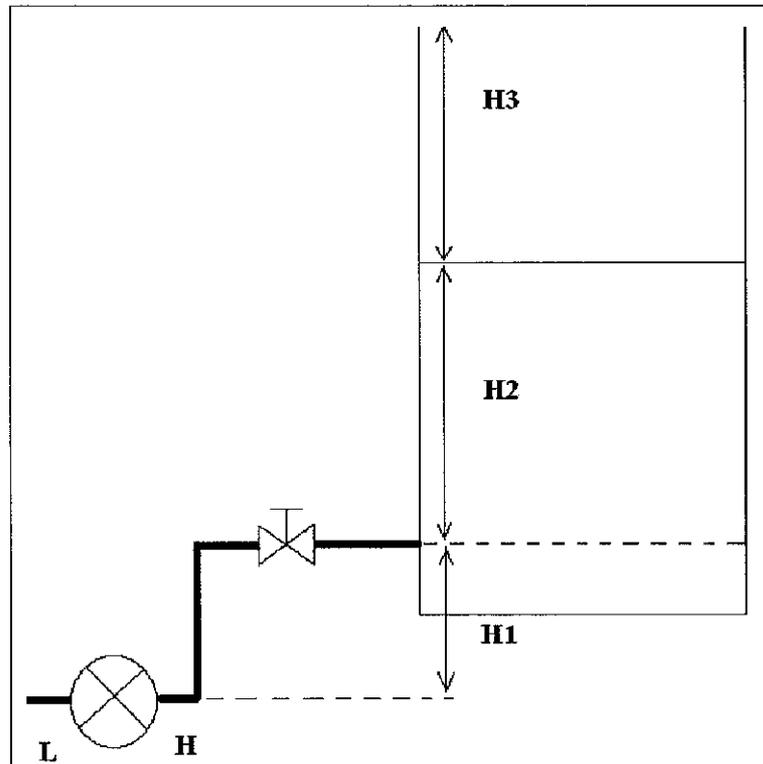
The static head of the liquid column and the atmospheric pressure (P_1) on the high side of the transmitter at maximum level is;

$P_1 = ((H_1 + H_2 + H_3) \times Rho \times gN/m^2) + Patm$

Where

P = Pressure in N/in2

H = height of liquid in in

Rho = density of liquid in kg/rn

g = intensity of gravity in N/kg

the low side of the transmitter : $P1 = P_{atm}$

The measured differential pressure is : $(H_1 + H_2 + H_3)*Rho*$ gN/m2. Since we are only interested in measuring the level between and maximum (H_3), the static head caused by $H_1 = H_2$ must be eliminated. This correction is called zero suppression

The zero suppression is : $(H_1 + H_2) \times Rho \times gN/m^2$

The measuring span of the d/p cell is: $H_3 \times Rho \times gN/m^3$

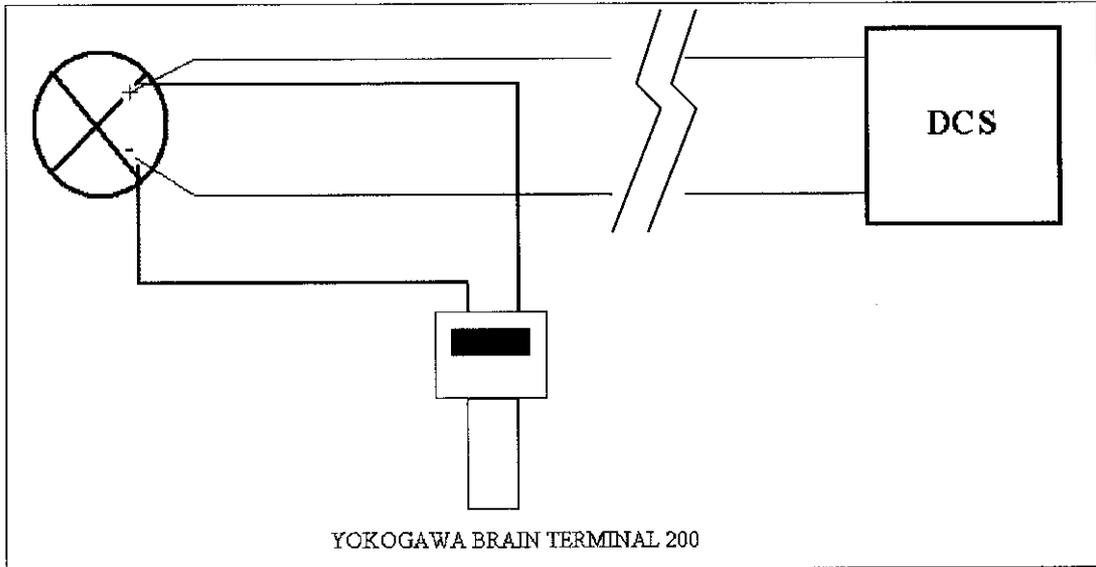**Figure 3.11: Calibrating level transmitter**

In the brain terminal (please refer to appendix 21) menu options, select the ADJ option and key in the following data.

Zero Adj: 0%

Zero dev: -29.22%

EXT Zero Adj: ENABLE

After keying in these settings, press the HOME key. Next, proceed to the SETTING option where the following data is keyed in:

Tag no: LT1

Press unit: mmH20

LRV: -9.981mmH20

URV: 812.9mmH20

At the analogue input configuration tab found in the Honeywell control builder software, the engineering unit range is from 0 to 100%, with a calibration bias of -1.7.

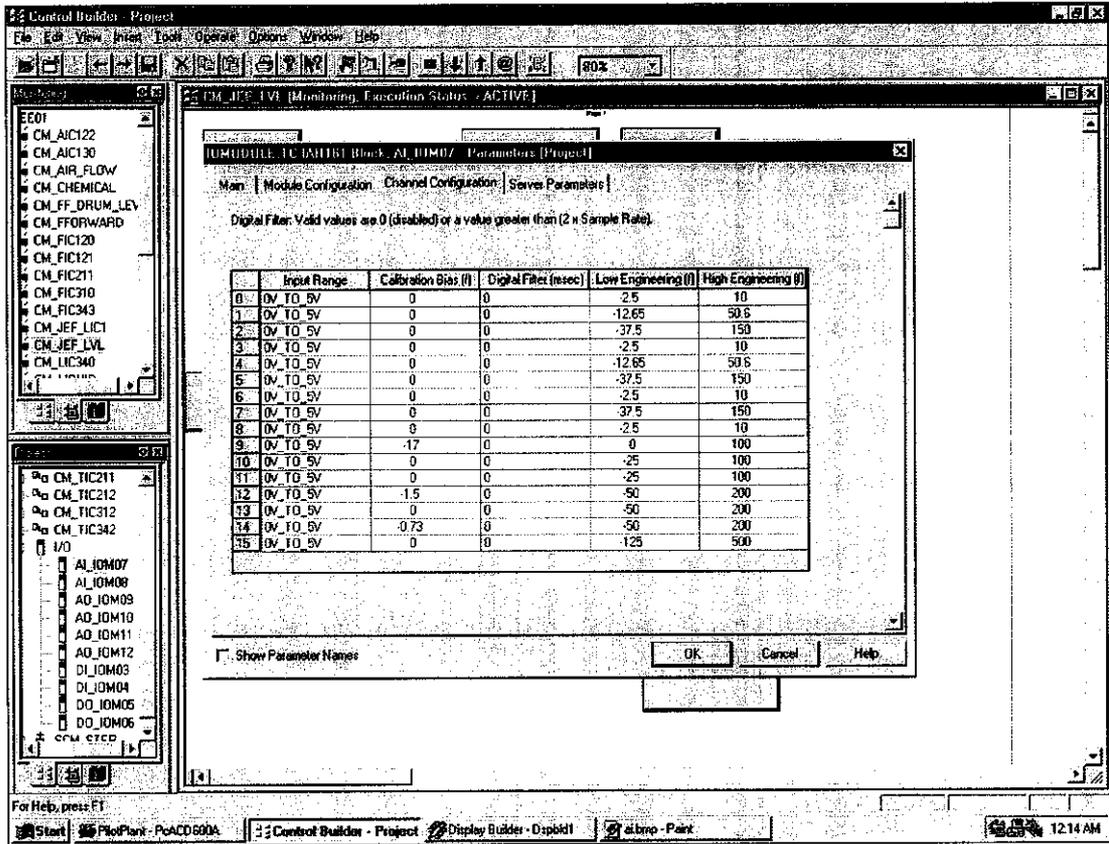|	Input Range	Calibration Bias (f)	Digital Filter (msec)	Low Engineering (f)	High Engineering (f)
0	0V_TO_5V	0	0	-2.5	10
1	0V_TO_5V	0	0	-12.65	50.6
2	0V_TO_5V	0	0	-37.5	150
3	0V_TO_5V	0	0	-2.5	10
4	0V_TO_5V	0	0	-12.65	50.6
5	0V_TO_5V	0	0	-37.5	150
6	0V_TO_5V	0	0	-2.5	10
7	0V_TO_5V	0	0	37.5	150
8	0V_TO_5V	0	0	-2.5	10
9	0V_TO_5V	-17	0	0	100
10	0V_TO_5V	0	0	-25	100
11	0V_TO_5V	0	0	-25	100
12	0V_TO_5V	-1.5	0	-50	200
13	0V_TO_5V	0	0	-50	200
14	0V_TO_5V	-0.73	0	-50	200
15	0V_TO_5V	0	0	-125	500

Figure 3.12: Setting Analogue input engineering unit range
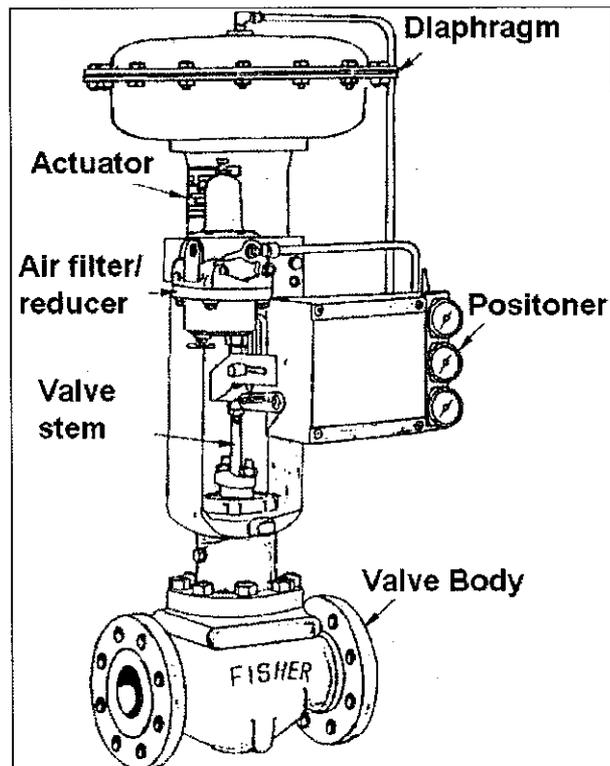
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3.7 CALIBRATION OF CONTROL VALVE

Figure 3.13: Control valve

The control valve before being put into service should be checked. The control valves position with respect to the electrical signal (4-20mA) from the DCS/Local controller should tally. Besides that the current signal should also tally with its equivalent pressure (3-15psi) after conversion by the positioner.

3.8 PUMP INTERLOCK SYSTEM

The pump interlock logic is shown below. LZ 1 will be OFF when the water level in tank A exceeds the maximum allowable level in tank A to prevent overflowing. LZ 2 will be OFF when the water level in Tank B falls below the minimum water level required to run the pump safely. PUMP ON is a selector switch on the DCS page. While DO_JEF_P1_CMMD is a Digital Output connected to a 24VDC Relay to turn on the Pump.
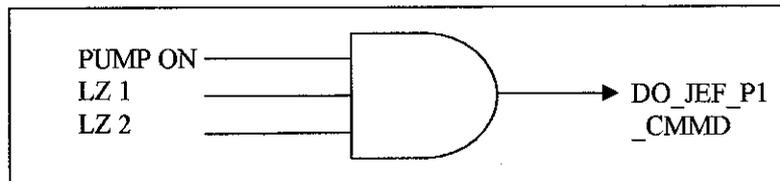
Figure 3.14: Interlock Logic

