SEQUENTIAL TRIPS OF HIGH WATER CUT WELLS

By

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FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
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CERTIFICATION OF APPROVAL

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Approved:

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TRONOH, PERAK

December 2006

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.

Supik Leykom

ABSTRACT

Baronia Production Platform (BNP – A) shutdown on high level of surge vessel was due to one of the crude oil transfer pump (COTP) trips. The response time for personnel from Baronia Quarters Complex (crew BNQ – B) especially during bad weather condition is a constraint. Currently BNP – A is running all the pump to sustain a high production of crude; the problem is to maintain the surge vessel level if one of the pump trips. This project is about integrating the instruments that will automate the sequential trips process to prevent a total shutdown of BNP –A by tripping the wells that have high percentage of water. The system is made use of the water cut sensors to determine the percentage of water inside the particular wells and a level transmitter to sense the process level inside the surge vessel. The new system was designed at the lowest possible costs but with high reliability. In designing the most applicable and reliable process level control system, the Programmable Logic Controller (PLC) was programmed to automate the sequential trips process.

ACKNOWLEDGEMENTS

Firstly, I would like to express my highly gratitude to The Almighty, for giving me the ability to conduct my project perfectly, without counting the tough and challenging moment that I have experienced during the event of carrying out several tasks.

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LIST OF ABBREVIATIONS

BNDP-A	Baronia Drilling Platform A
BNDP-I	Baronia Drilling Platform I
BNP-A	Baronia Production Platform A
BPD	Barrel Per Day
COTP	Crude Oil Transfer Pump
FCV	Flow Control Valve
FYP	Final Year Project
HHP	High High Pressure Separator
HP	High Pressure Separator
ID	Inner Diameter
I/P	Current to Pneumatic Converter
LCV	Level Control Valve
LED	Light Emitting Diode
LP	Low Pressure Separator
LT	Level Transmitter
MCOT	Miri Crude Oil Terminal
OD	Outer Diameter
PETRONAS	Petroliam Nasional Berhad
PLC	Programmable Logic Controller
PSIG	Per Square Inch Gauge
SSV	Surface Safety Valve
UTP	Universiti Teknologi PETRONAS

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The project involves the design of Sequential Trips of High Water Cut Wells at Baronia Production Platform A (BNP-A) located in Baram Delta, offshore of Sarawak, East Malaysia about 25 miles (40 Km) from Lutong terminal. BNP-A (Refer to Figure 1 for the Baronia Block Layout) is bridge linked and unmanned platform comprises of production platform, BNP-A and two drilling platforms, Baronia Drilling Platform A (BNDP-A) & Baronia Drilling Platform (BNDP-I). The main function of BNP-A is to accumulate and stabilize the incoming fluid (natural gas and crude oil) from BNDP-A and BNDP-I. BNDP-A and BNDP-I are the drilling platform that have a number of production wells which are used to bring up the crude oil from the reservoir. After the crude oil is stabilized, it is pumped to the onshore Miri Crude Oil Terminal (MCOT) using three COTP for the dehydration process. Simplified fluid process flow at BNP-A is shown in APPENDIX A.

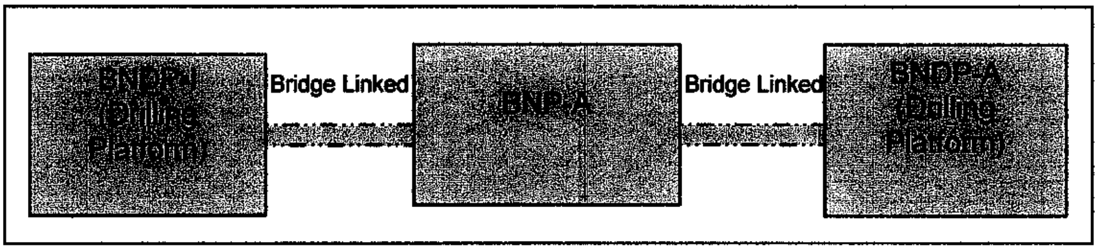

Figure 1: Baronia Platform Layout
(Adapted from BNP-A P&ID, Baronia Field Layout)

The general function of the entire separators are to separate the fluids and the natural gas. Beside that they are also used to decrease the pressure of the fluid to the atmosphere pressure. This means that when the fluids reach the surge vessel the process fluids must be at the atmosphere pressure to enable the COTP transferring the fluid to the MCOT. These COTPs are basically designed to work 24 hours per day in order to sustain the liquid level inside the surge vessel and of course to avoid the overflowing.

1.1.1 Problem Statement

The Baronia Production Platform (BNP – A) shutdown on high level of surge vessel was due to one of the crude oil transfer pump (COTP) trips. The response time for personnel from BARONIA Quarters Complex (crew BNQ – B) especially during bad weather condition is a constraint. Currently BNP – A is running all the pumps to sustain a high production of crude oil and by doing that, they have experienced a problem to maintain the surge vessel level if one of the pump trips. Based on that condition, an autostart mechanism is not an issue since there is no standby pump available recently.

Based on BNP-A 2005 shutdown data, the gain of 23k Barrel Per Day (BPD) can be realized from this project. Based on the worst case scenario if there is a problem on the BNP-A's COTP, the total time that the crew can rectify the problem is approximately 3 hours. Based on the BNP-A daily field report dated 7/12/2005, the total production for BNP-A is 42,361 Barrel Per Day (BPD) gross and 23,343 BPD (net) which is approximately 23kBPD (net).

Thus, BNP-A oil production per hour:

$$= \frac{23\text{kBPD}}{24\ \text{Hrs/D}} = 960\text{BPHrs}$$

Losses during pump trip:

= 960B/Hrs X 3 Hrs X USD 65/B X RM 3.6/USD

= RM 673,920

1.1.2 Facility Improvement Proposal

A study has been conducted to validate the originator proposal and found several options to be considered.

Option 1:

Installation of Sequential Trips of High Water Cut Well

Option 2:

Installation of additional pump (COTP)

Option 1 is the most effective way to resolve this problem since the modification and overall costs are not high compare to Option 2. Option 2 requires a major modification and the cost is absolutely expensive.

1.2 Objective and Scope of Study

In the event when COTP tripped, the surge vessel level can be sustained when the selected high water cut wells tripped. The objectives of initiating this project are to meet the following conditions:

- To prevent total shutdown of BNP – A, BNDP – A and BNDP-I
- To maintain the Baronia production rate at the desired value
- To improve the existing pneumatic sequential trips system using PLC based system

The scope for this project comprises of several major aspects as shown below:

- To determine the instruments that will automate the sequential trips process
- To select the most reliable water cut sensor to determine the percentage of water inside the particular wells
- To design a real system and to fabricate the platform model to visualize the real system

CHAPTER 2
LITERATURE REVIEW AND THEORY

2.1 Level Control Overview

Level control is extremely important for the successful operation of most oil and gas production activity globally, because it is through the proper control of flows and levels that that the production rates and inventories are achieved. Automatic control is required to prevent the level from overflowing or emptying completely when flow disturbances occur. The incoming fluid flowrate into the surge vessel must be equal to the outgoing flowrate in order to sustain the fluid level inside the vessel at the desired level. The outgoing flowrate from the surge vessel is normally controlled by the transfer pumps. This project is basically concern on the high level inside the surge vessel when one of the crude oil transfer pumps trips.

2.2 Process Control System using PLC

Generally speaking, process control system is made up of a group of electronic devices and equipment that provide stability, accuracy and eliminate harmful transition statuses in production processes. As a result of fast progress in technology, many complex operational tasks have been solved by connecting programmable logic controllers. Beside connections with instruments like operating panels, sensors, switches, valves and such, possibilities for communication among instruments are so great that they allow high level of exploitation and process coordination, as well as greater flexibility in realizing the process control system. Each component of the process control system plays an important role, regardless of its size. For example, without a sensor, PLC wouldn't know what exactly goes on in the process. In automated system, PLC controller is usually the central part of a process control system. With execution of a program stored in program memory, PLC continuously monitors status of the system through signals from input devices. Based on the logic implemented in the program, PLC determines which actions need to be executed with output instruments.

2.3 Systematic Approach in Designing a Process Control System

First, an instrument or a system that needed to be controlled is selected. Automated system can be a machine or a process and can also be called a process control system. Function of a process control system is constantly watched by input devices (sensors) that give signals to a PLC controller. In response to this, PLC controller sends a signal to external output devices (operative instruments) that actually control how system functions in an assigned manner. Secondly, all input and output instruments that will be connected to a PLC controller are specified. Input devices are various switches, sensors and such. Output devices can be solenoids, electromagnetic valves, motors, relays, magnetic starters as well as instruments for sound and light signalization. Third, a ladder diagram is developed for a program by following the sequence of operations that was determined in the first step. Finally, program is entered into the PLC controller memory. When finished with programming, checkup is done for any existing errors in a program code (using functions for diagnostics) and, if possible, an entire operation is simulated. By bringing supply in, system starts working.

2.4 Existing Level Control System at BNP-A

2.4.1 Level Control Loop Diagram on Surge Vessel at BNP-A

APPENDIX B shows the simplified instrument loop diagram for the level control on surge vessel at BNP-A. Level transmitter (LT) at the vessel serves as the controlling device to monitor the liquid level inside the vessel. Pneumatic output from the transmitter is sent to the COTP pneumatic speed controller through the local control panel. The COTP is driven by gas engine. Pneumatic speed controller is used to determine the ratio of gas to be fed to the gas engine with proportional to the level transmitter output. The greater the transmitter output, which means that the liquid level inside the vessel is higher, the faster the engine runs to sustain the liquid level inside the vessel. The pneumatic output is also sent to the level control valve. Level control valve is used to control the process flow outgoing from the surge vessel. The opening of this valve is proportional with the transmitter output. The instrument loop diagram involving only one COTP is shown in APPENDIX B. Basically the rest COTP are connected similarly as indicated by the dashed box in APPENDIX B.

2.4.2 Existing Sequential Trip Pneumatic Control System

A sequential pneumatic system is implemented to sustain the surge vessel in the event when COTP tripped. To sustain the vessel level when one of the duty pump (COTP) trips, the quantity of liquid being directed to vessel must be decreased by tripping the selected high water cut wells sequentially. To meet this objective, there are several new instruments that are combined to implement the sequential trips mechanism as shown in the dashed red box in Figure 2.

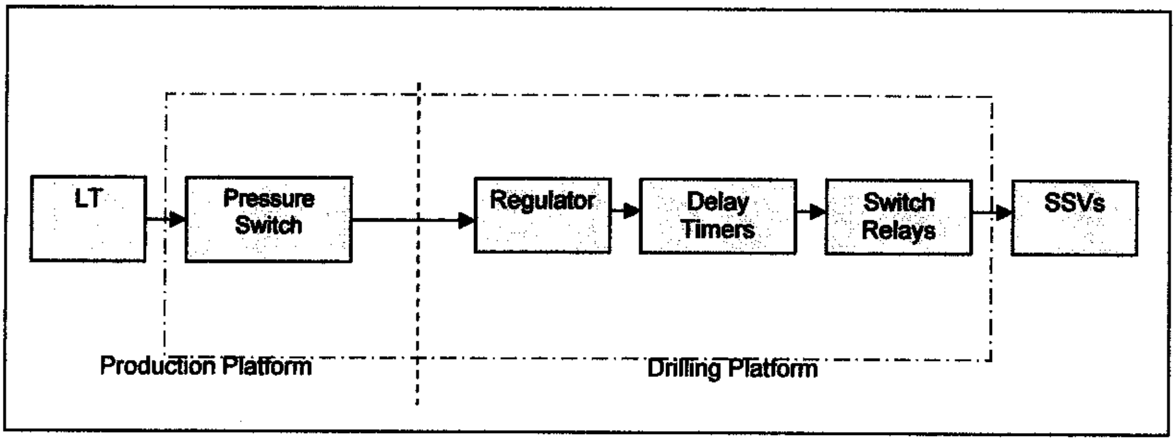

Figure 2: Existing Sequential Trip System Block Diagram

2.4.2.1 Instrument Applications for the Existing Sequential Trip Control System

2.4.2.1.1 Pneumatic Level Transmitter (LT)

Pneumatic level transmitter transmits a pneumatic output signal (3-15 psig) proportionally with the measured level inside the vessel

2.4.2.1.2 Pneumatic Pressure Switch

Pneumatic pressure switch receives the pneumatic signal from the level transmitter and trip when the output signal reaches the set point of the switch. Three pneumatic pressure switches are installed along the pneumatic pressure transmitter output signal line for the complete system.

2.4.2.1.3 Instrument Gas Regulator

Instrument gas regulator provides reduced pressures to the hydraulic relay.

2.4.2.1.4 Volume Bottle and Flow Control Valve (Delay Timer)

This accessory provides the delay time or sequence for the Surface Safety Valve (SSV) closing. All the selected wells are terminated in sequence when the COTP tripped.

2.4.2.1.5 Hydraulic Relay

Hydraulic relay used to control the open/close operating sequence of or Surface Safety Valves (SSV).

2.4.2.2 Technical Discussion for Existing Sequential Trip Control System

Level transmitter is used for a monitoring device which provides the proportional output signal (3-15 psig) with respect to the level measured inside the vessel. LT output signal is connected to a pressure switch which is set at specific trip setting. The setting is calculated based on the recommended level trip setting inside the vessel. As the liquid level rises above the level trip setting, LT sends the pneumatic signal to the pressure switch. The pressure switch trips which consequently blocks the supply to the hydraulic switch relay. As a result the hydraulic switch relay will be de-energized and blocks the hydraulic supply to the SSV. SSV then de-energized since the supply is exhausted which finally will cause the valve to close and terminate the flow. APPENDIX C basically shows a part of pneumatic sequential trip system currently implemented at BNP-A. The complete system involves the following:

- 1 unit of Level Transmitter (already exist)
- 3 units of pneumatic pressure switch
- 3 units of instrument gas regulator
- 5 units of volume bottle and flow control valve
- 8 units of hydraulic relay

BNP-A production receives fluids from 25 wellheads at the BNDP-A and BNDP-I drilling platform; 12 and 13 wellheads from BNDP-A and BNDP-I respectively. Among them six wells have been identified that produce high percentage of water as shown in Table 1. These wells are manually selected to be included in the sequential trip system. BN indicates Baronia, S for short string whereas L, for long string. Sometimes one particular well is made up of two strings configuration as well as one single string configuration. Close in priority will be based on the water cut percentage of the particular wells.

Table 1: Selected Wells and Water Cut Percentage

(Taken from BARONIA production data on 8/10/2005)

Group	Wells	Location	Water Cut Percentage	Priority
1	BN 10S	BNDP-A	92	1
	BN 7L	BNDP-A	85	
	BN 10L	BNDP-A	75	
3	BN 16S	BNDP-A	67	3
	BN 12	BNDP-A	75	
	BN 7S	BNDP-A	70	
2	BN 50S	BNDP-I	73	2
	BN 54S	BNDP-I	87	

High water cut wells are grouped into three (Refer to Table 1). They are divided based on the well water cut percentage & platform location. Each group of strings will be tripped by one pneumatic pressure switch which is set at specific setting and priority. Each string in every group will be tripped at different time depends on the set point of the pneumatic timer. The group that consists the considered poor performing wells as the priority wells to be closed. There are three pressure switches connected from the pneumatic level transmitter. Each pressure switch is set at specific setting. Each setting is shown in APPENDIX D1. The complete pneumatic sequential trip system for Group 1 is basically shown in APPENDIX C by the red-dashed box. The concept and the design of the system is applied to the two other groups to establish an overall complete sequential trip control system in BNP-A.

