NON INTRUSIVE LIQUID LEVEL DETECTION USING OPTICAL TECHNIQUE

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This report is submitted in partial fulfillment of the requirements for the awarded of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honors.

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FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

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To my beloved papa, mama, family and friends

for their never ending support and unconditional love

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ABSTRAK

Laporan ini mengandungi maklumat dan pengetahuan yang diperolehi dalam proses menyelesaikan Projek Sarjana Muda (PSM). Penerangan yang terkandung di dalam laporan ini adalah berdasarkan kajian dari petikan dan pengalaman semasa menyiapkan projek.

Seperti yang kita sedia maklum, terdapat pelbagai kaedah untuk mengesan paras cecair terdapat di pasaran. Diantaranya ialah teknologi mengesan paras cecair tanpa melibat sentuhan antara alat yang digunakan dan cecair. Ini adalah satu sistem tidak melibatkan penyentuhan secara fizikal dengan jenis cecair yang disukat.

Kaedah yang akan diaplikasikan di dalam projek ini adalah berdasarkan prinsip optik yang tidak bersentuhan degan cecair yang disukat. Kaedah yang diketengahkan ini adalah kaedah terbaru yang masih dalam tempoh kajian. Prinsip optik dipilih kerana kelajuan dan ketahanannya berbanding dengan kaedah lain. Konsep yang akan diaplikasikan adalah berdasarkan kecerahan cahaya yang diterima. Semakin tinggi paras cecair semakin rendah kecerahan cahaya yang diterima.

ABSTRACT

This report consists of the knowledge acquired and it encompasses the system and technologies that are applied in order to complete the final year project. The explanations are based on literatures, articles and experiences from the actual work done.

There are many types of liquid level detection already in existence in the market and it depends on the application by the user. Non-Intrusive liquid level detection is the system where the detection or measuring of the level of the liquid is done without any physical contact with the liquid.

The method is based on optical technology whereby object is in direct contact with the liquid. An optical technique was chosen because of its high speed performance as compared to other methods. The concept that will be use in the system is based on the intensity measurement of a laser in term of voltage. The depth of liquid will be measured based on intensity of laser light. The voltage decreases while the depth of liquid increases.

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PCB	Printed Circuit Board
LED	Light Emitting Diode
IC	Integrated Circuit
BCD	Binary Coded Decimal
VR	Variable Resistor
RF	Resonance Frequency
RGB	Red Green Blue
LASER	Light Amplification Stimulation Emissions Radiation
TX	Transmitter
RX	Receiver
PSM	Projek Sarjana Muda
UTeM	Universiti Teknikal Malaysia Melaka
FKEKK	Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
LD	Laser Diode

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

There are many technologies used to measure liquid level, available in the market. The examples are RF Admittance, Displacers/Floats, Capacitance, Ultrasonic, Radar, Nuclear, Differential Pressure, Bubbler and etc. All those types of level measurement can be accomplished for liquids, granular, slurries and interfaces. But the truth is that every technology for level measurement works, when used in the specific circumstances where they have a high probability of success.

Other than that, user demand also plays an important roles to decides the technology to be used in their industry. They have an options to used point level system or continuos level system. But most of the user wants a complete, automated control within a plant site would prefer a continuous level monitoring system. Furthermore, users need reliable measurement of the contents in their containers, that they will not cause and overflow or reduce the contents to a critical low point of jeopardizing the process.

Therefore, the existing technology offered both (point and continuos) for contact and non-contact mesurement depends on the measuring material. In Non-contact level measurement systems which include the used of laser, non-contact radar and ultrasonic, they generally show such systems consist of level sensors located above the material surface that emit signal and process the return signal(reflections of that signal). Materials that reflect better, produce stronger returns and permit measurement over larger distances. In general, solids do not reflect as well as certain type of liquids, so a given sensor and transmitter will typically be rated to measure over a shorter distance.

As this project focuses on liquid, its complexity to monitor the reflection is made more difficult because the material is not static in the tank. Furthemore, it is a continuous level measurement process. For these reasons, when designing the system for the project, other relaetd issues have to be considered to overcome the stated problems. The main advantage of using the non-intrusive method is that the sensors do not come into direct contact with the liquid. Only a light beam is transmited into the liquid. The light beam may be affected by airspace conditions like humidity, heavy vapors and vapor layer stratification due to temperature fluctuations, along with dealing with heavy dust in the airspace but these can be accounted and calibrated.

This technology can be used where non-contact to the liquid is desired especially liquid that is corrosive, contaminated or hazardous. It can be used for tank level measurement on almost any liquid whether in storage or during processing. It is versatile because any change to the product or process caused by temperature, pressure, density, conductivity, vapors or dust can be referred to a reference or threshold quantity. The transmitters and receivers can be concealed in transparent wells in the tank or container. Once installed, the system operates without harming the contents of the tank or container.

