VELOCITY MEASUREMENT OF MOVING PARTICLE USING COMBINATION OF LASER AND PHOTOTRANSISTOR

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Dedicated to my family, lectures and to all my friends,
My appreciation to all of you for providing me assistance and encouragement throughout my final year project in Universiti Teknikal Malaysia Melaka (UTeM)

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Assalamualaikum w.b.t

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I wish to express my appreciation for my project supervisor, Mr Adie bin Mohd Khafe for his excellent supervision, advices, suggestion, and comment throughout the completion and implementation of this project.

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ABSTRAK

Projek ini menceritakan tentang kajian mengenai penggunaan pengesan optikal untuk megukur kelajuan sesuatu bahan. Tujuan utama projek ini dijalankan adalah untuk mengukur satu objek yang dijatuhkan di dalam paip melalui suatu kawasan yang diletakkan pengesan. Untuk menjalankan pengukuran kelajuan, dua pasang pengesan diletakkan dibahagian atas dan juga dibahagian bawah, manakala teknik kait silang digunakan untuk mendapatkan bacaan kelajuan. Keluaran dapat dihasilkan apabila kedua-dua pengesan yang diletakkan di atas dan bawah telah menjalankan proses kait silang. Puncak bagi graf kait silang menunjukkan masa bagi objek bergerak dari atas ke aras bawah. Kelajuan dikira dengan mendarab masa dan jarak antara aras atas dan aras bawah pengesan tersebut. Projek ini menggunakan lapan pasang pengesan pada setiap aras. Setiap pasang pengesan akan diletakkan bertentangan antara satu sama lain dengan keadaan selari. Pancaran isyarat ini adalah terus. Litar ini akan dibangunkan yang mana ianya melibatkan rekaan litar pengawal isyarat dan juga reka bentuk bagi projek ini. Bagi memproses data, “Visual Basic 6.0” digunakan untuk membangunkan kaedah kait silang. Data akan dikumpulkan menggunakan “data acquisition system” dan ianya di setkan sebagai proses luar talian.

ABSTRACT

This project describes an investigation the use of optical sensor in order to measure the velocity of moving particle. The aim of the project is to obtain the velocity when objects are dropped through the sensing area of the pipe. To measure the velocity, two pairs of sensors are placed upstream and downstream on the pipe and cross-correlation method is used to obtain the velocity. The output is formed when both up stream and downstream sensors is cross-correlated. The peak of the cross-correlation graph represented the time for the object to move from upstream to downstream. The velocity is obtained by dividing the time and the distance between upstream and downstream. In this project, eight pairs of sensors were used. Each pair of transmitter and receiver are placed opposite and facing each other in a parallel manner. In this experiment, it is assume that the signal wave is in the straight ray propagation. Prototype circuits will be implement which is involved design of signal control circuit and also jig and fixture design or fabrication. For data processing method, Visual Basic 6.0 is used to implement the algorithm for cross-correlation method. The data is collected using data acquisition system and it is set an offline process.

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VB	-	Visual Basic
DAQ		Data Acquisition
PSM		Projek Sarjana Muda
LED		Light Emitting Diode
LASER		Light Amplification by Stimulation Emission of Radiation
RTD		Resistance Temperature Detector
EM		Electromagnetic
IR		Infrared
DC		Direct Current
AC		Alternating Current
TV		Television
A/D		Analog to Digital
DLL		Dynamic Linked Library

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CHAPTER I

INTRODUCTION

This chapter will discuss the overview process that involved for this project; the aims and specific objectives of the project, problem statements, work scope and methodology. The end of this chapter the thesis outline will be listed.

1.1 Introduction of The Project

This project implements the velocity measurement of moving particle by using combination of laser and phototransistor. It consists of hardware and software. In this project, two types of sensors are used as transmitter and receiver in order to detect the particle. There are several types of sensor which are capacitive sensor, differential transformer, piezeoelectric sensors, pyroelectric sensors, semiconductor sensors; light detectors, photodiode, phototransistor and others. Optical sensor will be used in this project where it is laser and phototransistor. The laser is function as transmitter while the receiver is the phototransistor. Low Pass Filter, amplifier and phototransistor are used in order to implement the receiver circuit. For Data processing method, Visual Basic 6.0 programming is used to implement algorithms for cross correlation calculation

in order to calculate the velocity of the particle. The interface between software and hardware is Data Acquisition System where the data is collected by the system.