2.4.2.3 Determining the Setpoint for the Pneumatic Switch Trip Setting

As per designed, there are four typical levels setting for the surge vessel refer APPENDIX D2). LL indicates the trip setting for the lowest level (LOW LOW). L indicates the level where the alarm is triggered to warn about the LOW level inside the vessel. H indicates the HIGH level inside the vessel to trigger the warning alarm. HH is the trip setting for the HIGH HIGH level inside the vessel. The first trip setting is set at 75 % of the vessel height. Second trip setting is set at the 80 % of the vessel height. Third trip setting is set at 85 % of the vessel height. Then we convert those heights to get the switch settings in term of the pneumatic pressure. The height of the vessel is 3175 mm.

As the liquid level inside the surge vessel rises above the first level trip setting, LT will send the pneumatic signal to the first pressure switch (PS-1). The pressure switch trips which consequently blocks the supply to the switch relay. As a result the switch relay will be de-energized and blocks the hydraulic supply to the SSV. SSV will be also de-energized since the supply is exhausted which finally will cause the first three SSV to close. Closing the first three SSV will reduce the amount of fluid coming into surge which will bring the liquid level to the normal level. But if liquid level inside the vessel keeps increasing even though the first three poor performing strings are closed, the second pressure switch will take place. The first pressure switch will not function anymore since it was tripped and depressurized. The wells in group 2 will be closed whenever the second pressure switch is triggered. The third pressure switch works similarly; it is used to close the wells in group three whenever the trip setting 3 is triggered.

2.4.2.4 Installation Block Diagram

Installation block diagram and platform layout is shown in APPENDIX E. One instrument support panel is installed on the cellar deck at BNP-A near to the existing instrument control panel to place three pneumatic pressure switches. At BNDP-A, there will be two support panels needed to place three switch relays, two set of volume accumulator and one regulator at each panel respectively. The tubing for instrument signal line from BNP-A to BNDP-A must be routed along the tubing tray on the bridge and as well as from BNP-A to BNDP-I since these three platforms are linked by bridge. The length of the bridge from BNP-A to BNDP-A and from BNP-A to BNDP-I is approximately 50 meters and 65 meters respectively. At BNDP-I, there will be also one single panel to place one instrument gas regulator, one set of accumulator and two hydraulic relays.

CHAPTER 3
METHODOLOGY AND PROJECT WORK

Basically this project involves the real system and the model design. For the real system the work scope is to do the detail design of the automated sequential trip control system at BNP-A. A plant model would be implemented to visualize the real system design. The real system and the model design are discussed further in the next subsection.

3.1 Real System Design

3.1.1 Real System Design Overview

The real design consists of three major parts which are:

1. Input Sensing Devices
    - Water Cut Sensors
    - Electronic Level Transmitter
2. PLC Controller
3. Output Devices
    - Control Valves
    - I/P Converter

The typical block diagram of the design is shown in APPENDIX F1. There are 25 units of water cut sensor needed to be installed at each well at BNDP-A and BNDP-I. New level transmitter will be installed for this new system which will be discussed later. Control valves already exist at each particular well.
Intelligence of an automated system depends largely on the ability of a PLC controller to read signals from different types of sensors and input devices. In this system water cut sensors and a level transmitter will serve as inputs to the PLC controller. Water cut sensor is used to determine the percentage of water in one particular well whereas the level transmitter will be used to measure the level inside the vessel and transmit the proportional output to the PLC. The PLC will make the decision to select the wells that have high percentage of water based on the water cut sensor readings. These

selected wells will be closed in whenever the level transmitter senses the high level inside the surge vessel. The PLC will also determine the sequence for the tripping of the selected wells based on the water cut percentage. The output of the PLC is transmitted to the final control element such as control valve to terminate the fluid flow from the wells.

As discussed earlier there are three main components in the real system as shown in APPENDIX F2 and F3. The level transmitter output is connected to the PLC as well as the water cut sensors. The level transmitter and the water cut sensors produce an analog output of 4-20mA with proportional to the process measurement. The 4 mA analog output indicates 0% of the process measurement whereas the 20 mA indicates the 100% of the measurement. The level transmitter and the water cut sensors are set at specific setpoint which are defined in the PLC. Water cut sensors continuously sense the water cut percentage inside the particular wells. The PLC will compare the water cut sensor reading with the setpoint. The level transmitter senses the level inside the surge vessel. When the level inside the vessel exceeds the setpoint, the PLC will send the output command to the selected wells that contain the water percentage higher than setpoint. The selected wells with high percentage of water then will be closed to sustain the level inside the surge vessel when the COTP tripped. The other wells that produce high percentage of crude oil are continuously producing. The output from the PLC is connected to the I/P converter whish is used to convert the electrical signal from the PLC to the proportional pneumatic signal. The pneumatic signal is send to the hydraulic relay which will be de-energized to block the hydraulic supply to the SSV. The SSV consequently will be tripped to terminate the crude oil flow.

3.1.2 Technical Overview for Instruments Used for the Actual System

3.1.2.1 Water Cut Sensor

After making the comparison of three s for water cut sensors (refer to APPENDIX G for the comparison table), decision have been made to choose Honeywell H_2O Analyzer System as the measurement device to determine the water cut percentage in the particular wells. Honeywell's H2Oil Analyzer System is ideal for the oil and gas industry. The H2Oil Analyzer System is an accurate, cost-effective, reliable water measurement solution for all petroleum recovery operations. The H2Oil Analyzer, which utilizes a simultaneous admittance calculation, accurately measures the amount of water in continuous-oil phase or continuous-water phase conditions through the entire composition range of 0% to 100% water. It is this technology that allows one model to cover all water percentage measurements for a specific line size, so there is no need to purchase several pieces of equipment. Other advantages are:

- It allows effective automation of oil and gas production facilities, including well test and flow stations
- It provides detailed knowledge of oil reservoir
- It reduces cost of operations
- It provides improved performance for percent water/oil measurement

3.1.2.2 Level Transmitter

Name and model selected for radar transmitter is the Rosemount 5600 Series as shown in Figure 3. It is an intelligent non-contacting radar level transmitter. The Rosemount Model 5600 uses state-of-the art microwave technology to get highest reliability and precision. It measures the level of liquids and slurries. The transmitter operates in a wide range of temperatures, pressures, vapour gas mixtures, and various process conditions.

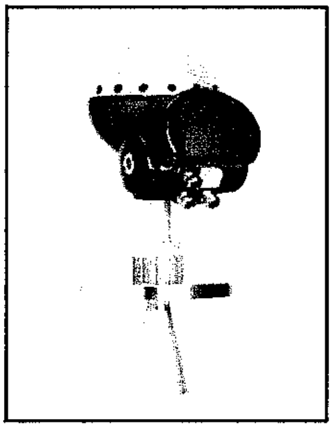

Figure 3: Rosemount 5600 Series
(http://www.emersonprocess.com/rosemount/products/level)

Several advantages of radar level transmitter are listed below:

- Non contact with process
- Not effected by density changes
- Not effected by aggressive chemical & disturbances
- No moving parts
- Less maintenance

3.1.2.3 The Programmable Logic Controller

PLC is actually an industrial microcontroller system where it has hardware and software specifically adapted to industrial environment. Block schema with typical components which PLC consists of is shown in APPENDIX H. Special attention needs to be given to input and output, because in these blocks protection is needed in isolating a CPU blocks from damaging influences that industrial environment can bring to a CPU via input lines. Program unit is usually a computer used for writing a program (often in ladder diagram).

Normally before a ladder diagram is developed, a process flow diagram must be produced to show the overall system working mechanism. Basically in the process flow diagram as shown in APPENDIX I two input sources are considered namely water cut sensor and level transmitter. Level Transmitter continuously measures the level inside the vessel. Transmitter output will serve as one of the PLC inputs. Water cut sensors continuously measure the water percentage inside the particular wells. Sensors outputs are directed to PLC input module. All the readings are stored in the PLC memory. A setpoint for level transmitter is stored in the PLC memory. The PLC will continuously compare the level transmitter reading with the setpoint. If the level transmitter reading exceeds the setpoint, a command will be executed to close the control valves through the PLC output module.

Before the PLC sends the command to the control valve, the wells with high water percentage are selected using the water cut sensors. Water cut sensors measure the water content inside the well flowline and sends the signal data to the same PLC. Setpoint for water cut percentage is set and stored in the PLC memory. PLC continuously compare the water cut sensors readings with the setpoint. It is recommended that any wells that produce water percentage higher than 80% will be closed in case of high level inside the surge vessel which means that the setpoint for the level transmitter has been exceeded.

3.1.3 Determining the setpoint for Level Transmitter and Water Cut Sensor

The most common current signal standard in modern use is the 4 to 20 milliamp (4-20 mA) loop, with 4 milliamps representing 0 percent of measurement, 20 milliamps representing 100 percent, 12 milliamps representing 50 percent, and so on. A convenient feature of the 4-20 mA standards is its ease of signal conversion to 1-5 volt indicating instruments. A simple 250 ohm precision resistor connected in series with the circuit will produce 1 volt of drop at 4 milliamps, 5 volts of drop at 20 milliamps, etc:

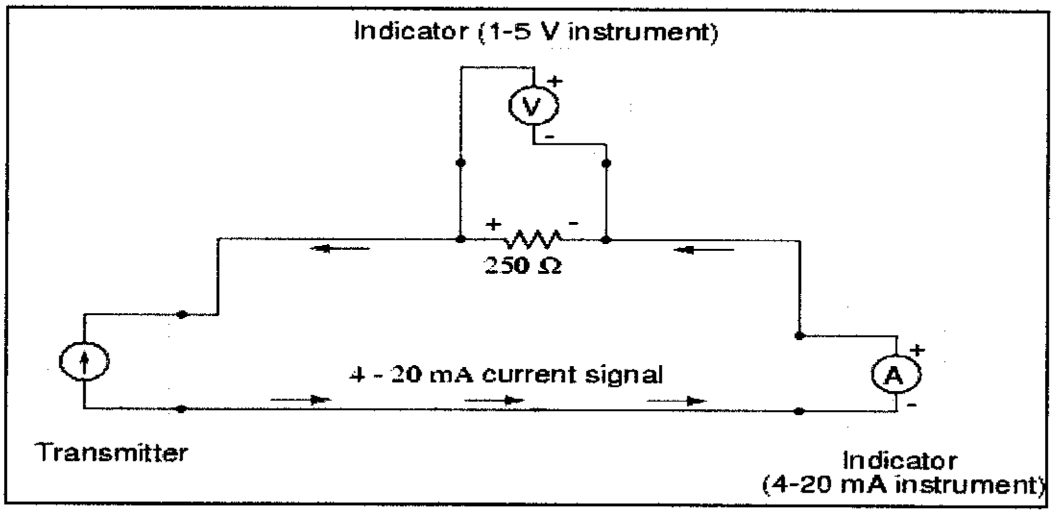

Figure 4: 4-20 mA Current Signal

(From http://www.allaboutcircuits.com/vol_1/chpt_9)

The trip setting for the level transmitter is set at 80 % of the level measurement inside the surge vessel. Therefore the setpoint is 16.8 mA. The 80% of the level measurement is equivalent to the 2540 mm of the internal diameter of the vessel which is 3175 mm. High percentage of water cut well is selected at 80% of the process measurement. Therefore the setpoint for each water cut sensor is set at 16.8m A. The wells that produce the water contain more than 80% should be closed as the setpoint of the level transmitter is exceeded when the COTP tripped. The corresponding 4-20 mA signal to the percent of measurement is shown in APPENDIX J.

3.1.4 Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (PID)

The immediate drawing crucial for instrumentation is P&ID from process, piping specification from piping. Basically these drawing and documents, and other project specifications are needed to begin the task of instrument and control design. For this project number of the instruments used is limited rather than considering the real plant process condition. For example supposedly based on the real situation there are 25 water cut sensors needed to measure the water percentage for 25 particular wells.

3.1.5 Instrument Loop Diagram

Instrument loop diagram is needed to show the interconnection detail between the instruments. The connection might be a pneumatic line or electrical line.

3.1.6 Installation Block Diagram for the Actual System

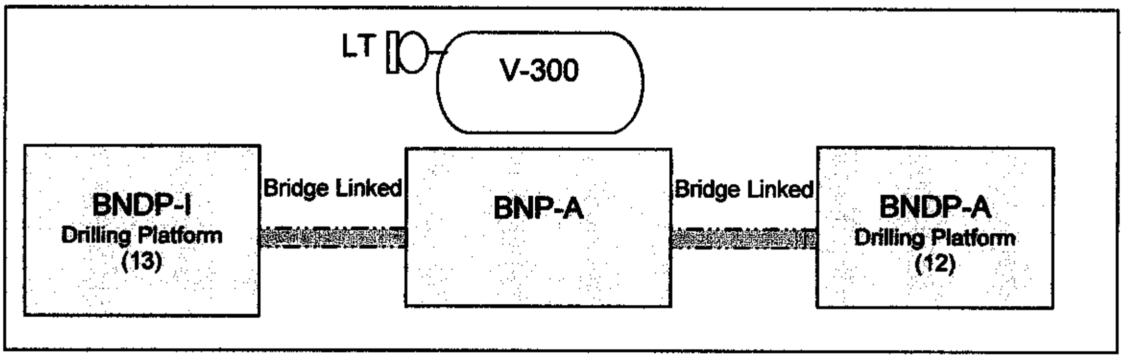

Figure 5: Installation Block Diagram

Figure 5 shows the installation block diagram for the actual system. There are 12 and 13 production wells currently installed at BNDP-A and BNDP-I respectively. This means that 12 pieces of water cut sensor shall be installed at BNDP-A and 13 at BNDP-I. There will be one level transmitter installed on the top of the vessel at BNP-A. The PLC module is recommended to be placed at BNP-A inside the instrument panel. Any connection from the water cut sensors to the PLC should be wire-connected which will be routed along the cable tray on the respective bridges.

3.2 Model Design

Figure 6 shows the flow chart of activities in order to complete the model design.

