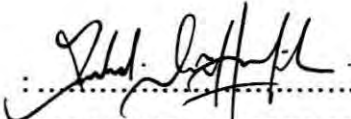


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**DESIGN AND IMPLEMENTATION OF AN AUTOMATED LIQUID LEVEL
CONTROLLER USING SENSOR AND PLC**

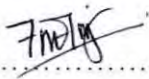
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**This Report Is Submitted In Partial Fulfillment of Requirements For The Bachelor
Degree of Electrical Engineering (Industrial Power)**

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APRIL 2006

“Hereby the author declares that all the material presented in this thesis to be the effort of the author herself. Any kind of materials that is not the effort of the author has been stated clearly in the references.”

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Date : 04 MEI 2006

Dedicated to:

Mak, Ayah, Adik-Adik, Kak Na, Kak Rah, Kak Mah, Abang, family and my beloved friends for giving me unconditional love and caring.....

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ABSTRACT

Design and implementation the automated liquid level controller using ultrasonic sensor and programmed PLC (Programmable Logic Controller) is a reverse engineering project, where level measurement can be defined as the determination of the position of an existing interface between two media. The ultrasonic sensor will provide the feedback information required to control the process based on a sound wave emission source and the reflection of a sound wave pulse. The PLC is a self contained, rugged computer designed to control processes and contains a microprocessor that has been programmed to drive the output terminals in a specific manner based on the signals from input terminals. Entirely this project consists two main parts in term of software development for PLC (Programmable Logic Controller), ladder diagram. For this project, the Omron SYSMAC CJ1H-series Programmable Controllers is used with the programming language of CX-One programmer. In term of hardware development it consists of sensor selection and design for automated liquid level controller. This controller can be used to control the water level in tank especially in plant, we have to maintain the water level in water tank that used for emergency case from condensate and also can detect if the tank is leaking.

ABSTRAK

Projek Rekabentuk dan Pembangunan Sistem Kawalan Automatik menggunakan 'PLC' bagi Ukuran Ketinggian Cecair dengan menggunakan pengesan 'Ultrasonic' adalah satu projek pembalikan kejuruteraan dimana ia menerangkan bahawa ukuran ketinggian tersebut boleh ditakrifkan sebagai penentuan kedudukan atau kehadiran permukaan diantara dua perantara. Pengesan 'Ultrasonic' yang digunakan akan mengesan ketinggian cecair tersebut dengan menggunakan sistem gelombang pantulan. 'PLC' adalah satu system kawalan proses dimana ia mempunyai mikropemproses yang telah diprogramkan untuk menjalankan terminal output dalam keadaan yang telah ditetapkan berdasarkan kepada isyarat daripada terminal input. Projek ini mempunyai dua bahagian utama iaitu pembangunan program computer untuk 'PLC'. 'SYSMAC CJ1H-series Programmable Controllers' telah digunakan disamping program daripada 'CX-One programmer'. Bagi pembagunan alatan pula, ia termasuklah pemilihan pengesan yang akan digunakan dan juga rekabentuk system yang dibangunkan. Alat kawalan ini boleh diaplikasikan dengan meluas terutamanya dalam industri petro kimia dimana ia sesuai digunakan untuk mengawal air di dalam tangki yang digunakan untuk kecemasandan juga ia dapat mengesan air yang keluar dari tangki sekiranya terdapat kebocoran.

CONTENTS

| CHAPTER | TITLE | PAGE |
|----------|--|------------|
| | PROJECT TITLE | i |
| | DECLARATION | ii |
| | DEDICATION | iii |
| | ACKNOWLEDGEMENT | iv |
| | ABSTRACT | v |
| | ABSTRAK | vi |
| | CONTENTS | vii |
| | LIST OF ABBREVIATIONS | x |
| | LIST OF TABLES | xi |
| | LIST OF FIGURES | xii |
| | LIST OF APPENDIXS | xvi |
| | | |
| I | INTRODUCTION | |
| | 1.0 Introduction | 1 |
| | 1.1 Project Liquid Level Control system Using PLC and Ultrasonic Sensor | 3 |
| | 1.2 The project Objectives | 4 |
| | 1.3 Benefit of Liquid level Controller System | 4 |
| | 1.4 Scope project | 5 |
| | 1.5 Problem Statement | 5 |
| | 1.51 Manual control System | 6 |
| | 1.52 Automatic Control System | 6 |