1.2 PROBLEM STATEMENT

Liquids such as alkaline or acid need special care in handling, say during the monitoring of the level in containers or tanks. Due to their corrosiveness, a non-intrusive method is best used where physical contact to the liquid can be avoided. Thus the project will be developed to monitor the liquid level using a column for the detection purposes. A reliable and not too expensive system can be employed to fulfill the objectives of the proposed project.

Moreover, the idea to develop this project is to contribute more options if not to overcome any shortcomings of existing systems currently available in the market. Using this method, the intensity of the light beam will decrease as the level of the liquid increases. By computing the power at the receiver to the level of the liquid, a consistent relationship can be developed and translated into liquid level. Once the maximum level is achieved, a signal can be sent to the valve to stop the inflow pipe.

It is much easier to design a non-contact detection system to monitor at specific level only. A continuous monitoring system requires a much higher resolution and is definitely more challenging. It is very important that the liquid in the tank does not overflow and reduce to a level below critical point. A non-intrusive system to be able to indicate the level of the liquid at any one point will be much preferred in such industries.

1.3 OBJECTIVE

Most non-contact level sensors cannot accurately measure distances that are close to the sensor itself. Sensors are typically installed to allow the transmitter to disregard measurements at these distances. This region is often called the blanking distance.Therefore, the objective of this project is to find various possible methods in liquid level measurement system, especially for hazardous material, highly viscous liquid and chemical.

Certain applications cannot be handled by a common detection method because some fluids can be very corrosive and hazardous to handle and it's best to avoid physical contact with them. For example, capacitance systems come into direct contact with the specimen. One major problem encountered with liquid level detectors is the coating or the wear and tear on the sensing elements. Even acid and caustics that don't appear to coat the sensing element are so conductive that the thin film they leave can cause serious errors in measurement.

This project is to investigate the relevant technology needed and come up with the most reliable and practical method in non-contacting liquid level detection.. Finally, a system will be designed and developed to be able to handle the task of detecting the liquid level from a minimum level to the maximum level.

1.4 SCOPE OF WORK

In order to implement the project, a few considerations have to be taken in terms of limitations or conditions to assure that the project will be successfully develop. There are a four main areas being identified or considered that needed to be worked out:

a) Types of Liquid

Clear liquid will be used in order to implement the method in mind. Such liquid like alkaline, acid, water and petrol can be the specimen.

b) Environment Requirement

It is important because it will affect the measurement performance. of measuring. The performance of laser is limited to cloudy and vapor space.

c) Source types

There are two types of source that are usually in used which is Light Emitter Diode (LED) and Laser Diode (LD). At the final of the PSM project, laser diode will be used.

d) Receiver and Transmitter Sensitivity

Sensitivity of transmitter and receiver is very important as it will determine the reliable and efficiency of the system.

This table below shows the parameters and operating conditions to be considered for the project

Table 1.1: Parameters and Operating Conditions

System Factor	Consideration /Choices
1.Types of Transmitter source	LASER
2.TX operating wavelength	650nm
3.Range of Receiver	400nm to 1100nm
4.Types of Liquid	Clear liquid(acid, alkaline or water)
5.Environmental requirement & Limitation	Limited to cloudy and black liquid or in tanks with transparent vapor space

Other scope of work includes;

1. Literature review to identify the sensors for optic detection, transmitter and type of liquid for the specimen of the project.
2. Sourcing for suitable and practical circuits for the project.
3. Develop a prototype system to achieve the objectives of the project.
4. Conduct analysis and testing on the project.
5. Finally to conduct and verify the functionality of the system.
6. Application of theoretical engineering principles especially on propagation of optic with the proposed project.
7. Design and production of the required circuit board for the project.

1.5 PROJECT METHODOLOGY

Project Outline

Achievement of the project objectives are based on the method and process employed and should be considered. The various steps below illustrate the process that have to be done from the beginning till the end of the project and being successfully executed. The subjects below are the outlines of the process:

1.5.1 Finding the project

The first step taken is to find a suitable project that is relevant and up to date with the technology of today. By referring to several sources such as books, through the internet and by referring to the supervisor, the various criteria for the project are used as to where to start.

1.5.2 Project planning

As the title of project was agreed upon and registered, the next step was to identify the project and discuss with supervisor about the best method to be used. In order to finish the project according to the time frame given, a Gantt chart as a guide line and progress of the project was prepared.