The following flow chart describes graphically how the pumps interlock functions. The interlock is needed to prevent any damages to the pump and to prevent from Tank A from overflowing
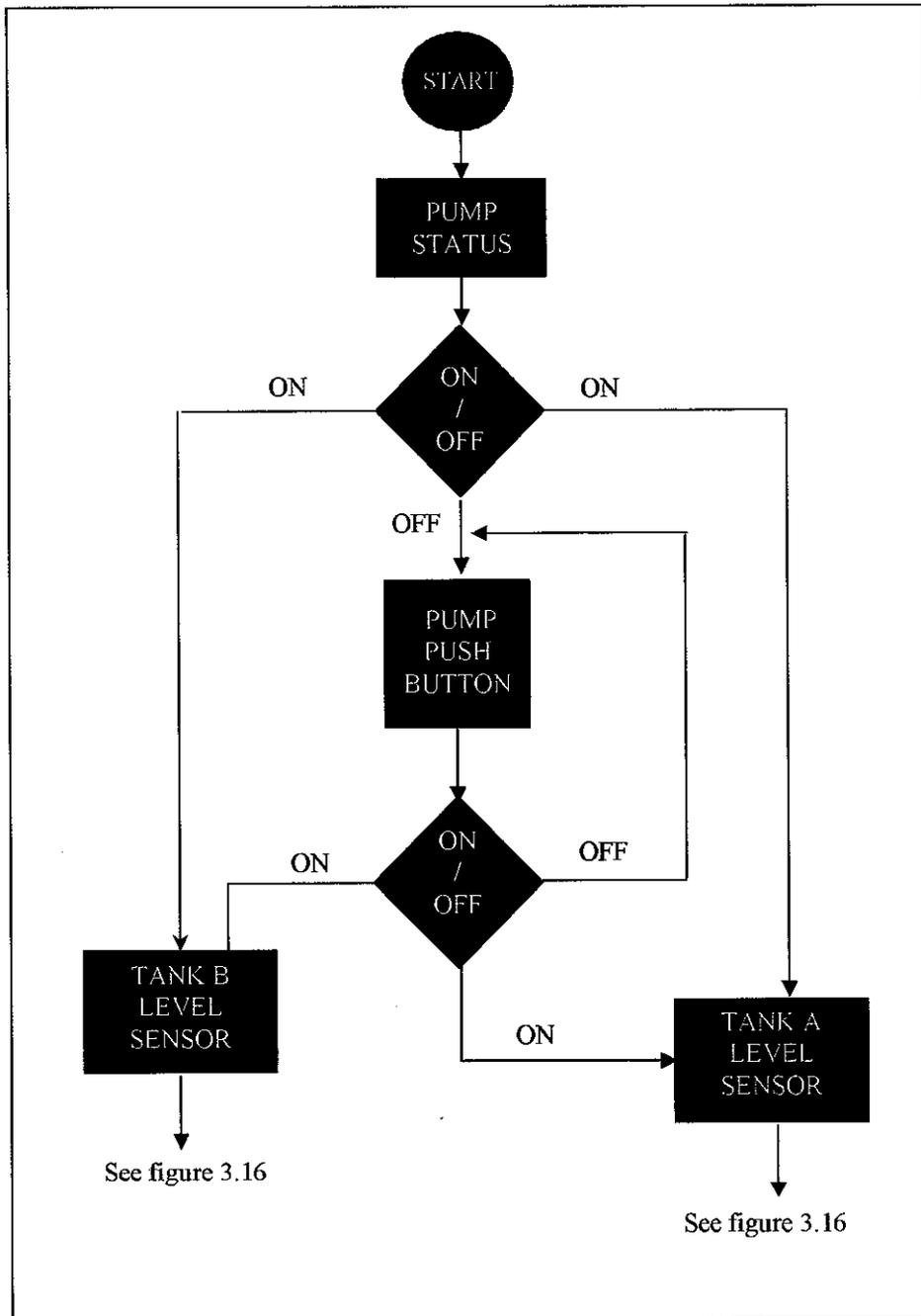
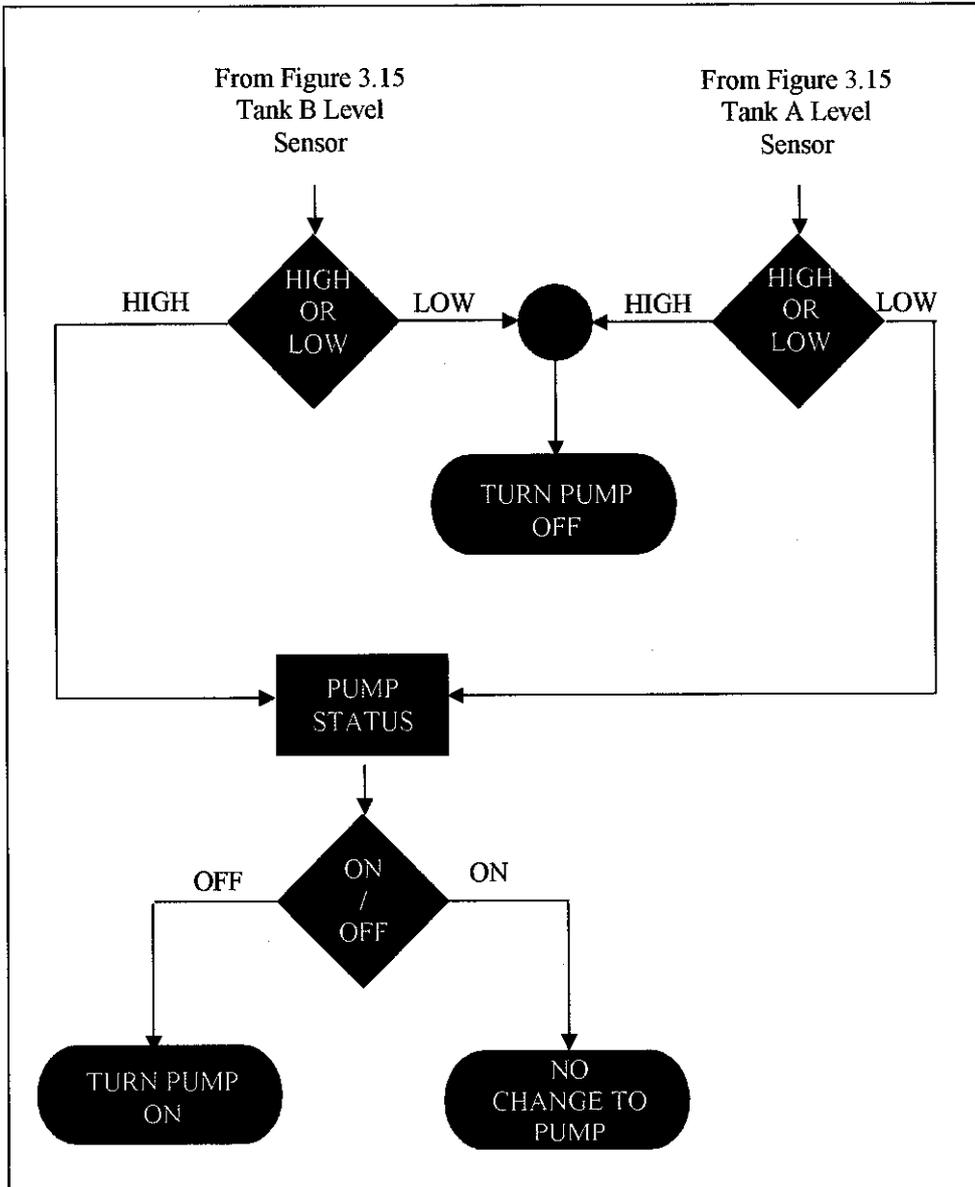**Figure 3.15: Pump Interlock Flow Chart**

Figure 3.16: Continuation of Pump Interlock Flow Chart
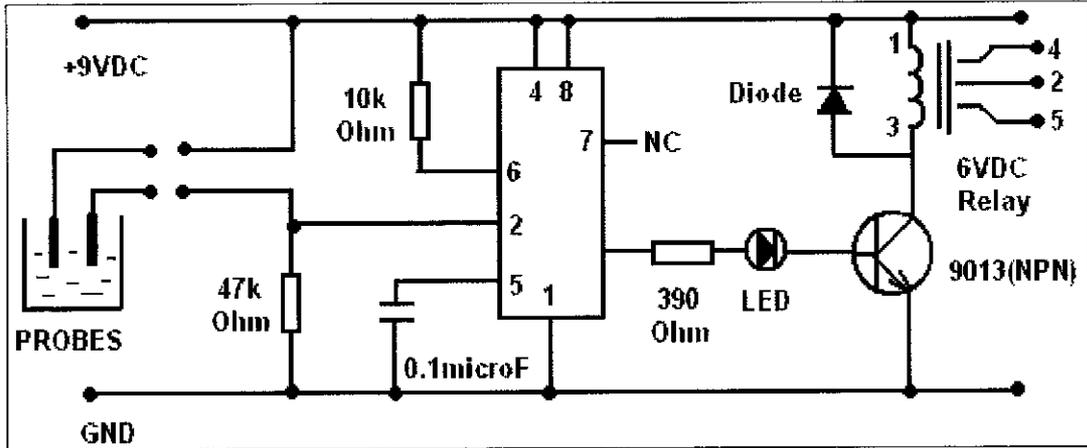
3.9 POINT LEVEL DETECTION CIRCUIT

Figure 3.17: Point Level Measurement Circuit

Two point level measurement devices will be used in the system, namely LZ 1 and LZ 2. LZ1 (Relay) when not energized is normally closed. This configuration was chosen as the water level in tank A during normal operation will be below this point, causing current to flow through the relay to the DCS. This enable continuous line monitoring to ensure that the line is healthy.

LZ2's relay is normally open when not energized; this is because the water level in the tank will submerge the probes during normal operation. When the water level goes below the probes, the relay is energized and sends a signal to the DCS. Besides sending signal to the DCS, LZ 1 and 2 are used to implement the interlock locally. This enable continuous line monitoring to ensure that the line is healthy.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 REMOTE CONTROL OF LEVEL CONTROL SYSTEM

The open tank level control was successfully implemented using the Honeywell Plantscape Distributed Control System. The interface to the plant consists of 4 main DCS pages. The page names and function are given below:

1. Open Tank Level Control System main page provides the operator with the overall layout of the plant, controller faceplate and pump control.

2. Open Tank Level Control System main trend page

   i. The trending page allows the user to monitor the process variable, set point and valve percentage opening.
   ii. Carry out controller tuning and process modeling.

3. Controller tuning guide provides the operator useful information regarding the Ziegler Nichols tuning method.

4. Process modeling guide explains how to use the trend page to obtain the process model using empirical modeling, namely the process reaction curve method.

4.2 OBTAINING THE PROCESS MODEL

In obtaining the process model, the controller was set to manual, the hand valve at the bottom of tank A was fully open (acts as disturbance to the system) and the manipulated variable, MV was increased from 5% to 10%. The process variable is then observed until it stops fluctuating. The following process reaction curve calculations are then carried out.
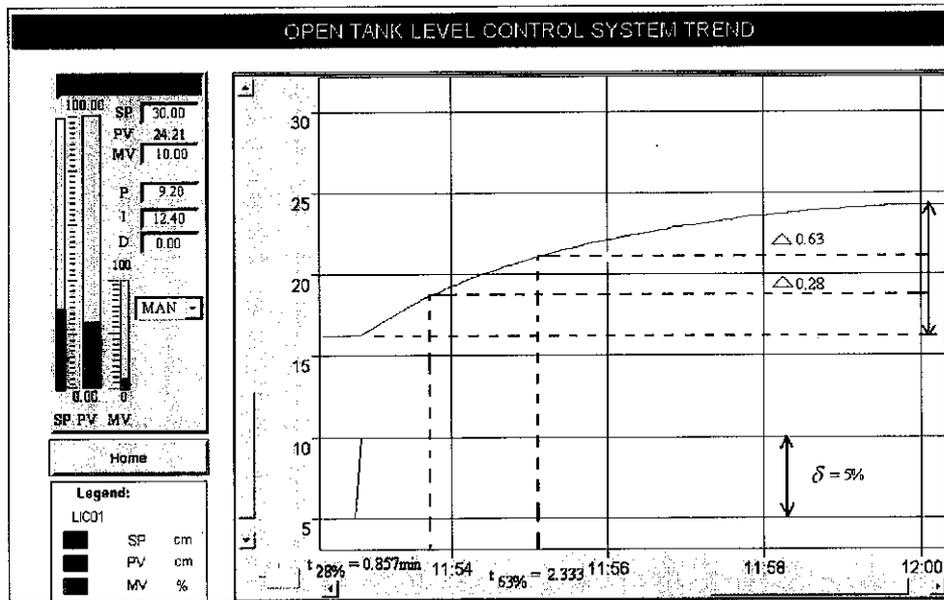
Figure 4.1: Process reaction curve calculations

$$K_P = \frac{\Delta}{\delta} = \frac{8cm}{5\%} = 1.6cm/\%$$

$0.63\Delta = 5.04cm$

$0.28\Delta = 2.24cm$

$t_{63\%} = 2.33\,min$

$t_{28\%} = 0.857\,min$

$\tau = 1.5(t_{63\%} - t_{28\%})$

$= 1.5(2.33 - 0.857)$

$= 2.2095$

$\theta = t_{63\%} - \tau$

$= 2.33 - 2.2095$

$= 0.1205$

$$\frac{Y(s)}{X(s)} = \frac{K_P e^{-\theta}}{\tau s + 1}$$

$$\frac{Y(s)}{X(s)} = \frac{1.6e^{-0.121s}}{2.21s + 1}$$

The transfer function obtained is a 1st order model with dead time. The model obtained is not an exact replica of the original system as there may be errors while performing the calculation, thus this model when used in the MATLAB simulation requires retuning of the PI controller. However, this model is sufficient for the SIMULINK controller simulations.

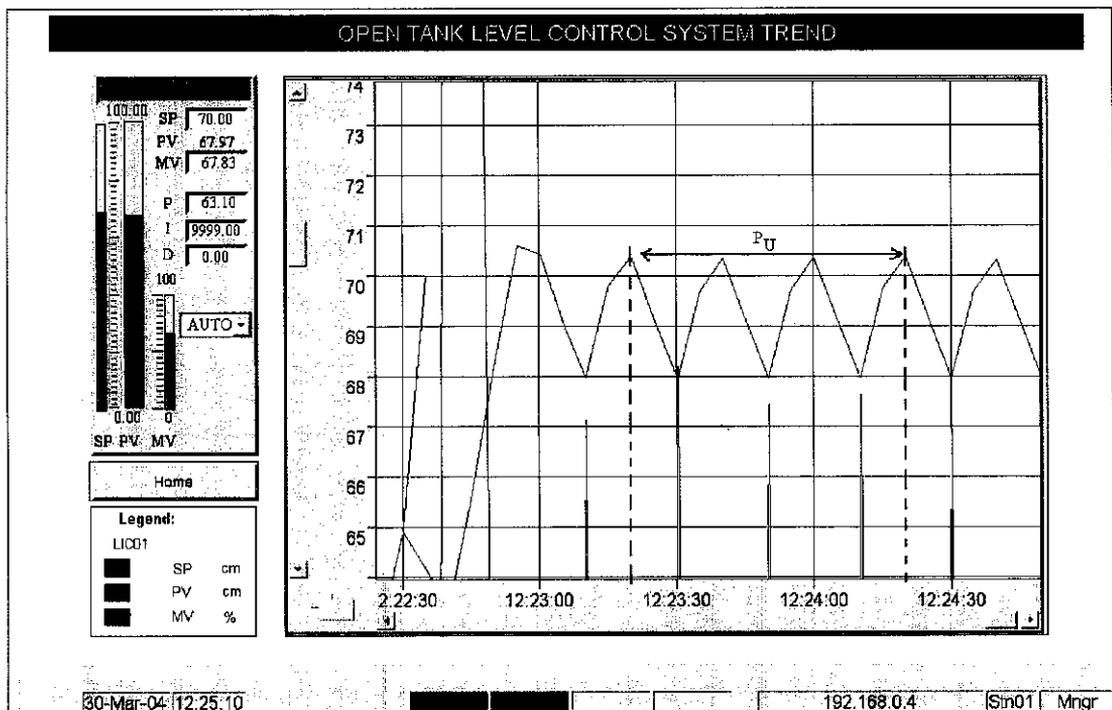## 4.3 TUNING THE HONEYWELL PLANTSCAPE PI CONTROLLER

Figure 4.2: Ziegler Nichols closed loop tuning method

Ziegler Nichols closed loop tuning methods were carried out in tuning the controller. The calculations performed are as follow:

P_U=60seconds

For 1 cycle

P_U=60/4=0.25minits

K_P=0.45(63.10)

=28.395

T_I(min)=P_U/1.2 = 0.208minits

After fine tuning of the PI parameters, the final values used are P=13, I=0.42 and D=0. After the finals adjustments are made to the controller parameters, the next step is the performance test. The following graph shows the response of the process to a set point change from 40 to 45 percent. The author had to tune a less aggressive controller in order to reduce the amount of oscillation around the set point.
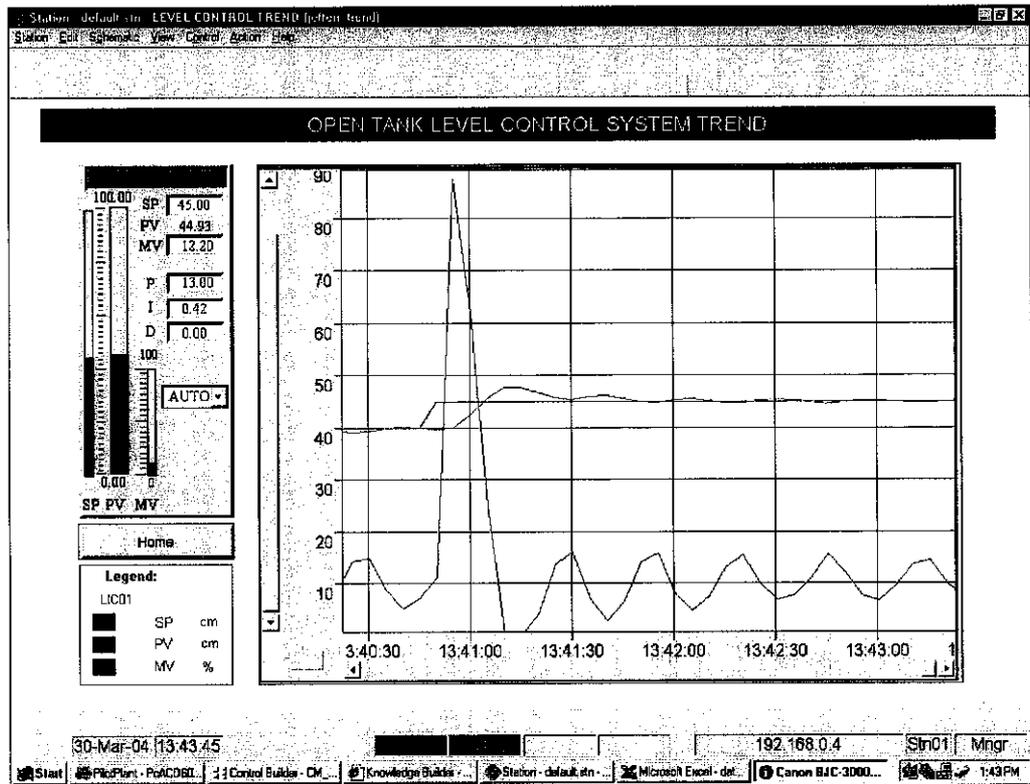