II CONTROL SYSTEM PROJECT

| | | |
|-------|--|----|
| 2.0 | Control System | 8 |
| 2.1 | Automation System | 9 |
| 2.2 | Process Control Industries | 11 |
| 2.2.1 | Batch process automation | 11 |
| 2.2.2 | Continuous control system | 15 |
| 2.3 | Level measurement | 16 |
| 2.4 | Flow Measurement | 21 |
| 2.5 | Sensor selection (Level) | 26 |
| 2.6 | Sensor selection (Flow) | 34 |
| 2.7 | Control Valve | 40 |
| 2.8 | On-off control system | 42 |
| 2.9 | PID (Proportional + Integral + Derivative) | 45 |
| 2.10 | PLC (Programmable Logic Controller) | 54 |
| 2.11 | Summary | 68 |

III METHODOLOGY

| | | |
|------|--|-----|
| 3.0 | Stages to Design a Project | 70 |
| 3.1 | Basic concept for this project | 71 |
| 3.2 | System Concept | 74 |
| 3.3 | The liquid level-Flow control Function | 75 |
| 3.4 | The Prototype design and Built up | 79 |
| 3.5 | Hardware installation | 81 |
| 3.6 | AC Motor and Pump Assembly | 82 |
| 3.7 | Sensor Assembly | 83 |
| 3.8 | Valve Assembly | 89 |
| 3.9 | Control Panel Assembly | 91 |
| 3.10 | Touch Screen Panel | 111 |
| 3.11 | RS232 DB9 Cable | 113 |

IV SOFTWARE DEVELOPMENT

| | | |
|-----|---|-----|
| 4.0 | System Design | 115 |
| 4.1 | The I/O List | 116 |
| 4.2 | Process Algorithm for PLC control | 116 |
| 4.3 | CJ-series Analog Input Units | 117 |
| 4.4 | The Ladder Diagram of Liquid Level Controller | 120 |

V THE RESULT AND FUTURE WORK

| | | |
|-----|-------------------------|-----|
| 5.0 | The Result of Project | 130 |
| 5.1 | The Project problems | 134 |
| 5.2 | The Project future work | 135 |
| | Project Schedule | 136 |
| | Conclusion | 138 |

| | | |
|--|-------------------|-----|
| | REFERENCES | 139 |
|--|-------------------|-----|

| | | |
|--|------------------|-----|
| | APPENDIXS | 141 |
|--|------------------|-----|

LIST OF ABBREVIATIONS

| | | |
|--------|---|--|
| AC | - | Alternate Current |
| ADCs | - | Analog to Digital Converter |
| CPU | - | Central Processing Unit |
| CX-P | - | CX-Programmer |
| DACs | - | Digital to Analog Converter |
| DC | - | Direct Current |
| EEPROM | - | Electrically Erasable Programmable ROM |
| EPROM | - | UV Erasable PROM |
| FBD | - | Function Block Diagram |
| IL | - | Instruction List |
| I/O | - | Input/Output |
| LAN | - | Local Area Network |
| LD | - | Ladder Diagram |
| P | - | Proportional |
| PD | - | Proportional + Derivative |
| PI | - | Proportional + Integral |
| PID | - | Proportional + Integral + Derivative |
| PLC | - | Programmable Logic Controller |
| SFC | - | Sequential Function Chart |
| WC | - | Water Closet |