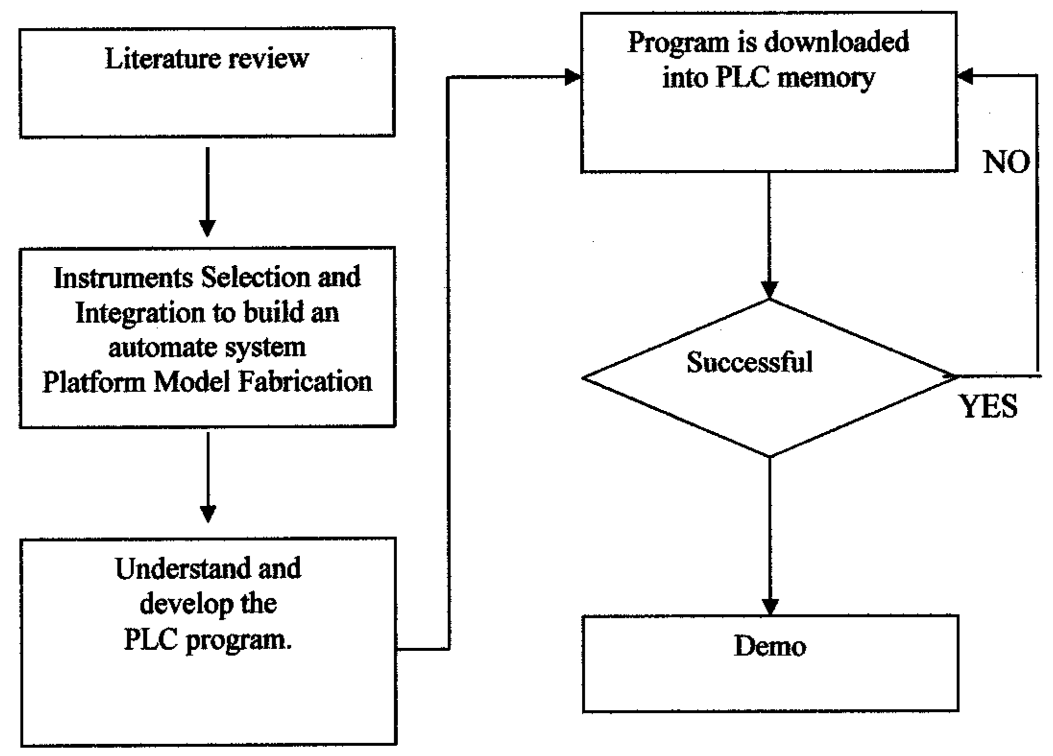

Figure 6: Flow Chart of the Methodology

3.2.1 OMRON PLC Programming - The Ladder Diagram

"Ladder" is the most frequent method of programming PLC controllers at present. Ladder diagram (or "relay diagram") is basically a symbolic representation of electric circuits. Symbols were selected that actually looked similar to schematic symbols of electric devices. Instructions for a ladder diagram may be divided into several basic groups according to their purpose:

- Input instructions
- Output instructions
- Control instructions
- Timer/counter instructions
- Data comparison instructions
- Logic instructions

In the model design a simple ladder diagram is developed to show the simulation for the automated sequential trip control system. Three logic (1/0) inputs were used rather than using the 4-20mA inputs signal. Two of them are assigned from the electronic water sensors and another was from the electronic water level detector. Digital input provides a basic input ON or OFF to the PLC. This mean that the PLC receives logic input either 1 or 0. There is no setpoint for the process measurement to be assigned in the PLC program. The PLC also does not perform any comparison instruction to compare the setpoint for the measurement devices with the input signal because the input is a discrete digital signal. Therefore assumption has been made such that all the inputs to the PLC give logic 1 (ON) whenever the setpoint of the measurement devices are exceeded. The output signals of the PLC are indicated by the LED on the PLC output module. This LED indicates the control valve. The ladder diagram for the model system is shown in APPENDIX K. The PUSH BUTTON 1 (PB 1) is used to running the PLC program. The PUSH Button 2 (PB 2) is used to reset or stop the program. From the ladder diagram it shows that the inputs of the PLC come from the output of two water sensors which are connected in series with the water detector output. Logically the corresponding control valves (CV) will be activated as the respective water sensors and the level detector are triggered simultaneously. The HR indicates the holding relay which is a built-in virtual relay inside the PLC itself.

3.2.2 Platform Model Design Overview

The model system design of this sequential trip control system would be definitely different from the real system designed for the actual facilities due to several limitations such as design cost to purchase the instruments needed. APPENDIX L1 and APPENDIX L2 show the block diagram and instrument loop diagram for the model system.

Electronic water detector circuit presents the water cut sensor and the water level sensor serves as the level transmitter which will be implemented in the sequential trip control system model. In Figure 7, there are two electronic water detectors and one level transmitter used for the model designs that serve as the input to the PLC. Electronic water cut detector is used to detect the present of water and gives a logic input to the PLC. Water level detector also gives a logic input to PLC as it detects high level on the process inside the vessel. The PLC determines the wells that contain a high percentage of water which will be closed in on high level inside the surge vessel when the COTP tripped. The simplified instrument loop diagram for the model system is shown in Figure 7.

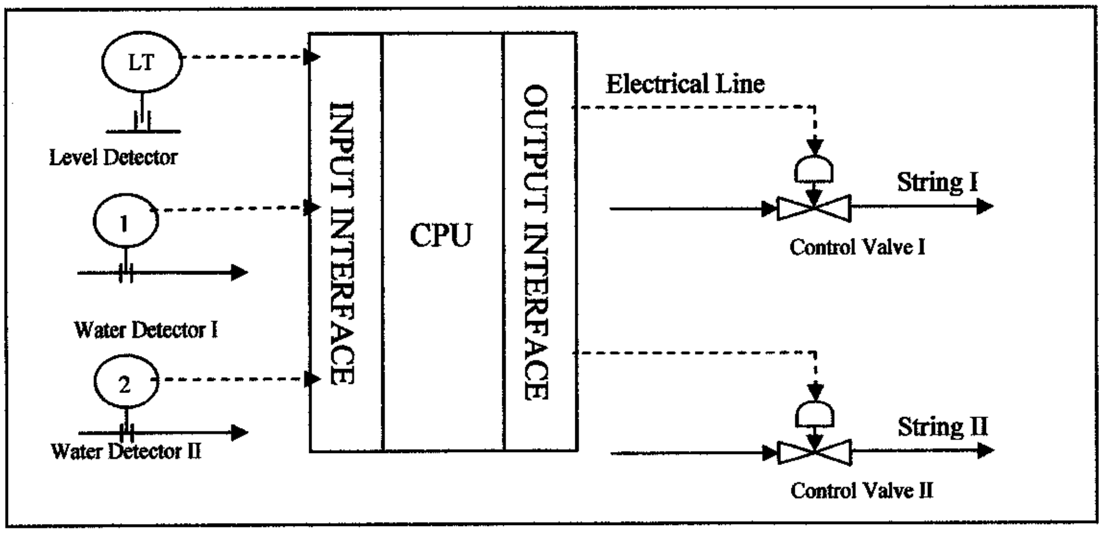

Figure 7: Simplified instrument loop diagram for the model system

3.2.2.1 Production Platform Model Fabrication

To visualize how the real system works, a production platform model was setup. For this model a platform structure made from the metal was used to support the production facilities such as liquid storage and control instruments such as pumps, water sensors, power pack, piping, PLC control panel and the control valves. Two important criteria must be considered to build up this platform model are operability and safety. Operability means the whole system is working correctly and having the right effect. Any operation within the design envelope should not cause a shutdown that could possibly lead to a violation of safety or negatively impact profitability. Selection of parameters may one of important factors that lead to the system operability. It is crucial to take the safety into account when designing a risk-potential system. The major objective of the safety system should be to prevent the undesirable events such as:

- Overpressure
- Leak
- Liquid over flow
- Underpressure

There are three main work scopes to setup this platform model namely:

- Platform structural fabrication
- Production and process facility fabrication
    - This include the platform facilities e.g. vessel, piping, pump, valve
- Instrumentation
    - Instrumentation may include liquid level sensor, water cut sensor, control valve, wiring, PLC, instrument control panel

The process media considered to be used at first is the diesel fuel. After a study on the diesel fuel compatibility has been conducted, it is shown that the diesel fuel is not a suitable process media to be used since it is reactive and flammable.

3.2.2.2 Description of Items Used for Platform

The summary of items used for the platform model is shown in TABLE 2. The platform model structure is made from a metal rack which is purchased from the hardware shop. The assembled platform model structure is shown in APPENDIX M. This platform structure is 24" long X 12"wide X 30" high. Four small rollers were installed at each of the structure leg to make it moveable.

Other items included were:

- Plastic Liquid Storage
- Rubber Tubing
- Water Pumps
- Control Valve
- Tee Connection
- Tube Connector
- Check Valve

Refer to APPENDIX M to see the items listed above.

Table 2: Items Listing

	Component	Size	Quantity
Platform Structural	Metal Rack	24"(L)X12"(W)X30"(H)	1 Set
Production & Process	Plastic Vessel (Square)	12"(L)X6"(W)X6"(H)	4
	Flexible plastic tube (piping)	¼"(ID)	2 meter
	Check Valves	¼"(OD)	3
	Tube Connector	¼"(OD)	8
	Tee Connector	¼"(OD)	5
	Electrical Liquid Pumps	-	3
Instrumentation	Water Cut Sensors	-	2
	Level Sensor	-	1
	Control Valves	-	2

3.2.2.3 Platform Model Process Flow Overview

The block diagram of process flow for the platform model is shown in the APPENDIX N. There are four water storages (vessel) namely VESSEL 1, VESSEL 2, RESERVOIR 1 and RESERVOIR 2. Three liquid transfer pumps are needed to provide the liquid flow. Two strings are to represent the actual production wells to be installed at RESERVOIR 2. At each string there was one control valve and water cut sensor. A level sensor was installed at VESSEL 2. Three sensors (two water cut sensor and one level sensor) were served as the PLC input whereas the control valves is the output to terminate the liquid flow. All the flowline is set up using the plastic tubing. Five TEEs are used to make a three-junction connection. Manually operated valves are installed purposely to isolate the process liquid from one vessel to another for the start-up or any modification or maintenance work.

3.2.3 The Electronics Water Sensor Working Mechanism

Water detector circuit and schematic diagram are shown in APPENDIX O1. Actually the working principle of this detector is simple. A probe made of a conductive material is used to sense the water which is connected to the circuit to produce the electric signal whenever the probe touches the water. For the sequential trip control system model the output signal from the circuit was served as the input to the PLC.

3.2.4 The Electronics Water Level Detector Working Mechanism

Water level detector circuit and schematic diagram are shown in APPENDIX O1. This sensor basically works similar with the water detector. This water level sensor works as the level transmitter in the real application for the sequential trip control system. A HIGH setpoint was determined and where the Hi-Probe was placed. As the water level exceeds the HIGH setpoint, the Hi-Probe senses the water. The Hi-Probe is connected to the circuit which produces the output signal and serves as the input to the PLC. The basic input and output connection of a PLC is shown in APPENDIX P.

3.2.5 Electronic Water Sensor and Water Level Detector Functionality Test

After the construction of the PCB board is completed, the circuits were tested for their functionality and reliability. The procedures of testing both circuits are described later.

3.2.5.1 Procedure for Testing the Electronic Water Level Detector

1) A 200-ml beaker, a digital multimeter, a 9-V Battery and a complete Electronic Water Level Detector circuit are gathered.
2) A 200-ml beaker is filled with water until the water level reaches half of the beaker height.

3) A 9-V battery is connected to the electronic water level sensor circuit.
4) Then the probe of the circuit is placed on the top of the beaker at the 90% of the beaker height.
5) A holder is used to hold the probe fixed at the top the beaker.
6) Next, two multimeter probes are connected to the circuit output terminal.
7) Water is added into the beaker until it reaches the detector probe.
8) The multimeter reading and the indicator (LED) is observed.
9) Finally, the water quantity inside the beaker is reduced to half again.
10) Step 7-9 is repeated for 5 times.

3.2.5.2 Procedure for Testing the Electronic Water Detector (with water)

1) A 200-ml beaker, a digital multimeter, a 9-V Battery and a complete Electronic Water Level Detector circuit are getting ready.
2) A 200-ml beaker is filled with water until the water level reaches half of the beaker height.
3) A 9-V battery is connected to the electronic water sensor circuit.
4) Next, two multimeter probes are connected to the circuit output terminal.
5) Water detector probe is contacted with the water.
6) The multimeter reading and the indicator (LED) is observed.
7) Finally, the detector probe is removed from the beaker.
8) Step 5-7 is repeated for 5 times.

3.2.5.3 Procedure for Testing the Electronic Water Detector (with cooking oil)

1) A 200-ml beaker, a digital multimeter, a 9-V Battery and a complete Electronic Water Level Detector circuit are getting ready.
2) A 200-ml beaker is filled with cooking oil until the oil level reaches half of the beaker height.
3) A 9-V battery is connected to the electronic sensor circuit.
4) Next, two multimeter probes are connected to the circuit output terminal.
5) Detector probe is contacted with the oil.
6) The multimeter reading and the indicator (LED) is observed.
7) Finally, the detector probe is removed from the beaker.
8) Step 5-7 is repeated for 5 times.

3.2.5.4 Procedure for Testing the Electronic Water Detector (with the mixture of water and cooking oil)

1) A 200-ml beaker, a digital multimeter, a 9-V Battery and a complete Electronic Water Level Detector circuit are getting ready.
2) A 200-ml beaker is filled with the mixture of cooking oil and water until the level reaches half of the beaker height.
3) A 9-V battery is connected to the electronic sensor circuit.
4) Next, two multimeter probes are connected to the circuit output terminal.
5) Detector probe is contacted with the liquid at different depth.
6) The multimeter reading and the indicator (LED) is observed.
7) Finally, the detector probe is removed from the beaker.
8) Step 5-7 is repeated for 5 times.

3.2.6 Platform Functionality Test

After the fabrication of the platform model was completed, the testing was performed to check whether the platform model is functioning as expected. The scope for the testing is to examine the durability of the platform model in several aspects such as the platform structure itself, the flowline connections if there is any leak, the liquid storage and the water pump functionality. Water pump are purposely to provide continuous flow from each vessel to another in order to visualize the real platform working operation.

3.2.6.1 Procedure for the Platform Testing

1) Water from the tap is slowly directed to the liquid storage namely RESERVOIR II until it reach 70 % of the vessel height.
2) Then the entire liquid storage is filled with the water at 70 % of the vessel height.
3) At this stage all the hand valve are OFF to terminate all the flow and prevent the overflow.
4) The platform model is observed for 10-20 minutes to check whether there is any leak.

5) The observation is recorded.
6) After 10-20 minutes, the water pump is switched ON.
7) Slowly open the all the hand valve until all the flow and level are stable and controllable at the desired point.
8) The liquid flow inside each tubing is observed.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Water Detector and Water Level Sensor Circuit Testing

Both circuits were working as expected during the testing.

4.1.1 Water Detector Testing (with water)

When the water sensor (probe) touched the water, the relay in the circuit immediately gives the output signal of 5 Volts. This reading is shown on the digital multimeter. The indicator (LED) is turned ON indicates that the circuit is working and an output signal has been triggered. In the sequential trip control system this relay acts like a switch to trigger the rated input source to the PLC.

4.1.2 Water Detector Testing (with cooking oil)

When the water sensor (probe) touched the oil, the relay in the circuit does not give any output signal. No reading is shown on the digital multimeter. The indicator (LED) is remains OFF indicates that the circuit is not working and the output signal has not been triggered. This water detector represents the actual water cut sensor which is used to detect the presence of water in the crude oil. This sensor should provide an output whenever it detects water.

4.1.3 Water Detector Testing (with the mixture of water and cooking oil)

When the sensor probe is contacted with the process liquid, the water sensor (probe) firstly touches the oil since the oil has less density than water. The relay in the circuit does not give any output signal. No reading is shown on the digital multimeter. The indicator (LED) is remains OFF indicates that the circuit is not working and the output signal has not been triggered. As the sensor probe is further brought down below the beaker, the probe start to contact with the water. After more then 5 seconds had contact with the water, the relay in the circuit immediately gives the output signal of 5 Volts. This reading is shown on the digital multimeter. The indicator (LED) is turned ON indicates that the circuit is working and an output signal has been triggered. This water detector represents the actual water cut sensor which is used to detect the presence of water in the crude oil. This sensor should provide an output whenever it detects water. Even though this circuit is working as expected but there are some limitations considered during this testing such as:

- The process liquid is different compared to the actual process
  In this testing cooking oil is used rather than the mixture of crude and water in the actual condition

4.1.4 Water Level Detector Testing

When the water sensor (probe) touched the water, the relay in the circuit immediately gives the output signal of 5 Volts. This reading is shown on the digital multimeter. The indicator (LED) is turned ON indicates that the circuit is working and an output signal has been triggered. In the sequential trip control system this relay acts like a switch to trigger the rated input source to the PLC. Even though this circuit is working as expected but there are some limitations considered in executing this testing such as:

- The process liquid is different compared to the actual process
  In this testing water is used rather than the mixture of crude and water in the actual condition
- Method of measurement
  In the actual design radar transmitter is used which is not contacting with the process fluid. For this model the water probe is contacted with the water.