Figure 4.3: PI performance test

4.4 TUNING THE MATLAB PI CONTROLLER

The PI controller was tuned using the Ziegler-Nichols open-loop methods. This method requires the calculation of Kp, T_I or T_D from the first-order-plus-deadtime model parameter and a process controllability α of the form,

$$G(s) = \frac{Ke^{-\theta_D s}}{\tau_1 + s} \ , \ \alpha = \frac{\theta_D}{\tau_1} \ .$$

The calculation also depends on the type of controller (P only, PI or PID). After performing the calculations required to obtain the process model, the following transfer function was obtained.

$$G(s) = \frac{Ke^{-\theta_D s}}{\tau_1 s + 1} = \frac{1.6e^{-0.121s}}{2.21s + 1}$$

The following parameters are used in the calculation of the P and I values.

$$\alpha = \frac{0.121}{2.21} = 0.05475 \ , \ K=1.6, \tau_1 = 3.33(1.3) = 4.3329 \ , \ \theta_D = 0.121$$

Table 3.3: Ziegler-Nichols open-loop tuning calculations

P Controller		
K_P	$\dfrac{1}{K\alpha}$	$\dfrac{1}{(1.6)(0.05475)} = 11.41$
PI Controller		
K_P	$\dfrac{0.9}{K\alpha}$	$\dfrac{0.9}{(1.6)(0.05475)} = 10.27$
T_I (min)	$3.33\theta_D$	$3.33(0.121) = 0.3993$
PID Controller		
K_P	$\dfrac{1.2}{K\alpha}$	$\dfrac{1.2}{(1.6)(0.05475)} = 13.7$
T_I (min)	$2\theta_D$	$2(0.121) = 0.242$
T_D (min)	$0.5\theta_D$	$0.5(0.121) = 0.0605$

However, these PI parameters were not used in the simulation as the controller was too aggressive. Thee parameters caused a unsatisfactory overshoot to the process response. Therefore fine tuning of the PI parameters was required. The parameters that were used are:

Table 3.4: SIMULINK PI Controller Fine Tuning

PI	Controller
K_P	0.1
T_I (min)	0.2min

4.5 TRAINING THE FUZZY PI CONTROLLER

The inference process methods used to train the fuzzy logic controller are the Sugeno method and Mamdani method. When using the Sugeno method, the first step to training the controller is to gather the process data by first simulating the system using a PI controller. The process data of interest here are the process variable, PV, manipulated variable, MV and error (SP-PV). These data are then inserted into an array of 16965x3. The number 16965 here is the number of data which consists of PV, Error and MV obtained from simulating the control system for 30000 .Next, the anfisedit GUI is opened and the training data loaded.

Next, the grid partition method is used to generate the FIS. The membership type for the input is then selected as gaussmf and linear for the output. The number of membership functions used for each of the two inputs is three. After making these changes, the controller is then trained. The optimisation method used is hybrid and the error tolerance is zero. To reduce the amount of error, a greater number of epoch should be used. After the minimum error is reached, the controller may be exported to the workspace for use in the control system. The controller is now trained to handle set point of any value ranging from 0 to 1.5.

The Mamdani method however does not use training data, instead the membership functions and rules must be adjusted manually. The following block diagram shows the simulation set-up. Please refer to appendix 1 and 2 for the FLC and PI control system subsystem details and anfisedit set-up.
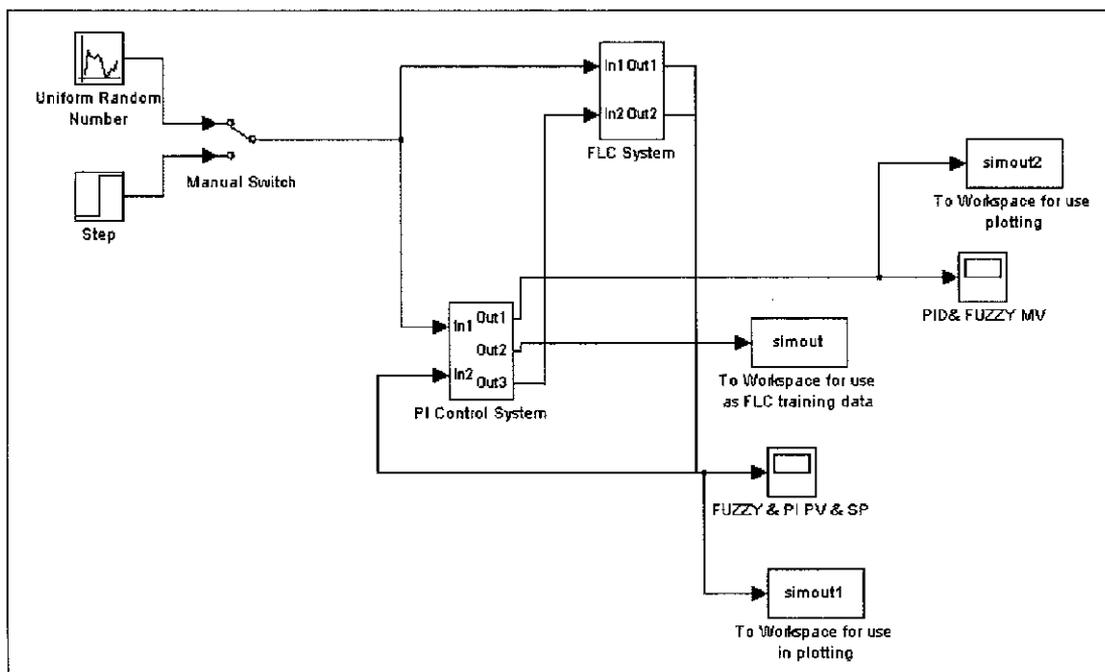

Figure 4.4: FLC and PI control system SIMULINK block diagram

4.6 PI VERSUS FUZZY PI CONTROLLER

The results of the MATLAB simulations indicate that fuzzy PI controllers are able to eliminate overshoot. However, after comparing the two inference process methods, the Sugeno method is a better choice as it is more robust when compared to the Mamdani method. Furthermore, as the Sugeno method uses data obtained from the plant, the Sugeno method is easier to tune.

The Mamdani method improves the process response by increasing the rise time and eliminating overshoot. The Mamdani method is harder to tune when compared to the Sugeno method. The Sugeno method on the other hand, is able to produce a robust controller compared to the Mamdani method and eliminate overshoot. The Sugeno method however, shows a slower rise time.

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The manipulated variable of the Mamdani FLC shows an erratic oscillation of the MV at the start of the simulation. Meanwhile, the Sugeno FLC MV shows a less aggressive response to a set point change as compared to the PI controller.
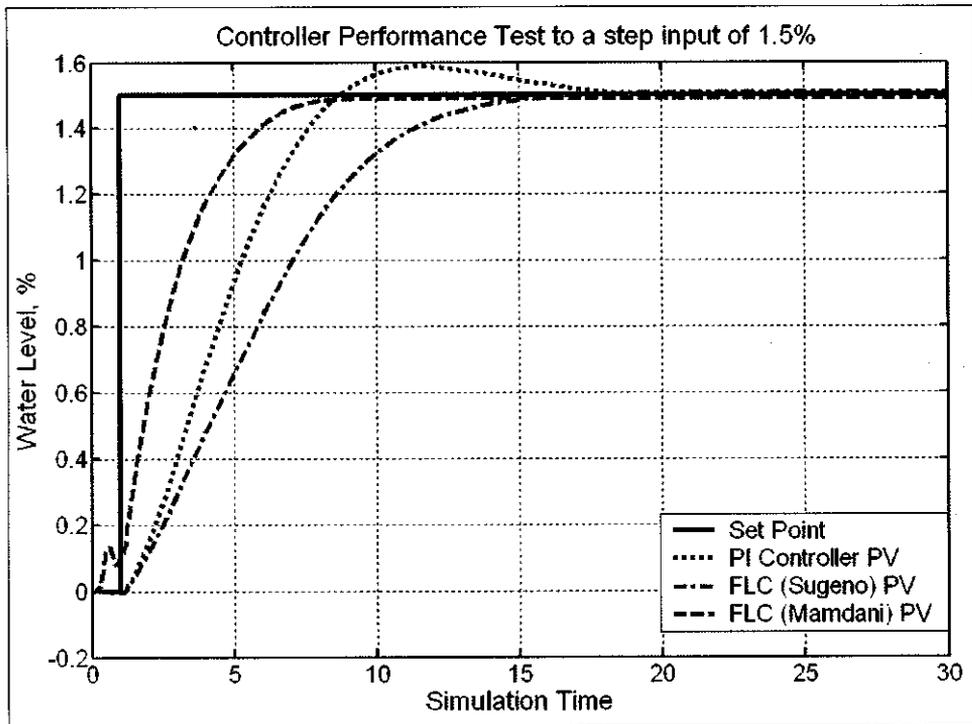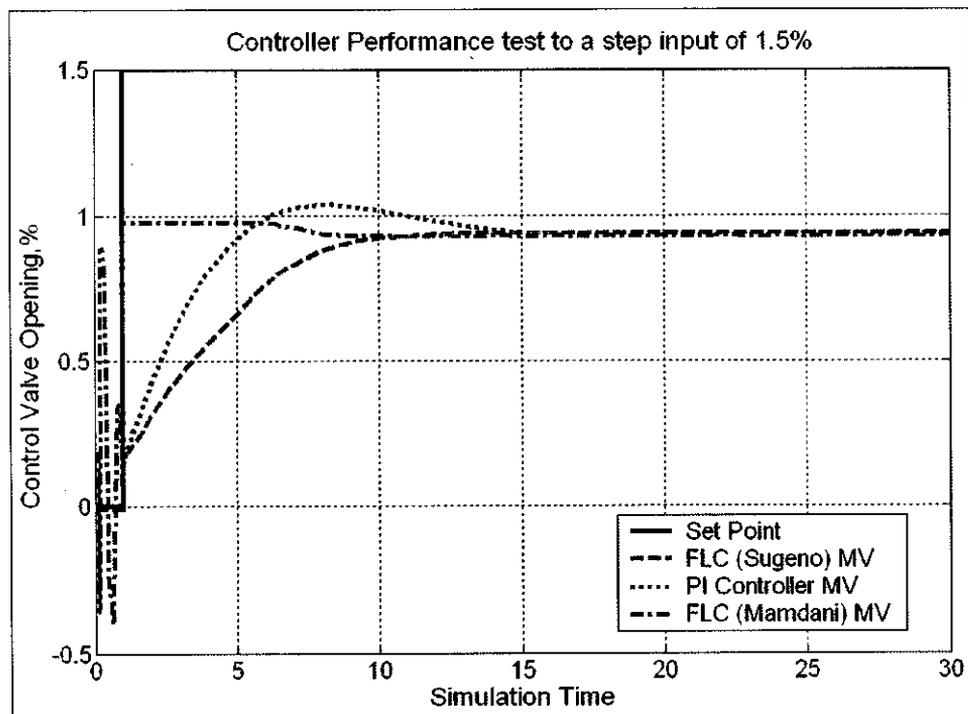
Figure 4.5: Controller Performance Test, PV

Figure 4.6: Controller Performance Test, MV

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Remote control of the plant was a success. Additional interlocks and protective devices were implemented and installed to protect the equipment from damage and minimize danger to the operator. The DCS pages allow for the user to monitor and control the process. In addition to this, the pages also provide the user with guidelines on how to tune PID controller and to obtain the process model.

After performing MATLAB simulations of the control system and comparing the performance of the PI controller and Fuzzy PI controller, the author can conclude the Fuzzy PI controller can provide better process response when used in a level control system.

The two process inference methods analysed, indicate that if a robust controller is highly needed then the Sugeno inference method should be used as this method can be trained for a wider range of set point changes. However, if an aggressive controller is needed, then the Mamdani inference method should be considered. Mamdani inference method allows the operator to tune the easily understandable membership functions thus allowing the operator to optimise the controller.

5.2 RECOMMENDATION

Even though both the author's objectives were met, there is still room for improvement. The current control system utilises feedback control to control the tanks inventory level. However, other control methods such as cascade control may also be implemented. The author was not able to implement this control method as the cascade control criteria require that a measured secondary variable be available. In this process, a flow meter should be used as a secondary variable. The placement of this flow meter is indicated in the P&ID below. The flow meter should be installed here as it is able to indicate the occurrence of an important disturbance which is tank A's hand valve opening.
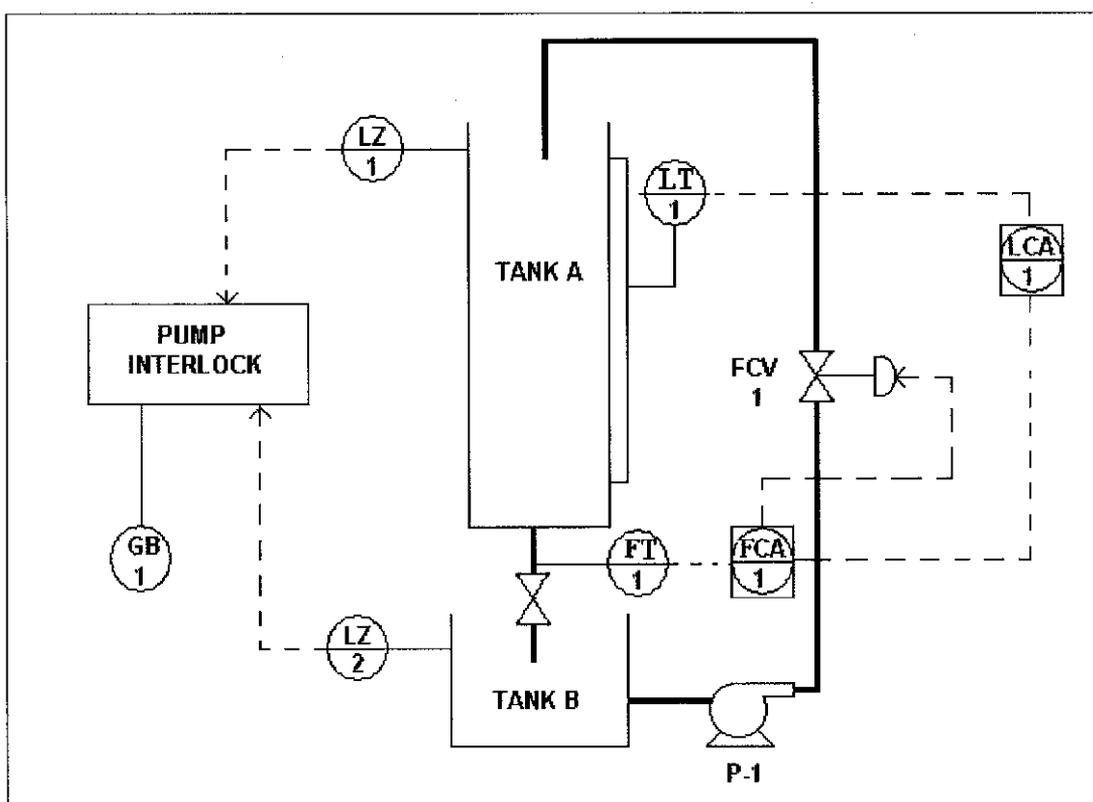

Figure 5.1: P&ID showing implementation of cascade control

The author recommends the implementation of the Fuzzy PI controller in the control system currently being used. This may be possible as MATLAB provide the C coding for the fuzzy inference engine. An option should be provided in the DCS graphics to allow the operator to select between conventional PID controller and Fuzzy PID controller.