LIST OF FIGURES

| NO | TITLE | PAGE |
|------|--|------|
| 1.0 | An example of a tank level control application | 2 |
| 1.1 | Simple manual control system | 6 |
| 2.0 | The real system of process control | 9 |
| 2.1 | Basic structure of automated system | 10 |
| 2.2 | General structure of an automated system | 10 |
| 2.3 | Process control system for automated liquid level controller | 11 |
| 2.4 | Water tank level continuous control | 15 |
| 2.5 | Two alternative of level measurement | 17 |
| 2.6 | Feedback control shows the continuous measurement | 21 |
| 2.7 | Flow calculation in pipes | 23 |
| 2.8 | Discrete Liquid level detectors | 27 |
| 2.9 | Continuous sonic type level measuring units | 28 |
| 2.10 | Continuous level sensor | 30 |
| 2.11 | Omron electronics ultrasonic sensor | 30 |
| 2.12 | Ultrasonic sensor operation | 31 |
| 2.13 | Wider applications of ultrasonic sensor | 32 |
| 2.14 | Top mounted sonic probe | 32 |
| 2.15 | Ultrasonic detector with two sensors | 33 |
| 2.16 | Various type of orifice plates | 35 |
| 2.17 | Venturi flow | 36 |
| 2.18 | A diagram of Vortex Flow meter | 38 |

| | | |
|------|---|----|
| 2.19 | Across the pipe ultrasonic flow meter | 39 |
| 2.20 | Inline flow sensor | 40 |
| 2.21 | On-off valve | 41 |
| 2.22 | 2/2-way solenoid valve | 42 |
| 2.23 | On-off system in a tank | 43 |
| 2.24 | Final control element and the control and controlled variable | 44 |
| 2.25 | Proportional functions eliminates offset | 46 |
| 2.26 | Integral functions compensates for rapid changes | 48 |
| 2.27 | Basic op-amps differentiator | 50 |
| 2.28 | Block diagram of a typical PID controller | 52 |
| 2.29 | Ideal PID position control | 53 |
| 2.30 | Block diagram of PID module | 53 |
| 2.31 | CJ1 series PLC from Omron Electronics | 55 |
| 2.32 | Overall dimension for CJ1 series PLC | 56 |
| 2.33 | CJ1G-CPU44H PLC units | 57 |
| 2.34 | System configuration | 57 |
| 2.35 | CJ1G-CPU44H CPU unit | 58 |
| 2.36 | Memory card used for program memory | 59 |
| 2.37 | A PLC and its related component | 60 |
| 2.38 | Analog I/O modules | 62 |
| 2.39 | I/O units | 62 |
| 2.40 | Block diagram of a PLC | 63 |
| 2.41 | Ladder diagram language | 65 |
| 2.42 | Function block diagram | 65 |
| 2.43 | Instruction list language | 66 |
| 2.44 | Sequential function chart language | 66 |
| 2.45 | A single phase motor (split phase) using a capacitor with a centrifugal Switch | 69 |
| 3.0 | Block Diagram of The Stages Design A Project | 71 |
| 3.1 | Typical overall batch process scheme | 73 |
| 3.2 | On-off system in a tank | 74 |

| | | |
|------|--|----|
| 3.3 | Liquid level – flow determination system for this project | 75 |
| 3.4 | Model liquid level controller | 76 |
| 3.5 | Process Algorithm for LOCAL control | 77 |
| 3.6 | Process Algorithm for REMOTE control | 78 |
| 3.7 | A front view 3D design of Hardware Liquid Level Controller using Solid Work | 79 |
| 3.8 | Basic design for the hardware | 80 |
| 3.9 | The back view 3D design of Hardware liquid level controller using Solid Work | 81 |
| 3.10 | The fully hardware installation on the aluminum rack | 82 |
| 3.11 | A principle running the single phase motor (split phase) using a capacitor with a centrifugal switch | 83 |
| 3.12 | The installation of the AC motor | 83 |
| 3.13 | Installation of ultrasonic sensor on the top of tank | 84 |
| 3.14 | Measurement variety materials | 85 |
| 3.15 | Sensing distance for E4PA-LS50-M1_N | 85 |
| 3.16 | Output circuit | 86 |
| 3.17 | Sensor I/O connector | 86 |
| 3.18 | Sensing possibility | 87 |
| 3.19 | Installation of INLINE flow sensor | 88 |
| 3.20 | Interconnection possibilities for inline flow sensor | 89 |
| 3.21 | Installation of Valve | 90 |
| 3.22 | Materials of valve | 91 |
| 3.23 | Construction circuit for hardware | 92 |
| 3.24 | The front side of control panel | 92 |
| 3.25 | Digital meter panel (process meter) | 93 |
| 3.26 | Nomenclature for process meter | 93 |
| 3.27 | Terminal arrangement | 95 |
| 3.28 | Connection for digital meter panel | 95 |
| 3.29 | Block diagram for process panel | 96 |
| 3.30 | Operating procedures for level | 97 |