Technical comparison on both this actual and model design is shown in APPENDIX Q.

4.2 Overall Platform Model Testing

The testing was performed in about one hour. Through 10-20 minutes after all the liquid storages are filled with water, several part of the flowline connections are identified that have a small leak. This is due to the improper sealing. The testing anywhere is continued since there is only a small leaking. The water pumps then switched ON. When the pump is turned ON, only a small flow is running inside the tubing. This is due to the pumps which are not good enough to provide sufficient pressure to push the liquid. As a conclusion the platform model is not working as expected due to some leak and pump failure. Quick investigation has been made and several assumptions and solution have been considered for the troubleshooting. The leaking part or connection is properly sealed to prevent any leak. The testing work and the complete platform structure are shown in APPENDIX R.

The second part of testing was performed a week later after all the identified failures were fixed. The platform model circuit is connected with the PLC to perform the logic mechanism for the automation control. Three inputs were going to the PLC whereas two outputs from the PLC were connected to the control valves. When the water pumps are turned ON, the liquid at each storage is moving and circulating. The level inside each storage is sustained and controlled by adjusting the respective hand valve to avoid overflow. After everything was in normal condition, the hand valve which is on the flowline outgoing from VESSEL II is turned nearly OFF to allow small liquid to be transferred thus to simulate the pump tripping. After a while the liquid level inside VESSEL II is increased as expected until it reached the setpoint before it was detected by the level sensor. Immediately the signal of the level detector is sent to the PLC thereby the respective sting that has high water contain was closed using the control valve. After almost three minutes the liquid level inside VESSEL II is reduced below the setpoint. As a conclusion, the platform model is completely working.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 The Actual System Design and the Comparison

Basically the model design is similar to the actual system technically except for the type instruments used. For the model system design simple water level detector and water detector circuit are used to represent the radar level transmitter and water cut sensor respectively. In the actual facility there are twenty five water cut sensors and one radar level transmitter to be used. In this project some limitations have been made such as only two water detectors were used and also the control valves. Refer to APPENDIX S for the comparison of these two systems presented in the table.

5.2 Comparison of the Existing and the new System of Sequential Trip Control System

5.2.1 Disadvantages of the Existing System

The high water cut wells are manually selected based on the daily production data. The water cut percentage in one particular well may vary from time to time. The selected wells are assumed producing unvarying (always high) water cut percentage from the date the data is taken to the upcoming time. Sometimes poor performing well have good potential to produce high percentage of crude oil which mean less water cut percentage. These selected wells are permanently integrated with the system and any modification to be made later on shall require lots of work and cost consumption. Therefore, this can be concluded that selecting the high water cut wells manually is not really a good practice.

5.2.2 *New Sequential Trip System Overview*

Water cut sensor will be installed at each every single well at Baronia Oil/Gas field to determine the water cut percentage of the well. The selected wells tripping mechanism is controlled using Programmable Logic Controller (PLC). The PLC makes the decision to determine the poor performing wells based on the water cut sensor readings. The PLC also determines the sequence for the tripping of the selected wells based on the water cut percentage. Electronic level transmitter will be used to measure the level inside the vessel and transmit the proportional output to the PLC. The PLC sends the signal to the hydraulic relay to trigger the selected poor performance wells in the case of high level inside the surge vessel.

5.3 Conclusion

The new sequential trip system will be more reliable and efficient to prevent the total shutdown of BNP – A, BNDP – A and BNDP-I in the event when one of the COTPs tripped. This PLC based sequential trip system is fully automatic to provide the improvement to the existing system. In this project a model is designed to present the real system. Some limitations have been considered in designing the model and there would be much different compared to the real system in terms of the type and number of instruments used and system situation.

5.4 Recommendation

The model system is designed by taking some limitations such as the type and the number of instruments used. There would be more advantages to build the model system using the actual instruments used in the operation in order to simulate the real system situation. It is recommended to install the new real sequential trips of high water cut wells system at BNP-A to prevent the total shutdown in the event when one of the COTPs trips.

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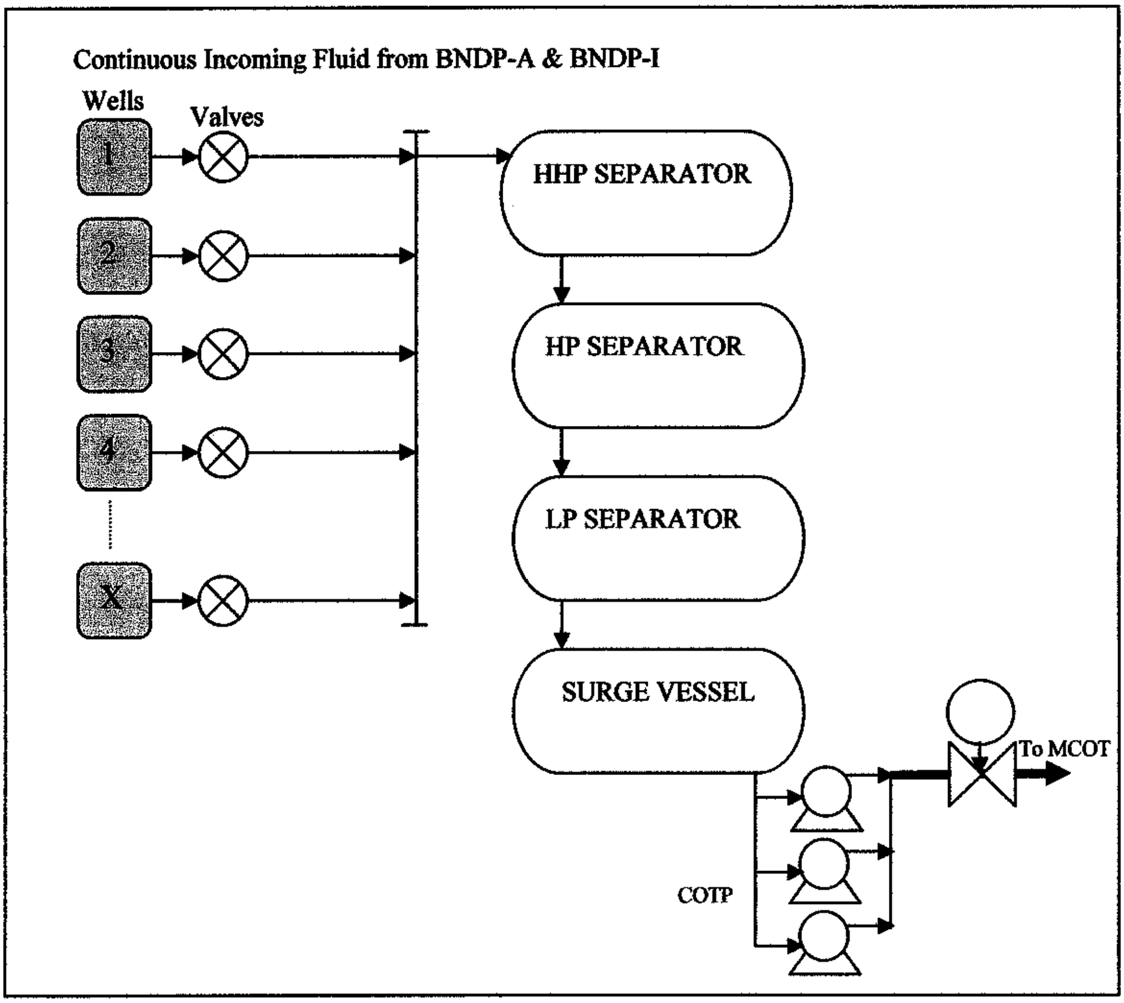
[10] Sunday, February 19, 2006 .Citing Internet Sources. URL http://content.honeywell.com/imc/ai/analyzerstrans/

APPENDIX A

SIMPLIFIED FLUID PROCESS FLOW DIAGRAM AT BNP-A

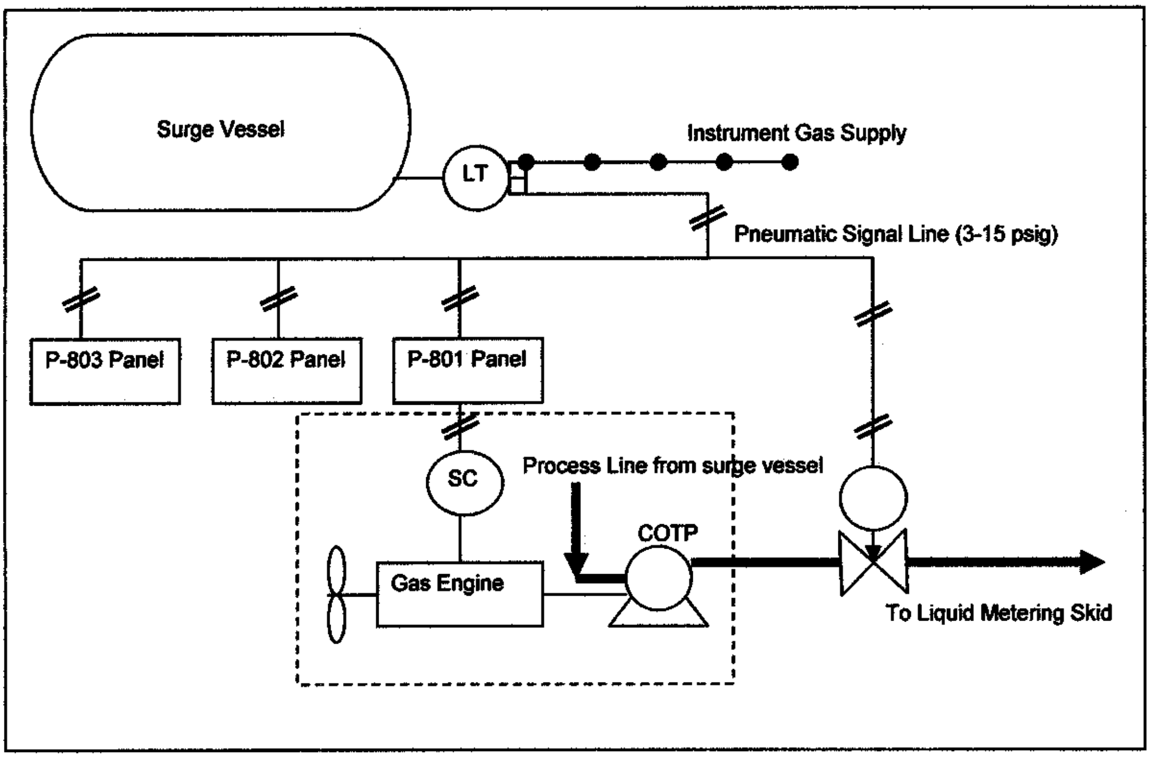
(Adapted from BNP-A P&ID)



APPENDIX B

INSTRUMENT LOOP DIAGRAM FOR LEVEL CONTROL (ONE COTP)

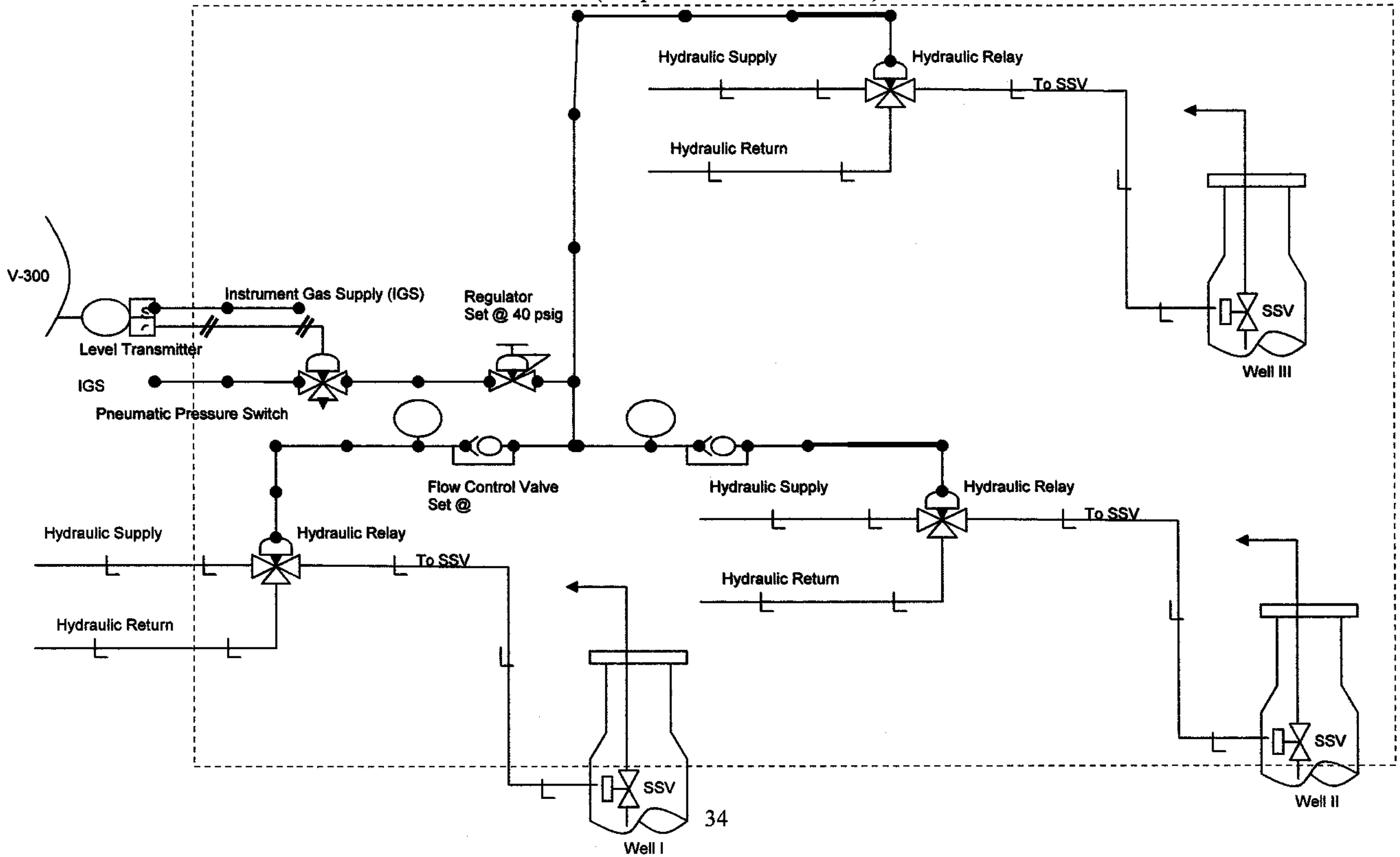
(Adapted from BNP-A P&ID)



APPENDIX C

LOOP DIAGRAM FOR THE EXISTING SEQUENTIAL TRIP CONTROL SYSTEM

(Adapted from BNP-A P&ID)