REFERENCES

1. Bartelt, Terry 2002, *Industrial Control Electronics Device, Systems and Applications*, New York, Thomson Learning

2. Marlin, Thomas E. 2000, *Process Control 2^{nd} edition*, Singapore, McGraw Hill

3. Richter, Herbert P and Schwan, W. Creighton, *Practical Electrical Wiring 17^{th} Edition*, McGraw Hill

4. PETRONAS Technical Standards

5. Honeywell Knowledge Builder Software

6. PETRONAS Skill Group 14 training manual

7. Muhammad Faizol Bin Mat Jusoh, *Liquid Level Controller using Matlab*, Electrical and electronics engineering Universiti Teknologi PETRONAS.
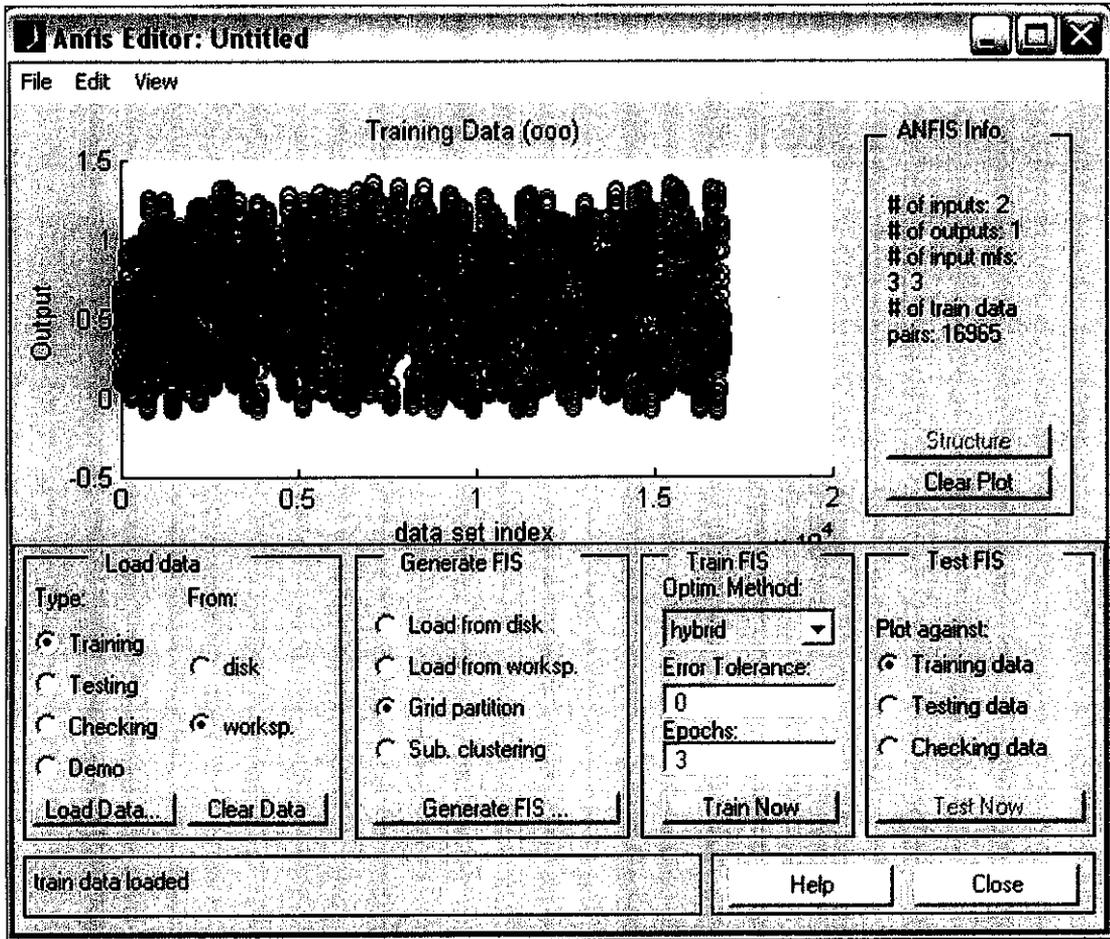
8. Reznik, Leonid 1997, *Fuzzy Controllers*, Newnes

APPENDICES
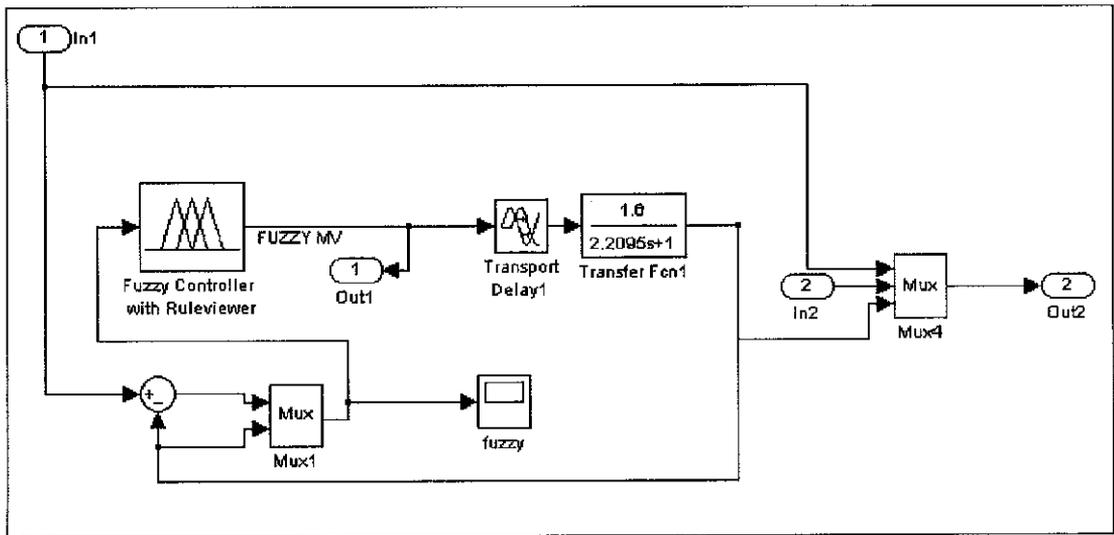
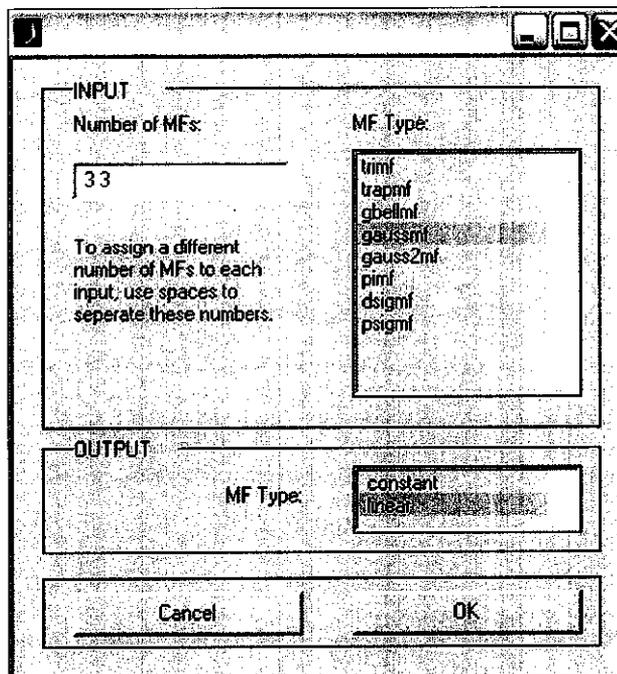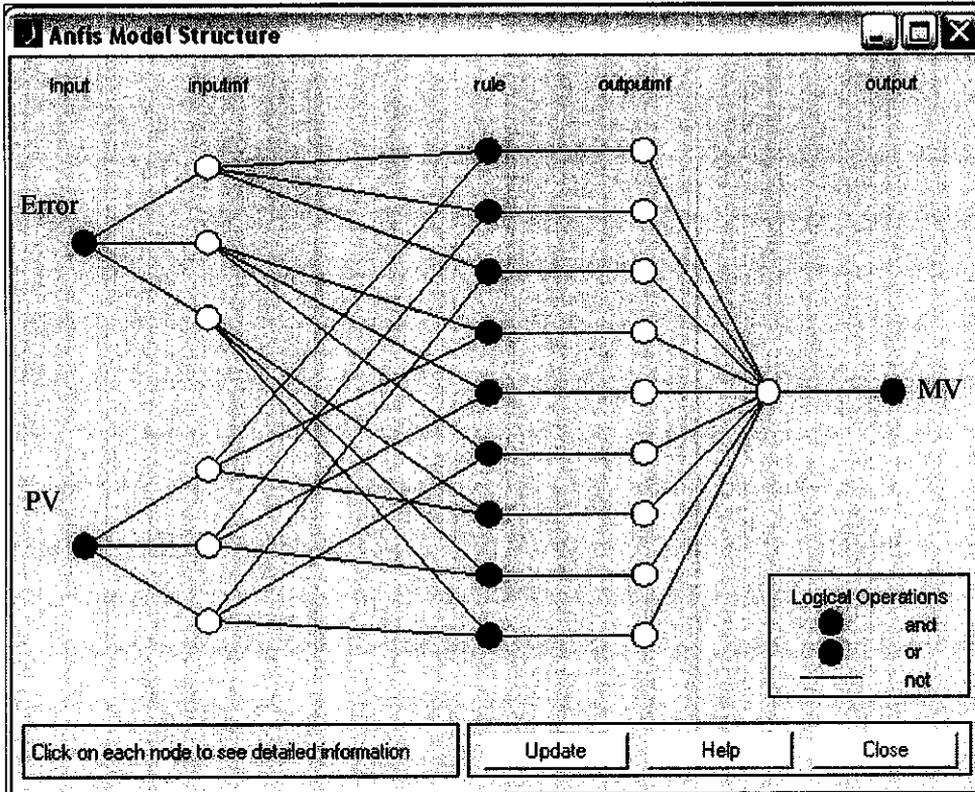**Appendix 1: Fuzzy Logic Control subsystem**
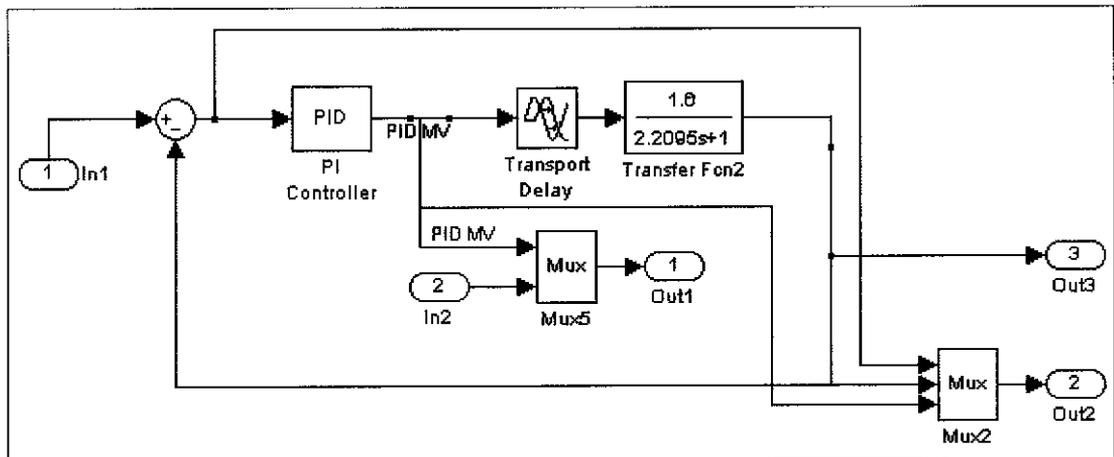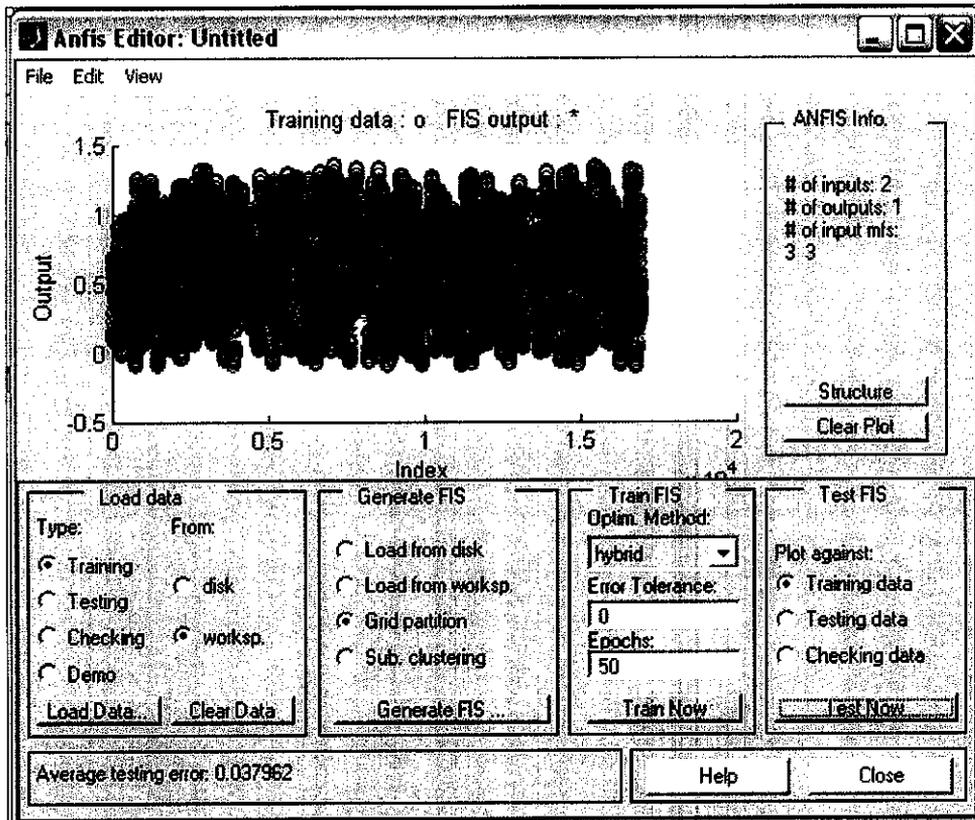

