NON-INTRUSIVE LIQUID LEVEL DETECTION SYSTEM USING ULTRASOUND TECHNOLOGY

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Computer Engineering) With Honours

Faculty of Electronic and Computer Engineering

Universiti Teknikal Malaysia Melaka

April 2008

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UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek	:	NON-INTRUSIVE LIQUID LEVEL DETECTION SYSTEM USING ULTRASONIC TECHNOLOGY.
Sesi Pengajian	:	2007/2008

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Special dedication to my lovely father and mother:

Shari Bin Che Lah

&

Wan Mekti Wan Yusoff.

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ACKNOWLEDGEMENT

Alhamdulillah, very thankful to Almighty Allah, because of His Compassion and grace, I am able to complete my Sarjana Muda project (PSM). I would like to express my heartfelt appreciation and gratitude to my parents, to my supervisor Mr. Tan Kim See, my lecturers, my classmates and to those who had given me the supports to successfully complete my project entitled : "Non-intrusive Liquid Level Detection System Using Ultrasound Technology". May all of you reap the blessing of the Almighty Allah because of your's kindness and assistance. Thank you very much.

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ABSTRACT

Liquid level detection can be achieved in many ways. In order not to adulterate the liquid to be measured, a non-intrusive liquid level detection system is best preferred. This project is exactly aimed to achieve just that where detection of the liquid level is done by applying ultrasound technology where the sensor does not come into physical contact with the liquid. Ultrasonic is a cyclic sound pressure with a frequency greater than the upper limit of human hearing which is around 20 kilohertz (20,000 hertz). This project can be used to determine the level of liquid at any stage in a tank or container. An ultrasonic sensor transmits ultrasonic waves from its sensor head and then receives the ultrasonic waves reflected from an object or liquid. By measuring the length of time it takes for the sonic waves to travel to the target and the reflected waves detected by the sensor again will provide the necessary variables in relation to the position of the target, in this case the level of the liquid. The indicated level can be computed and displayed on an LCD screen or a 7-segment display. The project will take off by first looking into the various methods currently in used for liquid level detection and some comparisons made of their advantages and disadvantages. Ultimately, the project will be a liquid detection system using ultrasound technology to meet the objectives of the proposed project. Another very important aspect this project is very relevant for liquid which may be corrosive, contaminated or hazardous. Non-intrusive liquid level detection system is practical for the industry that involves significantly in liquid measurement and level control.

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ABSTRAK

Pengesanan paras cecair boleh dilaksanakan dengan pelbagai cara. Untuk mengelakkan pencemaran pada cecair yang disukat, satu sistem pengesanan paras cecair bercirikan tanpa sentuhan adalah diutamakan. Projek ini adalah tepat dengan tujuan untuk mencapai perkara sedemikian iaitu pengesanan paras cecair dilakukan dengan menggunakan teknologi ultrasound di mana penderia tidak bersentuhan secara fizikal dengan cecair. Ultrasonik adalah pusingan tekanan bunyi dengan nilai frekuensinya melebihi nilai pendengaran manusia, iaitu lebih kurang pada 20kHz. Projek ini boleh digunakan untuk menentukan paras cecair pada mana-mana paras dalam satu tangki atau bekas. Pengesan ultrasonik memancarkan gelombang bunyi dari sumber bunyi dan akan menerima gelombang tersebut sekali lagi selepas dipantulkan oleh objek atau cecair. Apabila nilai panjang masa dikira dari masa pemancaran dan penerimaan gelombang bunyi, ia boleh digunakan untuk mengesan kedudukan objek atau aras sesuatu cecair dengan menukarkan pembolehubah yang diperolehi ke paras. Data yang diperolehi boleh ditukarkan kepada paras dan dipamparkan di skrin skrin LCD atau Pemampar 7 Segment. Projek akan bermula dengan meninjau kepada kaedah-kaedah, yang kini digunakan untuk mengesan paras cecair dan perbandingan dilakukan tentang kelebihan dan kekurangan antara satu sama lain. Secara keseluruhanya, projek ini adalah satu sistem pengesanan paras cecair menggunakan teknologi ultrasound untuk memenuhi objektif projek yang dicadangkan. Satu aspek yang amat penting bagi projek ini adalah pengunaan cecair di mana cecair itu berkemungkinan jenis menghakis, tercemar atau membahaya. Pembinaan satu sistem pengesanan paras cecair tanpa sentuh adalah praktikal bagi industri yang terlibat dalam pengukuran cecair dan kawalan paras.