1.5.3 Literature Review

Searching and have a deeper understanding on subjects related to the project would be the ideal proposition to begin with. Next, from the various texts, a feasible system to support the project was decided. In this project, a non intrusive system using laser beam would be used as the main principle of application to achieve the objectives of the project. It is also helpful to have a better understanding about the project based on the past researches. Other than that, it is necessary to discuss and work with other course-mates who are doing projects related to the same principles and technology even though their applications may be different.

1.5.4 Circuit Design

Circuit designs will be developed based on the information and references made and under the advices and suggestions of supervisor. Once identified, the various components and parts have to be purchased. Of course, the correct specifications and their requirements have to be carefully identified to avoid redundant and non compatible parts being supplied. For testing, analysis and troubleshooting, circuit simulation is best move to determine the functionality of the circuits. However, a comprehensive simulation is not possible as there is no such software available in the laboratory for optical circuits. The nearest to doing is the testing using Multisim and Pspice. In this process, the circuit can be tested so that there is no problem with the circuit later on. The circuit had to be simulated to assure that it can be used and fulfill the requirement of project.

Based on the requirement of the project, three blocks of circuit design have to be developed. The blocks of the system are shown in the figure below:

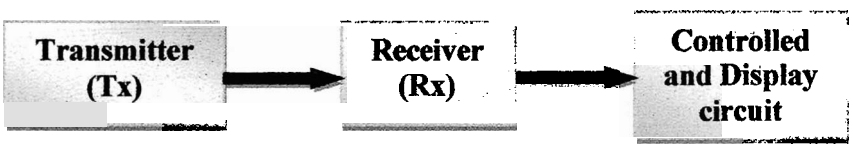

Figure 1.1: Block Diagram of Liquid Level of an Optical System

BLOCK 1 - Transmit an optical signal (light) constantly.

BLOCK 2 - Receive an optical signal and convert it to electrical signal

- Measure the intensity of light that receive in term of volt (V)

BLOCK 3 - Display the level of liquid reached.

- Future development to add a pump circuit.

Block 1 – Transmitter

Block 1 is a portable laser pointer, which is easily available and can be used as the transmitter. Therefore the design procedures proceed to the second block which is an important and the main area of the system.

Block 2- Receiver

Block 2 is the detector circuit that is used to detect light source from the laser pointer. The detector used is the Silicon PIN photodiode which has very short switching time (5 ns). Therefore, it has high sensitivity to detect the signal from the transmitter. The feature of SFH 203 P is suitable for this application from wavelength 400nm to 1100nm. Figure below is a schematic diagram of the receiver.

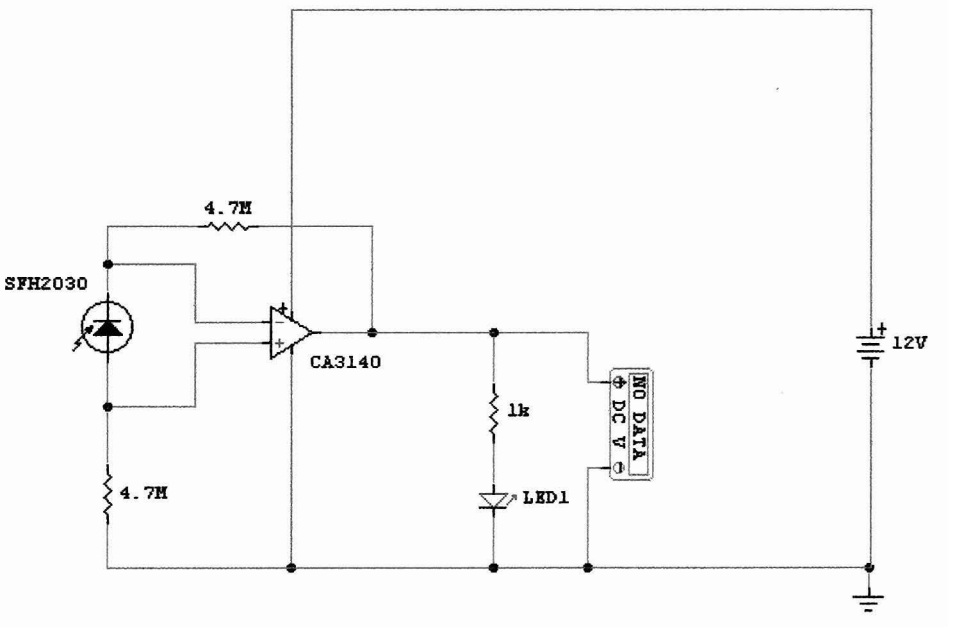

Figure 1.2: Receiver Schematic Diagram

CA 3140 is used to amplify the voltage that is received from the photodiode. It has a long duration timer and is suitable with photocurrent instrumentation produced by SFH 203P.