Appendix 2: PI Control subsystem

Appendix 3: Anfis Editor used to train Sugeno Fuzzy PI Controller
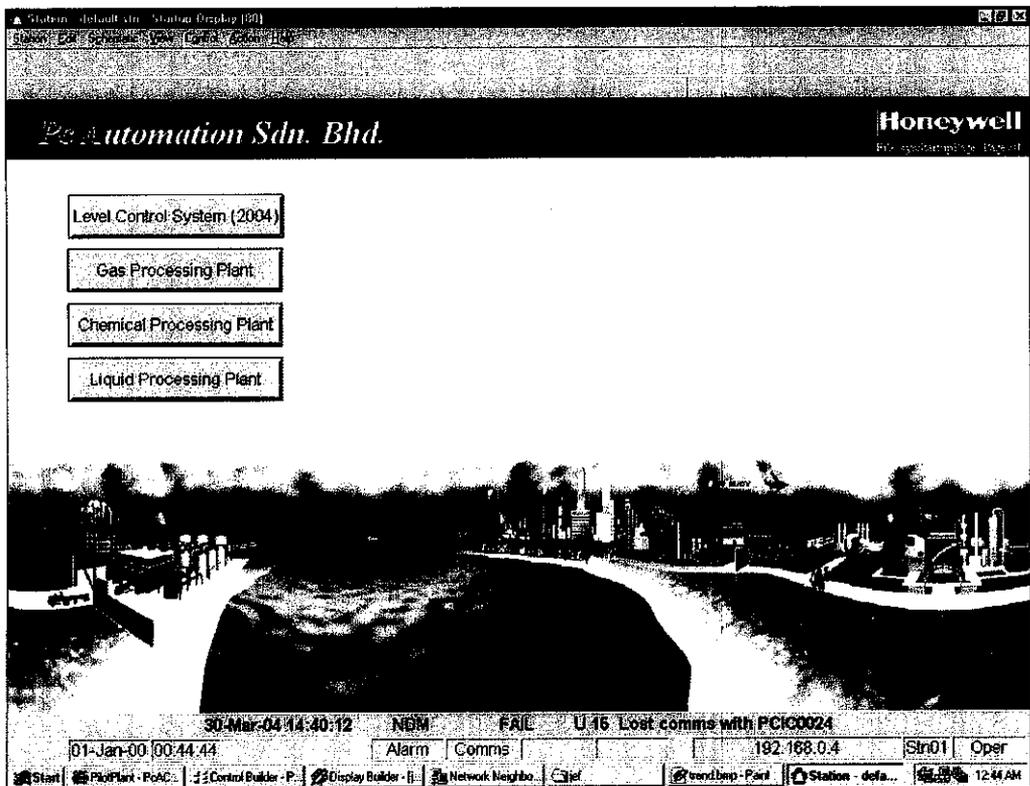

Appendix 4: Settings for GENERATE FIS (grid partition)

Appendix 5: Anfis Sugeno model structure

Appendix 6: Testing of Fuzzy PI controller

Appendix 7: DCS main page
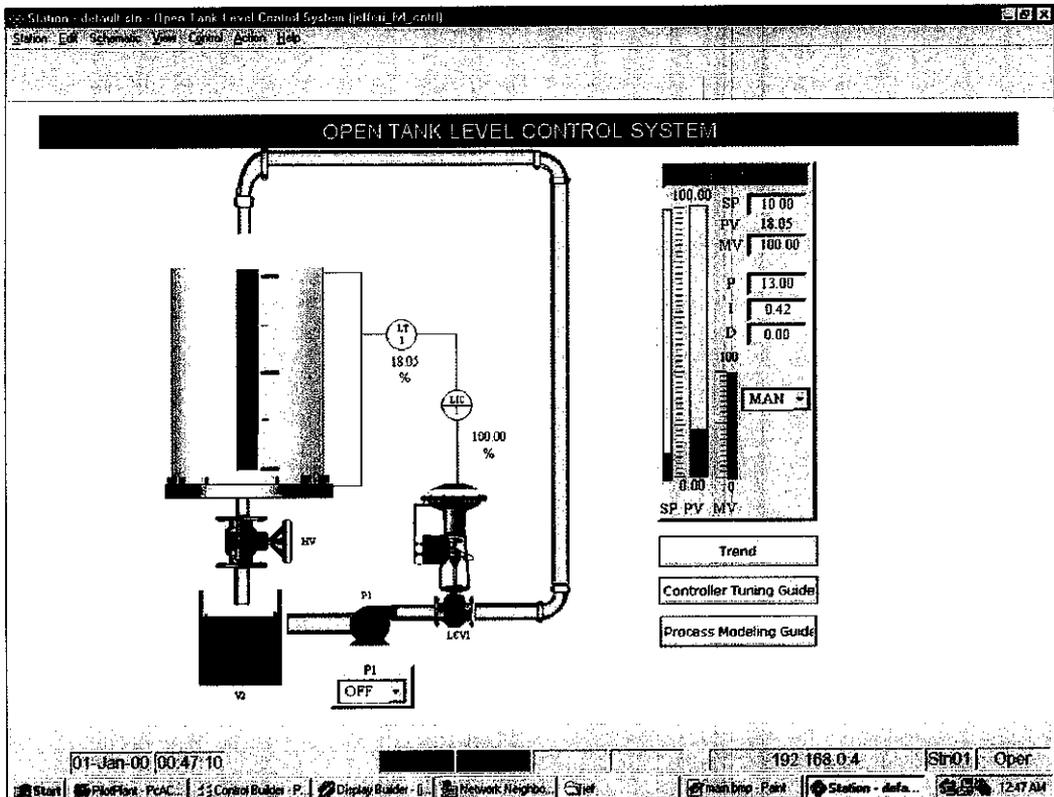
Appendix 8: Open Tank Level Control System main DCS page
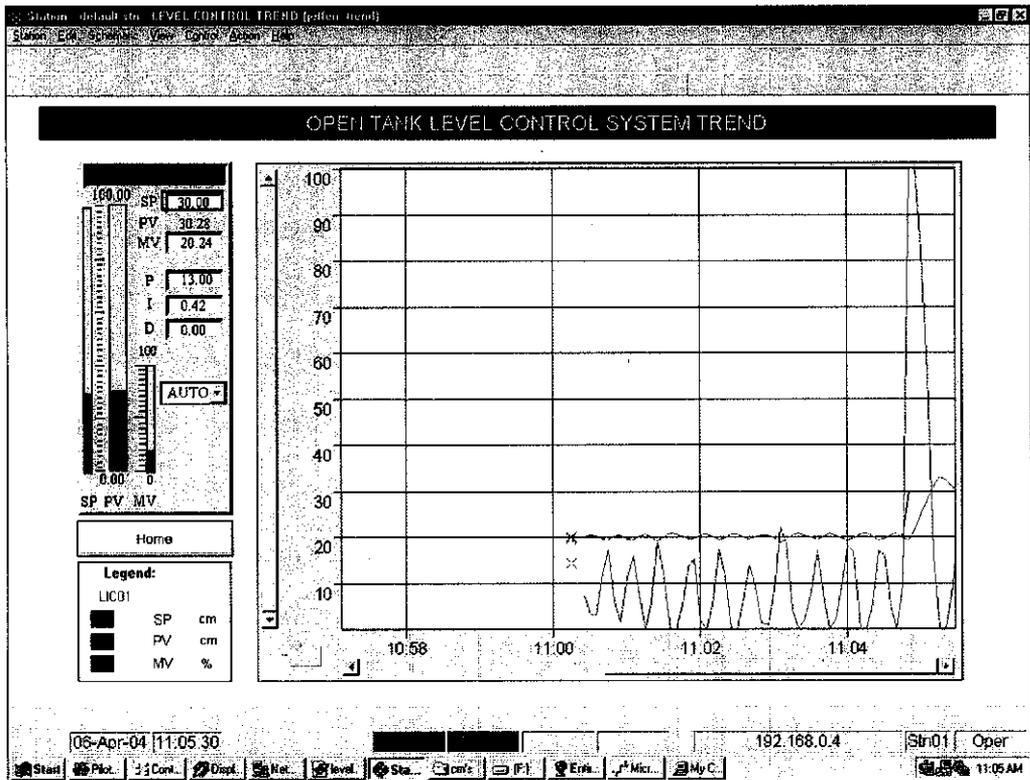
Appendix 9: Open Tank Level Control System trending DCS page

OPEN TANK LEVEL CONTROL SYSTEM SYSTEM MODELING

PROCESS REACTION CURVE METHOD

The steps involved when identifying the dynamic model of the system is as follows:

1. Allow the process to reach steady state
2. Introduce a single step change in the input variable
3. Collect input and output response data until the process gain reaches steady state.
4. Perform the graphical process reaction curve calculation as shown in the figure below

$$G_{r,ov}(s) = \frac{Ke^{-t_r}}{\tau_r s + 1}$$

$$y(t) = K(1 - e^{-(t-\theta_r)/\tau_r})$$

$$K = \frac{\Delta PV}{\Delta MV}, \qquad \tau_r = 1.5(T_4 - T_3); \qquad \theta_r = T_4 - \tau_r - T_1$$

Home

Appendix 10: Open Tank Level Control System (System modelling guide)

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OPEN TANK LEVEL CONTROL SYSTEM PID TUNING

ZIEGLER NICHOLS CLOSED LOOP TUNING METHOD

The methods used are as follows:

1. Start any trending (plotting) of the process variable.

2. Set the Kp and TD to their minimum values and the Ti time constant to its maximum value. Now place the controller in the Automatic state.

3. Increase the proportional gain in small steps. After each adjustment, observe the process variable response to a setpoint change. When sustained oscillations (amplitude is not increasing or decreasing) are observed, note the value of the proportional gain and the period (in minutes) of the oscillation, for better accuracy take the time it takes for 3 cycles to occur, and then find the average time for 1 cycle:

Gu = proportional gain for sustained oscillations

Pu = period of oscillations (in minutes)

4. Calculate the controller settings as shown in the TABLE

5. Make any final adjustments in Kp, Ti or TD to obtain the desired process variable response

Home

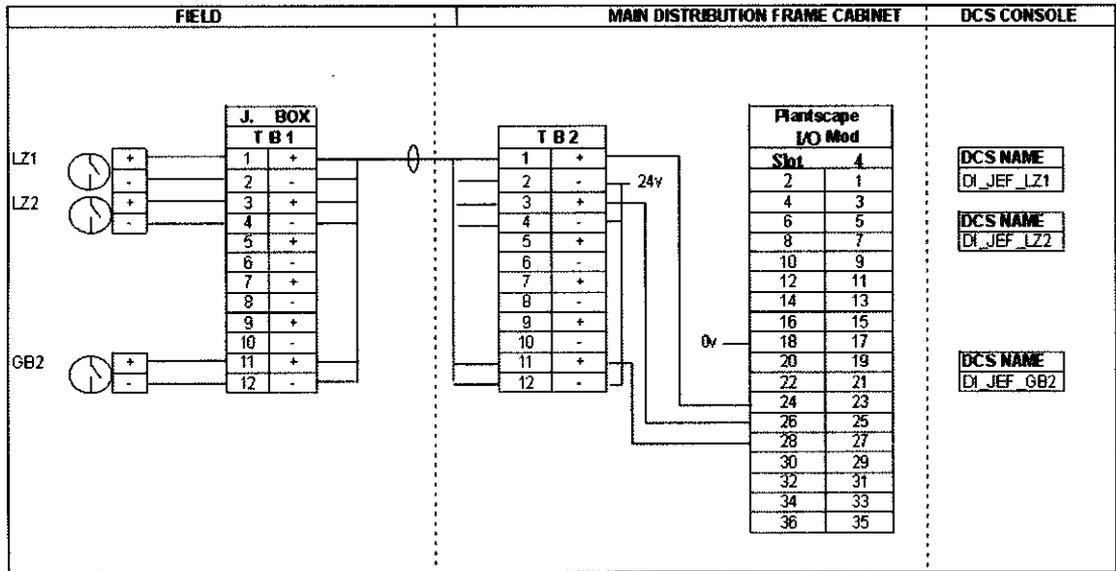06-Apr-04 11:05:47   192.168.0.4   Stn01   Oper
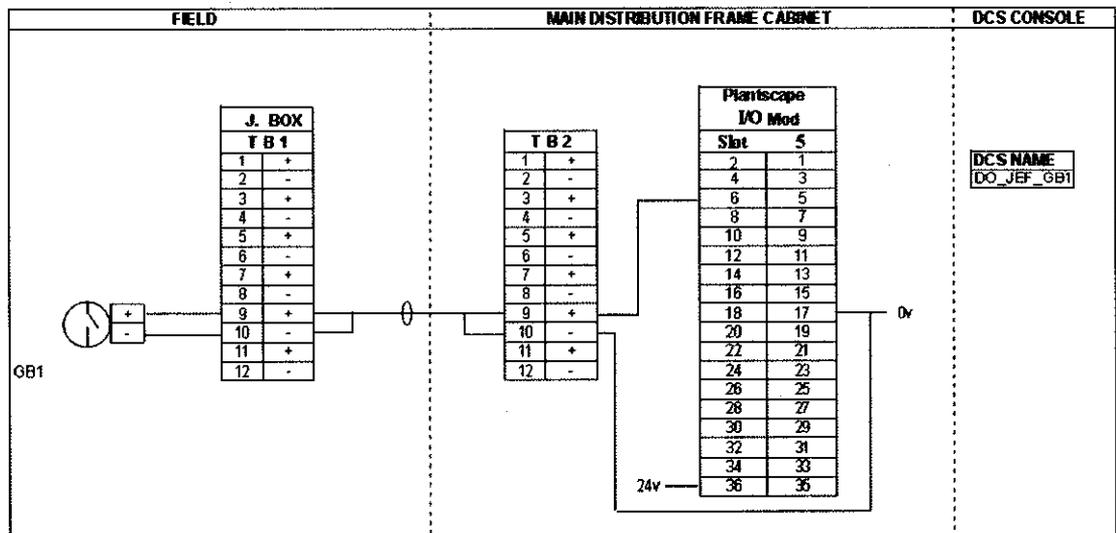
Appendix 11: Open Tank Level Control System PID tuning page