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CONTENT

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LIST OF TABLE

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LIST OF FIGURE

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LIST OF ABBREVIATION

LCD	-	Liquid Crystal Display
NILLDC	-	Non-intrusive Liquid Level Detection System
PC	-	Personal Computer
VB	-	Visual Basic
GUI	-	Graphical User Interface
CPU	-	Control Processing Unit
PSM	-	Project Sarjana Muda
CW	-	Continuous Wave
NDT	-	Non-Destructive Testing
NDE	-	Non-Destructive Evaluation
CA	-	Common Anode
LED	-	Light Emitter Diode
DC	-	Direct Current
SONAR	-	Sound Navigation and Ranging

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LIST OF APPENDIX

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CHAPTER I

INTRODUCTION

1.1 Introduction of the project

This project is to develop a non-intrusive liquid level detection system (NILLDC). The non-intrusive technique is by using an ultrasonic sensor that sends sonic waves to the target and detects the returned waves from the target. The determination of liquid level will be calculated and displayed and simulated using Microsoft Visual Basic and Proteus ISIS Professional. The value of liquid level can be displayed using LCD screen or Multiplexed Quad Seven Segment Display. As the liquid level gets higher towards the sensor, the time taken for the forward and return path will be shorter. This can be translated into the height of the liquid and thus the level of the liquid in the tank or container.

At the early stages, the various methods available to detect liquid level were studied and some comparisons on their advantages and disadvantages were analyzed. Finally, an in-depth study on the non intrusive liquid level detection employing ultrasound technology was conducted and a system was developed to achieve the objectives of the proposed. The keywords are non-intrusive, liquid-level and display. This project will be most suitable for handling liquids which are corrosive, contaminated or hazardous. This scope of work will include some software program and hardware development and design.

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1.2 Objective project

The objective that must be achieved in this project is to understand that non-intrusive liquid level detection is feasible and can be implemented with the existing technology. In this project and to achieve the objectives, the ultrasound technology using the concept of ultrasonic sensor literally does not come into physical contact with the liquid. The main objective of this project is to develop the non-intrusive liquid level detection system based on ultrasound technology using ultrasonic sensor. This project involved some initial study and research about the basic concept of liquid detection either non-intrusive or intrusive. It also included the research of liquid level control and measurements. In this project, the study about the transmitting and receiving concept of sound wave, the length of time taken by the incident and reflected waves, the equation of wave velocity and relation between time and distance. By doing this project, I need to familiarize myself with software tools like Multisim, Matlab, SourceBoost IDE, Microsoft Visual Basic (VB) and Proteus ISIS Professional programming. Multisim is used to simulate the operation of circuit, to calculate the electric quantities such as resistance, capacitance, and voltage in the circuit. The end result is to develop a non-intrusive liquid level detection system that has the ability to indicate the various level of the liquid and be monitored on a display.

1.3 Problem statement

It is quite common in the industries that the device or sensor used to sense the liquid level is often in direct contact with the liquid. The liquid, especially if it is corrosive will cause the sensor to be corroded over time. Besides, the liquid can be adulterated and change the quality of the liquid. Using ultrasonic sensor without touching the liquid will eliminate the above problems and the detection method is more efficient and safe, at the same time prolong the lifespan of the sensor and maintain the quality of liquid. Although the ultrasonic technology can be intrusive

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and non- intrusive, this project focuses on the non-intrusive technique to meet the objectives of the project.

1.4 Scope of project

In this project, the scope of project needs to cover all the data or information to achieve the objectives on this project. As I mentioned before, the basic technology that I need to research is about ultrasonic or ultrasound technology. So that, the important topic that I need to cover for the project is the introduction and research of ultrasonic sensor. Basically, ultrasonic using the sound wave to detect or measure the value of liquid level detection. Another scope that needs to cover is the concept of liquid level detection and controller. The operation of basic liquid level detection is important to relate with this project, because sometimes the concept is almost same although using different method. In this project, the value of liquid must displayed after the detection by ultrasound. To make sure it became realistic, the study also must cover about the value display of liquid level using software (Visual Basic and Matlab). For control system, the suggestion equipment to control is using microcontroller tool such as PIC 16F84 or PIC 18F77. So, the scope of project also need cover the study of microprocessor for full circuit configuration.