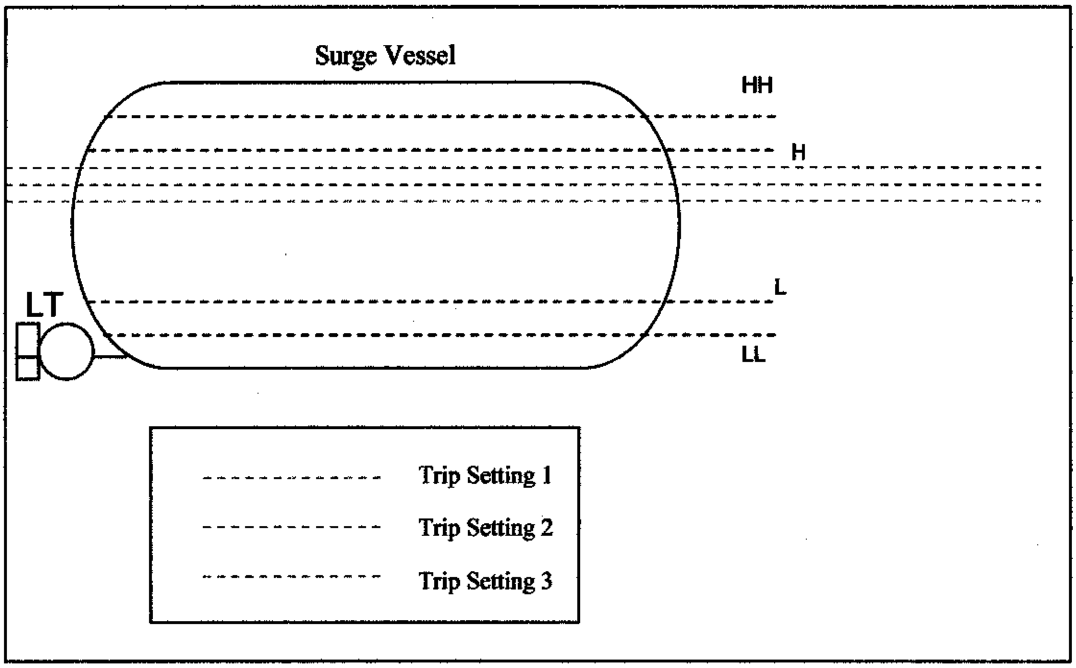


APPENDIX D

1. TRIP SETTING FOR PRESSURE SWITCHES

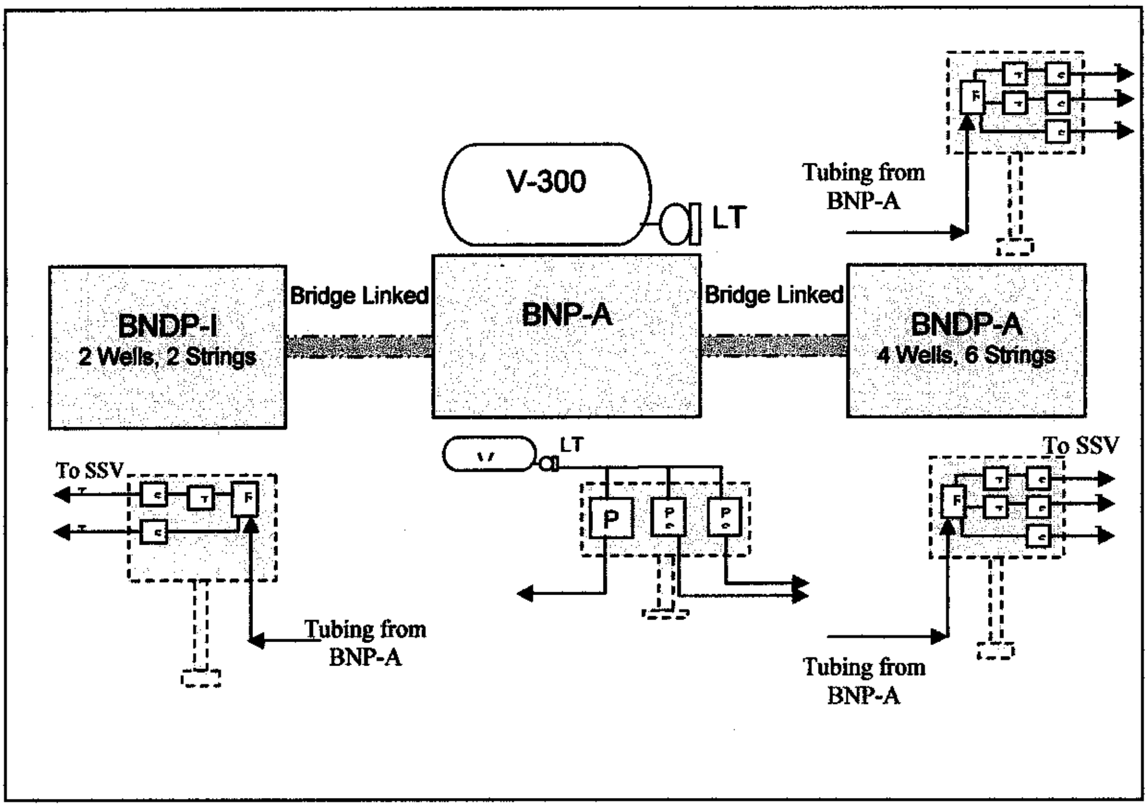
Trip Setting	Priority (setting to be triggered)	Recommended Height (mm)	Transmitter Output (psig)	Pressure Switch Setting (psig)
Trip Setting 1 (PS-1)	1	75% X 3175 = 2382	13.09	13.09
Trip Setting 2 (PS-2)	2	80% X 3175 = 2540	13.09	13.67
Trip Setting 3 (PS-3)	3	85% X 3175 = 2700	13.09	14.26