| | | |
|------|--|-----|
| 3.31 | Operating parameter | 98 |
| 3.32 | Operation level setting | 98 |
| 3.33 | Initial setting value procedure | 100 |
| 3.34 | Advanced function setting level procedure | 101 |
| 3.35 | Protect level procedure | 102 |
| 3.36 | Installation of Batch Controller | 103 |
| 3.37 | Burkert Batch Controller | 103 |
| 3.38 | Electrical connection for batch controller | 105 |
| 3.39 | Connection of flow sensor to the panel version | 105 |
| 3.40 | Main menu of the batch controller | 106 |
| 3.41 | Batch A setting | 107 |
| 3.42 | Calibration setting | 108 |
| 3.43 | Calibration menu for BURKERT Batch Controller 8025 | 111 |
| 3.44 | Touch screen panel | 112 |
| 3.45 | Touch screen panel design from computer | 112 |
| 3.46 | Designed using NS-Designer | 113 |
| 3.47 | RS232 DB9 serial cable | 114 |
| 4.0 | The whole system connected to the PLC | 115 |
| 4.1 | Input function block diagram | 117 |
| 4.2 | Input specification | 118 |
| 4.3 | Input Circuitry for analog input | 118 |
| 4.4 | Internal configuration for analog input | 119 |
| 4.5 | Voltage input disconnection | 119 |
| 4.6 | The Timer operation | 125 |
| 4.7 | Input numbers | 126 |
| 4.8 | I/O refresh data | 127 |
| 4.9 | Scaling output | 129 |
| 5.0 | Graph Setting value (L) versus time (s) | 131 |
| 5.1 | On-off control element | 132 |
| 5.2 | Continuous process for liquid level control | 133 |
| 5.3 | PID for continuous process | 134 |

LIST OF TABLES

| NO | TITLE | PAGE |
|-----------|--|-------------|
| 2.0 | Table shows the conversion between units | 18 |
| 2.1 | Volumetric flow rate | 24 |
| 2.2 | Mass flow rate | 24 |
| 3.0 | Output circuit | 87 |
| 3.1 | Function of every key | 94 |
| 3.2 | Indicator | 94 |
| 3.3 | Operating procedure | 96 |
| 3.4 | Function of the menus | 106 |
| 4.0 | Input signal range | 126 |
| 5.0 | Setting value versus time | 131 |
| 5.1 | Project schedule | 136 |

LIST OF APPENDIXS

| NO | TITLE |
|-----------|--|
| A | PLC Model CJIG, CPU type-CPU44H Datasheet |
| B | Ultrasonic Sensor Datasheet |
| C | INLINE Flow Sensor Datasheet |
| D | 2/2 Way Solenoid Valve Datasheet |
| E | Omron K3MA – J – A2 (digital meter panel)datasheet |
| F | Burkert Batch Controller (panel version)datasheet |
| G | Liquid Level control Ladder Diagram |

CHAPTER 1

INTRODUCTION

1.0 Introduction

Automatic control, by comparison with manual control system, applies to those things that are achieved, during normal operation, without human intervention. This type of control is used where continuous attention to system operation would be demanded for a long period without interruptions. Automatic control does not, however necessarily duplicate the type of control achieved by a human operator. Equipment that employs automatic control is limited to only those things that can be forecast by the input data. Terms such as closed loop control and feedback are commonly used to describe automatic control functions.