1.2 Aim and The Objectives in Solving The Problems

The aim of this project is to implement a simple velocity measurement of a solid particle that flows in a conveying pipe. The objectives in solving the problems in this thesis are to:

1. To use combination of Red Laser and phototransistor sensor in this project.
2. To utilized phototransistor as receiver and can be operated in switch mode either it can be on “off” (cut-off) or “on” (saturated) mode when response to the light.
3. To complete a project which is the particle velocity can be measured by implementing a design of hardware and software by using amplifier, low pass filter, phototransistor(switch) for hardware, while the software that will be used are Visual Basic and DAQ system.

1.3 The Problems Statement

In industry, for semi finish product which consists of mixture of liquid and solid, the value type measurement device cannot be used to measure flow velocity due to clog problem or the solid particle will damage the value itself. Hence, by applying the non-invasive (non local or noncontact) method of laser and optical sensor combined with cross-correlation method, this type of mixture flow can be measured.

1.4 Work Scope Project

1. Project is build up to implement the velocity of moving particle by using combination of laser and phototransistor sensors.
2. The software that will be used is Visual Basic 6.0 to implement cross-correlation algorithm from data obtained.
3. For velocity measurement, the sensors are located at upstream and downstream in order to capture the velocity of moving particle.
4. Design the transmitter and receiver circuit where the receiver circuit is being constructed to process signal from the receiver sensor.
5. Several different distances are used to get the different result of velocity and it will be compared between the theoretical calculation and experimental result.
6. DAQ card is used to collect the data of the velocity before transfer to Visual Basic.

1.5 Methodology

This project consists of hardware and software. Firstly for hardware, receiver circuit for sensor is designed. Then the circuit prototype is tested whether it is function as require or not. The output from the circuit should be 10V, if not troubleshoot will be doing in order to make the circuit function and get 10V output. The measurement of the velocity is measured as an object is dropped in the prototype pipe and the data will be collected by the DAQ card. Hence the data will be recorded in Data Access and then the velocity will be cross-correlated in VB 6.0 and the system is set as offline system.

1.6 Thesis Outline

Chapter one presents an introduction; overview process involved in this project; aim and the objectives of the project; problem statement; work scope of the project; methodology; and the thesis outline.

Chapter two covers the literature review. In this chapter optical sensor is used. Several type of sensor such as LED, Photodiode, Infrared and others will be discussed. There are different types of projections such as parallel beam projection; two rectilinear projection; orthogonal projection; fan beam projection; and others combination projection.

Chapter three covers the methodology of the project. All of the mechanism that involved in this project such as ;specific sensing mechanism; Visual Basic 6.0; cross-correlation method; parallel beam projection; arrangement of sensor for velocity measurement(jig &fixture); transmitter circuit; receiver circuit; and Data Acquisition System will also be discussed in this chapter.

Chapter four present the results from the hardware troubleshoot and the result from the measurement. .

Chapter five is the conclusion and recommendation of the thesis.

CHAPTER 2

LITERATURE REVIEW

There are several types of sensors that involved in industries, such as thermal sensor, photodetector sensors, capacitive sensor, semiconductor sensors and others. In this project, optical sensor will be used for the transmitter and receiver where optical sensor is one type of non- invasive mechanism. Arrangement of the sensor also needs to be considering where five main type of projection can be chosen in order to measure the velocity. There are parallel beam projection; orthogonal projection; two rectilinear projection; fan beam; and others combination from the main type of projection.

2.1 Sensors

Sensing is the most fundamental technique that senses the physical variables being measured. The sensor is a physical element that does this, and contains one or more transducers within it. The transducer converts or transforms one form of energy to another form in a detectable signal form; the energy includes various types of form- mechanical, electrical, optical, chemical, and so forth. In view of this, the transducer is an essential element of a sensor which needs to be contained within it. The transformer

raw signal usually contains low amplitude noise contaminated, narrow sensing range, nonlinearity, and so on. The signal conditioning units are usually necessary to make these raw of signal forms conditioned into desirable forms. Some sensors contain these conditioning units as part of their body but some are equipped with these units outside. [7]

Light is produced by the energy released when atoms are excited by heat, chemical reaction, or other means. Light is both a wave and a particle, and travels through space as electromagnetic waves. Each “colour” has a unique wavelength due to the wave motion. This wavelength is the distance a wave travels in one cycle. The light wavelength is express in term of nanometers since the wavelengths are short. The color green for the example is the most visible light with the approximate wavelength of 565nm. Light has neither mass nor charge even though it is a wave and a light particle is called a photon is classified as a particle because it is the smallest “piece” of light. This is an analogous to an electron being the smallest negatively charged “piece” of an atom.