2. TYPICAL AND NEW TRIP SETTING OF THE SURGE VESSEL



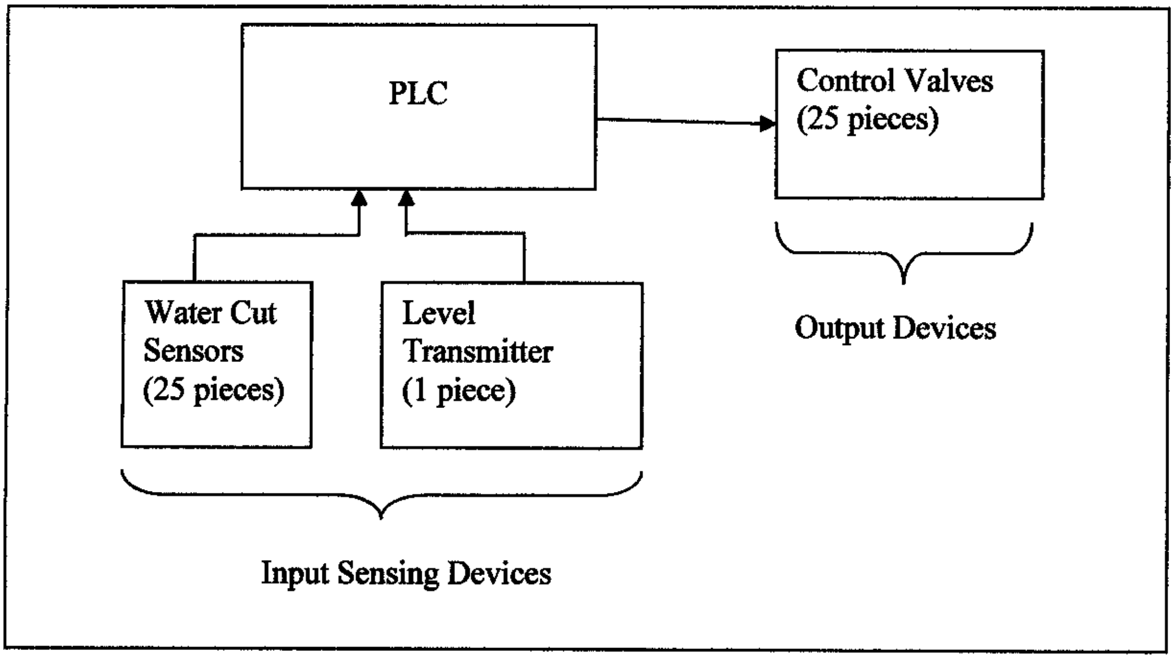
APPENDIX E

INSTALLATION BLOCK DIAGRAM AND PLATFORM LAYOUT

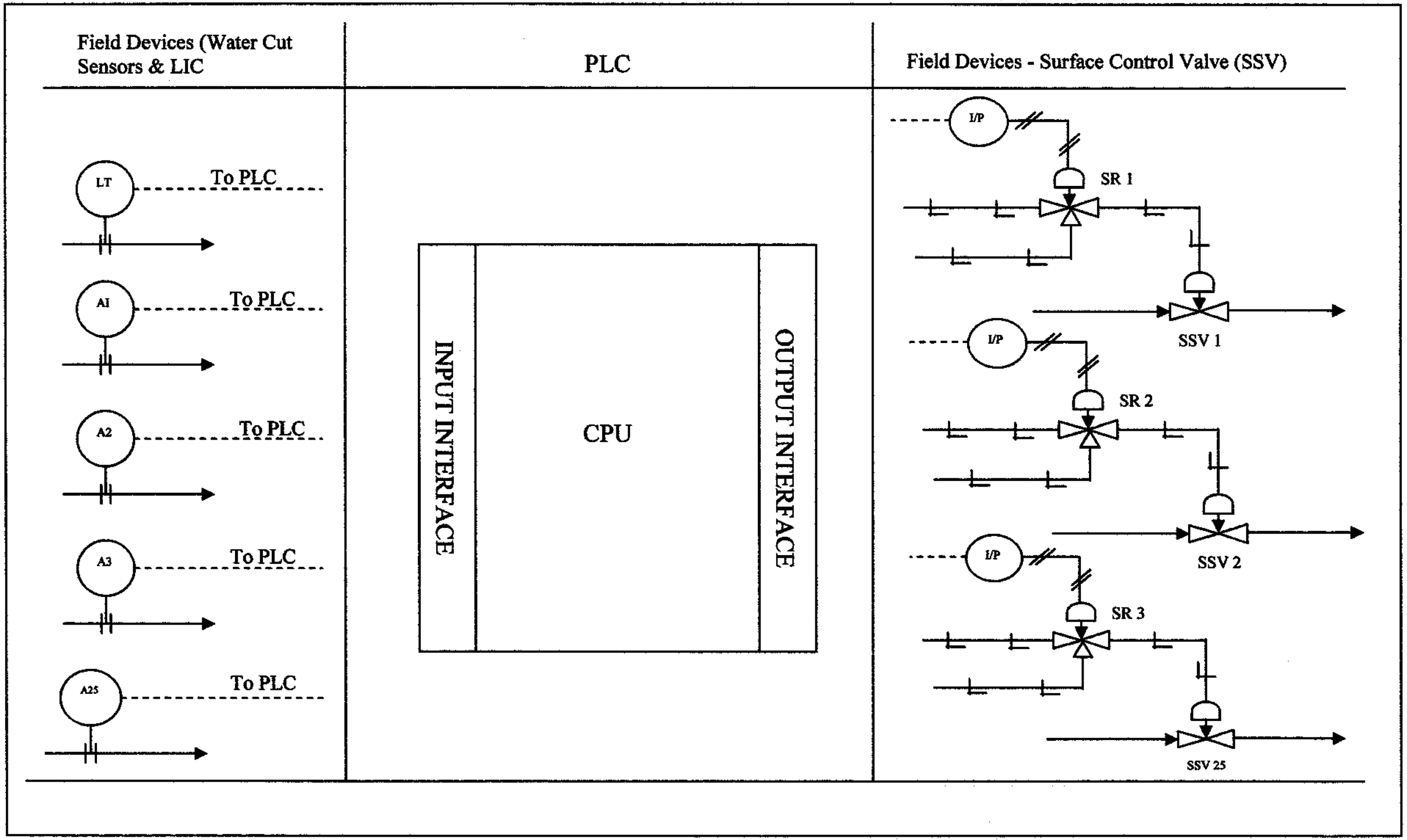


APPENDIX F

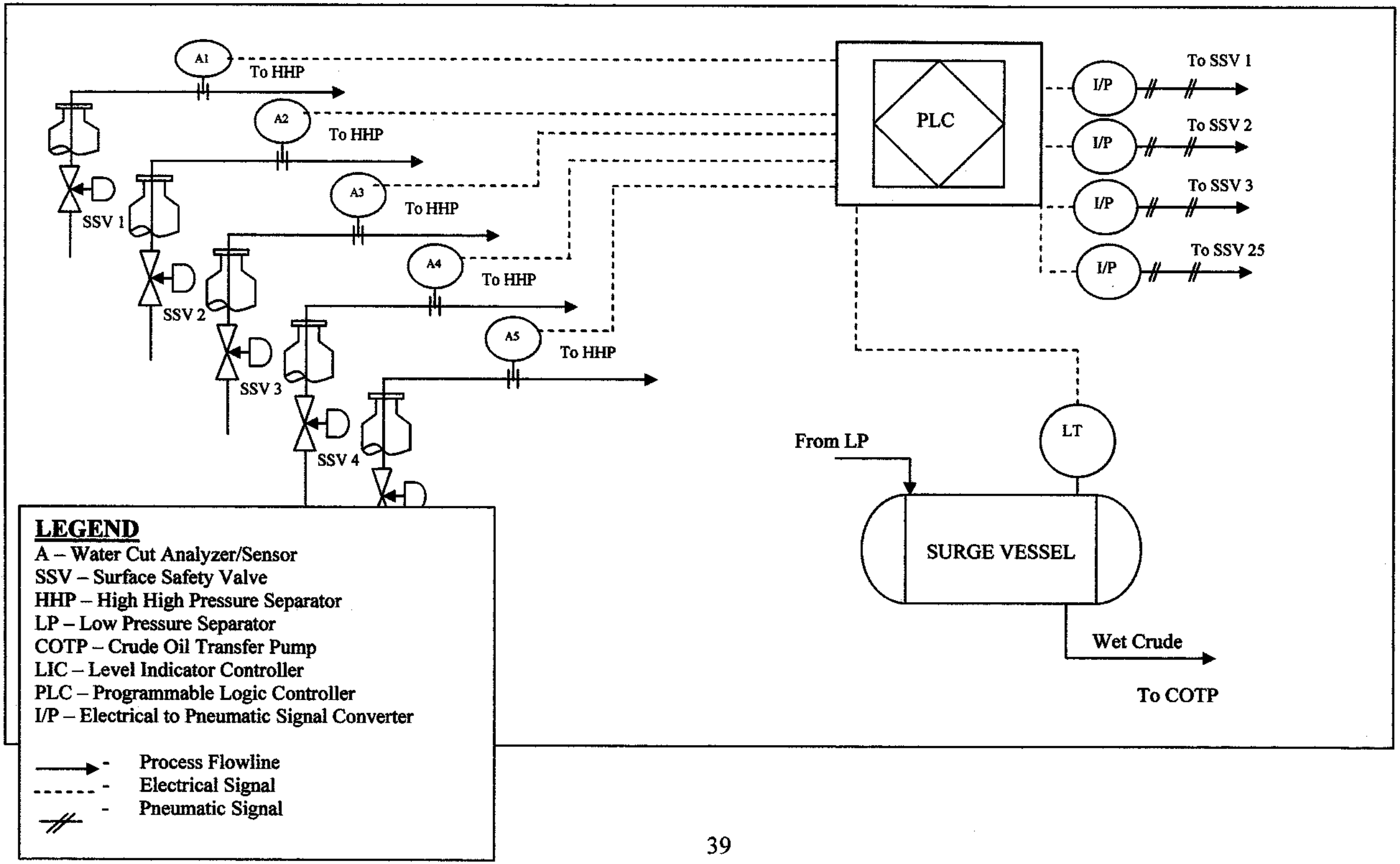
1. TYPICAL SYSTEM BLOCK DIAGRAM FOR THE ACTUAL SYSTEM



2. SIMPLIFIED INSTRUMENT LOOP DIAGRAM FOR THE ACTUAL SYSTEM IMPLEMENTATION



3. SIMPLIFIED PROCESS & INSTRUMENTATION DIAGRAM (PID) FOR THE REAL SYSTEM



APPENDIX G

WATER CUT SENSOR COMPARISON LIST

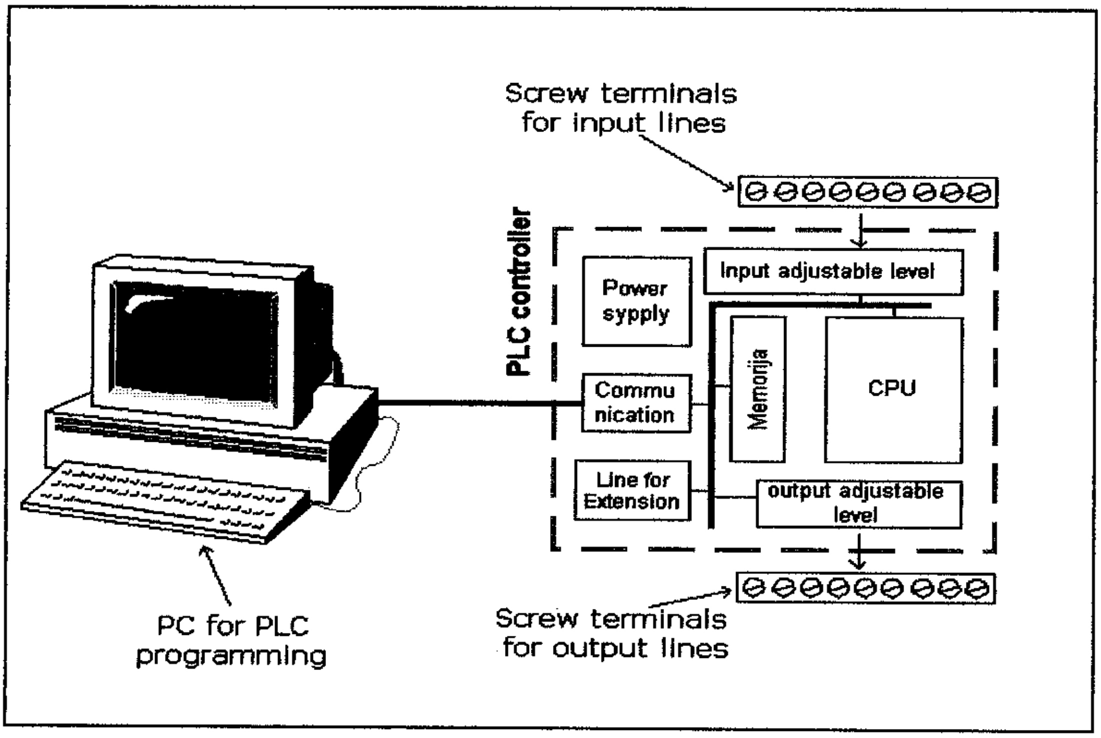
	Water-Cut Sensor		
	Red Eye	Honeywell H_2O Analyzer System	BS&W Water-Cut Sensor
Features/ Advantages	• Insensitive to entrained gas • Ignores salinity and dissolved gas • Unmatched accuracy at high water cuts • Full-range water cut, 0 to 100% • Inline for continuous real-time accuracy • Field-proven ruggedness and reliability • Convenient one-point field calibration • Easy installation and service • Full factory support • Affordable for widespread automation	• In-line, real-time water measurement • Continuous measurement from 0% to 100% water • Superior, non-intrusive sensor design • Compensated for temperature & salinity effects • 100 mS update rate • Tolerant to sand, grit, or entrained gases • Simple, automatic calibration • Multiple analog and digital I/O options • Allow effective automation of oil and gas production facilities, including well test and flow stations • Provide detailed knowledge of oil reservoir • Reduce cost of operations • Provide improved performance for percent water/oil measurement	• Microprocessor based electronics/Loop powered with user selectable • Serial interface for onsite or LAB Adjustments if necessary • Easy to remove PCB Card ranges from 0-65%
Disadvantages	• Needs additional transmitter to provide a digital or analog output of the water cut for input into a SCADA system or local RTU	-	-
Price	-USD1900	-USD1500	-USD2100

(Adapted from http://www.emersonprocess.com/rosemount/products/level & http://content.honeywell.com/imc/ai/analyzerstrans/)

APPENDIX H

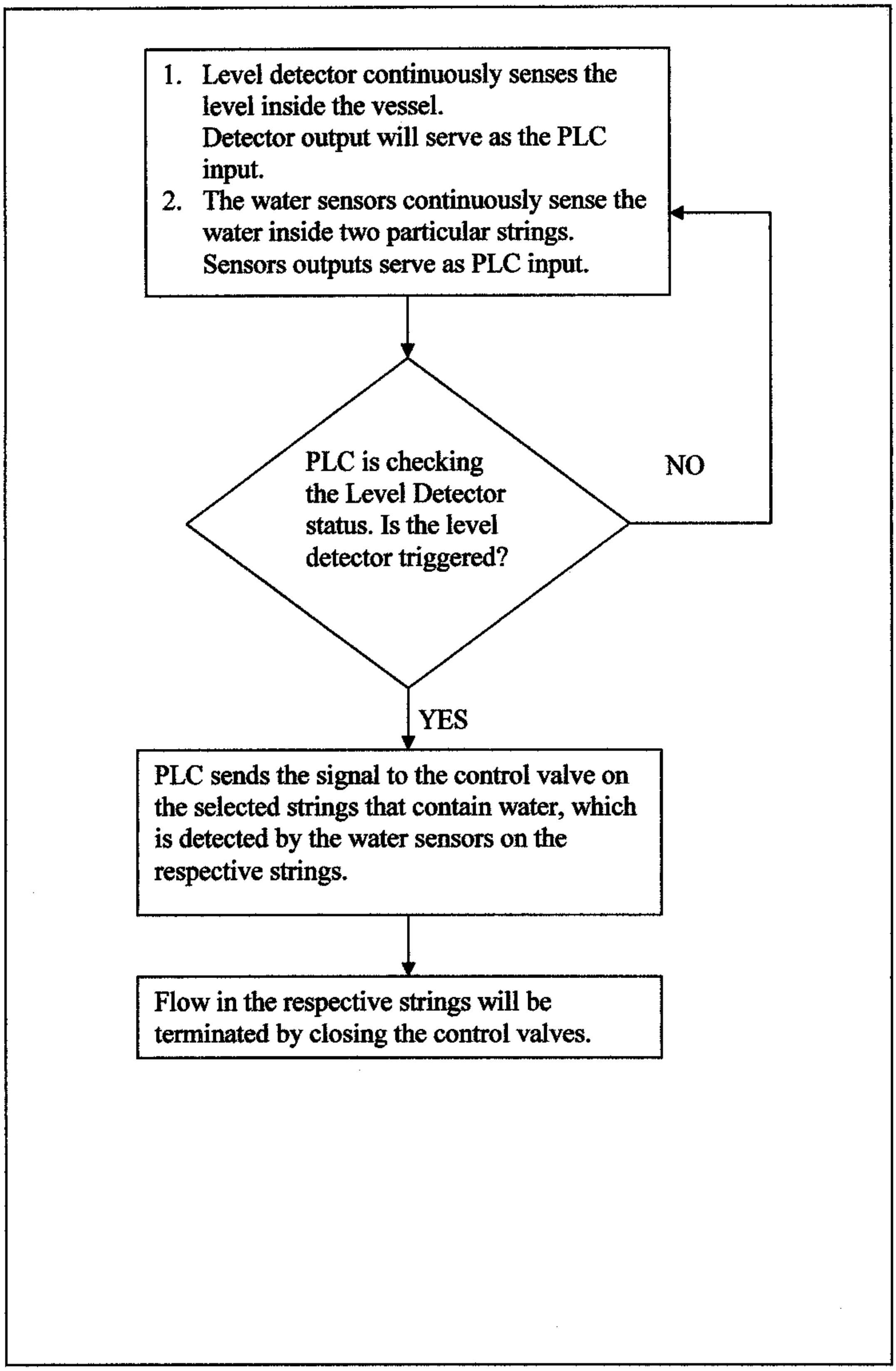
BASIC ELEMENTS OF A PLC CONTROLLER

(http://www.mikroelektronika.co.yu/english/product/books/PLCbook)



APPENDIX I

PROCESS FLOW DIAGRAM



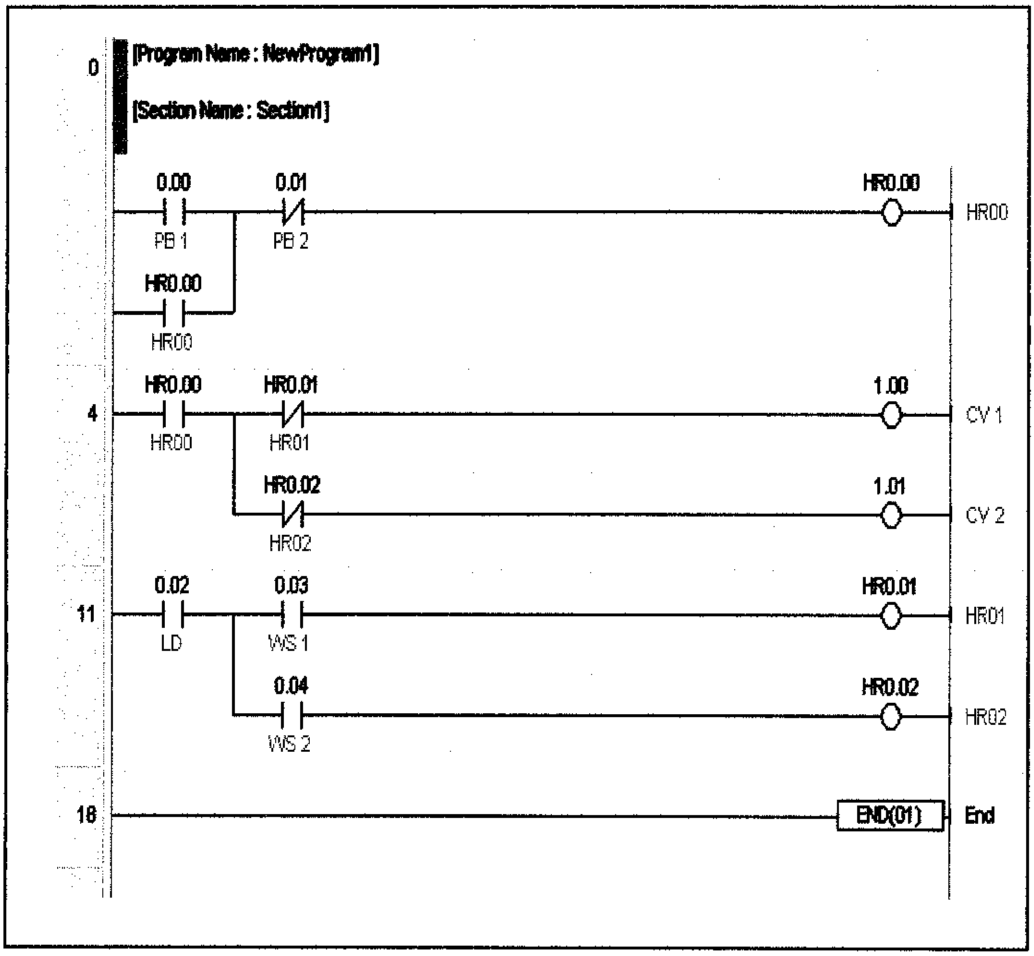
APPENDIX J

PERCENT OF MEASUREMENT TO 4-20 mA SIGNAL

Percent of measurement	4-20 mA Signal	1-5 V Signal
0	4.0 mA	1.0 V
10	5.6 mA	1.4 V
20	7.2 mA	1.8 V
25	8.0 mA	2.0 V
30	8.8 mA	2.2 V
40	10.4 mA	2.6 V
50	12.0 mA	3.0 V
60	13.6 mA	3.4 V
70	15.2 mA	3.8 V
75	16.0 mA	4.0 V
80	16.8 mA	4.2 V
90	18.4 mA	4.6 V
100	20 mA	5.0 V