1.5 Project methodology

As the final year project, this project needs more concentration on study case and the project construction base on ultrasonic sensing technology. The project methodology covers the whole flow of the project progress. The flowchart of the program was attached at the chapter 3. The basic method is:

a) References books, journal, thesis, work paper of conferences.
b) Discussion with lecturers and supervisor.
c) Discussion with classmate and course mate.

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d) References from web link internet.

e) Construction of software and hardware.

f) Troubleshooting of project.

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CHAPTER II

BACKGROUND OF PROJECT

2.1 Ultrasonic Sensing and Control Basics

Ultrasonic signals are like audible sound waves, except the frequencies are much higher. Our ultrasonic transducers have piezoelectric crystals which resonate to a desired frequency and convert electric energy into acoustic energy and vice versa. Figure 2.1 shows how sound waves, transmitted in the shape of a cone, are reflected from a target back to the transducer. An output signal is produced to perform some kind of indicating or control function. A minimum distance from the sensor is required to provide a time delay so that the 'echoes' can be interpreted. Variables which can effect the operation of ultrasonic sensing include: target surface angle, reflective surface roughness or changes in temperature or humidity. The targets can have any kind of reflective form, even round objects.

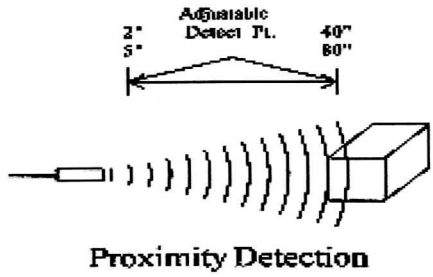

Figure 2.1 Figure of Distance Detection

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2.2 Advantages of Ultrasonic Sensors

When used for sensing functions, the ultrasonic method has unique advantages over conventional sensors. The advantage of ultrasonic sensor is discrete distances to moving objects can be detected and measured. Besides, ultrasonic sensor less affected by target materials and surfaces, and not affected by color. Solid-state units have virtually unlimited, maintenance free life, and ultrasonic sensor can detect small objects over long operating distances. Ultrasonic sensor also has resistance to external disturbances such as vibration, infrared radiation, ambient noise, and EMI radiation.

2.3 Measurement Principle and Effective Use of Ultrasonic Sensor

2.3.1 Measurement Principle of Ultrasonic Sensor

Ultrasonic sensors transmit ultrasonic waves from its sensor head and again receive the ultrasonic waves reflected from an object. By measuring the length of time from the transmission to reception of the sonic wave, it detects the position of the object.

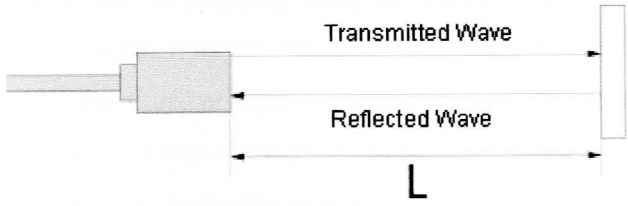

Figure 2.2 Figure Of Transmit and Receive Wave

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2.3.2 Roles of Temperature Sensor (FW-H10R)

The head sensor FW-H10R comes with a temperature sensor for temperature compensation. This is because the sound velocity in the atmosphere changes depending on temperature. The temperature sensor inside the sensor head senses the temperature and compensates for the changes of sound velocity.

2.3.3 Sound Velocity in the Atmosphere

The sound velocity in the atmosphere reaches 331.45 m/s when the temperature is 0°C. The sound velocity at different temperatures can be calculated with the following formula.

$$C = 331.45 \text{ m/s} + 0.607 \text{ m/s} \times T°C \qquad (2.1)$$

Where C: Sound velocity, T: Current temperature

Sound velocity increases by 0.607 m/s every time the temperature rises 1°C

2.4 Effective Use of Ultrasound Sensor

2.4.1 Detection of Liquid Level

Ultrasonic sensors are widely used for liquid level detection. However, in some cases, measurements may not be successful, such as when the surface of the liquid is rough or foamed up, or other objects on the liquid are wrongly detected. In such cases, place a pipe on top of the sensor head. By detecting the liquid level inside the pipe, a wavy surface and entering of bubbles can be prevented.

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