The control of liquid level in tanks and flow between tanks is a basic problem in the process industries. The process industries require liquids to be pumped, stored in tanks and then pumped into another tank. Many times the liquids will be processed by chemical or mixing treatment in the tanks, but always the level of fluid in the tanks must be controlled and the flow between tanks must be regulate. Often, the tanks are so coupled together that the levels interact and this must also be controlled.

Level and flow control in tanks are at the heart of all chemical engineering systems. But chemical engineering systems are also at the heart of our economies. Vital industries where liquid level and flow control are essential includes :

- Petro-chemical industries
- Paper making industries
- Water treatment industries

Our lives are governed by level and flow control systems. For example, medical physiology involves many fluid bio-control systems. Bio-systems in our body are there to control the rate that blood flows around our body. The water closet (WC) toilet in your apartment or house is also a liquid level control system. The swinging arm attached to the input valve of the WC water tank allows water to flow into the tank until the float rises to a point that closes the valve. This is the simple and effective level control system for water tanks. Although the WC toilet is now common, but the WC in one of the villages in London was in the *Herrenhaus*. It was a thing of great wonder. Visitors would admire the automatic refilling of the WC tank much more than the beauty of the house and that beautiful countryside.

Tank level control systems are everywhere. All of our process industries, the human body and fluid handling systems depend upon tank level control systems.



Figure 1.0 : An example of a tank level control application

It is essential for control system engineers to understand how tank control systems work and how the level control problem is solved.

1.1 Project Liquid Level Control System Using PLC and Ultrasonic Sensor

This Project Liquid Level Controller System Using PLC and Ultrasonic Sensor will be controlled using PLC (Programmable Logic Controller) as a demonstration. The main concept used in this project is process control concept with industrial measurement techniques that consists of flow and level measurement. Nowadays, many liquid level control system used everywhere especially in chemical industries. But the major function of the liquid level control system using PLC controller is to measure the liquid level in tank continuously, not depend on the highest or lowest point by giving the absolute value of measurement.

This liquid level controller system is not fully automatic system. This hardware can be function as local and remote control. For the local control, this system contain of one batch controller from Burkert as that function as a main controller, one Omron process meter (K3MA-J) to display the level measurement, local button, start button and stop button. We have to set certain value to the batch controller depend to the height of the process tank to allow the water flow through the control valve. The setting value normally set in Liter, but we can choose whether to set it in cm^3 , US gallon or IMP gallon. Before that we have to setting all the parameters in the batch controller. The further information about setting parameters can be referred to the Chapter 3. Once, the power supply is on, the start button must be pushed. Then, the water will pump from the storage tank to the flow sensor and then through the control valve. When the water comes to the process tank, the ultrasonic level sensor will detect the height of the water in that tank. The process meter will display the value of height of the water in the process tank. The setting parameter of process meter can be referred to the Chapter 3.

For the remote control system, programming PLC (Programmable Logic Controller) will be used to operate this hardware. The programming used is the ladder diagram programmed and the continuous level measurement detected. By using timer command in PLC, this project can be operated as continuous but it still used the on-off control process concept.

1.2 The Project Objectives

Accurate measurements of level are essential to provide good control in the process industries. Liquid level has no absolute value and is always relative to some reference point such as the top and bottom of the tank. There are several reasons to monitor the level of materials in containers can be divide to :

Monitoring

- i. To control and measure the liquid level in tank continuously.
- ii. To ensure that enough material is available to complete a particular batch production process.
- iii. To determine an inventory of the material in stock.

Safety

- i. To prevent an industrial accident by overfilling an open container.
- ii. To prevent the overfilling of a closed container or an enclosed system. This situation could cause an overpressure condition that may result in a rupture or explosion.
- iii. To monitor tank for leaking.

Economy

- i. Good level control of solid is also desirable; excessive built up in hoppers can be expensive to clear.