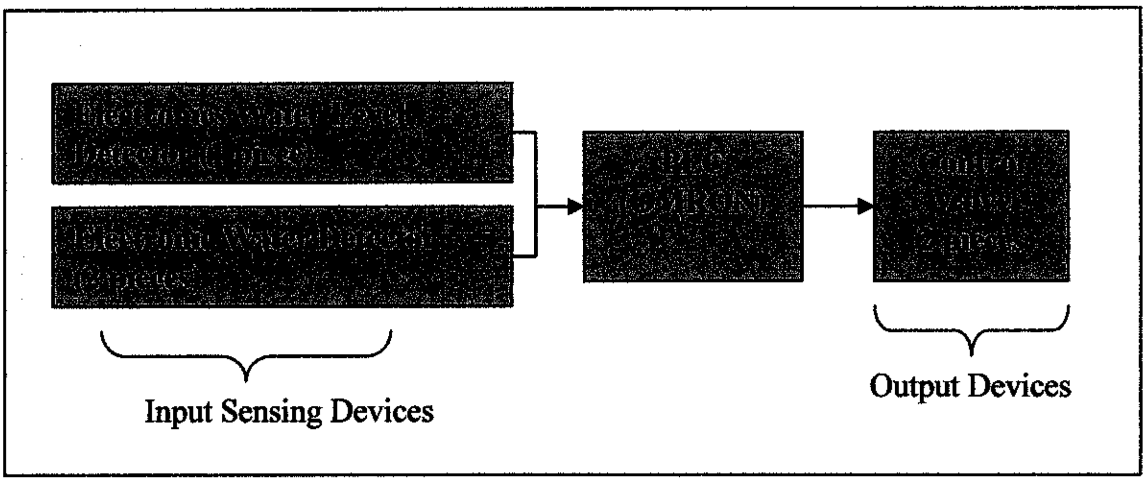
APPENDIX K

LADDER DIAGRAM FOR THE MODEL SYSTEM

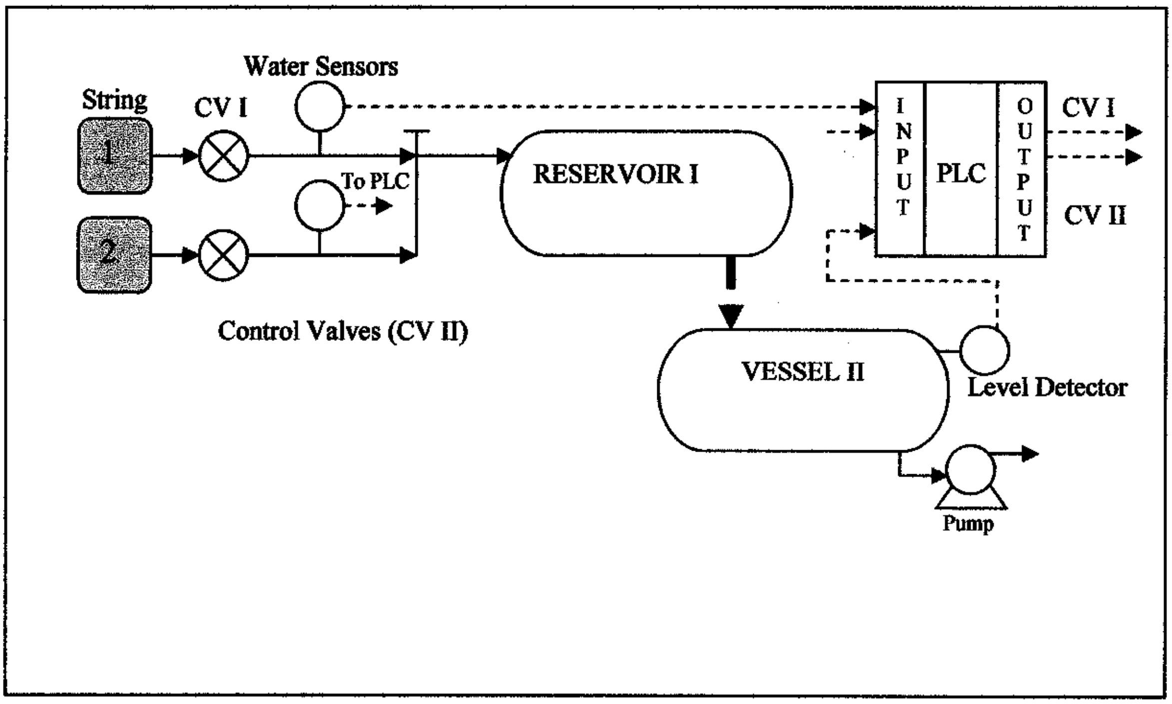


APPENDIX L

1. MODEL DESIGN BLOCK DIAGRAM

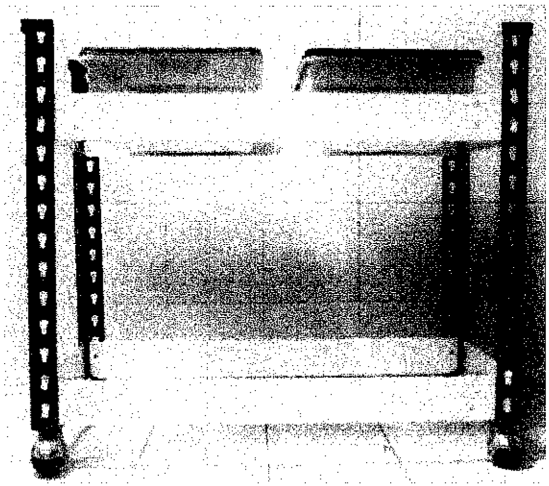


2. INSTRUMENT LOOP DIAGRAM FOR THE MODEL SYSTEM

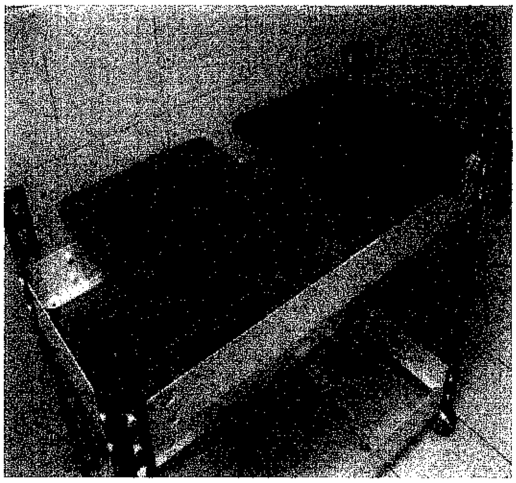


APPENDIX M

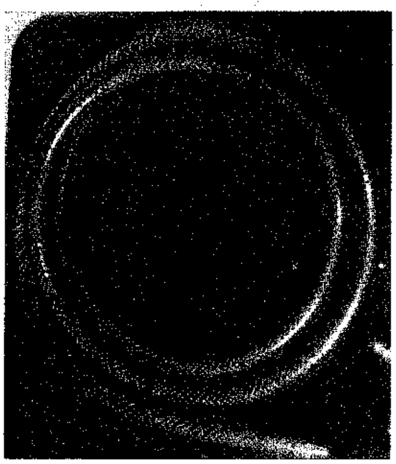
ITEMS FOR THE PLATFORM



PLATFORM MODEL STRUCTURE

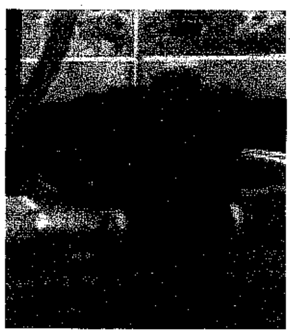


LIQUID STORAGE

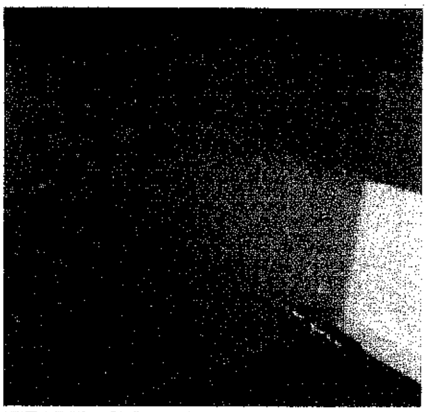


RUBBER TUBE

TEE CONNECTION & TUBE CONNECTOR



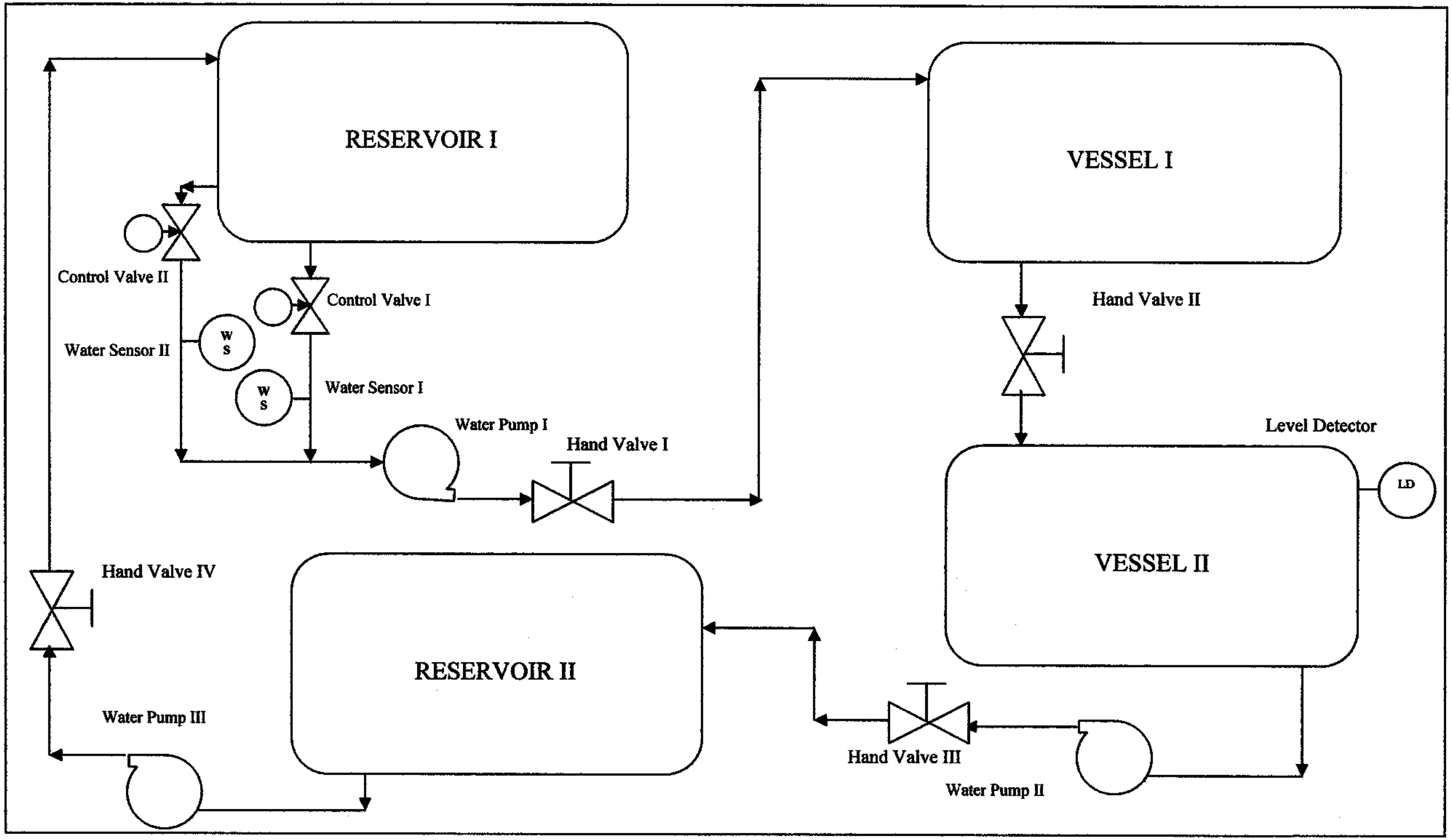
CONTROL VALVE



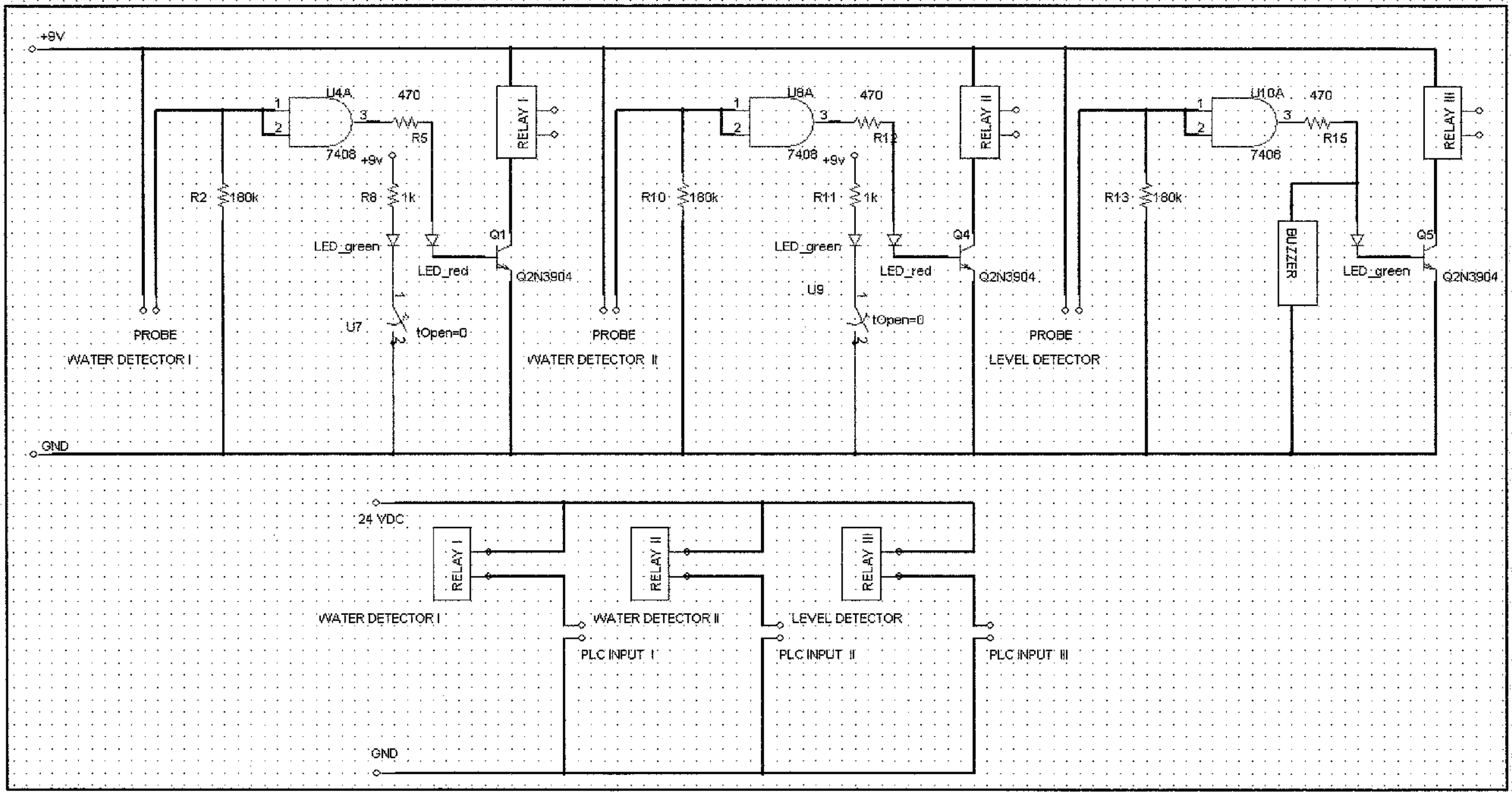
TUBE CONNECTOR IS INSTALLED AT LIQUID STORAGE

LIQUID PUMP

APPENDIX N
BLOCK DIAGRAM FOR THE PRODUCTION PLATFORM

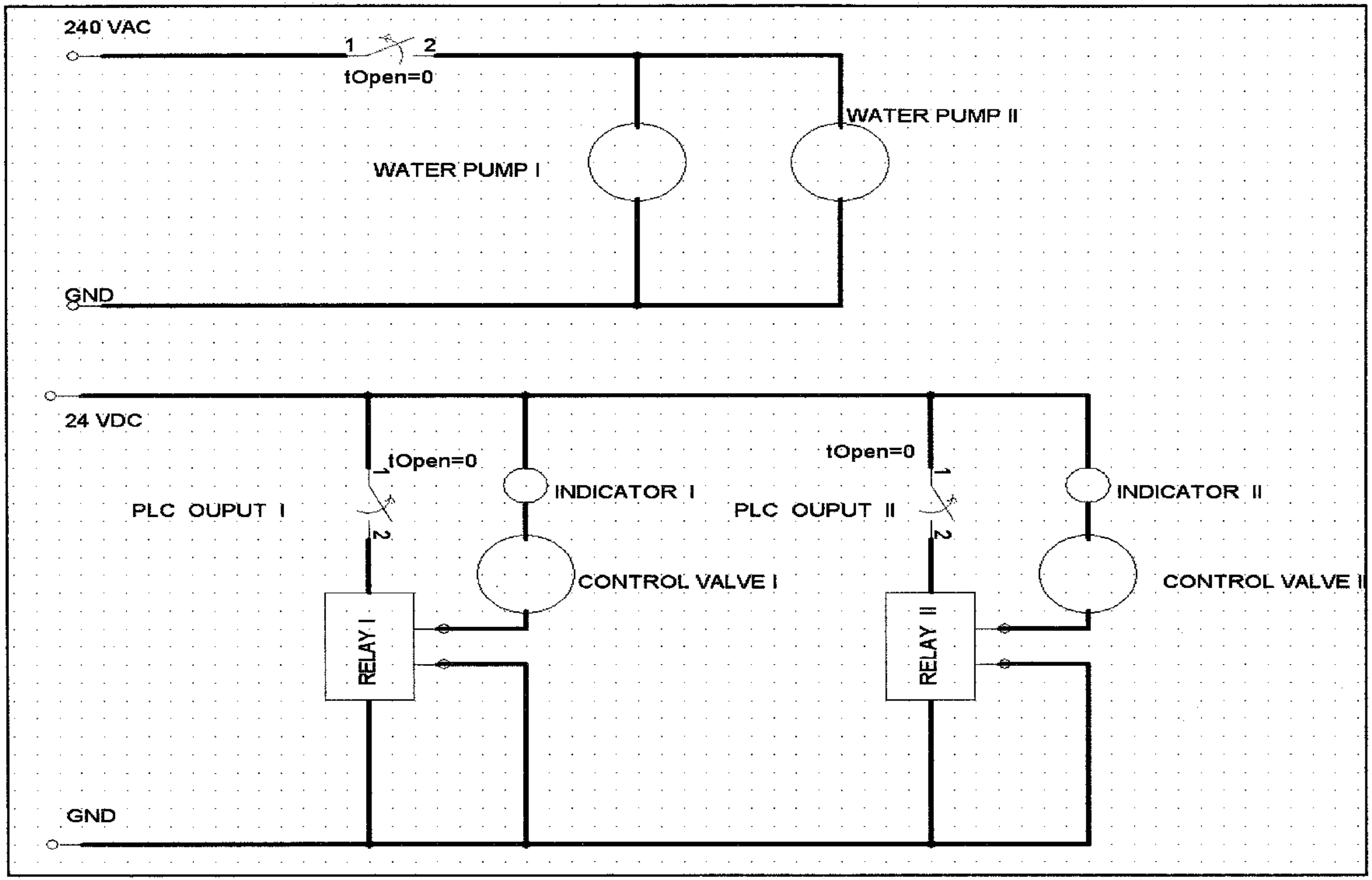


APPENDIX O
1. WATER DETECTOR AND LEVEL SENSOR SCHEMATIC DIAGRAM



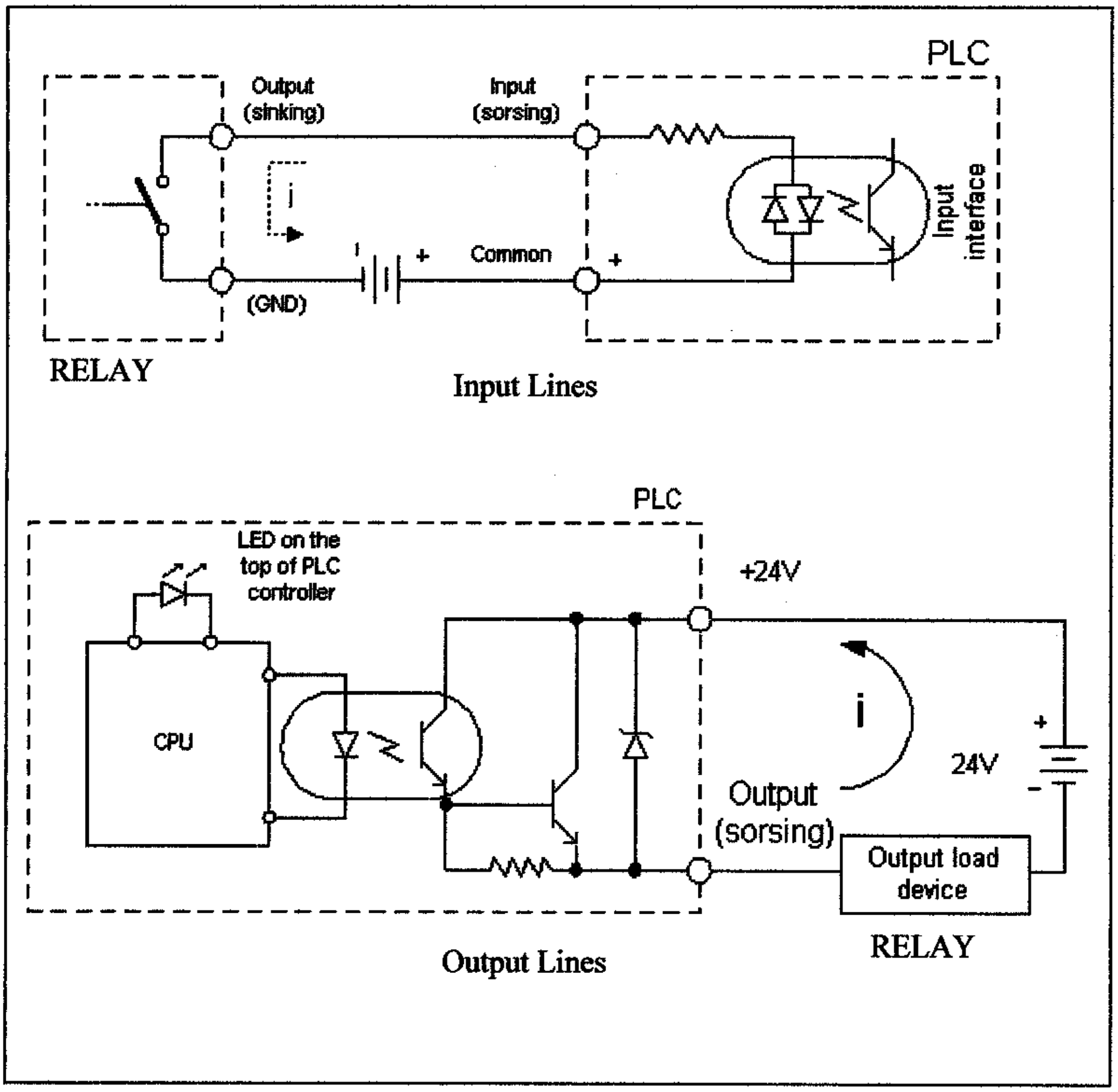
Supik Leykom
Department of Electrical & Electronics Engineering
Universiti Teknologi PETRONAS

2. WATER PUMP AND OUTPUT CONTROL VALVE CIRCUIT



APPENDIX P

PLC INPUT AND OUTPUT CONNECTION

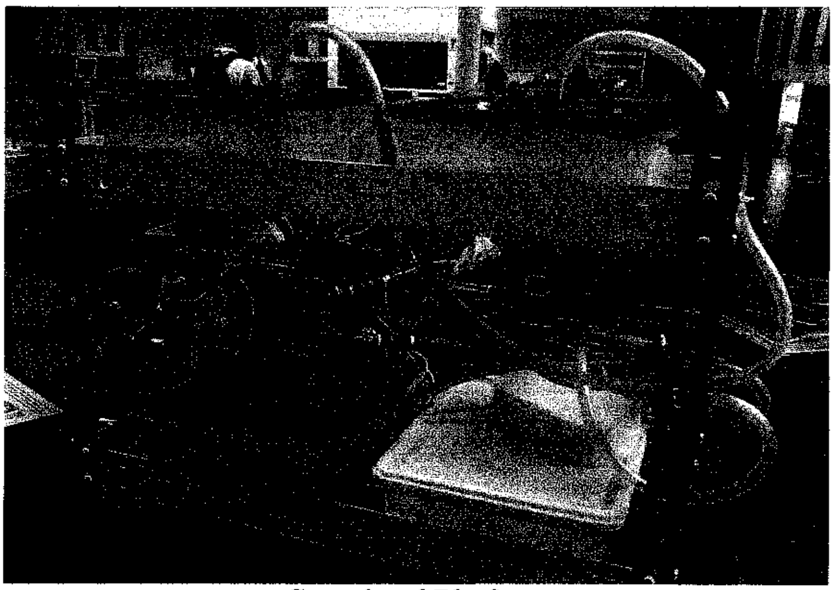


APPENDIX Q

TECHNICAL COMPARISON OF THE ACTUAL AND MODEL DESIGN

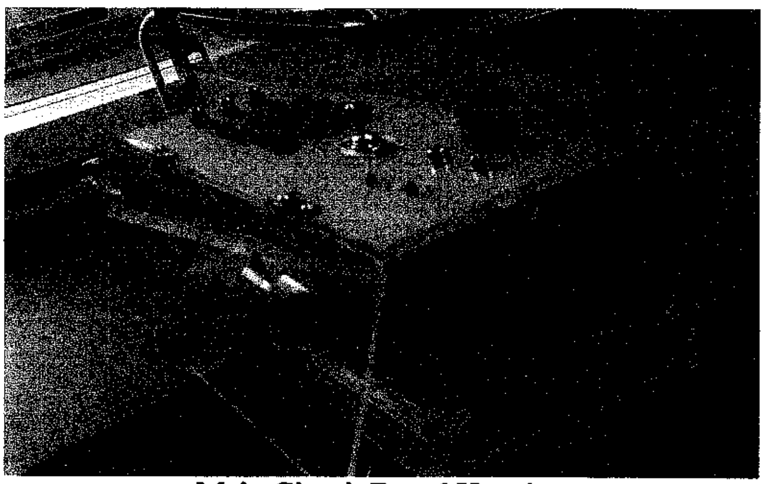
	System Design	
	Actual System	**Model**
Level Transmitter/Level Detector Output	4-20 mA	0 V or 5V
Water Cut Sensor/ Water Detector Output	4-20mA	0 V or 5V
Measurement Medium (Process Fluid)	3 phase fluid Water, Crude and Natural Gas	Mixture of Cooking Oil & Water
Measurement method for Level Transmitter/Water Level Detector with Process Fluid	Non-Contact	Contact
Measurement method for Water Cut Sensor/ Water Detector with Process Fluid	Contact	Contact

APPENDIX R
PICTURES TAKEN DURING THE TESTING

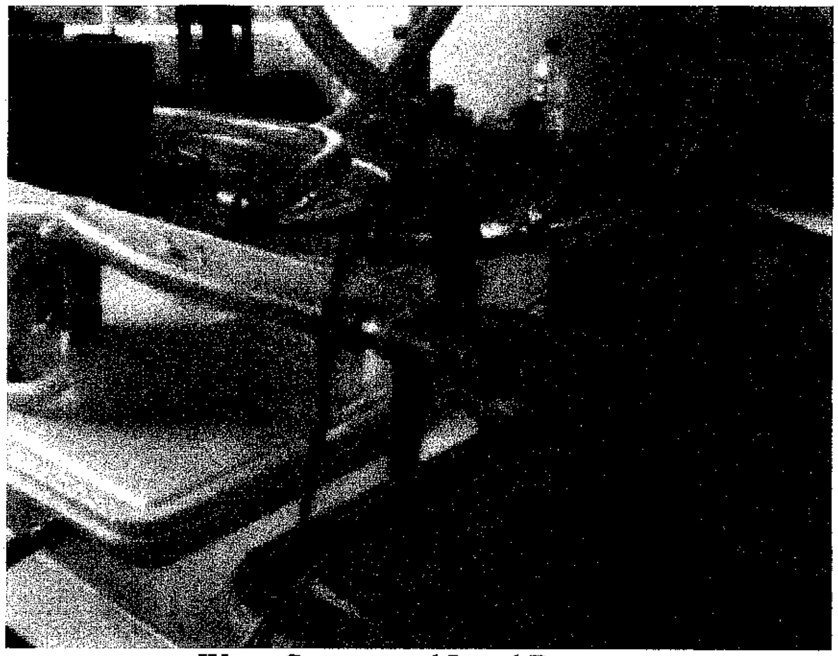


Completed Platform

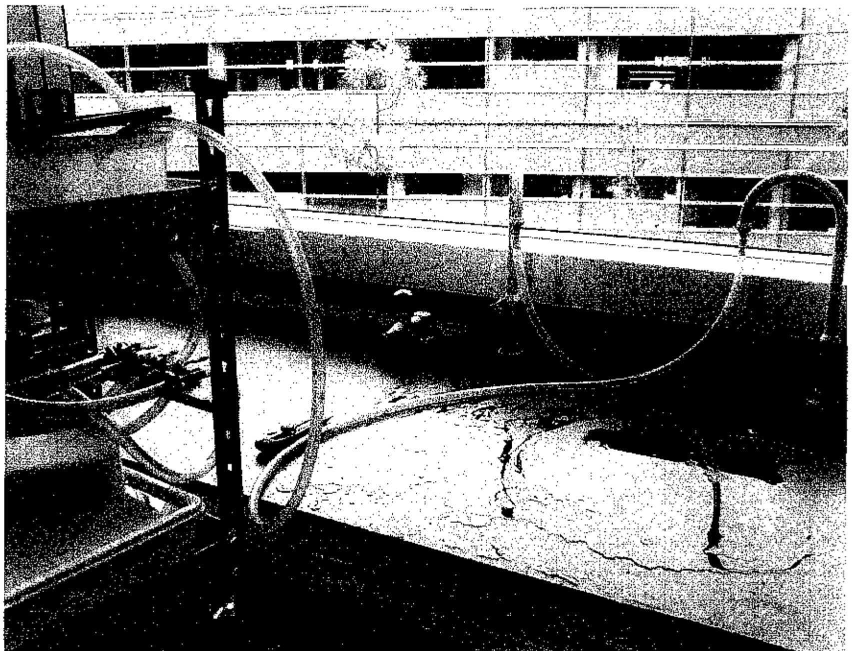
Control Valves



Main Circuit Board Housing



Water Sensors and Level Detector



Water from the tap is being directed to the liquid storage

Supik Leykom
Department of Electrical & Electronics Engineering
Universiti Teknologi PETRONAS

APPENDIX S

INSTRUMENT COMPARISON OF ACTUAL AND MODEL DESIGN

SYSTEM	INSTRUMENTS USED					
	Level Transmitter		**Water Cut Sensor**		**Control Valve**	
	Name	No. of Instruments Used	Name	No. of Instruments Used	Name	No. of Instruments Used
Actual	Rosemount 5600 Series	1	Honeywell H_2O Analyzer System	25	Surface Safety Valve (SSV)	25
Model	Electronic Water Detector	1	Electronic Water Level Detector	2	Electric Control Valve	2

APPENDIX T

1. Gantt Chart for Final Year Project

(First Semester, 19th January 2006 to 18th July 2006)