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Appendix 12:DETAILED EXPLANATION ON WIRING AND CONFIGURING DCS POINTS, CONTROL MODULE AND GRAPHICS.
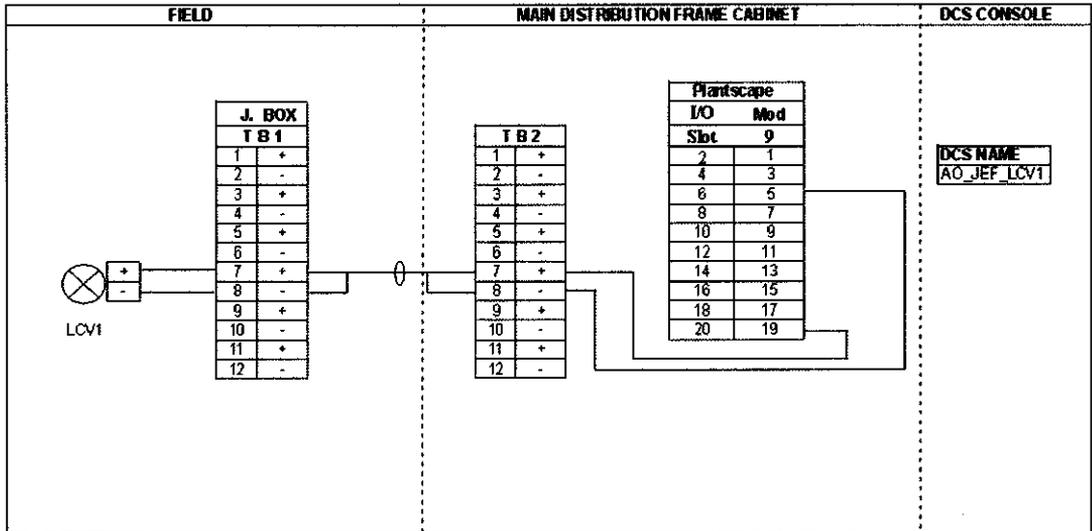
1. The following instrumentation loop diagrams show in detail how the instruments are wired to the Honeywell Plantscape Hybrid Controller. These drawing only show the new points that were added to the DCS system. For existing instrumentation loop diagrams please contact PC Automation Sendirian Berhad.
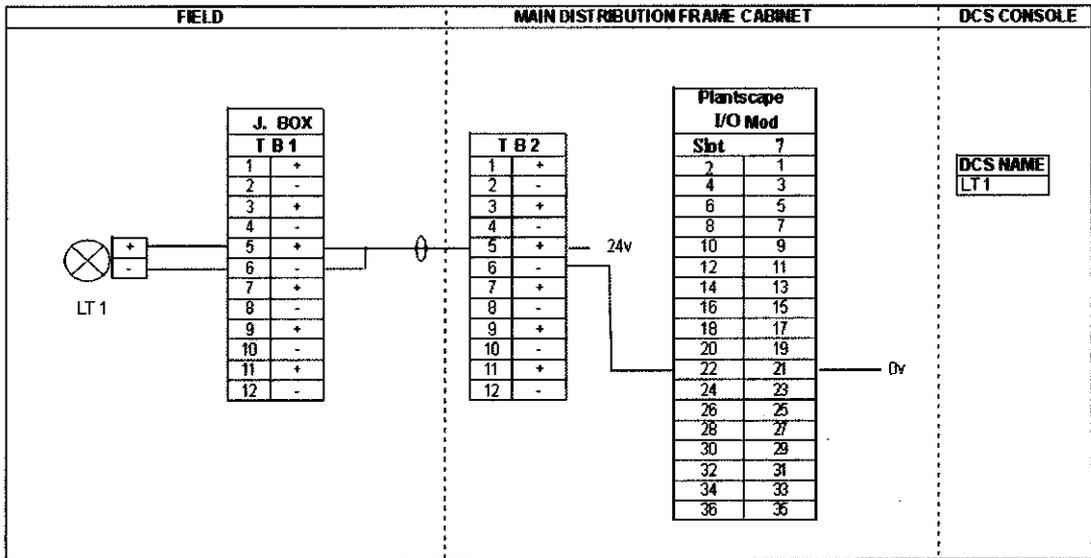

FIELD			MAIN DISTRIBUTION FRAME CABINET		DCS CONSOLE

J. BOX TB1 / TB2 / Plantscape I/O Mod Slot 4

LZ1, LZ2, GB2 (field instruments)

TB1: 1(+) 2(-) 3(+) 4(-) 5(+) 6(-) 7(+) 8(-) 9(+) 10(-) 11(+) 12(-)

TB2: 1(+) 2(-) 3(+) 4(-) 5(+) 6(-) 7(+) 8(-) 9(+) 10(-) 11(+) 12(-) — 24v, 0v

Plantscape I/O Mod Slot 4: 2/1, 4/3, 6/5, 8/7, 10/9, 12/11, 14/13, 16/15, 18/17, 20/19, 22/21, 24/23, 26/25, 28/27, 30/29, 32/31, 34/33, 36/35

DCS NAME: DI_JEF_LZ1, DI_JEF_LZ2, DI_JEF_GB2

Appendix 12.1: Digital Input Loop Diagram

FIELD			MAIN DISTRIBUTION FRAME CABINET		DCS CONSOLE

GB1 (field instrument)

J. BOX TB1: 1(+) 2(-) 3(+) 4(-) 5(+) 6(-) 7(+) 8(-) 9(+) 10(-) 11(+) 12(-)

TB2: 1(+) 2(-) 3(+) 4(-) 5(+) 6(-) 7(+) 8(-) 9(+) 10(-) 11(+) 12(-)

Plantscape I/O Mod Slot 5: 2/1, 4/3, 6/5, 8/7, 10/9, 12/11, 14/13, 16/15, 18/17, 20/19, 22/21, 24/23, 26/25, 28/27, 30/29, 32/31, 34/33, 36/35 — 0v, 24v

DCS NAME: DO_JEF_GB1

Appendix 12.2: Digital Output Loop Diagram

FIELD | **MAIN DISTRIBUTION FRAME CABINET** | **DCS CONSOLE**

Appendix 12.3: Analogue Output Loop Diagram

J. BOX TB1 (LCV1):

1	+
2	-
3	+
4	-
5	+
6	-
7	+
8	-
9	+
10	-
11	+
12	-

TB2:

1	+
2	-
3	+
4	-
5	+
6	-
7	+
8	-
9	+
10	-
11	+
12	-

Plantscape I/O Mod Slot 9:

I/O	Mod
2	1
4	3
6	5
8	7
10	9
12	11
14	13
16	15
18	17
20	19

DCS NAME: AO_JEF_LCV1

FIELD | **MAIN DISTRIBUTION FRAME CABINET** | **DCS CONSOLE**

Appendix 12.4: Analogue Input Loop Diagram

J. BOX TB1 (LT 1):

1	+
2	-
3	+
4	-
5	+
6	-
7	+
8	-
9	+
10	-
11	+
12	-

TB2:

1	+
2	-
3	+
4	-
5	+
6	-
7	+
8	-
9	+
10	-
11	+
12	-

24v

Plantscape I/O Mod Slot 7:

Slot	7
2	1
4	3
6	5
8	7
10	9
12	11
14	13
16	15
18	17
20	19
22	21
24	23
26	25
28	27
30	29
32	31
34	33
36	35

0v

DCS NAME: LT1

2. After the instruments have been wired to the DCS, the next step is to log in into the plantscape server using the username: ps_user and password:ps_user. After logging in, open the control builder software which is located in the start menu under Plantscape engineering tools. When prompt for the password enter the following, user name: mngr password: mngr1.
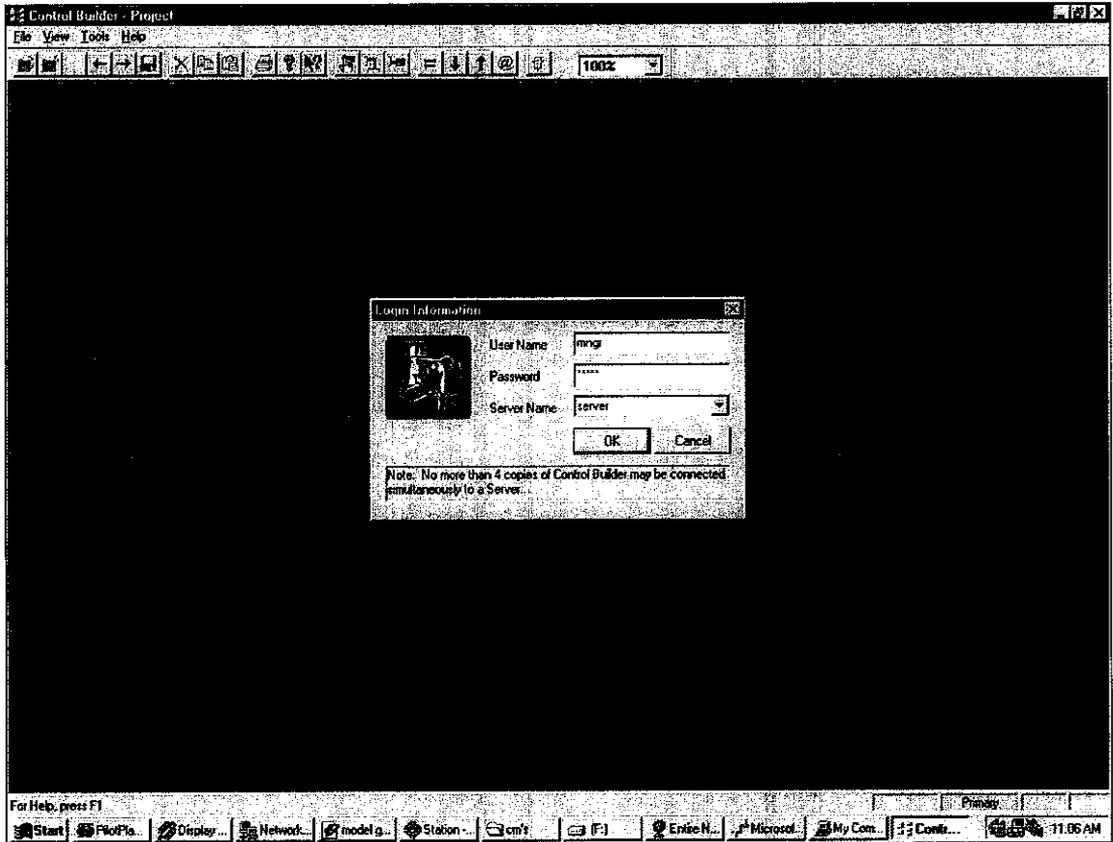

Appendix 12.5: Control builder login window

3. After successfully logged in, next create a new control module. By clicking FILE and create new control module. When the new control module window pops up, open the library tab, as shown in the figure below. Next drag the components you wish to use into the CM window.
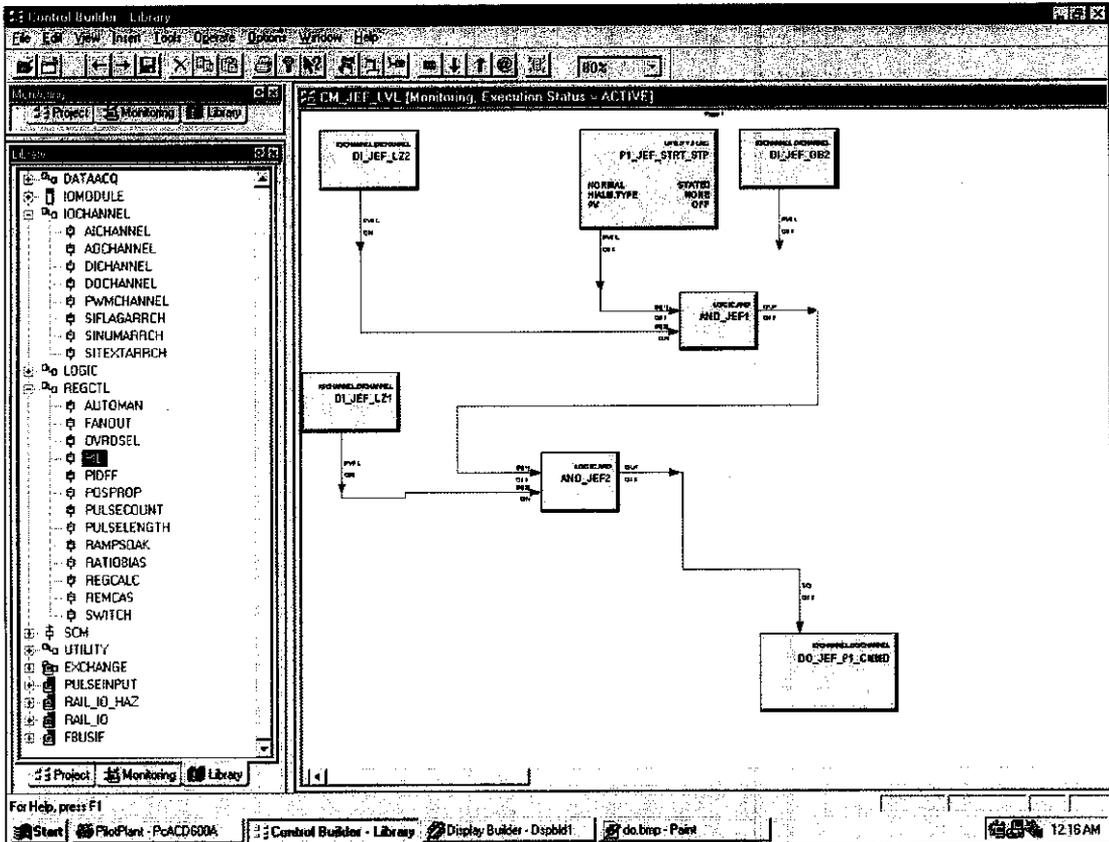
Appendix 12.6: Creating new CM

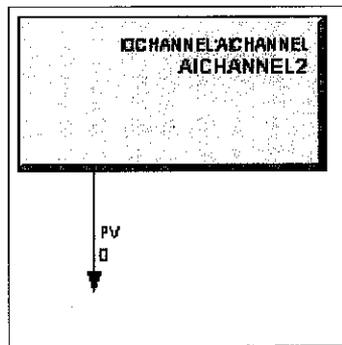4. Next, you have to associate I/O Channels to I/O Modules (IOMs).
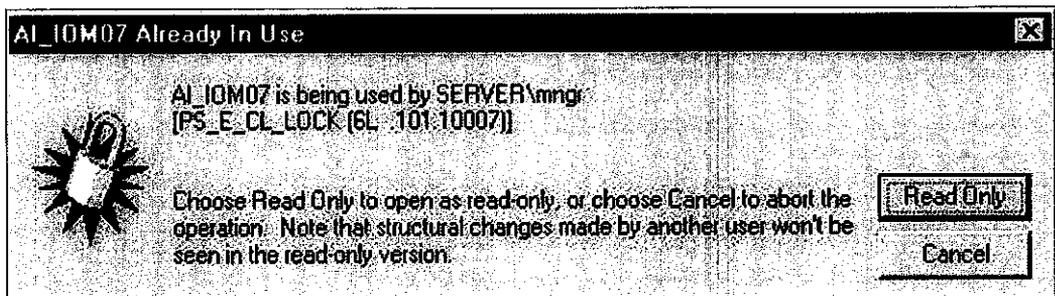
Appendix 12.7: Read Only Error message

NOTE: If you experience any READ ONLY error message please use the DATABASE MANAGER found under Plantscape Engineering tools to unlock any points or modules.