1.3 Benefit of Liquid Level Controller System

In the oil and natural gas industries, liquid level measurement is necessary have the following benefits;

- i. Compute tank inventories of hydrocarbon liquid products and utility liquids.
- ii. Protect equipment such as columns, compressor, turbines and pumps from damage.

- iii. Protect operating and maintenance personal against injury resulting from hydrocarbon, corrosive or toxic liquid spillage.
- iv. Protect the environment from the release of objectionable liquids into the rivers and the sea.
- v. Control phase separation processes and product loading operations.

1.4 Scope Project

The project scope for execution this project are ;

- i. Design and develop the complete automated system that will control the level by giving the absolute value and continuously in term of hardware and software development.
- ii. The hardware development consist of the ultrasonic sensor will detect the level measurement and controlled by PLC, flow sensor that will detect the flow rate of liquid, control valve as the control element, pump and motor.
- iii. The software development consists of CX-One programme as the programming language for Omron CJ1H-Series PLC unit and I will use the ladder diagram and Instruction List programming languages for the PLC.

1.5 Problem Statement

The key characteristic of control is to interfere, to influence or to modify the process. This control function or the interference to the process is introduced by an organization of parts (including operators in manual control) that, when connected together is called the Control System. Depending on whether a human body (the operator) is physically involved in the control system, they are divided into Manual Control and Automatic Control. Due to its efficiency, accuracy and reliability, automatic control is widely used in chemical processed. Therefore, for a control system to operate satisfactorily, it must have the abilities of measurement, comparison, computation and correction.

1.5.1 Manual control system

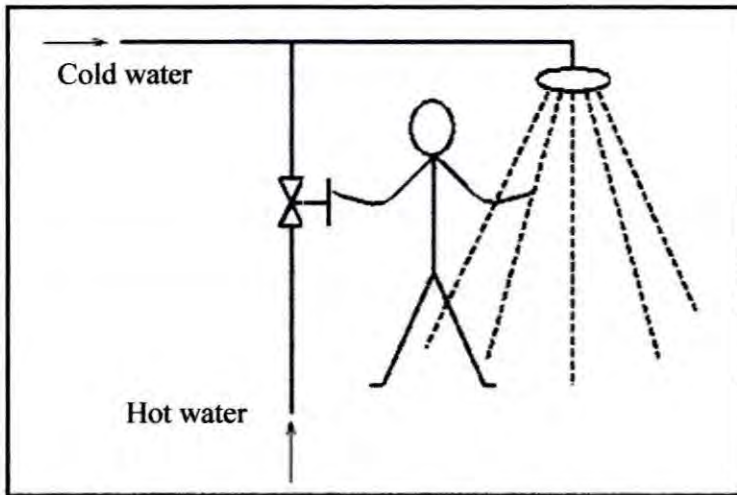


Figure 1.1 : Simple manual control system

To begin with the shower is cold. To start the heating process the valve in the hot water line is opened. The operator can then determine the effectiveness of the control process by standing below the shower. If the water is too hot, the valve should be closed a little or even turned off. If the water is not hot enough then the valve is left open or opened wider. This shows the human aided control used before the automated control system is recognized.

1.5.2 Automatic control system

Liquid level has no absolute value and always relative to some reference point such as the bottom or top of the tank. It is the height or depth of a liquid above a reference point and is specific to a particular vessel.

First we have the Controlled Variable. This is the basic process value being regulated by the system. It is the one variable that we are special interested. In feedback control the controlled variable is usually the measured variable. An important concept related to the controlled variable is the Set point. This is the predetermined desired value for the controlled variable. The objective of the control

system is to regulate the controlled variable at its set point. To achieve the control objective there must be one or more variables we can alter or adjust. These are called the Manipulated Variables. Conclusively, in the control system we adjust the manipulated variable to maintain the controlled variable at its set point. This meets the requirement of keeping the stability of the process and suppressing the influence of disturbances.

The main purpose for this project is to measure the liquid level in tank continuously, not depend on the highest or lowest point.