No	Detail/Week	1	2	3	4	5	6	7	Break	8	9	10	11	12	13	14	15	16	17	18	19	Remarks
1	Selection of topic																					
	- Topic proposal																					
	- Topic awarded																					
2	Preliminary Research Work																					
	- Problem Definition																					
	- Fundametal of PLC Concept																					
3	Submission of Preliminary Report																					
4	Further Research																					
	- Water Cut Sensor Technical Review																					
	- Current PLC technologies																					
5	Methodologies and Planning Documentation																					
6	Project Work																					
	- Overall Design system																					
	- Drawings, and																					
	- Concept																					
	- System Implementation																					
	- Simulation																					
7	Submission of Progress Report																					
8	Project Work (continue)																					
	- Study on PLC available at Laboratory																					
	- Assembly Language and Downloading																					
	- Design Simulation																					
9	Finalised all the findings																					
10	Revision on the current project status																					
11	Submission of Interim Report - Final Draft																					
12	Submission of Interim Report																					
13	Oral Presentation																					

APPENDIX T

2. Gantt Chart for Final Year Project
(Second Semester, 24th July 2006 to 22nd December 2006)

No	Detail/Week	1	2	3	4	5	6	7	Break	8	9	10	11	12	13	14	16	17	Remarks
1	Project Work Continue	■	■	■															
	- Continue on PLC Programming																		
	- Purchase the prototype hardware																		
2	Submission of Progress Report 1				■														
3	Project Work Contiune					■	■	■	■										
	- Continue on PLC Programming																		
	- Part by partTroubleshooting																		
4	Submission of Progress Report 2									■									
5	Project Work Contiune				■	■	■	■	■	■	■	■							
	- Complete the prototype setup																		
	- Done with the prototype (H/ware & S/ware)																		
6	Experiment on the system characteristics			■					■			■							
7	Troubleshooting and adjustment				■					■			■						
8	Methodologies and Planning Documentation					■	■	■	■	■	■								
9	Finalised all the findings										■	■							
10	Revision on the current project status			■	■				■	■		■	■						
11	Submission of Draft (dissertation) report											■							
12	Submission of Dissertation report (soft cvr)												■						
13	Submission of Technical Report														■				
14	Oral Presentation																	■	
15	Submission of Dissertation report (hard cover)																	■	