The following steps show to this association is done.

a. Right-click on the desired IO Channel block.
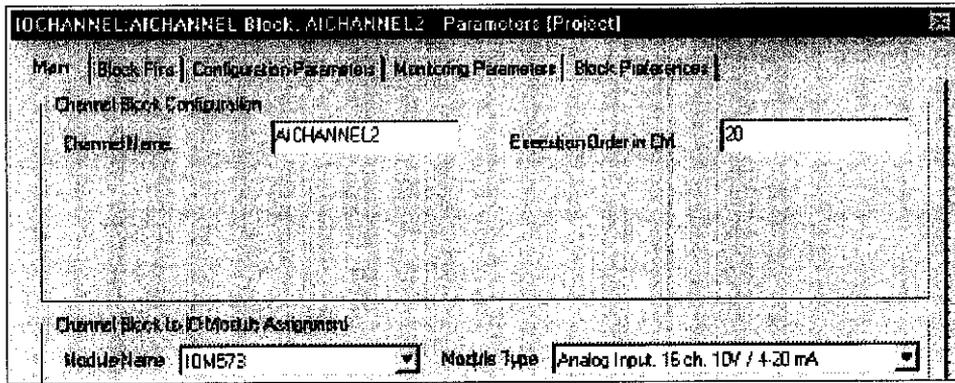

Appendix 12.8: AI channel block

b. Click on Configure Parameters ... IOC Block Object.
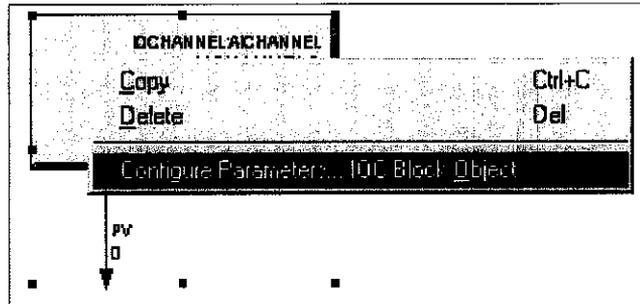
Appendix 12.9: Configure AI channel parameters

or, double-click on the desired IO **Channel** block.

c. On the Parameters Configuration form (Main tab), click on the Module Name drop-down box and select the I/O Module to which this I/O **channel** block is to be associated.

Appendix 12.10: Associating channel with I/O module

In the above example, AICHANNEL2 will be associated with IOM573.

d. Click on the **channel** number within this I/O module that is to contain this I/O **channel** block.
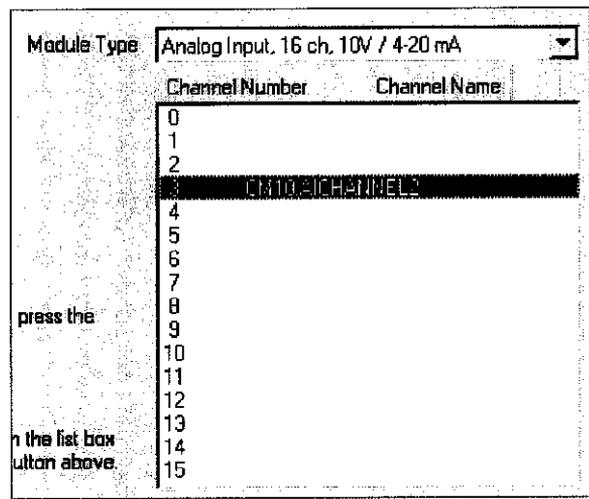
**Appendix 12.11: Select channel number in I/O module**

e. Click on the Assign Channel Block button. The I/O channel block has been assigned to channel number 3 in the I/O module.

5. After assigning the I/O channels to their respective I/O modules. We next check to see if they appear in the I/O modules. This is done by clicking the project tab and clicking the desired I/O module.
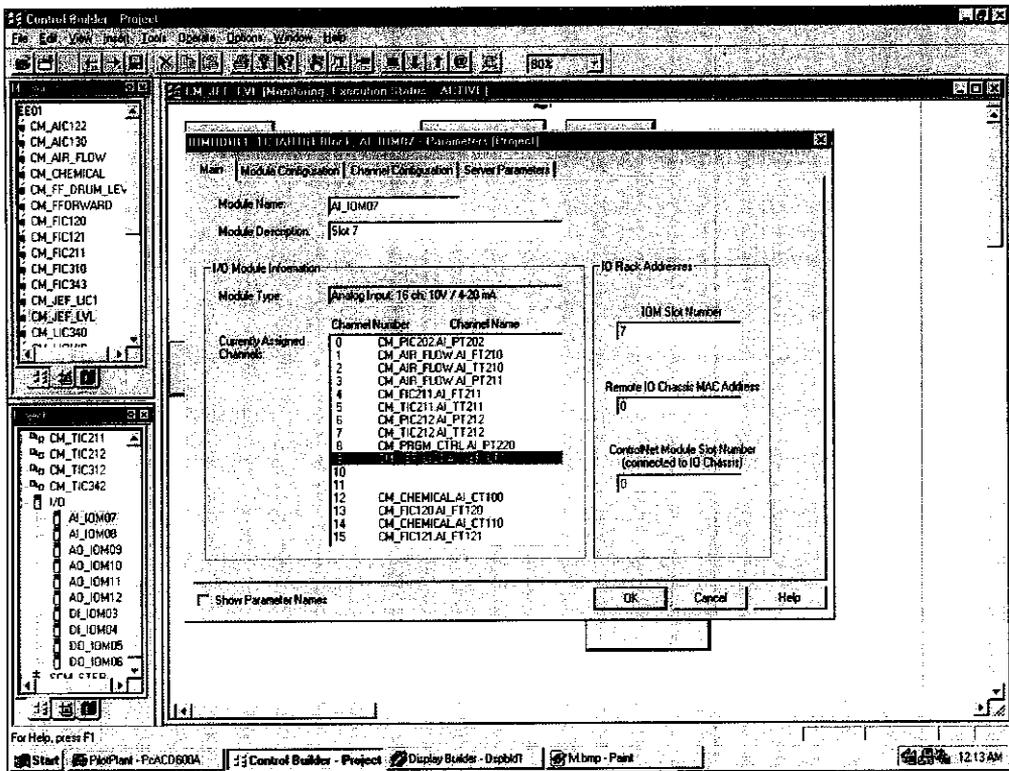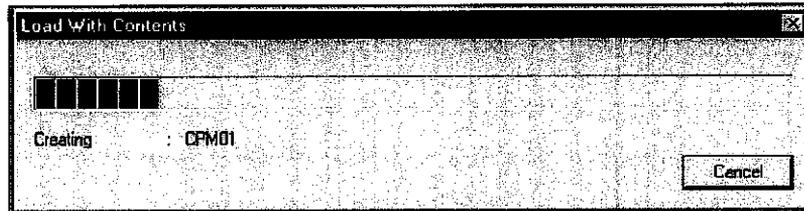
Appendix 12.12: Confirmation of point in I/O module

6. After you are satisfied with your control module, next assign the control module to CEE01.
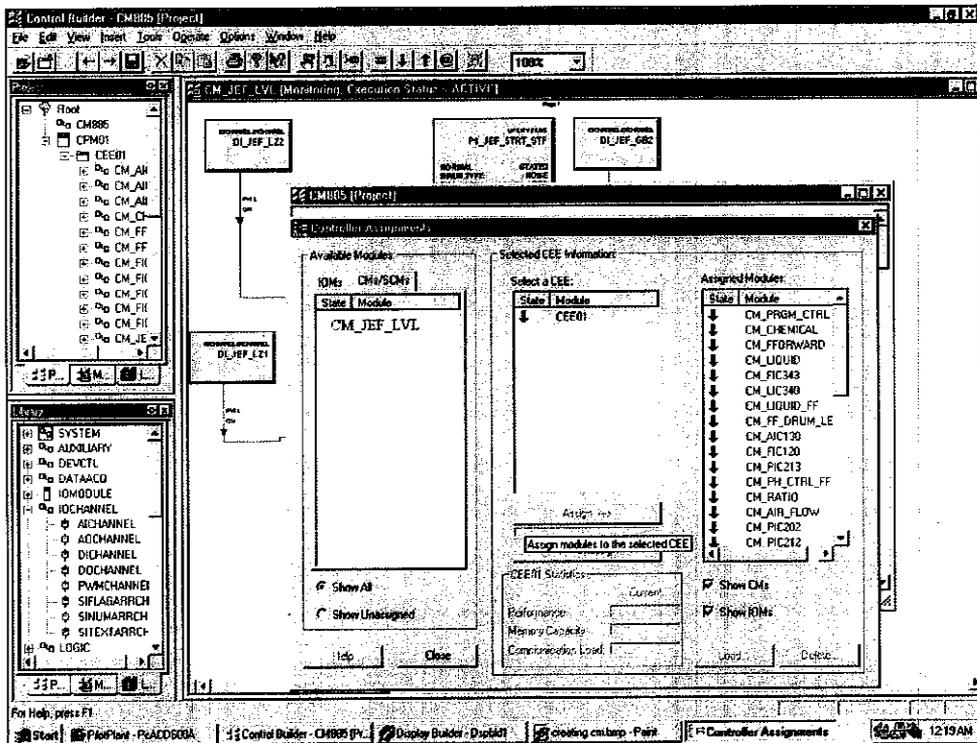

Appendix 12.13: Assigning CM to CEE01

7. Next the project control and I/O modules can be uploaded to the Hybrid controller. This is done by clicking TOOLS and LOAD WITH CONTENTS. The following window should appear.


Appendix 12.14: Load CPM with contents

8. Next, click on the MONITORING tab and highlight the CEE01. And click on ACTIVATE THIS CEE AND IT'S IOMs AND CMs as shown I nthe figure below.
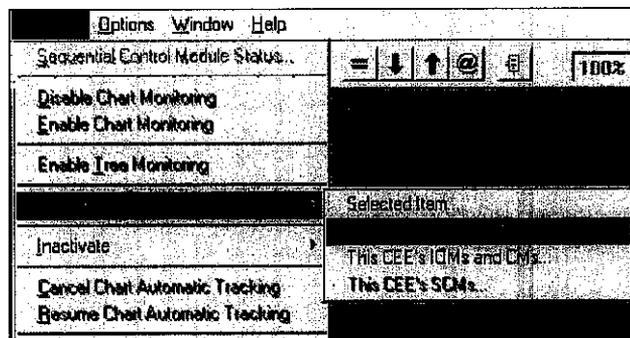

Appendix 12.15: Activating CM and I/O

9. The control module and its input/ouput modules have been successfully uploaded to the Hybrid controller. After completing this, we can then proceed to creating of the DCS graphics which willthen be used to control and monitor the plant.

10. Next open, the DISPLAY BUILDER. Faceplates, dynamic graphics can be found in the Honeywell graphic database. The following figure shows how the PV of the plant is displayed to the operator. First double click on the data point. Here click on the DATA tab and select the type of database link as POINT/PARAMETER. The point is selected as CM_JEF_LIC1 and parameter as PID1.PV. The same goes for all other points that you wish to display.
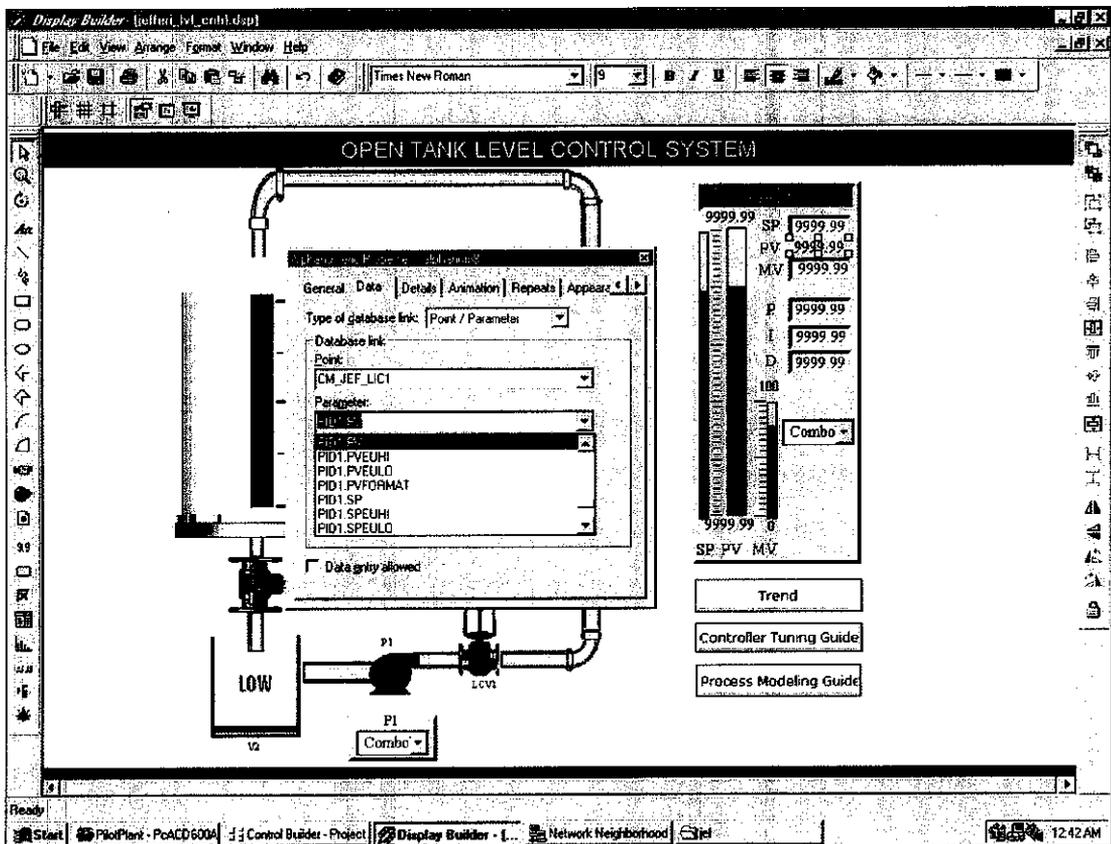