2.2 Optical Sensor

A desirable characteristic of sensors is that they have a negligible effect on the measured environment that is, the process. Thus, is a resistance-temperature detector (RTD) heats up its own temperature, there is less confidence that the RTD resistance truly represents the environment temperature. Much effort is made in sensor and transducer design to reduce backlash from the measuring instrument on its environment. When electromagnetic (EM) radiation is used to perform process-variable measurement, transducers that do not affect the system measured emerge. Such systems of measurement are called *nonlocal* or *noncontact* (non-invasive) because no physical contact is made with the environment of the variable. Noncontact characteristic measurements often can be made from a distance. [3]

In process control, EM radiation in either the visible or infrared light band is frequently used in measurement applications. The techniques of such application are called *optical* because such radiation is close to visible light. A common example of optical transduction is measurement of an object's temperature by its emitted EM radiation. Another example involves radiation reflected off the surface yield a level or displacement measurement. Optical technology is a vast subject covering a span from geometrical optics, including lenses, prism, grating, and the like, to physical optics, with lasers, parametric frequency conversion, and nonlinear phenomena. These subjects are all interesting, but all that is required for our purpose is a familiarity with optical principles and knowledge of specific transduction and measurement methods. [3]

2.2.1 Light Emitting Diode (LED)

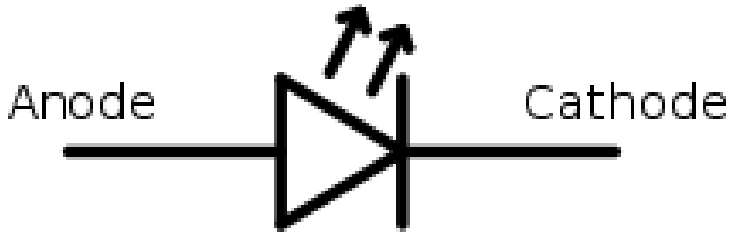

Figure 2.1 LED symbol

Light Emitting Diode (LED) is a visible light. It is manufactured to produce a variety of color such as infrared, red, green, yellow and others. It is simple optoelectronic illuminators whose brightness just increased with applied current. LED emits light when an electric current is applied in the forward direction of the device. The effect is a form of electroluminescence where incoherent and narrow-spectrum light is emitted. LEDs are widely used as indicator lights on electronic devices and increasingly in higher power applications. The size of LED is small and easy to install and more durable. This LED also an economic sensor where it is cheaper compare to other sensor such as phototransistor. Figure 2.1 above is the symbol of LED. LED has a voltage drop

of 1.5V to 2.5V when forward biases, somewhat more than small signal silicon diodes. It takes only a few milliamps of current of dimly light the diode [4].

2.2.2 Photodiode

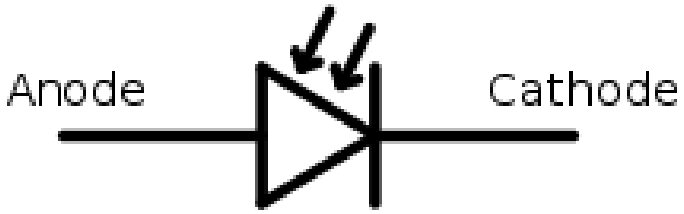

Figure2.2 Symbol of Photodiode

A variety of photodiode detectors are available for converting a light signal to the corresponding electrical signal for position detection. The semiconductor junctions are sensitive to light as well as heat. If a p-n junction is reversely biased, it has a high resistance. When it is exposed to light, photons impinging the junction can excite bound electrons and create new pairs of electrons and holes on both sides of the junction. Consequently, these separate and flow in opposite direction; electrons flow toward the positive side of the voltage source, whereas holes flow toward the negative side. This results in photocurrent, i_p which is directly proportional to the irradiance of the incoming light, I_r ($ip=C_I I_r$) where C_I is the proportionality constant depending on the area of the diode exposed to incoming light. For the characteristics of photodiode, the photocurrent ip is much larger than the dark current io (Ir=0) and it gets larger with increasing light irradiance or intensity. The photodiode is indicate by operating within the range of a reversed biased voltage that we can make the output current directly proportional to the irradiance or intensity of incident light. The dark current needs to kept as small as possible to have high sensitivity of a photodiode since the total current is composed of photo current and dark current(reverse leakage). Figure 2.2 above show the symbol of photodiode.