Appendix 12.16: Configuring DCS page

11. The trend window setting layout is slightly different, but its concept remains the same. Select the point that you wish to plot.
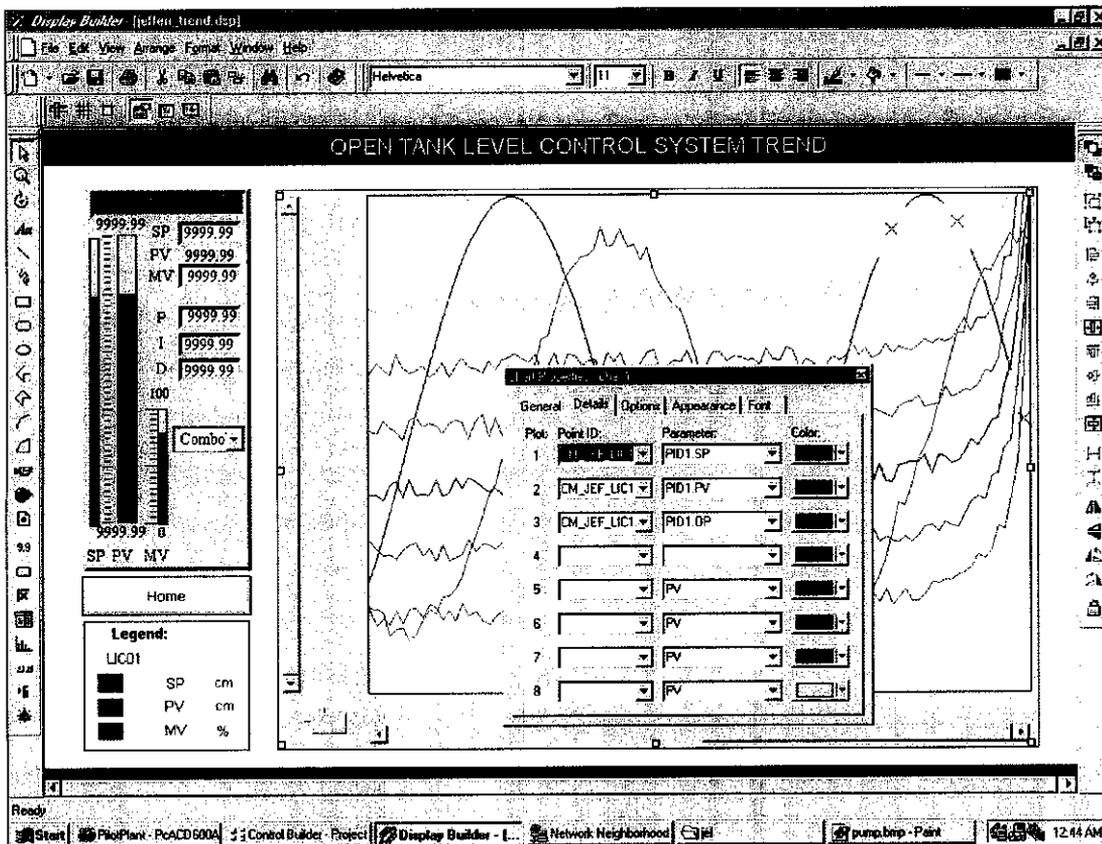
Appendix 12.17: Configuring trend page

12. After you are satisfied with your graphics, save the graphics as a *.dsp file in the C:\HONEYWELL\CLIENT directory and open the STATION application to use your graphic to monitor your plant.
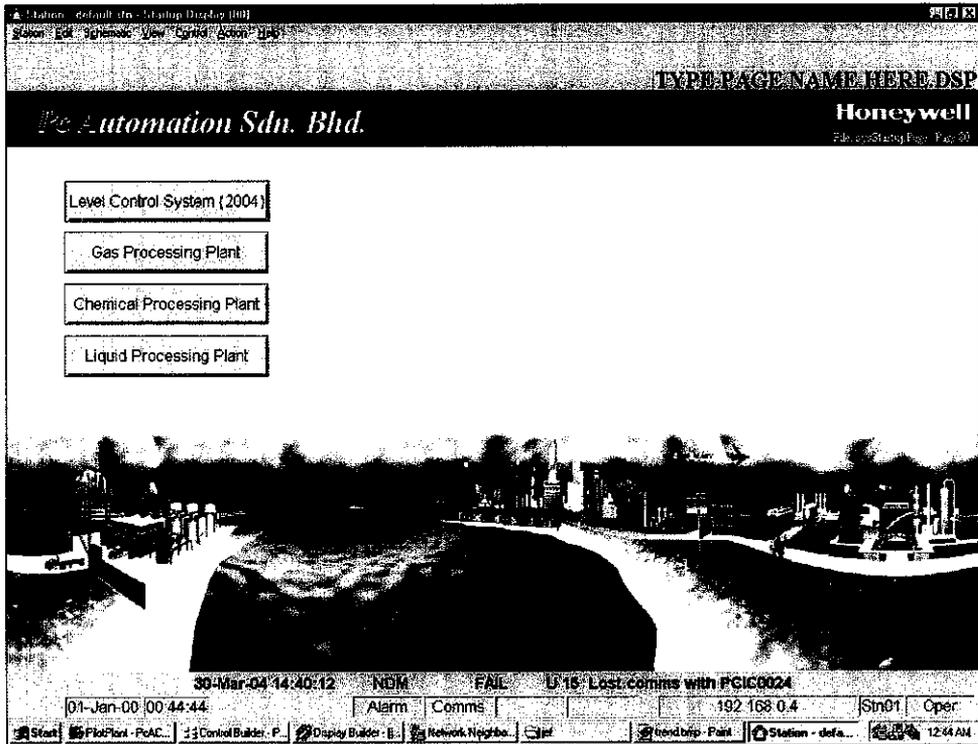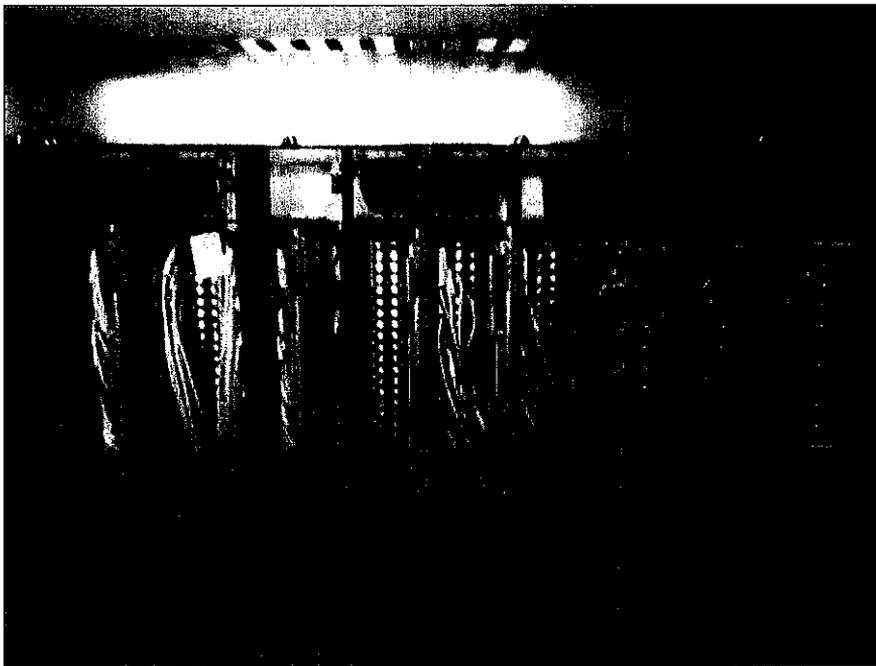

Appendix 12.18: Opening page without link at main DCS page
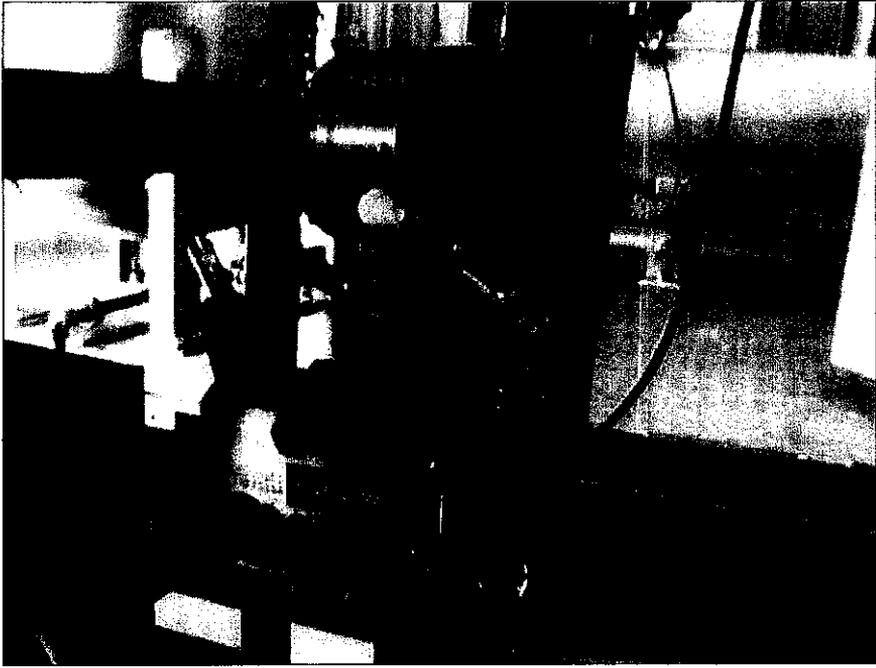
Appendix 13: Open Tank Level Control System in Instrumentation and control laboratory

Appendix 14: Water Pump used in System

Appendix 15: Wiring of instrumentation to Plantscape Hybrid Controller
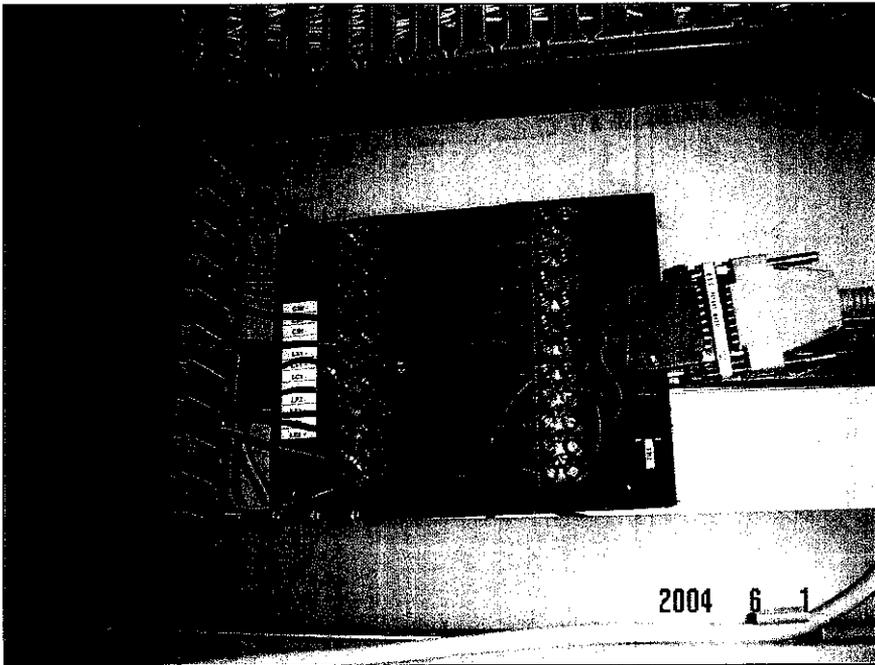
Appendix 16: Differential Pressure Level Transmitter
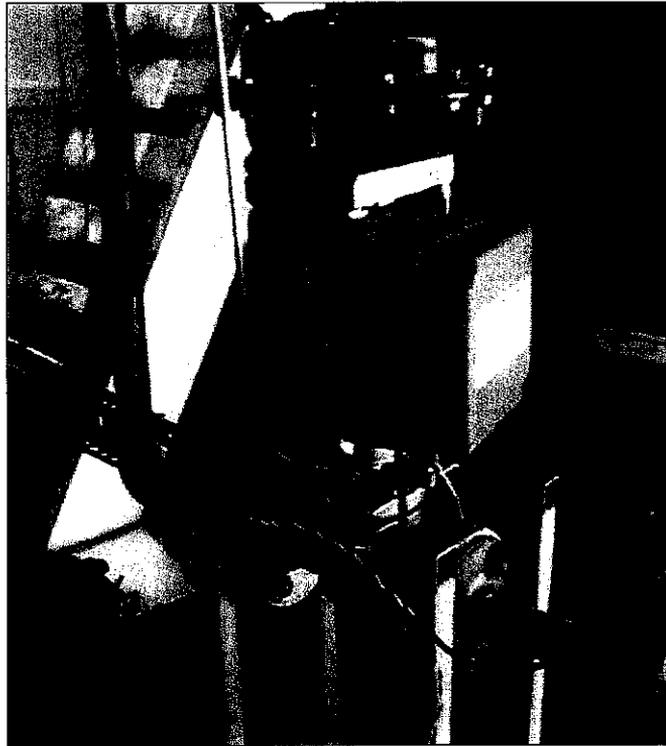

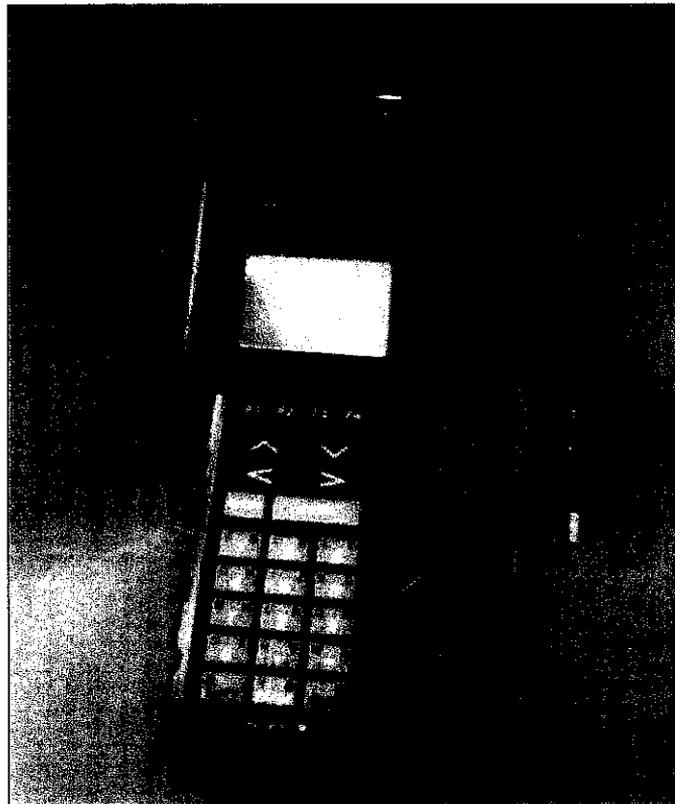**Appendix 17: Junction Box, JB**

Appendix 18: Wiring inside the JB

Appendix 19: Terminal Block 2 connections

Appendix 20: Control valve and positioner

Appendix 21: YOKOGAWA Brain Terminal used in calibrating the level transmitter

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Selection of Project Topic														
	-Propose Topic	▮													
2	Preliminary Research Work		▮	▮											
	-Previous work done by FYP student														
	-Identify limitation of existing control system														
	-List of references/literature														
	-Project planning														
3	Submission of Preliminary Report			●											
4	Project Work				▮	▮	▮	▮							
	- Wiring & Calibration of instruments														
	- DCS configuration & PI tuning														
5	Submission of Progress Report								●						
6	Project work continue								▮	▮	▮	▮			
	- Obtain system model & System simulation														
7	Submission of Interim Report Final Draft												●		
8	Oral Presentation													●	
9	Submission of Interim Report														●

● Suggested milestone

▮ Process

Appendix 22: Gantt chart for Final Year Project 1

No.	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Work Continue														
	- Developing fuzzy logic controller		■	■											
2	Submission of Progress Report 1			●											
3	Project Work Continue														
	- Connecting plant to DCS				■	■	■	■							
4	Submission of Progress Report 2								●						
5	Project work continue														
	- Test run of open tank level control system							■	■	■	■	■			
6	Submission of Dissertation Final Draft												●		
7	Oral Presentation													●	
8	Submission of Project Dissertation														●

● Milestone

■ Proposed Process

Appendix 23: Gantt chart for the Final Year Project 2

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